PALAEONTOLOGICAL HERITAGE: COMBINED FIELD-BASED & DESKTOP STUDY

Six Solar PV Projects within the Poortjie Renewable Energy Facility near Nelspoort, Beaufort West Local Municipality, Central Karoo District, Western Cape

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EXECUTIVE SUMMARY

Ziyanda Energy (Pty) Ltd, Pretoria is proposing to develop a cluster of up to six solar energy facilities (solar parks) *plus* associated infrastructure as a component of the Poortjie Renewable Energy Facility near Nelspoort in the Beaufort West Local Municipality (Central Karoo District), Western Cape Province.

The solar project areas are underlain by potentially fossiliferous sedimentary rocks of the Teekloof Formation (Lower Beaufort Group, Karoo Supergroup) of Late Permian age. While a sparse scatter of previously recorded vertebrate fossil sites are known in the wider region, it is not known if any of these fall within the solar project sites currently under consideration. Based on the recent 3-day palaeontological site visit, the great majority of the solar project areas is mantled by thick superficial deposits (alluvium, colluvium / eluvium, calcrete, soils) of low palaeosensitivity. Apart from occasional invertebrate trace fossils of limited scientific interest, the small number of tetrapod fossils recorded from Lower Beaufort Group bedrocks here comprise reworked, fragmentary bones preserved within channel basal breccias or weathered-out into surface gravels. No well-preserved, articulated postcrania or identifiable skull material of high scientific or conservation significance was recorded, although there is still potential for such material occurring at or beneath the surface within the sites. It is concluded that all six solar site options are in practice of Low Palaeosensitivity overall. The preliminary Low to Very High palaeosensitivity sensitivity mapped here by the DFFE Screening Tool is therefore *contested*.

Given the low overall palaeosensitivity of all six of the solar project areas, the proposed renewable energy developments are all of Low impact significance in terms of palaeontological heritage resources. The proposed developments are not fatally flawed and there are no objections on palaeontological heritage grounds to their authorisation.

None of the fossil sites recorded within the six solar project areas is of high scientific or conservation value and no mitigation is recommended in their regard. However, given the potential for the exposure or recognition of additional, scientifically valuable fossil occurrences within the project footprints, a Chance Fossil Finds Protocol, as outlined below and tabulated in Appendix 2, must be included within the Environmental Management Programme (EMPr) and fully implemented throughout the construction phase of the solar projects.

The Environmental Control Officer (ECO) / Environmental Site Officer (ESO) responsible for the development should be made aware of the possibility of important fossil remains (vertebrate bones, teeth, burrows, petrified wood, plant-rich horizons *etc.*) being found or unearthed during the construction phase of the development. Monitoring for fossil material of all major surface clearance and deeper (>1m) excavations by the ECO/ESO on an on-going basis during the construction phase is therefore recommended. Significant fossil finds should be safeguarded and reported at the earliest opportunity to Heritage Western Cape for recording and sampling by a professional palaeontologist (Contact details: Heritage Western Cape. 3rd Floor Protea Assurance Building, 142

Longmarket Street, Green Market Square, Cape Town 8000. Private Bag X9067, Cape Town 8001. Tel: 021 483 5959 Email: ceoheritage@westerncape.gov.za). The palaeontologist concerned will need to submit a Work Plan for approval by Heritage Western Cape.

1. INTRODUCTION & BRIEF

The company Ziyanda Energy (Pty) Ltd, Pretoria is proposing to develop a cluster of up to six 150MWp solar energy facilities (solar parks) *plus* associated infrastructure as a component of the Poortjie Renewable Energy Facility near Nelspoort in the Beaufort West Local Municipality (Central Karoo District), Western Cape Province. The six site options under consideration are each of approximately 300 ha total area and will be situated *c*. 70 km to the ENE of Beaufort West, SE of the N1 trunk road as well as the railway line from Cape Town into the interior. They are labeled A to F in the satellite map Figure 1 below. Each proposed solar PV facility will contain an on-site collector substation that will connect to the new Poortjie Wes Substation (subject to a separate Basic Assessment) *via* a132 kV Overhead line (OHL).

The six solar project areas are all located within the gazetted Beaufort West Renewable Energy Development Zone (REDZ 11) (*cf* Van der Walt 2019) and the central transmission corridor and they are therefore subject to a Basic Assessment Process. The present combined desktop and field-based palaeontological heritage report contributes palaeontological heritage data to the overarching Heritage Impact Assessment for each solar project that is being compiled by CTS Heritage, Cape Town (Contact details: Ms Jenna Lavin, CTS Heritage. 16 Edison Way, Century City, Cape Town. Tel: +27 (0)87 073 5739. Cell: +27 (0)83 619 0854. E-mail: info@ctsheritage.com). The independent EAP for these solar PV projects is Savannah Environmental (Pty) Ltd.

2. INFORMATION SOURCES

This combined desktop and field-based palaeontological heritage study of the six project areas for the Poortjie Renewable Energy Facility near Nelspoort was based on the following information resources:

1. Short project outlines, kmz files, screening reports and maps provided by CTS Heritage, Cape Town;

2. A desktop review of:

(a) the relevant 1:50 000 scale topographic maps (3223AA Nelspoort, 3223AB Kareebosch & 3222BB Renosterkop) and the 1:250 000 scale topographic map 3222 Beaufort West),
(b) Google Earth© satellite imagery,
(c) published geological and palaeontological literature, including the 1:250 000 geological map (3222 Beaufort West) and relevant sheet explanation (Johnson & Keyser 1979) as well as
(d) several previous and fossil heritage (PIA) assessments for renewable energy and transmission line projects in the Beaufort West region by the author and colleagues (*e.g.* Almond 2010a, 2011, 2021).

3. The author's field experience with the formations concerned and their palaeontological heritage (*cf* Almond & Pether 2008 and PIA reports listed in the References); and

4. A three-day field assessment of the six solar project areas by the author and an experienced field assistant (Ms Madelon Tusenius, *Natura Viva* cc), during the period 9 to 12 March 2022.

Although visibility in many areas was seriously constrained by dense grassy vegetation after heavy rains, these areas are not those with well-exposed, potentially fossiliferous Beaufort Group bedrock or older alluvial deposits along drainage lines. The season in which the site visit took place therefore has no critical bearing on the palaeontological study.

3. GEOLOGICAL CONTEXT

The Poortjie Renewable Energy Facility solar project areas are all situated in fairly flat-lying, semi-arid terrain within an otherwise dissected, hilly to mountainous zone that lies in front of the Great Escarpment, *i.e.* along the northwestern margins of the Great Karoo *sensu stricto* (*cf* Fig. 1, where relevant land parcels are indicated). The Karoo *koppies* in the region, such as Boegoeberg, Katjiesberg, Blinkwater se Berg and Bruinrug, reach elevations of 1300-1635 m amsl. and are generally capped by resistant-weathering dolerite. Numerous watercourses like the Soutrivier and Bufferlsrivier and their tributaries traverse the hilly pre-Escarpment Zone and drain into the topographically subdued Aberdeen *vlaktes* to the south.

The geology of the solar project areas is covered by 1: 250 000 geology sheet 3222 Beaufort West (Council for Geoscience, Pretoria; Johnson & Keyser 1979) (Fig. 2). Low-lying areas within the wider study region near Nelspoort are largely underlain by the mudrock-dominated fluvial succession of the Hoedemaker Member (Teekloof Formation, Lower Beaufort Group) of earliest Late Permian age while the overlying, sandstone-rich Oukloof Member (Teekloof Formation) is seen on the upper slopes of the higher *koppies* (Johnson *et al.* 2006) (Figs. 4 & 16). Detailed mapping of the Teekloof Formation members is unresolved due to the generally low levels of bedrock exposure here, especially as far as the potentially fossiliferous overbank mudrocks are concerned; these last are mainly seen in occasional incised streams and erosion gullies as well as farm dams and borrow pits. The Lower Beaufort Group sediments near the Great Escarpment are extensively intruded by Early Jurassic sills and dykes of the Karoo Dolerite Suite. These intrusions cap most of the *koppies* and build prominent ridges across the landscape. Intrusion of hot dolerite magmas and associated metasomatism by hot mineral-rich fluids has extensively baked and otherwise altered the Palaeozoic country rocks. Bedrocks in lower-lying areas are mostly blanketed by thick gravelly to sandy or silty alluvial deposits, eluvial surface gravels and soils of ill-defined Late Caenozoic age. Calcrete hardpans are widely developed in the subsurface here due to the high levels of carbonate derived from local dolerite weathering. Mountain slopes and low rocky scarps are for the most part mantled by rubbly doleritic and sandstone colluvial deposits.

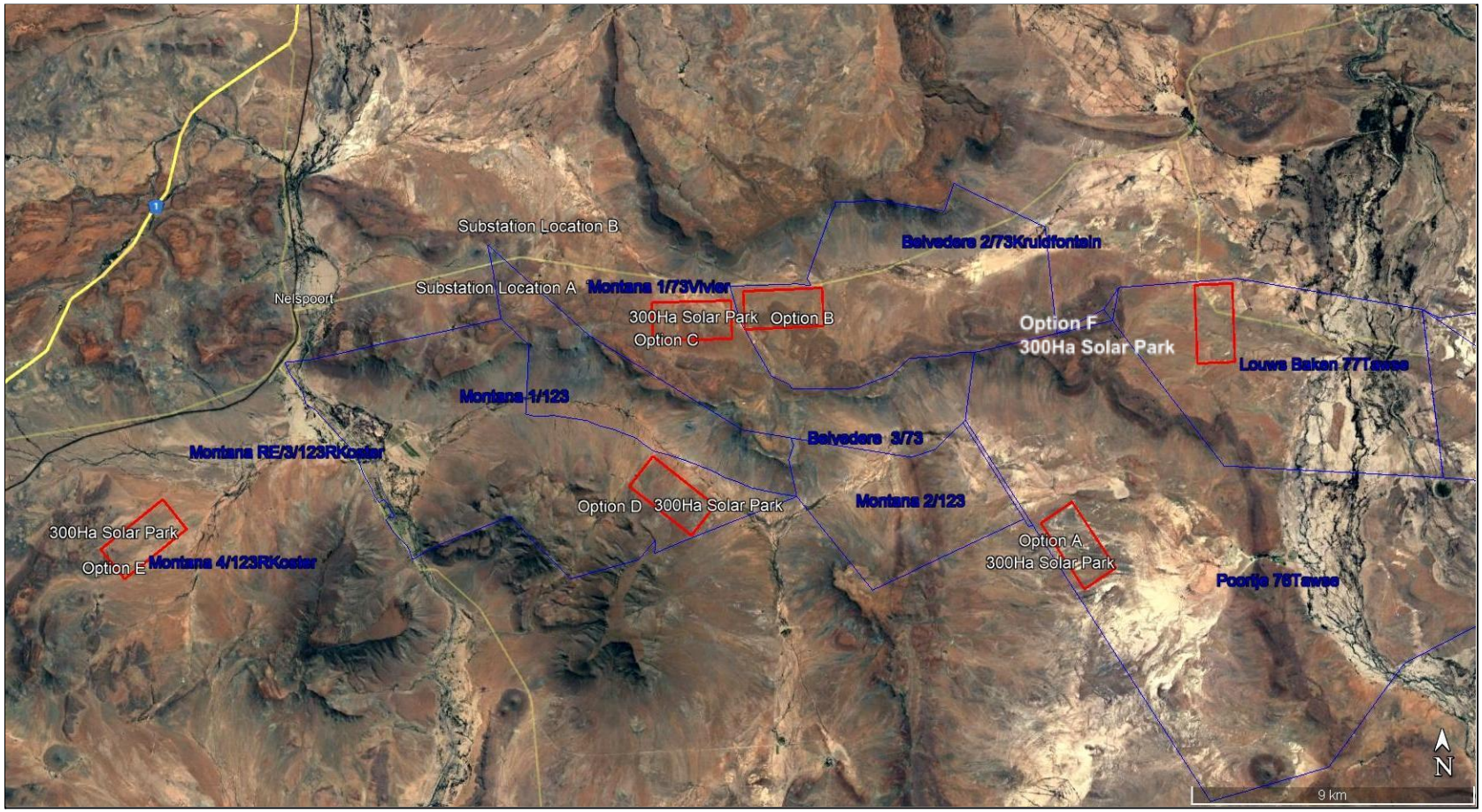

Figure 1: Google Earth© satellite map showing the location of the six proposed solar PV facilities (red rectangles, Options A to F) forming part of the Poortjie Renewable Energy Facility near Nelspoort, *c.* 70 km ENE of Beaufort West in the Beaufort West Local Municipality (Central Karoo District), Western Cape Province. The relevant land parcels are labeled in blue.

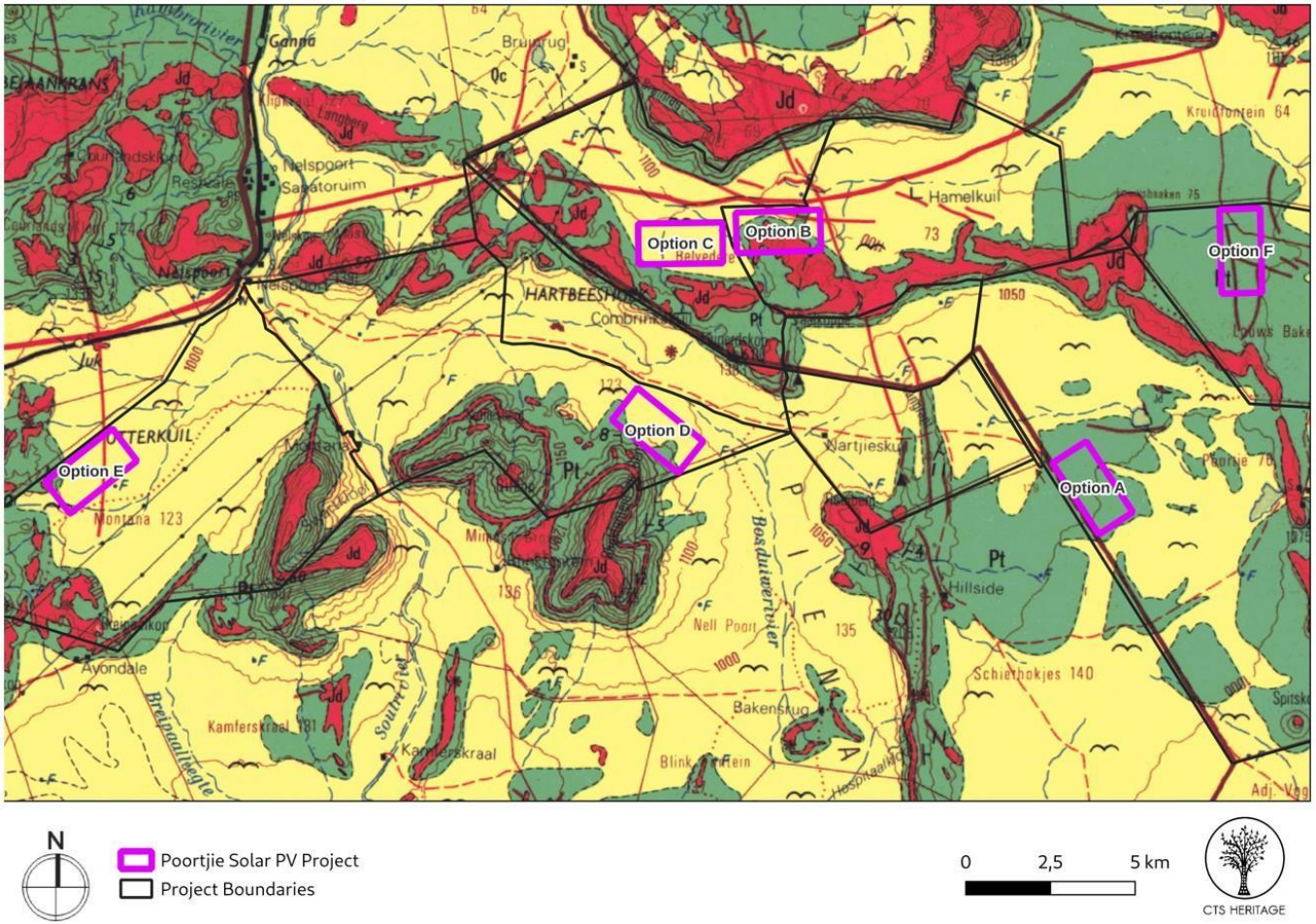

Figure 2: Extract from adjoining 1: 250 000 geology sheet 3222 Beaufort West (Council for Geoscience, Pretoria) showing the location of the six Poortjie Renewable Energy Facility solar project sites (A-F, lilac rectangles) (Map generated by CTS Heritage). The main geological units represented on the geological map include: Middle to Late Permian Teekloof Formation (Lower Beaufort Group) – Pt, green / blue-green (Pt). This is not differentiated into members on the map. Sills and dykes of the Early Jurassic Karoo Dolerite Suite – red (Jd). Late Caenozoic alluvium – yellow with "flying bird" symbol. *N.B.* Most young superficial deposits such as colluvium, pedocretes and soils are not mapped at 1: 250 000 scale but these obscure the older bedrocks over most of the solar project areas.

3. PALAEONTOLOGICAL HERITAGE CONTEXT

The bedrocks of the Hoedemaker Member which underlie the solar project areas at depth were originally assigned to the *Tropidostoma* Assemblage Zone (AZ) (Smith & Keyser 1995, Smith *et al.* 2012). They are now largely referred to the upper part of the newly defined *Endothiodon* Assemblage Zone (Day & Smith 2020), *viz*. the *Tropidostoma* – *Gorgonops* Subzone (Figs. 3 & 4). This diverse continental fossil biota of earliest Late Permian age is characterised by several medium to large-sized, dicynodonts such as *Tropidostoma*, *Rachiocephalus* and *Endothiodon* with its highly-specialized herbivorous dentition (the first large-bodied herbivore to appear after the end-Capitanian extinction event) as well as a range of small-bodied dicynodonts with or without post-canine teeth, palaeoniscoid bony fish, rhinesuchid temnospondyl amphibians, large herbivorous pareiasaur reptiles, the small, lizard-like reptile *Youngina* as well as several carnivorous gorgonopsian, therocephalian and cynodont therapsids. Non-vertebrate fossils include non-marine bivalve molluscs, a limited range of trace fossils (*e.g.* vertebrate tracks, tetrapod burrows, invertebrate burrows and trackways) as well as plant remains of the Gondwanan *Glossopteris* Flora.

No historical fossil sites are shown in the wider solar project area near Nelspoort on the 1: 250 000 geology sheet 3222 Beaufort West (Fig. 2) or on the early Karoo vertebrate fossil site map of Kitching (1977). Several recorded vertebrate fossil sites are shown here in the more recent map of Nicolas (2007), however (Fig. 5).

Low diversity trace fossil assemblages, but no vertebrate fossil remains, were recorded during a PIA study involving Hoedemaker Member sediments just to the NE of Beaufort West by Almond (2011) (see also related desktop study by Bamford 2021). Palaeontological assessments for two renewable energy projects in the vicinity (< 10km) of the present project areas, as indicated on the REEA renewable energy database provided by the DFFE, were not available for the present study, *viz*. the approved Poortjie Wes Wind Energy Project proposed by Terra Wind Energy Poortjie Wes (Pty) Ltd (DEA Ref. 12/12/20/2015) and the withdrawn / lapsed Beaufort West wind energy project proposed by Terra Wind Energy (Pty) Ltd (DEA Ref. 12/12/20/2301).

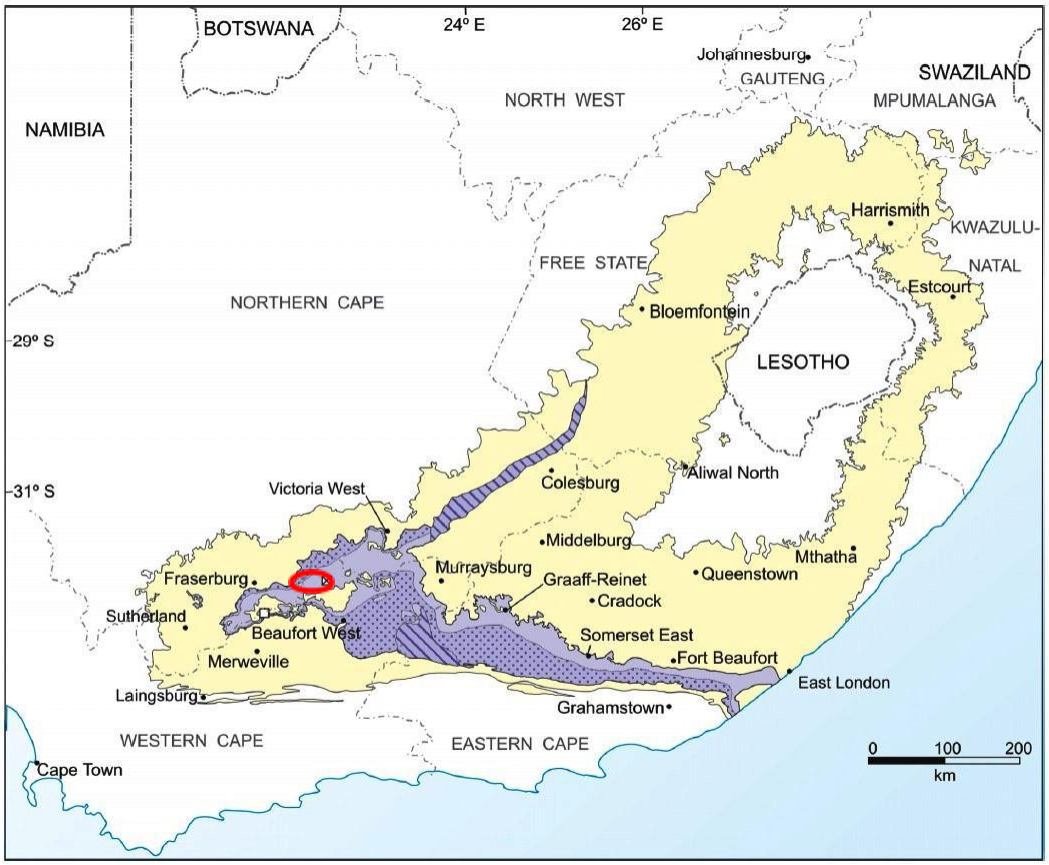

Figure 3: Distribution of the *Endothiodon* Assemblage Zone (AZ) within the Main Karoo Basin of the RSA (Day & Smith 2020). The Poortjie Renewable Energy Facility project area near the foot of the Great Escarpment near Nelspoort, to the NE of Beaufort West (red ellipse), probably falls largely or entirely within the *Tropidostoma – Gorgonops* Subzone (plain lilac area).

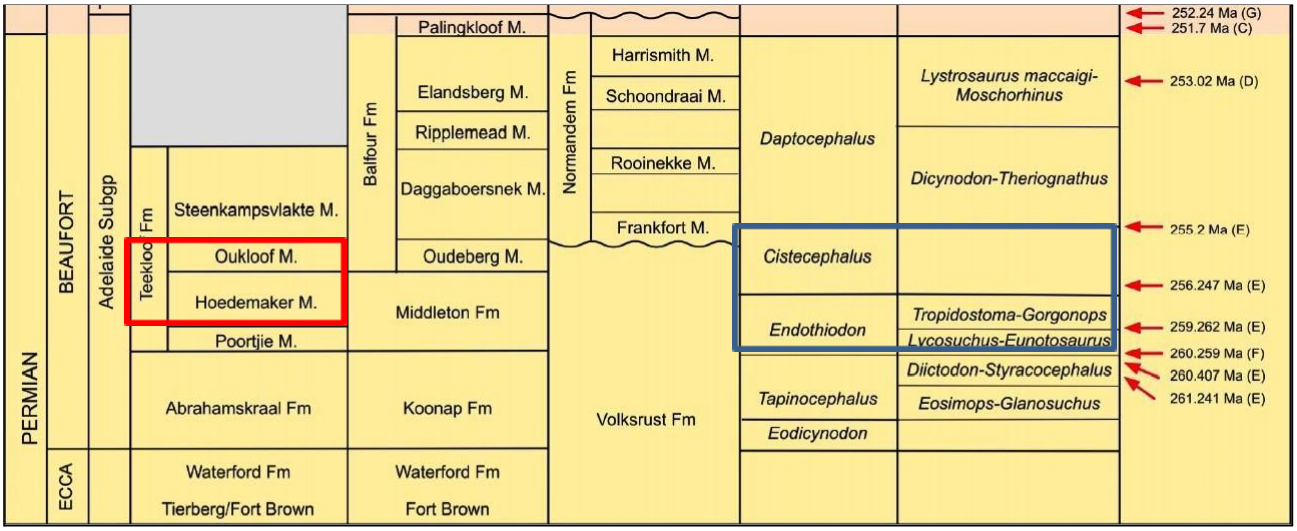

Figure 4: Chart showing the latest, newly revised fossil biozonation of the Lower Beaufort Group of the Main Karoo Basin (abstracted from Smith *et al.* 2020). Rock units and fossil assemblage zones mapped within the Poortjie Renewable Energy Facility project area are outlined in red and blue respectively.

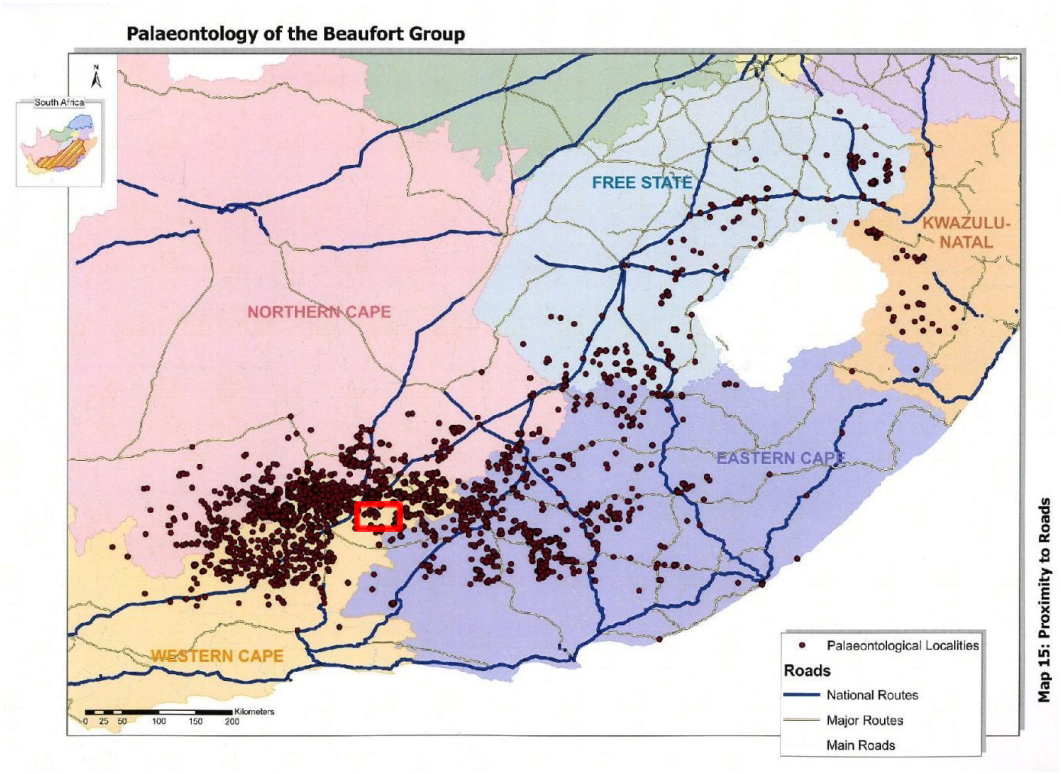

Figure 5: Distribution of recorded vertebrate fossil sites within the southern portion of the Main Karoo Basin (modified from Nicolas 2007). The location of the Poortjie Renewable Energy Facility project area between Nelspoort and Murraysburg is *approximately* indicated by the small red rectangle. Several tetrapod sites have been recorded here, close to the dissected Great Escarpment Zone, whereas very few sites are known from the topographically subdued Aberdeen *vlaktes* to the south.

4. RESULTS FROM PALAEONTOLOGICAL SITE VISIT

A short, illustrated account of the geology and palaeontological heritage observed at each of the six solar project areas (A to F in Figs. 1 & 2) is provided in this section of the report. GPS locality details of fossil material recorded during the site visits are tabulated in Appendix 1 with a short description and indication of its palaeontological heritage significance (Provisional Field Rating) (see also satellite maps Figures A1 to A3).

- **SOLAR SITE A**

Solar Site Option A on Farm Poortje 76 (1: 50 000 map 3222AB Kareebosch) (Figs. 6 to 11) is situated in low-lying, flattish terrain at around 990 to 1050m amsl. It lies between a N-S trending range of hills intruded by dolerite dykes in the west and a major dolerite ridge some 6 km to the east that runs near Poortjie Wes Farmstead. Satellite images suggest that bedrocks here are folded along W-E axes. The area mainly comprises gravelly to sandy *vlaktes* traversed by a few shallow stream lines draining to the SE. Satellite images show several pale areas of fine-grained silty alluvium, sheetwash and pan sediments with a few darker grey areas suggesting Beaufort Group mudrock exposure. However, most of these latter areas are covered with grey-green mudrock gravels or dark brown, ferruginised sandstone rubble with very little solid bedrock exposure. Where bedrocks crop out at surface there are occasional low rocky ridges of brownish sandstone, sometimes flaggy. Most of the project area is mantled by alluvial sands and gravels, eluvial and sheetwash surface gravels of wacke, mudstone flakes, dolerite, sparse rolled bone and reworked palaeocalcrete concretions (some secondarily ferruginised). There are also sparse clasts of grey-green, greenish-brown, orange-patinated, cherty

material with numerous bubble-like cavities which is probably of intrusive igneous origin. Rusty-brown, ferruginous carbonate pedocrete concretions which have weathered out from the underlying overbank mudrocks dominate eluvial surface gravels locally. Many areas of sandy alluvial soils feature dense to clumped grassy vegetation, limiting visibility.

Concentrations of weathered-out, disarticulated and fragmentary fossil remains of large-bodied tetrapods – possibly pareiasaur or large dicynodont such as *Endothiodon* - occur locally within surface float and sheetwash gravels (Figs. 12 to 14); some of this material is potentially identifiable. There are also widely scattered chunks of pinkish to lilac, well-rounded, partially ferruginised bone material ("rolled bone") which are probably unidentifiable (Fig. 15). They occur especially in areas where high concentrations of ferruginous pedocrete concretions are weathering out at surface (Fig. 11).

Figure 6: View southwards across Solar Site A showing flattish terrain with sandy to gravelly superficial sediment cover and vegetation of scattered karroid shrubs *plus* grass.

Figure 7: Rare, low exposure of well-jointed, flaggy channel sandstones of the Lower Beaufort Group.

Figure 8: The dark, grey-green, crumbly-weathering bedrocks seen here are composed of wacke (impure sandstone) rather than overbank mudrocks which are the main target of vertebrate fossil surveys.

Figure 9: Greyish areas on satellite images often prove to be due to a thin, gravelly cover of angular mudrock clasts rather than solid bedrock.

Figure 10: One of several open pan areas featuring sun-cracked siltstones with sparse sheetwash gravels, among which no petrified wood clasts were observed.

Figure 11: Eluvial and sheetwash surface gravels dominated by dark, rusty-brown ferruginous carbonate concretions weathering out from pedocrete-rich palaeosols within the underlying Lower Beaufort Group overbank mudrocks. Clasts of rolled bone are commonly found in this context (See Figure 15).

Figure 12: Isolated tetrapod bone among surface gravels – the end of a weathered long bone of a sizeable tetrapod (chunk is 8 cm wide) (Loc. 385).

Figure 13: Collection of bone chunks gathered from surface gravels within a small area and derived from one or more sizeable tetrapods – possible a large dicynodont or pareiasaur. Most such material is postcranial and probably unidentifiable but some cranial fragments (*e.g.* jaws with teeth) might be identified (scale in cm) (Loc. 381).

Figure 14: Two weathered-out, poorly-preserved bone fragments of a large tetrapod preserved within ferruginised palaeocalcrete concretions found as surface float (scale in cm) (Loc. 375).

Figure 15: Sample of widely scattered, well-rounded chunks of greyish to pink- or lilac-hued rolled bone encountered among surface gravels, especially those dominated by calcrete concretions (scale in cm and mm) (Loc. 390).

- **SOLAR SITE B**

Solar Site Option B on Farm Belvedere 2/73 (1: 50 000 map 3223AA Nelspoort) is situated in low-lying, flattish as well as slightly elevated, rocky terrain between 1100 and 1150 m amsl. on the southern side of the Nelspoort – Kruidfontein unpaved road (Figs. 17 to 23). A major E-W trending dolerite ridge runs to the south and extends into the project area. The site is overlooked from the north by the steep slopes of Bruinrug. The last is built of Hoedemaker Member mudrocks capped by the Oukloof Member sandstone package and then a dolerite sill (Fig. 16). A steep dolerite dyke cuts the slopes to the northeast and another WNW-ESE trending dyke traverses the north-eastern sector of the project area. The south-central sector of the project area features a major doleritic intrusion mantled by rusty-brown doleritic and sandstone rubble.

Alluvial sediments of an east-flowing drainage line are exposed in a large roadside borrow pit just to the NE and outside the project area (Fig. 20). Here saprolitic (*i.e. in situ*, weathered) grey-green mudrocks and flaggy sandstones of the Hoedemaker Member are seen to be intensely disrupted and veined by calcrete near-surface. Palaeocalcrete concretions in the bedrock are enveloped by later Quaternary-age calcrete. The overlying older alluvial deposits are also calcretised up to a depth of *c*. 2m with development of a laterally persistent subsurface calcrete hardpan.

Poor to reasonably good exposures of baked Beaufort Group bedrocks are seen locally, especially towards the eastern edge of the project area. Highly jointed, medium-grained, yellowish, grey-green and slightly purplish, medium-bedded channel wackes, locally ripple cross-laminated, build slightly elevated terrain here, most of which is obscured by surface gravels of wacke and dolerite. Multiple thin to well-developed (several dm thick), lenticular, partially ferruginised and leached (vuggy) basal breccias composed of mudflake and calcrete intraclast are common within the sandstone-dominated succession. Well-bedded, grey-green siltstones and interbedded

thin brownish sandstones with multiple, well-developed horizons of baked intraclast breccia with some pebble-sized palaeocalcrete clasts are well exposed in the bed of the stream towards the south-western corner of the project area.

Much of the lower-lying portions of the project area are covered by thick orange-brown alluvial sands with gravelly lenses and eluvial surface gravels with grassy and bossieveld vegetation with occasional boulder-sized, desert-varnished dolerite corestones and quartzite blocks. The finer surface gravels are composed of dolerite, metaquartzite, wacke and hornfels and are seen in open, unvegetated areas. Angular greysish mudrock clasts and doleritic corestones are seen along shallow erosion gullies but good mudrock exposures are not seen here away from major drainage lines. Gulley erosion within these lower lying portions of the project area expose thick, pinkish to orange-brown alluvial sandy surface soils with cobbly to pebbly gravels of dolerite, hornfels, wacke, calcrete *etc*.

Major dolerite intrusion in the vicinity has probably compromised most fossil originally preserved within the sedimentary country rocks here. Very sparse, unidentifiable fragments of reworked bone are observed within the basal breccia facies which show evidence for thermal metamorphism, secondary mineralisation and leaching due to dolerite intrusion (Fig. 24). Such fragmentary reworked fossil remains are generally of low scientific value. Simple, horizontal to oblique invertebrate borrows (*c*. 4 mm diameter) are seen on upper bedding planes of cross-laminated, medium-grained channel wackes (Fig. 25).

Figure 16: The Oukloof Member sandstone package overlying gentler slopes of Hoedemaker Member mudrocks (both subunits of the Teekloof Formation) on Bruinrug, situated just to the north of solar site options B and C.

Figure 17: Good exposures of thin-bedded, tabular, grey-green Hoedemaker Member siltstones in the bed of a watercourse near the SW corner of the project area. Note the thick alluvial soil cover in the stream banks.

Figure 18: Well-jointed, yellowish-brown channel wackes of the Hoedemaker Member in higher-lying terrain in the western sector of the project area.

Figure 19: Well-developed, gravelly breccio-conglomerates are associated with sandstone facies in the project area (here in the SW corner) and are an important target for vertebrate fossil prospecting (*cf* Figure 24).

Figure 20: A thick, regional calcrete hardpan beneath sandy alluvial soils as well as calcrete veining of the underlying Beaufort Group mudrocks are well seen in the large borrow pit just north of the project area.

Figure 21: Low-lying sectors of the project area are largely mantled by thick, orange-brown sandy alluvial soils with eluvial surface gravels of dolerite, metaquartzite *etc*.

Figure 22: The thickness of the sparsely gravelly, sandy alluvial soils is well seen in occasional shallow erosion gullies,

Figure 23: Higher-lying terrain the southern sector of the project area is largely covered by rusty-brown doleritic rubble.

Figure 24: Occasional fragments of reworked tetrapod bone (arrowed) occur within the basal channel sandstone breccias, but most have probably been destroyed by leaching and thermal metamorphism (scale in cm) (Loc. 420). Such material is generally of low scientific value.

Figure 25: Current ripple cross-laminated sandstone bed tops locally display low diversity trace fossil assemblages of simple horizontal to oblique invertebrate burrows (scale in cm) (Loc. 421).

- **SOLAR SITE C**

Solar Site Option C on Farm Montana 1/73 (1: 50 000 map 3223AA Nelspoort) is situated in low-lying, flattish terrain between 1100 and 1130 m amsl. on the southern side of the Nelspoort – Kruidfontein unpaved road (Figs. 29 to 31). A major E-W trending dolerite ridge runs to the south and the site is overlooked from the north by the steep slopes of Bruinrug. A drainage line just north of the project area runs westwards into the Bruinrug dam.

Most of the solar project area is clothed in low *bossieveld* and grassy vegetation, with very little bedrock exposure. Large portions of the area are mantled by rusty brown doleritic scree and colluvial / eluvial gravels. Finer sheetwash gravels are dominated by clasts of wacke, dolerite, hornfels, vein quartz and metaquartzite with an admixture of calcrete. The north-eastern corner of the area is traversed by a zone of fine-grained alluvium. Areas of gullied sands and gravels feature occasional crudely flaked, weathered ESA artefacts of dolerite and metaquartzite.

Flat terrain in the west is underlain by thin orange, sandy soils overlying an extensive calcrete hardpan with sparse eluvial surface gravels of dolerite, hornfels, wacke *etc*, Open patches reveal rounded, desert varnished dolerite corestones. Good vertical sections along the banks and bed of a N-S trending, incised stream show 2-3 m of orange sandy soils with doleritic surface gravels overlying a well-developed calcrete hardpan. Calcretised gravels at the base of the soil profile are downwasted onto the underlying hardpan.Greyish areas seen on satellite images proved to be not bedrock but fine surface gravels of grey-green wacke, siltstone and dolerite. No significant areas of Lower Beaufort Group bedrocks were encountered during the site visit, as shown on the 1: 250 000 geological map (Fig. 2).

No fossil remains were recorded within the solar project area during the site visit.

Figure 26: The local stratigraphy is exposed in the bed and banks of a N-S trending incised stream crossing the solar project area (see following figure).

Figure 27: Detail of the section illustrated above showing a well-developed, gravelly calcrete hard pan in the stream bed overlain by doleritic gravels and thick alluvial sands.

Figure 28: Flat terrain in the western sector of the project area with thin sandy soils overlying a near-surface hardpan. A major E-W dolerite ridge runs south of the project area in the background.

Figure 29: Open, unvegetated patches with sandy soils and a sparse patina of eluvial and sheetwash gravels of dolerite, metaquartzite, hornfels *etc*. The steep, dolerite-capped slopes of Bruinrug are seen to the northeast in the background.

Figure 30: Gullied thick, orange-brown sandy soils with downwasted eluvial gravels, including a few flaked stone artefacts of dolerite and quartzite.

Figure 31: Close-up of surface gravels in grey-hued area seen on satellite images (hammer = 30 cm). The grey hues are due to angular gravels of mudrock and wacke rather than solid sedimentary bedrock.

- **SOLAR SITE D**

Solar Site Option D on farm Farm Montana 123 (1: 50 000 map 3223AA Nelspoort) is situated in the valley of the Bosduiverivier, a tributary of the Soutrivier, on the northern footslopes of Blinkfontein se Berg, between elevations of c.1050 to 1100m amsl. The area is flat-lying to gently sloping with occasional low scarps and is drained by several shallow, NE-flowing streams.

Most of the area is covered by sandy to gravelly alluvial soils with dense grassy and low shrubby vegetation. A large proportion of the project area is mantled by cobbly to bouldery colluvial, eluvial and alluvial surface gravels and brownish, sandy alluvial soils, with abundant, mostly angular, rusty-brown doleritic and brownish quartzitic gravel material. Well-rounded, black-patinated (desert varnished) dolerite corestones are derived from major sills intruding the Teekloof Formation bedrocks on Blinkfontein se Berg. A well-developed calcrete hardpan occurs beneath the doleritic surface rubble in some areas.

Bedrock exposure levels are generally very low (Figs. 32 to 39). Some grey patches seen on satellite images in the central and north-western sectors of the area reflect fine sheetwash surface gravels of angular to platy mudrock rather than solid bedrock. Low, north- and north-east facing scarps and gullied hillslopes within and just outside the area (especially towards the southeast) show locally good exposures of massive to thin-bedded, blue-grey to blue-grey and subordinate purple-brown Teekloof Formation silty mudrocks. These contain occasional well-developed pedogenic calcrete horizons (palaeosols) and thin interbeds of grey-green crevasse splay wacke (locally with wave-rippled bed tops) as well as thinly interbedded wacke-siltstone packages of possible riverbank (levee) facies. A thick, grey-green, medium-grained body of tabular-bedded channel wacke contains large oblate concretions of diagenetic ferruginous carbonate towards the top.

Despite the occurrence of occasional good, gullied Beaufort Group bedrock exposures within and just outside the project area, no fossil vertebrate or other palaeontological material was recorded during the site visit.

Figure 32: View southwards across flat, grassy solar project area with Blinkfontein se Berg behind, capped by a dolerite sill.

Figure 33: View across low-relief, sandy to gravelly alluvial terrain towards the Bosduiverivier and Luiperdskop in the northeast.

Figure 34: Good gullied exposures of multi-hued overbank mudrocks of the Teekloof Formation in the south-eastern sector of the project area.

Figure 35: Detail of exposure illustrated above, here showing massive, crumbly mudrocks, a thin crevasse splay wacke and a thin-bedded heterolithic package (hammer = 30 cm).

Figure 36: Thick package of well-jointed, grey-green channel wackes. Large sphaeroidal concretions of ferruginous carbonate occur within this body (not seen here).

Figure 37: Rubbly colluvial fan gravels dominated by clasts of rusty-brown dolerite and brown quartzite (baked sandstone) along the higher-lying, SW margins of the project area.

Figure 38: Well-developed hardpan of creamy-hued calcrete exposed beneath doleritic surface gravels overlying Beaufort Group mudrocks.

Figure 39: Many greyish areas on satellite images reflect fine sheetwash surface gravels of reworked mudrock rather than solid bedrock.

- **SOLAR SITE E**

Solar Site Option E on Farm Montana 123 (1: 50 000 map 3222BB Renosterkop) is situated in low-lying, flattish terrain at around 1020 to 1070m amsl. at the northeastern foot of Boegoeberg, some 4 km SE of the N1 and railway line into the interior (Figs. 40 to 44). The alluvial terrain here is drained towards the east into a N-flowing tributary of the Soutrivier near Nelspoort. With the exception of low doleritic exposures in the far west, the project area is entirely mantled with alluvial sediments and grassy and bossieveld vegetation with no exposures of Beaufort Group bedrocks encountered during the site visit or visible on satellite images (greyish patches on satellite images reflect dark surface gravels rather than bedrock). Greyish bedded sedimentary bedrocks are seen on the eastern footslopes of Boegoeberg, just outside the project area, where they are likely to be extensively baked by dolerite intrusions. Ground visibility was negligible for much of the area due to dense grassy vegetation but the local geology can be inferred from more open, unvegetated areas visited within a few 100m of the SE boundary of the project area. Here are seen low exposures of well-jointed channel sandstone (probably thermally metamorphosed) as well as eluvial and alluvial surface gravels dominated by dolerite corestones and quartzitic sandstone. Shallow gulley erosion has locally exposed a calcrete hardpan mantled by fine calcrete rubble as well as gritty coarse sands with dispersed fine gravels lying beneath the surface gravels and unconsolidated silty to sandy alluvial soils. The coarser, semi-consolidated older alluvium displays distinctive polygonal cracking patterns that might be related to permafrost conditions during the Pleistocene Epoch.

No fossil remains were recorded during the short site visit. Given the absence of Beaufort Group bedrock exposure, the extensive thermal metamorphosis of the bedrocks in the vicinity of Boegoeberg as well as the general scarcity of significant palaeontological heritage within the pervasive Late Caenozoic superficial sediments, the palaeosensitivity of Solar Site E is rated as LOW.

Figure 40: View SE across flat, sandy alluvial terrain in the solar project area with grassy and low shrubby vegetation and no bedrock exposure.

Figure 41: Open area with sandy alluvial soils and dispersed alluvial or eluvial (downwasted) surface gravels, mainly of baked quartzite and dolerite. Bedded Lower Beaufort Group sediments are seen on the slopes of Boegoeberg in the background.

Figure 42: Low exposure of jointed Beaufort Group channel sandstone or quartzite situated some 300m SE of the solar project area. No bedrock exposures were encountered within the solar project area itself.

Figure 43: Gullied exposure of semi-consolidated, gritty older alluvium with polygonal cracking pattern, shortly SE of the solar project area which is probably underlain by similar sediments of possible Pleistocene age.

Figure 44: Local exposure of a previously subsurface calcrete hardpan mantled by fine calcrete and other gravels (hammer = 30 cm).

- **SOLAR SITE F**

Solar Site Option F on Farm Louws Baken 77 (1: 50 000 map 322AB Kareebosch) is situated in low-relief terrain at elevations of *c*. 1000 to 1010 m amsl. between a major dolerite ridge in the west and the alluvial *vlaktes* of the Buffelsrivier in the east (Figs. 45 to 53). Much of the area is flat and gravelly with some open, sandy to silty patches and there are also low ridges of Beaufort Group channel sandstone, especially in the north, as well as rubbly dolerite, especially in the south. Satellite imagery suggests that the bedrocks here are folded along WSW-ESE axes. The brownish channel sandstones (wackes) are well jointed, sometimes flaggy and contain occasional mudflake intraclasts and are well jointed, possibly karstified, with some surfaces showing lichen weathering. Only a few, limited areas with surface exposure of hackly-weathering, grey-green to purple-brown overbank mudrocks of the Hoedemaker Member are seen, mainly associated with shallow drainage lines and erosion gullies. Horizons of pale greyish pedocrete feature lenses and concretions of palaeocalcrete within the mudrocks that are sometimes septarian. A possible neptunean dyke of brownish sandstone, probably generated by dewatering, was observed along a probably minor fault line, associated with quartz mineral lineation. The dolerite dykes weather out as low ridges with a rubbly surface of rusty-brown boulder rubble and dark, blocky-weathering, well-indurated hornfels along their margins. The silty to sandy alluvial soils are locally calcretised and thin, angular to subrounded eluvial surface gravels (sometimes desert varnished) of wacke, dolerite, greyish palaeocalcrete, creamy-white Quaternary calcrete and orange-patinated hornfels occur widely outside unvegetated pan areas.

The only fossils observed comprised a few isolated or clustered angular fragments or subrounded rolled blocks of pale fossil bone occurring as float within surface gravels, in some cases associated with pedocrete-rich mudrock exposures (Figs. 54 & 55). They belong to medium- to large-sized tetrapods – possibly pareiasaurs or large dicynodonts - but are unidentifiable as to anatomy and taxonomic affinities and therefore of low scientific significance.

Figure 45: Thin, well-jointed channel sandstone of the Lower Beaufort Group (hammer = 30 cm).

Figure 46: Shallow stream gulley in the southern project area exposing hackly-weathering, grey-green and purple-brown mudrocks of the Hoedemaker Member.

Figure 47: Pedocrete horizon of pinkish-grey palaeocalcrete – a primary focus for fossil vertebrate recording (Hammer = 30 cm).

Figure 48: Subvertical narrow dyke of pale sandstone intruding Lower Beaufort Group mudrocks (hammer = 30 cm). Such sedimentary dykes may have been generated by dewatering along minor fractures or fault lines.

Figure 49: Dolerite dyke marked by dark, rusty-brown, rubbly corestones building a low ridge.

Figure 50: Contact between rusty-brown, fine-grained cooled margin of a dolerite dyke and dark, grey-green, blocky-weathering hornfels (baked mudrock) with the dyke's metamorphic aureole (hammer = 30 cm).

Figure 51: Downwasted (eluvial) and sheet-washed surface gravels, here composed mainly of subrounded cobble- and pebble-sized clasts of dark brown, patinated wacke.

Figure 52: Surface gravels dominated by orange-patinated, pebble-sized clasts of hornfels, some of which are anthropogenically flaked.

Figure 53: Open, pan-like area with desiccation-cracked silty alluvial soils. Such areas can be readily searched for reworked fossil wood, none of which was recorded here, however.

Figure 54: Typical examples of well-rounded "rolled bone" within surface gravels near good exposures of Hoedemaker Member overbank mudrocks (Loc. 370) (scale in cm and mm).

Figure 55: Two, closely associated fragments of dense white bone of a medium to large tetrapod (perhaps a pareiasaur or large dicynodont) found in float overlying surface exposure of Hoedemaker Member overbank mudrocks (Loc. 369) (scale in cm).

5. SITE SENSITIVITY VERIFICATION

Preliminary palaeosensitivity mapping of the Poortjie Renewable Energy Facility solar sites based on the DFFE Screening Tool is shown below in map Figure 56. Outcrop areas of Lower Beaufort Group bedrocks shown on the 1: 250 000 geology map (Fig. 2) are assigned a Very High palaeosensitivity, mapped alluvial areas a Low palaeosensitivity and dolerite intrusions an Insignificant / Zero palaeosensitivity.

While a sparse scatter of previous vertebrate fossil sites are known in the wider region (Fig. 5), it is not known if any of these fall within the six solar project sites currently under consideration. Based on the recent 3-day palaeontological site visit, the great majority of the solar project areas is mantled by thick superficial deposits (alluvium, colluvium / eluvium, calcrete, soils) of low palaeosensitivity (Section 4). Apart from occasional invertebrate trace fossils of limited scientific interest, the small number of tetrapod fossils recorded from Lower Beaufort Group bedrocks here comprise reworked, fragmentary bones preserved within channel basal breccias or weathered-out into surface gravels. No well-preserved, articulated postcrania or identifiable skull material of high scientific or conservation significance was recorded, although there is still potential for such material occurring at or beneath the surface within the sites.

It is concluded that all the solar site options are in practice of Low palaeosensitivity overall, so the preliminary DFFE site sensitivity mapping shown in Figure 56 is *contested* here.

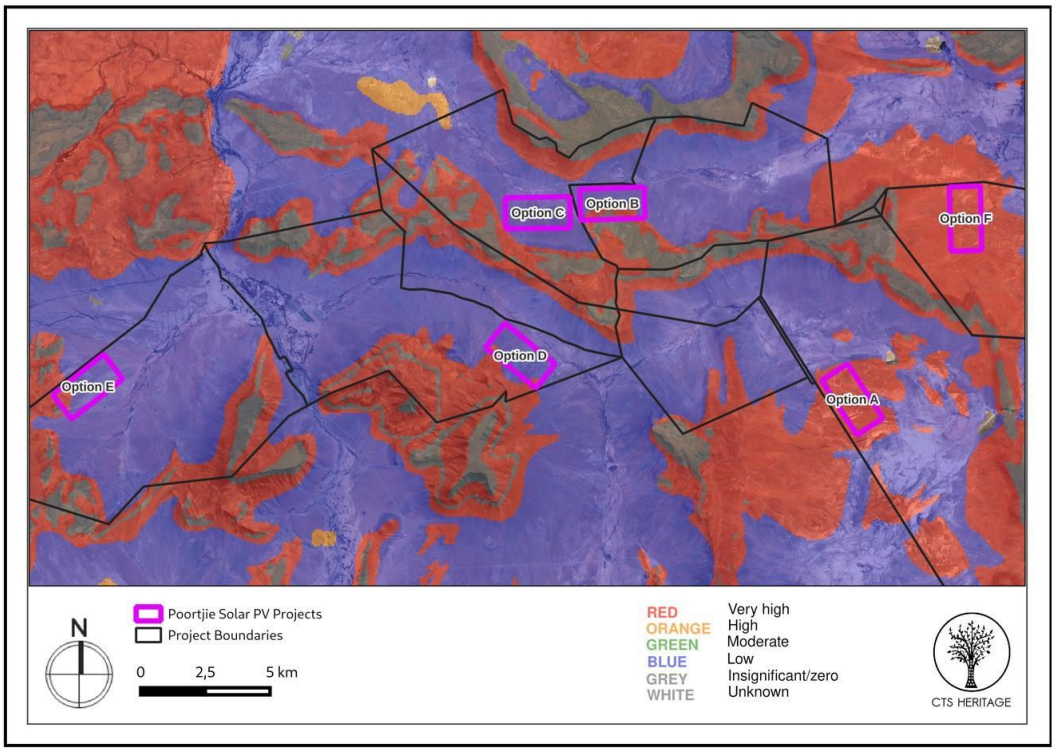

Figure 56: Provisional palaeosensitivity mapping for the six Poortjie Renewable Energy Facility solar project areas (lilac rectangles) (Image based on the DFFE Screening Tool and provided by CTS April 2022). The Low to Very High palaeosensitivity shown here for the various sites is *contested* in the present report.

6. CONCLUSIONS & RECOMMENDATIONS

Only a sparse scatter of fragmentary fossil vertebrate material as well as occasional low diversity invertebrate trace fossils have been recorded from the Lower Beaufort Group bedrocks within the six solar project areas near Nelspoort, while no fossil remains were observed within the overlying Late Caenozoic superficial deposits. None of the recorded fossil sites is of significant scientific or conservation interest.

Given the inferred low overall palaeosensitivity of all six of the solar project areas, the proposed renewable energy developments are all of Low impact significance in terms of palaeontological heritage resources. The proposed developments are not fatally flawed and there are no objections on palaeontological heritage grounds to their authorisation.

None of the fossil sites recorded within the six solar project areas is of high scientific or conservation value and no mitigation is recommended in their regard. Given the potential for the exposure or recognition of additional, scientifically valuable fossil occurrences within the project footprints, a Chance Fossil Finds Protocol, as outlined below and tabulated in Appendix 2, must be included within the Environmental Management Programme (EMPr) and fully implemented throughout the construction phase of the solar projects.

The Environmental Control Officer (ECO) / Environmental Site Officer (ESO) responsible for the development should be made aware of the possibility of important fossil remains (vertebrate bones, teeth, burrows, petrified wood, plant-rich horizons *etc.*) being found or unearthed during the construction phase of the development. Monitoring for fossil material of all major surface clearance and deeper (>1m) excavations by the ECO/ESO on an on-going basis during the construction phase is therefore recommended. Significant fossil finds should be safeguarded and reported at the earliest opportunity to Heritage Western Cape for recording and sampling by a professional palaeontologist (Contact details: Heritage Western Cape. 3rd Floor Protea Assurance Building, 142 Longmarket Street, Green Market Square, Cape Town 8000. Private Bag X9067, Cape Town 8001. Tel: 021 483 5959 Email: ceoheritage@westerncape.gov.za). The palaeontologist concerned will need to submit a Work Plan for approval by Heritage Western Cape.

7. ACKNOWLEDGEMENTS

Ms Jenna Lavin of CTS Heritage, Cape Town is thanked for commissioning this study as well as for providing the necessary project information. The companionship in the field, palaeontological contributions as well as logistical backup kindly provided by Ms Madelon Tusenius are all highly appreciated, as always.

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9. SHORT CV OF 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 the University of Tübingen in Germany, and has carried out palaeontological research in Europe, North America, the Middle East as well as North and South Africa and Madagascar. 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 numerous palaeontological impact assessments for developments and conservation areas in the Western, Eastern and Northern Cape, Limpopo, Northwest Province, Mpumalanga, Gauteng, KwaZulu-Natal and the Free State under the aegis of his Cape Town-based company *Natura Viva* cc. He has served as a member of the Archaeology, Palaeontology and Meteorites Committee for Heritage Western Cape (HWC) and an advisor on palaeontological conservation and management issues for the Palaeontological Society of South Africa (PSSA), HWC and SAHRA. He is currently compiling technical reports on the provincial palaeontological heritage of Western, Northern and Eastern Cape for SAHRA and HWC. Dr Almond is an accredited member of PSSA and APHP (Association of Professional Heritage Practitioners – Western Cape).

Declaration of Independence

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

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

APPENDIX 1: POORTJIE RENEWABLE ENERGY FACILITY SOLAR PROJECT AREAS NEAR NELSPOORT FOSSIL SITE DATA – MARCH 2022

All GPS readings were taken in the field using a hand-held Garmin GPSmap 64s instrument. The datum used is WGS 84.

Please note that:

- Locality data for South African fossil sites in *not* for public release, due to conservation concerns.
- The table does *not* represent all potential fossil sites within the project area but only those sites recorded during the field survey. The absence of recorded fossil sites in any area therefore does *not* mean that no fossils are present there.
- The detailed stratigraphic data for each site is provisional and has yet to be confirmed.

The recorded fossil sites are mapped in satellite Figures A1 – A3 below.

LOC	GPS data	Comments
355	S32° 05' 56.4" E23° 19' 15.7"	Louws Baken 77. Hoedemaker Member, Teekloof Formation. Small blocks of rolled bone among sheet wash surface gravels. Proposed Field Rating IIIC Local Resource. No recommended mitigation.
369	S32° 06' 49.4" E23° 19' 18.6"	Louws Baken 77. Hoedemaker Member, Teekloof Formation. Two substantial blocks of tetrapod bone (medium to large tetrapod, unidentifiable) within float overlying stream side exposure of overbank siltstones. Proposed Field Rating IIIC Local Resource. No recommended mitigation.
370	S32° 06' 44.2" E23° 19' 22.3"	Louws Baken 77. Hoedemaker Member, Teekloof Formation. Two small, well-rounded blocks of rolled tetrapod bone (medium to large tetrapod, unidentifiable) within float overlying stream side exposure of Beaufort Group overbank siltstones. Proposed Field Rating IIIC Local Resource. No recommended mitigation.
375	S32° 06' 28.7" E23° 18' 33.7"	Farm Poortjie 76. Hoedemaker Member, Teekloof Formation. Scatter of weathered-out, poorly-preserved postcranial (and *possible* cranial) remains of a large tetrapod within surface float. Proposed Field Rating IIIB Local Resource. Material to be sampled by professional palaeontologist in the pre-construction phase.
380	S32° 09' 43.2" E23° 15' 57.4"	Farm Poortjie 76. Hoedemaker Member, Teekloof Formation. Isolated postcranial bone of a large tetrapod within surface float (possibly from same individual as at Loc. 381). Proposed Field Rating IIIB Local Resource. Material to be sampled by professional palaeontologist in the pre-construction phase.
381	S32° 09' 40.9" E23° 15' 59.1"	Farm Poortjie 76. Hoedemaker Member, Teekloof Formation. Extensive scatter of numerous weathered-out postcranial (and *possible* cranial) remains of one or more large tetrapod within surface float. Proposed Field Rating IIIB Local Resource. Material to be sampled by professional palaeontologist in the pre-construction phase.
385	S32° 10' 01.2" E23° 15' 53.2"	Farm Poortjie 76. Hoedemaker Member, Teekloof Formation. Isolated fragment of limb bone of a large tetrapod within sheetwash gravels. Proposed Field Rating IIIB Local Resource. Material to be sampled by professional palaeontologist in the pre-construction phase.

388	S32° 10' 11.7" E23° 16' 29.8"	Farm Poortjie 76. Hoedemaker Member, Teekloof Formation. Isolated small chunk of pinkish rolled bone within surface gravels. Proposed Field Rating IIIC Local Resource. No mitigation recommended.
390	S32° 09' 49.7" E23° 16' 02.5"	Farm Poortjie 76. Hoedemaker Member, Teekloof Formation. Numerous pebble- to cobble-sized fragments of pinkish to lilac hued rolled tetrapod bone (largely unidentifiable) among concentrations of weathered-out ferruginous carbonate concretions. Proposed Field Rating IIIC Local Resource. No mitigation recommended.
420	S32° 06' 06.0" E23° 09' 29.6"	Farm Belvedere 2/73. Hoedemaker Member, Teekloof Formation. Thin, secondarily baked and leached mudflake intraclast breccias within sandstone package containing sparse, poorly-preserved fragments of reworked bone. Proposed Field Rating IIIC Local Resource. No mitigation recommended.
421	S32° 06' 06.0" E23° 09' 31.2"	Farm Belvedere 2/73. Hoedemaker Member, Teekloof Formation. Upper bedding planes of cross-laminated, medium-grained channel wackes with simple horizontal to oblique invertebrate borrows (*c*. 4 mm diameter). Proposed Field Rating IIIC Local Resource. No mitigation recommended.

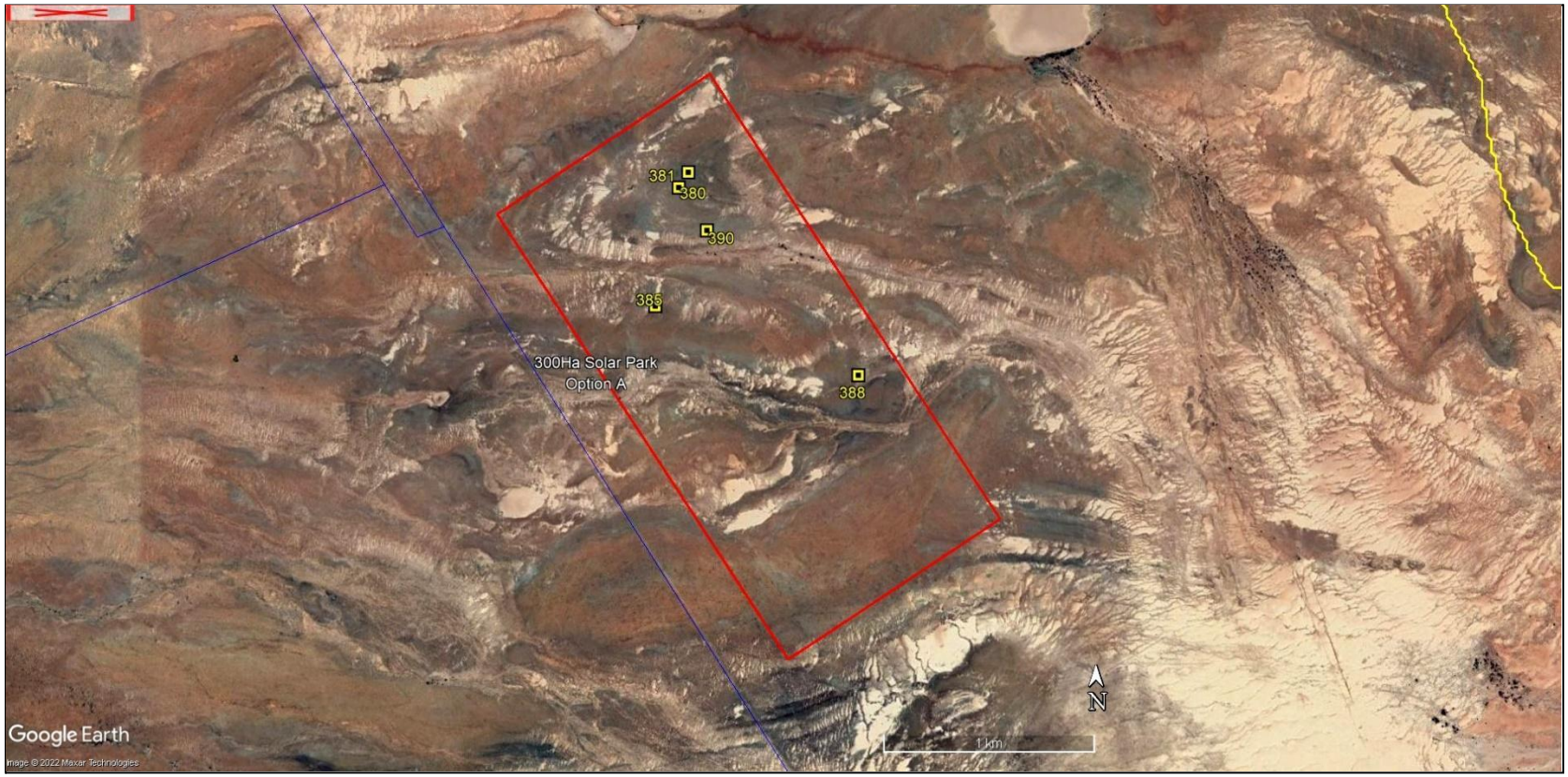

Figure A1: Google Earth© satellite image showing numbered fossil sites (yellow) recorded within the solar Option A project area (red rectangle).

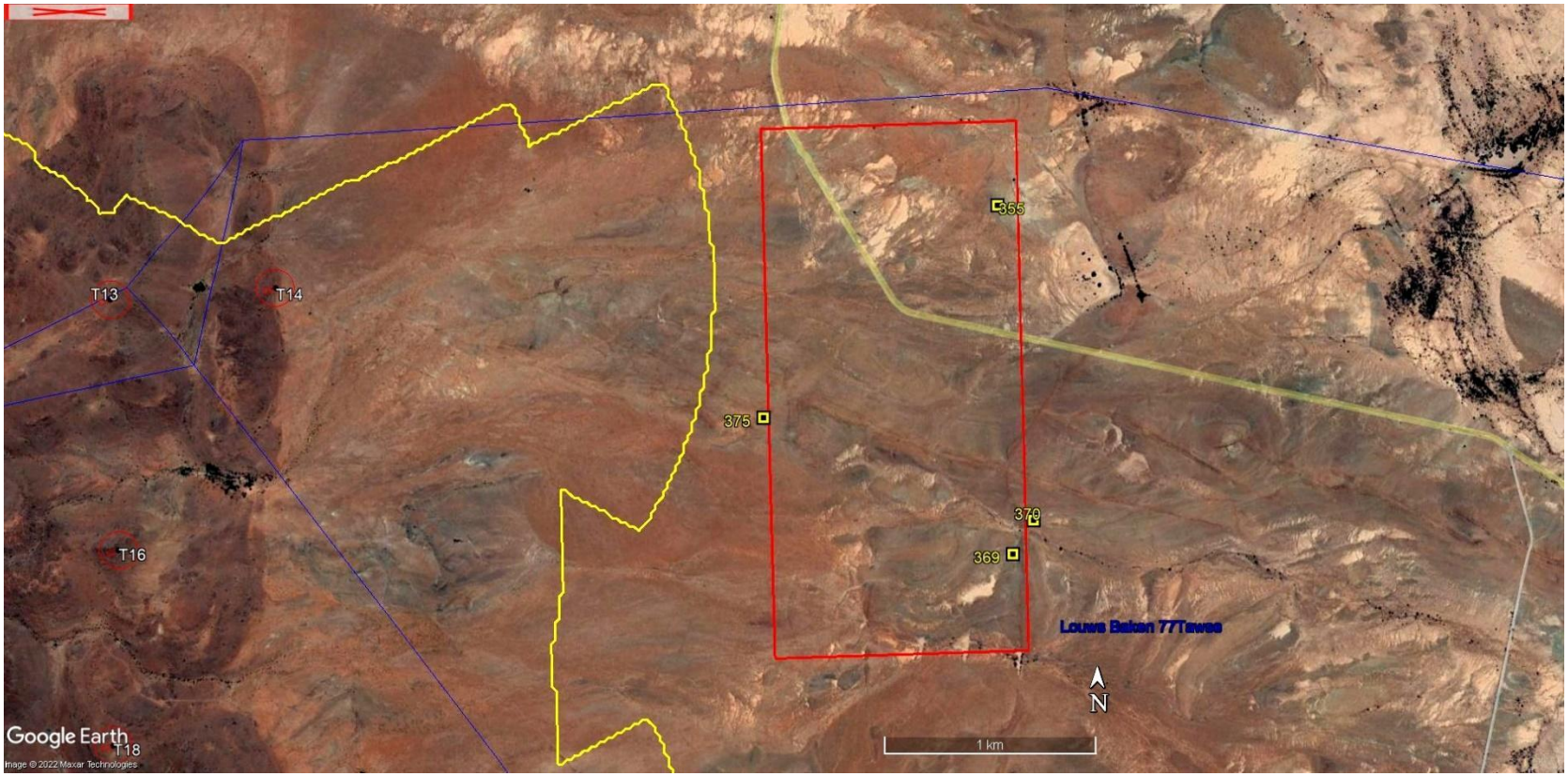

Figure A2: Google Earth© satellite image showing numbered fossil sites (yellow) recorded within the solar Option F project area (red rectangle).

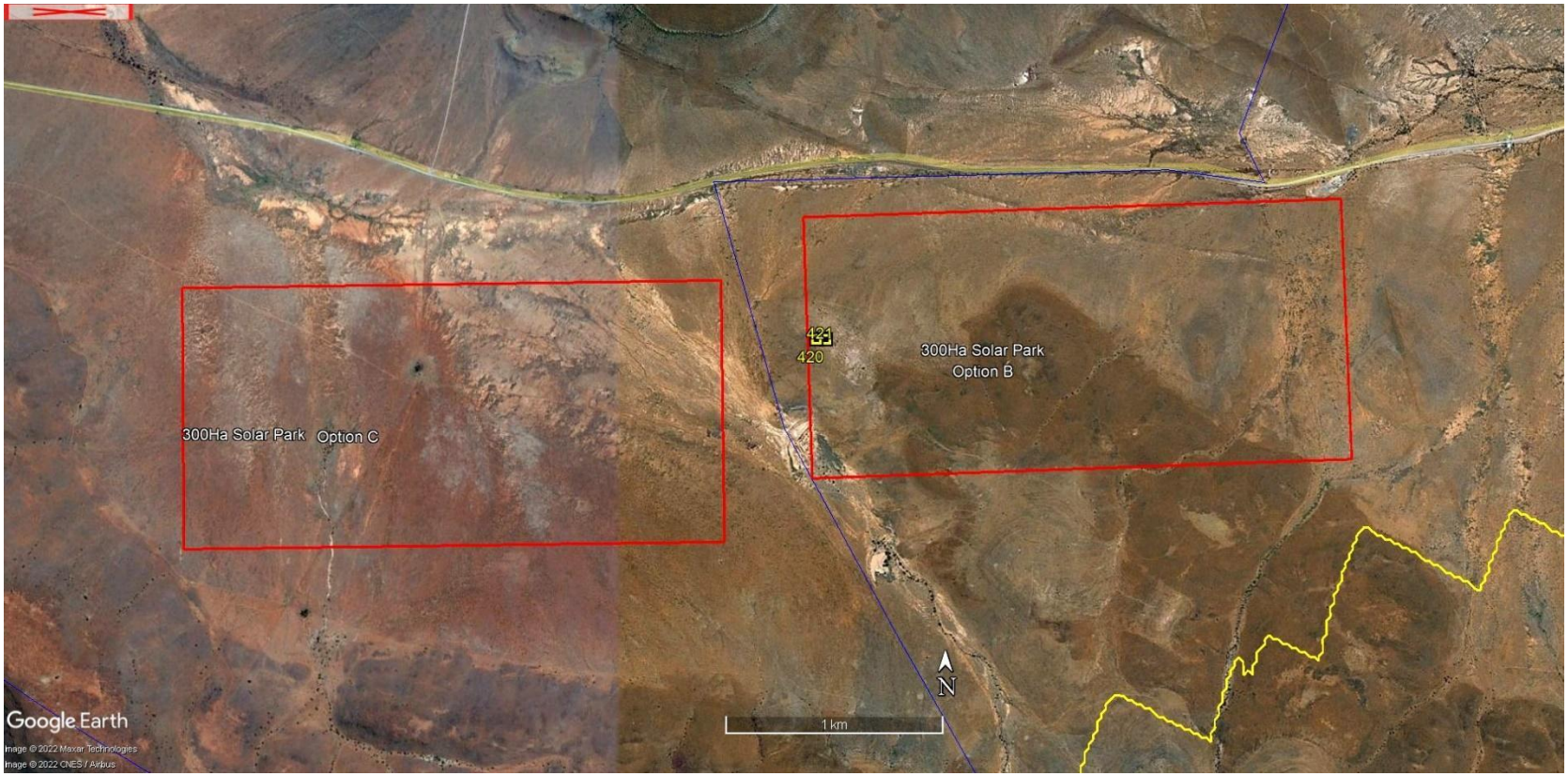

Figure A3: Google Earth© satellite image showing numbered fossil sites (yellow) recorded within the solar Option B project area (red rectangle).

APPENDIX 2: CHANCE FOSSIL FINDS PROTOCOL

<table>
<tr><th colspan="3">Solar PV Projects within the Poortjie Renewable Energy Facility near Nelspoort</th></tr>
<tr><td>Province & region:</td><td colspan="2">Western Cape (Central Karoo District, Beaufort West Local Municipality)</td></tr>
<tr><td>Responsible Heritage Resources Agency</td><td colspan="2">Heritage Western Cape (Contact details: Heritage Western Cape. 3rd Floor Protea Assurance Building, 142 Longmarket Street, Green Market Square, Cape Town 8000. Private Bag X9067, Cape Town 8001. Tel: 021 483 5959 Email: ceoheritage@westerncape.gov.za)</td></tr>
<tr><td>Rock unit(s)</td><td colspan="2">Teekloof Formation (Lower Beaufort Group), Late Caenozoic alluvium, colluvium, calcrete pedocretes, surface gravels & soils</td></tr>
<tr><td>Potential fossils</td><td colspan="2">Fossil vertebrate bones, teeth, trace fossils (e.g. vertebrate and invertebrate burrows), trackways, petrified wood, plant-rich beds in the Lower Beaufort Group bedrocks.
Fossil mammal bones, teeth, horn cores, freshwater molluscs, calcretised trace fossils (e.g. termitaria, rhizoliths), plant material in Late Caenozoic alluvium, calcretes.</td></tr>
<tr><td rowspan="5">ECO protocol</td><td colspan="2">1. Once alerted to fossil occurrence(s): alert site foreman, stop work in area immediately (N.B. safety first!), safeguard site with security tape / fence / sand bags if necessary.</td></tr>
<tr><td colspan="2">2. Record key data while fossil remains are still in situ:
● Accurate geographic location – describe and mark on site map / 1: 50 000 map / satellite image / aerial photo
● Context – describe position of fossils within stratigraphy (rock layering), depth below surface
● Photograph fossil(s) in situ with scale, from different angles, including images showing context (e.g. rock layering)</td></tr>
<tr><td>3. If feasible to leave fossils in situ:
● Alert Heritage Resources Agency and project palaeontologist (if any) who will advise on any necessary mitigation
● Ensure fossil site remains safeguarded until clearance is given by the Heritage Resources Agency for work to resume</td><td>3. If not feasible to leave fossils in situ (emergency procedure only):
● Carefully remove fossils, as far as possible still enclosed within the original sedimentary matrix (e.g. entire block of fossiliferous rock)
● Photograph fossils against a plain, level background, with scale
● Carefully wrap fossils in several layers of newspaper / tissue paper / plastic bags
● Safeguard fossils together with locality and collection data (including collector and date) in a box in a safe place for examination by a palaeontologist
● Alert Heritage Resources Agency and project palaeontologist (if any) who will advise on any necessary mitigation</td></tr>
<tr><td colspan="2">4. If required by Heritage Resources Agency, ensure that a suitably-qualified specialist palaeontologist is appointed as soon as possible by the developer.</td></tr>
<tr><td colspan="2">5. Implement any further mitigation measures proposed by the palaeontologist and Heritage Resources Agency</td></tr>
<tr><td>Specialist palaeontologist</td><td colspan="2">Record, describe and judiciously sample fossil remains together with relevant contextual data (stratigraphy / sedimentology / taphonomy). Ensure that fossils are curated in an approved repository (e.g. museum / university / Council for Geoscience collection) together with full collection data. Submit Palaeontological Mitigation report to Heritage Resources Agency. Adhere to best international practice for palaeontological fieldwork and Heritage Resources Agency minimum standards.</td></tr>
</table>