PALAEONTOLOGICAL HERITAGE ASSESSMENT: DESKTOP STUDY

PROPOSED DAWID KRUIPER REST CAMP AND PICNIC SITES AT THE VEERTIENDE AND BEDINKT WATERHOLES, KALAHARI GEMSBOK NATIONAL PARK / KGALAGADI TRANSFRONTIER PARK, NORTHERN CAPE PROVINCE

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EXECUTIVE SUMMARY

Following a Basic Assessment process, SANParks has received environmental authorisation for three small tourism developments within the Kalahari Gemsbok National Park (a component of the Kgalagadi Transfrontier Park) in the Northern Cape. These proposed developments include a 28-bed tourism accommodation called Dawid Kruiper Rest Camp, the Bedinkt Picnic Site (ablutions and 10 picnic tables) and the Veertiende Waterhole Picnic Site (ablutions and 10 picnic tables). The three proposed tourism developments are all underlain by geologically youthful (probably Pleistocene to Recent) terrestrial sediments of the Kalahari Group that occur widely within the broader Kalahari Desert region of southern Africa.

Dune sands of the Gordonia Formation underlying the **David Kruiper Rest Camp** are generally of low palaeosensitivity although they may contain various subfossils such as calcretized rhizoliths (root casts) and termitaria, ostrich egg shells and the shells of land snails. Impacts on nearby leached or calcretised alluvium and pan sediments associated with the Auob River will be minimal. Calcretised material in the nearby borrow pit is already disturbed.

The new **Veertiende Waterhole** and **Bedinkt Picnic Sites** overlie pale, leached alluvial sands and possibly older calcretised riverine or pan sediments. Potentially fossiliferous, pale greyish calcretised pan sediments crop out along the eastern bank of the Auob River just to the south of the Veertiende Waterhole Picnic Site but are unlikely to be significantly impacted by this development.

In view of (1) the small footprints of the three proposed developments, especially in the context of very widely occurring younger Kalahari Group sediments, and (2) the generally low palaeosensivity of these sediments, it is concluded that the impact significance of the construction and operational phases in all cases is VERY LOW. There are no fatal flaws and no objections on palaeontological grounds to authorisation of the proposed developments.

Given the low palaeosensitivity and small area of all three project footprints, further specialist palaeontological studies and monitoring are not recommended here, pending the potential discovery of new fossil remains (*e.g.* vertebrate bones and teeth, rich assemblages of non-marine molluscs or trace fossils) during the construction phase. It is recommended that:

- The Environmental Control Officer (ECO) responsible for the tourism developments should be aware of the possibility of important fossils (*e.g.* shells, trace fossils, mammalian bones and teeth) being present or unearthed on site and should regularly 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 made 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 (Contact details: SAHRA, 111 Harrington Street, Cape Town. PO Box 4637, Cape Town 8000, South Africa. Phone: +27 (0)21 462 4502. Fax: +27 (0)21 462 4509. Web: www.sahra.org.za). This is so that 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 are summarized as a tabulated Chance Fossil Finds Procedure in Appendix 1 and should be incorporated into the Environmental Management Plan (EMP) for the tourism projects.

The palaeontologist concerned with recording and mitigation work will need a valid palaeontological 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 palaeontological heritage studies developed by SAHRA (2013).

2. INTRODUCTION & BRIEF

South African National Parks (SANParks) is proposing to establish a 28-bed tourism accommodation facility known as the David Kruiper Rest Camp (DKRC) as well as two picnic sites with ablutions and 10 picnic tables *per* site at the Veertiende and Bedinkt boreholes within the Kalahari Gemsbok National Park (KGNP), a component of the Kgalagadi Transfrontier Park (KTP) (See map figures 1 & 2). The following details of each of the three developments have been abstracted directly from the Final Basic Assessment Report for the project compiled by Delron Environmental Assessment Practitioners (November 2017).

- **David Kruiper Rest Camp**

The proposed David Kruiper Rest Camp (DKRC) is situated on Farm 643 in the ZF Mgcawu Magisterial District and Dawid Kruiper Local Municipality of the Northern Cape Province. It lies within the Khomani San Concession Area of the Kalahari Gemsbok National Park (KGNP), a component of the Kgalagadi Transfrontier Park (KTP). It is situated on a sand dune approximately 1 km off the Mata Mata Road, west of the Auob River and approximately 4,5 km north of confluence of the Auob and Nossob Rivers and approximately 10 km north of the Twee Rivieren Rest Camp (Figs. 1 & 4).

The proposed development will entail the clearance of approximately 3 500 m² (0,35 ha) of indigenous vegetation (*Acacia (Vachellia) haematoxylon* parallel high dune veld) for the construction of 10 accommodation units, reception complex, pool building, parking areas, access roads to units and pedestrian access passages to the units.

- **Veertiende Waterhole Picnic Site**

The proposed Veertiende Waterhole Picnic Site is situated in the western sector of the Kalahari Gemsbok National Park on the Mata Mata Road, approximately 83 km from Twee Rivieren and approximately 33 km from the Mata Mata Rest Camp (Figs. 1 & 6).

The proposed development will entail the construction of 10 picnic areas (shaded seating and tables), an ablution building and demarcated parking areas next to the picnic areas within 32 meters from the edge of the Auob River. The approximate overall size of a picnic site will be 2 500 m² (0,25 ha).

- **Bedinkt Picnic Site**

The proposed Bedinkt Picnic Site is situated along the eastern border of the Kalahari Gemsbok National Park, close to the Botswana Border, on the Nossob Road approximately 35 km north of the Nossob Rest Camp (Figs. 1 & 8).

The proposed development will entail the clearance of approximately 2 500 m² (0,25 ha) of indigenous vegetation (*Acacia (Vachellia) erioloba-Rhigozum trichotomum - Stipagrostis obtusa* open tree savanna) for the construction of 10 picnic areas, an ablution building, access road and demarcated parking areas.

The Basic Assessment Report (BAR) in support of the application for environmental authorisation for the proposed developments, made in terms of the Environmental Impact Assessment Regulations of 8 December 2014 under the National Environmental Management Act, 1998 (Act No. 107 of 1998) (NEMA)(as amended), was compiled by the independent Environmental Assessment Practitioners DELRON CONSULTING (Pty) Ltd, Pretoria (Contact details: Mr. Pieter De Lange, DELRON CONSULTING (Pty) Ltd. Address: 9B Woodlands, Moreleta Park, Pretoria. P.O. Box 177 WOODLANDS 0072. Mobile: 082 571 5396. Fax: 086 588 4242. E-mail: pieter@delron.co.za).

Environmental Authorisation has now been granted by the Department of Environment, Forestry and Fisheries (DFFE) (REF. 14/12/16/3/3/1/1826) with a condition that a desktop palaeontological heritage assessment (PIA) be conducted. The DFFE has requested that the Heritage Impact Assessment (AIA / HIA) by Nelius Kruger (2017) of Exigo[3], Pretoria, be revised to include the PIA. DFFE has also required that the PIA report be submitted to the South African Heritage Resources Agency (SAHRA) for comment.

The present desktop palaeontological heritage report for the three developments in the Kalahari Gemsbok National Park has accordingly been commissioned on behalf of SANParks by Ms Esther Howard, their Project Administrator & Environmental Officer (Contact details: Tel: 012-426 5050. Cell: 083 791 4911. E-mail: esther.howard@sanparks.org).

Figure 1: Map of the Kalahari Gemsbok National Park showing the location of the three proposed new tourism-related developments.

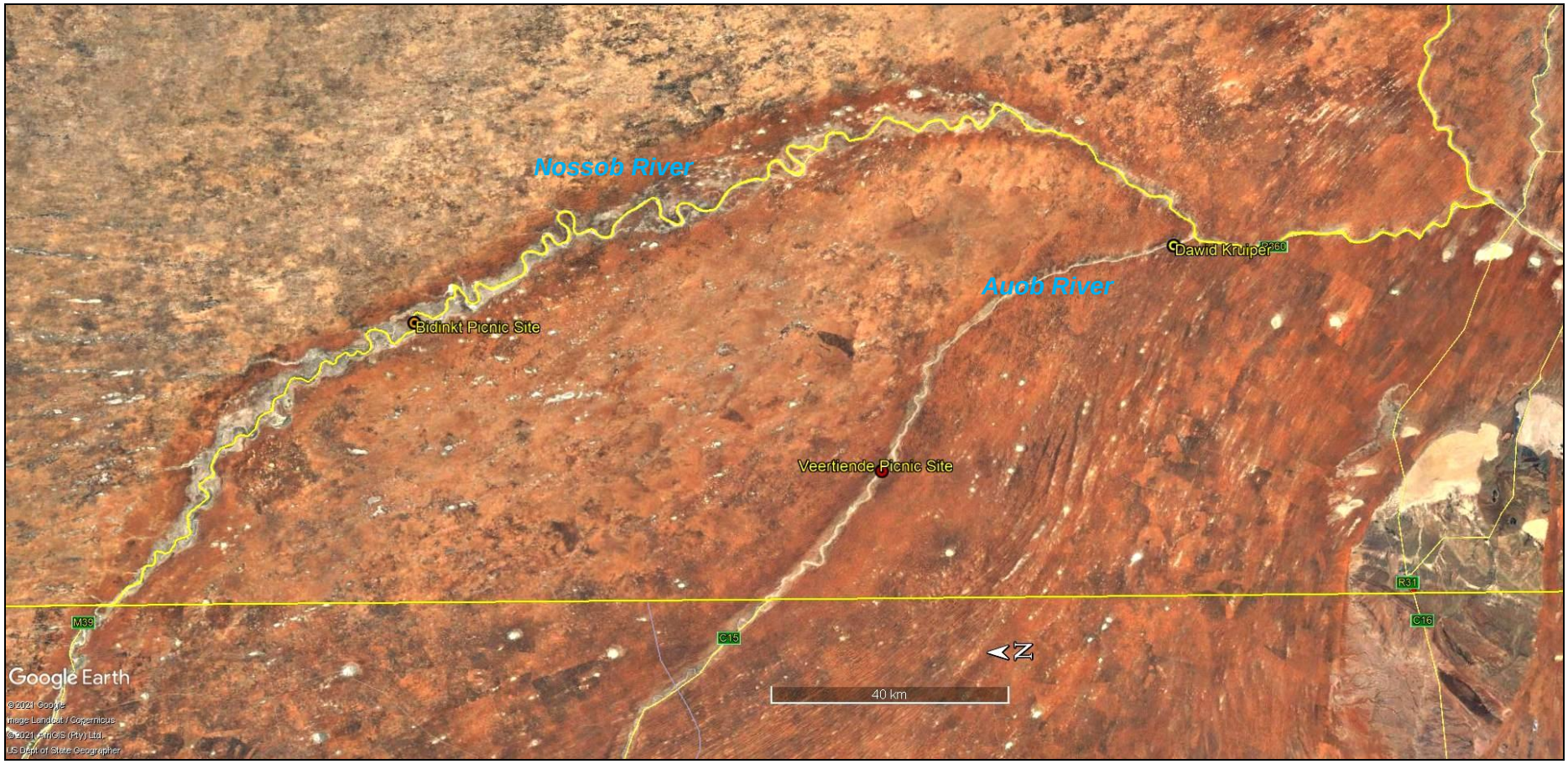

Figure 2: Google Earth© satellite image showing the Kalahari Gemsbok National Park on the border of the RSA, Namibia and Botswana and the location of the three proposed new tourism developments.

2.1. Legislative context for this palaeontological assessment

The proposed tourism developments in the Kalahari Gemsbok National Park overlie potentially fossiliferous sediments of Late Caenozoic age (Kalahari Group). Fossils preserved within the bedrocks and superficial deposits within the development footprint may be disturbed, damaged or destroyed during the construction phase of the project. The total 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.

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

(1) The protection of archaeological and palaeontological sites and material and meteorites is the responsibility of a provincial heritage resources authority.
(2) All archaeological objects, palaeontological material and meteorites are the property of the State.
(3) Any person who discovers archaeological or palaeontological objects or material or a meteorite in the course of development or agricultural activity must immediately report the find to the responsible heritage resources authority, or to the nearest local authority offices or museum, which must immediately notify such heritage resources authority.
(4) No person may, without a permit issued by the responsible heritage resources authority—
(a) destroy, damage, excavate, alter, deface or otherwise disturb any archaeological or palaeontological site or any meteorite;
(b) destroy, damage, excavate, remove from its original position, collect or own any archaeological or palaeontological material or object or any meteorite;
(c) trade in, sell for private gain, export or attempt to export from the Republic any category of archaeological or palaeontological material or object, or any meteorite; or
(d) bring onto or use at an archaeological or palaeontological site any excavation equipment or any equipment which assist in the detection or recovery of metals or archaeological and palaeontological material or objects, or use such equipment for the recovery of meteorites.
(5) When the responsible heritage resources authority has reasonable cause to believe that any activity or development which will destroy, damage or alter any archaeological or palaeontological site is under way, and where no application for a permit has been submitted and no heritage resources management procedure in terms of section 38 has been followed, it may—
(a) serve on the owner or occupier of the site or on the person undertaking such development an order for the development to cease immediately for such period as is specified in the order;
(b) carry out an investigation for the purpose of obtaining information on whether or not an archaeological or palaeontological site exists and whether mitigation is necessary;
(c) if mitigation is deemed by the heritage resources authority to be necessary, assist the person on whom the order has been served under paragraph *(a)* to apply for a permit as required in subsection (4); and
(d) recover the costs of such investigation from the owner or occupier of the land on which it is believed an archaeological or palaeontological site is located or from the person proposing to undertake the development if no application for a permit is received within two weeks of the order being served.

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

2.2. General approach used for palaeontological desktop studies

The present report, based on a desktop analysis of the study region in the Kalahari Gemsbok National Park, provides an assessment of the observed or inferred palaeontological heritage within the three project areas, with recommendations for specialist palaeontological mitigation where this is considered necessary. Minimum standards for the palaeontological component of heritage impact assessment reports have been developed by SAHRA (2013).

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 (*e.g.* Almond 2015) and the author's field experience (Consultation with professional colleagues as well as examination of institutional fossil collections may play a role here, or later during the compilation of the final report). This data is then used to assess the palaeontological sensitivity of each rock unit to development (Provisional tabulations of palaeontological sensitivity of all formations in the Western, Eastern and Northern Cape have already been compiled by J. Almond and colleagues (*e.g.* Almond & Pether 2008). The likely impact of the proposed development on local fossil heritage is then determined on the basis of (1) the palaeontological sensitivity of the rock units concerned and (2) the nature of the development itself, most notably the extent of fresh bedrock excavation envisaged.

When rock units of moderate to high palaeontological sensitivity are exposed within the development footprint, a Phase 1 field-based study by a professional palaeontologist is usually warranted. Most detrimental impacts on palaeontological heritage occur during the construction phase when fossils may be disturbed, destroyed or permanently sealed-in during excavations and subsequent construction activity. Where specialist palaeontological mitigation is recommended, this may take place before construction starts or, most effectively, during the construction phase while fresh, potentially fossiliferous bedrock is still exposed for study. Mitigation usually involves the judicious sampling, collection and recording of fossils as well as of relevant contextual data concerning the surrounding sedimentary matrix. The palaeontologist concerned would need to apply beforehand for a fossil collection permit from the South African Heritage Resources Agency, SAHRA (Contact details: SAHRA, 111 Harrington Street, Cape Town. PO Box 4637, Cape Town 8000, South Africa. Phone: +27 (0)21 462 4502. Fax: +27 (0)21 462 4509. Web: www.sahra.org.za).

It should be emphasised that, *provided* appropriate mitigation is carried out, many developments involving bedrock excavation actually have a *positive* impact on our understanding of local palaeontological heritage. Constructive collaboration between palaeontologists and developers should therefore be the expected norm.

2.3. Information sources

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

- A short project description and field photos (Basic Assessment Report, Delron 2017, AIA / HIA report by Nelius Kruger 2017), maps and kmz files provided by SANParks;
- A review of the relevant satellite images, topographical maps and scientific literature, including published geological maps and accompanying sheet explanations (Thomas *et al.* 1988, Thomas & Thomas 1989);
- The author's previous field experience with the formations concerned and their palaeontological heritage (*cf* Almond & Pether 2008, Almond 2015).

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 the present study area in the Kalahari Gemsbok National Park there is little previous palaeontological work, apart from that outlined in the geological sheet explanations by Thomas *et al.* (1988) and Thomas & Thomas (1989). Older, potentially fossiliferous bedrocks are largely mantled by younger Kalahari sands so their fossil content is poorly documented.

3. GEOLOGICAL CONTEXT

The geology of the three tourism project study areas in the Kalahari Gemsbok National Park is shown on the adjoining 1: 250 000 geology maps 2520 Nossob and 2620 Twee Rivieren (Council for Geoscience, Pretoria) (Figs. 5, 7 & 9 herein), a short explanation to which has been published by Thomas *et al.* (1988) (Also relevant is the explanation to the Noenieput 1: 250 000 map area to the south by Thomas & Thomas 1989). The area lies within the southern portion of the Late Cretaceous to Recent Kalahari Basin which is infilled by a thick succession of consolidated to unconsolidated continental sediments referred to the **Kalahari Group** (Fig. 3). They include fluvial gravels, sands, lacustrine and pan mudrocks, diatomites and diatomaceous limestones, evaporites, consolidated to unconsolidated aeolian sands and various pedocretes (especially calcrete).

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 **Budin Formation** is a mudrock-rich succession variously lying at or towards the base of the Kalahari Group where it generally infills pre-Kalahari palaeochannels and is not seen in surface exposures. Its age is poorly defined, but probably Tertiary. The dominant lithologies are massive (unstratified) reddish and brown claystones and marls (calcareous clays). These muds were probably deposited within shallow saline lakes that formed as a consequence of blocking of the southward-flowing proto-Molopo River in Late Cretaceous times. However, in some areas the fine-grained basal Kalahari claystones may have been generated by *in situ* weathering of underlying bedrocks, *i.e*. represent saprolite (Thomas 1981, Dingle *et al.* 1983, Partridge *et al.* 2006, Haddon 2005). Thin pebbly or coarse sandy horizons occur towards the base of the Budin succession that follows the gravel-rich **Wessels Formation** or directly overlies older basement rocks. The thickness of the Budin rocks in the Twee Rivieren 1: 250 000 sheet area varies from 40 to 100 m, with 80 m of red clays recorded from boreholes near the Molopo River to the north of Askham (Thomas *et al.* 1988).

The unconsolidated, reddish aeolian sands of the **Gordonia Formation** (Kalahari sands) at the top of the Kalahari Group succession are considered to range in age from the Late Pliocene / Early Pleistocene to Recent, dated in part from enclosed Middle to Late Stone Age stone tools (Dingle *et al*., 1983). The recent extension of the Pliocene - Pleistocene boundary from 1.8Ma back to 2.588 Ma places the Gordonia Formation entirely within the Pleistocene Epoch. Most of the sand is considered to be of local origin (Partridge *et al.* 2006). In the Mier area the sands build sparsely vegetated linear dunes with a pronounced NW-SE orientation that may have originated in Pleistocene times. Along water courses and inter-dune areas the sands are reworked by stream action and sheet wash; leached sands here may appear greyish or white. In the Twee Rivieren 1: 250 000 sheet area the sands are 10 to 20 m thick on average, but may be up to 40 m thick in some areas (Thomas *et al.* 1988). These unconsolidated sands are 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 or other bedrocks, as well as by calcretes of Pleistocene age or younger age (**Mokalanen Formation**).

Based on satellite imagery, 1: 250 geological maps as well as field photos provided in the Final Basic Assessment Report by Delron (2017) and the HIA / AIA report by Kruger (2017), the geological setting of each of the three project sites can be briefly described as follows:

- **David Kruiper Rest Camp**

The rest camp project area is largely underlain by deep, unconsolidated, partially vegetated Pleistocene to Recent aeolian sands of the Gordonia Formation located just west of the Auob River in a region characterised by NW-SE striking linear dunes (Fig. 4). The associated borehole in the Auob River bed will penetrate Late Caenozoic alluvial sediments (pale on satellite images) and perhaps older subunits of the Kalahari Group at depth. Pale calcretised alluvial or pan sediments for use as road material are exposed in a decommissioned burrow pit to the north of the project area where the solar panels will be situated. This last area is already highly disturbed by previous

mining activity. The calcretised alluvial and / or pan areas along the Auob are depicted in darker yellow on the geological map (Fig. 5). Impacts on these older sediments will probably be minimal in terms of their widespread occurrence within the Kalahari Region.

- **Veertiende Waterhole Picnic Site**

The picnic site overlies pale sandy alluvial sediments on the eastern bank of the Auob River. It lies on, or just beyond, the northern edge of a small pan called Groot Skrypan (Fig. 7). Gullied pale grey sediments cropping out along the banks of the Auob River to the south of the picnic site that are clearly seen on satellite images (arrowed in Fig. 6) are probably calcretised pan and / or alluvial sediments. Construction and operation of the proposed small picnic site is unlikely to have a significant impact on these older pan sediments.

- **Bedinkt Picnic Site**

The picnic site along the western banks of the Nossob River lies within a broad, NNW-SSE trending pale zone seen on satellite images that probably represents the Nossob River Valley floor which is flanked by subparallel, orange-hued linear sand dunes of the Gordonia Formation (Fig. 8). Pale greyish areas here probably represent pale alluvial sands and older leached or calcretised alluvial and / or pan sediments (Fig. 9). Construction and operation of the proposed small picnic site is unlikely to have a significant impact on these older pan sediments.

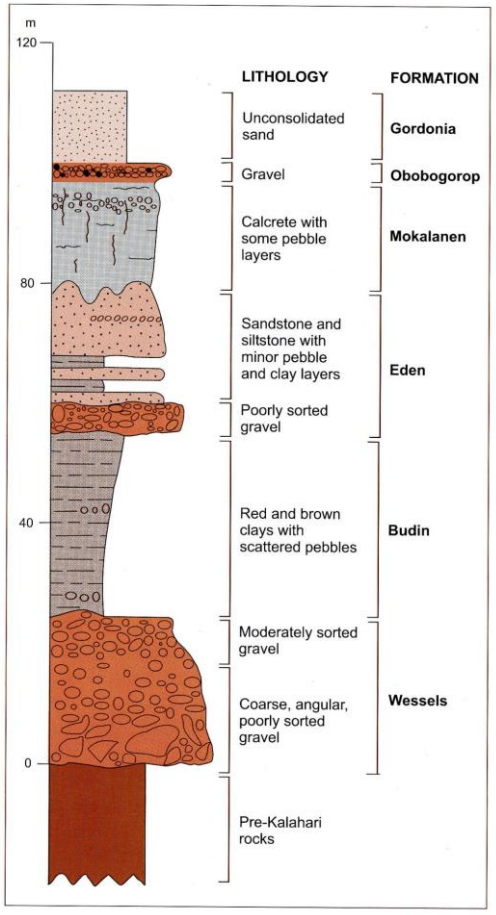

Figure 3: Generalised stratigraphy of the Kalahari Group (From Partridge *et al.* 2006).

Figure 4: Google Earth© satellite image showing the location of the proposed Dawid Kruiper Rest Camp, situated on a sand dune approximately 1 km off the Mata Mata Road, west of the Auob River and approximately 4,5 km north of the confluence of the Auob and Nossob Rivers, Kalahari Gemsbok National Park.

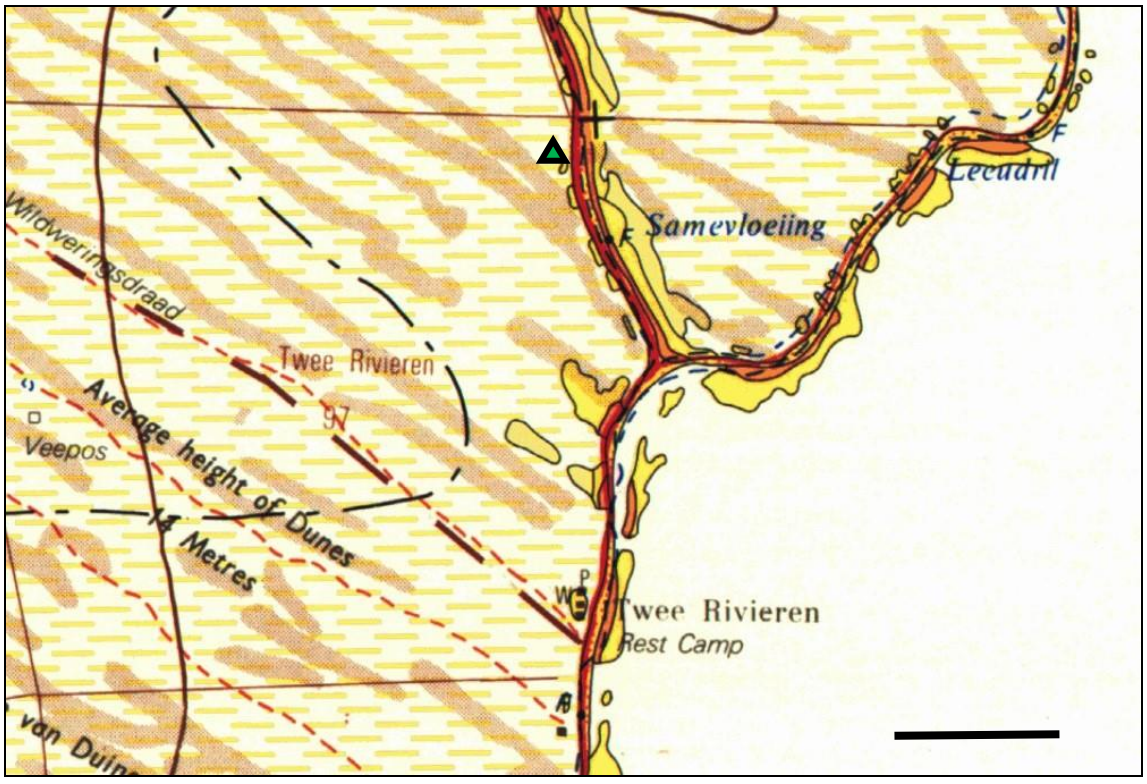

Figure 5: Extract from 1: 250 000 geological map 2620 Twee Rivieren (Council for Geoscience, Pretoria) showing the location of the proposed proposed Dawid Kruiper Rest Camp, Kalahari Gemsbok National Park (green triangle). The project area is underlain by modern dune sands (pale yellow striped area) with calcretised sediments and pale sandy alluvium along the Auob River cropping out just to the east. Scale bar = 3km. N towards the top of the image.

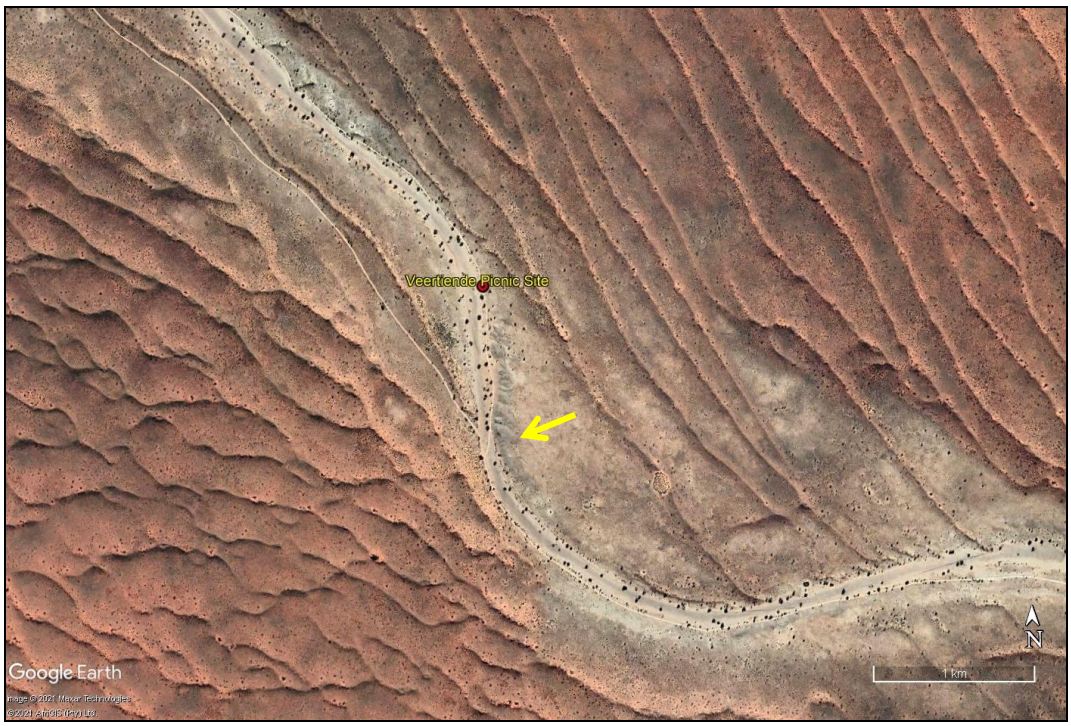

Figure 6: Google Earth© satellite image showing the location of the proposed Veertiende Waterhole Picnic Site, situated in the western sector of the Kalahari Gemsbok National Park on the Mata Mata Road, approximately 83 km from Twee Rivieren and approximately 33 km from the Mata Mata Rest Camp. Note greyish calcretised pan sediments of Groot Skrypan along the banks of the Auob River just to the south (arrowed).

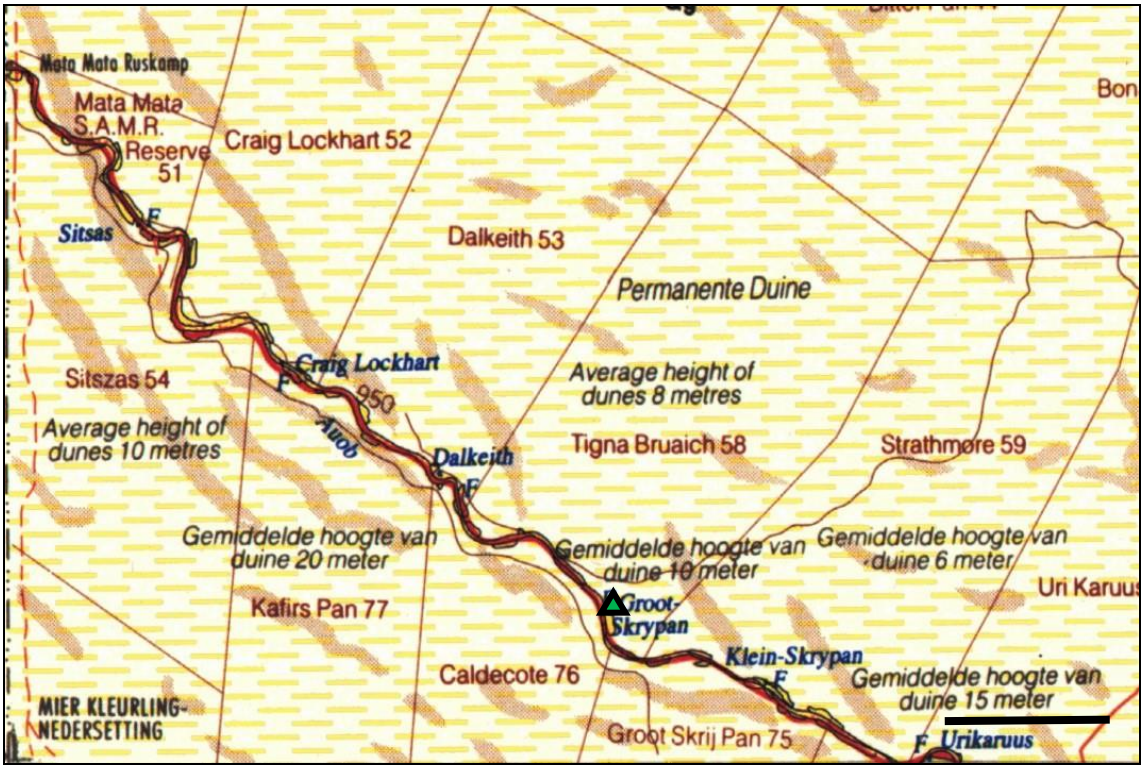

Figure 7: Extract from 1: 250 000 geological map 2620 Twee Rivieren (Council for Geoscience, Pretoria) showing the location of the proposed proposed Veertiende Waterhole Picnic Site, Kalahari Gemsbok National Park (green triangle). The site lies on the NE bank of the Auob River towards the NW end of Groot Skrypan (dark yellow). Scale bar = 3km. N towards the top of the image.

Figure 8: Google Earth© satellite image showing the location of the proposed Bedinkt Picnic Site along the eastern border of the Kalahari Gemsbok National Park, close to the Botswana Border, on the Nossob Road approximately 35 km north of the Nossob Rest Camp. Pale greyish areas along the Nossob River Valley here probably represent pale leached alluvial sands and older calcretised alluvial and / or pan sediments.

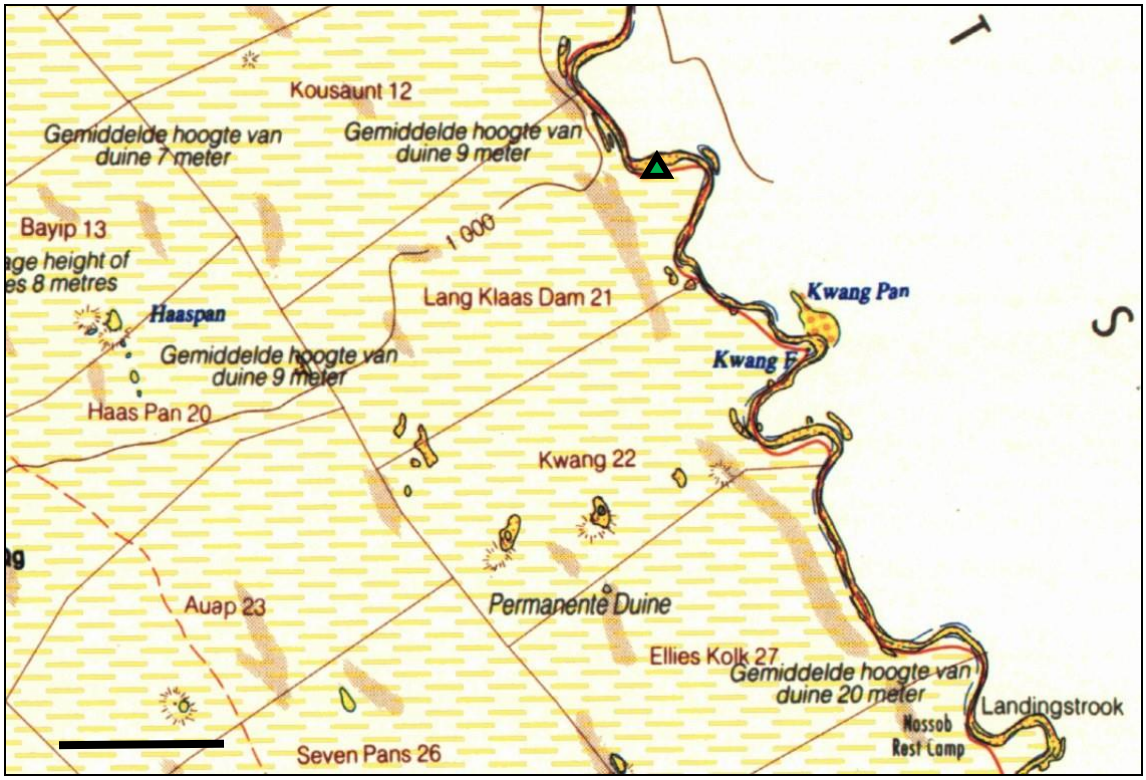

Figure 9: Extract from 1: 250 000 geological map 2520 Nossob (Council for Geoscience, Pretoria) showing the location of the proposed proposed Bedinkt Picnic Site, Kalahari Gemsbok National Park (green triangle). Darker yellow, stippled areas are calcretised pan and alluvial sediments while pale yellow dashed areas represent dune sands. Scale bar = 3km. N towards the top of the image.

4. PALAEONTOLOGICAL HERITAGE

A wide spectrum of fossil groups are have been recorded from the Late Cretaceous to Recent **Kalahari Group**, including palynomorphs (fossil pollen and spores), root casts (rhizomorphs / rhizoliths) and animal burrows (*e.g.* termitaria), rare vertebrate remains (mammals, fish, ostrich egg shell *etc*), diatoms, freshwater stromatolites, freshwater and terrestrial shells (gastropods, bivalves), ostracods (seed shrimps) and charophytes (Almond & Pether 2008, Almond 2015). Most of these fossils are associated with ancient pans, lakes and river systems and have received only limited attention from academic palaeontologists. Although generally sparse and low in diversity, they may occur widely within the vast Kalahari Basin region. The basal Late Cretaceous gravels and lacustrine clays are probably fossiliferous (bones, teeth, petrified wood, palynomorphs) but are only very rarely exposed at surface.

Despite their inferred lacustrine origin, no fossil remains (*e.g.* fish, molluscs, plant debris, microfossils) have been reported from the **Budin Formation** to the author's knowledge, apart from calcified rhizoliths in the Sishen area (Partridge *et al.* 2006, p. 591). This may be because the lakes were shallow and saline, or perhaps due to very poor exposure for palaeontological studies. Fossil remains have not been recorded from the coarse, downwasted gravels of the **Obogorogop Formation** that are largely derived from erosion of Dwyka Group bedrocks.

The Pleistocene to Recent **Gordonia Formation** dune sands were mainly active during cold, drier intervals of the Pleistocene Epoch that were inimical to most forms of life, apart from hardy, desert-adapted species. Porous dune sands are not generally conducive to fossil preservation. However, mummification of soft tissues may play a role here and migrating lime-rich groundwaters derived from the underlying bedrocks (including, for example, dolerite) may lead to the rapid calcretisation of organic structures such as burrows and root casts. Occasional terrestrial fossil remains that might be expected within this unit include calcretized rhizoliths (root casts) and termitaria (*e.g. Hodotermes*, the harvester termite), ostrich egg shells (*Struthio*) and shells of land snails (*e.g. Trigonephrus*) (Almond *in* Macey *et al.* 2011, Almond & Pether 2008). These Kalahari fossils (or subfossils) can be expected to occur sporadically but widely, and the overall palaeontological sensitivity of the Gordonia Formation is therefore considered to be low.

Other fossil groups such as freshwater bivalves and gastropods (*e.g. Corbula, Unio*) and snails, ostracods (seed shrimps), charophytes (stonewort algae), diatoms (microscopic algae within siliceous shells) and stromatolites (laminated microbial limestones) are associated with local watercourses and pans (Thomas *et al.* 1988) where they may be preserved within calcretised deposits. Microfossils such as siliceous diatoms may be blown by wind into nearby dune sands. Calcretes of the **Mokolanen Formation** might also contain trace fossils such as rhizoliths, termite and other insect burrows, or even mammalian trackways. Mammalian bones, teeth and horn cores (also tortoise remains, and fish, amphibian or even crocodiles in wetter depositional settings such as pans) may be expected occasionally expected within Kalahari Group sediments and calcretes, notably those associated with ancient, Plio-Pleistocene alluvial gravels. However, such fossil sites are likely to be sparsely distributed and their locations difficult to predict, given the extensive younger sedimentary cover

5. CONCLUSIONS & RECOMMENDATIONS

The three proposed tourism developments in the Kalahari National Park are all underlain by geologically youthful (probably Pleistocene to Recent) terrestrial sediments of the Kalahari Group that occur widely within the broader Kalahari Desert region of southern Africa.

Dune sands of the Gordonia Formation underlying the David Kruiper Rest Camp are generally of low palaeosensitivity although they may contain various subfossils such as calcretized rhizoliths (root casts) and termitaria, ostrich egg shells and the shells of land snails. Impacts on nearby leached or calcretised alluvium and pan sediments associated with the Auob River will be minimal. Calcretised material in the nearby borrow pit is already disturbed.

The new Veertiende Waterhole and Bedinkt Picnic Sites overlie pale leached alluvial sands and possibly older calcretised riverine or pan sediments. Potentially fossiliferous, pale greyish calcretised pan sediments crop out along the eastern bank of the Auob River just to the south of the Veertiende Waterhole Picnic Site but are unlikely to be significantly impacted by this development.

In view of (1) the small footprints of the three proposed developments, especially in the context of very widely occurring younger Kalahari Group sediments, and (2) the generally low palaeosensivity of these sediments, it is concluded that the impact significance of the construction and operational phases in all cases is VERY LOW. There are no fatal flaws and no objections on palaeontological grounds to authorisation of the proposed developments.

Given the low palaeosensitivity and small area of all three project footprints, further specialist palaeontological studies and monitoring are not recommended here, pending the potential discovery of new fossil remains (*e.g.* vertebrate bones and teeth, rich assemblages of non-marine molluscs or trace fossils) during the construction phase. It is recommended that:

- The Environmental Control Officer (ECO) responsible for the tourism developments should be aware of the possibility of important fossils (*e.g.* shells, trace fossils, mammalian bones and teeth) being present or unearthed on site and should regularly 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 made 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 (Contact details: SAHRA, 111 Harrington Street, Cape Town. PO Box 4637, Cape Town 8000, South Africa. Phone: +27 (0)21 462 4502. Fax: +27 (0)21 462 4509. Web: www.sahra.org.za). This is so that 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 are summarized as a tabulated Chance Fossil Finds Procedure in Appendix 1 and should be incorporated into the Environmental Management Plan (EMP) for the tourism projects.

The palaeontologist concerned with recording and mitigation work will need a valid palaeontological 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 palaeontological heritage studies developed by SAHRA (2013).

6. ACKNOWLEDGEMENTS

Ms Esther Howard, Project Administrator & Environmental Officer for SANParks, is thanked for commissioning this study and for kindly providing all the necessary background information.

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8. QUALIFICATIONS & EXPERIENCE OF THE AUTHOR

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

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

Declaration of Independence

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

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

<table>
<tr><th colspan="3">APPENDIX 1: CHANCE FOSSIL FINDS PROCEDURE: Tourism development in the Kalahari Gemsbok National Park, Northern Cape</th></tr>
<tr><td>Province & region:</td><td colspan="2">Northern Cape Province: Kalahari region</td></tr>
<tr><td>Responsible Heritage Resources Agency</td><td colspan="2">SAHRA (Contact details: SAHRA, 111 Harrington Street, Cape Town. PO Box 4637, Cape Town 8000, South Africa. Phone: +27 (0)21 462 4502. Fax: +27 (0)21 462 4509. Web: www.sahra.org.za).</td></tr>
<tr><td>Rock unit(s)</td><td colspan="2">Late Caenozoic aeolian sands, sandy alluvium, calcretised alluvium and pan sediments</td></tr>
<tr><td>Potential fossils</td><td colspan="2">Calcretized rhizoliths (root casts) and termitaria, ostrich egg shells and shells of land snails within dune sands.
Vertebrate bones & teeth, vertebrate and other burrows (e.g. calcretised termitaria, rhizoliths), non-marine mollusc shells.</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>