PALAEONTOLOGICAL HERITAGE ASSESSMENT: DESKTOP STUDY

Proposed single-circuit BPBH and KDLO Interconnector 22kV powerline near Boshof, Boshof District, Free State

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EXECUTIVE SUMMARY

The great majority of the proposed 22 kV power line route near Boshof, Free State, traverses unfossiliferous Karoo dolerite bedrocks. Potentially-fossiliferous Tierberg Formation (Ecca Group, Karoo Supergroup) marine sediments of Permian age are not mapped in the study area and, if present in the subsurface, are likely to be extensively disrupted by calcrete development. Only the very short terminal sectors at either end of the proposed 22 kV powerline might be palaeontologically sensitive due to the presence here of potentially-fossiliferous, calcretised alluvial and / or *vlei* deposits; these might be associated with Pleistocene mammalian remains or other fossils / subfossils (*e.g.* plant material) as well as stone artefacts. No known palaeontological sites or highly-sensitive no-go areas have been identified within the proposed 22 kV powerline corridor. Given the shortness of the sectors traversing potentially-sensitive alluvial deposits, as well as the small scale of excavations involved in the construction of a 22 kV power line, the palaeontological impact significance of this electrical infrastructure development is rated as VERY LOW.

Pending the potential discovery of significant fossil remains during the construction phase, no further specialist palaeontological studies or mitigation are recommended for the BPBH and KDLO Interconnector 22 kV powerline project. Chance fossil finds such as vertebrate bones and teeth, petrified wood or shells should be safeguarded - preferably *in situ* - and reported by the ECO as soon as possible to the South African Heritage Resources Agency, SAHRA (See appended Chance Fossil Finds Procedure). These recommendations should be incorporated into the Environmental Management Programme (EMPr) for the electrical infrastructure development.

1. INTRODUCTION & BRIEF

Eskom is proposing to construct a new *c*. 15 km-long, 22 kV single circuit power line – the BPBH and KDLO Interconnector 22 kV powerline – in an agricultural area some 10 km northwest of the small town of Boshof, Free State Province (Figs. 1 & 2).

The proposed development involves disturbance or excavations into potentially fossiliferous calcrete and alluvial deposits. A desktop palaeontological impact assessment conducted by a qualified palaeontologist has therefore been requested by SAHRA (Letter of 27 November 2017, CaseID: 11892). The present palaeontological assessment of the project has been commissioned by Zitholele Consulting, Midrand, in accordance with the requirements of the National Heritage Resources Act, 1999 (Contact details: Dr Mathys Vosloo. Zitholele Consulting, Building 1, Maxwell Office Park, Magwa Crescent West, Waterfall City, Midrand, RSA. Tel: +27 11 207 2060; Fax: +27 86 674 6121; Cell: +27 84 748 3018; E-mail: mathysv@zitholele.co.za).

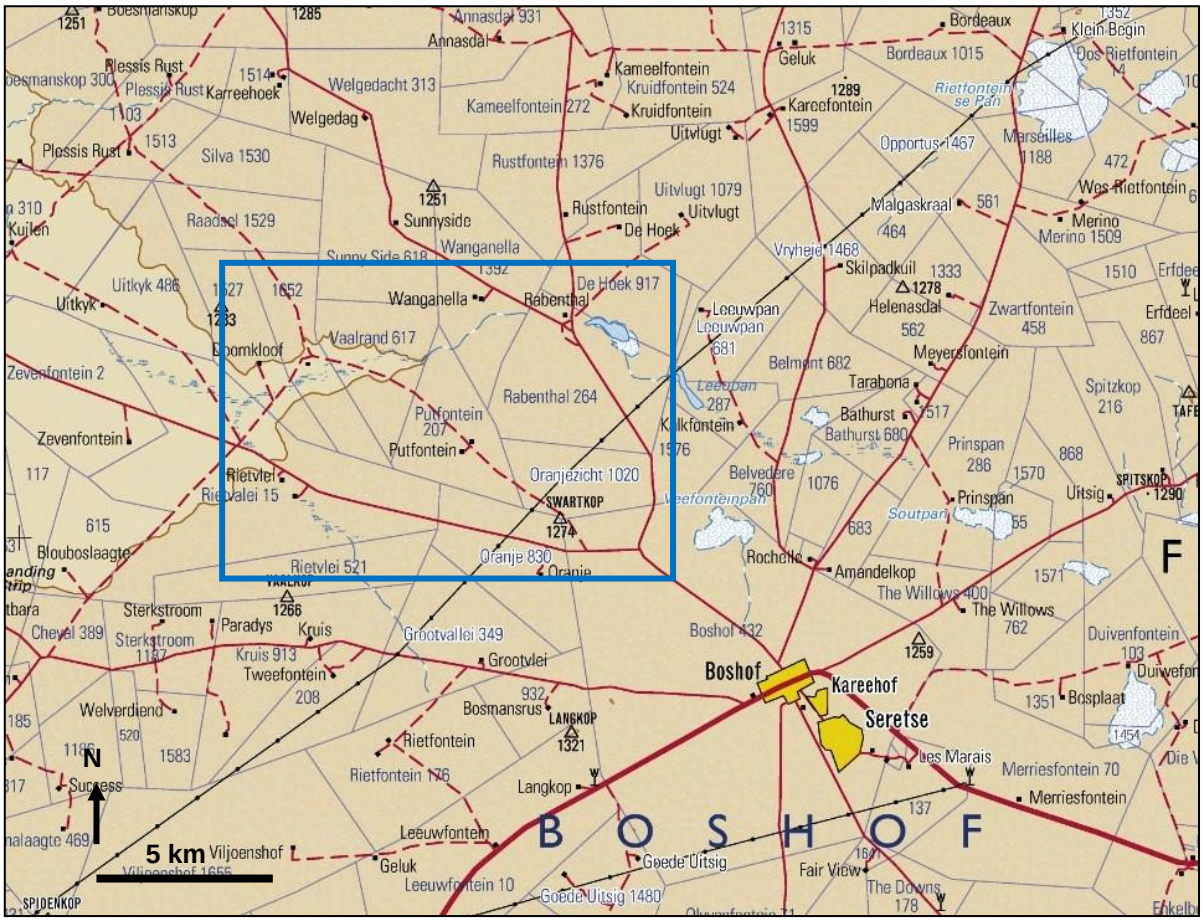

Figure 1: Extract from 1: 250 000 topographical map 2824 Kimberley (Courtesy of the Chief Directorate: National Geo-spatial Information, Mowbray) showing the approximate location of the 22 kV power line study area to the northwest of Boshof, Free State (blue rectangle).

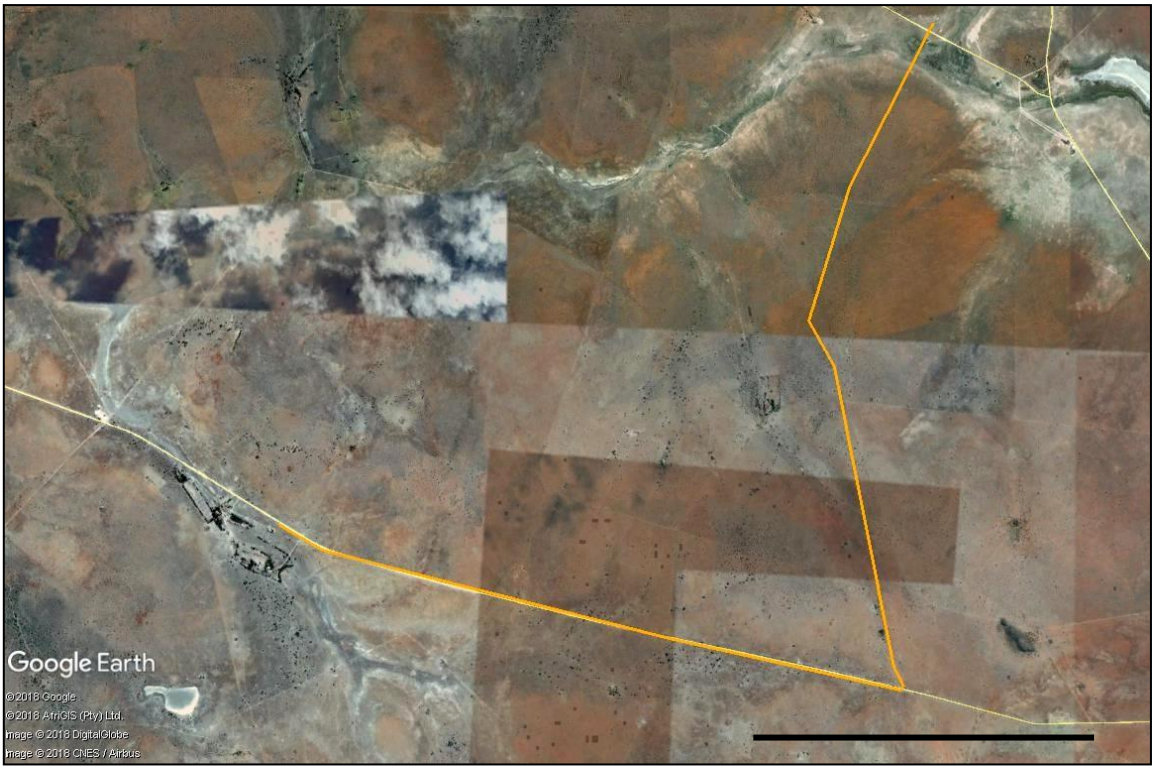

Figure 2 (previous page). Google Earth© satellite image of the area northwest of Boshof, Free State, showing the corridor for the proposed single-circuit BPBH and KDLO Interconnector 22 kV power line (orange line) (Scale bar = 7 km; N towards top of image). Pale areas along drainage lines at either end of the power line corridor are underlain by potentially-fossiliferous calcretised superficial deposits (*e.g.* alluvium).

1.1. Legislative context of this palaeontological study

The power line footprint is situated in a region that is underlain by potentially fossiliferous sedimentary rocks of Permian and Late Caenozoic age (Sections 2 and 3). The construction phase of the development entails surface clearance and small excavations into the superficial sediment cover and perhaps locally into the underlying bedrock as well. All these developments may adversely affect fossil heritage preserved at or beneath the surface of the ground within the study area by destroying, disturbing or permanently sealing-in fossils that are then no longer available for scientific research or other public good.

The various categories of heritage resources recognised as part of the National Estate in Section 3 of the National Heritage Resources Act (1999) 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 have been developed by SAHRA (2013).

1.2. Approach to the palaeontological heritage assessment

In preparing a palaeontological desktop study the potentially fossiliferous rock units (groups, formations *etc*) represented within the study area are determined from geological maps and satellite images. The known fossil heritage within each rock unit is inventoried from the published scientific literature, previous palaeontological impact studies in the same region, and the author's field experience (Consultation with professional colleagues as well as examination of institutional fossil collections may play a role here, or later following field assessment during the compilation of the final report). This data is then used to assess the palaeontological sensitivity of each rock unit to development Provisional tabulations of palaeontological sensitivity of all the relevant formations have been compiled by Almond and Pether (2008). The potential impact of the proposed development on local fossil heritage is then determined on the basis of (1) the palaeontological sensitivity of the rock units concerned and (2) the nature and scale of the development itself, most significantly the extent of fresh bedrock excavation envisaged. When rock units of moderate to high palaeontological sensitivity are present within the development footprint, a Phase 1 field assessment study by a professional palaeontologist is usually warranted to identify any palaeontological hotspots and make specific recommendations for any mitigation required before or during the construction phase of the development.

On the basis of the desktop and Phase 1 field assessment studies, the likely impact of the proposed development on local fossil heritage and any need for specialist mitigation are then determined. Adverse palaeontological impacts normally occur during the construction rather than the operational or decommissioning phase. Phase 2 mitigation by a professional palaeontologist – normally involving the recording and sampling of fossil material and associated geological information (*e.g.* sedimentological data) may be required (a) in the pre-construction phase where important fossils are already exposed at or near the land surface and / or (b) during the construction phase when fresh fossiliferous bedrock has been exposed by excavations. To carry out mitigation, the palaeontologist involved will need to apply for a palaeontological collection permit from the relevant heritage management authority, *i.e.* the South African Heritage Resources Agency, SAHRA. It should be emphasized that, *providing appropriate mitigation is carried out*, the majority of developments involving bedrock excavation can make a *positive* contribution to our understanding of local palaeontological heritage.

1.3. Information sources

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

1. A short project outline and kmz files provided by Zitholele Consulting, Midrand;

2. A review of the relevant scientific literature, including published geological maps and accompanying sheet explanations (Bosch 1993) as well as previous palaeontological assessment reports for the broader region (*e.g.* Almond 2010a, 2012b, 2013b, Bamford 2014, Rossouw, undated);

3. The author's database on the geological formations concerned and their palaeontological heritage);

4. Google Earth© satellite imagery.

1.4. 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.

To the author's knowledge, there have been very few field-based palaeontological studies in the Boshof region. Confidence levels for this palaeontological assessment are therefore only MODERATE.

2. GEOLOGICAL BACKGROUND

The proposed new 22 kV power line traverses fairly flat-lying, agricultural terrain to the northwest of Boshof, Free State, at elevations between *c*. 1200-1250 m amsl. (Fig. 2). This area lies within the Southern Highveld Geomorphic Province of Partridge *et al.* (2010), drained by the Vaal River to the north and the Modder River to the south. The power line corridor intersects shallow drainage lines - tributaries of the Leeurivier, itself a tributary of the Vaal – at both the north-eastern and western ends of the line. These drainage lines are associated with *vlei* areas and – outside the power line footprint itself – with small pans. A small dolerite *koppie*, Swartkop (1274 m amsl), projects above the *vlaktes* some 1.4 km east of the power line corridor.

The geology of the Boshof area is shown on 1: 250 000 geological map 2824 Kimberley (Council for Geoscience, Pretoria) (Fig. 3) for which a short explanation has been published by Bosch (1993). The entire power line route is underlain at depth by igneous bedrocks of the Early Jurassic **Karoo Dolerite Suite** (Jd, pink in Fig. 3) (Duncan & Marsh 2006). An extensive dolerite sill in this region intrudes Permian marine basinal sediments of the **Tierberg Formation** (Ecca Group, Karoo Supergroup) (Pt, orange in Fig. 3). The Tierberg Formation is a recessive-weathering, mudrock-dominated succession consisting predominantly of dark, well-laminated, carbonaceous shales with subordinate thin, fine-grained sandstones (Visser *et al.* 1977, Prinsloo 1989, Zawada 1992, Bosch 1993, Le Roux 1993, Viljoen 2005, Johnson *et al*., 2006). The Tierberg shales are Early to Middle Permian in age and were deposited in a range of offshore, quiet water environments below wave base. These include basin plain, distal turbidite fan and distal prodelta settings in ascending order (Viljoen 2005, Almond 2008). Thin coarsening-upwards cycles occur towards the top of the formation with local evidence of soft-sediment deformation, ripples and common calcareous concretions (often with well-developed cone-in-cone structures). A restricted, brackish water environment is reconstructed for the Ecca Basin at this time. Close to the contact with Karoo dolerite intrusions the Tierberg mudrocks are baked to a dark grey hornfels with a reddish-brown crust or patina (Prinsloo 1989). Tough clasts of reworked hornfels are often well-represented in surface gravels overlying Ecca bedrocks and may be anthropogenically flaked. It is unlikely that shallow 22 kV powerline footings will intersect fresh (*i.e.* unweathered) Ecca sedimentary bedrocks anywhere along the proposed corridor.

The Palaeozoic and Mesozoic bedrocks in the Boshof region are extensively mantled by **Late Caenozoic superficial deposits**, notably including pan sediments, alluvial and *vlei* deposits (blue "flying bird" and grassy symbols in Fig. 3), downwasted surface gravels (*e.g.* dolerite rubble) and lateritic or sandy soils (*e.g.* aeolian sands). The older alluvial and pan deposits are extensively calcretised, as is usually the case in doleritic regions; this is seen by pale creamy hues along drainage lines in satellite images. Exposures of **calcrete** or **surface limestone** (Qc, yellow in Fig. 3) occur overlying the Karoo Dolerite Suite - the probable source of much of the carbonate – at either end of the 22 kV power line route, and are also associated with pan sediments overlying the Tierberg outcrop elsewhere. These pedogenic limestone deposits replace or displace the near-surface bedrocks to a depth of several meters. They reflect seasonally arid climates in the region over the last five or so million years and are briefly described for the Kimberley sheet area by Bosch (1993). Although calcrete is still forming in the study area today, it originally develops in the subsurface and when exposed at the surface is "almost definitely fossil" (Botha 1988). Key review papers on South African calcretes are those by Netterberg (1978, 1980 among other papers). Calcrete types commonly encountered include glaebular calcrete (with discrete nodules), honeycomb calcrete (with coalescent glaebules) and hardpan calcrete (solid limestone within at most minor voids). The surface limestones may reach thicknesses of over 10 m, but are often much thinner, and are locally conglomeratic with clasts of reworked calcrete as well as exotic pebbles.

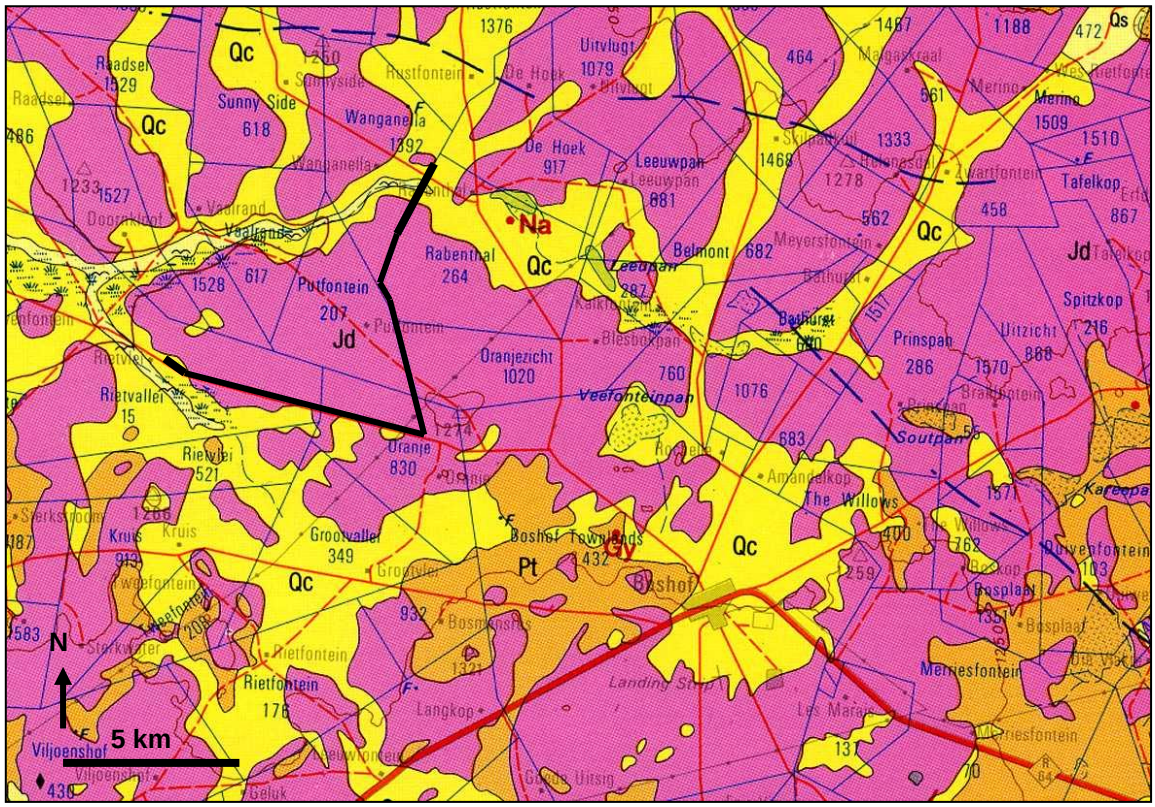

Figure 3: Extract from 1: 250 000 geology map 2824 Kimberley (Council for Geoscience, Pretoria) showing the corridor for the proposed single-circuit BPBH and KDLO Interconnector 22 kV powerline near Boshof, Free State (black line). The study area is largely underlain by Early Jurassic Karoo dolerite intrusions (Jd, pink) that here intrude Permian basinal mudrocks of the Tierberg Formation (Ecca Group; Pt, buff). There are small outcrop areas of Late Caenozoic calcretes (Qc, yellow) as well as alluvium and vlei deposits along drainage lines (blue flying bird and grassy symbols respectively).

3. PALAEONTOLOGICAL HERITAGE

The Karoo dolerite bedrocks underlying the greater part of the study area are high temperature igneous rocks and are themselves completely unfossiliferous. Direct impacts of 22 kV power line footings on fresh fossiliferous Ecca Group sediments are unlikely. The Tierberg Formation is not mapped at surface within the power line footprint and, if present subsurface, is likely to be mantled by thick superficial deposits such as calcrete. In this region, the near-surface Ecca Group bedrocks are very often extensively disrupted and veined by Quaternary calcrete, compromising their palaeontological sensitivity (*cf* Almond 2013a).

The various younger superficial deposits in the region, including aeolian sands, alluvium, calcretes and pan deposits, are generally poorly known and usually of low sensitivity in palaeontological terms. However, these deposits may occasionally contain important Late Caenozoic fossil biotas, notably the bones, teeth and horn cores of mammals as well as remains of reptiles like tortoises, non-marine molluscs (bivalves, gastropods), ostrich egg shells, trace fossils (*e.g.* calcretised termitaria, coprolites), plant remains such as peats or palynomorphs (pollens, spores) in organic-rich alluvial horizons as well as siliceous diatoms in pan sediments. Calcrete hardpans might also contain trace fossils such as rhizoliths, termite nests and other insect burrows, or even mammalian trackways. In particular, Pleistocene and older alluvial, pan and *vlei* deposits have yielded important fossil mammalian remains as well as stone artefacts in the Free State region (*e.g.* Skead 1980, Klein 1984, MacRae 1999, Partridge & Scott 2000, Brink & Rossouw 2000, Churchill *et al.* 2000, Rossouw 2006, Rossouw undated).

4. CONCLUSIONS & RECOMMENDATIONS

The great majority of the proposed 22 kV power line route near Boshof, Free State, traverses unfossiliferous Karoo dolerite bedrocks. Potentially-fossiliferous Tierberg Formation (Ecca Group, Karoo Supergroup) marine sediments of Permian age are not mapped in the study area and, if present in the subsurface, are likely to be extensively disrupted by calcrete development. Only the very short terminal sectors at either end of the proposed 22 kV powerline might be palaeontologically sensitive due to the presence here of potentially-fossiliferous, calcretised alluvial and / or *vlei* deposits; these might be associated with Pleistocene mammalian remains or other fossils / subfossils (*e.g.* plant material) as well as stone artefacts. No known palaeontological sites or highly-sensitive no-go areas have been identified within the proposed 22 kV powerline corridor. Given the shortness of the sectors traversing potentially-sensitive alluvial deposits, as well as the small scale of excavations involved in the construction of a 22 kV power line, the palaeontological impact significance of this electrical infrastructure development is rated as VERY LOW.

Pending the potential discovery of significant fossil remains (*e.g.* mammalian bones or teeth) during the construction phase, no further specialist palaeontological studies or mitigation are recommended for the BPBH and KDLO Interconnector 22 kV powerline project. Chance fossil finds such as vertebrate bones and teeth, petrified wood or shells should be safeguarded - preferably *in situ* - and reported by the ECO as soon as possible to 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). This is so that appropriate mitigation (*i.e.* recording, sampling or collection) by a palaeontological specialist can be considered and implemented (Please refer to the tabulated Chance Fossil Finds Procedure appended to this report). The palaeontologist concerned with mitigation work would need a valid fossil collection permit from SAHRA and any material collected would have to be curated in an approved depository (*e.g.* museum or university collection) (SAHRA 2013). These recommendations should be incorporated into the Environmental Management Programme (EMPr) for the electrical infrastructure development.

5. ACKNOWLEDGEMENTS

Dr Mathys Vosloo of Zitholele Consulting, Midrand, is thanked for commissioning this report and for providing the relevant background information.

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7. 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, Limpopo, Northwest,

Mpumalanga, KwaZulu-Natal and the Free State under the aegis of his Cape Town-based company *Natura Viva* cc. He has previously served as 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><td colspan="3">CHANCE FOSSIL FINDS PROCEDURE: 22 kV Transmission Powerline</td></tr>
<tr><td>Province & region:</td><td colspan="2">Boshof District, Free State</td></tr>
<tr><td>Responsible Heritage Resources Authority</td><td colspan="2">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 alluvium and calcretes along drainage courses</td></tr>
<tr><td>Potential fossils</td><td colspan="2">Bones, teeth and horn cores of mammals, freshwater molluscs, petrified wood, calcretised termitaria, stone artefacts and other trace fossils</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 Authority 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 Authority 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 Authority and project palaeontologist (if any) who will advise on any necessary mitigation</td></tr>
<tr><td colspan="2">4. If required by Heritage Resources Authority, 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 Authority</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 Authority. Adhere to best international practice for palaeontological fieldwork and Heritage Resources Authority minimum standards.</td></tr>
</table>