PALAEONTOLOGICAL HERITAGE ASSESSMENT: DESKTOP STUDY

Proposed Aggeneis-Paulputs 400 kV Transmission Powerline and Substation Upgrades, Namaqua & Siyanda Districts, Northern Cape Province

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EXECUTIVE SUMMARY

Eskom is proposing to construct a new 400 kV transmission powerline of about 100 km length between the existing Aggeneis substation near Aggeneys to the existing Paulputs substation near Pofadder, Namaqua & Siyanda Districts, Northern Cape Province. Three route alignments (Corridors 1, 2 & 3) are currently under consideration, with a possible short deviation (3A) in the case of Corridor 3. The electrical infrastructure project will also entail upgrading the existing Aggeneis and Paulputs Substations with concomitant small increases in their footprints.

The powerline and substation study area is underlain at depth by igneous and metamorphic basement rocks of Precambrian age as well as by a mantle of varied superficial deposits such as aeolian sands, gravels and alluvium of the Pleistocene to Recent Kalahari Group. In terms of palaeontological sensitivity outcrop areas of basement rocks are negligible while the overlying Late Caenozoic superficial deposits are generally of low to very low sensitivity. No highly-sensitive palaeontological sites or no-go areas have been identified within the 400 kV powerline and substation study area. The ancient Koa River Palaeovalley area near Aggenys, largely buried beneath younger cover sands (Fig. 1), may feature important Tertiary fossils at depth but these are very unlikely to be directly impacted by the shallow excavations envisaged for the present electrical infrastructure project. Narrow zones of Late Caenozoic alluvium associated with larger water courses traversing the study area may contain fossils (*e.g.* mammalian bones, teeth) but these are probably very sparse, while placement of pylon footings close to drainage lines is unlikely.

Impacts on unique or irreplaceable fossil heritage resources due to the proposed development are improbable and their severity is anticipated to be negligible since (1) highly significant fossil sites are unlikely to be affected and (2) in most cases these impacts can be mitigated through an appropriate Chance Fossil Finds Procedure. The overall impact significance of the proposed 400 kV Aggeneis to Paulputs powerline and associated small-scale substation developments is rated as VERY LOW in terms of palaeontological heritage resources. This assessment applies to all powerline route options under consideration (Corridors 1,2,3 and 3A). From a palaeontological heritage viewpoint, Corridor 3 is least preferred because it traverses a longer portion of the Koa River Palaeovalley as well as more alluvial zones along modern water courses. Corridor 1 is most preferred because it largely follows an existing powerline servitude so disturbance of surface sediments (*e.g.* for new access roads) is minimal. Cumulative impacts inferred for the various powerline and alternative energy developments in the Aggeneys – Pofadder – Paulputs region of the Northern Cape are assessed 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 400 kV Aggeneis to Paulputs 400 kV powerline project and associated

electrical substation developments. Chance fossil finds such as vertebrate bones and teeth 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 developments.

1. INTRODUCTION & BRIEF

Eskom is proposing to construct a new 400 kV transmission powerline between the existing Aggeneis substation, situated approximately 5 km southwest of the mining town of Aggeneys, to the existing Paulputs substation, located approximately 35 km northeast of the small town of Pofadder, Namaqua & Siyanda Districts, Northern Cape Province (Fig. 1). The proposed transmission line will be approximately 100 km in length. Three route alignments (Corridors 1, 2 & 3 in Fig. 1) are currently under consideration, with a possible short deviation (3A in Fig. 1) in the case of Corridor 3. For the purposes of route determination, 2 km-wide route corridors are being assessed, widening to 4 km close to Paulputs Substation. The proposed powerline tower types employed would be *c.* 30 m to 35 m in height with a footprint ranging from approximately 64 m^2 to 3 400 m^2 in area, depending on the tower type used. Tower spacing would be approximately 400 m, depending on the towers to be used and the environmental setting. A *c*. 8 m wide strip would be cleared of all trees and shrubs down the centre of the transmission powerline servitude for stringing purposes. A vehicle access road - needed during both the construction and operational / maintenance phases of the transmission powerline - will run along the entire length of the servitude. Any new access roads required will be established during the construction phase and will follow existing roads as far as possible. They will be constructed by driving over the vegetation where feasible, rather than grading or blasting. Otherwise it will be necessary to construct a new gravel road wider than 4 m with a reserve less than 13,5 m. Route alternative Corridor 1 from Aggeneis to Paulputs follows the existing 220 kV powerline which has an existing access road. If Corridor 1 becomes the chosen final route, then the existing road will require widening by 4 m. The Aggeneis – Paulputs electrical infrastructure project will also entail upgrading the existing Aggeneis Substation (footprint 11.6 ha) and Paulputs Substation (footprint 3 ha) with concomitant small increases in their footprints.

The proposed development involves disturbance or excavations into potentially fossiliferous sediments of the Kalahari Group as well as alluvial, and possibly also pan, deposits. A desktop palaeontological heritage assessment for the proposed electrical infrastructure development has been requested by SAHRA (CaseID: 11686. Interim Comment of 20 October, 2017). The present palaeontological assessment of the project has accordingly been commissioned by Mokgope Consulting, Johannesburg, in accordance with the requirements of the National Heritage Resources Act, 1999 (Contact details: Ms Judith Fasheun. Mokgope Consulting. P.O. Box 2363 . Highlands North, Johannesburg, 2037. Telephone: 011 440 1817; Fax: 086 607 9481; Cell: 076 876 2672; E-mail: judy@mokgope.co.za).

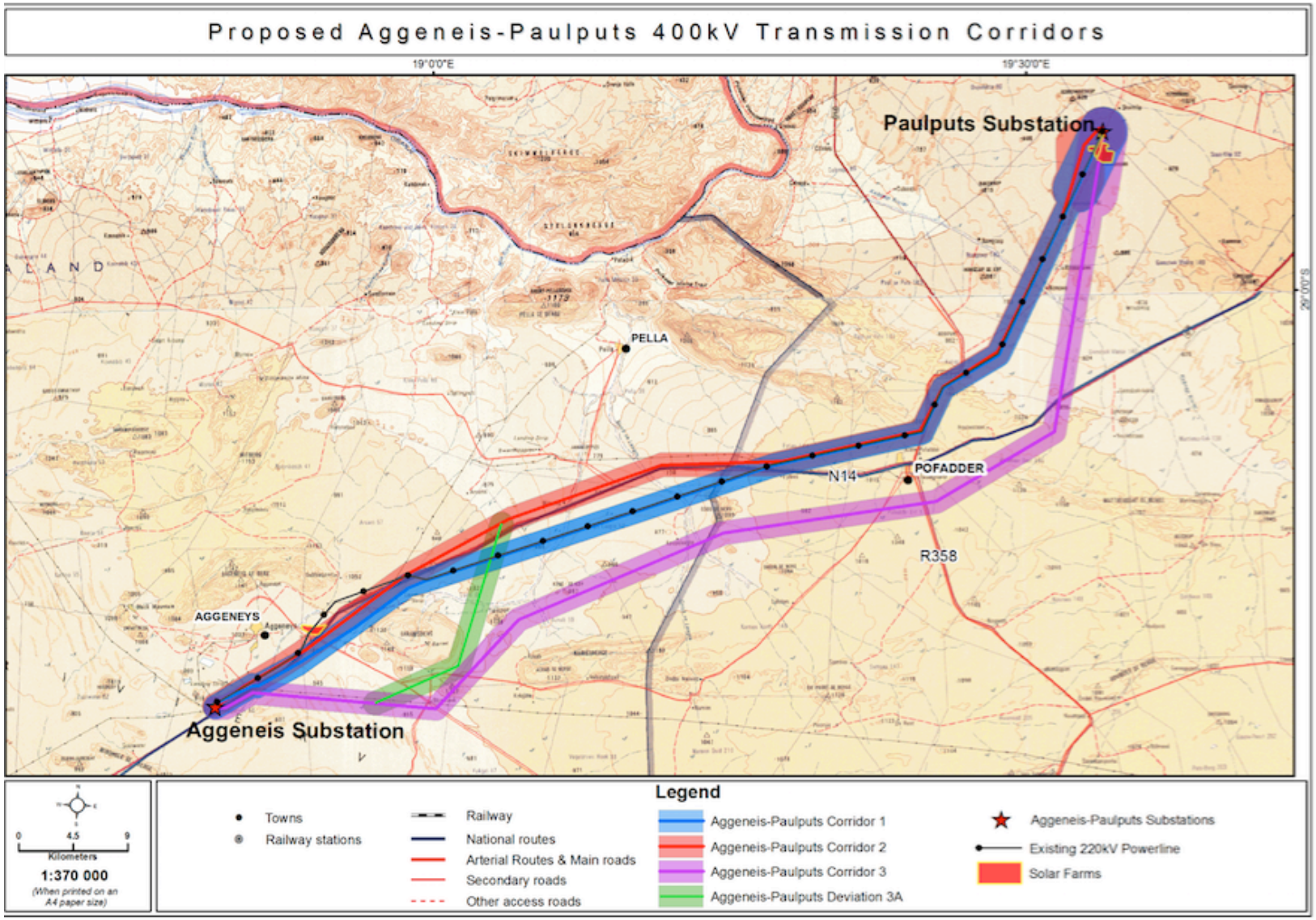

Figure 1: Map showing the three route options (Corridors 1, 2 & 3 with possible deviation 3A) under consideration for the proposed new 400 kV transmission line between the existing Aggeneis and Paulputs Substations, Namaqua and Siyanda Districts, Northern Cape. Corridor 1 is the preferred route option and largely follows an existing 220 kV powerline and associated access road (black line with dots).

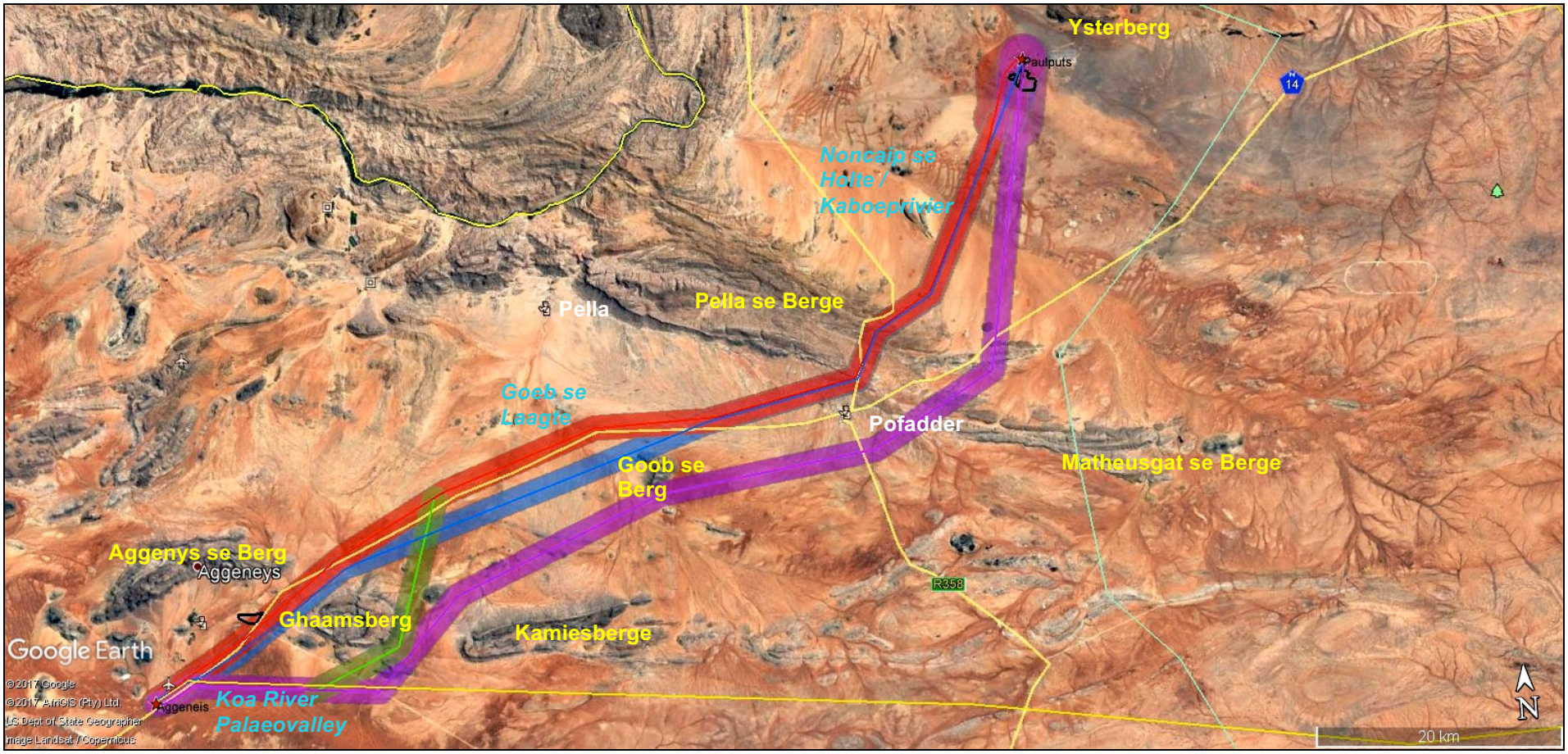

Figure 2. Google Earth© satellite image of the Aggeneis – Pofadder - Paulputs 400 kV powerline study region running on both sides of the N14 tar road and showing the nature of the desert terrain in this part of northern Bushmanland featuring sandy to gravelly *vlaktes* and Inselberge of basement rocks (powerline route options as in Figure 1). Note the palaeontologically sensitive Loa River Palaeovalley region near Aggenys in the southwest.

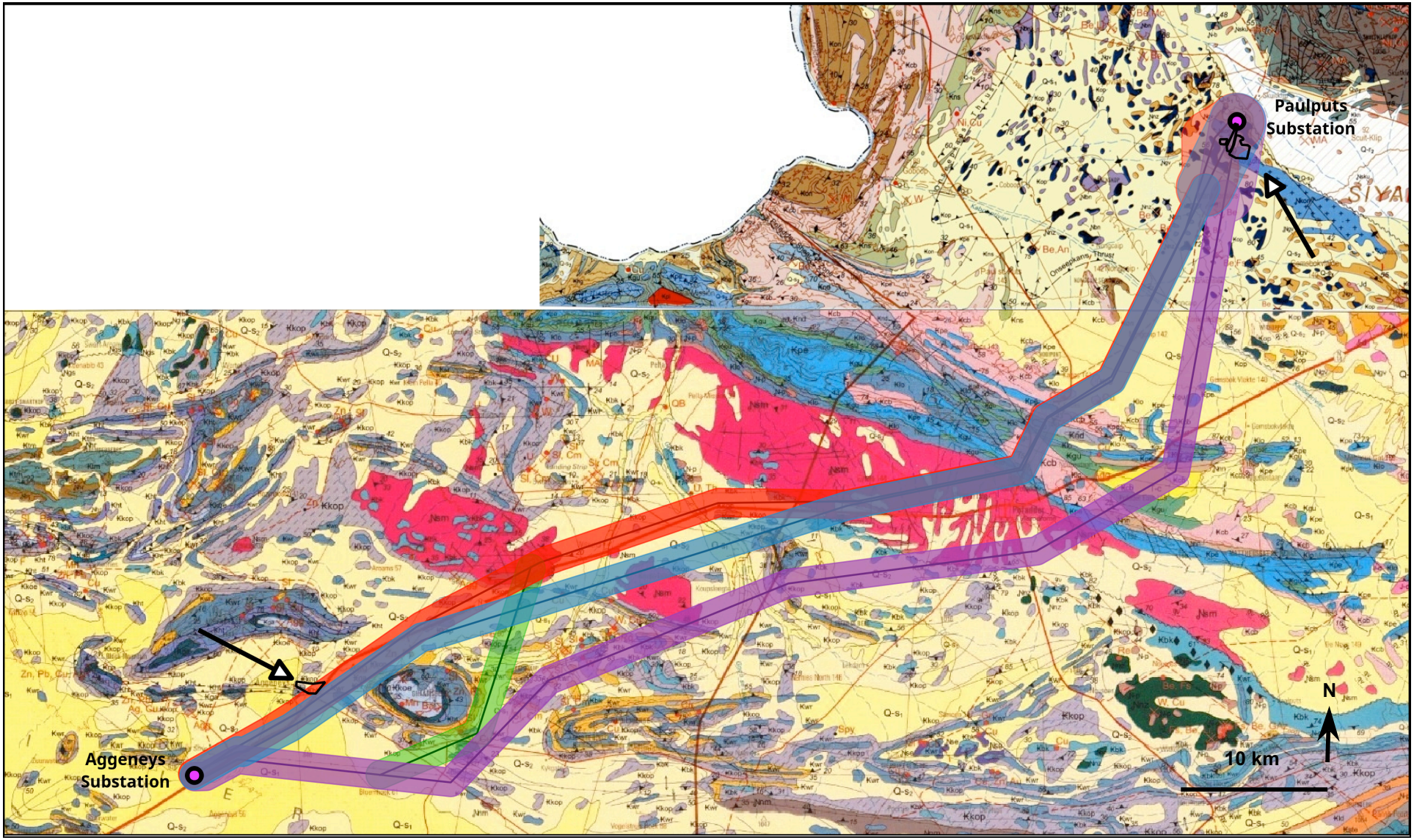
Paulputs
Substation
Aggeneys
Substation
N
10 km

Figure 3 (previous page). Extract from adjoining 1: 250 000 geology sheets 2918 Pofadder and 2818 Onseepkans (Council for Geoscience, Pretoria) showing the main rock units traversed by the various 400 kV powerline corridor options under consideration (Powerline colour scheme as for Figure 1). These include numerous different Late Precambrian (Mokolian) metasediments and intrusive rocks of the Namaqua-Natal Province that build the rocky Inselberge shown in dark colours (*e.g.* Bushmanland Group) and which are all unfossiliferous. These are mantled with a range of Late Caenozoic superficial deposits including aeolian sands (Qs1, dark yellow), scree, rock rubble, sandy and gravelly soils (Qs2, darker yellow) as well as alluvium that can be broadly included within the Quaternary to Recent Kalahari Group and are, at most, sparsely fossiliferous (Map prepared by CTS Heritage, Cape Town).

1.1. Legislative context of this palaeontological study

The development footprint is situated in an area that is underlain by potentially fossiliferous sedimentary rocks of Precambrian to 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 formations in Northern Cape have already 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 kindly provided by Mokgope Consulting, Johannesburg;
2. A review of the relevant scientific literature, including published geological maps and accompanying sheet explanations (Moen & Toogood 2007, Agenbacht 2007) as well as previous palaeontological assessment reports for the broader region (*e.g.* Almond 2011, 2012, 2013a, 2013b, 2014, 2015, 2016);

3. The author's database on the geological formations concerned and their palaeontological heritage (See Almond & Pether 2008);
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 no specialist palaeontological field-based studies in this part of the Northern Cape region. Confidence levels for this palaeontological assessment are therefore only MODERATE.

2. GEOLOGICAL BACKGROUND

The Aggeneis – Paulputs powerline study area lies traverses a very arid region of northern Bushmanland at a distance of some 20 to 50 km south of the Orange River (Gariep), running either side of the N14 tar road between Springbok and Kakamas and close to the small towns of Aggeneys and Pofadder. This mixed sandy and rocky desert region – assigned to the Lower Vaal & Orange Valleys Geomorphic Province of Partridge *et al.* (2010) – is drained by several non-perennial tributaries of the Gariep drainage system such as the Goeb se Laagte south of Pella and the Noncaip se Holte / Kaboeprivier system northeast of Pofadder. From Aggeneis Substation in the west the various powerline route options run ENE towards Pofadder across sandy to gravelly *vlaktes* at elevations of *c*. 800 to *c*.1100 m amsl which lie between rocky Inselberge of Precambrian basement rocks, including the Aggenys se Berg (1140 m amsl), Ghaamsberg (1150 m amsl) and Goob se Berg (10190 m amsl). To the northeast of Pofadder the powerline routes cross the WNW-ESE trending rocky ridge linking the Pella se Berge with the Matheusgat se Berge, heading northeast across the Kaboep Rivier drainage line to terminate at Paulputs Substation located close to the foot of the Ysterberg (1075 m amsl), some 30 km SE of Onseepkans. The surface terrain within the majority of the study region, away from the rocky *rante* and *koppies*, is predominantly sandy to gravelly, with low hills and patchy outcrops of basement rocks as well as a number of shallow, ephemeral streams.

The geology of the Aggenys – Pofadder - Paulputs region is shown on adjoining 1: 250 000 geological maps 2918 Pofadder and 2818 Onseepkans (Council for Geoscience, Pretoria) (Fig. 3) (Agenbacht 2007, Moon & Toogood 2007) and - from a palaeontological heritage viewpoint at least - is fairly similar across the entire study region. The scattered basement inliers are composed of a variety of resistant-weathering igneous and high grade metamorphic rocks - mainly gneisses, schists, quartzites and amphibolites - of Late Precambrian (Mokolian / Mid-Proterozoic) age. These ancient basement rocks are assigned to the Namaqua Sector of the **Namaqua-Natal Province** and are approximately one to two billion years old (Cornell *et al.* 2006, Moen 2007, Agenbacht 2007, Moen & Toogood 2007). The numerous different units of Mokolian basement in the study region are described in the relavent sheet explanations and include (1) rocks of older, Keisian age such as gneisses of Gladkop Metamorphic Suite and metasediments of the Droeboom Group, Bushmanland Group (Kamiesberg and Aggenys Subgroups) and (2) younger, Namaquan metasediments and intrusive rocks (*e.g.* Swartmodder Gneiss). Since none of these basement rocks is fossiliferous, they will not be treated in more detail in this report.

The flatter, lower-lying portions of the study area – including most of those parts that will be directly affected by the proposed electrical infrastructure development - are underlain by a spectrum of unconsolidated superficial sediments of Late Caenozoic age. These include **Quaternary to Recent sands and gravels** of probable braided fluvial or sheet wash origin (**Q-s**$_2$ in Fig. 3), as well as a veneer of downwasted suface gravels and colluval (rocky scree) deposits that are not indicated separately on the geological map. The alluvial and colluvial sediments are locally overlain, and perhaps also underlain, by unconsolidated aeolian (*i.e.* wind-blown) sands of the **Gordonia Formation** (**Kalahari Group**) that are Pleistocene to Holocene in age (**Q-s$_1$** in Fig. 3; orange dunes on satellite images; Fig. 1). All these superficial sediments can be broadly subsumed into the Late Cretaceous to Recent **Kalahari Group**, the geology of which is reviewed by Partridge *et al.* (2006). Narrow strips of Late Caenozoic **sandy to gravelly alluvium** occurs along drainage courses such as the tributaries of the Goeb se Laagte south of Pella and the Noncaip se Holte / Kaboeprivier system northeast of Pofadder.

An important Caenozoic geological feature in the Aggenys area is the **Koa River Palaeovalley** - a defunct south bank tributary of the River Orange of Late Tertiary (Miocene – Pliocene) age that fed into the palaeo-Orange River near Henkries (Malherbe *et al*. 1986, De Wit 1990, 1993, 1999, De Wit *et al*. 2000, Partridge *et al.* 2006). Consolidated Miocene alluvial deposits are preserved locally along the palaeovalley (Section 3) whose alignment can be readily seen on satellite images where it is marked by intermittent pans and a veneer of orange-brown Kalahari wind-blown sands (Fig 1. See also the arcuate band of yellow Q-s$_1$ on the geological map for this area, Fig. 3). The Koa

River Palaeovalley runs at depth along a SE-NE line through the Aggeneis Substation area and is traversed to the greatest extent by the westernmost, W-E trending sector of Corridor 3.

2.1. Kalahari Group

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 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, p. 291). Note that 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 present study area the sands build arrays of sparsely-vegetated linear dunes in the Koa River Palaoevalley area near Aggenys as well as along the Kaboeprivier drainage line; some of these dune fields 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. The sands may be up to 40 m thick in some areas. These unconsolidated sands are locally to extensively underlain by thin surface gravels formed from down-wasted (residual) or water-transported clasts, as well as by calcretes of Plio-Pleistocene or younger age (Mokalanen Formation). Calcrete formation is often prevalent in low-lying areas associated with basic intrusions but is not mapped on the relevant 1: 250 000 maps of the study region.

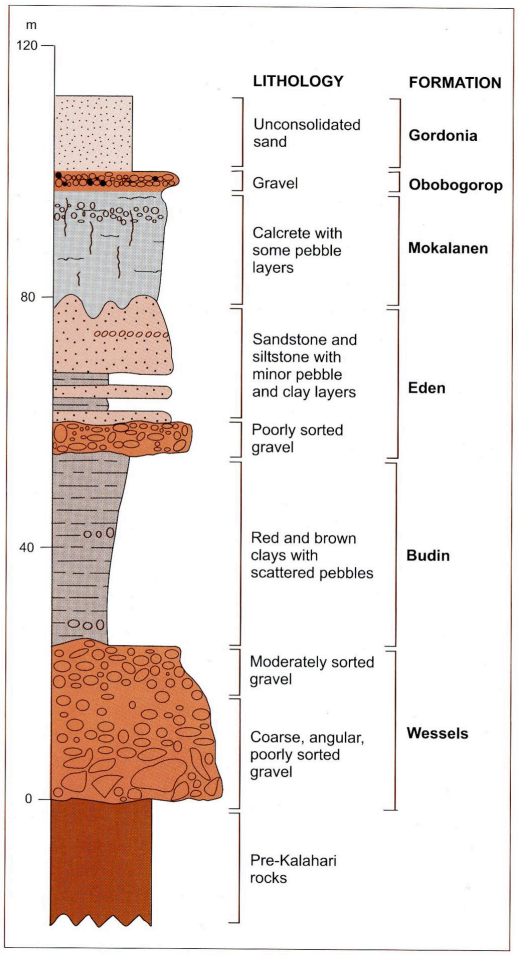

Figure 4. Generalised stratigraphy of the Kalahari Group (From Partridge *et al.* 2006). Only the Gordonia Formation aeolian sands are mapped in the present study area, but older gravels and calcretes, as well as Late Tertiary alluvial sediments at depth along the Koa River Palaeovalley, are possibly also present here.

3. PALAEONTOLOGICAL HERITAGE

The Mid Proterozoic (Mokolian) igneous and metasedimentary basement rocks of the **Namaqua-Natal Province** are entirely unfossiliferous (Almond & Pether 2008). Fossil biotas recorded from each of the main sedimentary rock units mapped in the Aggeneys region and along the Orange River to the north have been reviewed in several previous palaeontological heritage assessments by the author Almond (*e.g.* 2011, 2012, 2013a, 2013b, 2014, 2015, 2016; see also Almond & Pether 2008, Almond 2009, Almond *in* Macey *et al.* 2011 and extensive references therein).

An important Early to Middle Miocene vertebrate faunule has been recorded from alluvial deposits (gravels, grits and lenses of sand, clay) of the **Koa River Palaeo-valley** system at Bosluis Pan, some 50 km SSW of Aggeneys. The fossil fauna has been dated to 15-16 Ma and is reviewed by Senut *et al*. (1996; see also Malherbe *et al*. 1986, De Wit 1999, Partridge *et al*. 2006, Agenbacht 2007, Almond *in* Macey *et al.* 2011). It includes rare bones, tusks, molars and numerous tooth fragments of *Gomphotherium*, a four-tusked, browsing proboscidean with characteristic rounded (mastodont) tooth cusps. There are also crocodile teeth and tortoise shell fragments, as well as remains of grazing elephant shrews, giraffids, bovids, a rhinocerotid and air-breathing catfish. However, fossiliferous fluvial sediments have not yet been recorded from the northern sector of the Koa River Valley near Aggeneys itself; if present, they are likely to be deeply buried beneath superficial sediments (*e.g.* younger alluvium, aeolian sands). It is noted that this potentially palaeontologically-sensitive feature is not picked up on the SAHRIS palaeosensitivity map (Fig. 5) due to the overlying mantle of lower-sensitivity Kalahari Group sediments. Significant impacts on any subsurface fossils within the study areas for the 400 kV transmission lines, electrical substation and associated infrastructure are not anticipated here since deep excavations are not involved.

The various younger superficial deposits of the **Kalahari Group** in Bushmanland, including aeolian sands, alluvium, calcretes and pan deposits, are poorly known in palaeontological terms. The fossil record of the Kalahari Group as a whole is generally sparse and low in diversity; no fossils are recorded here in the Pofadder and Onseepkans geology sheet explanations by Agenbacht (2007) and Moen and Toogood (2007) respectively. The Kalahari beds may very 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.

Potentially fossiliferous Tertiary or Pleistocene “high level gravels” are not mapped along the various south bank tributaries of the Orange River traversing the powerline study area and are probably not present this far from the river (*cf* Moen & Toogood 2007). The last authors record small relict patches of older silty alluvium at 50 m above modern river level with subfossils of freshwater snails in the Onseepkans sheet area but it is unlikely that similar deposits will be represented within the powerline footprint that ends 30 km southeast of Onseepkans.

Consolidated older alluvium, calcrete hardpans as well as spring and pan deposits may occasionally contain important fossil biotas, notably the bones, teeth and horn cores of mammals as well as remains of reptiles like tortoises (Kiberd 2006). Impressive concentrations of intact or comminuted, tiny non-marine snails are found along the edge of the pan Swartkolkvloer, 50 km southwest of Brandvlei (Kent & Gribnitz 1985, Almond *in* Macey 2011). They are associated with fossil remains of fishes, birds, crabs and undetermined teeth that remain unsampled and unstudied (*ibid*.). The well-known Kathu Pan site in the Kalahari Region has yielded important Pleistocene mammalian remains, peats as well as Acheulean and MSA stone tools (Klein 1984, 1988, Beaumont *et al.* 1984, Beaumont 1990, Beaumont 2004, MacRae 1999, Partridge & Scott 2000). Other late Caenozoic fossil biotas that may occur within these superficial deposits include non-marine molluscs (bivalves, gastropods), ostrich egg shells, trace fossils (*e.g.* calcretised termitaria, coprolites, invertebrate burrows, rhizocretions), and plant material such as peats or palynomorphs

(pollens) in organic-rich alluvial horizons and diatoms in pan sediments. In Quaternary deposits, fossil remains may be associated with human skeletal material or artefacts such as stone tools of palaeontological as well as archaeological interest. Surface gravels concentrated by sheetwash and downwasting may contain resistant clasts of silicified wood as well as bones and teeth that have been reworked from older sediments (*e.g.* petrified wood blocks from the Karoo Supergroup or Tertiary alluvium).

4. CONCLUSIONS & RECOMMENDATIONS

In terms of palaeontological sensitivity, outcrop areas of basement rocks are negligible while the overlying Late Caenozoic superficial deposits (alluvium, gravels, aeolian sands *etc*) are generally of low to very low sensitivity (See extract from the SAHRIS palaeosensitivity map, Figure 5). No highly-sensitive palaeontological sites or no-go areas have been identified within the 400 kV powerline and substation study area. The Koa River Palaeovalley area near Aggenys (Indicated in Fig. 1, but not reflected in Fig. 5) may feature important Tertiary fossils at depth but these are very unlikely to be directly impacted by the shallow excavations envisaged for the present electrical infrastructure project. Narrow zones of Late Caenozoic alluvium associated with larger water courses traversing the study area may contain fossils (*e.g.* mammalian bones, teeth) but these are probably very sparse, while placement of pylon footings close to drainage lines is unlikely.

Impacts on unique or irreplaceable fossil heritage resources due to the proposed development are improbable and their severity is anticipated to be negligible since (1) highly significant fossil sites are unlikely to be affected and (2) in most cases these impacts can be mitigated through an appropriate Chance Fossil Finds Procedure (See below). The overall impact significance of the proposed 400 kV Aggeneis to Paulputs powerline and associated small-scale substation developments is rated as VERY LOW in terms of palaeontological heritage resources. This assessment applies to all powerline route options under consideration (Corridors 1,2,3 and 3A). From a palaeontological heritage viewpoint, Corridor 3 is least preferred because it traverses a longer portion of the Koa River Palaeovalley (Fig. 2) as well as more alluvial zones along modern water courses (green strips in Fig. 5). Corridor 1 is most preferred because it largely follows an existing powerline servitude so disturbance of surface sediments (*e.g.* for new access roads) is minimal. Cumulative impacts inferred for the various powerline and alternative energy developments in the Aggeneys – Pofadder – Paulputs region of the Northern Cape are assessed 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 400 kV Aggeneis to Paulputs 400 kV powerline project and associated electrical substation developments. Chance fossil finds such as vertebrate bones and teeth 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 developments.

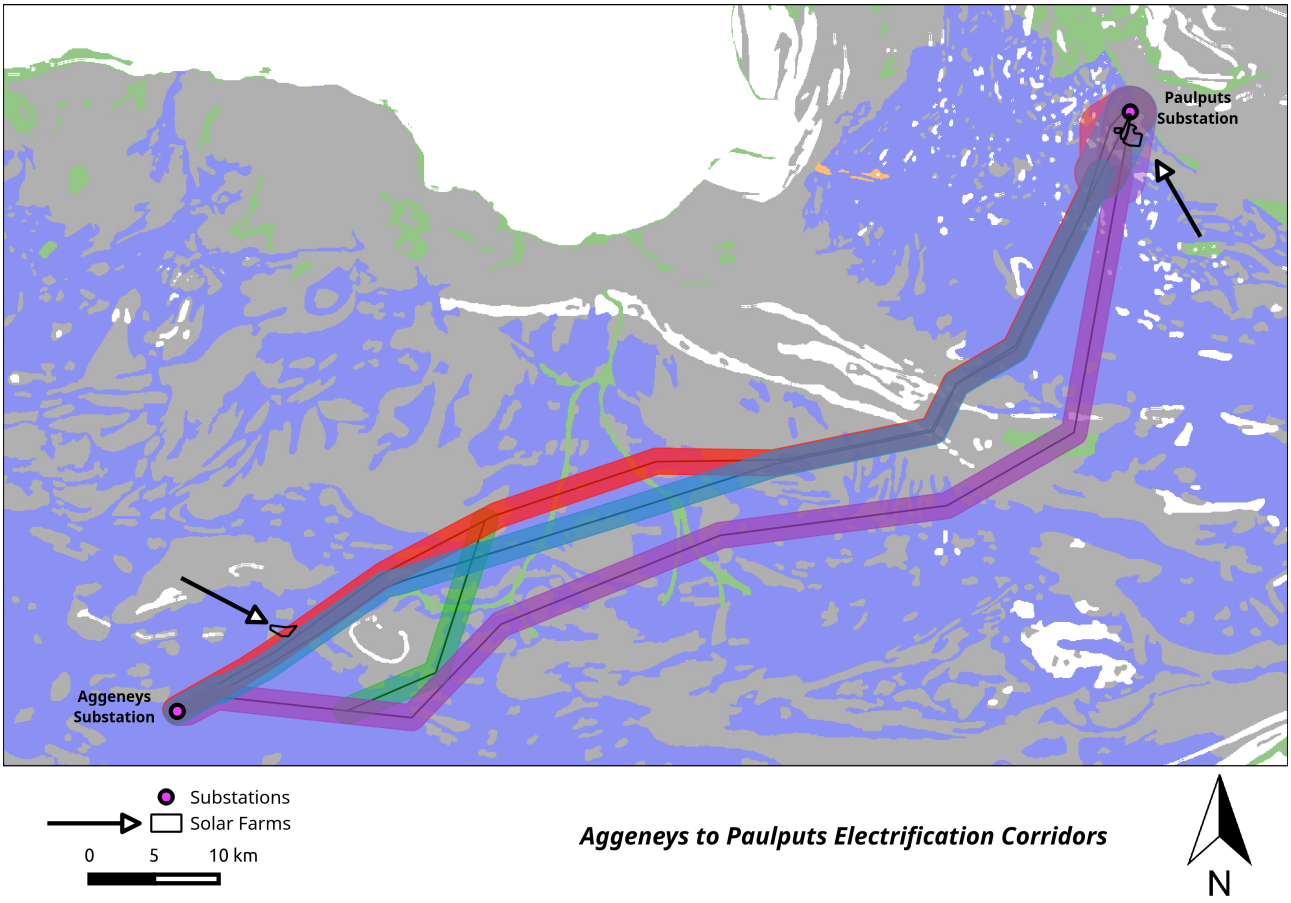

Figure 5. Extract from the SAHRIS palaeosensitivity map showing the Aggeneis – Paulputs 400 kV powerline study region (Map prepared by CTS Heritage, Cape Town). The great majority of the region is of negligible (grey) to low (blue) palaeosensitivity, broadly reflecting the distribution of basement and Kalahari Group rocks respectively. Narrow zones of medium palaeosensitivity are mapped along major water courses (green). Note that the potentially palaeontologically-sensitive Koa River Palaeovalley region near Aggenys (See Fig. 1) is *not* reflected in this map due to the Kalahari Group cover sediments.

5. ACKNOWLEDGEMENTS

Ms Judith Fasheun of Mokgope Consulting, Johannesburg, is thanked for commissioning this report and for providing the relevant background information. I am very grateful to Mr Nic Wiltshire of CTS Heritage, Cape Town, for preparing the critical geological and palaeosensitivity maps at very short notice.

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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><th colspan="3">CHANCE FOSSIL FINDS PROCEDURE: Aggeneis-Paulputs 400 kV Transmission Powerline and Substation Upgrades</th></tr>
<tr><td>Province & region:</td><td colspan="2">Namaqua and Siyanda Districts, Northern Cape</td></tr>
<tr><td>Responsible Heritage Management 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 along larger water courses (including buried Koa River Palaoevalley near Aggenys)</td></tr>
<tr><td>Potential fossils</td><td colspan="2">Bones, teeth and horn cores of mammals, freshwater molluscs, petrified wood, calcretised termitaria 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 Management 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 Management 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 Management Authority and project palaeontologist (if any) who will advise on any necessary mitigation</td></tr>
<tr><td colspan="2">4. If required by Heritage Management 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 Management 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 Management Authority. Adhere to best international practice for palaeontological fieldwork and Heritage Management Authority minimum standards.</td></tr>
</table>