PALAEONTOLOGICAL SPECIALIST STUDY: COMBINED DESKTOP & FIELD-BASED ASSESSMENT

Proposed Tsitsikamma Community Wind Energy Facility near Humansdorp, Kouga Local Municipality, Eastern Cape Province

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PALAEONTOLOGICAL HERITAGE IMPACT STATEMENT

Exxaro Resources and Watt Energy (Pty) Ltd is proposing to develop a wind energy facility (WEF) of up to 100 MW generating capacity on a site some 25 km to the west-southwest of Humansdorp, Kouga Local Municipality, Eastern Cape Province. The northern and central portions of the study site are largely underlain by six sedimentary formations of Palaeozoic age assigned to the Cape Supergroup (Table Mountain and Bokkeveld Groups). Only three of these Palaeozoic rock units – the Cederberg, Baviaanskloof and Gydo Formations – are of marine origin and potentially sensitive from a fossil heritage viewpoint. However, their outcrop areas within the study area are very narrow and ill-defined, the bedrocks here are usually mantled by thick (several meters), unfossiliferous superficial sediments (soil, alluvium *etc*), while their fossil content at or near surface has been seriously compromised by both intense tectonic deformation (*e.g.* cleavage formation) as well as deep chemical weathering. In practice, the palaeontological sensitivity of these rock units is therefore very low. The southern portion of the Tsitsikamma Community WEF study area is covered by Late Caenozoic aeolianites (wind-blown dune sands) that are generally fossil-poor and will not be directly impacted by the development.

The proposed wind turbine sites will be confined to the central portion of the broader study area and almost all of them overlie fluvial sediments of the Table Mountain Group that are normally only sparsely fossiliferous. Furthermore, the Table Mountain Group sediments beneath the coastal plain here have been intensely deformed (folding) and weathered, further lowering their palaeontological sensitivity. Significant new, low diversity trace fossil assemblages were recorded from a quarry site in the uppermost Peninsula Formation (late Ordovician Period) near Rosenhof (Farm 717). The site lies just outside the study area and will not be directly impacted by the wind farm development.

All of the alternative route options for the 132 kV transmission line connecting the Tsitsikamma Community WEF to the Eskom grid at the existing Melkhout or Dieprivier Substations transect deformed and weathered bedrocks of low palaeontological heritage significance. There is no preference for one or other route on fossil heritage grounds. Furthermore, no further specialist studies or mitigation for the transmission line component of the Tsitsikamma Community WEF are recommended here.

Impacts of wind farm projects on fossil heritage are generally direct, negative, of local significance and confined to the construction phase. Fossils preserved at or below the land surface may be disturbed, damaged, destroyed or sealed-in by developments such as excavations for wind turbine foundations, access roads and ancillary infrastructure.

Following field assessment, the impact significance of the construction phase of the proposed wind farm project is assessed as LOW(negative) as far as fossil heritage is concerned. There are no fatal flaws in the development proposal on these grounds. Further specialist studies or mitigation by a professional palaeontologist are not recommended for this project, pending the discovery of significant new fossil heritage resources during development.

Monitoring of all substantial bedrock excavations for fossil remains by the ECO during the construction phase is recommended. In the case of any significant new fossil finds (*e.g.* shell beds, vertebrate teeth, bones, burrows, petrified wood), these should be safeguarded - preferably *in situ* - and reported by the ECO as soon as possible to the relevant heritage management authority (SAHRA) so that any appropriate mitigation by a palaeontological specialist can be considered and implemented, at the developer's expense.

These recommendations should be incorporated into the EMP for the Tsitsikamma Community Wind Energy Facility.

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

Providing that the recommended mitigation measures are carried through, it is likely that the potentially negative impacts of the proposed development on local fossil resources will be substantially reduced and, furthermore, they will partially offset by the positive impact represented by increased understanding of the palaeontological heritage of the Humansdorp region

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1. INTRODUCTION

1.1. Outline and location of the proposed development

The company Exxaro Resources and Watt Energy (Pty) Ltd is proposing to develop a commercial wind energy facility and associated infrastructure, known as the Tsitsikamma Community Wind Energy Facility, on a site situated to the south of the N2 trunk road some 25 km WSW of the town of Humansdorp, Kouga District Municipality, Eastern Cape Province (Figs. 1-2). The proposed wind farm will occupy an area of approximately 54 km^2 and will have a generating capacity of up to 100 MW. The following land parcels, currently used mainly for agriculture, are involved in the wind farm development: Portions 19 and 22 of Zalverige Valley 660, Portions 3 and 5 of Vergaaderingskraal 675, Portion 1 of Ou Driefontein 721, Portion 2 of New Driefontein 720, Portions 3 - 9 of Wittekleibosch 787, Farm 818, Remainder of Farm 678 and Portion 3 of Kliprug 676.

The wind energy facility will consist of the following main infrastructural components:

- Wind Turbines with a total generating capacity of *c.*100 MW;
- Foundations to support the turbine towers;
- Underground cables between turbines;
- A substation within the development site;
- A 132 kV overhead power line which will link to the existing Eskom Melkhout or Dieprivier Substations;
- Internal access roads to each wind turbine;
- Workshop/administration building.

The layout for the proposed wind energy facility has not yet been finalized. Likely wind turbine positions are shown in Fig. 3.

Alternative routes for the 132 kV overhead transmission line are shown in Fig. 1.

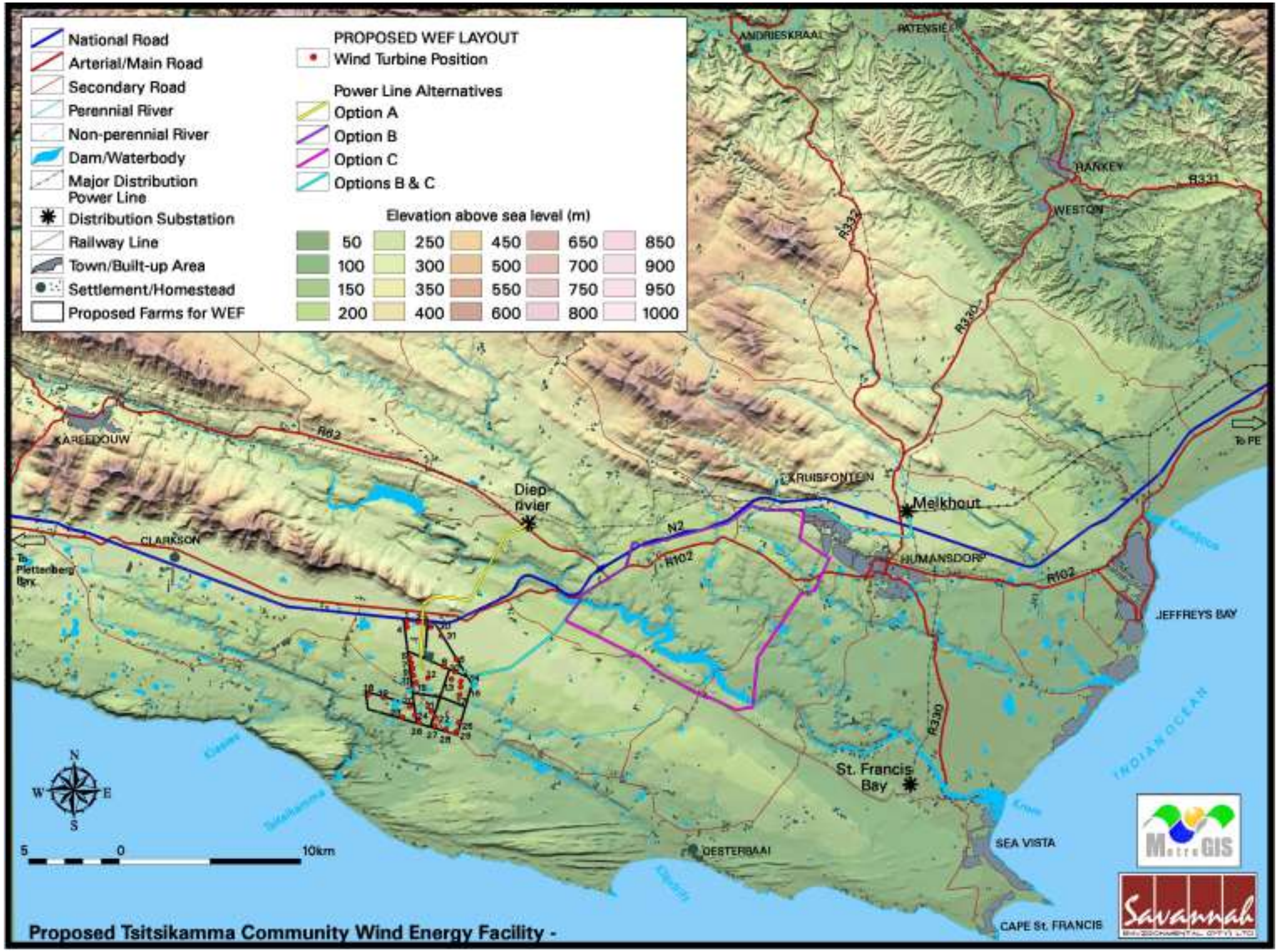

Fig. 1. Map showing the location of the proposed Tsitsikamma Community Wind Energy Facility on the southern side of the N2 and *c.* 25km WSW of Humansdorp, Alternative routes for the 132 kV overhead transmission line are also shown here (Image kindly provided by Savannah Environmental (Pty) Ltd). Proposed wind turbine positions are indicated by small red dots.

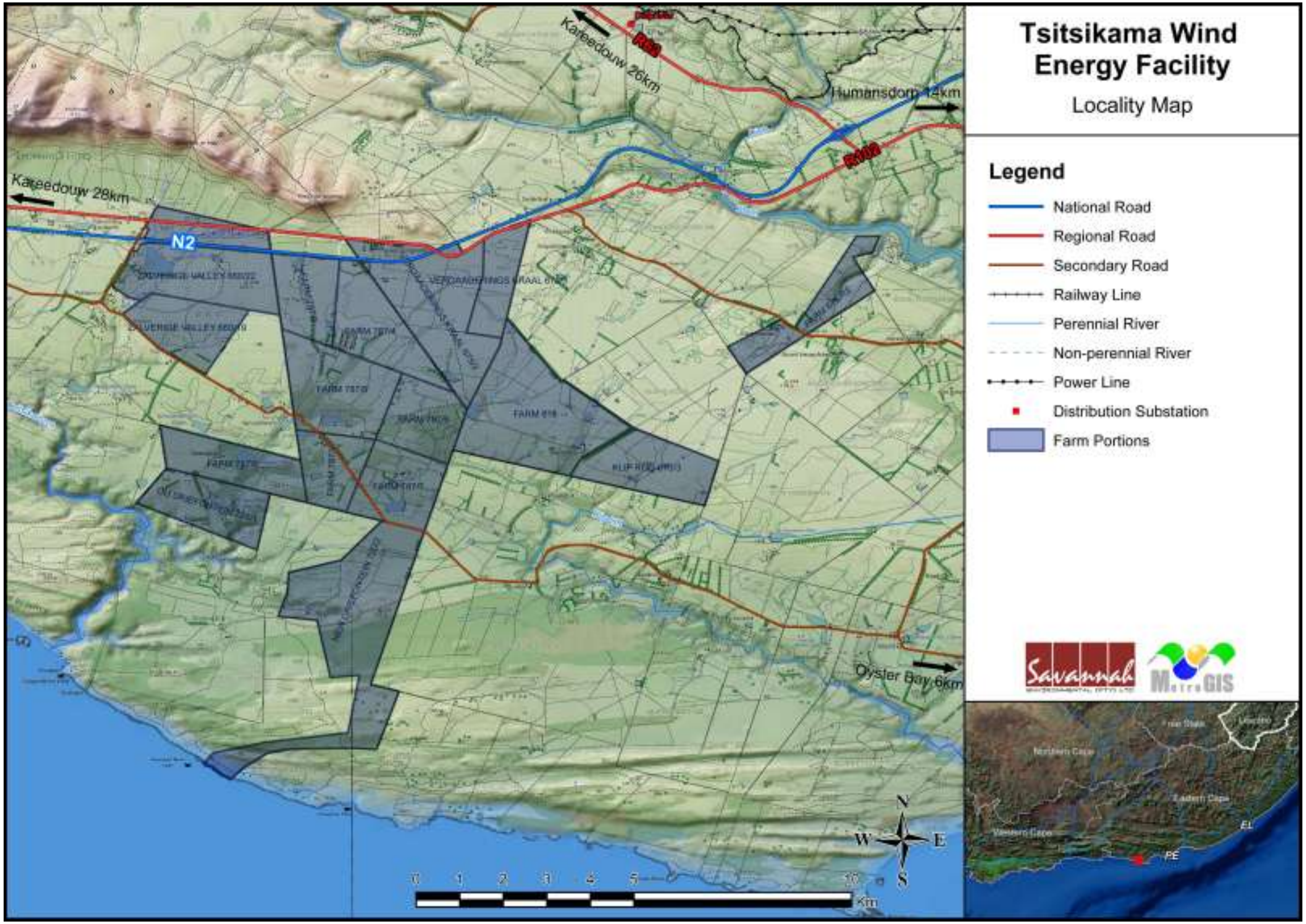

Fig. 2. Map of the broader study area for the proposed Tsitsikamma Community Wind Energy Facility near Humansdorp showing the various land parcels involved (Image kindly provided by Savannah Environmental (Pty) Ltd). As shown in the previous and following figures, wind turbines will probably be located in the north-central portion of the study area only.

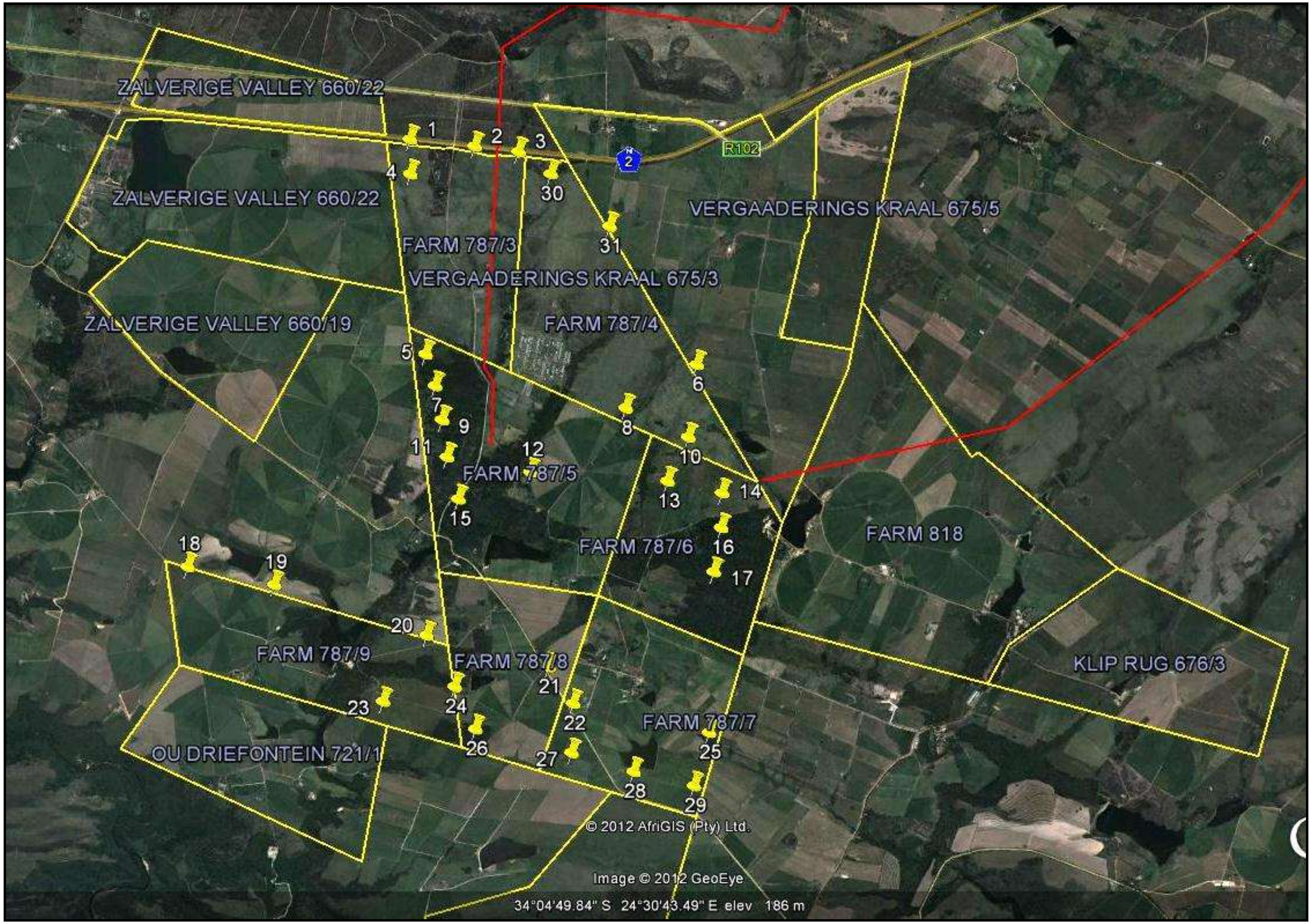

Fig. 3. Google earth© satellite image of the north-central portion of the Tsitsikamma WEF study area showing approximate positions of the 31 wind turbines.

1.2. Approach to the study

The present desktop report, commissioned by Savannah Environmental (Pty) Ltd, Sunninghill, Gauteng, forms part of the comprehensive EIA for the proposed Tsitsikamma Community Wind Energy Facility and it will also inform the Environmental Management Plan for the project. This development falls under Section 38 (Heritage Resources Management) of the South African Heritage Resources Act (Act No. 25 of 1999). The various categories of heritage resources recognised as part of the National Estate in Section 3 of the Heritage Resources Act include, among others:

- geological sites of scientific or cultural importance
- palaeontological sites
- palaeontological objects and material, meteorites and rare geological specimens

Minimum standards for the palaeontological component of heritage impact assessment reports are currently being developed by SAHRA. The latest version of the SAHRA guidelines is dated November 2011.

A desktop palaeontological assesment of the Tsitsikamma Community WEF was commissioned by Savannah Savannah Environmental (Pty) Ltd and submitted in August 2011 (Almond 2011b). The desktop report made the following recommendations:

> Given the uncertainties concerning the geological mapping of the poorly-exposed, potentially fossiliferous marine rock formations within the study area, as well as their actual palaeontological sensitivity on the ground, it is recommended that a Phase 1 pre-construction field assessment of the broader development area, including the final development footprint, by a professional palaeontologist be carried out to identify possible zones or areas of high palaeontological sensitivity and to recommend any further mitigation measures deemed necessary. Note that the recommended field assessment is *not* restricted to the development footprint alone because bedrock exposure here may be inadequate to adequately assess buried fossil heritage. Assessment of the entire development area is also generally recommended by the APM sections of SAHRA and Heritage Western Cape.

The present two-day field assessment and report were accordingly commissioned by Savannah Savannah Environmental (Pty) Ltd. This palaeontological specialist report provides an assessment of the observed or inferred palaeontological heritage within the study area, with recommendations for specialist palaeontological mitigation where this is considered necessary.

In preparing a palaeontological desktop study the potentially fossiliferous rock units (groups, formations *etc*) represented within the study area are determined from geological maps. The known fossil heritage within each rock unit is inventoried from the published scientific literature, previous palaeontological impact studies in the same region, and the author's field experience (Consultation with professional colleagues as well as examination of institutional fossil collections may play a role here, or later following 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 the Western, Eastern and Northern Cape have already been compiled by J. Almond and colleagues; *e.g.* Almond *et al.* 2008). The likely impact of the proposed development on local fossil heritage is then determined on the basis of (1) the palaeontological sensitivity of the rock units concerned and (2) the nature and scale of the development itself, most 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 (*e.g.* SAHRA for the Eastern Cape). 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. Terms of reference

The author has been commissioned by Savannah Environmental (Pty) Ltd to provide specialist palaeontological input to undertake an environmental impact assessment and compile an environmental management plan for the proposed Tsitsikamma Community Wind Energy Facility in the form of a combined desktop and fieldwork report that is to include the following components:

- An indication of the methodology used in determining the significance of potential environmental impacts;
- A description of all environmental issues that were identified during the environmental impact assessment process;
- An assessment of the significance of direct, indirect and cumulative impacts;
- A description and comparative assessment of all alternatives identified during the environmental impact assessment process;
- Recommendations regarding practical mitigation measures for potentially significant impacts, for inclusion in the Environmental Management Plan (EMP);
- An indication of the extent to which the issue could be addressed by the adoption of mitigation measures;
- A description of any assumptions, uncertainties and gaps in knowledge
- An environmental impact statement.

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.

In the case of the Tsitsikamma Community WEF study area a major limitation is the low level of bedrock exposure. However, in the author's opinion field study of the available exposures within and along the margins of the study area has allowed an adequate assessment of palaeontological heritage resources relevant to the proposed development.

1.5. Information sources

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

1. A short project outline provided by Savannah Environmental (Pty) Ltd;

2. A review of the relevant scientific literature, including published geological maps and accompanying sheet explanations as well as several palaeontological impact studies in the Humansdorp region (*e.g.* previous desktop study for this project by Almond 2011a as well as studies by Almond 2009, 2010a 2011b);

3. A two-day palaeontological field assessment (22-23 May, 2012) of the broader study are by the author;

4. The author's previous field experience with the formations concerned and their palaeontological heritage.

2. GEOLOGY OF THE STUDY AREA

2.1. Outline of geological setting

The Tsitsikamma Community Wind Energy Facility study area is situated on the southern coastal plain near Humansdorp, Eastern Cape. Much of this hilly to undulating region (Fig. 6) lies at elevations of around 100 to 130m amsl with an overall seawards slope from about 280m amsl inland along the foothills of the Kareedouwberge down to the modern coastline. The coastal plain here is dominated by a wide, topographically subdued, wave-cut platform which probably corresponds to the so-called George Terrace between George and Port Elizabeth that is of inferred Late Tertiary (Middle Miocene) age (Roberts *et al.* 2008). The extensive marine platform has been modified by subsequent tectonic uplift and consequent erosional incision of younger river systems, such as the Tsitsikamma, Kromrivier and Klipdrif Rivers, as well as by later eustatic transgressions close to the coast. In some areas, well seen on satellite images, prominent-weathering ridges of tough Table Mountain Group quartzites still project above the flat-lying coastal plain (*e.g.* Vergadering's Kraal 675/5, Loc. 600; Figs. 7 & 9).

The geology of the Tsitsikamma study area near Humansdorp is shown on the 1: 250 000 geology sheet 3324 Port Elizabeth published by the Council for Geoscience, Pretoria (Toerien & Hill 1989) (Fig. 5). Additional relevant data is provided by the more recent 1: 50 000 geological sheet explanation for the Port Elizabeth – Uitenhage area to the east (Le Roux 2000) as well as the older sheet explanation by Haughton *et al.* (1937) covering the coastal belt near the Gamtoos Valley.

The northern and central portions of the study area, as well as the outlying area in the northeast (Farm 678/RE), are largely underlain by Early to Middle Palaeozoic sedimentary rocks of the **Cape Supergroup**. These comprise rocks of the sandstone-dominated **Table Mountain Group** of Ordovician to Early Devonian age and the immediately overlying, mudrock-dominated lowermost **Bokkeveld Group** of Early Devonian age. The stratigraphic relationships of the six sedimentary formations concerned are shown below in Fig. 4. They include:

- predominantly fluvial sandstones and quartzites of the **Peninsula** (Op), **Goudini** (Sg) and **Skurweberg (**Ss**) Formations**, of Ordovician to Silurian age;
- post-glacial mudrocks of the **Cederberg Formation** (Oc) of late Ordovician age (Note that the glacial diamictites of the underlying **Pakhuis Formation** are not mapped separately in this area);
- earliest Devonian wackes (= impure sandstones) and mudrocks of the **Baviaanskloof Formation** (S-Db), interpreted to be inshore coastal marine to paralic (near-shore) fluvial deposits;
- shallow marine mudrocks and subordinate sandstones of the **Gydo Formation** (Dg) of Early Devonian age.

Most of these rocks have a poor fossil record but those three marine units emphasized with an asterisk in Fig. 4 are potentially highly fossiliferous, as outlined in Section 3. These three sensitive units crop out in the central and northeastern sectors of the study area (Fig. 4). The Cape Supergroup rocks in the study area lie within the south-eastern sector of the Cape Fold Belt of Permo-Triassic age. Levels of tectonic deformation here are high as a result of intense crustal compression, with steep bedding plane dips of the order of 60º to 80º within tight folds along subparallel WNW-ESE trending axes (Some of these folds are overturned towards the north, as indicated by inverted bedding). A major anticlinal axis runs along the line of the Kareedouwberge, with a broad zone of Peninsula Formation quartzites at its core. Several smaller-scale anticlinal and synclinal folds extend to the northeast and southwest of this major structure, largely constructed of Nardouw Subgroup (= upper Table Mountain Group) and lower Bokkeveld Group rocks. Narrow outcrops of Gydo Formation are mapped along the cores of the tight synclines. The mudrock-dominated successions of the Cederberg and Gydo

Formations here are highly cleaved, and perhaps locally faulted- or squeezed-out, but levels of metamorphism within the Cape Fold Belt are generally low.

Due to protracted chemical weathering of bedrocks beneath the southern coastal plain in Tertiary times, most of these sedimentary rocks have been converted to poorly consolidated, easily eroded *saprolite* (*in situ* weathered bedrock), often pale or multi-hued due to the formation of kaolinitic clays and secondary ferruginous mineralisation respectively (Fig. 6). Because of the overall low relief and extensive chemical weathering of the coastal plain bedrock exposures here are very limited, and mainly restricted to artificial excavations such as quarries, borrow pits, road cuttings and trenches. Under these circumstances, accurate geological mapping is impossible, and so the outcrop areas shown in Fig. 5 must be regarded as a provisional "best guess" pending further subsurface data.

A substantial portion of the Palaeozoic bedrocks within the northern and central study area are mantled by a veneer of **Late Caenozoic superficial sediments**; these are not mapped at 1: 250 000 scale, however. They include various soils - clay-rich soils overlying the Cederberg and Gydo Formation, colluvial and down-wasted sandstone or quartizte gravels overlying the arenitic Table Mountain Group units, as well as fine-grained to gravelly alluvium along river and stream courses. Pedocretes, such as silica-rich silcretes and iron-rich ferricretes, are generally well-developed on the southern coastal plain (*e.g.* Roberts 2003). Relict patches of ancient alluvial gravels (Late Caenozoic / Pleistocene "High Level Gravels") are not mapped within the study area but may also be present here on a small scale (*e.g.* along the margins of older water courses). Within the narrow southern portion of the study area that extends southwards to the rocky coast (Farm New Driefontein 720/2) the wave-cut coastal platform incised into Palaeozoic bedrocks is mostly blanketed by aeolianites (*i.e.* wind-blown sands) of Late Caenozoic age. These poorly consolidated to unconsolidated dune sands are assigned to the **Nanaga** (Late Pliocene / Pleistocene) and **Schelm Hoek** (Recent) Formations of the **Algoa Group**. The modern coastline features rocky exposures of the quartzitic Skurweberg Formation and doubtless also Pleistocene to Recent coastal conglomerates, gravels and sands. Since they will not be directly impacted by the proposed wind farm development, these coastal and near-coastal rocks are not considered further here.

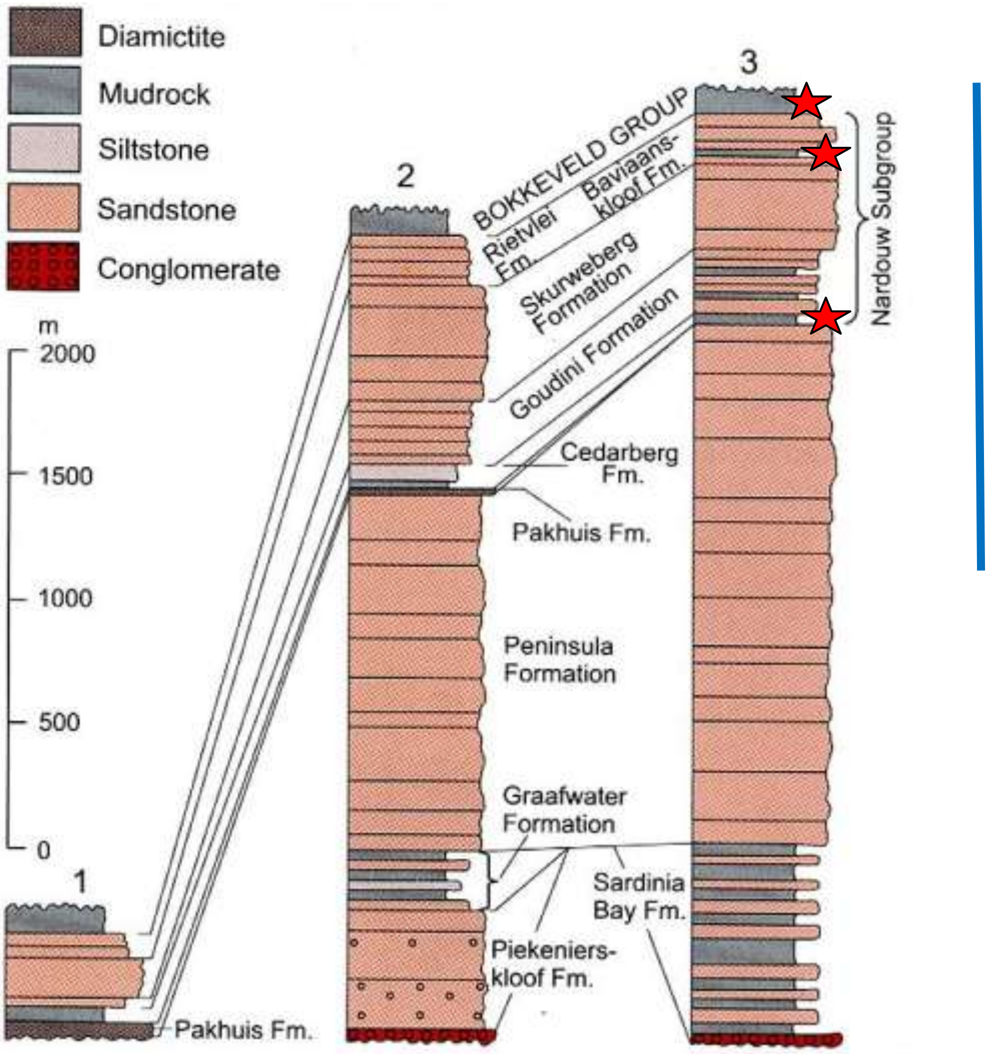

Fig. 4. Stratigraphy of the Table Mountain Group in the Western and Eastern Cape outcrop areas (From Thamm & Johnson 2006). Column 3 for the Eastern Cape is most relevant for the present study near Humansdorp. The vertical blue line indicated formations represented within the Tsitsikamma study area. Table Mountain Group formations above the Cederberg Formation are grouped within the Nardouw Subgroup. The fossiliferous basal mudrocks of the overlying Bokkeveld Group belong to the Gydo Formation that is mapped within the study area. The three marine rock units indicated with a red asterisk – *i.e.* Cederberg, Baviaanskloof and Gydo Formations - are potentially of high palaeontological sensitivity. The remaining units are predominantly non-marine and generally have a poor fossil record.

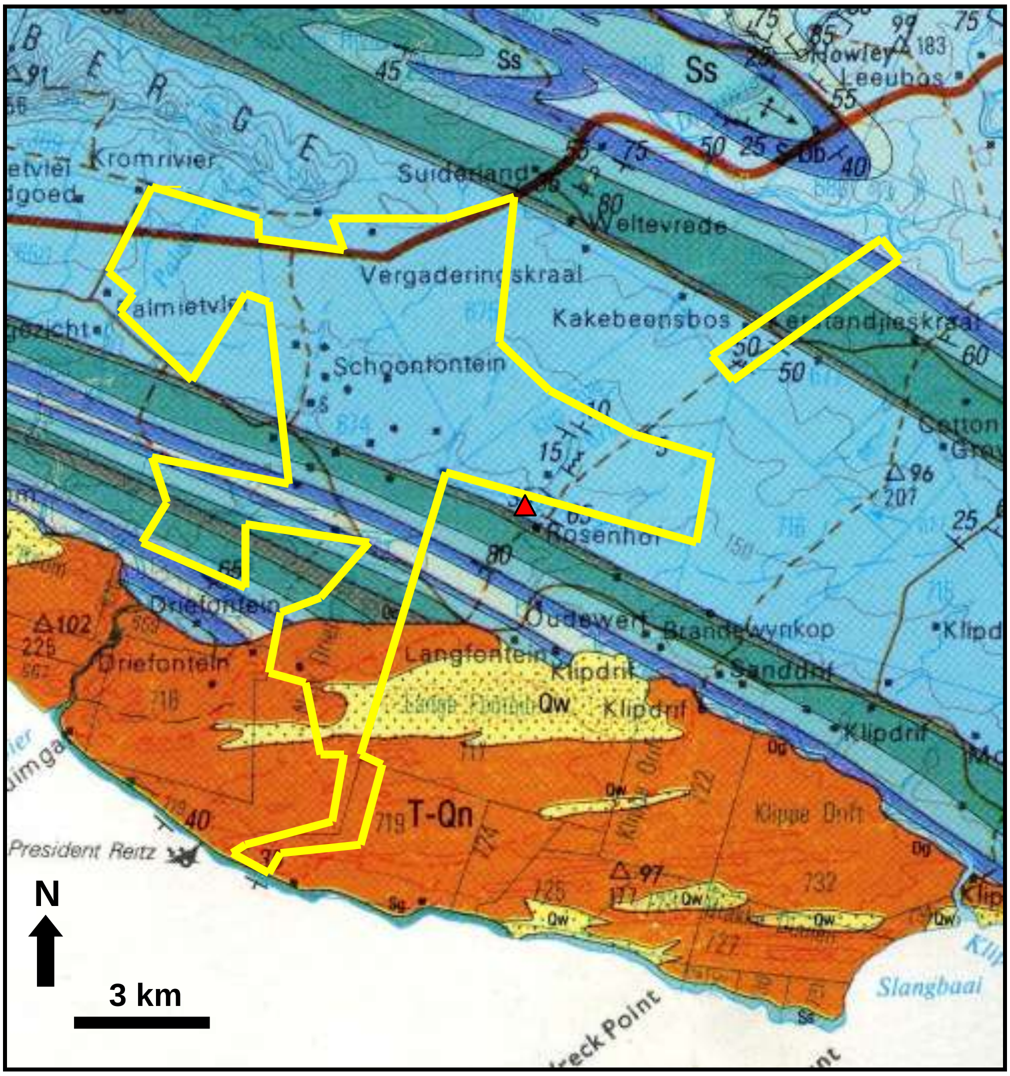

Fig. 5. Extract from 1: 250 000 geology sheet 3324 Port Elizabeth (Council for Geoscience, Pretoria) showing *approximate* outline of the broader Tsitsikamma study area near Humansdorp (yellow polygons). A more accurate delineation of the land parcels involved and the major roads in the area is shown above in Figs. 2 & 3. Proposed wind turbine positions, shown in Fig. 3, largely overlie the Peninsula Formation.

The main geological units represented within the study include the following formations (Palaeontologically more sensitive marine units indicated in red):

TABLE MOUNTAIN GROUP (Ordovician to Early Devonian)

Peninsula Formation (Op, middle blue)
Cederberg Formation (Oc, grey)
Goudini Formation (Og, green)
Skurweberg Formation (Ss, pale blue)
Baviaanskloof Formation (S-Db, dark blue)

BOKKEVELD GROUP (Early Devonian)

Gydo Formation (Dg, v. pale blue)

ALGOA GROUP (Late Caenozoic, Quaternary to Recent)

Nanaga Formation (T-Qn, orange-brown)
Schelm Hoek Formation (Qw, yellow with dots)

Fig. 6. Typical rolling hill landscape in the southwestern portion of the study area (Ou Driefontein 721) showing exposure of pale, highly weathered bedrock (saprolite) around a farm dam.

Fig. 7. Low ridges of Peninsula Formation quartzites projecting above the flat coastal plain on Vergadering's Kraal 675/5 (Loc. 600). The Kareedouwberge are seen in the background.

In the following section of this report the main geological units represented within the Tsitsikamma wind energy facility study area are briefly described, with short notes on representative exposures from the study area, paying special attention to those formations that may be of palaeontological heritage significance. GPS data for all localities mentioned in the text is provided in the Appendix.

2.2. Table Mountain Group

Useful overviews of Table Mountain Group geology in general include Rust (1967, 1981), Hiller (1982), Malan & Theron (1989), Broquet (1992), Johnson *et a*l., (1999), De Beer (2002), Thamm & Johnson (2006), and Tankard *et al*., (2009). For the Port Elizabeth sheet area specifically, these rocks are briefly described by Toerien and Hill (1989) and Le Roux (2000) as well as in older sheet explanations such as those by Engelbrecht *et al*. (1962) and Haughton *et al*., (1937). Also useful are various reports by the South African Committee for Stratigraphy (SACS), such as those by Malan *et al*. (1989), Malan and Theron (1989) and Hill (1991).

The Mid to Late Ordovician **Peninsula Formation** is a very thick succession of resistant-weathering, well-washed, braided fluvial sandstones and quartzites with subordinate pebbly lenses and thin (< 1m) heterolithic (mudrock / sandstone) intervals with sparse trace fossils that are attributed to intermittent marine transgressive events (Toerien & Hill 1989, Le Roux 2000). Common sedimentary structures include unidirectional cross-bedding and over-turned cross-bedding. The thickness of the formation is unclear due to the frequent occurrence of tectonic reduplication but is unlikely to be more than 3000m.

Most of the proposed wind turbine positions for the Tsitsikamma WEF overlie the outcrop area of the Peninsula Formation. Good exposures of steeply SSW-dipping beds of the Peninsula Formation are exposed in a quarry on Farm 717, 0.5 km northwest of Rosenhof Farmstead, and just outside the WEF study area (Fig. 8, Locs. 602-3). The quarry lies on the north side of a stream valley that runs along the outcrop of the Cederberg Formation, so the rocks in the quarry belong to the uppermost part of the Peninsula Formation. Here pale grey, tabular to lenticular, thin- to medium-bedded, tabular cross-bedded to laminated fluvial quartzites and impure wackes with thin darker grey mudrocks, occasional intraformational mudflake breccias and linear-crested current ripples are seen. High levels of bioturbation are seen at many horizons (Section 3.1) and some bedding surfaces are covered with stylolites, indicating diagenetic dissolution . The facies seen here differ markedly from the regressive pebbly quartzites of the Late Ordovician Fold Zone that build the uppermost Peninsula Formation in its western outcrop area (*e.g.* Cederberg Mountains).

Locally low to prominent ridges of Peninsula Quartzites project above the general level of the coastal plain. Near Kakebeensbos (Kakebeensbosch Farm 678, Loc. 196a at 180 m amsl) the quartzites form striking, well-rounded and locally highly polished rocky outcrops (Fig. 9). Polishing and smoothing might be due to sand abrasion during drier, colder intervals of the Pleistocene Epoch.

Fig. 8. Steeply-dipping, tabular cross-bedded fluvial quartzites of the uppermost Peninsula Formation, quarry site on Farm 717, 0.5 km northwest of Rosenhof Farmstead (Loc. 603).

Fig. 9. Smoothed and polished Peninsula Formation quartzite outcrop on Kakebeensbosch Farm 678 (Loc. 196a).

Fig. 10. Small trench exposure of dark grey, cleaved mudrocks of the Cederberg Formation near Rosenhof, Farm 717 (Loc. 607).

Fig. 11. Thick ferricrete gravels mantling the Cederberg Formation outcrop area on Farm Karkerbeenbosch 677 (Loc. 595) (Hammer = 29 cm).

Fig. 12. Highly weathered, steeply-dipping, cross-bedded and laminate quartzites of the Goudini Formation, smaller quarry northwest of Rosenhof, Farm 717.

Fig. 13. Quarry face into deeply weathered Table Mountain Group rocks (probably Skurweberg Formation) on Farm Ou Driefontein 721 (Loc. 579) showing recumbent folding and pinching out of dark grey mudrock interbeds.

Fig. 14. Steeply dipping, highly weathered quartzites of the Baviaanskloof Formation just west of the Kromrivier gorge, Farm Diep Rivier's Mond 358 (Loc. 594). Note rubbly ferruginous gravels overlying the truncated beds here.

The **Cederberg Formation** of Latest Ordovician (Hirnantian) age is a thin, coarsening-upwards succession of mudrocks, siltstones and sandstones that was deposited within shallowing, frigid post-glacial seas following a short-lived, multiple Gondwana glacial event. The Cederberg rocks are generally recessive-weathering and poorly-exposed; pervasive cleavage formation may be expected in the Port Elizabeth sheet area. Dark, carbonaceous, finely-laminated shales with occasional dropstones typify the lower part of the succession.

Glacial rocks (sandy, muddy and pebbly diamictites) of the **Pakhuis Formation** that occur directly below the Cederberg mudrocks in the Western Cape are not separately mapped in the study area. However, Toerien and Hill (1989) mention sporadically-developed glacial diamictites within the lower part of the "Cederberg Formation" (technically Winterhoek Subgroup) outcrop area in the Humansdorp District. They are exposed, for example, on the banks of the Kouga River. There is therefore a possibility that Pakhuis sediments occur within the Tsitsikamma study area (*e.g.* along incised river banks); any such exposures would be of geological rather than palaeontological interest.

The narrow outcrop areas of the Cederberg Formation in the Tsitsikamma study region are generally obscured by drift deposits. These include thick (several meters) of ferricretised gravels that are exposed on both side of the dust road on Farm Karkerbeenbosch 677 (Loc. 595, Fig. 11). The gravels are capped by brown loamy soils with occasional quartzite float blocks. No fresh exposures of Cederberg Formation mudrocks are seen here but these are temporarily exposed in a deep trench near the main quarry northwest of Rosenhof (Loc. 607). Here a stream valley follows the narrow, NW-SE trending outcrop area of the Cederberg Formation which is largely mantled with rubbly stream alluvium and soils. The lower Cederberg Formation mudrocks are dark grey, thinly laminated, micaceous and highly cleaved (Fig. 10).

The **Goudini Formation** (Sg) consists predominantly of quartzose sandstones, frequently cross-bedded, that characteristically display reddish to brownish tints due to higher levels of iron and / or manganese impurities compared with the purer underlying and overlying Peninsula and Skurweberg Formations. Sandstone beds are generally thinner, and heterolithic successions (*i.e.* interbedded sandstones and mudrocks) commoner, than in the overlying Skurweberg Formation. Consequently exposures of the Goudini rocks are more recessive weathering. The mudrocks, which are often reddish in colour, are rarely exposed. In the Western Cape at least, occasional trace fossil assemblages within the Goudini Formation suggest intermittent marine influence but the bulk of the succession is probably fluvial in origin.

Deeply weathered, leached, friable quartzites and sandstones of the Goudini Formation are exposed in the smaller of two quarries 0.5 km northeast of Rosenhof (Farm 717) (Fig. 12, Loc. 604). These beds shortly overlie the outcrop area of the Cederberg Formation.

The **Skurweberg Formation** (Ss) is dominated by very pale, resistant-weathering sandstones and quartzites that typically show well-developed unidirectional (current) cross-bedding and sometimes thin quartz pebble lenticles (These last far less common in the Eastern than Western cape outcrops). Bedding is often thick (thicknesses of one or more meters are common) and although thin, lenticular, dark mudrock intervals also occur, these are rarely exposed at outcrop. Sedimentological features within this formation indicate deposition across an extensive sandy alluvial braidplain.

A sizeable, deep quarry on the edge of a stream valley on Ou Driefontein 721 (Loc. 579) is excavated into Table Mountain Group quarzites of uncertain stratigraphic position, probably the Skurweberg Formation (Fig. 13). Notable here is the deep weathering of the quartzites, which are very pale, locally ferruginised, and crumbly due to leaching, as well as the high levels of tectonic deformation. The latter is picked out by recumbent folds in the quartzites and intermittently thickened or pinched-out grey mudrock interbeds, as well as by extensive quartz veining.

The **Baviaanskloof Formation** (S-Db) is typically less clean-washed than the older subunits of the Nardouw Subgroup, giving darker hues and more recessive weathering patterns. Sandstones are often (but not invariably) greyish, impure wackes and may be massive or ripple cross-laminated. Dark grey to black carbonaceous and micaceous mudrock intervals are quite common but rarely well exposed (A *c.* 15m-thick band of micaceous shale within the upper Baviaanskloof Formation in the Gamtoos area is mentioned by Haughton *et al*., 1937, for example). The heterolithic "passage beds" of the Baviaanskloof Formation incorporate the sedimentary transition between the fluvial-dominated lower units of the Nardouw Subgroup and the marine shelf sediments of the Lower Bokkeveld Group (Fig. 4). Locally abundant shelly fossils such as articulate brachiopods, trace fossils as well as wave ripple lamination demonstrate the shallow marine origins of at least some of the upper sandstones, while the dark mudrocks with dense mats of vascular plant remains may be lagoonal in origin (See Section 3).

Steeply dipping, subvertical to overturned beds of the Baviaanskloof Formation are exposed in road cuttings on Farm Diep Rivier's Mond 358, just west of the Kromrivier river gorge (Loc. 594, Fig. 14). Here thin- to thick-bedded, tabular, well-jointed grey quartzites show well-developed tabular and small scale cross bedding / lamination, with occasional overturned cross-sets due to dewatering soon after deposition. As a result of high levels of weathering and attendant secondary mineralisation the quartzites of locally friable and stained to give buff, ochreous and reddish hues. The truncated tops of the steeply inclined TMG beds and intervening gullies are overlain by up to a meter or more of poorly sorted, rubbly, downwasted surface gravels of angular quartzitic, ferruginised clasts.

2.3. Lower Bokkeveld Group

The lower **Bokkeveld Group** (= **Ceres Subgroup**) – represented here only by the **Gydo Formation** (Dg) - is a thick succession of fine- to medium-grained sedimentary rocks that were laid down in a range of shallow to moderately deep continental shelf environments during the Early to Middle Devonian Period (*c*. 140 to 390 Ma, *i.e*. Emsian to Eifelian; Ma = million years ago). Throughout this period of deposition the Cape Basin was situated at high palaeolatitudes (over 70º S) and was gradually approaching the southern palaeopole. In the eastern outcrop area of the Bokkeveld Group, near Port Elizabeth, it reaches a total thickness of *c*. 3.5km. Precise figures are difficult to obtain due to tectonic thickening and reduplication (folding, thrust faulting *etc*) as well as generally poor exposure. Key geological references for the Bokkeveld Group succession include Tankard and Barwis (1982), Theron and Loock (1988), Hiller and Theron (1988), as well as Theron and Johnson (1991), Broquet (1992), Thamm & Johnson (2006). Brief accounts of the Bokkeveld Group in the Port Elizabeth region have been given recently by Toerien and Hill (1989), and Le Roux (2000).

The rocks forming the Bokkeveld Group are predominantly fine-grained mudrocks – *claystones* formed from soft muds (mainly clay minerals) and *siltstones* formed from slightly larger, silt-sized particles including small quartz grains and micas. Extensive fresh outcrops are rare due to post-Gondwana weathering as well as drift (scree, soil *etc*) and vegetation cover. Sandstone-dominated successions with total thicknesses in the range of 50-100m also occur and are sometimes mapped as separate formations. The Ceres Subgroup has accordingly been subdivided into a series of six laterally persistent formations, alternately dominated by mudrocks and sandstones. However, with the exception of the basal **Gydo Formation** (Dg) with an estimated thickness of some 500m, these formations are generally grouped together as a single stratigraphic unit (Dc) on the published 1: 250 000 geology map of the Port Elizabeth region, due to poor exposure and locally intense folding towards the eastern end of the Cape Fold Belt (Toerien and Hill 1989). The clay-rich sediments of the lower Bokkeveld Group have often suffered extensive cleavage formation in the Humansdorp area (Haughton *et al.* 1937) and deep Tertiary-age chemical weathering is also likely here.

The Bokkeveld sandstones are typically thin-bedded (dm scale to 50 cm or more), poorly-sorted by grain-size, and compositionally "impure"; *i.e.* they contain a small proportion of clay or mica minerals, tiny rock fragments (*lithic* grains), and feldspar in addition to the dominant mineral quartz. The technical term for quartz sandstones that contain over 15% of other (non-quartz) grain types is *wackes*, in contrast to purer quartz sandstones (> 85% quartz) such as those of the Table Mountain Group which are called *arenites*. The readily decomposed impurities give the Bokkeveld sandstones / wackes slightly darker, buff to brownish colours and a more friable or crumbly texture than pure sandstones or quartzites. Due to their higher clay and mica content the former are also more likely to develop a pronounced cleavage as a result of tectonic deformation than are purer sandstones, and are therefore more prone to weathering. Quartz cements are less well developed in the impure Bokkeveld sandstones than in the Table Mountain Group arenites, though true, tough-weathering quartzites do occasionally occur in the Bokkeveld Group.

The Bokkeveld Group rocks in the study region are very poorly exposed, mainly due to deep weathering and ready erosion of these mudrock-dominated successions. Highly cleaved, deeply weathered, multi-hued Bokkeveld Group saprolites are exposed in road cuttings just east of the Impofu Dam (Locs. 592, 593, Fig. 15). The original bedding orientation is usually very difficult to discern. The Bokkeveld saprolite is overlain by about one meter of ferricrete gravels and greyish silty soils.

Fig. 15. Multihued, cleaved Bokkeveld Group saprolite in road cutting just east of the Impofu Dam, overlain by ferricrete gravels and brown silty soils (Loc. 592) (Hammer = 29 cm).

2.4. Algoa Group

The coastal belt to the southwest of Humansdorp is overlain by discrete patches of unconsolidated Holocene aeolian sands of the **Schelm Hoek Formation** (Qw). A large proportion the modern dunes are heavily vegetated with small unvegetated areas clearly visible as pale patches on satellite images. Inland, on the higher ground, the modern aeolianites overlie older (Plio-Pleistocene) palaeodune sands of the **Nanaga Formation** (T-Qn). East-west trending linear dunes of semi-consolidated Nanaga sands, vegetated in part, are well seen on satellite images. Both these coastal aeolianite units belong to the upper part of the Late Cenozoic **Algoa Group** (Le Roux 1990, Maud & Botha 2000, Roberts *et al*., 2006).

The coastal aeolianites (ancient or "fossil" dune sands) of the **Nanaga Formation** (T-Qn) of Pliocene to Early Pleistocene age crop out extensively to the west of Port Elizabeth (Le Roux 1992). They comprise calcareous sandstones and sandy limestones showing large scale aeolian cross-bedding and may reach thicknesses of 150m or more (Maud & Botha 2000). The Nanaga aeolianites are typically partially to well-consolidated, although unconsolidated sands also occur west of Port Elizabeth (Le Roux 2000). The upper surface of the aeolianites weathers to calcrete and red, clay-rich soil. The age of the palaeodunes decreases towards the modern coastline, reflecting marine regression (relative sea level fall) during the period of deposition. The more highly elevated, inland outcrops may even be Miocene in age (Roberts *et al*., 2006). Typically the ancient dunes are preserved as undulating ridges of rounded hills trending parallel to the modern shoreline (Le Roux 1992). These ridges are visible in satellite images of the study area.

Modern aeolian sands of the **Schelm Hoek Formation** (Qw; Le Roux 1990, Le Roux 2000, Illenberger 1992) are still-active dune sands of Holocene age (last 6500 years). They may be up to 100m thick, with an average of 30m, and extend up to 6km from the coast. In addition to unconsolidated, well-sorted, calcareous aeolian sands the Schelm Hoek Formation contains abundant shell middens of the Late Stone Age (Roberts *et al.*, 2006). Palaeosols (ancient soil

horizons) and peats are absent according to Le Roux (2000, Table 3) whereas Illenberger (1992) records the presence of fossil soils.
The Nanaga Formation ancient sand dune outcrop area in the southern part of the study region is heavily vegetated by fynbos (Fig. 16, Driefontein720/2).

A wide range of other **superficial deposits**, mostly of Quatenary to Recent age, mantle the older bedrocks within the Tsitsikamma Community WEF study area, several of which have been briefly described above. The outcrop areas of the Cape Supergroup rocks, both quartzitic and mudrock-dominated, on the coastal plateau are usually overlain by a horizon of ferruginised quartzite or mudrock surface gravels (Figs. 14, 15 & 18). Some of these gravels have been extensively mineralised by silica and iron minerals to form silcretes and ferricretes, with various intermediate forms. For example, over two metres of coarse, poorly sorted surface gravels are exposed in road cuttings on Diep Rivier's Mond 358, on the coastal plateau just east of the Kromrivier gorge (Loc. 599. Fig. 17). Here orange to buff, semi-consolidated, clast-supported breccias of angular quartzite or sandstone blocks up to 30cm are embedded in a gritty, ferruginous matrix. The blocks often show a tan-coloured siliceous patina. Subordinate well-rounded, reworked fluvial pebbles are also found here, many with a deep ferromagnesian mineral staining.

Large areas of the WEF study area are covered in brown silty to loamy soils up to several meters thick (*e.g.* Loc. 598, Figs. 18 & 19). Excavations in low-lying, poorly drained areas show dark peaty soils from modern to subfossil *vlei* settings (*e.g.* Loc. 601, Farm 818).

Fig. 16. Fynbos-covered ancient dunes of the Nanaga Formation on Driefontein 720/2, looking due south.

Fig. 17. Thick, blocky ferricretised breccias in road cutting on Diep Rivier's Mond 358 (Loc. 599) (Hammer = 29 cm).

Fig. 18. Deeply-weathered Table Mountain Group saprolite overlain by orange-brown ferricrete gravels and brown silty soils (Loc. 601) (Hammer = 29 cm).

Fig. 19. Thick, brown, silty modern soils with no gravels overlying the Peninsula Formation outcrop area, roadcutting on Zalverige Valley 660/19 (Hammer = 29 cm).

3. PALAEONTOLOGICAL HERITAGE

A brief review of the fossil assemblages recorded from the various geological formations represented within the Tsitsikamma Community WEF study area is given here (GPS data for all localities mentioned in the text is provided in the Appendix). Most of these rock units are only sparsely fossiliferous to unfossiliferous. However, elsewhere in the broader Cape region diverse and scientifically important fossil assemblages have been recorded from the Cederberg and Baviaanskloof Formations of the Table Mountain Group as well as the Gydo Formation at the base of the Bokkeveld Group. The palaeontological sensitivity of all these three rock units has been seriously compromised in the Tsitsikamma Community WEF study region near Humansdorp as a result of high levels of tectonic deformation (*e.g.* cleavage formation) as well as deep chemical weathering since the fragmentation of Gondwana some 120 million years ago. Furthermore, the outcrop areas of the mudrock-rich sedimentary successions that are most likely to yield fossil remains are narrow and ill-defined, and are largely mantled in a veneer of superficial deposits such as soil, alluvium and downwasted, ferruginised gravels that shield the fossiliferous bedrocks from significant disturbance during development.

3.1. Fossils in the Table Mountain Group

Body fossils (shells, teeth, bones *etc*) are so far unknown from the **Peninsula Formation** but a modest range of shallow marine to nearshore fluvial and / or estuarine trace fossils have been recognised, mainly from the Western Cape outcrop area (*e.g.* Rust 1967, Potgieter & Oelofsen 1983, Broquet 1990, 1992, Almond 1998a,b, Braddy & Almond 1999, Thamm & Johnson 2006). These traces include trilobite resting and feeding burrows (*Cruziana*, *Rusophycus*), arthropod trackways (*e.g. Diplichnites, Palmichnium*) that are variously attributed to eurypterids, crustaceans or trilobites, palmate, annulated feeding burrows (*Arthrophycus*), dense assemblages (“pipe rock”) of vertical dwelling burrows of unknown suspension feeders (*Skolithos, Trichichnus*), vertical columns or cones of densely reworked sediment (*Metaichna* / possible *Heimdallia*), and several types of horizontal burrows

(*Palaeophycus,* possible *Aulichnites*). Recessive weathering of trace-rich heterolithic intervals is undoubtedly responsible for under-recording of fossils within the Peninsula Formation. It is likely that relatively unweathered samples of fine-grained muddy sediments within these heterolithic intervals may eventually yield microfossil assemblages (*e.g.* organic-walled acritarchs) of biostratigraphic and palaeonvironmental significance.

For the most part, Peninsula Formation arenites in the Tsitsikamma Community WEF study area are highly weathered while heterolithic successions rich in mudrock interbeds are not exposed at surface. Unusually abundant, low diversity trace fossil assemblages are present, however, in the uppermost Peninsula Formation quarry exposures near Rosenhof farmstead (Farm 717, Locs. 602 - 603, just outside the WEF study area). Trace fossils are preserved here on upper and lower bedding plane surfaces, as well as within beds, of quartzites and thin siltstone interbeds. Numerous blocks of rock that have recently been excavated from the quarry to build a causeway as well as rock faces within the quarry itself display interesting trace fossil rich horizons. Levels of bioturbation (sediment mixing) by infaunal invertebrates was very high at some levels. Similar trace-rich beds have not been recorded from the uppermost Peninsula Formation in its western outcrop area, where these beds form part of the well-known "Fold Zone" beneath the Pakhuis Formation.

Trace fossils recorded from the Rosenhof quarry site include:

- Vertical cylindrical burrows of the *Skolithos* ichnofacies cm wide (so called "Pipe rock"; *cf* Almond 1998a, 1998b) (Fig. 20). Some of these burrows may be simple *Skolithos* tube dwellings of filter-feeders. Others probably form part of the more complex "gyrophyllitid" burrow systems listed below. A convex-upwards meniscate back-fill maybe present in some cases. In cross-section some of the tube burrows have a thick outer mantle and a narrow, softer-weathering core. Burrows traversing mudrock interbeds are sand infilled and secondarily ferruginised.
- Rare bilobate scratch burrow of the ichnogenus *Rusophycus* preserved as negative epichnia (Fig. 24). These were probably generated by trilobites or other arthropods.
- Bilobate, trough- or tunnel-shaped feeding traces of the ichnogenus *Cruziana*, also attributed to trilobites (Fig. 23, A). The burrows are straight to gently curved, with a median ventral furrow and transverse to oblique scratch marks.
- Possible biconvex *Lockeia* burrows generated by infaunal bivalves (dwelling or escape burrows).
- Abundant flower-shaped "gyrophyllitids" (*cf* Seilacher 2007, pp. 136-137) with a central vertical tubular burrow from the top of which radiate numerous flattened, petaloid or tubular structures within the bedding plane (Figs. 21-22). The tubes penetrate through laminated quartzites while the upper, horizontal petaloid portion is developed on sandstone or siltstone interfaces. The precise geometry and systematic status of these traces are currently uncertain. The may well be intrastratal burrows and totally bioturbate some horizons. Affinities with the asterosomids (*cf Asterosoma radiciforme* in Seilacher 2007, pp. 134-135) also need to be considered. The "gyrophyllitid" burrows have been previously observed in sandstone beach boulders of probable Peninsula Formation arenites near Cape St Francis (Tom Barry, pers. comm.), some 33 km southeast of the Rosenhof quarry occurrences, but have never been formally described. To the authors knowledge, this is the first time they have been recorded *in situ* within the Table Mountain Group.
- Horizontal, straight to gently curved burrows up to 4cm across showing an imbricate substructure (Fig. 23, B). These are possibly teichichoid spreiten burrows or somehow related to the associated cruzianaeform burrows.

The Rosenhof quarry trace fossil assemblages are unusual in terms of their stratigraphic position (uppermost Peninsula Formation) and taxonomic composition, notably the highly abundant "gyrophyllitid" burrow systems. They certainly warrant formal palaeontological study and sampling in future, including analysis of their palaoecological setting (perhaps marginal marine to estuarine) within the context of the predominantly fluvial Peninsula Formation.

Fig. 20. Widely-spaced vertical cyclindrical burrows with a darker infill penetrating cryptically laminated grey quartzites, upper Peninsula Formation Rosenhof (Loc. 602) (Scale *c*. 16 cm long). These are probably underlying components of the "gyrophyllitid" burrow systems illustrated below.

Fig. 21. Quartzite bedding plane covered with radiating tubular systems of gyrophyllitid-type burrows (Loc. 602) (See next figure for detail) (Scale = *c.* 16 cm).

Fig. 22. Detail of highly-bioturbated bedding plane shown above. The positive-weathering "petals" of the burrow systems radiate from a cm-wide central tube.

Fig. 23. Sole surface of a quartzite bed showing large, straight to curved horizontal burrows (Loc. 602). Some of these (A) are bilobate and probably belong to the arthropod ichnogenus *Cruziana*. Others (B) show a substructure of imbricated sediment wedges. Hammer = 29 cm.

Fig. 24. Bilobate arthropod resting or feeding scratch burrow of the ichnogenus *Rusophycus* preserved in negative relief on a quartzite upper bedding plane (Scale in cm).

Apart from vague meniscate backfilled burrows from late glacial or postglacial dropstone argillites in the Hex River Valley, no fossil remains have been described from the **Pakhuis Formation** (Almond 2008).

An exceptionally important and interesting biota of soft-bodied (*i.e.* unmineralised) and shelly invertebrates, primitive jawless vertebrates and microfossils has been recorded since the middle 1970s from finely laminated, black mudrocks of the **Soom Member**, forming the lower, mudrock-dominated portion of the **Cederberg Formation**. This is one of only two so-called soft-body *Lagerstaette* of Late Ordovician age recorded worldwide (the other example was recently discovered in Canada; Young *et al.,* 2007). The "Soom Shale" is between 10-15m thick, and fossils occur sporadically throughout the succession, from 1m above the base upwards. This biota has been extensively reviewed by Aldridge *et al*. (1994, 2001) and Selden and Nudds (2004) while much new information remains to be published (See review in Almond 2008 and refs. therein). The macrofossils include a range of macroalgae, shelly invertebrates (*e.g.* inarticulate brachiopods, conical-shelled nautiloids and other molluscs, crustaceans, unmineralised trilobites and eurypterids or "water scorpions") and several groups of primitive jawless fish (*e.g.* anaspids, conodonts). Important microfossil groups include chitinozoans, spore tetrads of land plants and marine acritarchs. A further interesting category of fossils recorded from the Soom Member of Kromrivier are bromalites. These are the various fossilised products of ancient animal guts such as droppings (coprolites), regurgitates and stomach contents that sometimes contain the comminuted remains of recognisable prey animals such as conodonts or brachiopods (Aldridge *et al*., 2006). The majority of Soom fossils have been collected from a handful of localities, most of which lie on the Clanwilliam sheet within the central to northern Cederberg (Gray *et al*. 1986, Cocks & Fortey 1986, Theron *et al*. 1990, Aldridge *et al*. 1995). New fossiliferous localities have recently been identified in the Clanwilliam area, while well preserved trilobite trace fossils (*Rusophycus*) have been collected from thin tempestite sandstones towards the base of the Soom Member in the Hex River Mountains by Almond (unpublished obs., 2011).

A low diversity shelly faunule, dominated by articulate and inarticulate brachiopods together with a small range of trace fossils is recorded from the heterolithic **Disa Member** that forms the upper portion of the Cederberg Formation. Marine invertebrate fossils have been recorded from the Disa Member in the Groot Winterkoek mountains near Porterville, some 30km southeast of Piketberg, while important post-glacial trace fossil assemblages are known from the Clanwilliam region (Rust 1967b, Cocks *et al.* 1970, Cocks & Fortey 1986, Almond 2008).

The potentially fossiliferous beds of the Cederberg Formation are almost nowhere exposed within the Tsitsikamma Community WEF study area. Where dark mudrocks are seen (*e.g.* Loc. 607, Fig. 10, near Rosenhof) they are too cleaved and weathered to yield recognisable fossils, although some microfossils may still remain here.

The fossil record of the **Goudini** and **Skurweberg Formations**, dominated by braided fluvial sandstones, is very sparse indeed. This reflects major global regression (low sea levels) during the Silurian Period, peaking during the latter part of the period (Cooper 1986). Sporadic, low diversity ichnoassemblages from thin, marine-influenced stratigraphic intervals have been recorded from all three Nardouw formations in the Western Cape by Rust (1967a, 1981) and Marchant (1974). There are also scattered, often vague reports of trace fossils in geological sheet explanations and SACS reports (*e.g.* Malan *et al.* 1989, De Beer *et al.* 2002). Most involve "pipe rock" (*Skolithos* ichnofacies) or various forms of horizontal epichnial burrows, including possible members of the *Scolicia* group which may be attributable to gastropods. Also recorded are typical Early Silurian palmate forms of the annulated burrow *Arthrophycus*, poorly preserved "bilobites" (bilobed arthropod scratch burrows), gently curved epichnial furrows and possible arthropod tracks (Almond 2008). It is possible that more diverse ichnoassemblages (and even microfossils from subordinate mudrock facies where these have not been deeply weathered or tectonised) may eventually be recorded from the more marine-influenced outcrops of the Eastern Cape Fold Belt.

A distinctive marine shelly invertebrate faunule of Early Devonian, Malvinokaffric aspect characterises the upper portion of the **Baviaanskloof Formation** from the Little Karoo eastwards along the Cape Fold Belt. It is dominated by the globose, finely-ribbed articulate brachiopod *Pleurothyrella africana*. Rare homalonotid trilobites, a small range of articulate and inarticulate brachiopods, nuculid and other bivalves, plectonotid "gasteropods" and bryozoans also occur within impure brownish-weathering wackes (Boucot *et al*. 1963, Rossouw *et al*. 1964, Johnson 1976, Toerien & Hill 1989, Hill 1991, Theron *et al.* 1991, Almond *in* Rubidge *et al*. 2008). In many cases fossil shells are scattered and disarticulated, but *in situ* clumps of pleurothyrellid brachiopods also occur. This shelly assemblage establishes an Early Devonian (Pragian / Emsian) age for the uppermost Nardouw Subgroup, based on the mutationellid brachiopod *Pleurothyrella* (Boucot *et al*. 1963, Theron 1972, Hiller & Theron 1988). Trace fossils include locally abundant, mud-lined burrows (*Palaeophycus*, *Rosselia*) and rare giant rusophycid burrows of Devonian aspect (*R. rhenanus*) that are attributed to homalonotid trilobites. Recently, dense assemblages of primitive vascular plants with forked axes and conical terminal "sporangia" that are provisionally ascribed to the genus *Dutoitia* have been collected from Baviaanskloof Formation mudrocks near Cape St Francis, Eastern Cape (Dr Mark Goedhart, Council for Geoscience, Port Elizabeth, pers. comm., 2008; Robert Gess pers. comm., 2011; *cf* Hoeg 1930, Anderson & Anderson 1985).

With the exception of the uppermost Peninsula Formation trace fossil assemblages described earlier, no body or trace fossils were observed within the Table Mountain Group rocks within the Tsitsikamma Community WEF study area. Apart from low exposure levels, this is probably due to high levels of bedrock weathering beneath the coastal plateau.

3.2. Fossils in the Lower Bokkeveld Group (Ceres Subgroup)

The most important fossil groups recorded from the lower Bokkeveld Group (Ceres Subgroup) include shelly marine invertebrates and traces (burrows *etc*), together with rare fish remains, primitive vascular plants, trace fossils (burrows, borings *etc*) and microfossils (*e.g.* foraminiferans, ostracods, palynomorphs). The overall palaeontological sensitivity of this stratigraphic unit is generally considered to be high to very high (Almond *et al*. 2008), but may be compromised locally by cleavage and weathering (*cf* Haughton *et al.* 1937, p. 23).

The Lower Bokkeveld Group is especially well known for its rich fossil assemblages of **marine invertebrates** of Early to Mid-Devonian age. The main invertebrate taxa concerned are trilobites, brachiopods, molluscs and echinoderms. Numerous more minor groups are also recorded - corals, conulariids, hyolithids, tentaculitids *etc* - making the Bokkeveld Group one of the palaeontologically most important Devonian units in the southern hemisphere. Fossil invertebrates are especially diverse and abundant within the mudrock-dominated formations, although low-diversity sandstone-hosted fossils assemblages also occur. Shells are generally preserved as external and internal moulds and casts (*e.g.* Schwarz 1906, Reed 1925, Du Toit 1954, Cooper 1982, Oosthuizen 1984, Hiller 1995, Hiller & Theron 1988, Theron & Johnson 1991, Jell & Theron 1999, Thamm & Johnson 2006, Almond 2008). Remarkably rich marine trace fossil assemblages are also known from the lower Bokkeveld Group, especially in nearshore facies (Almond 1998a, 1998b).

The only **vascular plants** recorded from the Ceres Subgroup are a small range of dichotomously branching, leafless forms known as psilophytes (*e.g. Dutoitia*) and primitive lycopods or "club mosses" such as *Palaeostigma*. The material is generally transported (washed offshore from the land), poorly preserved, and has mainly been recorded from the eastern outcrop area of the Bokkeveld Group (Plumstead 1967, 1969, Theron 1972, Anderson and Anderson 1985).

Very sparse **fossil fish** remains have been recorded from the Ceres Subgroup (Gydo and Tra Tra Formations), several retaining their original phosphatic bony material. They comprise acanthodians ("spiny sharks"), primitive sharks, placoderms, and bony fish or osteichthyans, but so far no agnathans (Almond 1997, Anderson *et al*. 1999a, 1999b). The material is fragmentary but of considerable palaeontological significance since so little is known about Early Devonian ichthyofaunas of the ancient supercontinent Gondwana.

So far, the great majority of published records of fossils from the Ceres Group refer to the much better known western outcrop areas in the Western Cape. In the Eastern Cape Province, where the potentially fossiliferous mudrocks are frequently highly deformed, cleaved, and often deeply weathered or covered by dense vegetation, the fossil known record is still rather sparse and understudied. Most of the early geological mapping surveys revealed very few useful fossil records – essentially a scattering of poorly preserved, often deformed marine shells and locally abundant trace fossils (*e.g.* Haughton 1928, 1935, Haughton *et al*., 1937, Engelbrecht *et al*., 1962). Apart from probable records of the primitive vascular plant *Dutoitea*, most early records of plant material and arthropods from the Bokkeveld Group in the Eastern Cape (such as those from near Port Alfred) are probably more correctly assigned to the younger lower Witteberg Group (*e.g.* Anderson & Anderson 1985).

Within the western part of the Eastern Cape Province, only a handful of productive fossil localities within the Ceres Subgroup have been recorded so far. Most notably, these include the Cockscomb area between Willowmore and Steytlerville, Klein Kaba near Alexandria, and the Uitenhage North area (*e.g.* Theron 1972, Johnson 1976, Hiller 1980, Oosthuizen 1984, Toerien & Hill 1989, Le Roux 2000). As is the case to the west, shelly fossils are most abundant in the mudrock-dominated formations, including the Gydo, Voorstehoek and Tra Tra Formations. Indeed, the Voorstehoek Formation in the Eastern Cape may prove quite productive, although the assignation of some faunal records to this unit requires confirmation (*e.g.* Hiller 1980, Oosthuizen 1984, Hiller 1990). Useful faunal lists for the rich Gydo Formation biota at the Cockscomb Mountains and the unconfirmed Voorstehoek Formation biota at Klein Kaba are given by Oosthuizen (1984, Table III and p.138 respectively). The Cockcomb biota is preserved as moulds within early diagenetic nodules of phosphatic or other composition (*cf* Browning 2008). It includes a wide range of trilobites, brachiopods, bivalves, gastropods, crinoids, a possible echinoid, corals, abundant well-preserved conulariids, ostracods and various problematic groups (*e.g.* hyolithids, tentaculitids and other tubular fossils). The Klein Kaba faunule listed by Oosthuizen (1984) is dominated by a number of articulate brachiopods, but also comprises gastropods, bivalves, nautiloids, trilobites , crinoids, conulariids, various tubular fossils and traces.

The mudrock-dominated Bokkeveld Group sediments within the Tsitiskamma WEF study area are very poorly exposed, and where visible are deeply weathered and cleaved (e.g. Fig. 15). The likelihood of useful fossil material being preserved under these circumstances is very low.

3.3. Fossils in the Algoa Group

The sparse palaeontological record of the Pliocene to Early Pleistocene **Nanaga Formation** is summarised by Le Roux (1992) and Almond (2010). The fossil biota consists of fragmentary marine shells, foraminifera (shelled protozoans *cf* McMillan 1990), and a small range of terrestrial snails (*e.g. Achatina / Cochliostoma, Tropidophora, Trigonephrus, Natalina*). Dense arrays of calcretised rhizoliths (root casts) commonly occur in these and contemporary Plio-Pleistocene aeolianites along the southern and southwestern coast (Roberts *et al*., 2009); spectacular arrays of *megarhizoliths* were recorded from the Nanaga Formation of the Coega area, Eastern Cape by Almond (2010), for example. A wider range of terrestrial fossils might be found here in future, albeit only rarely due to extensive post-depositional diagenesis (*e.g.* solution and repreciptation of carbonate by groundwater). They might include mammal remains from hyaena lairs, such as are recorded from contemporary Langebaan Formation aeolianites in the SW Cape (Roberts *et al.*, 2006 and refs therein).

The modern coastal aeolianites of the **Schelm Hoek Formation** are generally unfossiliferous to sparsely fossiliferous. However, local concentrations of a wide range of Holocene palaeontological material may occasionally be found here (Engelbrecht *et al*., 1962, Illenberger 1992, Le Roux 2000, Roberts 2006, Almond 2010. See especially the useful summary by Pether 2008). These include, for example, mammal bones and teeth (*e.g.* in hyaena dens, burrows), tortoise remains, ostrich egg shell, terrestrial snails (*e.g.* the dune snails *Achatina*, *Trigonephrus*), comminuted shell debris (molluscs, echinoid spines, calcareous algae), plant remains (charcoal, rootlets, peats), trace fossils (*e.g.* burrows, mammalian footprints, Stone Age tools), and various groups of microfossils (foraminiferans, pollens, spores). Vertebrate fossils are rare; elephant tusks have been recorded from dunes to the west of Port Elizabeth (Le Roux 2000). In anthropogenic shell middens mollusc taxa such as the edible white mussel *Donax* predominate.

No fossils were recorded from the Algoa Group sediments in the Tsitsikamma WEF study area during the present field assessment. These rocks are poorly exposed and lie outside the likely development footprint.

3.4. Fossils within other Caenozoic superficial deposits

Sparse fossil remains have been recorded from Tertiary or younger silcretes (*i.e.* silica-cemented pedocretes) of the Grahamstown and equivalent formations by Roberts (2003) and earlier authors. These include a small range of trace fossils (*e.g.* rhizoliths or plant root casts and invertebrate burrows such as *Skolithos*), charophyte algae (calcareous stoneworts), reed-like wetland plants resembling the extant *Phragmites* (*fluitjiesriet*), and reworked Late Permian silicified wood from the Beaufort Group (See also Adamson 1934, Du Toit 1954, and Roberts *et al.,* 1997). Silicified termitaria might also be expected here, although termite activity is inhibited by waterlogged soils that probably prevailed in areas where silcrete formation occured.

Neogene to Recent alluvial deposits may also contain fossil remains of various types. In coarser sediments (*e.g.* conglomerates) these tend to be robust, highly disarticulated and abraded (*e.g*. rolled bones, teeth of vertebrates) but well-preserved skeletal remains of plants (*e.g.* wood, roots) and invertebrate animals (*e.g.* freshwater molluscs and crustaceans) as well various trace fossils may be found within fine-grained alluvium. Human artefacts such as stone tools that can be assigned to a specific interval of the archaeological time scale (*e.g.*

Middle Stone Age) can be of value for constraining the age of Pleistocene to Recent drift deposits like alluvial terraces. Ancient alluvial "High Level Gravels" tend to be coarse and to have suffered extensive reworking (*e.g.* winnowing and erosional downwasting), so they are generally unlikely to contain useful fossils.

No fossils were recorded from various types of superficial sediments represented within the Tsitsikamma WEF study area during the present field assessment. Dark, carbonaceous vlei mudrocks adjacent to a dam of Farm 818 (Loc. 601) may contain wetland plant subfossils and palynomorphs that may be of palaeoecological interest.

4. ASSESSMENT OF IMPACTS ON FOSSIL HERITAGE

The proposed Tsitsikamma Community Wind Energy Facility is located in an area of the southern Cape coastal plain that is underlain by a number of geological formations of Palaeozoic to Late Caenozoic age, three of which are known to contain important fossil heritage resources elsewhere in the Cape region, *viz*. the Cederberg, Baviaanskloof and Gydo Formations. The most sensitive sectors of the study area from a palaeontological viewpoint are located in the central and northeastern regions, as shown on the geological map Fig. 5 above. It is noted that the outcrop areas of the three formations are both narrow and ill-defined (schematic) on the available 1: 250 000 geological maps, as well as unclear on satellite images of the region.

The construction phase of the development will entail substantial excavations into the superficial sediment cover (soils *etc*) and perhaps also into the underlying bedrock. These notably include excavations for the wind turbine and transmission line pylon foundations, buried cables, new internal access roads and foundations for associated infratructure such as a substation and workshop / administration building. In addition, sizeable areas of potentially fossiliferous bedrock may be sealed-in or sterilized by infrastructure such as hard standing areas for each wind turbine, lay down areas and access roads. All these developments may adversely affect potential fossil heritage within the study area by damaging, destroying, disturbing or permanently sealing-in fossils that are then no longer available for scientific research or other public good.

Once constructed, the operational and decommissioning phases of the wind energy facility will not involve further adverse impacts on palaeontological heritage, however.

The inferred impact of the proposed wind farm development on local fossil heritage is analysed in Table 1 below, based on the system developed by Savannah Environmental (Pty) Ltd.

In general, the destruction, damage or disturbance out of context of fossils preserved at the ground surface or below ground that may occur during construction represents a *negative* impact that is limited to the development footprint. Such impacts can usually be mitigated but cannot be fully rectified (*i.e. permanent*). Because of the generally sparse occurrence of fossils within most of the formations concerned as well as within the overlying superficial sediments (soil *etc*), as inferred from better exposed localities elsewhere, the magnitude and probability of impacts are conservatively rated as *low*.

Due to the high to very high levels of bedrock weathering and tectonic deformation observed within and close to the Tsitsikamma WEF study area, the impact significance of the construction phase of the proposed wind farm project is assessed as LOW. Recorded fossil sites here lie outside the development area. There are no fatal flaws in the development proposal as far as fossil heritage is concerned. Alternative sites or site plans are not under consideration at this stage.

It should be noted that should fossils be discovered before or during construction and reported by the responsible ECO to the responsible heritage management authority (SAHRA) for professional recording and collection, as recommended here, the overall impact significance of the project would remain LOW. Residual negative impacts from loss of fossil heritage would be partially offset by an improved palaeontological database as a direct result of appropriate mitigation. This is a *positive* outcome because any new, well-recorded and suitably curated fossil material from this palaeontologically under-recorded region would constitute a useful addition to our scientific understanding of the fossil heritage here.

Despite the low levels of bedrock exposure within the study area, confidence levels for this assessment are HIGH following the two-day field assessment of representative geological sites.

4.1. Comparative assessment of alternative 132 kV transmission line routes

A brief desktop assessment of the palaeontological heritage impact of the various alternative routes for the 132 kV powerline connecting the Tsitsikamma Community WEF with existing substations at Dieprivier, along the R62, or at Melkhout, north of Humansdorp, is given here (See Fig. 1). This assessment is based on experience with the relevant rock units obtained during the present field assessment as well as other impact studies in the region (*e.g.* Almond 2010a, 2011a).

Option A (yellow line in Fig. 1) crosses the eastern tip of the Kareedouwberge range that is mainly built of highly folded Table Mountain Group rocks. A short final sector near Dieprivier Substation may impact potentially fossiliferous marine rocks of the Gydo Formation (Bokkeveld Group) but these are likely to be highly cleaved and weathered along the core of a narrow syncline here. The impact significance of this route is rated as LOW, with no specialist mitigation recommended.

Option B (purple line in Fig. 1) is entirely underlain by mudrocks of the Bokkeveld Group along the south side of the N2 between the Tsitsikamma Community WEF and Humansdorp. The present field study shows that these sediments and highly deformed, cleaved and deeply weathered so their palaeontological sensitivity is now very low. The impact significance of this route is rated as LOW, with no specialist mitigation recommended.

Option C (pink line in Fig. 1) has a western NW-SE sector that runs over sediments of the upper Table Mountain Group and an eastern SW-NE sector terminating at Humansdorp that traverses the outcrop area of the Bokkeveld Group. As indicated by the present field study, as well as a previous desktop study by Almond (2011a) in the region to the southwest of Humansdorp, the palaeontological sensitivity of all these rocks is rates as low. The impact significance of this route is rated as LOW, with no specialist mitigation recommended.

Options B&C (blue-green line in Fig. 1) refers to a short transmission line sector between Humansdorp and the Melkhout Substation to the north of town. This sector is largely underlain by fluvial sediments of the Skurweberg Formation (Table Mountain Group) that are of low palaeontological sensitivity (*cf* also impact assessment for this area by Almond 2010a). The impact significance of this route is rated as LOW, with no specialist mitigation recommended.

In conclusion, all the alternative route options for the 132 kV transmission line are of low palaeontological heritage significance, and there is no preference for one or other route on fossil heritage grounds. Furthermore, no further specialist studies or mitigation for the transmission line component of the Tsitsikamma Community WEF are recommended. This evaluation is included in the overall impact assessment of the project given in Table 1 below.

Table 1: Assessment of impacts of the proposed Tsitsikamma wind energy facility (including alternative 132 kV transmission line routes) on fossil heritage resources during the construction phase of the development (*N.B.* Significant impacts are not anticipated during the operational and decommissioning phases).

Nature of impact: Disturbance, damage, destruction or sealing-in of fossil remains preserved on or beneath the ground surface within the development area, notably by bedrock excavations during the construction phase of the wind energy facility.		
	Without mitigation	**With mitigation**
Extent	Local (1)	Local (1)
Duration	Permanent (5)	Permanent (5)
Magnitude	Low (1)	Low (1)
Probability	Improbable (1)	Improbable (1)
Significance	**Low (7)**	**Low (7)**
Status	Negative	Negative (loss of fossils) & positive (improved fossil database following mitigation)
Reversibility	Irreversible	Irreversible
Irreplaceable loss of resources?	Yes	Yes
Can impacts be mitigated?	Yes	Yes.
Mitigation: Monitoring of all substantial bedrock excavations for fossil remains by ECO, with reporting of new finds to SAHRA for possible specialist mitigation.		
Cumulative impacts: Unknown (Insufficient data on local wind farm developments available)		
Residual impacts: Partially offset by *positive* impacts resulting from mitigation (*i.e.* improved palaeontological database).		

5. RECOMMENDED MITIGATION AND MANAGEMENT ACTIONS

Given the low to very low impact significance of the proposed WEF development as far as palaeontological heritage is concerned, no further specialist studies or mitigation are considered necessary for this project.

During the construction phase all substantial bedrock excavations should be monitored for fossil remains by the responsible ECO. In the case of any significant fossil finds (*e.g.* shell beds, vertebrate teeth, bones, burrows, petrified wood) during construction, these should be safeguarded - preferably *in situ* - and reported by the ECO as soon as possible to the relevant heritage management authority (SAHRA) so that any appropriate mitigation by a palaeontological specialist can be considered and implemented, at the developer's expense.

These mitigation recommendations should be incorporated into the EMP for the Tsitsikamma Community Wind Energy Facility.

Providing that the recommended mitigation measures are carried through, it is likely that any potentially negative impacts of the proposed development on local fossil resources will be substantially reduced and, furthermore, they will partially offset by the *positive* impact represented by increased understanding of the palaeontological heritage of the Humansdorp region.

Please note that

- All South African fossil heritage is protected by law (South African Heritage Resources Act, 1999) and fossils cannot be collected, damaged or disturbed without a permit from SAHRA or the relevant Provincial Heritage Resources Agency;

- The palaeontologist concerned with mitigation work will need a valid collection permit from SAHRA;

- All palaeontological specialist 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 as far as possible to the minimum standards for Phase 2 palaeontological studies currently being developed by SAHRA.

6. RECOMMENDATIONS FOR THE DRAFT ENVIRONMENTAL MANAGEMENT PLAN

The following measures for inclusion in the Environmental Management Plan for the proposed Tsitsikamma Community Wind Energy Facility development near Humansdorp are outlined below, according to the scheme developed by Savannah Environmental (Pty) Ltd. Note that the operational and decommissioning phases of the development are unlikely to have significant impacts on palaeontological heritage and no further recommendations are made in this regard.

OBJECTIVE: Safeguarding, recording and sampling of any important fossil material exposed during the construction phase of the WEF development.

Project component/s	Construction of wind turbine emplacements, buried cables, access roads, transmission pylons, substations and ancillary buildings
Potential Impact	Disturbance, damage, destruction or sealing-in of scientifically valuable fossil material embedded within bedrock or weathered-out at ground surface
Activity/risk source	Extensive bedrock excavations and surface disturbance (*e.g.* road construction, excavations for wind turbine foundations, cables *etc*)
Mitigation: Target/Objective	Recording, judicious sampling and curation of any important fossil heritage exposed during construction within Tsitsikamma development area.

Mitigation: Action/control	**Responsibility**	**Timeframe**
1. Monitoring of all bedrock excavations. Fossil finds to be safeguarded and reported to SAHRA for possible mitigation.	ECO	Construction phase
2. Recording and judicious sampling of representative as well as any exceptional fossil material from the development footprint	Professional palaeontologist assisted by ECOs	Construction phase
3. Curation of fossil specimens at an approved repository (*e.g.* museum)	Professional palaeontologist	Following mitigation
4. Final technical report on palaeontological heritage within study area	Professional palaeontologist	Following mitigation and preliminary analysis of fossil finds

Performance Indicator	Identification of any new palaeontological hotspots within broader development footprint by ECO. Cumulative acquisition of geographically and stratigraphically well-localised fossil records, samples and relevant geological data from successive subsections of the development area. Submission of interim and final technical reports to SAHRA by palaeontologist involved with any mitigation work.
Monitoring	Monitoring during construction phase of fresh bedrock exposures within development footprint by ECO and, if necessary, by professional palaeontologist.

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APPENDIX: GPS LOCALITY DATA FOR SITES LISTED IN TEXT

All GPS readings were taken in the field using a hand-held Garmin GPSmap 60CSx instrument. The datum used is WGS 84.

LOCALITY NO.	GPS READING (S, E. m amsl)
592	S34 02 27.8 E24 35 23.2 139 m
693	S34 02 25.9 E24 34 41.2 88 m
694	S34 02 24.5 E24 33 20.3 185 m
695	S34 03 21.5 E24 33 56.1 177 m
696	S34 04 18.1 E24 35 38.1 163 m
697	S34 06 50.0 E24 28 16.2 49 m
698	S34 04 50.5 E24 27 35.2 144 m
699	S34 02 22.9 E24 33 24.4 184 m
700	S34 03 51.4 E24 31 57.1 210 m
701	S34 05 00.0 E24 31 39.5 159 m
702	S34 06 04.0 E24 32 07.2 103 m
703	S34 05 59.2 E24 32 10.2 103 m
704	S34 06 03.9 E24 32 03.9 93 m
705	S34 06 03.9 E24 32 08.8 93 m
706	S34 06 02.4 E24 32 09.8 86 m
707	S34 06 02.4 E24 32 09.7 87 m

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 under the aegis of his Cape Town-based company *Natura Viva* cc. He is 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 APHAP (Association of Professional Heritage Assessment 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 wind farm 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
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***Natura Viva* cc**