11. Palaeontological

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EXECUTIVE SUMMARY

The Mossel Bay Wind Energy Project study area is largely underlain by (1) Silurian braided river deposits of the Skurweberg Formation (Table Mountain Group), (2) Early Cretaceous fluvial sediments of the Kirkwood Formation (Uitenhage Group), and (3) a range of duricrusts (cemented soils and gravels) and poorly consolidated superficial deposits, most of which are probably of Tertiary age (Grahamstown Formation). The Table Mountain Group rocks underlying the higher ground are of low palaeontological sensitivity. On the southern coastal plain their limited fossil content has been largely destroyed by intense tectonic deformation in the Permo-Triassic Cape Orogeny (mountain-building event) as well as by deep chemical weathering under humid tropical climates during the Late Cretaceous to Tertiary period beneath the so-called “African Surface”. Exposures of the Kirkwood Formation that underlies lower-lying ground are very limited due to extensive cover by superficial sediments (mainly lag gravels, soils, alluvium) and vegetation. This formation has yielded important Cretaceous dinosaur remains and petrified wood elsewhere but no fossil remains were noted within the study area during the fieldwork, and there are no known records of fossils from this region in the literature. A variety of Tertiary to Quaternary duricrusts - tough, secondarily cemented superficial deposits including silica-rich silcretes and iron-rich ferricretes - are present in the study area but these are also apparently unfossiliferous.

The effective palaeontological sensitivity of the various sedimentary rocks in the study area is now low in general. It is concluded that the proposed wind energy project will have a very low impact on the limited local fossil heritage, whether at the construction stage or later. It is considered that no further palaeontological heritage studies or specialist mitigation are warranted for this alternative energy project, pending the exposure of substantial fossil remains (*e.g.* vertebrate bones and teeth, large blocks of petrified wood) during the construction phase.

The ECO responsible for the development should be alerted to the possibility of fossils being found on the surface or exposed by fresh excavations during construction. Should substantial fossil remains be discovered during construction, these should be safeguarded (preferably *in situ*) and the ECO should alert Heritage Western Cape so that appropriate mitigation (*e.g.* recording, sampling or collection) can be taken by a professional palaeontologist. The specialist involved would require a collection permit from Heritage Western Cape. Fossil material must be curated in an approved repository (*e.g.* museum or university collection) and all fieldwork and reports should meet the minimum standards for palaeontological impact studies developed by SAHRA. These recommendations should be incorporated into the EMP for the Mossel Bay Wind Energy Project.

1. INTRODUCTION & BRIEF

The company Mossel Bay Energy IPP (Pty) Ltd, P.O. Box 281, Hartenbos 6520, is proposing to develop a wind energy facility of up to 80 MW generating capacity on a site located approximately 10 km northwest of Mossel Bay and 5 km northeast of the PetroSA Refinery on the northern side of the N2 highway, Mossel Bay Municipality, Eden District Municipality, Western Cape (Figs. 1, 2). The study area of approximately 1370 ha comprises six property portions on the Farm Welbedacht 215 and Bergsig Game Farm (Bergsig Game Farm 356/0, 215/13, 353/0, 365/0 and Welbedacht 215/3, 215/15). These farms are currently used for animal husbandry and agriculture, primarily the grazing of domestic and game animals.

The main components of the proposed wind energy facility that are relevant to the present report are:

- Up to 40 wind turbines, each of 1.6 to 3 MW output;
- Concrete foundations to support the wind turbine towers;
- Internal access roads to each turbine, approximately 5 meters wide;
- Underground cables connecting the wind turbines;
- A 22/66kV electrical substation and 66kV overhead line to connect the wind farm to the existing Eskom Duinzicht substation;
- Possible upgrading of existing roads for the transportation of the turbines to the wind energy facility;
- Buildings to house the control instrumentation and backup power support, as well as a store room for the maintenance equipment.

The study area is underlain by potentially fossiliferous Palaeozoic and Mesozoic bedrocks as well as Caenozoic drift deposits. A Phase 1 combined desktop and field-based assessment of palaeontological heritage has been commissioned as part of the scoping phase of a full EIA for this project by Coastal and Environmental Services (CES), Grahamstown (Contact details: 67 African Street, Grahamstown 6139; Telephone: +27 46 622 2364; Fax: +27 46 622 6564; Website: www.cesnet.co.za; Email: info@cesnet.co.za).

1.1. Potential implications of this project for fossil heritage

The proposed wind energy facility is located in an area of the Cape Fold Belt and south coastal plain that is underlain by potentially fossiliferous sedimentary rocks of the Cape Supergroup and Uitenhage Group that are of Early Palaeozoic to Mesozoic age. The construction phase of the development will entail substantial excavations into the superficial sediment cover (soils *etc*) and also into the underlying bedrock. These include excavations for the turbine foundations, buried cables (*c*. 1m deep), any new gravel roads and transmission line pylons. In addition, sizeable areas of bedrock may be sealed-in or sterilized by associated infrastructure such as hard standing areas for the wind turbines, lay-down areas, ancillary buildings (*e.g.* control and storage buildings) as well as the new gravel road system. All these developments may adversely affect potential fossil heritage 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. Once constructed, the operational and decommissioning phases of the wind energy facility will not involve further adverse impacts on palaeontological heritage.

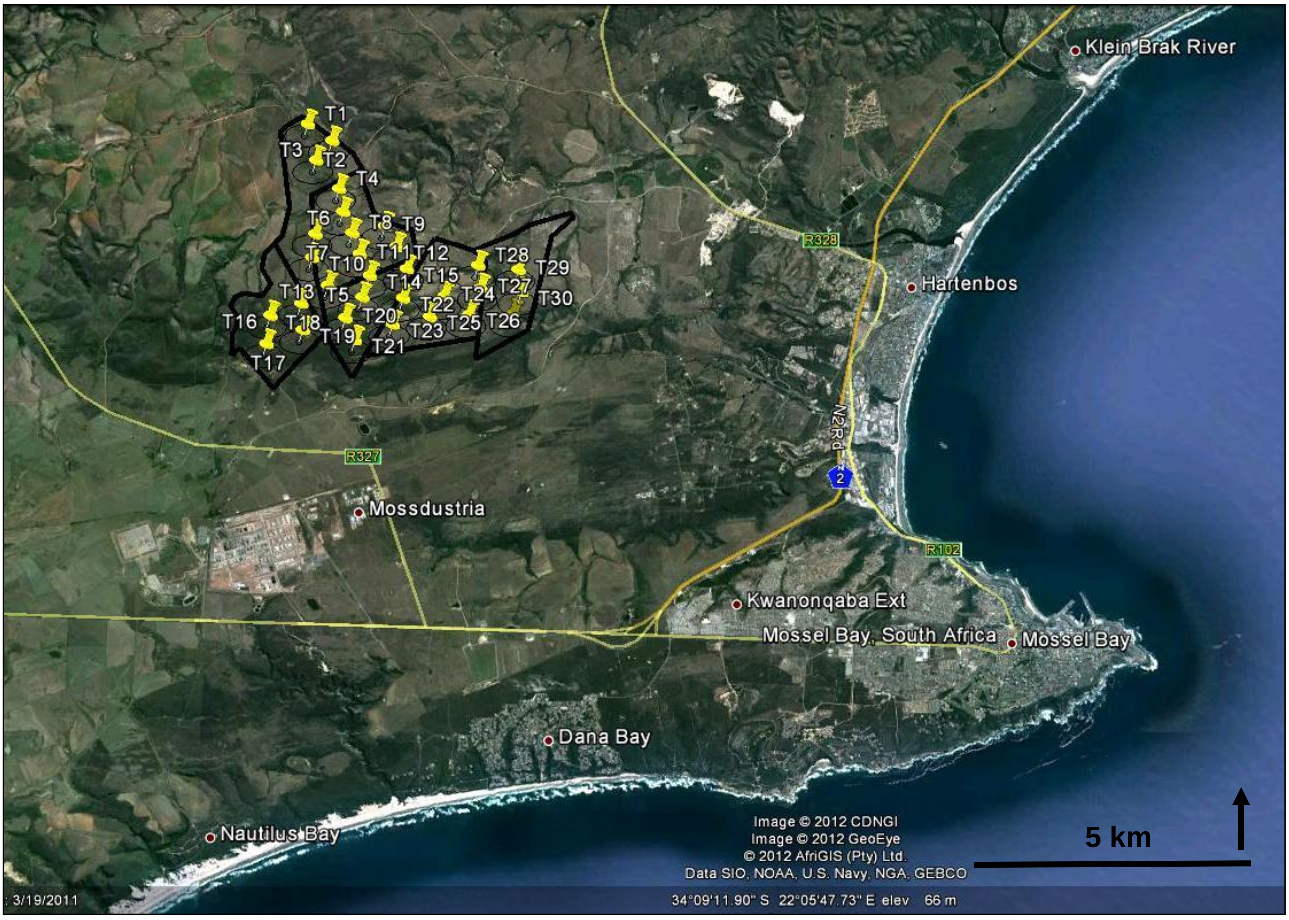

Figure 1: Google earth© satellite image of the area to the northwest of Mossel Bay, Western Cape, showing location of the proposed wind energy facility just to the northeast of the PetroSA refinery. See following figure for more detailed aerial view of the study area.

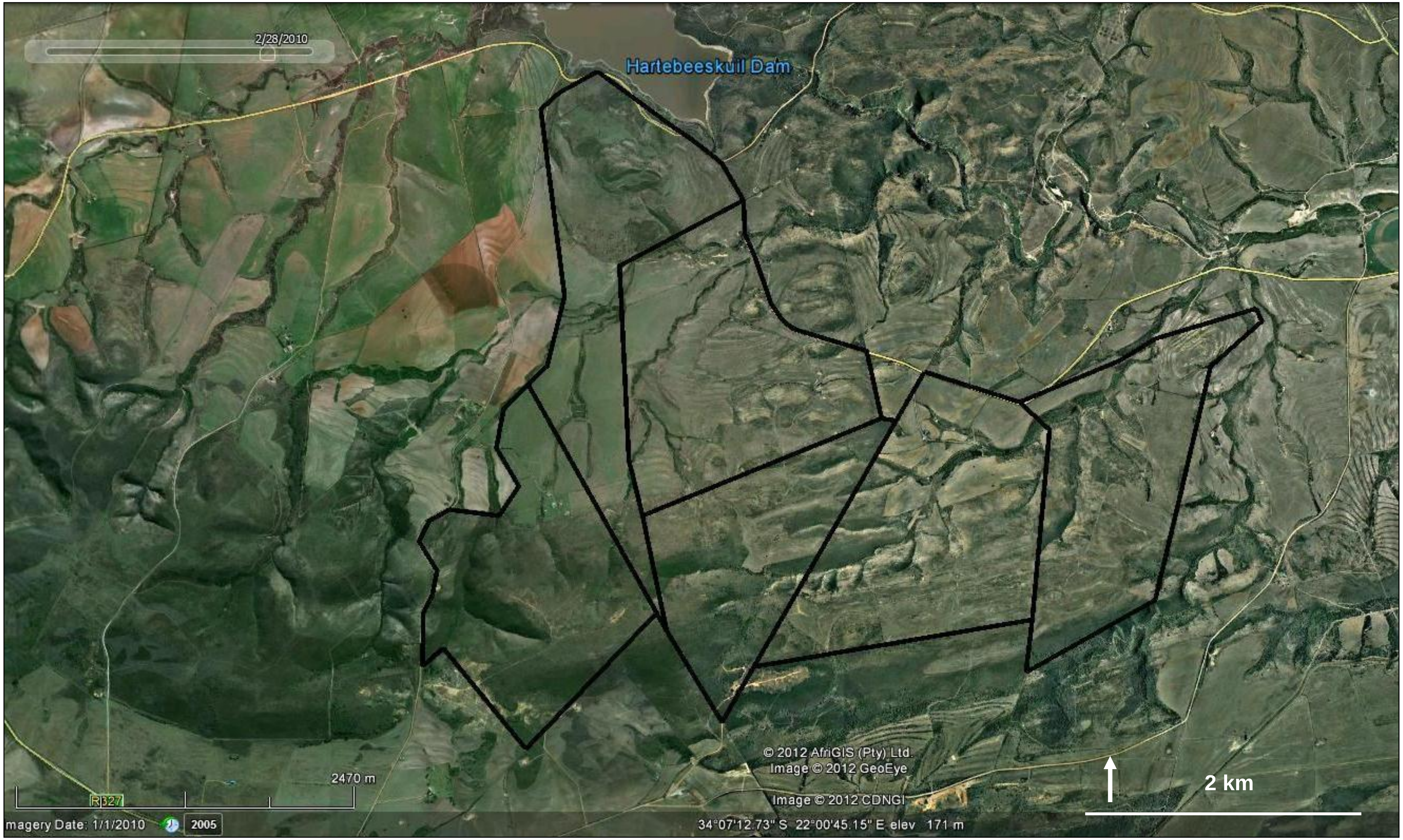

Figure 2: Google Earth© satellite image of the land parcels constituting the Mossel Bay Wind Energy Project study area (black polygons) to the northwest of Mossel Bay.

1.2. Scope of work

The Scope of Work for the present Phase 1 field-based study of palaeontological resources within the wind energy project study area has been defined by CES, Grahamstown as follows:

1. Provide a summary of the relevant legislation;
2. Conduct a site inspection as required by national legislation;
3. Determine the likelihood of palaeontological remains of significance in the proposed site;
4. Identify and map (where applicable) the location of any significant palaeontological remains;
5. Assess the sensitivity and significance of palaeontological remains in the site;
6. Assess the significance of direct and cumulative impacts of the proposed development and viable alternatives on palaeontological resources;
7. Identify mitigatory measures to protect and maintain any valuable palaeontological sites and remains that may exist within the proposed site;
8. Prepare and submit any permit applications to relative authorities;
9. Preparation of a draft and final specialist report.

1.3. Approach to this study

The present report represents a combined desktop and field-based assessment of palaeontological heritage resources within the Mossel Bay Wind Energy Project study area. 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 2011.

This palaeontological specialist report provides an assessment of the observed or inferred palaeontological heritage within the wind energy facility study area, with recommendations for specialist palaeontological mitigation where this is considered necessary. The report is based on (1) a review of the relevant scientific literature, including recent fossil heritage assessments (*e.g.* Almond 2010) (2) published geological maps and accompanying sheet explanations, (3) the author's extensive field experience with the formations concerned and their palaeontological heritage, and (5) a one and a half -day field assessment over the period 11-12 April 2012 carried out by the author.

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 scoping during the compilation of the final report). This data is then used to assess the palaeontological sensitivity of each rock unit to development (Provisional tabulations of palaeontological sensitivity of all formations in the Western, Eastern and Northern Cape have already been compiled by J. Almond and colleagues; *e.g.* Almond & Pether 2008). The likely impact of the proposed development on local fossil heritage is then determined on the basis of (1) the palaeontological sensitivity of the rock units concerned and (2) the nature and scale of the development itself, most notably the extent of fresh bedrock excavation envisaged. When rock units of moderate to high palaeontological sensitivity are present within the development footprint, a field-based assessment by a professional palaeontologist is usually warranted.

The focus of the field-based assessment work is *not* simply to survey the development footprint or even the development area as a whole (*e.g.* farms or other parcels of land concerned in the development). Rather, the palaeontologist seeks to assess or predict the diversity, density and distribution of fossils within and beneath the study area, as well as their heritage or scientific interest. This is primarily achieved through a careful field examination of one or more representative exposures of all the sedimentary rock units present (*N.B.* Metamorphic and igneous rocks rarely contain fossils). The best rock exposures are generally those that are easily accessible, extensive, and fresh (*i.e.* unweathered) and include a large fraction of the stratigraphic unit concerned (*e.g.* formation). These exposures may be natural or artificial and include, for example, rocky outcrops in stream or river banks, cliffs, quarries, dams, dongas, open building excavations or road and railway cuttings. Uncemented superficial deposits, such as alluvium, scree or wind-blown sands, may occasionally contain fossils and should also be included in the scoping study where they are well-represented in the study area. It is normal practice for impact palaeontologists to collect representative, well-localized (*e.g.* GPS and stratigraphic data) samples of fossil material during scoping studies. All fossil material collected must be properly curated within an approved repository (usually a museum or university collection).

Before fieldwork commenced, a preliminary screening of satellite images and 1: 50 000 maps of the Mossel Bay study area was conducted to identify sites of potentially good bedrock exposure to be examined in the field. Most of these sites, which were relatively few in number, were situated in the higher lying, southern portion of the area. The sites included both natural exposures (*e.g.* stream beds, rocky slopes, gullies) as well as artificial exposures such as quarries, dams and cuttings along farm tracks.

Note that while fossil localities recorded during fieldwork within the study area itself are obviously highly relevant, most fossil heritage here is embedded within rocks beneath the land surface or obscured by surface deposits (soil, alluvium *etc*) and by vegetation cover. In many cases where levels of fresh (*i.e.* unweathered) bedrock exposure are low, the hidden fossil resources have to be *inferred* from palaeontological observations made from better exposures of the same formations elsewhere in the region but outside the immediate study area. Therefore a palaeontologist might reasonably spend far *more* time examining road cuts and borrow pits close to, but outside, the study area than within the study area itself. Field data from localities even further afield (*e.g.* an adjacent province) may also be adduced to build up a realistic picture of the likely fossil heritage within the study area.

On the basis of the desktop and 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. Mitigation by a professional palaeontologist – normally involving the recording and sampling of fossil material and associated geological information (*e.g.* sedimentological data) – is usually most effective during the construction phase when fresh fossiliferous bedrock has been exposed by excavations, although pre-construction recording of surface-exposed material may sometimes be more appropriate. To carry out mitigation, the palaeontologist involved will need to apply for a palaeontological collection permit from the relevant heritage management authority (*i.e.* Heritage Western Cape, Cape Town). 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.

1.5. Assumptions and 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, however.

In the case of palaeontological desktop studies without supporting 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 palaeontological field studies in the Mossel Bay study region, the main limitation is the very low levels of bedrock exposure due to extensive cover by superficial deposits (alluvial gravels, pedocretes, soil, alluvium *etc*) and vegetation. Despite very limited bedrock exposure, confidence levels in the conclusions presented here moderately high, also based on field studies elsewhere in the region (*e.g.* Almond 2010).

2. GEOLOGICAL BACKGROUND

The geology of the study area is depicted on two adjacent 1: 250 000 sheets: sheet 3420 Riversdale and sheet 3322 Oudtshoorn. Unfortunately, there is considerable mismatch in mapping and mapping styles across the border between these sheets. A more consistent and detailed map of the area is provided on 1: 50 000 geology sheets 3421BB and 3422AA (Council for Geoscience, Pretoria; Viljoen & Malan 1993) (Fig. 3).

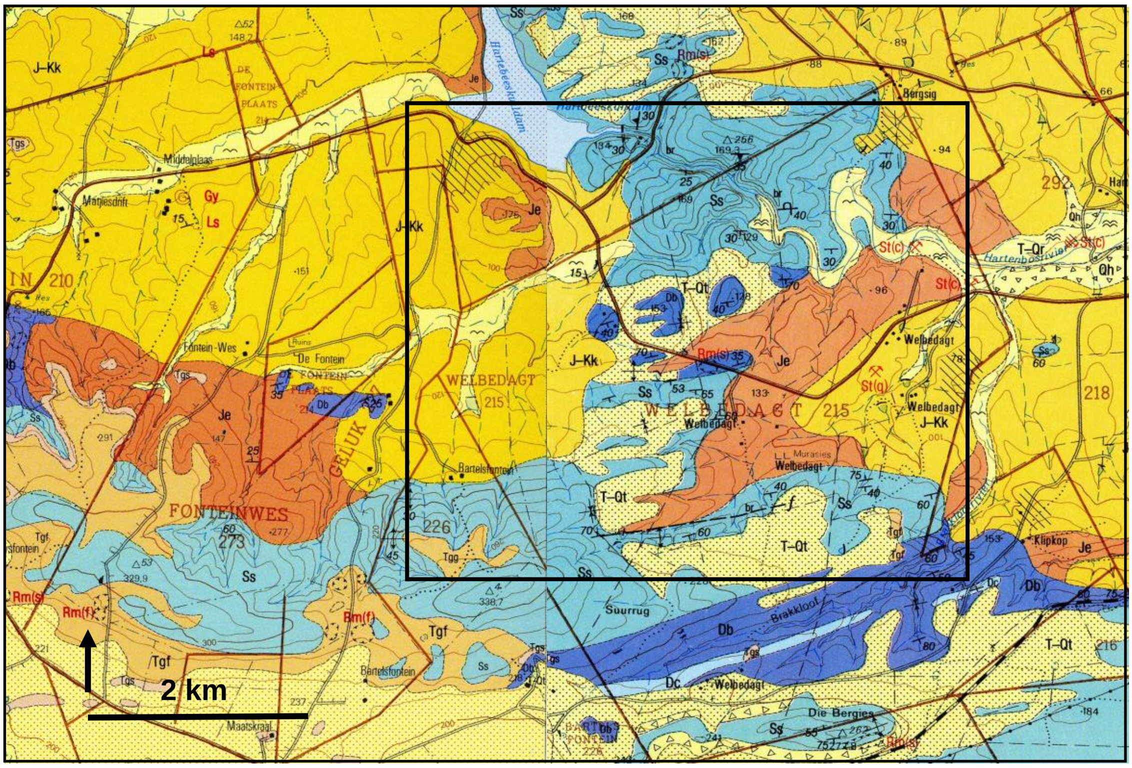

Figure 3: Extracts from adjacent 1: 50 000 geology sheets 3421BB and 3422AA (Council for Geoscience, Pretoria) showing *approximate* outline of the study area to the northwest of Mossel Bay (black rectangle). The main geological units represented within the study area are:

1. TABLE MOUNTAIN GROUP (Nardouw Subgroup):
Skurweberg Formation - Ss (pale blue), Sk (lilac)
Baviaanskloof Formation – Db (dark blue)

2. UITENHAGE GROUP
Kirkwood Formation – J-Kk (yellow)
Enon Formation - Je (orange)

3. LATE CAENOZOIC SUPERFICIAL DEPOSITS
Grahamstown Formation – Tgg (tan, High Level Gravels), Tgf (ferricrete)
Gritty sand and debris - T-Qt (pale yellow with stipple)
Quaternary to Recent alluvium – pale yellow with “flying bird” symbol

The northern sector of the Mossel Bay Wind Energy Project study area comprises low-lying, gently hilly country at *c*. 50-120m amsl that is traversed by incised streams that are tributaries of the Hartenbos River to the north. This area is largely underlain by readily-weathered sandstones and mudrocks of the **Kirkwood Formation** (**Uitenhage Group**) of Early Cretaceous age (J-Kk) and perhaps also by pebbly conglomerates of the **Enon Formation** (Ke). With the exception of a few stream cuttings, dam sites and hill slopes, the Mesozoic rocks here are entirely mantled by soil, pedocretes (*e.g.* ancient alluvial gravels) and other superficial deposits. The stream valleys are lined with dense vegetation, with little river bank exposure. Flatter areas are cultivated, and larger rocks from the fields have been collected into heaps or dumped along the stream banks. Informative exposures of the Enon Formation were not encountered during fieldwork and this (largely unfossiliferous) rock unit will therefore not be treated at any length here. The delimitation of the Enon Formation outcrop area appears to be problematic, given the very poor levels of exposure here.

The southern sector features higher ground up to 340 m amsl forming a broadly west-east trending ridge of **Table Mountain Group** sandstones and quartzites. These last rocks belong mainly to the **Skurweburg Formation** (Ss in Fig. 3) of Silurian age. It is possible that small outcrop areas of other subunits of the Table Mountain Group are also represented here (*e.g.* Early Devonian **Baviaanskloof Formation**), as indicated by the more recent geological maps (Fig. 3), but this could not be verified in the field and only the Skurweberg succession will therefore be considered further here. Even in the higher lying areas slopes are usually gentle and flatter-lying areas have been cultivated in the past and in some cases still are. Even in this higher-lying southern area rocky outcrops are very limited and the bedrocks are generally obscured by soil, pedocretes, gravels and vegetation (Figs. 4, 5). Pedocretes include well-developed **ferricretes** (ancient soils and gravels cemented by ferruginous minerals) and **silcretes** (ditto, cemented by siliceous cements) of probable Late Caenozoic age (perhaps Late Tertiary) that can be assigned to the **Grahamstown Formation** (Tgg, Tgf). Downwasted gravels and sandy deposits that mantle much of the Skurweberg outcrop area are mapped in Fig. 3 as "gritty sand and debris" (T-Qt).

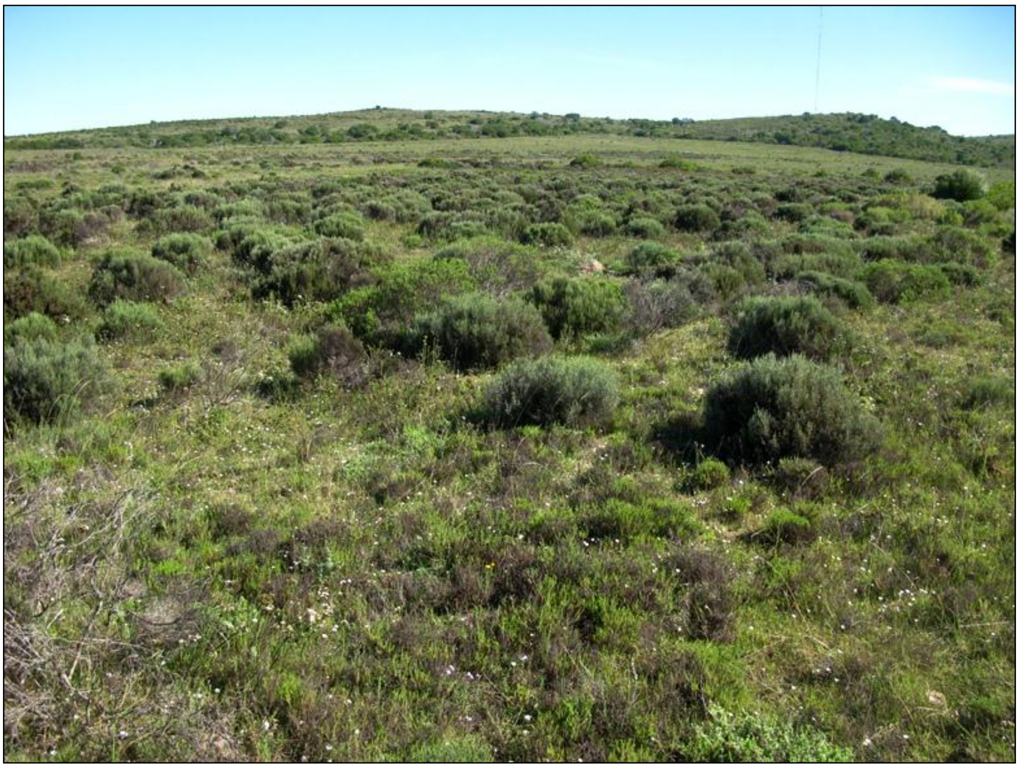

Fig. 4. View westwards across the well-vegetated upland plateau (ancient land surface) on Welbedagt 215, showing wind mast in top right. Note lack of bedrock outcrop here.

Fig. 5. View southwards across gently hilly lowlands, underlain by readily-eroded Cretaceous rocks, towards low hills of Table Mountain Sandstone on Bergsig Game Farm. Note general lack of rocky outcrop in both lowland and upland areas.

In the following section of this report is given a summary of the three main sedimentary rock successions represented in the study area near Mossel Bay, together with a brief, illustrated account of the sedimentary rocks encountered during field work. Much of this background data has been abstracted from a recent field study for a wind energy development some 10 km west of the present study area (Almond 2010). GPS data for all localities mentioned is provided in the appendix.

2.1. Skurweberg Formation

Quartzitic and feldspathic sandstones of the **Skurweberg Formation** (previously known as the Kouga Formation, Sk, in this region) of Silurian age build the higher lying ground in the southern part of the study area. The Skurweberg rocks within the southern portion of the Cape Fold Belt here are strongly folded along multiple E-W trending fold axes, and steep bedding dips are common.

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). The Skurweberg Formation is dominated by very pale, resistant-weathering sandstones and quartzites that typically show well-developed unidirectional, south to southeast-directed current cross-bedding, occasionally deformed or overturned during post-depositional dewatering. Thin quartz pebble sheets and lenticles mantle many erosional surfaces. 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 on the margins of Gondwana. Small scale (several meter thick) upward coarsening cycles are recorded within the Skurweberg Formation and may reflect changes in relative sea level or perhaps the infilling of local depressions on the braidplain by progradation of proximal fluvial facies (Malan *et al.* 1994).

The most extensive exposures of Skurweberg Formation rocks occur along the northern edge of the Table Mountain Group outcrop area as low, intermittent outcrops of pale grey, thin to thick-bedded quartzite and sandstone. Sedimentary fabrics vary from massive to tabular cross-bedded and horizontally laminated. Pebbles are sparse and mudrock interbeds, though doubtless present subsurface, are generally not exposed. The dip of the Skurweberg beds is variable, with southerly dips most common. However, subvertical bedding associated with tight isoclinal folding is observed locally. Many outcrops show a pervasive, closely-spaced tectonic cleavage that is often inclined at a high angle to the bedding (Fig. 7). Narrow bands of quartz veining and tectonic brecciation occur within more highly deformed zones (Figs. 8 and 9).

The Skurweberg rocks have been extensively planed off by protracted erosion during post-Gondwana times to form stepped pediment surfaces which may be related to the African Surface of earlier authors (Section 2.3 below). Good examples of deeply-weathered, secondarily ferruginised Skurweberg saprolite (*in situ* weathered bedrock) is seen in the southwestern corner of Bergsig Game Farm (Fig. 11). Typically these ancient elevated land surfaces are mantled in a range of siliceous and ferruginous duricrusts (Section 2.3).

Fig. 6. Rocky cliff of pale, thick-bedded Skurweberg Formation quartzites in the banks of a narrow stream valley, Bergsig Farm (Hammer = 32 cm) (Loc. 452).

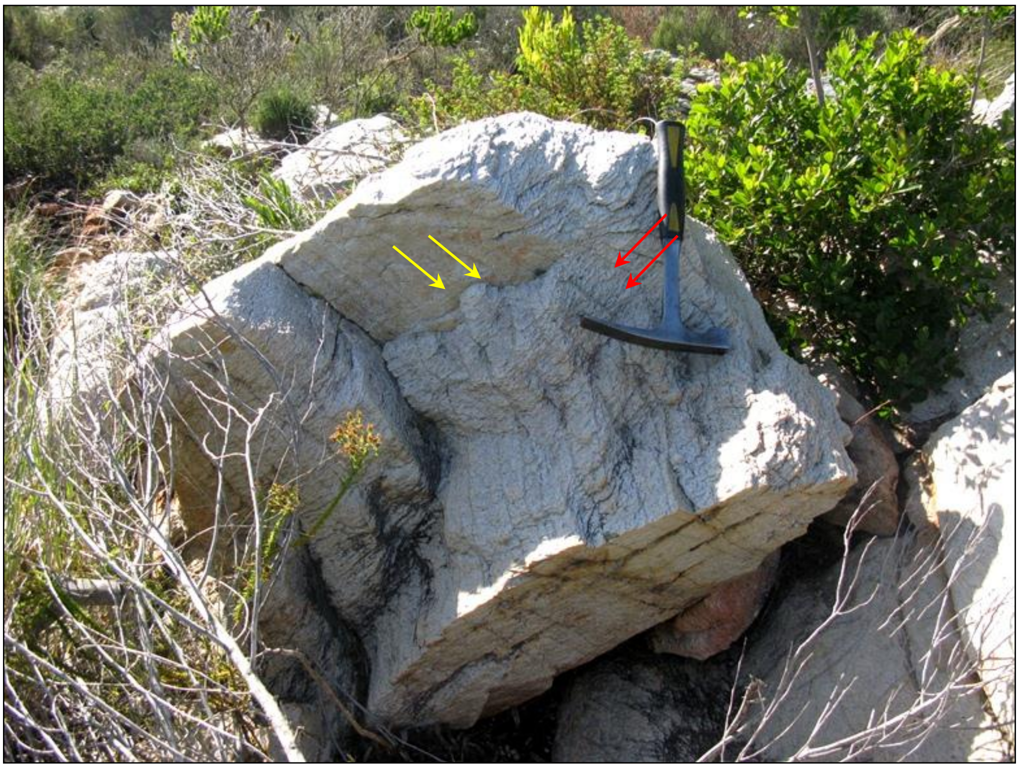

Fig. 7. Low, isolated exposure of Skurweberg Formation quartzites showing steeply south-dipping bedding (yellow arrow) transected by pervasive, closely-spaced north-dipping cleavage (red arrow), Bergsig Game Farm (Hammer = 32 cm) (Loc. 441).

Fig. 8. Bedding plane exposure of Skurweberg Formation quartzites showing pervasive east-west trending bedding / cleavage lineation and subparallel milky quartz veins, Bergsig Game Farm (Hammer = 32 cm) (Loc. 451).

Fig. 9. West-East trending prominent-weathering ridges of silicified fault breccia and vein quartz on hillslope exposure of Skurweberg Formation, Welbedagt 215 (Hammer = 32 cm) (Loc. 473).

Fig. 10. Exposure of thin-bedded, horizontally-laminated and weathered sandstones of the Skurweberg Formation dipping steeply southwards, Bergsig Game Farm (Hammer = 32 cm) (Loc. 448).

Fig. 11. Deeply-weathered and ferruginised Skurweberg saprolite (*in situ* weathered bedrock) overlain by ferricrete gravels, southwestern edge of Bergsig Game Farm (Hammer = 32 cm) (Loc. 464).

2.2. Kirkwood Formation

The Uitenhage Group is a 3.5km thick succession of Mesozoic fluvial, estuarine and marine sediments spanning the Late Jurassic to Early Cretaceous Periods (*c*. 150-125 Ma). A useful recent review of these rocks has been given by Shone (2006) and an extensive account of their representatives in the Mossel Bay – Herbertsdale area can be found in Viljoen and Malan (1993). These form part of an extensive series of Uitenhage Group rocks infilling a series of down-faulted hinge basins along the so-called Worcester- Pletmos line, stretching from Worcester in the West to Mossel Bay and Plettenberg Bay in the east. Only the Kirkwood Formation will be treated further here since convincing Enon Formation exposures were not encountered during fieldwork.

The **Kirkwood Formation** (J-Kk) comprises readily-weathered, silty overbank mudrocks and subordinate channel sandstones and pebbly conglomerates of fluvial origin and Early Cretaceous (Berriasian / Valanginian). Key geological accounts of the Kirkwood Formation include those by Rigassi & Dixon (1972), McLachlan & McMillan (1976), Tankard *et al.* (1982), Dingle *et al.,* (1983) and Shone (2006). Early geologists called these rocks the "Variegated Marls" referring to the distinctive reddish-brown, pinkish and greenish-grey colour spectrum shown by the sediments (*NB* "marl" is a misnomer, technically referring only to calcareous, clay-rich mudrocks). Another older name for the same succession was the "Wood Beds", referring to the abundant petrified wood recorded in the Algoa Basin and elsewhere (see fossil record below). Volcanic tuffs (ashes) and reworked tuffs constitute an important component of the Kitkwood succession in parts of the Herbertsdale – Hartenbos Basin (Viljoen & Malan 1993). Tuff-rich Kirkwood successions are marked on the NW and E margins of the study area in Fig. 3 (cross-hatching).

At the time that the Uitenhage sediments were being deposited, some 140 million years ago, Africa and South America – previously united within the West Gondwana supercontinent - were starting to pull apart. Uplift, faulting and erosion of the youthful southern African continent led to the rapid deposition of huge amounts of alluvium by systems of meandering rivers and estuaries fringing a new Mediterranean-sized seaway that was opening up in the southern Cape area. Well-preserved calcrete-rich palaeosols (fossil soils) within the Kirkwood alluvium suggest that prevailing climates were semi-arid, warm to hot, with a low seasonal rainfall of 100-500mm / year. This pattern is supported by the abundance of leathery- and small-leaved plants in the fossil flora, while well-developed seasonal growth rings are preserved in at least some fossil woods.

Very few, and small, exposures of Kirkwood Formation bedrocks were encountered in the study area during fieldwork. The main examples include greenish-grey, sparsely pebbly, thin-bedded sandstones and desiccation-cracked siltstones capping a low hill on the eastern edge of the study area (Fig. 12), as well as small gully exposures on Welbedagt 215 (Fig. 13) and the Bergsig Game Farm. Most of the Kirkwood outcrop area is soil-covered. However, the presence of underlying Kirkwood rocks is often betrayed by the abundance of polymict pebbles weathering out of the surface deposits (Figs. 14 – 16). The pebbles are often very well-rounded and smooth, while some (*e.g.* milky quartz) have a distinctive high polish. Among the exotic rock types represented are cherty micro-breccias, reddish-brown jasper, a range of banded types of chalcedony, weathered, kaolinitised granites and spherulitic ochreous material possibly sourced from the lower Ecca Group (Fig. 16).

Fig. 12. Hilltop exposure of thin-bedded, north-dipping, grey-green Kirkwood Formation sandstones on Welbedagt 215 with sparse cover of downwasted resistant pebbles and cobbles (Loc. 472). Volcanic ashes are mapped in this area.

Fig. 13. Small exposure of Kirkwood Formation grey-green mudrocks in a stream gully, Welbedagt 215, with overlying gravel-rich soils (Loc. 469).

Fig. 14. Pebbly gravels weathering out of pale grey-green soils in the Kirkwood Formation outcrop area, Welbedagt 215 (Loc. 465). Fossil remains such as dinosaur teeth and silicified wood might be associated with such downwasted gravels, though none were found here.

Fig. 15. Detail of pebbly gravels seen in previous figure showing polymict, multihued lithologies, high degree of rounding and often high polish (Scale in cm).

Fig. 16. Selected highly-polished exotic pebbles of cryptocrystalline quartz, micro-breccia as well as (on LHS) ochre-coloured clast with spherulitic texture, possibly from the lower Ecca Group, Kirkwood Formation outcrop area, Welbedagt 215. The largest pebble here is 8.5 cm long.

2.3. Grahamstown Formation

According to classical, broad-scale studies of the geomorphic (landscape) evolution of southern Africa much of the southern coastal plain south of the Cape Fold Belt forms part of the so-called **African Surface** (King 1962, Partridge & Maud 1987, 2000, Partridge 1998, Marker & McFarlane 1997) (Fig. 17). This ancient, relict land surface is considered to have developed over a period of some 40 to 60 million years following the break-up of the supercontinent Gondwana, *i.e.* during the Cretaceous to Paleogene (Early Tertiary) Periods, and to have been affected by subsequent tectonic movements, crustal warping and erosional dissection. As a result of deep chemical weathering under humid, tropical climates and long periods of tectonic stability, the surface is characterized by deeply weathered *saprolite* (*in situ* weathered bedrock) and capped by *duricrusts* of silcrete and/or ferricrete reflecting the increased mobility of silica and iron under these circumstances (Marker & McFarlane 1997, Marker *et al.* 2002). Purported remnants of the African Surface are concentrated in the Caledon-Swellendam, Heidelberg-Riversdale, Albertinia-Mossel Bay and Grahamstown areas along the south and southeast coast. Detailed studies in the Albertinia area recognise elements of this composite surface lying between 120 and 400m+ above sea level and demonstrate that it is multiple in nature, with at least four subcomponents (here at 120-140m, 200m+, 330m +, and 380-400m+ asl), and that it is clearly polycyclic in origin (Marker & McFarlane 1997). Indeed, the existence of an extensive, recognisable African Surface has been questioned by recent workers such as Roberts (2003). He argues that multiple episodes of landscape erosion and duricrust formation, influenced by a complex interplay of tectonic, eustatic and climatic factors, have occurred during the Late Mesozoic to Pleistocene interval, several of which are conflated within the classic concept of the African Surface. In his view "This term should be confined to the (very) few instances where a surface can be demonstrated to have undergone only one cycle of erosion and weathering since the dismemberment of Gondwana". In the present study region near Mossel Bay the coastal sector of the south coastal plain is assigned to the **Post-African 1 Surface** of Early Miocene to Late Pliocene age at *c*. 150m asl. (Partridge & Maud 1987, 2000, Partridge 1998; Fig. 10). The higher-lying, 200-300m asl surface of which the southern portion of the study area may well form a part would be assigned to the "African Surface" *sensu stricto* by these authors.

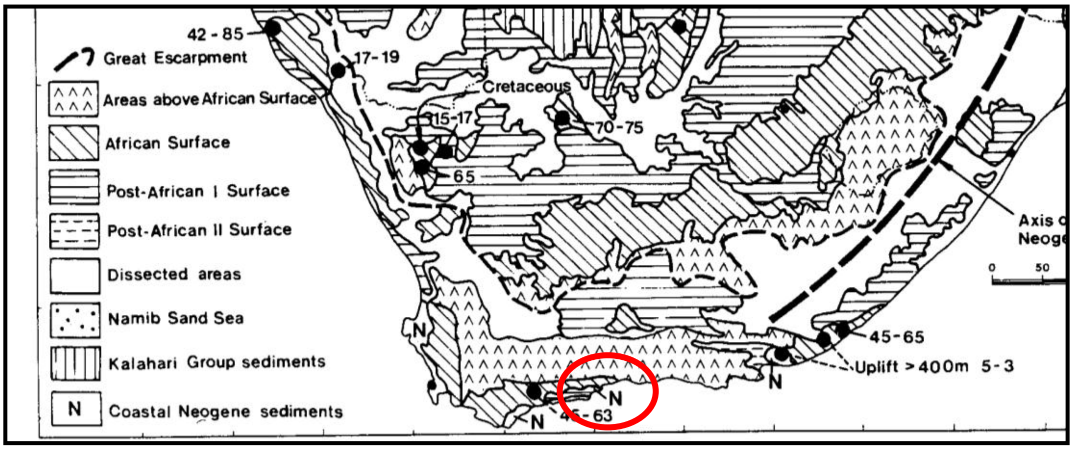

Fig. 17. Major geomorphic regions in southern Africa (Modified from Partridge 1998). Note that in the study region (red ellipse) the interior of the southern Cape coastal belt is assigned here to the so-called Cretaceous to Early Miocene African Surface, while the Post-African 1 surface of Miocene-Pliocene age is recognised closer to the modern coast.

Extensive relictual patches of *in situ* Tertiary-age silcretes, ferricretes and associated lag gravels capping deeply weathered Table Mountain Group and Kirkwood Formation bedrocks in the study area are assigned to the **Grahamstown Formation (Tgg, Tgf)**. These resistant-weathering duricrusts represent secondarily cemented fluvial and other superficial drift deposits, as well as downwasted gravels derived from older or higher-lying weathering profiles (Summerfield 1983, Malan *et al.* 1994, Marker & McFarlane 1997, Botha 2000, Marker *et al.* 2002, Roberts 2003). The genesis of South African near-surface silcretes on alluvial plains and terraces has been discussed extensively by Roberts (2003) who relates them to episodes of poor-drainage and moist, humid climates following long periods of tectonic stability. The majority of silcretes on the coastal platform of the southeastern Cape are inferred to be Paleogene in age, though some may well be Neogene. They reflect multiple periods of silica solution and precipitation. Their complex, polycyclic origin is indicated by the wide spectrum of contrasting facies seen within the silcrete cappings. They range from massive, grey to buff fine-grained silcretes showing a well-developed conchoidal fracture that are formed from fine-grained sands and silicified saprolite, to vein quartz - rich gravelly silcretes and spectacular silcretized breccio-conglomerates containing cobble and boulder-sized megaclasts of reworked, older silcrete. The rounding of some silcrete intraclasts implies a measure of current transport (but may be enhanced by conchoidal fracture).

Typically the silcrete cappings overlie pallid to ferruginised saprolite and often grade laterally or vertically into ferruginised silcrete and full-blown ferricrete facies. Well-developed, *in situ* ferricretes occur commonly within the study area, while ferricretised silcretes and gravels are also observed. According to Roberts (2003) and Roberts *et al.* (2008) the formation of silcretes and ferricretes was often contemporaneous and controlled by fluctuating hydrological and geochemical conditions, with low (acidic) pH favoring ferricrete and higher (alkaline) pH favouring silcrete genesis. The widespread occurrence of laterite weathering, with leaching of bases and silica and enrichment in iron, on the southern coastal plain is documented by Marker *et al.* (2002) and attributed to a protracted period of humid climates in the Tertiary. Silcretes may be preferentially preserved over ferricretes because the latter often occur higher in the weathering profile and are less indurated, so they are more prone to subsequent denudation.

Gentle hillslopes and upland plateaux throughout the study region feature substantial mantles of colluvial, fluvial and downwasted lag gravels that are informally referred to as **High Level Gravels** (HLG) and reflect ancient land surfaces and drainage systems of Tertiary age. These heterogeneous deposits of wide-ranging Caenozoic age are usually included for mapping purposes within the **Grahamstown Formation**. In some cases the gravels are largely composed of angular to subangular clasts that have clearly experienced little transport from source (Fig. 20). True alluvial terrace gravels (Tgg) comprise very well-rounded cobbles and boulders, mostly consisting of Table Mountain Group sandstones and quartzites, many of which bear a brownish patina of iron oxides, as well as minor silcretes. Excellent examples are seen at 140 m amsl on the Bergsig Game Farm capping north-facing hillslopes just south of the Hartebeeskuil Dam. The HLG deposits here are many meters thick (*N.B.* These pebbly deposits are mapped as Enon Formation in Fig. 3, which may well be correct). Larger boulders within higher-lying (180m amsl) HLG frequently have impact crescents (percussion marks) on their surfaces, emphasizing the highly vigorous river currents responsible for transporting these megaclasts from outcrops of Table Mountain Group rocks to the south or north (Fig. 19, Loc. 449). At similar elevations elsewhere on Bergsig Game Farm (170m amsl, Loc. 450) coarse, poorly-sorted silcretised breccias directly overlie Table Mountain Group bedrocks (Fig. 21). This last duricrust is apparently associated with an existing water course.

Well-developed ferricrete duricrusts, as well as transitional silcrete-ferricrete lithologies, occur at various localities and elevations within the study area. Metallic-hued ferricretes at 170m amsl on Bergsig Farm are probably enriched in manganese ores (*e.g.* psilomelane) (Fig. 22). Extensive occurrences of rusty-hued, angular ferricrete and silcrete gravels cap the higher ground on the southern side of Bergsig Farm and were previously quarried here (Fig. 23; Tgg in map Fig. 3).

A wide range of silty to gravelly alluvial and colluvial deposits (*e.g.* T-Qt in Fig. 3) are present in the study area but good sections are rarely seen away from excavations for farm dams and erosion gullies (Fig. 24). Also of potential palaeontological interest are possibly thick accumulations of dark, carbonaceous silts associated with vlei areas (Fig. 25).

Fig. 18. Low cliff or krans of silicified, well-rounded High Level Gravels of the Grahamstown Formation, north-facing hillslope on northern portion of Bergsig Game Farm, just south of the Hartebeeskuil Dam (Hammer = 32 cm) (Loc. 459). These rocks are mapped as Enon Formation in Fig. 3, which may be the correct interpretation.

Fig. 19. Half-buried boulder High Level Gravels exposed in a farm track on southern portion of Bergsig Game Farm (Hammer = 32 cm) (Loc. 449). Impact crescents are seen on some of the boulders.

Fig. 20. Coarse, angular to subrounded, downwasted gravels of Table Mountain Group quartzite at 100 m amsl, Welbedagt 215. Similar gravels mantle large portions of the southern uplands in the study area (Hammer = 32 cm) (Loc. 468).

Fig. 21. Silcretised breccias of Table Mountain Group clasts overlying Skurweberg Formation bedrocks in a stream valley, Bergsig Game Farm (Hammer = 32 cm) (Loc. 450).

Fig. 22. Metallic-looking, manganese-rich ferricretes at *c*. 170 m amsl on Bergsig Game Farm (Hammer = 32 cm) (Loc. 443).

Fig. 23. Rusty-hued silcrete / ferricrete breccia that mantles extensive areas at *c*. 280 m amsl on the southern part of Bergsig Game Farm and was previously quarried in this area (Hammer = 32 cm) (Loc. 462).

Fig. 24. Section through typical colluvial deposits exposed in dam excavation showing poorly-sorted clasts of Table Mountain sandstone in a sandy to silty matrix (Hammer = 32 cm) (Loc. 442).

Fig. 25. Accumulation of dark, carbonaceous muds in a vlei area, Bergsig Game Farm (Loc. 446). Older carbon-rich mudrocks may contain peats, palynomorphs (pollens, spores) as well as the bones and teeth of mammals and other fauna that died in the area.

3. PALAEONTOLOGICAL HERITAGE

The fossil heritage within each of the three main units of sedimentary rocks that are represented within the Mossel Bay Wind Energy Project study area is outlined here.

3.1. Skurweberg Formation (Palaeontological sensitivity LOW)

The fossil record of the lower Nardouw Subgroup, dominated by braided fluvial sandstones, is generally very sparse. This largely non-marine unit 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 (1967, 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 *Skolithos* ichnofacies assemblages characterised by locally abundant vertical burrows of the ichnogenus *Skolithos*. These burrows are generally attributed to suspension-feeding invertebrates inhabiting turbulent, inshore habitats (Seilacher 2007). Dense assemblages of these burrows in Palaeozoic rocks are often referred to as “pipe rock” (Rust 1967, 1981). There are additionally 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, some of which are probably attributable to trilobites), vertical spreiten burrow of the ichnogenus *Heimdallia*, gently curved epichnial furrows and possible arthropod tracks (Almond 1998a, 1998b, 2008, unpublished observations). It is possible that more diverse ichnoassemblages - and even microfossils (*e.g.* organic-walled acritarchs) 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. However, exposure of these recessive-weathering finer-grained sediments is generally very poor.

It should be emphasized that the Table Mountain Group rocks within the southern Cape Fold Belt have frequently experienced fairly extreme levels of tectonism, including intense folding, faulting, jointing, brecciation, quartz veining and cleavage development, the last especially within finer-grained facies (*i.e.* mudrocks). These effects, combined with low grade regional or dynamic metamorphism and deep, intense weathering since the break-up of Gondwana (*e.g.* leaching, secondarily mineralization, notably by iron and manganese compounds, and karstic solution weathering), have conspired to severely compromise the preservation of fossils even within that minority of Table Mountain Group rocks that may originally have contained a fairly rich palaeontological heritage.

No trace or other fossils were recorded from the Table Mountain Group within the present study area near Mossel Bay. Potentially fossiliferous heterolithic or mudrock-rich successions are not well exposed. Futhermore, the TMG rocks here are often folded, intensely cleaved as well as deeply weathered in many parts of the study area.

3.2. Kirkwood Formation (Overall palaeontological sensitivity = HIGH but generally LOW in study area)

The Kirkwood Formation is the most palaeontologically productive unit in southern Africa that yields terrestrial biotas of Early Cretaceous age. Its overall palaeontological sensitivity is rated as high (Almond *et al.* 2008). Fossils include vascular plants (including concentrations of petrified logs, lignite beds, charcoal), tetrapod vertebrates (notably dinosaurs) and freshwater invertebrates, among others (Du Toit 1954, McLachlan & McMillan 1976, Almond 2010 and further references listed below). Recent palaeontological research has yielded a number of new dinosaur taxa, for the most part from the Algoa Basin to the northeast of Port Elizabeth, but also from the Oudtshoorn Basin of the Little Karoo (De Klerk 2008).
The palaeobotanically famous "Variegated Marls" and "Wood Beds" of the Kirkwood Formation in the Eastern Cape have yielded a diverse fossil flora. Woody vegetation was dominated by gymnosperms including conifers such as *Araucaria* and *Podocarpus*, extinct cycad-like bennettitaleans like *Zamites*, as well as true cycads. In addition there are charophytes (stoneworts, an advanced group of freshwater algae), bryophytes (liverworts) and pteridophytes such as ferns (Tate 1867, Seward 1903, Du Toit 1954, McLachlan & McMillan 1976, 1979, Anderson & Anderson 1985, Bamford 1986, MacRae 1999). Angiosperms (flowering plants), which first radiated during this period, are not represented, however. Plant microfossils include pollens, spores and cuticular fragments, while amber and charcoal are locally common. So far no inclusions such as fossil insects have been recorded within the amber, which represents the oldest Cretaceous material recorded from Gondwana.

Cretaceous dinosaurs have been collected from the Kirkwood Formation of the Algoa Basin since the mid nineteenth century and a number of exciting new finds have been made recently. Most of the Kirkwood dinosaur fossils found so far are highly fragmentary, however. The earliest discoveries, in 1845, were of the stegosaur *Paranthodon* from Bushman's River Valley and represent some of the first dinosaur finds made anywhere in the world (De Klerk 1995, 2000). The gigantic remains – mainly isolated vertebrae, leg bones and teeth - of several different titanosaurid and diplodocid sauropods are known from the Algoa and Oudtshoorn Basins (Rich *et al*., 1983, De Klerk 2008). These include the poorly-known *Algoasaurus* from Dispatch near Port Elizabeth (a possible camarasaurid), most of whose bones were made into bricks before they could be rescued (Broom 1904), and huge bones from the Calitzdorp area that were originally described as a giant plesiosaurus (Hoffman 1966). Disarticulated remains of numerous juveniles (hatchlings) of a primitive iguanodontian were discovered recently near Kirkwood (Forster & De Klerk 2008 and paper in press). The most completely preserved Kirkwood dinosaur is the small coelurosaur therapod *Nquebasaurus* (De Klerk *et al*., 2000); recent studies suggest this form may in fact be more closely related to the bird-like dinosaurs or alvarezsaurids (B. De Klerk, pers. comm., 2010). At least one other theropod, a basal tetanuran, is known from fragmentary remains in the Kirkwood Formation (Rich *et al*., 1983, Mateer 1987, Forster *et al*., 2009). Other vertebrate fossil groups from the Kirkwood Formation include frogs, crocodiles, turtles, sphenodontid and other lizards, mammals and freshwater fish such as garfish (De Klerk *et al*., 1998, Rich *et al*., 1983, Ross *et al*., 1999).

Non-marine invertebrate fossils in the Kirkwood Formation are represented by freshwater or estuarine molluscs (*e.g.* unionid bivalves), rare insects such as beetles, and several groups of small crustaceans including ostracods (seed shrimps), conchostracans (clam shrimps) and notostracans (tadpole shrimps) (McLachlan & McMillan 1976, Dingle *et al.* 1983, MacRae 1999, Rich *et al*. 1983, Ross *et al*. 1999, Mostovski & Muller 2010). Trace fossils include borings into petrified tree trunks that are variously attributed to bivalves (*Gastrochaena*) and insects (possibly beetles).

Fossils from the Kirkwood Formation in the Herbertsdale – Mossel Bay are recorded by Rogers and Schwarz (1900), Seward (1903, 1907), Haughton *et al.* (1937), Du Toit (1954), McLachlan and McMillan (1976), Dingle *et al.* (1983), Anderson and Anderson (1985) as well as Viljoen and Malan (1993). Lignite-rich mudrocks east of Herbertsdale contain compressions or impressions of vascular plants including ferns (*Osmundites, Cladophlebis*), cycads (*Taeniopteris*) and gymnosperms (*Taxities, Podocarpus*. Note that Dingle *et al.* 1983, in their Table 16, tentatively suggest that these plants may in fact come from the Enon Formation but this is probably incorrect). Prospecting shafts for coal were sunk in this area; the precise location of the original locality is unfortunately unknown. Silicified wood, including “broken logs” from Uitenhage conglomerates and greenish-grey mudrocks in the Mossel Bay area (probably Kirkwood Formation), is mentioned by Haughton *et al.* (1937, pp. 16-17; McLachlan and McMillan, 1976). Small wood fragments of silicified wood – but no other Kirkwood fossils - were recorded some 10 km to the west of the present study area by Almond (2010). Laminated mudrocks (*i.e*. shales) containing abundant compressions of freshwater conchostracan crustaceans are recorded from the farm Matjiesfontein 210 close to the western boundary of the study area and are also well known in the Heidelberg Basin to the west along the Worcester-Pletmos basin line (Jones, 1901, Viljoen & Malan 1993).

No fossils were recorded from the few, small exposures of the Kirkwood Formation observed within the present study area. It is possible that a protracted search among the downwasted Kirkwood pebbly material might yield clasts of reworked silicified wood or even dinosaur teeth and bones.

3.3. Caenozoic drift deposits (Overall palaeontological sensitivity = LOW)

Sparse fossil remains have been recorded from Tertiary or younger silcretes of the Grahamstown Formation and equivalent duricrust units 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 occurred. Narrow, regularly-spaced vertical tubes seen within many silcretes are apparently abiogenic and not relict root structures (Roberts 2003, p. 3 and his fig. 2.6).

Neogene to Recent colluvial, alluvial and lag gravel, sand and clay deposits may also contain fossil remains of various types. In coarser sediments like 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 as various trace fossils may be found within fine-grained alluvium. Embedded 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 to modern alluvial and colluvial “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. Fine-grained carbonaceous muds associated with *vlei* areas may contain peats, palynomorphs (pollens, spores) and other microfossils as well as the bones and teeth of mammals and other fauna that dies in the area.

No fossils were observed within the Caenozoic duricrusts or other superficial deposits in the study area.

4. CONCLUSIONS & RECOMMENDATIONS

The Mossel Bay Wind Energy Project study area is largely underlain by (1) Silurian braided river deposits of the Skurweberg Formation (Table Mountain Group), (2) Early Cretaceous fluvial sediments of the Kirkwood Formation (Uitenhage Group), and (3) a range of duricrusts (cemented soils and gravels) and poorly consolidated superficial deposits, most of which are probably of Tertiary age (Grahamstown Formation).

The Table Mountain Group rocks underlying the higher ground are of low palaeontological sensitivity. On the southern coastal plain their limited fossil content has been largely destroyed by intense tectonic deformation in the Permo-Triassic Cape Orogeny (mountain-building event) as well as by deep chemical weathering under humid tropical climates during the Late Cretaceous to Tertiary period beneath the so-called “African Surface”.

Exposures of the Kirkwood Formation are very limited here due to extensive cover by superficial sediments (mainly lag gravels, soils, alluvium) and vegetation. This formation has yielded important Cretaceous dinosaur remains and petrified wood elsewhere but no fossil remains were noted within the study area during the fieldwork, and there are no known records of fossils from this region in the literature.

A variety of Tertiary to Quaternary duricrusts - tough, secondarily cemented superficial deposits including silica-rich silcretes and iron-rich ferricretes - are present in the study area but these are also apparently unfossiliferous.

The effective palaeontological sensitivity of the various sedimentary rocks in the study area is now low in general. It is concluded that the proposed wind energy project will have a very low impact on the limited local fossil heritage, whether at the construction stage or later. It is considered that no further palaeontological heritage studies or specialist mitigation are warranted for this alternative energy project, pending the exposure of substantial fossil remains (*e.g.* vertebrate bones and teeth, large blocks of petrified wood) during the construction phase.

The ECO responsible for the development should be alerted to the possibility of fossils being found on the surface or exposed by fresh excavations during construction. Should substantial fossil remains be discovered during construction, these should be safeguarded (preferably *in situ*) and the ECO should alert Heritage Western Cape so that appropriate mitigation (*e.g.* recording, sampling or collection) can be taken by a professional palaeontologist.

The specialist involved would require a collection permit from SAHRA. Fossil material must be curated in an approved repository (*e.g.* museum or university collection) and all fieldwork and reports should meet the minimum standards for palaeontological impact studies developed by SAHRA.

These recommendations should be incorporated into the EMP for the Mossel Bay Wind Energy Project.

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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 NUMBER	GPS READING	COMMENTS
441	S34 06.924 E22 00.627 129 m	Thin-bedded, cleaved Skurweberg
442	S34 07.082 E22 00.642 139 m	Thick sandy colluvium / alluvium with sparse gravels
443	S34 07.185 E22 00.551 171 m	Ferricrete
444	S34 07.404 E22 00.285 185 m	Cleared stone heaps incl. large HLG boulders
445	S34 07.712 E22 00.319 195 m	Downwasted gravels incl. silcretes
446	S34 07.821 E22 00.409 178 m	Dam / vlei area with carbonaceous muds
447	S34 07.856 E22 00.446 183 m	Skurweberg exposure, steep dips
448	S34 07.895 E22 00.400 187 m	Ditto
449	S34 07.833 E22 00.395 181 m	Bouldery HLG
450	S34 07.517 E22 00.055 172 m	Silcretised breccia in stream gully
451	S34 07.576 E21 59.739 177 m	Isoclinally folded, cleaved Skurweberg
452	S34 07.620 E21 59.703 185 m	Skurweberg cliff exposure
453	S34 07.016 E21 59.898 125 m	Surface gravels
454	S34 06.873 E22 00.123 105 m	Ferricrete blocks (displaced)
455	S34 06.830 E22 00.192 97 m	Cobbly HLG
456	S34 06.827 E22 00.287 97 m	Small Kirkwood exposure in stream bank
457	S34 06.363 E21 59.733 132 m	Downwasted HLG, blocks of silcretised HLG
458	S34 06.136 E21 59.772 141 m	Blocks of pebbly silcrete
459	S34 06.196 E21 59.730 172 m	Low cliff of silcretised HLG
460	S34 06.626 E21 59.675 94 m	Silty alluvium nr dam
461	S34 07.979 E21 59.381 278 m	Ferricretised gravels, quarry area
462	S34 07.998 E21 59.453 285	Ditto
463	S34 07.971 E21 59.694 285 m	Ditto
464	S34 08.235 E21 59.057 276 m	Ferruginised Skurweberg saprolite
465	S34 06.870 E22 02.407 49 m	Kirkwood downwasted polymict gravels
466	S34 07.209 E22 02.210 75 m	Downwasted TMG gravels
467	S34 07.301 E22 02.220 87 m	Ditto
468	S34 07.375 E22 02.260 96 m	Angular TMG downwasted gravels
469	S34 07.445 E22 02.204 87 m	Kirkwood exposure in stream gully nr dam
470	S34 07.018 E22 02.530 52 m	Kirkwood downwasted polymict gravels
471	S34 06.992 E22 02.522 65 m	Kirkwood sandstones with sparse pebbles
472	S34 06.974 E22 02.514 78 m	Kirkwood sandstones with sparse pebbles
473	S34 07.681 E22 01.349 156 m	Fault breccia in Skurweberg

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 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, Limpopo, Free State and Gauteng 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 alternative energy 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.

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