PALAEONTOLOGICAL SCOPING REPORT
PROPOSED BOULDERS WIND FARM
SALDANHA BAY LOCAL MUNICIPALITY
VREDENBURG DISTRICT, WESTERN CAPE

WIND ENERGY FACILITY ON TEN FARM PORTIONS NEAR VREDENBURG

by

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For
Vredenburg Windfarm (Pty) Ltd

6 November 2017 (ver. 2)

EXECUTIVE SUMMARY

1. Site Name

Boulders Wind Farm.

2. Location

PROJECT NAME	BOULDERS WIND FARM		
APPLICANT	Vredenburg Windfarm (Pty) Ltd.		
MAGISTERIAL DISTRICT	VREDENBURG		
1:50000 SHEETS	3217DB & DD VREDENBURG & 3218CA & CC VELDDRIF		
EAP	Savannah Environmental (Pty) Ltd.		
FARM PORTIONS	**AREA (ha)**	**LONG/X**	**LAT/Y**
Boebezaks Kraal 2/40	891.17	17.975604	-32.824055
Boebezaks Kraal 3/40	328.97	17.937967	-32.812369
Boebezaks Kraal 5/40	271.58	17.966956	-32.802540
Davids Fontyn 7/18	428.98	17.985935	-32.754831
Davids Fontyn 9/18	85.61	17.982545	-32.766650
Frans Vlei 2/46	149.91	18.014946	-32.812901
Het Schuytje 1/21	445.59	17.995935	-32.801106
Schuitjes Klip 1/22	843.56	17.954199	-32.763474
Schuitjes Klip 3/22	899.61	17.964885	-32.785052
Uitkomst RE/6/23	757.15	17.928193	-32.799086
PROJECT AREA EXTENT	**5102.13**		

3. Locality Plan

See Figure A.

4. Description of Proposed Development

The Applicant, Vredenburg Windfarm (Pty) Ltd, proposes to construct the Boulders Wind Farm on ten properties near Vredenburg (Saldanha Bay Municipality) (Figure A). Savannah Environmental (Pty) Ltd has been appointed to undertake the Scoping and EIA process, as required by the NEMA (No. 107 of 1998, as amend.), on behalf of Vredenburg Windfarm (Pty) Ltd.

A contracted capacity of up to 140MW is envisaged for the proposed wind farm. A site development plan, with turbine positions and infrastructure layouts, is not presented for evaluation at this scoping stage. The project may entail up to 45 wind turbines, with access roads, layout areas, connecting cabling trenches, substations, office and workshop and powerline to connect to the grid.

5. Heritage Resources Identified

The Project Area encompasses two terrains (Figure A):

1. The eastern **Granitic Hills Terrain** which lacks significant coastal-plain deposits other than a soil mantle.
2. The western **Coastal Formations Terrain** which includes the Miocene formations forming Soetlandskop in the north and the Pliocene to Recent formations which infill the Uitkomst Embayment.

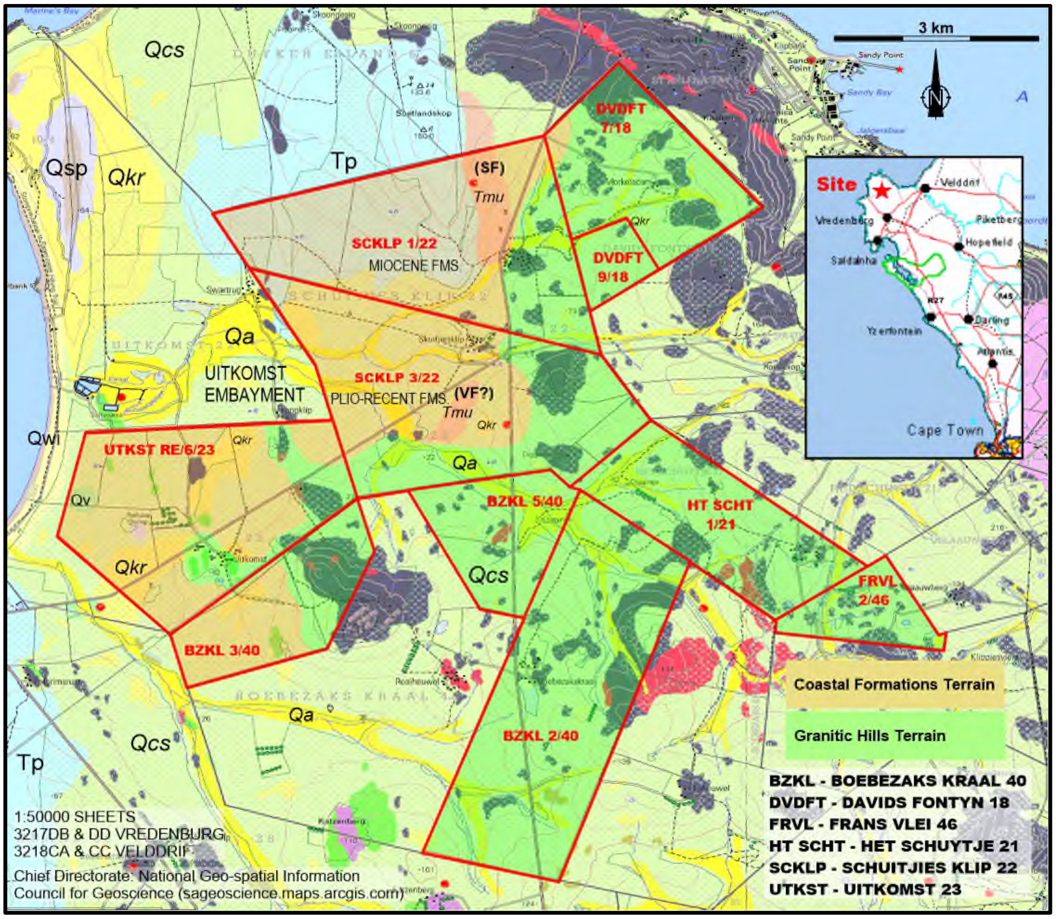


Figure A: Palaeontological sensitivity terrains. Detailed legend on Figure 3.

6. Anticipated Impacts on Heritage Resources

Impact
The Project Area is mostly comprised of the Granitic Hills Terrain of low sensitivity where the potential impact is low. The Coastal Formations Terrain in the western portion of the Project Area is of high sensitivity where the potential impact is high. The construction of the proposed Boulders Wind Farm will result in a direct, negative impact on palaeontological/scientific heritage in the absence of effective mitigation. With successful mitigation the impact should be positive.

Issue	Nature of Impact	Extent of Impact	No-Go Areas
Excavation into fossiliferous deposits.	Permanent loss of fossil heritage and allied geo-scientific data.	Cultural, heritage and scientific impacts are of regional to national extent.	Not identified. Excavations may provide useful exposures.
Reversibility	The loss of fossil material is irreversible.		
Irreplaceability	The loss of fossil material is irreplaceable.		
Mitigation	With due mitigation the impact can be partly mitigated – valuable fossil may be lost in spite of mitigation.		
Knowledge gaps & further study			
This review has identified several aspects of the stratigraphy and fossil heritage in the Project Area which require investigation and which would be informed by mitigation at sensitive locations.			

7. Recommendations

The Granitic Hills Terrain (Figure A) is of low palaeontological sensitivity and the potential impact of the proposed development in that area is low. It is therefore the preferred location for the proposed wind turbines. Even so, there is a small probability that fossils could be uncovered. As part of the EMPr for the Construction Phase of the project, construction staff must be informed to be alert for and report occurrences of bones and shells or other unusual objects (Appendix 2). The Fossil Finds Procedure (Appendix 3) which is applicable to all earth works, must be included in the EMPr for the Construction Phase of the proposed WEF.

The Coastal Formations Terrain is of high palaeontological sensitivity and the potential impact of the proposed development in that area is high. Nevertheless, excavations in this area are acceptable with due mitigation. All excavations in this area must be inspected by the contracted palaeontologist. The aim of field inspection is to examine a representative sample of the various deposits exposed in the turbine excavations, recording context, fossil content and to take samples of the fossils and sediments, thereby providing a positive benefit. Should any wind turbines be sited in the Coastal Formations Terrain, where fossil shell beds may be intersected in excavations, the specifics of setting up a monitoring and inspection programme will be agreed between the developer, the ECO and construction contractors, where it is important to liaise with respect to the scheduling of excavations.

No further pre-construction study is required for the Boulders Wind Farm subject to the inclusion of the specialist recommendations being included in the Environmental Management Programme.

8. Author/s and Date

John Pether
6 November 2017

CONTENTS

DECLARATION OF INDEPENDENCE

Palaeontological Scoping Report, Proposed Boulders Wind Farm.
Saldanha Bay Local Municipality, Vredenburg District, Western Cape.
Wind Energy Facilities on Ten Farm Portions near Vredenburg.

Terms of Reference

This assessment forms part of the Scoping Heritage Assessment in the EIA process and it assesses the overall palaeontological (fossil) sensitivities of formations in the proposed Project Area.

Declaration

I …**John Pether**……, as the appointed independent specialist hereby declare that I:

- act/ed as the independent specialist in the compilation of the above report;
- regard the information contained in this report as it relates to my specialist input/study to be true and correct, and
- do not have and will not have any financial interest in the undertaking of the activity, other than remuneration for work performed in terms of the NEMA, the Environmental Impact Assessment Regulations, 2014 and any specific environmental management Act;
- have and will not have any vested interest in the proposed activity proceeding;
- have disclosed to the EAP any material information that has or may have the potential to influence the decision of the competent authority or the objectivity of any report, plan or document required in terms of the NEMA, the Environmental Impact Assessment Regulations, 2014 and any specific environmental management act;
- have provided the EAP with access to all information at my disposal regarding the application, whether such information is favourable to the applicant or not; and
- am aware that a false declaration is an offence in terms of regulation 48 of the 2014 NEMA EIA Regulations.

Signature of the specialist

Date: 6 November 2017

CURRICULUM VITAE

The author is an independent consultant/researcher and is a recognized authority in the field of coastal-plain and continental-shelf palaeoenvironments and is consulted by exploration and mining companies, by the Council for Geoscience, the Geological Survey of Namibia and by colleagues/students in academia pursuing coastal-plain/shelf projects.

Expertise

- Shallow marine sedimentology.
- Coastal plain and continental shelf stratigraphy and the interpretation of open-pit exposures, onshore and offshore cores and offshore sampling and mining.
- Marine macrofossil taxonomy (molluscs, barnacles, brachiopods).
- Marine macrofossil taphonomy.
- Sedimentological and palaeontological field techniques in open-cast mines (including finding and excavation of vertebrate fossils (bones).

Membership of Professional Bodies

- South African Council of Natural Scientific Professions. Earth Science. Reg. No. 400094/95.
- Geological Society of South Africa.
- Palaeontological Society of Southern Africa.
- Southern African Society for Quaternary Research.
- Accredited member, Association of Professional Heritage Practitioners, Western Cape.

ABBREVIATIONS & ACRONYMS

asl.	above (mean) sea level.
BA	Basic Assessment Process.
EIA	Environmental Impact Assessment.
EMPr	Environmental Management Programme.
ESA	Early Stone Age. The archaeology of the Stone Age between 2 000 000 and 250 000 years ago.
Fm.	Formation.
HIA	Heritage Impact Assessment.
LIG	Last Interglacial. Warm period 128-118 ka BP. Relative sea-levels higher than present by 4-6 m. Also referred to as Marine Isotope Stage 5e or “the Eemian”.
HWC	Heritage Western Cape.
LSA	Late Stone Age. The archaeology of the last 40 000 years associated with fully modern people.
MIS	Marine isotope stages (MIS), marine oxygen-isotope stages, or oxygen isotope stages (OIS), are alternating warm and cool periods in the Earth's paleoclimate, deduced from oxygen isotope data reflecting changes in temperature derived from data from deep

	sea core samples. Working backwards from the present-day interglacial which is MIS 1, stages with odd numbers represent warm interglacial intervals and stages with even numbers represent cold glacial periods.
MSA	Middle Stone Age. The archaeology of the Stone Age between 40-400 000 years ago associated with early modern humans.
NEMA	National Environmental Management Act 107 of 1998, as amended.
OSL	Optically stimulated luminescence. See glossary.
PIA	Palaeontological Impact Assessment.
ToR	Terms of Reference.
WEF	Wind Energy Facility.

GLOSSARY

~ (tilde)	Used herein as "approximately" or "about".
Aeolian	Pertaining to the wind. Refers to erosion, transport and deposition of sedimentary particles by wind. A rock formed by the solidification of aeolian sediments is an aeolianite.
Alluvium	Sediments deposited by a river or other running water.
Archaeology	Remains resulting from human activity which are in a state of disuse and are in or on land and which are older than 100 years, including artefacts, human and hominid remains and artificial features and structures.
Baseline	Information gathered at the beginning of a study which describes the environment prior to development of a project and against which predicted changes (impacts) are measured.
Bedrock	Hard rock formations underlying much younger sedimentary deposits.
Calcareous	sediment, sedimentary rock, or soil type which is formed from or contains a high proportion of calcium carbonate in the form of calcite or aragonite.
Calcrete	An indurated deposit (duricrust) mainly consisting of Ca and Mg carbonates. The term includes both pedogenic types formed in the near-surface soil context and non-pedogenic or groundwater calcretes related to water tables at depth.
Clast	Fragments of pre-existing rocks, *e.g.* sand grains, pebbles, boulders, produced by weathering and erosion. Clastic – composed of clasts.
Colluvium	Hillwash deposits formed by gravity transport downhill. Includes soil creep, sheetwash, small-scale rainfall rivulets and gullying, slumping and sliding processes that move and deposit material towards the foot of the slopes.
Coversands	Aeolian blanket deposits of sandsheets and dunes.
Duricrust	A general term for a zone of chemical precipitation and hardening formed at or near the surface of sedimentary bodies through pedogenic and (or) non-pedogenic processes. It is formed by the accumulation of soluble minerals deposited by mineral-bearing waters that move upward, downward, or laterally by capillary

	action, commonly assisted in arid settings by evaporation. Classified into calcrete, ferricrete, silcrete.
Ferricrete	Indurated deposit (duricrust) consisting predominantly of accumulations of iron sesquioxides, with various dark-brown to yellow-brown hues. It may form by deposition from solution or as a residue after removal of silica and alkalis. Like calcrete it has pedogenic and groundwater forms. Synonyms are laterite, iron pan or "koffieklip".
Fluvial deposits	Sedimentary deposits consisting of material transported by, suspended in and laid down by a river or stream.
Fossil	The remains of parts of animals and plants found in sedimentary deposits. Most commonly hard parts such as bones, teeth and shells which in lithified sedimentary rocks are usually altered by petrification (mineralization). Also impressions and mineral films in fine-grained sediments that preserve indications of soft parts. Fossils plants include coals, petrified wood and leaf impressions, as well as microscopic pollen and spores. Marine sediments contain a host of microfossils that reflect the plankton of the past and provide records of ocean changes. Nowadays also includes molecular fossils such as DNA and biogeochemicals such as oils and waxes. A trace fossil is the track or footprint of a fossil animal that is preserved in stone or consolidated sediment.
Heritage	That which is inherited and forms part of the National Estate (Historical places, objects, fossils as defined by the National Heritage Resources Act 25 of 1999).
Optically stimulated luminescence - OSL	Optically stimulated luminescence. One of the radiation exposure dating methods based on the measurement of trapped electronic charges that accumulate in crystalline materials as a result of low-level natural radioactivity from U, Th and K. In OSL dating of aeolian quartz and feldspar sand grains, the trapped charges are zeroed by exposure to daylight at the time of deposition. Once buried, the charges accumulate and the total radiation exposure (total dose) received by the sample is estimated by laboratory measurements. The level of radioactivity (annual doses) to which the sample grains have been exposed is measured in the field or from the separated minerals containing radioactive elements in the sample. Ages are obtained as the ratio of total dose to annual dose, where the annual dose is assumed to have been similar in the past.
Palaeontology	The study of any fossilised remains or fossil traces of animals or plants which lived in the geological past and any site which contains such fossilised remains or traces.
Palaeosol	An ancient, buried soil formed on a palaeosurface. The soil composition may reflect a climate significantly different from the climate now prevalent in the area where the soil is found. Burial reflects the subsequent environmental change.
Palaeosurface	An ancient land surface, usually buried and marked by a palaeosol or pedocrete, but may be exhumed by erosion (*e.g.* wind erosion/deflation) or by bulk earth works.

Peat	partially decomposed mass of semi-carbonized vegetation which has grown under waterlogged, anaerobic conditions, usually in bogs or swamps.
Pedocrete	A duricrust formed by pedogenic processes.
Pedogenesis/pedogenic	The process of turning sediment into soil by chemical weathering and the activity of organisms (plants growing in it, burrowing animals such as worms, the addition of humus *etc.*).
Rhizolith	Fossil root. Most commonly formed by pedogenic carbonate deposition around the root and developed in palaeosols.
Stone Age	The earliest technological period in human culture when tools were made of stone, wood, bone or horn. Metal was unknown.
Stratotype locality	The place where deposits regarded as defining the characteristics of a particular geological formation occur.
Trace fossil	A structure or impression in sediments that preserves the behaviour of an organism, such as burrows, borings and nests, feeding traces (sediment processing), farming structures for bacteria and fungi, locomotion burrows and trackways and traces of predation on hard parts (tooth marks on bones, borings into shells by predatory gastropods and octopuses).

GEOLOGICAL TIME SCALE TERMS.

For more detail see www.stratigraphy.org.

ka: Thousand years or kilo-annum (10^3 years). Implicitly means "ka ago" *i.e.* duration from the present, but "ago" is omitted. Only used for durations extending from the Present. For durations only "kyr" is used instead, or sometimes "KY".

Ma: Millions years, mega-annum (10^6 years). Implicitly means "Ma ago" *i.e.* duration from the present, but "ago" is omitted. Only used for durations extending from the Present. For durations only "Myr" is used instead, or sometimes "MY".

Holocene: The most recent geological epoch commencing 11.7 ka till the present.
Pleistocene: Epoch from 2.6 Ma to 11.7 ka. Late Pleistocene 11.7–126 ka. Middle Pleistocene 135–781 ka. Early Pleistocene 781–2588 ka (0.78-2.6.Ma).

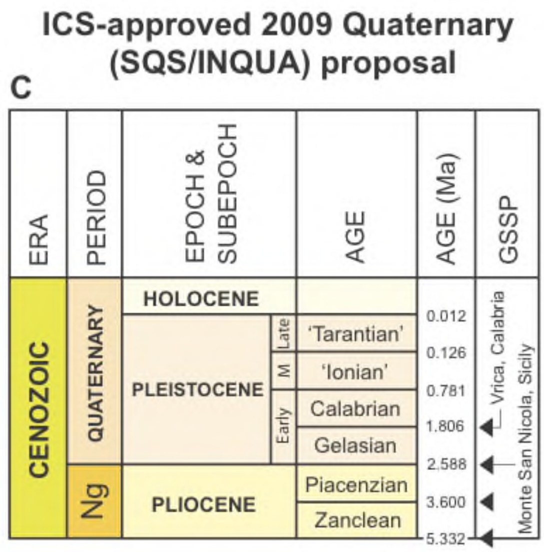
Quaternary: The current Period, from 2.6 Ma to the present, in the Cenozoic Era. The Quaternary includes both the Pleistocene and Holocene epochs. As used herein, early and middle Quaternary correspond with the Pleistocene divisions, but late Quaternary includes the Late Pleistocene and the Holocene.
Pliocene: Epoch from 5.3-2.6 Ma.
Miocene: Epoch from 23-5 Ma.
Oligocene: Epoch from 34-23 Ma.

Eocene: Epoch from 56-34 Ma.

Paleocene: Epoch from 65-56 Ma.

Cenozoic: Era from 65 Ma to the present. Includes Paleocene to Holocene epochs.

Cretaceous: Period in the Mesozoic Era, 145-65 Ma.



Mid Pliocene Warm Period (MPWP): An interval of warm climate and high sea level around ~3 Ma. When this interval was referred to as "mid-Pliocene" the boundary between the Pliocene and Quaternary was set younger, at 1.8 Ma at the beginning of the Calabrian (see figure above). Now that the Pliocene/Quaternary boundary is set further back in time by international agreement to the beginning of the Gelasian at ~2.6 Ma, the MPWP at ~3 Ma is no longer "mid", but is in the late Pliocene. However, for continuity it is still being referred to as the MPWP.

1 INTRODUCTION

1.1 BACKGROUND

The Applicant, Vredenburg Windfarm (Pty) Ltd, proposes to construct the Boulders Wind Farm on ten farmland properties on the Vredenburg Peninsula (Saldanha Bay Municipality, Western Cape) (Figure 1). Savannah Environmental (Pty) Ltd has been appointed to undertake the Scoping and Environmental Impact Assessment (EIA) process, as required by the National Environmental Management Act (No. 107 of 1998, as amended), on behalf of Vredenburg Windfarm (Pty) Ltd.

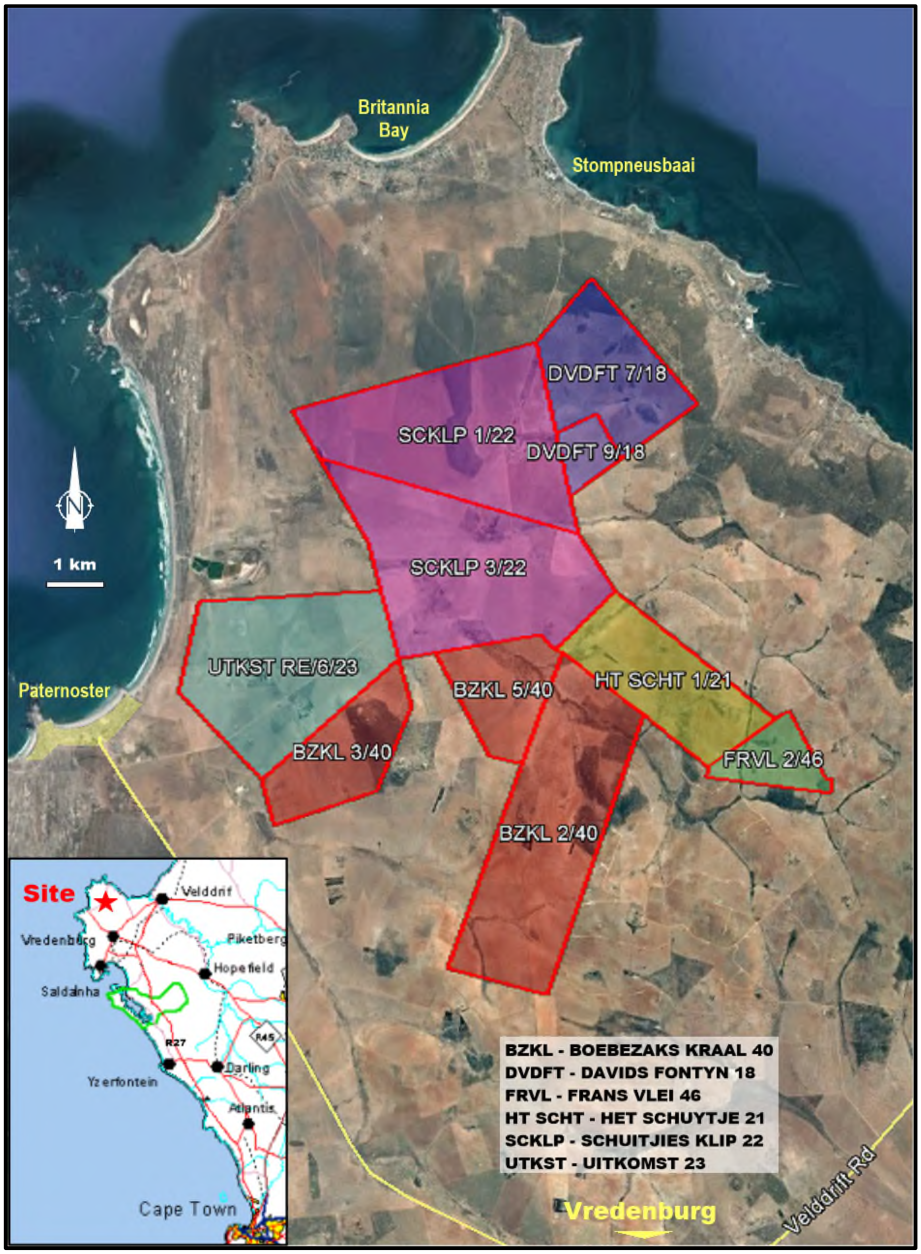


Figure 1: Locations of properties involved in the proposed Boulders Wind Farm.

1.2 TERMS OF REFERENCE

This assessment forms part of the Heritage Impact Assessment in the EIA process and it assesses the probability of palaeontological materials (fossils) being uncovered in the subsurface and being disturbed or destroyed in the process of bulk earth works.

The purpose of the Scoping Report is to identify and evaluate the main issues and potential impacts of the proposed project at a desktop level based on existing information and should:

» Identify potential sensitive environments and receptors that may be impacted on by the proposed facility and the types of impacts (i.e. direct, indirect and cumulative) that are most likely to occur.
» Provide an evaluation of the expected significance of identified impacts (including nature, extent, significance, consequence, duration and probability of the impacts including the degree to which these impacts can be reversed; may cause irreplaceable loss of resources; and can be avoided, managed or mitigated)
» Identify sensitive and "No-Go" areas, where applicable.

2 PROJECT DESCRIPTION

The proposed Boulders Wind Farm is a Wind Energy Facility (WEF) with a contracted capacity of up to 140MW. It is proposed to be constructed and operated within a project area comprised of 10 farm properties situated north of Vredenburg town (Figure 1 & Table 1).

Table 3: Proposed Boulders Wind Farm – Project Area Farm Portions.

PROJECT NAME	**BOULDERS WIND FARM**		
APPLICANT	Vredenburg Windfarm (Pty) Ltd.		
MAGISTERIAL DISTRICT	VREDENBURG		
1:50000 SHEETS	3217DB & DD VREDENBURG & 3218CA & CC VELDDRIF		
EAP	Savannah Environmental (Pty) Ltd.		
FARM PORTIONS	**AREA (ha)**	**LONG/X**	**LAT/Y**
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Uitkomst RE/6/23	757.15	17.928193	-32.799086
PROJECT AREA EXTENT	**5102.13**		

The current land use is agricultural, involving sheep and cattle farming, with fields tilled for wheat and other winter grains and rotated with pasture or crops such as lupins.

A site development plan, with turbine positions and infrastructure layouts, is not presented for evaluation at this scoping stage. The project will entail up to 45 wind turbines.

For the evaluation of the palaeontological impact it is the extent/scale of the deeper excavations to be made that are the main concern, mainly the foundations for the wind turbines. The foundations for the wind turbines require excavations of up to 3.3 m deep and encompassing up to 1200 m3. The connecting cabling trenches, although probably quite narrow and shallow (<1.0 m deep), will traverse considerable lengths. Other shallow excavations may be required for the foundations of substations, an office and a workshop. Access roads will connect the turbines and facilities and temporary roads and laydown areas will be required during construction. The footings of the transmission line pylons that connect to the national grid are relatively minor in scale.

3 APPLICABLE LEGISLATION

The National Heritage Resources Act (NHRA No. 25 of 1999) protects archaeological and palaeontological sites and materials, as well as graves/cemeteries, battlefield sites and buildings, structures and features over 60 years old. The South African Heritage Resources Agency (SAHRA) administers this legislation nationally, with Heritage Resources Agencies acting at provincial level.

According to the Act (Sect. 35), it is an offence to destroy, damage, excavate, alter or remove from its original place, or collect, any archaeological, palaeontological and historical material or object, without a permit issued by the South African Heritage Resources Agency (SAHRA) or applicable Provincial Heritage Resources Agency, viz. Heritage Western Cape (HWC). Notification of SAHRA or the applicable Provincial Heritage Resources Agency is required for proposed developments exceeding certain dimensions (Sect. 38-1).

In terms of the National Environmental Management Act (No. 107 of 1998, as amended) an EIA report for a proposed development must include a Heritage Impact Assessment (Sect. 38), which is applicable in this case.

4 METHODOLOGY

4.1 INFORMATION

An important source of geological and palaeontological information for the area is the geological map by Visser & Schoch (1972) and the accompanying explanation (Visser & Schoch, 1973). More recently the geological map of the area has been updated at a finer scale by Roberts & Siegfried (2014). The relevant parts of these maps are reproduced in Figures 2 and 3. Other references are cited in the normal manner and included in the References section. This report differs in some respects from published literature on the local coastal stratigraphy, based on the author's observations in the area and wider afield on the West Coast.

4.2 ASSUMPTIONS AND LIMITATIONS

Palaeontological sensitivity is evaluated in terms of standard criteria (Appendix 1). The main assumption is that the fossil potential of a formation in the study area will be typical of that found in the region and more specifically, similar to that already observed in the study area. A limitation on predictive capacity exists in that it is not possible to predict the buried fossil content of an area or formation other than in such general terms.

5 THE AFFECTED ENVIRONMENT

5.1 GEOLOGICAL AND PALAEONTOLOGICAL SETTING

5.1.1 The Bedrock Geology

The older bedrock of the region consists of **Malmesbury Group** shales. Their origin dates from over 560 Ma (Ma: million years ago, Mega-annum), when muddy sediments, impure limestones and subsea basalts were deposited into the Adamastor Ocean that once existed on the western margin of the early continent (Gresse et al. 2006). Subsequently, during the assembly of supercontinent Gondwana, continental drift closed up the Adamastor Ocean and its infill was compressed and welded onto the older part of southwestern Africa, metamorphosing the muds and lavas into tightly-folded shales and metavolcanic greenstones. During this process, between 550 and 515 Ma, the compressed Malmesbury Group was intruded at depth by molten magmas that solidified and crystallized to become the "**Cape Granite Suite**" (Figures 2 &3), comprised of various granites that are now exposed as hills in many places, such as around Vredenburg. The Malmesbury Group shales have been eroded off the Vredenburg Peninsula, exposing the granites.

It is evident from Figures 2 and 3 that the soils of the eastern and central parts of the Project Area are underlain by bedrock granites which are not of palaeontological interest.

5.1.2 The Sandveld Group

To the north, east and south of the granites forming the Vredenburg Peninsula the erodible shale bedrock of the Malmesbury Group has mostly been eroded away by ancient rivers to well below sea level and is buried beneath the sediments of the **Sandveld Group** (Roberts et al., 2006). These sediments are of later Cenozoic age, deposited during the Neogene and Quaternary periods, i.e. during the last 20 million years.

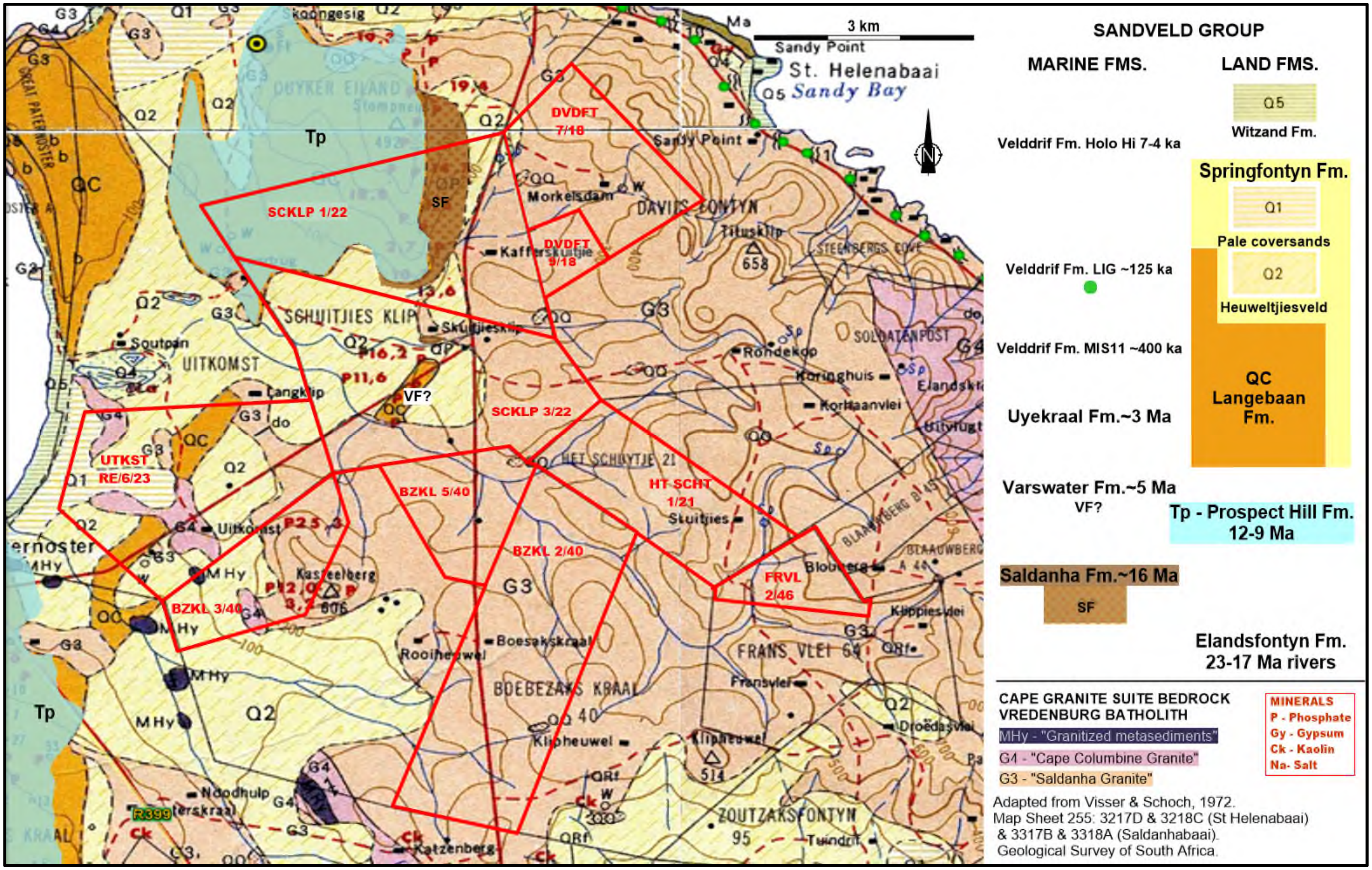

Figure 2: Geology of the Project Area modified after Visser & Schoch, 1973. Legend reflects updated stratigraphy.

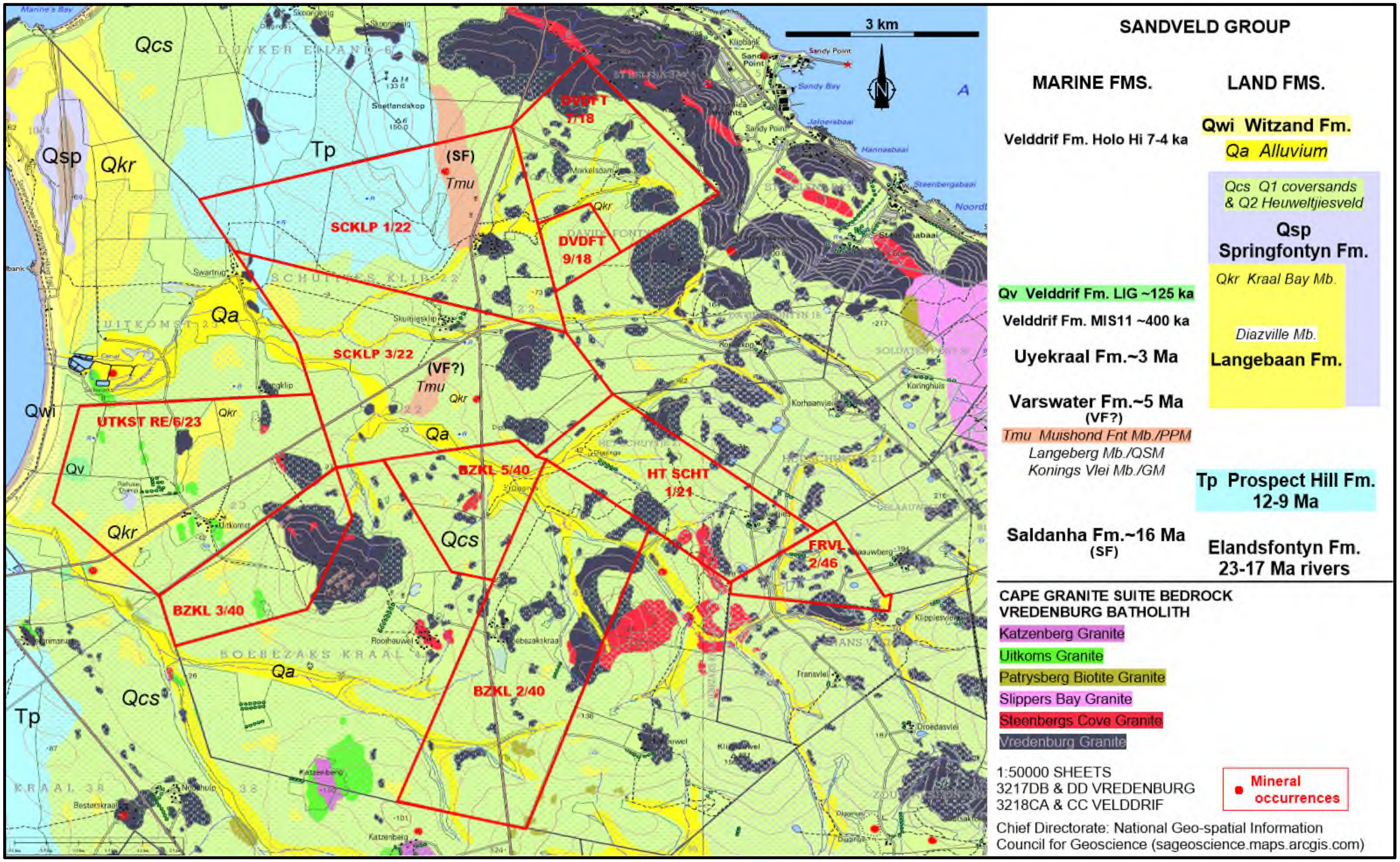

Figure 3: Geology of the Project Area after Roberts & Siegfried, 2014.

The early coastal plain would have been inundated or transgressed by the sea during times of late Cretaceous high sea-levels and transgressive Eocene events also affected the coastal plain. This earlier marine record, with palaeoshorelines that now would have been uplifted to >100 m asl., has been eroded from the coastal plain. Most of this erosion is thought to have occurred during times of pronounced lowered sea levels associated with global cooling and major ice sheet growth on Antarctica during the Oligocene Epoch 34-24 Ma. River valleys were incised to greater depths and flushed of pre-existing deposits.

5.1.3 The Early Miocene Rivers

The buried valleys eroded in the Malmesbury shales are filled with the **Elandsfontyn Formation**, the oldest formation of the Sandveld Group, consisting of fluvial and marsh deposits laid down by meandering rivers under humid climatic conditions (Rogers, 1980, 1982). The formation does not underlie the Project Area, but is included for completeness and its notable fossil content indicating a very different palaeoclimatic regime along the West Coast. The formation has abundant plant fossils in places, including lignified logs and plant material. Fossil pollen is indicative of yellowwood (podocarp) subtropical evergreen forest with lianas and vines, and swamps with palms, ferns and mangroves (Roberts et al., 2017). The Elandsfontyn Formation is early to middle Miocene in age (Coetzee, 1978; Rogers, 1982; Hendey, 1981). This was an interval 23-16 Ma of slow global warming and rising sea level which culminated in the Mid-Miocene Climatic Optimum ~16 Ma.

5.1.4 The Marine Record

The oldest Cenozoic fossiliferous marine deposits preserved on the coastal plain are of mid-Miocene age and were laid down during and just after the Mid-Miocene Climatic Optimum ~16-14 Ma. The ancient shoreline of the transgression maximum (highest level reached by sea level) is now found about 90-120 m asl., to which it has been uplifted by the continental edge bobbing up slightly. There is apparently little obvious evidence preserved in the Saldanha region of this time when the sea lapped high against the granite hills, such as the seacliffs and boulder beaches seen elsewhere. However, not all evidence of this time when the coastal plain was so extensively submerged has been lost. The phosphate mineralisation around the summit of Kasteelberg (Boebezaks Kraal, Figure 2) dates from this time when granite summits were islands and offshore seabird roosts covered in guano. The phosphorus leached from the guano and impregnated the underlying granite, forming a kind of "mineralogical fossil". Similar occurrences are found on several other coastal summits in the region that were islands during the mid-Miocene submergence

Phosphatic marine sediments at high elevations (>~40 m asl.) have previously been recognised in boreholes, usually beneath younger formations. Up till now these deposits have been included in the Varswater Formation, but their stratigraphic context indicates an older, probable mid-Miocene age. For instance, phosphatic

Miocene marine deposits underlie the later Miocene Prospect Hill Formation aeolianites (Figure 2, red Ps beneath Tp polygons). The most interesting occurrence of potential Miocene marine deposits occurs on the northern farm Schuitjies Klip 1/22, where phosphatic deposits crop out on the eastern hillside of Soetlandskop (Figure 2, SF, brown area). The mid-Miocene marine deposits are accommodated in the **Saldanha Formation** (Tankard, 1975).

Subsequent Pliocene palaeoshoreline deposits (5-3 Ma) are found below ~50 m asl. (Pether *et al*., 2000). In the southwestern Cape, these Pliocene marine deposits are collectively known as the **Varswater Formation** (e.g. Roberts & Siegfried, 2014), but this usage subsumes formations of distinctly different ages.

The stratotype locality of the Varswater Formation is at the West Coast Fossil Park, where the extensive fossil bone assemblage recovered from the phosphate quarry indicates the early Pliocene age (Hendey, 1981). These fossils were deposited in an estuarine setting during the transgression to ~50 m asl., about 5 Ma during the global warming of the Early Pliocene Warm Period. In the wider area, when sea level later receded from ~50 m asl. between 5-4 Ma, fossiliferous shallow-marine deposits were left mantling the emerged coastal plain.

Sea level rose again during the warming towards the Mid-Pliocene Warm Period ~3.0 Ma (see Glossary), to a level now ~30 m asl. In the Saldanha embayment west of the West Coast Fossil Park, the flat plain extending towards the coast is underlain by these deposits, called the "**Uyekraal Formation**" (Rogers *et al*., 1990). The Uyekraal marine beds are spatially consistent with being equivalent to 30 m Package deposits (now called the Hondeklipbaai Formation), seen in Namaqualand diamond mines as a substantial, prograded marine formation built out seawards from a sea-level maximum of 30-35 m asl. (Pether, 1994; Pether, in Roberts *et al*., 2006). This formation, up to a few km wide, underlies the outer part of the coastal plains of the West Coast.

Further shallow-marine beds occur along the coast below ~15 m asl. in a narrow fringe around the coast. These "raised beaches" were deposited at various times during the Quaternary Period and are collectively called the **Velddrif Formation**. The older raised beach is informally called the "8-12 m Package" (Pether *et al*., 2000) and it is quite likely that these deposits relate to a prominent middle Quaternary highstand of sea level ~400 ka (ka: thousands of years ago), during the **Marine Isotope Stage 11 interglacial** (MIS 11). The most prominent Velddrif Formation exposures are those of deposits of the **Last Interglacial** (LIG), deposited about 125-120 ka and which relate to a mean sea level of about 5-6 m asl. (Figure 2, green dots). The youngest of the raised beaches is the **Holocene Highstand** which relates to a relative sea-level of 2-3 m asl. which was deposited 7-4 ka. Prior to that sea-level was much lower than present, by about 120 m, during the Last Ice Age maximum (Last Glacial maximum, LGM), when much of the continental shelf was exposed and the shoreline was considerably farther to the west.

5.1.5 The Aeolian Record

During periods of lowering sea level, extensive dune plumes were blown from the ancient shorelines. These calcareous dunes, mainly composed of tiny shell fragments, are evident in the coastal landscape as the ridges, low hills and mounds beneath a capping calcrete crust. The aeolianites overlie the marine deposits of the coastal plain, resting on wind-deflation erosion surfaces formed on the marine deposits, and are comprised of sand blown off the palaeoshorelines by southerly winds and also reworked from the marine deposits. The oldest dunes recognised comprise the **Prospect Hill Formation** (Tp, Figures 2 & 3) which is the high aeolianite ridge backing the coastal plain between Saldanha Bay to Paternoster and which also caps the high ground on Schuitjies Klip 1/22 and the neighbouring Duyker Eiland. The formation includes fossil eggshell fragments of the extinct ostrich *Diamantornis wardi* and extinct forms of land snails (Roberts & Brink, 2002). Based on dated occurrences of fossil ostrich eggshell in the Namib, East Africa and Arabia, an age of 12-9 Ma is indicated for the Prospect Hill Formation dunes.

Surface outcrops of the younger, calcified aeolianites of the **Langebaan Formation** occupy large areas of the landscape (Figure 2, QC, Figure 3, Qkr). At this stage the Langebaan Formation includes various aeolianites of different ages and is an "amalgam" of the calcareous dune plumes that formed on the coastal plain, at differing places and times, mainly during the last ~4 Ma (Pliocene to the late Quaternary). This is reflected in the different ages indicated from fossils found at various places:

- a late Pliocene or younger age (Diazville lower quarry, Roberts & Brink, 2002).
- early Quaternary (Skurwerug, Hendey & Cooke, 1985).
- middle and late Quaternary ages are indicated by relationships to Last Interglacial (~125 ka) and earlier shoreline deposits and by dating of aeolianites by luminescence methods (OSL) (Roberts *et al*., 2009).

The **Springfontyn Formation** is an informal category that accommodates the mainly non-calcareous, quartz-sand-rich, windblown sand sheets and dunes that have covered parts of the coastal landscape during the Quaternary. In the literature hitherto the formation has also included thicknesses of much older, largely structureless quartzose sands that underlie the calcareous Langebaan Formation aeolianites, as well as younger quartzose coversands, dunes and soils that mantle the landscape.

Clearly the perceived ambit of the Springfontyn Fm. is problematic and varies between researchers, but the merits and demerits of previous assignments of deposits to this formation will not be disentangled herein. This author restricts the ambit of the Springfontyn Formation to quartzose sand sheets and dunes that have been deposited during the Quaternary and which form part of the modern coastal landscape. Buried formations comprised of leached quartz sands (e.g. glass sands), usually only encountered in boreholes, are excluded. These are aeolianites of considerable age (e.g. later Miocene), or decalcified sands that have not been recognised as marine in origin and been included in the "catch-all" Springfontyn Fm.

The Springfontyn Formation in the Project Area is comprised of the surficial aeolian units mapped by Visser & Schoch (1972, 1973) who differentiated the coversands by their surface appearance into 2 surficial units, **Q2** (older cover) and **Q1** (younger cover) (Figure 2). Unit Q2 is characterised by its surface manifestation as the distinct Heuweltjiesveld, the densely dot-patterned landscape of low hillocks that are termitaria. Its true spatial extent is not immediately appreciated from Figure 2 as it covers the granite hills and laps over the Langebaan Fm., but for the purposes of geological mapping these overlap areas are not shown. It is also apparent that Q2 underlies areas now covered by Q1 coversand.

On the latest geological map (Figure 3) the distinct Q2 Heuweltjiesveld soil cover and the pale Q1 coversands are not differentiated, but are obscured together as "sandy loam" (Figure 3, Qcs). Instead, the Springfontyn Fm. is identified and mapped only where there are local accumulations of remobilized coversands (e.g. the patch at the refuse dump on Uitkomst RE/6/23 (Figure 3).

The dot-patterned Q2 Heuweltjiesveld is merely the surface-soil characteristic of Unit Q2. Not much detail is known about Unit Q2 at depth (Sub-Q2). Pedogenic layers of ferruginous concretions, clayey beds and minor calcretes occur among sandy-soil beds. Clearly Q2 will differ from place to place according to the local setting. In this area, in addition to mainly windblown sands from the south, Sub-Q2 will likely comprise the local colluvial/hillwash/sheetwash deposits, small slope-stream deposits, alluvium in the lower valleys and vlei and pan deposits.

Surface Unit Q1 is a younger "coversand" geological unit and is "white to slightly-reddish sandy soil" (Visser & Schoch, 1973). These are patches of pale sand deposited in geologically-recent times. In places these sands are undergoing semi-active transport and locally have been remobilized into active sandsheets and dunes. Chase & Thomas (2007) have cored Q1 coversands in a regional survey of various settings along the West Coast and applied optically stimulated luminescence (OSL) dating techniques to establish the timing of sand accumulation. Their results indicate several periods of deposition of Q1 during the last 100 ka, with activity/deposition at 63–73, 43–49, 30–33, 16–24 and 4–5 ka. Notably, underlying sands produced dates from ~150 to ~600 ka, reflecting the accumulation of Unit Q2 in the middle Quaternary.

The Springfontyn Formation aeolianites date from at least ~600 ka, if not older and, in parts, may be of similar ages as parts of the Langebaan Fm., but derived from less calcareous sources and/or deposited in settings more prone to subsequent groundwater leaching in water tables. The reworking of older coastal-plain deposits was likely the major sediment source.

The latest addition of dunes to the coastal plain is known as the **Witzand Formation** (Rogers, 1980), for obvious reason (Q5, Figure 2; Qwi, Figure 3). These are sands blown from the beach in the last several thousand years and accumulated in the form of a narrow dune cordon or "sand wall" parallel to the coast, or as dune plumes transgressing a few kilometres inland. The Witzand Formation does not occur in the Project Area.

6 EXPECTED GEOLOGY AND PALAEONTOLOGY

6.1 FOSSILS IN THE MARINE FORMATIONS

Fossil shells (snails, clams, barnacles, corals) are common to abundant in well-preserved marine deposits, but may be limited or dissolved away completely in deposits that have been subject to decalcification by groundwaters. Distinct faunas are associated with the various marine environments such as foreshore, surf-zone, shoreface and shelf deposits. Each marine formation also includes important extinct fossil shell species which are characteristic of that formation and which facilitate correlation of formations over wide regions.

The remains of marine mammals (whales, dolphins, seals), and of seabirds, occur sparsely in the marine deposits. Rolled, petrified bones and teeth of land mammals, which were eroded from older, pre-existing terrestrial deposits, occur in the marine gravels. Fish teeth are quite common, especially shark teeth. The hard parts of crustaceans, such as crab claws, are often present. A large array of trace fossils occur, made by the many animals that dwell within or forage in the sediments.

Microfossils, the minute, sandgrain-size shells of the unicellular foraminifera, are an important component of marine sediments. Analysis of microfossils from coastal marine and aeolian formations on the west and south coasts by micropalaeontologist Dr Ian McMillan has shown that the coastal-plain marine formations, and the aeolianites derived from them, can be distinguished on the basis of foraminiferal assemblages and key species.

6.1.1 The Saldanha Formation

As mentioned above, the oldest, potentially fossil-bearing marine sediments occur on Schuitjies Klip 1/22 where **Saldanha Formation** phosphatic sediments form the eastern flank of Soetlandskop, between 40-100 m asl. (Figure 2). Higher up the flank of Soetlandskop the phosphatic deposits are overlain by the later Miocene Prospect Hill Formation aeolianite (Figures 2 & 3). Roberts & Siegfried (2014) have assigned the phosphatic deposits to the Muishond Fontein Phosphorite Member of the early Pliocene Varswater Fm. (Tmu, Figure 3). However, this correlation is untenable, accepting that the overlying aeolianite is indeed the much older Prospect Hill Formation. Furthermore, the high elevation of these deposits is incompatible with Pliocene sea-level history. The correlation of these deposits with the Saldanha Formation is indicated by (SF) on Figure 3.

The phosphatic material comprises brown sandstones, brown nodules and friable, sandy phosphatic limestone, interbedded with layers of shelly limestone (Visser & Schoch, 1973). This material also crops out lower down beside the drainage in the valley at the Schuitjiesklip werf, indicating that the formation is preserved beneath the Q2 coversands, as is also evident from the presence of phosphatic deposits intersected at depth by drilling (Figure 2, red Ps). More information on the nature of the strata comprising Soetlandskop has recently been provided in a phosphate exploration report by Simón & González (2011). The drilling results indicate that the deposits, up to ~30 m thick, will be intersected on the hill flanks (Figure 4).

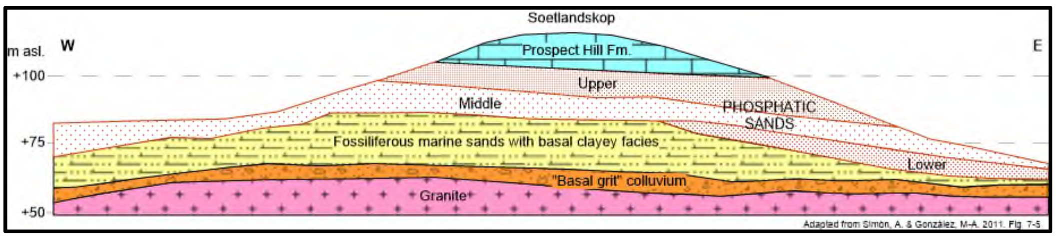

Figure 4: Section through Soetlandskop on Schuitjies Klip 1/22.

Overlying a "Basal Grit" unit of probable colluvial origin is a fossiliferous marine unit which includes beds with marine shell. Aeolian deposits with terrestrial snail shells also occur. The overlying Phosphatic Sands are divided into three units based on phosphatic content, with a phosphate-poor "Middle Zone" separating the Lower and Upper, phosphate-richer zones. It is possible that the Phosphatic Sands represent marine sands that have been reworked into aeolianites.

Significance

Excavations on the eastern flanks of Soetlandskop and vicinity will intersect the outcropping or thinly buried phosphatic deposits. As mentioned, hitherto the phosphatic deposits comprising Soetlandskop have been correlated with the early Pliocene Varswater Formation, but it is suggested here that instead these deposits relate to the high sea levels of the mid-Miocene Warm Period ~16 Ma. The recovery of marine fossils from the Soetlandskop area will resolve the issue and is of importance because the existence of mid-Miocene marine deposits in the Saldanha region, the postulated and elusive Saldanha Formation, has long been debated.

6.1.2 The Varswater Formation

Marine deposits of the early Pliocene Varswater Formation may be preserved in places below ~50 m asl. but are usually buried beneath the aeolianites of the Langebaan Formation. Notably however, the new mapping by Roberts & Siegfried (2014) shows outcrop assigned to the Varswater Formation in the centre of Schuitjies Klip 3/22, assigned to the Muishond Fontein Phosphorite Member (Tmu, Figure 3) and described as "phosphatic, shelly limestone of uncertain stratigraphic affinity drapes a rare marine-cut surface sloping from 20 to 38 m asl.". Situated on the flanks of a drainage interfluve, this outcrop had previously been mapped as phosphatic Langebaan Formation aeolianite (Figure 2).

The correlation of this outcrop with the Varswater Formation by Roberts & Siegfried (2014) is clearly tentative. Nevertheless, marine deposits preserved at these elevations are feasibly of early Pliocene age, but in this context are likely to have been deposited during the retreat of sea level from the early Pliocene sea-level maximum, i.e. are regressive, prograded shoreline deposits. Although this outcrop is correlated with the Muishond Fontein Phosphorite Member by Roberts & Siegfried (2014), on the basis of its phosphatic nature, this unit at the Langebaanweg type locality was evidently deposited in a low-gradient embayment during the preceding rising sea level and is not strictly equivalent to the subsequent regressive deposits that mantled the coastal plain where steeper bedrock gradients and open-coastal, exposed conditions prevailed.

Significance

The new mapping by Roberts & Siegfried (2014) has drawn attention to the presence of an outcrop that has potential to provide new insight into the geological history and fossil heritage of the Saldanha region, in particular the nature of the early Pliocene marine record preserved on the Vredenburg Peninsula, in a setting different to that of the Varswater Formation type locality. The recovery of marine fossils from this outcrop is of importance as these may resolve the issue of the nature and age of this deposit.

6.1.3 The Uyekraal Formation

Outcrops of the late Pliocene (~3 Ma) marine Uyekraal Formation are not mapped in the Project area. Fossil oysters have been found at ~30 m asl. on the northern slopes of Soetlandskop on Duyker Eiland and this occurrence may represent the transgressive maximum palaeoshoreline of the Uyekraal Formation. As with the preceding Varswater Fm., these deposits underlie Langebaan Fm. aeolianites, but are regressive deposits which occur below ~30 m asl. and may overlie the eroded Varswater Formation or granite bedrock.

Significance

This formation may be encountered beneath the aeolianites and coversands that mantle the western parts of Schuitjies Klip 22, Boebezaks Kraal 3/40 and much of Uitkomst RE/6/23. The recovery of marine fossils from excavations in this part of the coastal plain will serve to confirm the predicted presence of this formation.

6.1.4 The Velddrif Formation

A small area is mapped as the Velddrif Formation near the western boundary of Uitkomst RE/6/23 (Figure 3, Qv), where shelly material is evidently exposed at the surface at 6-7 m asl. by deflation of the thin coversand.

Significance

The "raised beach" deposits of the Quaternary Velddrif Formation are quite common fringing the Vredenburg Peninsula. These are mainly rocky-shore, open-coast deposits which are of low palaeontological sensitivity. However, the occurrence on Uitkomst is likely to be lagoonal deposits, with a different shell fossil fauna which is known to include species which no longer occur in the modern fauna. In the event of exposure, the shell fauna must be duly sampled and the sedimentology recorded in order to establish the age of the deposit (LIG?, MIS 11?) and the sea-level applicable to the genesis of the deposit.

6.2 Fossils in the Aeolian Formations

Fossils in the aeolianites (Prospect Hill, Langebaan, Springfontyn fms.) are associated with particular contexts. Many fossils are associated with old, buried surfaces in the aeolianites (palaeosurfaces), usually formed during wetter or less windy periods, with reduced rates of sand accumulation and with soil formation showing the surface stability. The soils may be mere humic horizons formed on a short-lived palaeosurface, and reddened terra rosa soils and pedogenic calcretes formed beneath more persistent palaeosurfaces. The common fossils include shells of various land snails, fossil tortoises, and rodent and mole bones. Larger animal bones (antelopes, zebra, rhino, elephant, pigs, ostriches etc.) are sparsely scattered on palaeosurfaces within aeolianites. Blowout or deflation erosional palaeosurfaces carry fossils concentrated by the removal of sand by the wind, such as land snails and tiny rodent fossils which reflect the palaeoenvironment such as the vegetation type. The interdune areas between dune ridges may host deposits associated with small springs/seeps and marshy vleis which are richly fossiliferous, including fossil plant material, aquatic snails and frogs.

An abundance of trace fossils occur, most obviously the root casts of plants which are associated with palaeosols and buried surfaces. Other common trace fossils include various insect burrows, termitaria, mole burrows and the tracks of animals. In vertical section the animal tracks are recognised by abrupt disturbances of the dune lamination, but they a fortuitously exposed in plan where "flagstone" aeolianite layers have slid away. Where sands were sufficiently firm larger burrows may occur such as those made by aardvarks. These may be subsequently occupied by hyaenas whose bone-collecting behavior results in concentrations of bones of antelopes and carnivores in the lairs. Burrows and grottos formed beneath calcrete layers also provide lairs for the bone collectors, which also include other small carnivores and porcupines.

6.2.1 The Prospect Hill Formation

This formation underlies a large part of Schuitjies Klip 1/22 where it comprises the southern slopes of Soetlandskop (Figures 2 & 3). The fossils recorded hitherto are the aforementioned eggshell fragments of the extinct ostrich *Diamantornis wardi* of later Miocene age, some fossil bones including the extinct three-toed horse *Hipparion*, also of later Miocene age, and poorly-preserved, indeterminate antelope bones. Roberts (1997) notes that the abundance of fossil tortoises in the Prospect Hill Formation Member far exceeds that in the younger, Langebaan Formation aeolianites. Extinct land snails occur, including a giant form of the common land snail *Trigonephrus*.

Significance

The fossil content of the Prospect Hill Formation is based on finds in the Prospect Hill area near Saldanha and no finds are specifically recorded from the formation where it comprises Soetlandskop in and around the northern Project Area. Therefore additional fossil evidence to support the correlation of these Soetlandskop calcreted aeolianites with the Prospect Hill Formation is required. Notably, extinct fossil tortoises are known from the Miocene of Namibia and from the early Pliocene Varswater Formation and tortoises are therefore useful for dating and correlation purposes. However, the identity of the fossil tortoises in the Prospect Hill Formation has not been established.

6.2.2 The Langebaan Formation

Outcrops of this formation occur west of the granitic terrain on Schuitjies Klip 3/22, Uitkomst RE/6/23 and Boebezaks Kraal 3/40 (Figure 2, QC) and it is expected to be present beneath the Q2 and Q1 coversands on these properties. On the later map a more extensive distribution is indicated and denoted as the younger, late Quaternary Kraal Bay Member of the Langebaan Fm. (Figure 3, Qkr). However, older aeolianites overlying the Pliocene marine formations are also likely to be present. Patches of calcrete on the hills of the granitic terrain are also depicted as the Langebaan Formation (Qkr), but although some of these may be remnant patches of aeolianite, many may just be calcrete formed in the weathering profile of the granite.

Significance

The aeolianites of the West Coast, mainly the Langebaan Fm., have been a prime source of information on the Quaternary faunas and archaeology of the Western Cape. Aeolianites do not appear to be very fossiliferous to the cursory eye, but the fossils that have been found are of profound scientific value, further raising international interest in the region.

6.2.3 The Springfontyn Formation

The Springfontyn Formation occurs in two contexts in the Project Area:

- The Granite Hills Terrain – above ~35 m asl. in the east.
- The Uitkomst Embayment – low-gradient coastal plain below ~35 m asl. in the west.

The Granite Hills Terrain comprises farm portions 7 and 9 of Davids Fontyn 18, Het Schuytje 1/21, Frans Vlei 2/46 and portions 2 and 5 of Boebezaks Kraal 40. These are all entirely situated on Q2 "heuweltjiesveld" (Springfontyn Fm.) that mantles the hills of unfossiliferous granites (Figures 2 & 3). Similarly, Q2 soil on granite underlies large parts of portions 1 and 3 of Schuitjies Klip 22, Uitkomst RE/6/23 and Boebezaks Kraal 3/40. The more detailed mapping of the granites (Figure 3) shows outcrops where the overlying Q2 deposits are absent or thin.

In the Uitkomst Embayment (western parts of Schuitjies Klip 22, Uitkomst RE/6/23 and Boebezaks Kraal 3/40) the deposits beneath the Q2 soil thicken down into the drainages to the west (Figure 2). On the lowermost slopes of the granites the subsurface is expected to be dominated by colluvial deposits. Within the drainages the deposits of small fluvial systems will feature. Both colluvial and alluvial sediments will interfinger with the much more widely distributed aeolian deposits that make up the subsurface of Q2 to the west. The fossil potential of the hill-flank deposits is lower than aeolianites, due to probable slow accumulation rates, leaching, pedogenesis and the absence of a high calcareous content to buffer leaching processes that slowly dissolve bone and shell. Notwithstanding, fossil material may occur very sporadically on palaeosurfaces within the colluvium on hill flanks.

Fossils are sparse in the Q1 and Q2 coversands and soils, but fossil bones in a primary context are occasionally discovered and are typically exposed during construction of coastal developments where the finds are large bones that get readily noticed, such as bigger antelopes and buffalo, rhino, hippo, bush pigs and elephants. The fossil bones are often on a palaeosurface underlying the coversands such as the calcreted top of the Langebaan Formation aeolianites, or the Q2 palaeosurface beneath Q1 sands. The bones of an elephant were discovered in the Q2 sands on the Langebaan Golf Estate. Fossil shells and bones in the subsurface of the Q1 and Q2 sands are often in an archaeological context.

Significance

The Granite Hills Terrain slopes which comprise most of the Project Area have low palaeontological sensitivity and thus the bulk earth works for the turbines should have low palaeontological impact in this area. Nevertheless, fossils could occur, such as within the microtopography of the granite formed by weathered-out jointing crevices and perhaps even within ancient seashore potholes and gullies.

The Uitkomst Embayment area, in contrast, has accumulated Springfontyn Fm. sediments and therefore there is greater potential for fossil finds. Nevertheless, there have been few fossil finds in the past from within the surficial coversands and the palaeontological sensitivity is therefore low. It is possible that archaeological material may occur, as indicated by "out of place" marine shell (limpets, mussels), pottery pieces and quartz or silcrete stone tools. An important, potentially fossil-bearing palaeosurface occurs beneath the Q2 unit where it overlies the Langebaan Formation.

7 SIGNIFICANCE

The general significances of coastal-plain fossils involves:

- The history of coastal-plain evolution.
- The history of past climatic changes, past biota and environments.
- Associations of fossils with buried archaeological material and human prehistory.
- For radiometric and other dating techniques (rates of coastal change).
- Preservation of materials for the application of yet unforeseen investigative techniques.

Past discoveries show that the fossil potential within and beneath coversands, dunes and in aeolianites can be very significant. The most well-studied is Elandsfontein, where blowouts of the coversand exposed thousands of underlying fossil bones and Stone Age tools, the occurrence of which is associated with a fossil vlei formed due to higher water tables in the past (Klein *et al*., 2007). Notably, prior to the wind erosion of coversands at Elandsfontein, there would have been no indication of the fossil wealth just below, which included a cranium of the pre-modern human *Homo heidelbergensis*. At Geelbek Dunefield the deflation hollows located between the wind-blown, actively-mobile sand dunes are a source of mammalian fossils and Stone Age tools, with more being constantly exposed (Kandel *et al*., 2003). Examples of hyaena bone accumulations in dens within the partly-lithified dune rocks are the Sea Harvest and Hoedjiespunt sites in Saldanha Bay. Hoedjiespunt is the find site of fossil teeth of a hominid in deposits 200-300 ka old. The Sea Harvest site produced an essentially modern human tooth that is older than 40 ka. Both sites provided considerable samples of the faunas of those times, thanks to the brown hyaenas.

Fossil finds in the Project Area may shed light on the following significant questions concerning aspects of coastal-plain history:

- The age of the higher-lying phosphatic marine deposits in the Saldanha area is controversial, due to the lack of age constraints from fossils. On Schuitjies Klip 1/22, fresh exposures of the postulated Saldanha Formation mid-Miocene phosphatic deposits may provide fossils that are informative.
- The Prospect Hill Formation aeolianites have age constraints in only a few places, none of which are from the northern outcrops on the Vredenburg Peninsula on Schuitjies Klip 1/22.
- The marine Varswater Formation may be represented by reported shelly deposits on Schuitjies Klip 3/22 – fossil confirmation is required.
- The marine Uyekraal Formation must occur, but exposures are not known and it will evidently only be encountered in excavations.

- The aeolian Langebaan Formation in the Project Area is assigned to the late Quaternary Kraal Bay Member (post LIG), but older parts/members must be present, such as where it overlies the Varswater Fm. on Schuitjies Klip 3/22.
- The unit below the Q2 Heuweltjiesveld soil (Sub-Q2) is very poorly known – any fossils or archaeological finds would be an improvement.
- The Velddrif Formation occurrence and fossils in the surface exposure mapped on Uitkomst RE/6/23 lacks observational data.

8 NATURE OF THE IMPACT OF BULK EARTH WORKS ON FOSSILS

Fossils are rare objects, often preserved due to unusual circumstances. This is particularly applicable to vertebrate fossils (bones), which tend to be sporadically preserved and have high value with respect to palaeoecological and biostratigraphic (dating) information. Such fossils are non-renewable resources. Provided that no subsurface disturbance occurs, the fossils remain sequestered there.

When excavations are made they furnish the "windows" into the coastal plain depository that would not otherwise exist and thereby provide access to the hidden fossils. The impact is positive for palaeontology, provided that efforts are made to watch out for and rescue the fossils. Fossils and significant observations will be lost in the absence of management actions to mitigate such loss this loss of the opportunity to recover them and their contexts when exposed at a particular site is irreversible. The status of the potential impact for palaeontology is not neutral or negligible.

Although coastal coversands are not generally very fossiliferous, it is quite possible that fossiliferous material could occur. The very scarcity of fossils makes for the added importance of watching for them.

There remains a medium to high risk of valuable fossils being lost in spite of management actions to mitigate such loss. Machinery involved in excavation may damage or destroy fossils, or they may be hidden in "spoil" of excavated material.

8.1 EXTENT

The physical extent of impacts on potential palaeontological resources relates directly to the extent of subsurface disturbance.

The cultural, heritage and scientific impacts are of regional to national extent, as is implicit in the NHRA 25 (1999) legislation and, if scientifically important specimens or assemblages are uncovered, are of international interest. This is evident in the amount of foreign-funded research that takes place by scientists of other nationalities. Loss of opportunities that may arise from a significant fossil occurrence (tourism, employment) filters down to regional/local levels.

8.2 DURATION

The initial duration of the impact is shorter term (~year) and primarily related to the period over which the excavations are made. This is the "time window" for mitigation.

The impact of both the finding or the loss of fossils is permanent. The found fossils must be preserved "for posterity"; the lost, overlooked or destroyed fossils are lost to posterity.

8.3 INTENSITY

The intensity of the potential impact of bulk earthworks on fossil resources is determined by the palaeontological sensitivity of the affected formations. Allied to this is the scale of the intended earthworks. Overall, the palaeontological sensitivity of coastal-plain deposits is HIGH (Almond & Pether, 2008; Appendix 1) due to previous fossil finds of high scientific importance.

The Project Area encompasses two terrains (Figure 5):

- The eastern **Granitic Hills Terrain** which lacks significant coastal-plain deposits other than a soil mantle and which is of low palaeontological sensitivity.
- The western **Coastal Formations Terrain** of high palaeontological sensitivity which includes the Miocene formations forming Soetlandskop in the north and the Pliocene to Recent formations which infill the Uitkomst Embayment, where the intensity of impact will be high in the absence of effective mitigation.

8.4 PROBABILITY

In the **Granitic Hills Terrain** the likelihood of fossil finds is improbable. In the **Coastal Formations Terrain** the likelihood of fossil finds is probable.

8.5 CONFIDENCE

The level of confidence of the probability and intensity of impact on the coastal-plain deposits is medium to high.

8.6 CUMULATIVE IMPACT

The cumulative result of coastal developments is the inevitable permanent loss of fossils. Conversely, with due attention to mitigation and the successful rescue of fossils, there is an accumulation of scientific evidence and knowledge about the palaeoenvironments of the past, the evolution of the southern African fauna and the contexts of our prehistoric ancestors.

9 SUMMARY SCOPING IMPACT TABLE

Table 4: Summary of Impacts.

Impact			
The Project Area is mostly comprised of the Granitic Hills Terrain of low sensitivity where the potential impact is low. The Coastal Formations Terrain in the western portion of the Project Area is of high sensitivity where the potential impact is high. The construction of the proposed Boulder Wind Farm will result in a direct, negative impact on palaeontological/scientific heritage in the absence of effective mitigation. With successful mitigation the impact should be positive.			
Issue	**Nature of Impact**	**Extent of Impact**	**No-Go Areas**
Excavation into fossiliferous deposits.	Permanent loss of fossil heritage and allied geo-scientific data.	Cultural, heritage and scientific impacts are of regional to national extent.	Not identified. Excavations may provide useful exposures.
Reversibility	The loss of fossil material is irreversible.		
Irreplaceability	The loss of fossil material is irreplaceable.		
Mitigation	With due mitigation the impact can be partly mitigated – valuable fossil may be lost in spite of mitigation.		
Knowledge gaps & further study			
This review has identified several aspects of the stratigraphy and fossil heritage in the Project Area which require investigation and which would be informed by mitigation at sensitive locations.			

10 SUMMARY AND RECOMMENDATIONS

The Granitic Hills Terrain (Figure 5) is of low palaeontological sensitivity and the potential impact of the proposed development in that area is low. It is therefore the preferred location for the proposed wind turbines. Even so, there is a small probability that fossils could be uncovered. As part of the EMPr for the Construction Phase of the project, construction staff must be informed to be alert for and report occurrences of bones and shells or other unusual objects (Appendix 2). The Fossil Finds Procedure (Appendix 3) which is applicable to all earth works, must be included in the EMPr for the Construction Phase of the proposed WEF.

The Coastal Formations Terrain is of high palaeontological sensitivity and the potential impact of the proposed development in that area is high. Nevertheless, excavations in this area are acceptable with due mitigation. All excavations in this area must be inspected by the contracted palaeontologist. The aim of field inspection is to examine a representative sample of the various deposits exposed in the turbine excavations, recording context, fossil content and to take samples of the fossils and sediments, thereby providing a positive benefit.

Should any wind turbines be sited in the Coastal Formations Terrain, where fossil shell beds may be intersected in excavations, the specifics of setting up a monitoring and inspection programme will be agreed between the developer, the ECO and construction contractors, where it is important to liaise with respect to the scheduling of excavations.

No further pre-construction study is required for the Boulders Wind Farm subject to the inclusion of the specialist recommendations in the Environmental Management Programme (Appendices 2 & 3).

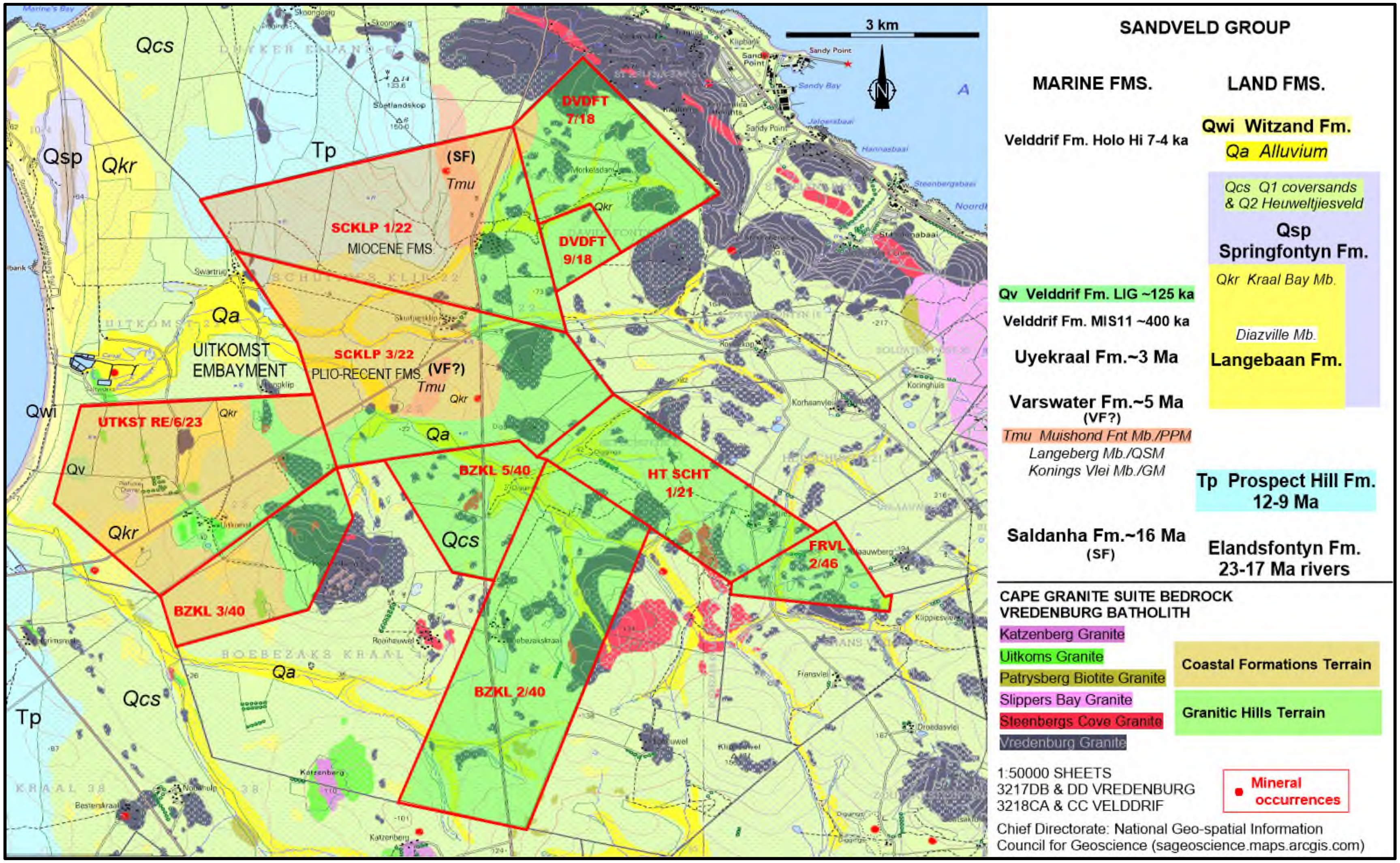

Figure 5: Geological map with palaeontological sensitivity terrains.

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12 APPENDIX 1. PALAEONTOLOGICAL SENSITIVITY RATING

Palaeontological Sensitivity refers to the likelihood of finding significant fossils within a geologic unit.

HIGH: Assigned to geological formations known to contain palaeontological resources that include rare, well-preserved fossil materials important to on-going palaeoclimatic, palaeobiological and/or evolutionary studies. Fossils of land-dwelling vertebrates are typically considered significant. Such formations have the potential to produce, or have produced, vertebrate remains that are the particular research focus of palaeontologists and can represent important educational resources as well.

MODERATE: Formations known to contain palaeontological localities and that have yielded fossils that are common elsewhere, and/or that are stratigraphically long-ranging, would be assigned a moderate rating. This evaluation can also be applied to strata that have an unproven, but strong potential to yield fossil remains based on its stratigraphy and/or geomorphologic setting.

LOW: Formations that are relatively recent or that represent a high-energy subaerial depositional environment where fossils are unlikely to be preserved, or are judged unlikely to produce unique fossil remains. A low abundance of invertebrate fossil remains can occur, but the palaeontological sensitivity would remain low due to their being relatively common and their lack of potential to serve as significant scientific resources. However, when fossils are found in these formations, they are often very significant additions to our geologic understanding of the area. Other examples include decalcified marine deposits that preserve casts of shells and marine trace fossils, and fossil soils with terrestrial trace fossils and plant remains (burrows and root fossils)

MARGINAL: Formations that are composed either of volcaniclastic or metasedimentary rocks, but that nevertheless have a limited probability for producing fossils from certain contexts at localized outcrops. Volcaniclastic rock can contain organisms that were fossilized by being covered by ash, dust, mud, or other debris from volcanoes. Sedimentary rocks that have been metamorphosed by the heat and pressure of deep burial are called metasedimentary. If the meta sedimentary rocks had fossils within them, they may have survived the metamorphism and still be identifiable. However, since the probability of this occurring is limited, these formations are considered marginally sensitive.

NO POTENTIAL: Assigned to geologic formations that are composed entirely of volcanic or plutonic igneous rock, such as basalt or granite, and therefore do not have any potential for producing fossil remains. These formations have no palaeontological resource potential.

Adapted from Society of Vertebrate Paleontology. 1995. Assessment and Mitigation of Adverse Impacts to Nonrenewable Paleontologic Resources - Standard Guidelines. News Bulletin, Vol. 163, p. 22-27.

13 APPENDIX 2. BASIC MEASURES FOR THE CONSTRUCTION EMPR.

OBJECTIVE: To see and rescue fossil material that may be exposed in the various excavations made for installation foundations and cabling.		
Project components	Foundation excavations for wind turbines. Foundation excavations for substations. Trenches for cabling linking turbines and substations. Spoil from excavations.	
Potential impact	Loss of fossils by their being unnoticed and/ or destroyed.	
Activity/ risk source	All bulk earthworks.	
Mitigation: target/ objective	To facilitate the likelihood of noticing fossils and ensure appropriate actions in terms of the relevant legislation.	
Mitigation: Action/ control	**Responsibility**	**Timeframe**
Inform staff of the need to watch for potential fossil occurrences.	Boulders Wind Farm, ECO, contractors.	Pre-construction.
Inform staff of the procedures to be followed in the event of fossil occurrences.	ECO/specialist.	Pre-construction.
Monitor for presence of fossils	Contracted personnel and ECO.	Construction.
Liaise on nature of potential finds and appropriate responses.	ECO and specialist.	Construction.
Excavate main finds, inspect pits & record selected, key/higher-risk excavations.	Specialist.	Construction.
Obtain permit from HWC for finds.	Specialist.	Construction
Performance Indicator	Reporting of and liaison about possible fossil finds. Fossils noticed and rescued.	
Monitoring	Due effort to meet the requirements of the monitoring procedures.	

14 APPENDIX 3. FOSSIL FIND PROCEDURES

14.1 MONITORING

A constant monitoring presence over the period during which excavations for developments are made, by either an archaeologist or palaeontologist, is generally not practical.

The field supervisor/foreman and workers involved in digging excavations must be encouraged and informed of the need to watch for potential fossil and buried archaeological material. Workers seeing potential objects are to report to the field supervisor who, in turn, will report to the ECO. The ECO will inform the archaeologist and/or palaeontologist contracted to be on standby in the case of fossil finds.

To this end, responsible persons must be designated. This will include hierarchically:

- The field supervisor/foreman, who is going to be most often in the field.
- The Environmental Control Officer (ECO) for the project.
- The Project Manager/Site Agent.

Should the monitoring of the excavations be a stipulation in the Archaeo-logical Impact Assessment, the contracted Monitoring Archaeologist (MA) can also monitor for the presence of fossils and make a field assessment of any material brought to attention. The MA is sufficiently informed to identify potential fossil material and liaise with the palaeontologist and this avoids additional costs to monitoring by a palaeontologist.

14.2 FOSSIL FINDS

The procedures below are couched in terms of finds of fossil bones and teeth that usually occur sparsely in coastal-plain formations and have high scientific value.

Fossil bones in poorly-consolidated deposits are usually fragile and disintegrate upon being dug up, appearing as loose fragments in the excavated material and in the cut side of the excavation. In cemented deposits such as sandstones and calcretes, the fossil bone parts are embedded in broken chunks of rock and are more difficult to spot. A few bits of broken bones or teeth may not seem very important, but the animal represented by the fragments, still living today or extinct, can often be identified by the fossil specialist. This identification then contributes to the knowledge of the landscapes of the past by providing an indication of the age of the enclosing bed and the environment back then.

In most contexts it is improbable that fossil finds will require declarations of permanent "No Go" zones. A temporary pause in activity at a limited locale is usually required. The strategy is to rescue the material as quickly as possible.

14.3 PROCEDURE FOR FOSSIL FINDS

In the process of digging the excavations fossil bones may be spotted in the hole sides or bottom, or as they appear in excavated material on the spoil heap.

Response by personnel in the event of bone finds:

- Stop work! The site foreman and ECO must be informed.
- Protect the find site from further disturbance and safeguard all fossil material in danger of being lost such as in the excavator bucket and scattered in the spoil heap.
- The ECO or site agent must immediately inform Heritage Western Cape (HWC) and/or the contracted standby palaeontologist of the find and provide via email the information about the find, as detailed below.
  - o Date
  - o Position of the excavation (GPS) and depth.
  - o A description of the nature of the find.
  - o Digital images of the excavation showing vertical sections (sides) and the position of the find showing its depth/location in the excavation.
  - o A reference scale must be included in the images (tape measure, ranging rod, or object of recorded dimensions).
  - o Close-up, detailed images of the find (with scale included).

Heritage Western Cape has provided a Recording Form which is included overleaf and is also available from:
http://www.sahra.org.za/sahris/sites/default/files/heritagereports/HWC%20Procedure%20Chance%20finds%20of%20Palaeontological%20Material%20June%202016.pdf

Heritage Western Cape (HWC) and/or the contracted standby palaeontologist will assess the information and a suitable response will be established which will be reported to the developer and the ECO, such as whether rescue excavation or rescue collection by a palaeontologist is necessary.

The response time/scheduling of the rescue fieldwork is to be decided in consultation with developer/owner and the ECO. It will probably be feasible to "leapfrog" the find proceed to the next excavation, or continue a trench excavation farther along, so that the work schedule and machine time is minimally disrupted.

It is suggested that the name/s of the person/s who spotted the fossil should be recorded and additional photographs be taken of the person/s at the find. This is for due recognition to be recorded with the find and, if the find proves newsworthy, for publicity purposes.

14.4 APPLICATION FOR A PERMIT TO EXCAVATE AND COLLECT

A permit from Heritage Western Cape is required to excavate fossils. The applicant should be the qualified specialist responsible for assessment, collection and reporting (palaeontologist).

Should fossils be found that require rapid collecting an application for a palaeontological permit must be made to HWC immediately.

In addition to the information and images of the find, the application requires details of the registered owners of the sites, their permission and a site-plan map.

All fossils must be deposited at a SAHRA-approved institution.

14.5 Recording Form

FOSSIL DISCOVERIES: HWC PRELIMINARY RECORDING FORM		
Name of project & developer:		
Name of fossil location:		
Date of discovery:		
Description of situation in which the fossil was found:		
Description of context in which the fossil was found:		
Description and condition of fossil identified:		
GPS coordinates:	Lat:	Long:
If no co-ordinates available then please describe the location:		
Time of discovery:		
Depth of find in hole		
Photographs (tick as appropriate and indicate number of the photograph)	Digital image of vertical section (side)	
	Fossil from different angles	
	Wider context of the find	
Temporary storage (where it is located and how it is conserved)		
Person identifying the fossil	Name: Contact:	
Recorder	Name: Contact:	
Photographer	Name: Contact:	