HWC INTERIM CASE NO. 24102123

PALAEONTOLOGICAL IMPACT ASSESSMENT

PROPOSED VAN DYKSBAAI RESIDENTIAL DEVELOPMENT ON ERVEN 1469 1470 1471 1473 & 1479

Gansbaai, Overstrand Municipality, Hermanus Magisterial District, Western Cape

APPLICANT
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18 NOVEMBER 2024

EXECUTIVE SUMMARY

1. Site Name

Proposed Van Dyksbaai Residential Development on erven 1469, 1470, 1471, 1473 and 1479.

2. Location

Van Dyksbaai is south of Gansbaai on the Gansbaai-Danger Point promontory at the coast between Kleinbaai and Franskraalstrand (Figure 1).

3. Locality Plan

The Site Development Plan is presented in Figure 3.

4. Proposed Development

The subdivision of the erven into 123 residential plots (~6.72 ha) and ~2.65 ha of Open Space (Figure 3). It is assumed that the development entails conventional building construction methods, with wall foundations in wider trenches suitable for bearing on the sandy substratum. Trenches along the roads will be required for connections to municipal services for water, electricity, wastewater/sewerage and stormwater run-off diversion.

Minor amendments of the layout of the residential SDP do not affect the recommendations of this PIA report.

5. Affected Formations

The development area is on vegetated dunes of the Holocene **Strandveld Formation** which overlie older calcified dunes of the mid to late Quaternary **Waenhuiskrans Formation** (Figure 5).

6. Anticipated Impacts

The intensity or magnitude of impact relates to the palaeontological sensitivities of the affected formations (Appendix 1) and the volume of disturbance by excavation. The proposed development involves trenches for building foundations (0.6-1.0 m depth) and services infrastructure (1.0-2.0 m depth).

Due to its young Holocene age the **Strandveld Fm. dunes** typically host Late Stone Age archaeological material and the bones of “modern” (extant) animals which, not being very old, are termed “subfossils”. The large bones of elephant, rhino, and hippo who died in the Strandveld Fm. dunes have occasionally been uncovered during sand quarrying and developments, but are apparently rare finds. Deflation and passage of the Strandveld dunes would have moved embedded material down onto deflation palaeosurfaces and deeper down onto the underlying palaeosurface on top of the calcreted and cemented Waenhuiskrans Fm.

The subfossil bones are expected to be of latest Quaternary, later Holocene age (mainly less than about 7 thousand years old) and are likely to be mainly members of the extant, modern fauna, but unexpected species which do not belong to the modern/historical fauna may occur, due to fluctuations in the prehistoric palaeoclimate of the region. Due to its proximity to the coast the MODERATE rating of the Strandveld Fm. on the proposed development site is endorsed (Appendix 1).

The fossil bones that may occur in the **Waenhuiskrans Fm**. in the Project Area are expected to be of late-middle to earlier-late Quaternary age, between ~170 to ~80 ka (Figure 4) and, like the later Strandveld Fm. dunes sands, also mainly comprised of representatives of the extant fauna, but unexpected species of a different fauna are more likely to occur, as a result of phases of different ecological and palaeoclimatic conditions in the past, as well as the bones of some species which became extinct in the geologically-recent past. Intersections of the upper, variously calcreted Waenhuiskrans Fm. in earthworks are expected to be limited in volume relative to the affected volume of overlying dune coversands.

The later-mid Quaternary to present day faunas are fairly well known from archaeological sites and hyaena bone accumulations and additional finds are considered to be of moderate scientific importance, *i.e*. 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 sensitivity rating (Appendix 1

7. Recommendations

The possible presence of fossils in the subsurface does not have an a priori influence on the decision to proceed with the proposed development and there are no NO-GO Zones identified. The potential impact has a moderate influence upon the proposed project, consisting of implemented mitigation measures recommended below, to be followed during the Construction Phases.

Although the inspection of construction excavations may be specified in the Archaeological Impact Assessment, it is not feasible for a specialist monitor to be continuously present during the Construction Phases, when fossil bones may be unearthed at any time. For successful mitigation, it is therefore crucial that earth works personnel must be involved in mitigation by watching for fossil bones as excavations are being made. It is recommended that a protocol for finds of buried fossil bones, the Fossil Finds Procedure (FFP) (Appendix 2), is included in the Environmental Management Plan (EMP) for the proposed development.

The field supervisor/foreman and workers involved in excavations must be informed of the need to watch for fossil bones and archaeological material. Workers seeing potential objects are to cease work at that spot and to report to the works supervisor who, in turn, will report to the Environmental Control Officer (ECO) and/or the Developer. The ECO/Developer will contact and liaise with Heritage Western Cape and the standby archaeologist or palaeontologist on the nature of the find and suitable consequent actions such as immediate site inspection, application for a palaeontological collection permit and drafting of a work plan for the collection of the find.

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COMPLIANCE WITH APPENDIX 6 OF THE 2014 EIA REGULATIONS

Requirements of Appendix 6 – GN R326 (7 April 2017)	Addressed in the Specialist Report
1. (1) A specialist report prepared in terms of these Regulations must contain- a) details of- i. the specialist who prepared the report; and ii. the expertise of that specialist to compile a specialist report including a curriculum vitae;	vi.
b) a declaration that the specialist is independent in a form as may be specified by the competent authority;	v.
c) an indication of the scope of, and the purpose for which, the report was prepared;	Section 1.
(cA) an indication of the quality and age of base data used for the specialist report;	Sections 5, 7 & 13.
(cB) a description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change;	Sections 10 - 12.
d) the duration, date and season of the site investigation and the relevance of the season to the outcome of the assessment;	N/A
e) a description of the methodology adopted in preparing the report or carrying out the specialised process inclusive of equipment and modelling used;	Section 5.
f) details of an assessment of the specific identified sensitivity of the site related to the proposed activity or activities and its associated structures and infrastructure, inclusive of a site plan identifying alternatives;	Sections 8 - 11.
g) an identification of any areas to be avoided, including buffers;	N/A
h) a map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers;	Figures 2, 5 & 8.
i) a description of any assumptions made and any uncertainties or gaps in knowledge;	Section 6.
j) a description of the findings and potential implications of such findings on the impact of the proposed activity or activities;	Sections 8 – 11.
k) any mitigation measures for inclusion in the EMPr;	Section 12 & App. 2.
l) any conditions for inclusion in the environmental authorisation;	Section 12.
m) any monitoring requirements for inclusion in the EMPr or environmental authorisation;	Section 12 & App. 2.
n) a reasoned opinion- i. whether the proposed activity, activities or portions thereof should be authorised; (iA) regarding the acceptability of the proposed activity and activities; and ii. if the opinion is that the proposed activity, activities or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the EMPr, and where applicable, the closure plan;	Sections 11 & 12.
o) a description of any consultation process that was undertaken during the course of preparing the specialist report;	Not Applicable
p) a summary and copies of any comments received during any consultation process and where applicable all responses thereto; and	Not Applicable
q) any other information requested by the competent authority.	Not Applicable
2. Where a government notice gazetted by the Minister provides for any protocol of minimum information requirement to be applied to a specialist report, the requirements as indicated in such notice will apply	Site sensitivity verification requirements where a specialist assessment is required but no specific assessment protocol has been prescribed. **See Appendix 1**.

DECLARATION OF INDEPENDENCE

PALAEONTOLOGICAL IMPACT ASSESSMENT

PROPOSED VAN DYKSBAAI RESIDENTIAL DEVELOPMENT ON ERVEN 1469 1470 1471 1473 & 1479

Gansbaai, Overstrand Municipality, Hermanus Magisterial District, Western Cape

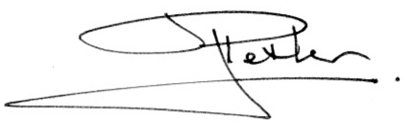
Terms of Reference

This assessment forms part of the Heritage Assessment and it assesses the overall palaeontological (fossil) sensitivities of formations underlying the 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: 18 November 2024

CURRICULUM VITAE

John Pether, M.Sc., Pr. Sci. Nat. (Earth Sci.)

Independent Consultant/Researcher recognized as an authority with 38 years' experience in the field of coastal-plain and continental-shelf palaeoenvironments, fossils and stratigraphy, mainly involving the West Coast/Shelf of southern Africa. Has been previously employed in academia (South African Museum) and industry (Trans Hex, De Beers Marine). At present an important involvement is in Palaeontological Impact Assessments (PIAs) and mitigation projects in terms of the National Heritage Resources Act 25 (1999) (~350 PIA reports to date) and is an accredited member of the Association of Professional Heritage Practitioners (APHP). Continues to be involved as consultant to offshore and onshore marine diamond exploration ventures. Expertise includes:

- Coastal plain and shelf stratigraphy (interpretation of open-pit exposures, on/offshore cores and exploration drilling).
- Sedimentology and palaeoenvironmental interpretation of shallow marine, aeolian and other terrestrial surficial deposits.
- Marine macrofossil taxonomy (molluscs, barnacles, brachiopods) and biostratigraphy.
- 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.
- Association of Professional Heritage Practitioners (APHP), Western Cape. Accredited Member No. 48.

Past Clients Palaeontological Assessments

AECOM SA (Pty) Ltd.	Guillaume Nel Environmental Management Consultants.
Agency for Cultural Resource Management (ACRM).	Klomp Group.
AMATHEMBA Environmental.	Megan Anderson, Landscape Architect.
Anél Blignaut Environmental Consultants.	Ninham Shand (Pty) Ltd.
Arcus Gibb (Pty) Ltd.	PD Naidoo & Associates (Pty) Ltd.
ASHA Consulting (Pty) Ltd.	Perception Environmental Planning.
Aurecon SA (Pty) Ltd.	PHS Consulting.
BKS (Pty) Ltd. Engineering and Management.	Resource Management Services.
Bridgette O'Donoghue Heritage Consultant.	Robin Ellis, Heritage Impact Assessor.
Cape Archaeology, Dr Mary Patrick.	Savannah Environmental (Pty) Ltd.
Cape EAPrac (Cape Environmental Assessment Practitioners).	Sharples Environmental Services cc
CCA Environmental (Pty) Ltd.	Site Plan Consulting (Pty) Ltd.
Centre for Heritage & Archaeological Resource Management (CHARM).	SRK Consulting (South Africa) (Pty) Ltd.
Chand Environmental Consultants.	Strategic Environmental Focus (Pty) Ltd.
CK Rumboll & Partners.	UCT Archaeology Contracts Office (ACO).
CNdV Africa	UCT Environmental Evaluation Unit
CSIR - Environmental Management Services.	Urban Dynamics.
Digby Wells & Associates (Pty) Ltd.	Van Zyl Environmental Consultants
Enviro Logic	Western Cape Environmental Consultants (Pty) Ltd, t/a ENVIRO DINAMIK.
Environmental Resources Management SA (ERM).	Wethu Investment Group Ltd.
Greenmined Environmental	Withers Environmental Consultants.

Stratigraphic consulting including palaeontology

Afri-Can Marine Minerals Corp	Council for Geoscience
De Beers Marine (SA) Pty Ltd.	De Beers Namaqualand Mines.
Geological Survey Namibia	IZIKO South African Museum.
Namakwa Sands (Pty) Ltd	NAMDEB

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 (alluvial).

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.

asl.: above (mean) sea level.

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, such as shells and shell fragments.

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.

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.

Conglomerate: A cemented gravel deposit.

Coversands: Aeolian blanket deposits of sandsheets and smaller dunes.

Fluvial deposits: Sedimentary deposits consisting of material transported by, suspended in and laid down by a river or stream.

Fm.: Formation.

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.

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).

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, MIS 1 in the scale, stages with even numbers representing cold glacial periods, while the odd-numbered stages represent warm interglacial intervals (see Figure 4).

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.

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.*).

Pedocrete: A duricrust formed by pedogenic processes.

PIA: Palaeontological Impact Assessment.

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.

Stratotype locality: The place where deposits regarded as defining the characteristics of a particular geological formation occur.

Tectonic: Relating to the structure of the earth's crust and the large-scale processes which take place within it (faulting and earthquakes, crustal uplift or subsidence.

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).

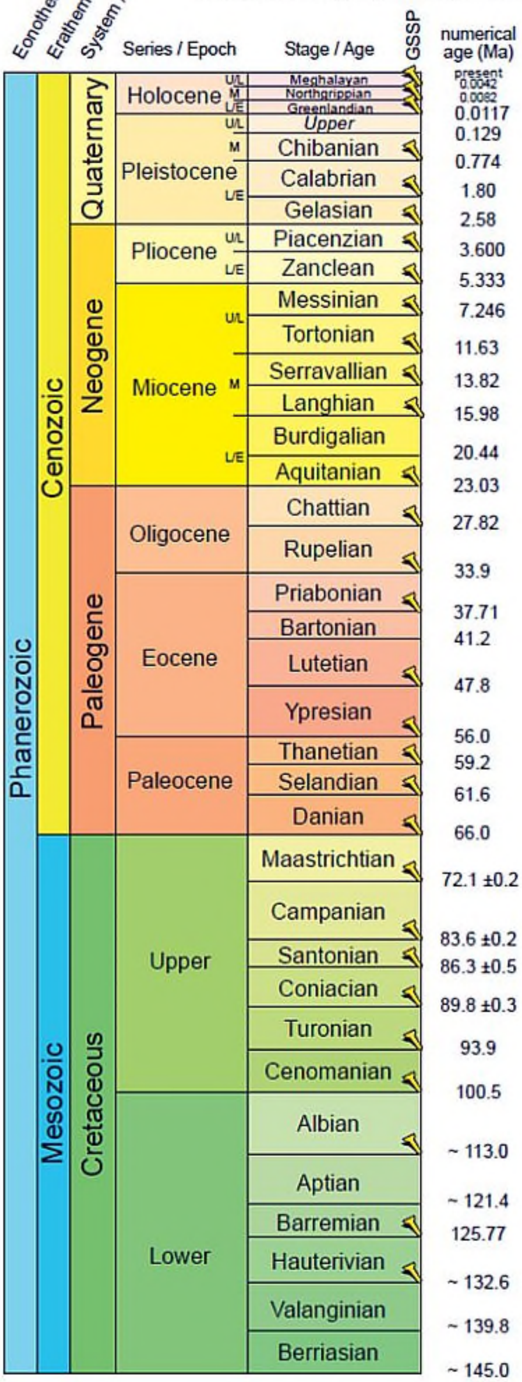
GEOLOGICAL TIME SCALE TERMS

For more detail see www.stratigraphy.org.

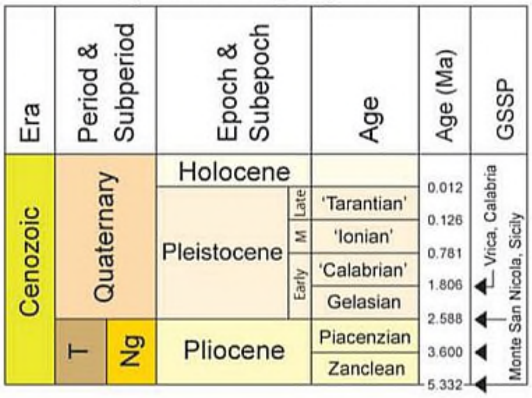
ka: Thousand years or kilo-annum (10^3 years). Implicitly means “ka ago” *i.e*. duration from the present, but “ago” is omitted. The “Present” refers to 1950 AD. Not used for durations not extending from the Present. For a duration only “kyr” is used.

Ma: Millions years, mega-annum (10^6 years). Implicitly means “Ma ago” *i.e.* duration from the present, but “ago” is omitted. The “Present” refers to 1950 AD. Not used for durations not extending from the Present. For a duration only “Myr” is used.

Mesozoic and Cenozoic Chronostratigraphy
From: International Commission on Stratigraphy.
Chronostratigraphic Chart 2023/06.pdf



ICS-approved 2009 Quaternary (SQS/INQHA) Proposal



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.

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.

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1. INTRODUCTION

The Applicant, K.J. McMahon of the JP Gemert Testamentary Trust, proposes to construct a residential development on erven 1469, 1470, 1471, 1473 and 1479, just south of Gansbaai at Van Dyksbaai (Figure 1). Lornay Environmental Consulting is undertaking the Environmental Impact Assessment (EIA) Report for the proposed development. The Agency for Cultural Resource Management (ACRM) has been appointed to undertake the Heritage Impact Assessment (HIA). This Palaeontological Assessment is part of the HIA and is to inform about the palaeontological sensitivities of the Project Area and the probability of fossils being uncovered in the subsurface and being disturbed or destroyed during the Construction Phase of the proposed development.

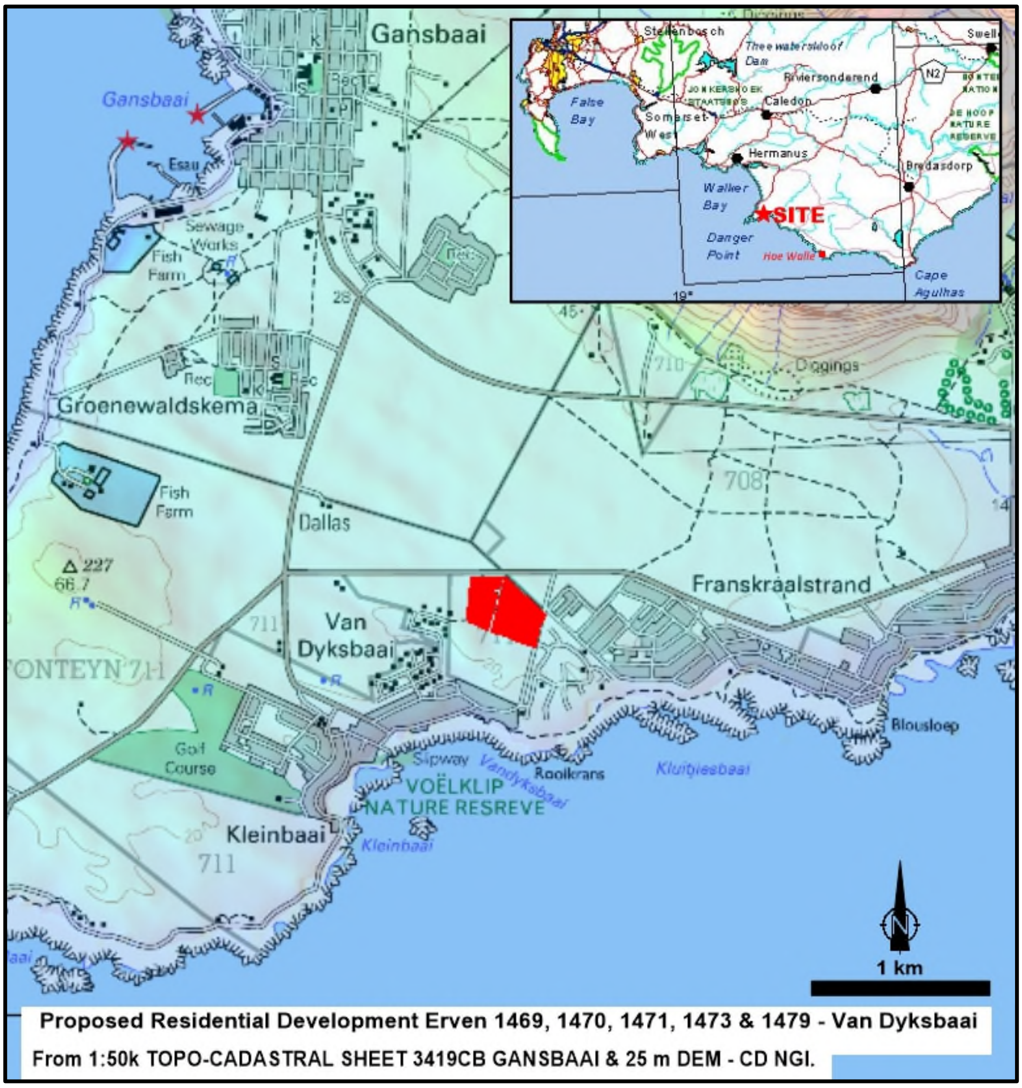


Figure 1. Location of the proposed residential development Project Area.

2. LOCATION

The proposed development is approached via the R43 through Gansbaai and the turnoff south to Kleinbaai (Figure 1). Farther on is the turnoff east to Franskraal via Dyer Street and a short distance on is Van Dyk Street and the Project Area (Figure 2).

Centre co-ordinates of the proposed development area: -34.608610°S / 19.362596°E.

Figure 2. The erven for the proposed residential development in Van Dyksbaai.

3. DESCRIPTION OF THE PROPOSED ACTIVITY

The proposed Site Development Plan (SDP) for the development is presented in Figure 3. Minor amendments of the layout of the residential SDP do not affect the recommendations of this PIA report.

It is proposed that the erven be rezoned from Agricultural and subdivided into 123 residential plots (~6.72 ha) and ~2.65 ha of Open Space (Figure 3).

It is assumed that the development entails conventional building construction methods, with wall foundations in wider trenches suitable for bearing on the sandy substratum.

Trenches along the roads will be required for connections to municipal services for water, electricity, wastewater/sewerage and stormwater run-off diversion.

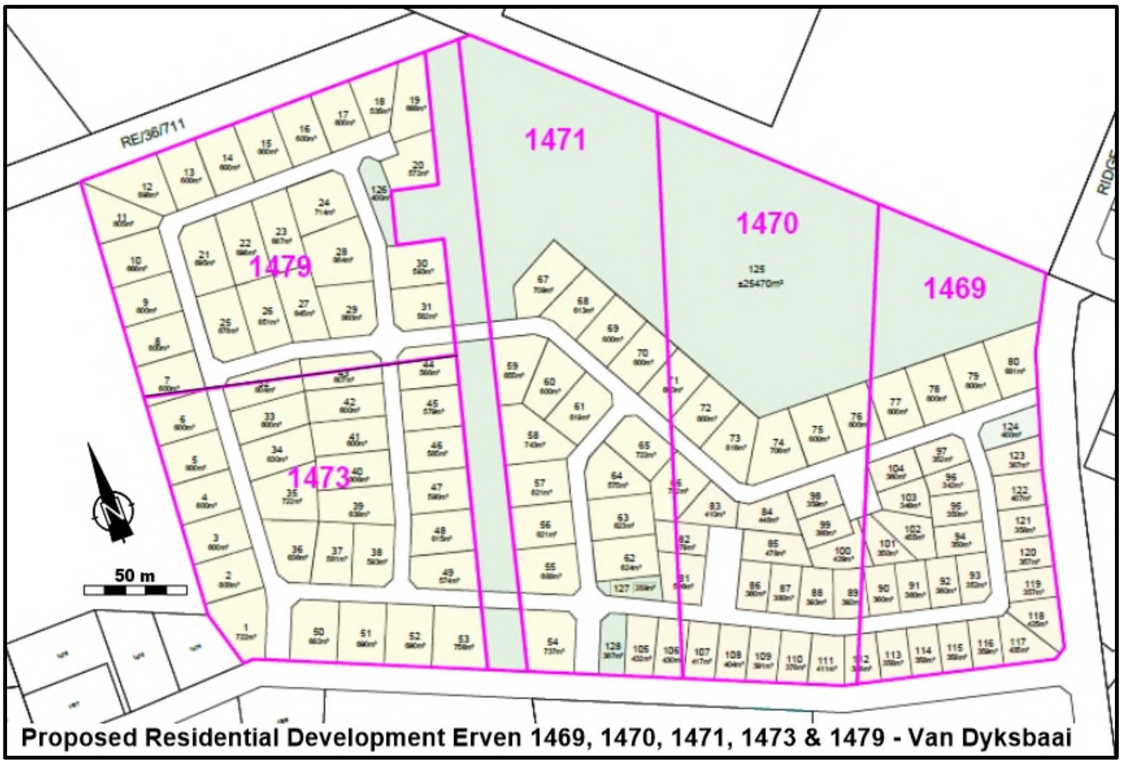


Figure 3. Site Development Plan.

4. 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. According to the Act (Sect. 35), it is an offence to destroy, damage, excavate, alter of 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). If the areal scale of subsurface disturbance and exposure exceeds 300 m in linear length and 5000 m^2 (0.5 ha) (NHRA 25 (1999), Section 38 (1)), the development must be assessed for heritage impacts (an HIA) that may include an assessment of palaeontological heritage (a PIA).

5. METHODOLOGY

As a desktop study, this report relies on the author's familiarity with the scientific literature pertaining to the geology and palaeontology of the coastal plains, together with own observations. The main geological information pertinent to the site is from Gresse & Theron (1992) and the relevant geological map (3319 Worcester), part of which is reproduced in Figure 5. Other sources include Thamm & Johnson (2006). A general introduction to the Bredasdorp Group coastal plain deposits is Roberts *et al*. (2006). Additional relevant articles will be cited in the normal manner in the text and included in the References section.

6. GAPS, ASSUMPTIONS AND UNCERTAINTIES

The assumption is that the fossil potential of a formation in the Project Area will be typical of that found in the region and more specifically, similar to that already observed in the surrounds of the Project Area. In many cases the information on fossil content is limited to the basics, such as in the case of geological mapping when the fossils are not the immediate focus. Scientifically important fossil bone material is expected to be sparsely scattered in coastal-plain deposits, but unless large and obvious, is not generally seen, under-estimating the fossil prevalence. Much depends on careful scrutiny of exposures and on spotting fossils as they are uncovered during digging *i.e.* by monitoring excavations. 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 general terms.

Note that different types of fossils occur in a single formation which differ in their scientific/palaeontological importance. The fossil bones and teeth of vertebrate animals are always of high palaeontological sensitivity and scientific importance and generally occur quite sparsely in deposits. For example, in aeolian formations the scarce fossil bones are rated HIGH, while fossil shells of land snails and the trace fossils made by termite burrowing are commonly present and are of LOW palaeontological sensitivity.

7. REGIONAL GEOLOGICAL SETTING

7.1 THE BEDROCK

The bedrock of the surrounding area consists of **Table Mountain Group** (**TMG**) formations (Figure 5) , well known for considerable thicknesses of well-lithified sandstones that comprise the mountain ranges of the Cape Fold Belt, exemplified by the steep-sided Franskraal se Berge. Extending seawards from the abrupt slope break at 50 m asl. at the foot of the mountain is a gently-sloping coastal plain which is a marine-cut platform, eroded and planed off during high sea levels when ancient shorelines lapped around the Franskraal se Berge.

The bedrock of the area is the **Peninsula Formation** of the Table Mountain Group which is exposed along the shoreline and inland (Figure 5, Ope). The Peninsula Fm. is of early Ordovician age (490-470 Ma) (Ma = million years ago) and is mainly comprised of fluvial quartzitic sandstones and conglomerates which were deposited by numerous braiding river courses that wandered across vast alluvial plains, unrestricted by the sediment binding of vegetated banks as land plants were only just beginning to appear. Hitherto only trace fossils (burrows and tracks) have been recorded from the Peninsula Formation.

7.2 THE BREDASDORP GROUP

7.2.1 Mio-Pliocene Marine Formations

The Bredasdorp Group encompasses the Cenozoic deposits (younger than 66 Ma) which overlie the eroded surfaces of the aforementioned bedrock strata which were bevelled by marine erosion during transgressions by high sea levels. The associated marine deposits preserved in the southern Cape are the shelly calcareous sands and conglomerates of the **De Hoopvlei Formation**. The De Hoopvlei Formation is actually a composite “formation group” made up of marine formations of different ages which relate to periods of global warming which substantially melted polar ice and raised sea level. These are the Mid-Miocene Climatic Optimum ~16-15 Ma, the Early Pliocene Warm Period ~5-4 Ma and the Late Pliocene Warm Period ~3.0 Ma. The maximum palaeoshorelines altitudes attained are the result of a combination of the actual sea levels plus uplift of the subcontinent. The highest elevation marine deposits of the De Hoopvlei Fm. extend seawards from a highstand of sea level at ~110 m asl. and are of mid-Miocene age, those below ~60 m asl. are of early Pliocene age and marine deposits below ~30 m asl. are of late Pliocene age. The De Hoopvlei Fm. beneath the Gansbaai area are the latter late Pliocene marine deposits.

7.2.2 Mio-Pliocene Aeolianites

During and after the withdrawal of the marine inundations a huge pile of ancient dune sand has accumulated episodically on the coastal platforms, blown inland from the ancient sandy shorelines. These variously-cemented dunes (aeolianites), consigned to the **Wankoe Formation**, are much evident in the regional landscape of the inland coastal plains as old, calcrete-capped, rounded dune ridges ("Wankoe se Rante" or "Die Harde Duine") and are particularly well displayed where erosion, road cuttings and limestone quarries reveal their internal, large-scale dune-slipface crossbedding. Old aeolianites correlated with the Wankoe Fm. are not exposed in the Gansbaai area where younger aeolianites mantle the narrow coastal plain.

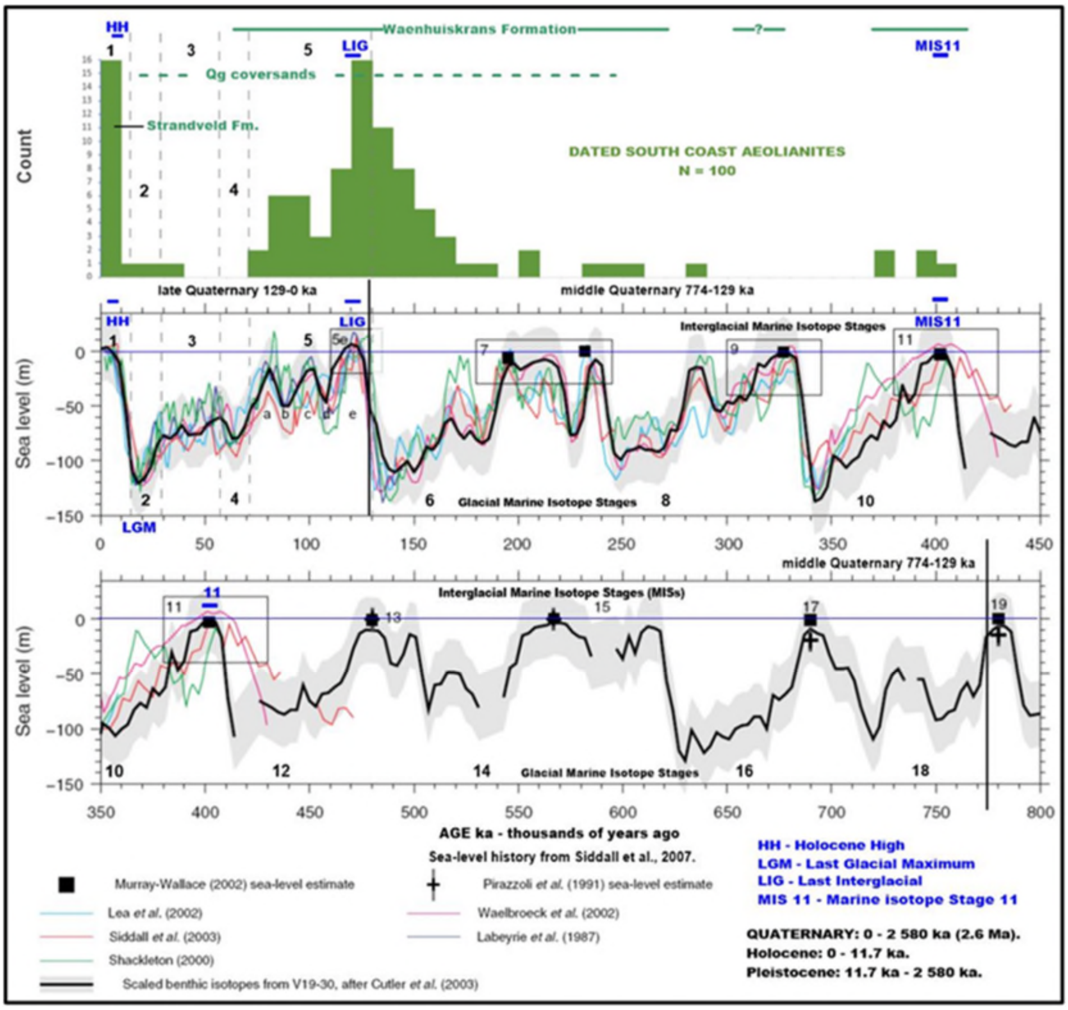


Figure 4. Sea-level history for the last 800 kyr with numbered Marine Isotope Stages showing the ages of the Klein Brak Formation raised beaches and OSL dates from South Coast aeolianites.

7.2.3 Quaternary Sea Levels and Raised Beaches

Since the end of the Pliocene Epoch ~2.6 Ma the Earth has been in the Quaternary Period, when there was a major expansion of the polar ice caps, mainly in the Northern Hemisphere.

This was the onset of more marked, repetitive Ice Ages (glacials) when the expanded ice on continents subtracted water from the oceans and sea level rose and fell repeatedly. Sea levels fluctuated at positions mainly below the present level and down as much as ~130 m bsl. during glacial maxima (Figure 4), exposing much of the continental shelves (*e.g*. the Agulhas Bank) and increasing the width of the coastal plains for considerable time spans. Figure 4 shows the sawtooth pattern of sea-level and glacial/interglacial cycles of the last 800 thousand years (800 kyr) and the division into numbered Marine Isotope Stages (MISs) based on the oxygen isotope ratios from deep-sea shelly microfossils, which reflect the global volume of water bound up as polar ice. The cold Ice Age palaeoclimates were interrupted by brief intervals of rapid global warming, called interglacials, of which the present time is an example, when sea levels were similar to the present level or just several metres above or below present level.

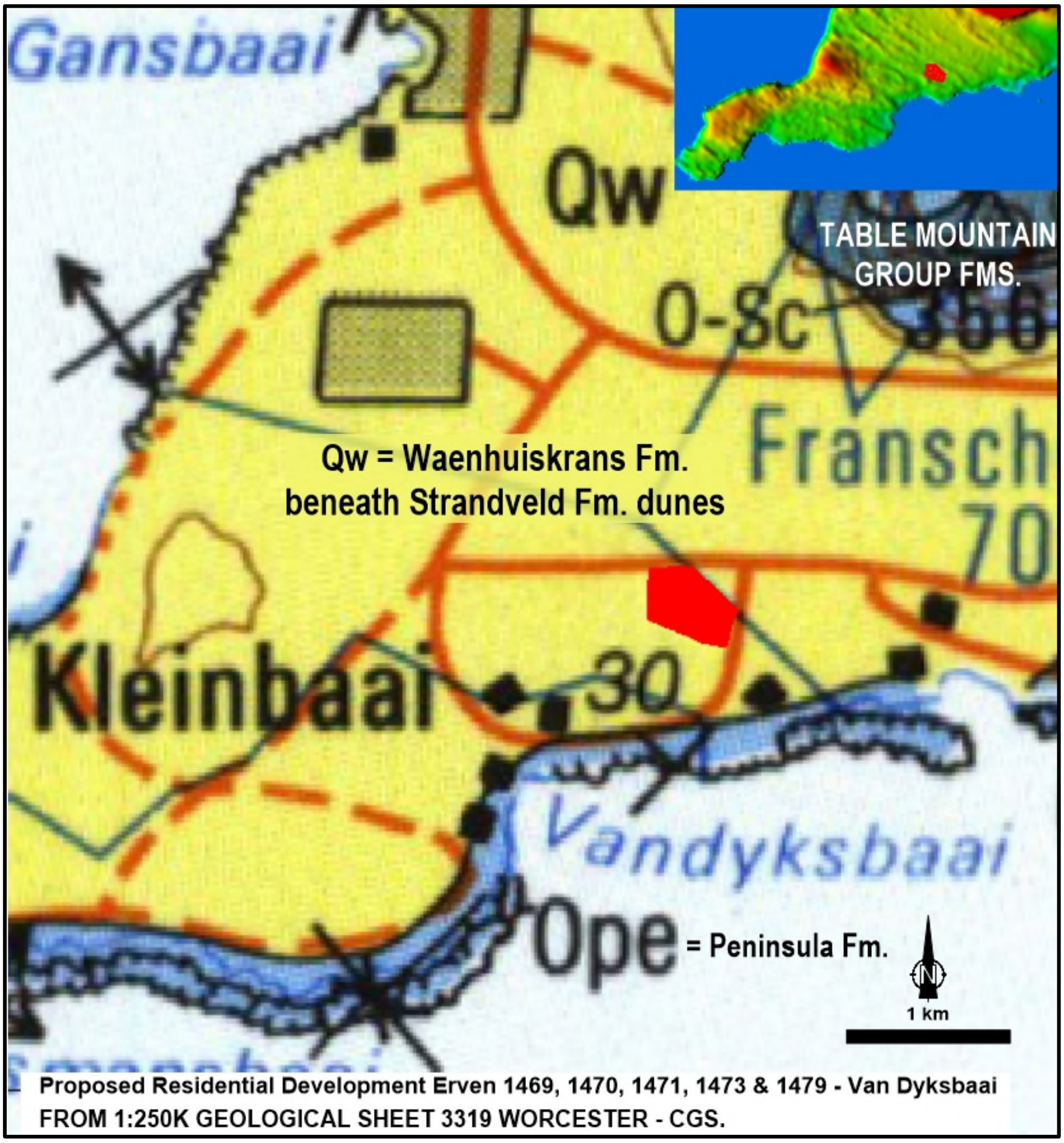


Figure 5. Geological context of the proposed development at Van Dyksbaai.

When sea level was higher than present for brief periods "raised beaches" were deposited around the coast. These Quaternary-age raised beaches and estuarine deposits are accommodated in the **Klein Brak Formation** (Figure 4). The higher-lying, older raised beach occurs at 8-15 m asl. and relates to the **MIS 11 interglacial** high sea level that occurred around

400 ka (ka = thousand years ago). Most of the raised beach deposits which are exposed at places along the coast date to the **Last Interglacial** about 125 ka (Figure 4, LIG/MIS 5e) and occur up to 5-6 m asl. The youngest raised beach is 2-3 m asl. and is known as the "**Holocene High**". It was deposited between 7-4 ka in as the coastline was slightly uplifted in response to the loading of the oceans with polar meltwaters.

The high sea levels penetrated inland along valleys, expanding estuaries which today have their margins fringed by older estuarine deposits. These high sea levels lapped onto the edge of the ancient bedrock of the Mio-Pliocene marine platform or onto older dunes and were later buried under younger dunes, embedding the raised beaches in notches in the coastal aeolianites. Exposures of the Klein Brak Fm. are usually too small to be depicted at the scale of 1:250 000 geological maps. Many exposures of the Klein Brak Fm. occur along eroded coastal cliffs beneath calcreted aeolianites of the Waenhuiskrans Fm.

7.2.4 Quaternary Aeolianites

During interglacial to intermediate sea levels dune plumes migrated onto the present-day coastal plain, sourced both from the raised beach shorelines and from now-submerged shorelines. These younger aeolianites comprise the **Waenhuiskrans Formation**, depicted as **Qw** (Figure 5) and so named after this place near Arniston where they form the low sea cliffs at the coast (Malan, 1989). Similar to the Wankoe Fm. aeolianites there is a calcrete-capped relict dune-ridge topography and internally the formation is comprised of "packages" of dune accumulation defined by separating reddish palaeosols or calcrete pedocretes.

The 100 *OSL dates/ages obtained from the Waenhuiskrans Fm. sands (Roberts *et al*., 2014) are shown in Figure 4 which indicates that aeolianites accumulated mainly since the glacial MIS 6 Ice Age ~170 ka, increased as the rising sea level approached the present coastline, to peak during the Last Interglacial +6 m sea level, and then to taper off as the sea level subsequently fell to below the present level and the shorelines became more remote from the present coastline. (*- see glossary)

The latest addition of dunes to the coastal plain is the **Strandveld Formation**. These are loose, white, non-vegetated and vegetated dune sands blown from the beaches in the last several thousand years, during the Holocene and accumulated in the form of dune fields or plumes migrated several kilometres inland, or formed across capes as headland bypass dune fields, or in the form of a narrow dune cordon or "sand wall" parallel to the coast, depending on the direction of the most effective wind and the orientation of the coast. The Strandveld Fm. dune fields are readily remobilized when the vegetation is destroyed by veld fires.

Note that the pale sands of the Strandveld Fm. mantle much of the coastal plain, but are only depicted on the geological maps where there are active to semi-active dunes, such as the large dune field sourced from the sandy shores of Walker Bay to the north of Gansbaai. The topography of the Gansbaai peninsula shows subdued, vegetated dune ridges which are the relicts of parabolic dunes of a headland bypass dune system formed under the influence of the strong north-westerlies of winter (Figures 1 & 5 inset).

8. AFFECTED FORMATIONS

The development area is on old vegetated dunes of the **Strandveld Fm**, as is evident in the rounded-off dune ridges trending to the southeast across the area (Figures 5 & 6). The Strandveld Fm. dune ridges are underlain by the **Waenhuiskrans Fm**. (Figure 5). Presumably there are outcrops of calcrete and cemented aeolianite in the area, such as on ridge flanks or between ridges. On an older 1963 geological map the area is depicted as "calcified dune sand".

Figure 6. Cutting through the Strandveld Fm. dune ridge along Dyer Str. at location marked in Fig. 2 and inset showing ridge topography.

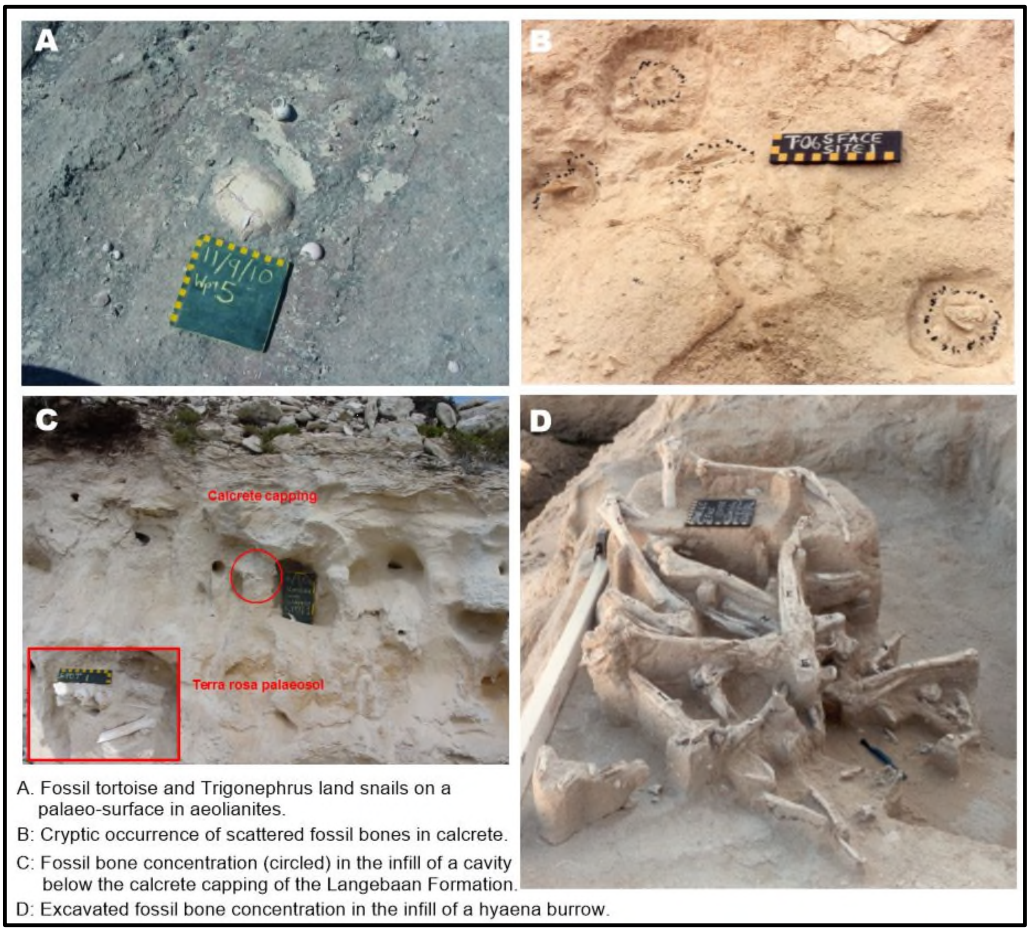
9. PALAEONTOLOGY – FOSSILS IN AEOLIANITES

For the most part the aeolian formations have a sparse fossil bone content. Fossils are understandably very sparse in the main part of "fossil dunes" that were previously actively migrating and which are typified by the large-scale crossbedding formed by the advancing dune front or "slipface". Most commonly seen is the ambient fossil content of dune sands: land snails, tortoise shells/bones (Figure 7A), mole-rat bones and ostrich eggshell fragments. Other small bones occur very sparsely such as birds, lizards, snakes and small mammal bones (*e.g.* various rodents).

The ambient fossil content is more abundant in association with palaeosurfaces and their associated soils (palaeosols and calcrete pedocretes), formed during periods of dune stabilization and which define aeolian packages and larger formations. Other palaeosurfaces are formed by wind deflation exposing and concentrating fossils, and by dune migration wherein the ambient fossil content is concentrated on the palaeosurface the dunes are traversing, leaving their fossil content behind in a deflation lag. Importantly, the bones of larger animals (*e.g.* antelopes), and archaeological material, are also more persistently present along the palaeosurfaces which separate the major aeolianite units. An important palaeosurface is that beneath the coversands and formed on top of the erosion surface and calcrete developed in the uppermost Waenhuiskrans Fm.

The important fossil bones of larger animals, as mentioned, are overall sparse in aeolianites, but occur in markedly greater abundance on palaeosurfaces surrounding water sources such as the margins of local vleis and springs/seeps formed in interdune areas. The deposits of local ponds are locally interbedded in aeolianites and are richly fossiliferous, including fossil plant material, aquatic snails and frogs.

The most spectacular bone concentrations found in aeolianites are due to the bone-collecting behaviour of hyaenas which store them in and around their lairs (Figure 7). The large burrows made by aardvarks and warthogs are appropriated by the hyaenas. Such bone accumulations are, of course, younger than the aeolianite into which the burrow was made.



A. Fossil tortoise and Trigonephrus land snails on a palaeo-surface in aeolianites.
B: Cryptic occurrence of scattered fossil bones in calcrete.
C: Fossil bone concentration (circled) in the infill of a cavity below the calcrete capping of the Langebaan Formation.
D: Excavated fossil bone concentration in the infill of a hyaena burrow.

Figure 7. Examples of fossil bones in aeolianites.

10. ANTICIPATED IMPACT ON PALAEONTOLOGICAL RESOURCES

The intensity or magnitude of impact relates to the palaeontological sensitivities of the affected formations (Appendix 1) and the volume of disturbance by excavation. The proposed development involves trenches for building foundations (0.6-1.0 m depth) and services infrastructure (1.0-2.0 m depth).

Due to its young Holocene age the Strandveld Fm. dunes typically host Late Stone Age archaeological material and the bones of “modern” (extant) animals which, not being very old, are termed “subfossils”. The large bones of elephant, rhino, and hippo who died in the Strandveld Fm. dunes have occasionally been uncovered during sand quarrying and developments, but are apparently rare finds. Deflation and passage of the Strandveld dunes would have moved embedded material down onto deflation palaeosurfaces and deeper down onto the underlying palaeosurface on top of the calcreted and cemented Waenhuiskrans Fm.

Along the South Coast (Worcester and Riversdale geological maps) the Strandveld Fm. has not been accorded a palaeontological sensitivity rating and is UNCLASSIFIED (left clear). However, along the West Coast the equivalent Witzand Fm. is accorded MODERATE palaeontological sensitivity and this sensitivity has been applied to the Strandveld Fm. in the version of the map used in the EIA Screening Tool Palaeontology Theme Sensitivity. The MODERATE rating is applicable close to the coast where subfossil bones in archaeological sites occur, but sites are less common inland. The subfossil bones are expected to be of latest Quaternary, later Holocene age (mainly less than about 7 thousand years old) and are likely to be mainly members of the extant, modern fauna, but unexpected species which do not belong to the modern/historical fauna may occur, due to fluctuations in the prehistoric palaeoclimate of the region. Due to its proximity to the coast the MODERATE rating of the Strandveld Fm. on the proposed development site is endorsed (Appendix 1). Although considered to be subfossil remains, radiocarbon dating and geochemical isotope analyses of teeth and bones yield valuable information of changing ecological conditions during the last several thousand years.

Figure 8. Palaeontological sensitivities of formations in the Van Dyksbaai area.

The palaeontological sensitivity of the Cenozoic coastal formations is generally rated high and this particularly applies to the potential for the scientifically valuable fossil bones of terrestrial animals to occur (Almond & Pether, 2008, 2009). According to SAHRIS the Waenhuiskrans Formation is rated Very High (Figure 8), due to previous fossil bone finds in coastal developments. The Very High rating requires "field assessment and protocol for finds". However, a field survey is precluded by the formation being mainly beneath the thickly vegetated Strandveld Fm. dune sands and fossil bones may only be exposed during vegetation clearing and the Construction Phase earthworks.

The fossil bones that may occur in the Waenhuiskrans Fm. in the Project Area are expected to be of late-middle to earlier-late Quaternary age, between ~160 to ~80 ka (Figure 4) and, like the later Strandveld Fm. dunes sands, also mainly comprised of representatives of the extant fauna, but unexpected species of a different fauna are more likely to occur, as a result of phases of different ecological and palaeoclimatic conditions in the past, as well as the bones of some species which became extinct in the geologically-recent past. Intersections of the upper, variously calcreted Waenhuiskrans Fm. in earthworks are expected to be limited in volume relative to the affected volume of overlying dune coversands.

The later-mid Quaternary to present day faunas are fairly well known from archaeological sites and hyaena bone accumulations and additional finds are considered to be of moderate scientific importance, *i.e.* 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 sensitivity rating (Appendix 1). These criteria apply to both the Strandveld Fm. dunes and the Waenhuiskrans Fm.

11. SUMMARY IMPACT TABLE

IMPACT ON THE STRANDVELD FM. DUNE SANDS AND WAENHUISKRANS FM. AEOLIANITE.

CONSTRUCTION PHASE	**Without Mitigation**	**With Mitigation**
Potential impact and risk:	Palaeontological heritage.	
Nature of impact:	Loss of fossil bones and archaeological material from excavations in the loose Strandveld Fm. dunes and upper Waenhuiskrans Fm. aeolianite.	
Extent and duration:	Site and permanent.	Regional to international and permanent.
Intensity/Sensitivity:	Moderate.	Moderate.
Consequence of impact or risk:	Permanent loss of material palaeontological heritage.	Permanent loss of material palaeontological heritage.
Probability of occurrence:	Probable, distinct possibility.	Probable, distinct possibility.
Degree to which the impact may cause irreplaceable loss of resources:	Complete loss of fossil resources.	Significant loss may still occur.
Degree to which the impact can be reversed:	Irreversible.	Irreversible.
Indirect impacts:	Impoverished landscape geohistory.	Enriched landscape geohistory.
Cumulative impact:	Permanent loss of fossils and the associated scientific implications.	Some fossils are rescued for posterity and available for scientific study.
Residual impact:	Permanent loss of fossils and the associated scientific implications.	Some fossils are rescued for posterity and available for scientific study.
SIGNIFICANCE RATING:	MEDIUM NEGATIVE.	MEDIUM TO HIGH POSITIVE.
Degree to which the impact can be avoided:	Low. The locations of fossil bones in the coversands and aeolianites cannot be predicted.	
Degree to which the impact can be managed:	Low. There is a high risk of valuable fossils being lost despite management actions to mitigate such loss.	
Degree to which the impact can be mitigated:	Moderate.	
Proposed mitigation:	• Construction personnel to be alert for rare fossil bones and follow "Fossil Finds Procedure". • Cease construction on discovery of fossil bones and protect fossils from further damage. • Contact appointed archaeologist/palaeontologist or HWC providing information and images. • The aforementioned will assess the information and establish suitable response, such as the importance of the find and measures for preservation, collection and record keeping. • Exposed fossiliferous sections in earthworks recorded and sampled by appointed specialist. • Fossils and their contextual information must be deposited at a SAHRA/HWC-approved institution.	

The ranking criteria are according to the scheme in Appendix 3.

	Extent	**Duration**	**Intensity**	**Status**	**Probability**	**Significance**	**Confidence**
Without mitigation	Local 1	Permanent 5	Moderate 6	Negative	Probable 3	Medium 36	M
With mitigation	Local 1	Permanent 5	Moderate 6	Positive	Probable 3	Medium 36	M

Without mitigation the significance of the impact is MEDIUM negative due to probable loss of fossil heritage, but the actual significance will not be known. The rescue of fossil bones from loss will have a positive outcome and, depending on the scientific importance of the find, may result in an impact of MEDIUM to HIGH significance.

12. RECOMMENDATIONS

The possible presence of fossils in the subsurface does not have an *a priori* influence on the decision to proceed with the proposed development. However, mitigation measures are essential. The potential impact has a moderate influence upon the proposed project, consisting of implemented mitigation measures recommended below, to be followed during the vegetation clearing and Construction Phases.

Although the inspection of construction excavations may be specified in the Archaeological Impact Assessment, it is not feasible for a specialist monitor to be continuously present during the Construction Phases, when fossils may be unearthed at any time. The rescue of fossil bones during earth works critically depends on spotting this material as it is uncovered during digging.

For successful mitigation, it is therefore crucial that earth works personnel must be involved in mitigation by watching for fossil bones as excavations are being made.

It is recommended that a protocol for finds of buried fossil bones, the Fossil Finds Procedure (FFP), is included in the Environmental Management Plan (EMP) for the proposed development.

The Fossil Finds Procedure included as Appendix 2 provides guidelines to be followed in the event of fossil bone finds in the excavations. The works supervisor/foreman and workers involved in excavating the building foundations, infrastructure trenches and stormwater drainage must be informed of the need to watch for fossils and archaeological material. Workers seeing potential objects are to cease work at that spot and to report to the works supervisor who, in turn, will report to the Environmental Control Officer (ECO) and/or the Developer. The ECO/Developer will contact and liaise with Heritage Western Cape and the standby archaeologist or palaeontologist on the nature of the find and suitable consequent actions such as immediate site inspection, application for a palaeontological collection permit and drafting of a work plan for the collection of the find.

If a significant occurrence of fossil bones in a palaeontological context is discovered a professional palaeontologist must be appointed to collect them and to record their contexts. Said palaeontologist must also undertake the recording of the stratigraphic context and sedimentary geometry of the exposure, the sampling of ambient small fossil content and the compilation of the report for distribution to Heritage Western Cape, SAHRA, the approved curatorial institution and local heritage interest groups.

A permit from HWC is required to excavate fossil bone finds. The applicant should be the qualified specialist responsible for assessment, collection and reporting (palaeontologist). Should fossils be found that require rapid collecting, application for a palaeontological permit with supporting work plan will immediately be made to HWC. The application requires the details and permission of the registered owner of the site. The fossils and their contextual information must be deposited at a SAHRA/HWC-approved institution. The rescue of discovered palaeontological remains by a contracted specialist shall be at the Developer's expense.

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14. APPENDIX 1. PALAEONTOLOGICAL SENSITIVITY RATING

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

VERY HIGH: Formations/sites known or likely to include vertebrate fossils pertinent to human ancestry and palaeoenvironments and which are of international significance.

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/MEDIUM: 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.

15. APPENDIX 2. FOSSIL FINDS PROCEDURE

15.1 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. These may include:

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

15.2 RESPONSE BY PERSONNEL IN THE EVENT OF FOSSIL BONE FINDS

The most important fossils of concern are the fossil bones and teeth of land animals.

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, such as in chunks of calcrete and aeolianite.

- Stop work at fossil find. 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. Fossil bone-bearing chunks of calcrete can be stockpiled in a safe location.
- The ECO or site agent must immediately inform the monitoring archaeologist who will liaise with Heritage Western Cape (HWC) and the contracted standby palaeontologist on the nature of the find and provide via email the information about the find, as detailed below.
  - Date
  - Position of the excavation (GPS) and depth.
  - A description of the nature of the find.
  - Digital images of the excavation showing vertical sections (sides) and the position of the find showing its depth/location in the excavation.
  - A reference scale must be included in the images (tape measure, ranging rod, or object of recorded dimensions).
  - Close-up, detailed images of the find (with scale included).

The 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 or not.

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 and continue excavation farther along, so that the work schedule and machine time are minimally disrupted. The strategy is to rescue the material as quickly as possible.

15.3 APPLICATION FOR A PERMIT TO COLLECT FOSSILS

A permit from HWC and a Work Plan 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, application for a palaeontological permit must be made to HWC immediately. The application requires the details and permission of the registered owner of the site. The fossils and their contextual information must be deposited at a SAHRA/HWC-approved institution. The rescue of discovered palaeontological remains by a contracted specialist shall be at the Developer's expense.

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16. APPENDIX 3. METHODOLOGY FOR ASSESSING THE SIGNIFICANCE OF IMPACTS

EFFECT	**Extents/Spatial Scale**		**E**
	Localized	At localized scale and a few hectares in extent.	1
	Study area	The proposed site and its immediate environs.	2
	Regional	District and Provincial level.	3
	National	Country.	4
	International	Internationally.	5
	Duration/Temporal Scale		**D**
	Very short	Less than 1 year.	1
	Short term	Between 2 to 5 years.	2
	Medium term	Between 5 and 15 years.	3
	Long term	Exceeding 15 years and from a human perspective almost permanent.	4
	Permanent	Resulting in a permanent and lasting change.	5
	Magnitude/Intensity (Palaeontological Sensitivity)		**M**
	No potential	Formations entirely lacking fossils such as igneous rocks.	0
	Marginal	Limited probability for producing fossils from certain contexts at localized outcrops.	2
	Low	Depositional environment where fossils are unlikely to be preserved, or are judged unlikely to produce unique fossil remains.	4
	Medium	Strong potential to yield fossil remains based on stratigraphy and/or geomorphologic setting.	6
	High	Formations known to contain palaeontological resources that include rare, well-preserved fossil materials.	8
	Very high	Formations/sites known or likely to include vertebrate fossils pertinent to human ancestry and palaeoenvironments and which are of international significance.	10
	Probability/Likelihood		**P**
	Very improbable	Probably will not happen.	1
	Improbable	Some possibility, but low likelihood.	2
	Probable	Distinct possibility of these impacts occurring.	3
	Highly probable	The impact is most likely to occur.	4
	Definite	The impact will definitely occur regardless of prevention measures.	5

SIGNIFICANCE = (E+D+M) x P		
< 30	LOW	The impact would not have a direct influence on the decision to develop in the area
30-60	MEDIUM	The impact could influence the decision to develop in the area unless it is effectively mitigated
>60	HIGH	The impact must have an influence on the decision process to develop in the area