SRK Project Number 373512

PALAEONTOLOGICAL IMPACT ASSESSMENT
DESKTOP STUDY

PROPOSED SEAVIEW LOW-COST HOUSING DEVELOPMENT
NELSON MANDELA BAY MUNICIPALITY, EASTERN CAPE

By

John Pether, M.Sc., Pr. Sci. Nat. (Earth Sci.)
Geological and Palaeontological Consultant
P. O. Box 48318, Kommetjie, 7976
Tel./Fax (021) 7833023
Cellphone 083 744 6295
jpether@iafrica.com

Prepared at the Request of

SRK Consulting (South Africa) (Pty) Ltd.
Ground Floor Bay Suites
1a Humewood Rd.
Humerail
Port Elizabeth 6001
South Africa

22 March 2017

CONTENTS

EXECUTIVE SUMMARY

1. SITE NAME

Proposed Seaview Low-Cost Housing Development, Nelson Mandela Bay Municipality, Eastern Cape.

2. LOCATION

Erfs 590, 238, 240 and Farm 28 portions 1 and 10 (see Appendix 1).

3. LOCALITY PLAN

See Figure 1 and Appendix 1.

4. PROPOSED DEVELOPMENT

The Nelson Mandela Bay Municipality (NMBM) proposes to construct a low income housing development and associated facilities in Seaview, Port Elizabeth, in order to provide housing and facilities for the communities currently living in the Zweledinga and New Rest informal settlements near Seaview. Two development options are proposed for development. Option 1 involves the construction of ~400 units in the informal areas and adjacent unforested areas. Option 2 entails ~1000 units on the transformed land of Portion 1 of Farm 28.

SRK Consulting (SRK) has been appointed by the NMBM to conduct the Environmental Impact Assessment (EIA) in terms of the National Environmental Management Act 107 of 1998 (NEMA), as amended, and the Environmental Impact Assessment (EIA) Regulations, 2010, for the proposed housing development.

This report outlines the nature of palaeontological/fossil heritage resources in the subsurface of the affected area and suggests mitigatory actions to be taken in the event of the discovery of fossils during earth works, for inclusion in the Environmental Management Plan for the Construction Phases.

5. PALAEONTOLOGICAL HERITAGE RESOURCES IDENTIFIED

Both Option 1 and Option 2 for the proposed housing sites are situated on the coastal slope between ~40 to 100 m asl. which is comprised of vegetated aeolian dune ridges of the **Schelm Hoek Formation** (Figures 2, 4). The depth of earth works entailed in the development is limited to a few metres, the deeper holes being made to accommodate the sanitation system.

The marine Alexandria Formation is not likely to be encountered in excavations in the project area. Similarly, the older aeolianites of the Nanaga and Nahoon formations are not likely to be intersected, although this possibility may not be dismissed entirely. However, any such intersection is likely to be superficial, just penetrating the underlying formation. The Salnova Formation will not be intersected.

This assessment therefore entails the palaeontological sensitivities of the fossil content of the Schelm Hoek Formation aeolianites. These are sands blown from the beaches in the last ~12 thousand years, during the Holocene. On this part of the coast these dunes dominate the landscape as parallel dune ridges transgressing inland in the form of parabolic or “hairpin” dunes. The sands were sourced from sandy beaches just offshore which were submerged as sea-level rose towards the present level, after the low levels of the Last Ice Age.

6. ANTICIPATED IMPACTS

This impact assessment refers to the occurrence of sparse, high value vertebrate fossil bone material in the Schelm Hoek Formation and thus applies to both Option 1 and Option 2. The fossil bones are sparse, but those that have been found in the coastal aeolianites are of profound scientific value and of international interest. The vertebrate fossils (bones) that may be destroyed/lost (or found) are likely to be additions to the latest Quaternary fauna of the region. Such fossil bones may be associated with buried archaeological material.

In consideration of the relatively limited depth of bulk earthworks (*cf*. quarrying/mining) and that a major fossil find of international significance is not expected, the palaeontological sensitivity is rated as LOW.

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7. RECOMMENDATIONS

A practical monitoring and mitigation programme must be implemented during the Construction Phases of the proposed housing development. Appendix 3 outlines monitoring by construction personnel and general Fossil Find Procedures for various scenarios. In the event of possible fossil and/or archaeological finds, the contracted archaeologist or palaeontologist must be contacted. For possible fossil finds, the palaeontologist will assess the information and liaise with the developer and the ECO and a suitable response will be established.

DECLARATION BY THE INDEPENDENT PERSON WHO COMPILED A SPECIALIST REPORT OR UNDERTOOK A SPECIALIST PROCESS

PALAEONTOLOGICAL IMPACT ASSESSMENT
DESKTOP STUDY

PROPOSED SEAVIEW LOW-COST HOUSING DEVELOPMENT
NELSON MANDELA BAY MUNICIPALITY, EASTERN CAPE

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. Mitigatory actions to be taken with respect to the occurrence of fossils during bulk earth works are proposed.

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, 2010 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, 2010 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 71 of GN No. R. 543, 2010.

Signature of the specialist

Date: 22 March 2017

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 shelf stratigraphy (interpretation of open-pit exposures and on/offshore cores).
- 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.

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1 INTRODUCTION

The Nelson Mandela Bay Municipality (NMBM) proposes to construct a low income housing development and associated facilities in Seaview, Port Elizabeth (Figure 1), in order to provide housing and facilities for the communities currently living in the Zweledinga and New Rest informal settlements near Seaview. Two development options are proposed for development, involving the deforested portions of five properties in the area, namely erfs 590, 238, 240 and Farm 28 portions 1 and 10 (Appendix 1). Option 1 involves the construction of ~400 units in the informal areas and adjacent unforested areas. Option 2 entails ~1000 units on the transformed land of Portion 1 of Farm 28.

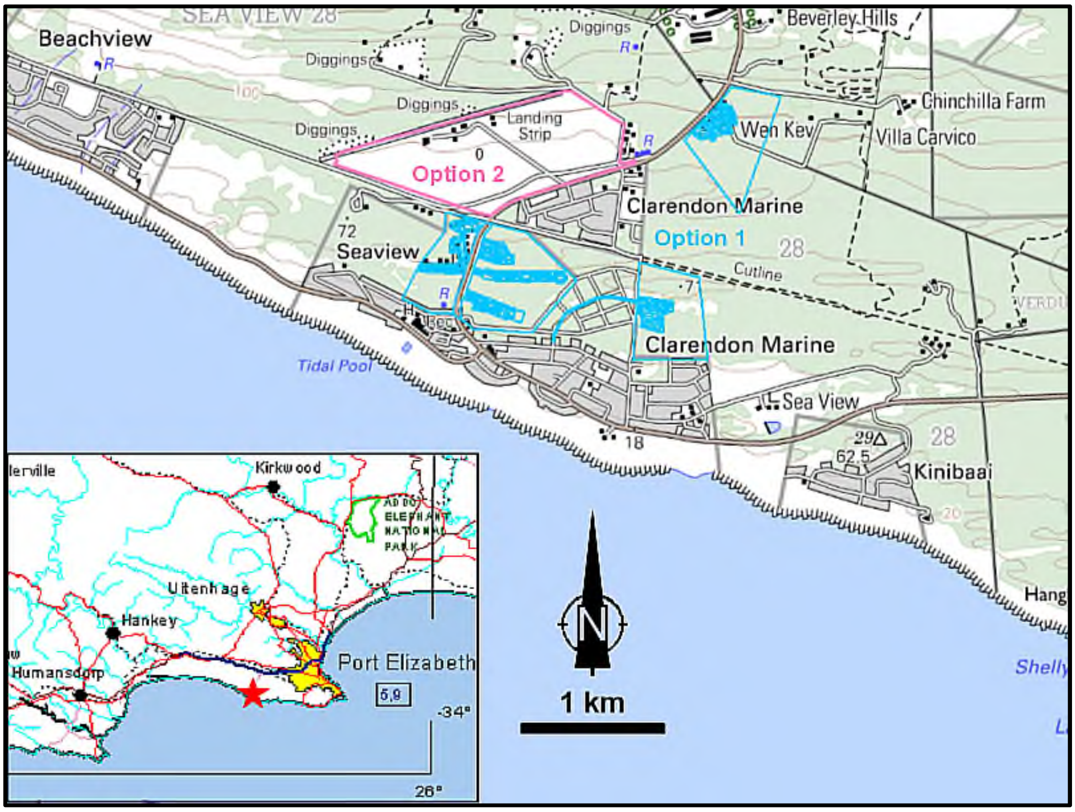

Figure 1. Location of the proposed Seaview Low Income Housing Development. Extract from 1:50000 topo-cadastral map 3325CD_3425AB_2002_ED4_GEO.TIF. Chief Directorate National Geo-spatial Information of South Africa.

SRK Consulting (SRK) has been appointed by the NMBM to conduct the Environmental Impact Assessment (EIA) in terms of the National Environmental Management Act 107 of 1998 (NEMA), as amended, and the Environmental Impact Assessment (EIA) Regulations, 2010, for the proposed housing development.

This report assesses the probability of palaeontological materials (fossils) being uncovered in the subsurface and being disturbed or destroyed in the process of earth works associated with the construction of the proposed housing development. The main purposes are to:

- Outline the nature of palaeontological/fossil heritage resources in the subsurface of the affected area.
- Suggest the mitigatory actions to be taken with respect to the occurrence of fossils during earth works.

Palaeontological interventions mainly happen once fossil material is exposed at depth, *i.e.* once the EIA process is done and construction commences. The action plans and protocols for palaeontological mitigation must therefore be included in the Environmental Management Plan (EMP) for the project. Included herein is a general fossil-finds procedure for the appropriate responses to the discovery of paleontological materials during construction of the proposed housing development.

2 APPROACH AND METHODOLOGY

2.1 AVAILABLE INFORMATION

The relevant geological maps are the 1:250 000 Geological Series sheet 3324 Port Elizabeth, together with its explanation (Toerien & Hill, 1989), and the 1:50 000 Geological Series sheet 3324CD & 3425AB Uitenhage (Council for Geoscience, Pretoria). Useful summary texts of coastal geology are Maud & Botha (2000) and Roberts *et al.* (2006), while Almond *et al.* (2009) summarise the fossil heritage of the Eastern Cape.

The younger geological record of the **Algoa Group** formations, which overlie the bedrock of folded and deformed, ancient metasediments of the Pre-Cape Gamtoos Group, is of concern here. Le Roux published the results of his work on the Algoa Group formations in several publications. The relevant articles will be cited in the normal manner in the text and included in the References section.

2.2 ASSUMPTIONS AND LIMITATIONS

It is not possible to predict the buried fossil content of an area other than in general terms, based on the depositional environments of the formations and the fossils that have been found. In particular, the important fossil bone material is generally sparsely scattered in most deposits and much depends on spotting this material as it is uncovered during digging *i.e.* by monitoring excavations.

3 GEOLOGICAL SETTING

3.1 THE BEDROCK GEOLOGY

The bedrock underlying the coastal formations in this area is only exposed along the shoreline and comprises deformed and metamorphosed sediments (metasediments) of the **Kleinrivier Formation** of the **Gamtoos Group** (Figure 2). These are mudrocks (phyllites), grits and conglomerates of late Precambrian age, deposited 600-540 Ma (Ma = million years ago). The earliest fossils occur in rocks of similar age and these are enigmatic microfossils (acritarchs) and impressions of larger, fan-like life forms of uncertain affinities called vendozoans. This bedrock will not be encountered in the project area and is not considered further.

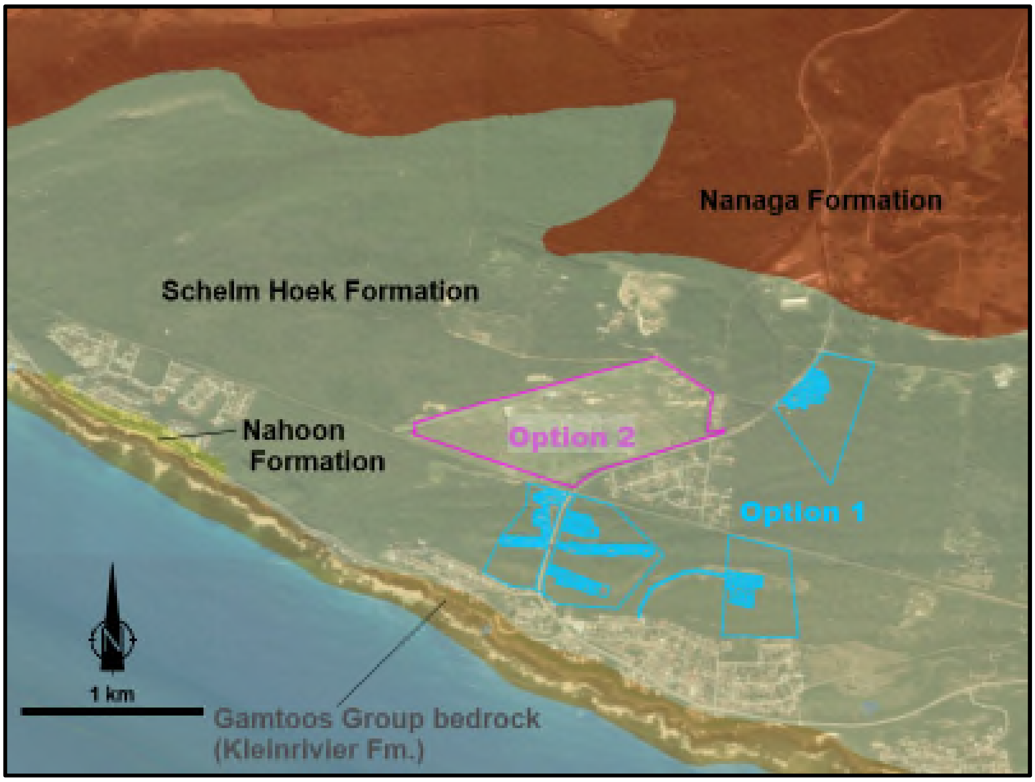

Figure 2. Geology of the project area. Adapted from Geological Sheet 3324CD & 3425AB Uitenhage (Council for Geoscience).

3.2 THE TERTIARY MARINE DEPOSITS

After the breakup of Gondwana, the early Cretaceous Uitenhage Group was deposited in local downfaulted basins along the coast. During later Cretaceous and Cenozoic times marine transgressions eroded the coastal edge, forming bevels or marine platforms. Along the southern Cape coast, the combination of marine platform formation and uplift has produced a large-scale stepped profile. A "High Coastal Platform" forms the higher, older part of the coastal plain where it is now uplifted up to its present altitude of between ~200-300 m asl. (Marker, 1984). Marine deposits have mostly been eroded away from the "High Coastal

Platform", but patches remain in places east of Port Elizabeth. These include rare Late Cretaceous deposits (Igoda Formation, ~70 Ma) and limestone deposits of Eocene age assigned to the **Bathurst Formation**, the oldest formation of the **Algoa Group**. Microfossils in the Bathurst Formation indicate an age of 54-46 Ma which corresponds with the Early Eocene Climatic Optimum, a time of pronounced global warming and high sea level.

Younger shallow-marine deposits mantle the bedrock of the "Lower Coastal Platform" below ~200 m asl. and these shelly calcareous sands and conglomerates comprise the **Alexandria Formation**. The Alexandria Formation is a composite of sea-level history and should be elevated to Subgroup status as it is comprised of three formations of distinctly different ages. These formations also correspond with times of global warmth and high sea levels due to melting of Antarctic ice: the Mid Miocene Warm Period 17-14 Ma, the Early Pliocene Warm Period 5-4 Ma and the Mid Pliocene Warm Period ~3 Ma. These formations are easily recognized in the extensive diamond-mining pits on the West Coast, but their contacts or boundaries are not as readily seen in the discontinuous exposures of the South and East Coasts.

The Alexandria Formation is highly fossiliferous in places, with a wide range of marine shells and trace fossils (Le Roux, 1987, 1993), but overall has been subjected to various degrees of dissolution of the fossil shells, as well as cementing, so that often just shell moulds remain.

3.3 THE MIO-PLIOCENE AEOLIANITES

Subsequent to 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) are much evident in the regional landscape as old, calcrete-capped, rounded dune ridges and are particularly well displayed where erosion, road cuttings and limestone quarries reveal their internal, large-scale dune-slipface crossbedding. The older aeolianites that cover the Mio-Pliocene Alexandria Formation marine deposits are consigned to the **Nanaga Formation** (Le Roux, 1992).

Beneath the capping calcrete crust the Nanaga Formation aeolianites include further calcretes and leached *terra rosa* (reddish) soils at depth, attesting to episodes of sand accumulation during windy/dry periods, separated by less windy/wetter periods of reduced sand accumulation, with the calcrete and soil formation showing the surface stability. Runoff during wetter intervals induces colluviation of steeper dune slopes, rounding off the dune crests and ridges and infilling lower interdune areas. The buried soil profiles often occur within such colluviated sand intervals.

The maximum ages of these old aeolianites is the age of the marine formations that underlie them and thus the Nanaga Formation aeolianites must also become younger towards the coast. However, age gap varies considerably and the time of dune deposition may be significantly younger than the eroded marine formation finally being covered up. The oldest aeolianites at high elevation could be of later Miocene age, similar to the Prospect Hill Formation aeolianites on the West Coast which are dated to 12-9 Ma on the basis of finds of fossil eggshell of an extinct ostrich. The youngest Nanaga Formation aeolianites postdate the younger ~3 Ma old part of the underlying Alexandria Formation and could be latest Pliocene or early Quaternary in age.

Fossils are sparse in the Nanaga Fm. aeolianites and include various land snails, fossil plant roots associated with palaeosols and trace fossils, the most abundant being the burrow systems of termites.

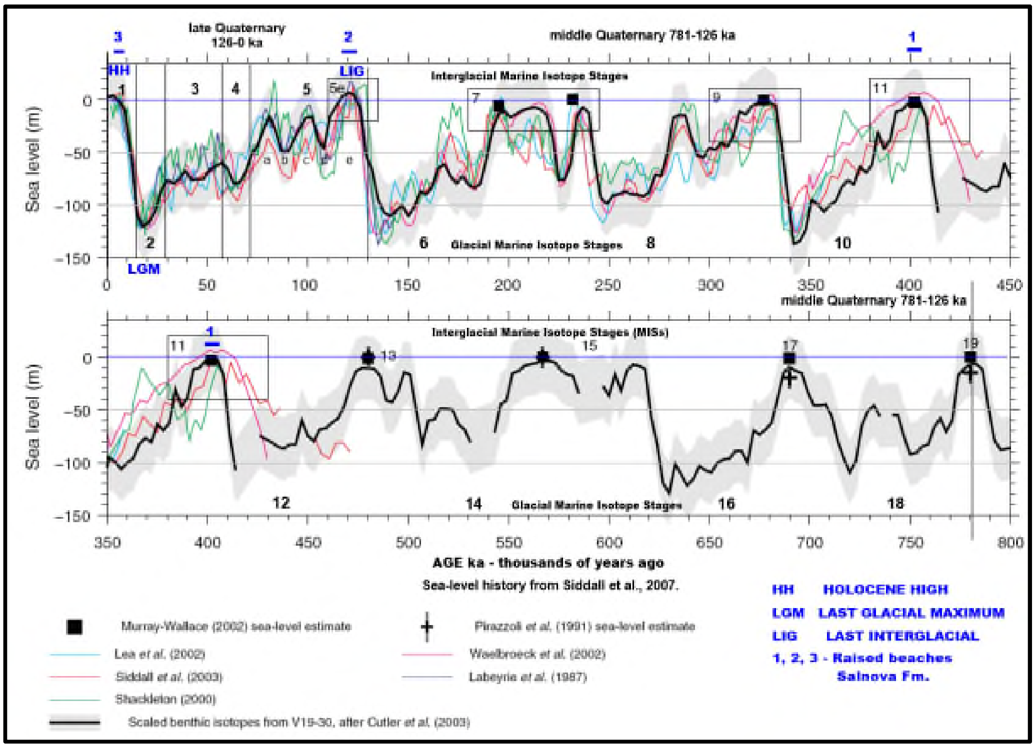

Figure 3. Sea-level history of the last 800 ka, during the middle and late Quaternary. Adapted from Siddall et al., 2007.

3.4 THE QUATERNARY RECORD

Since ~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 (Figure 3). Sea levels fluctuated at positions mainly below the present level and down as much as ~130 m bsl. during glacial maxima, exposing much of the continental shelves (*e.g*. the Agulhas Bank) and increasing the width of the coastal plains, albeit temporarily. The generally colder 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. The glacial/interglacial palaeoclimatic fluctuations are numbered as Marine Isotope Stages (MISs) (Figure 3), based on the deep sea record of oxygen isotopes incorporated in microfossil shells which reflects temperature and global ice volumes.

During interglacial to intermediate shoreline levels dune plumes migrated onto the present-day coastal plain, sourced from now-submerged beaches. These younger aeolianites comprise the **Nahoon Formation** (Le Roux, 1989). Similar to the Nanaga Fm. aeolianites there is a calcrete-capped relict dune-ridge topography and "packages" of dune accumulation defined by palaeosols.

These younger aeolianites can be dated by the OSL method (see glossary) and this has now shown that aeolianite deposition has occurred on the southern Cape coast since the later part of the mid Quaternary, at >200 ka and 189-160, 128-104, 90-88 and 80-67 ka, during interglacial and intermediate sea-level high stands (Bateman *et al*., 2004) (ka = thousands of years ago). In the Wilderness embayment the successive dune cordons are dated to 241-221 ka, 159-143 ka, 130-120 ka and 92-87 ka (Bateman *et al*., 2011). The cliffed aeolianites east of Stilbaai produced dates of 140-90 ka that indicate deposition mainly during MIS 5 (Roberts *et al*., 2008).

During some of the previous warm interglacials sea level was higher than present and lapped onto the coast (Figure 3), depositing "raised beaches" around the coast, mostly on the bedrock platform and also onto notches eroded into older Nahoon or Nanaga formation aeolianites. These "raised beaches" are found below ~15 m asl. and constitute the **Salnova Formation** which is defined to include the Quaternary raised beaches fringing the coast (Le Roux, 1991).

The older raised beach deposits in the Mossel Bay area have been OSL-dated to an older interglacial high sea level around 400 ka (MIS 11, Figure ?) and record a sea level highstand of ~13 m asl. (Roberts *et al*., 2012). Present sea level was evidently not exceeded during the MIS 9 and MIS 7 interglacials (Figure ?). However, deposits relating to the MIS 7 interglacial about 200 ka are often found interbedded in the bases of the aeolianite seacliffs, exposed in the intertidal zone and below sea level (*e.g*. at Waenhuiskrans and False Bay). These include estuarine/lagoonal and coastal vlei deposits, the latter reflecting high water tables associated with the nearby high sea level. The vlei deposits include organic-rich and peaty beds with terrestrial fossil bones.

Present sea level was exceeded again by about 6 m during the Last Interglacial interval of global warmth (LIG or MIS 5e, Figure 5, ~125 ka). This is the most prominent raised beach noticeable around the coast and it is usually overlain by younger aeolianites equivalent to the Nahoon Formation. The fossil shell fauna of the Quaternary raised beaches is predominantly composed of "modern" or living species, but not all of them live along the coast today. The shell beds are famous for exotic, warm-water species that today live further north in tropical latitudes.

During the recent past, only 7-4 ka (early to mid-Holocene), sea level was again higher than present by 2-3 m. This is the mid-Holocene highstand ("Holocene High") raised beach. It is preserved beneath Holocene dunes on sandy coastal stretches, but is usually absent on exposed rocky coasts.

The latest addition of dunes to the coastal plain is the **Schelm Hoek Formation**. These are sands blown from the beaches in the last ~12 thousand years, during the Holocene. On this part of the coast these dunes dominate the landscape as parallel dune ridges transgressing inland in the form of parabolic or “hairpin” dunes. The sands were sourced from sandy beaches that are now submerged by sea-level rise towards the aforementioned Holocene High.

3.5 LOCAL GEOLOGICAL SETTING

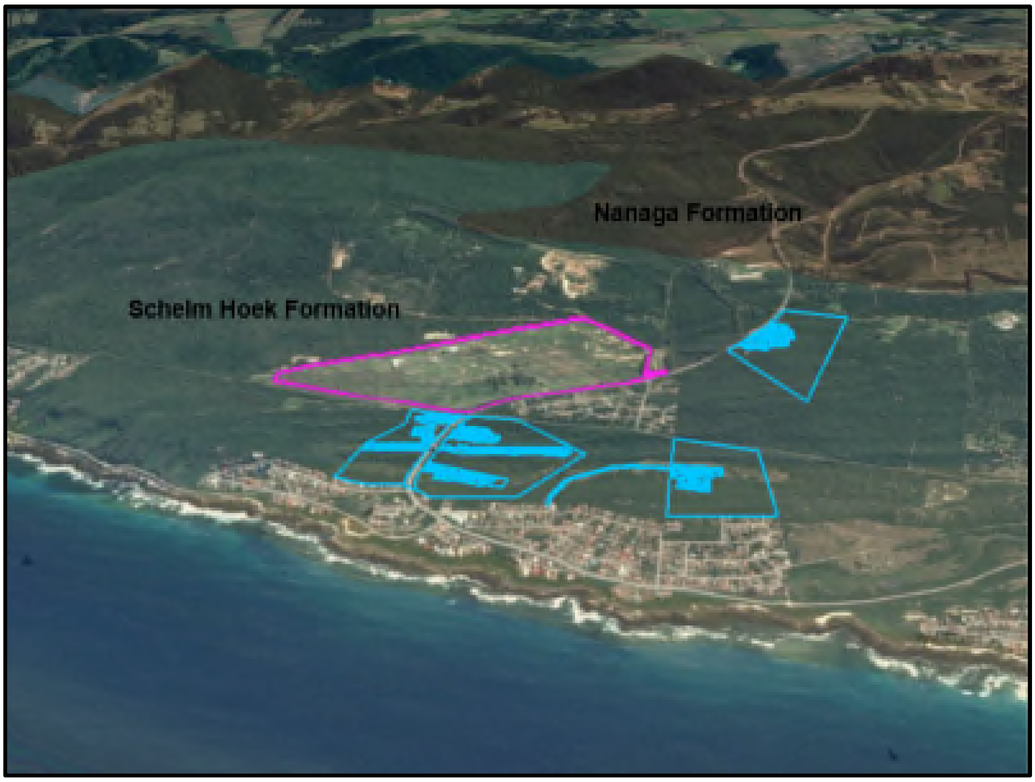

Figure 4. Simulated aerial view of the project area, looking north (Google Earth).

Both Option 1 and Option 2 for the proposed housing sites are situated on the coastal slope between ~40 to 100 m asl. which is comprised of vegetated aeolian dune ridges of the **Schelm Hoek Formation** (Figure 4). The depth of earth works entailed in the development is limited to a few metres, the deeper holes being made to accommodate the sanitation system.

The marine Alexandria Formation is not likely to be encountered in excavations in the project area. Similarly, the older aeolianites of the Nanaga and Nahoon formations are not likely to be intersected, although this possibility may not be dismissed entirely. However, any such intersection is likely to be superficial, just penetrating the formation. The Salnova Formation will not be intersected.

This assessment therefore entails the palaeontological sensitivities of the fossil content of the Schelm Hoek Formation aeolianites.

3.6 PALAEONTOLOGY OF AEOLIANITES

The Schelm Hoek Formation is expected to have a fossil background typical of aeolianites, *viz*. various land snails, tortoise, rodent and mole bones and ostrich eggshell are fairly common. Small land snails and tiny rodent fossils also reflect the palaeoenvironments such as the vegetation type.

Larger animal bones (antelopes, zebra, rhino, elephant, pigs, ostrich *etc*.) are sparsely scattered on palaeosurfaces with aeolianites. In an aeolian accumulation, the lowermost parts tend to contain more fossil bones; on the eroded palaeosurface formed on older aeolianites. The interdune areas between dune ridges may host deposits associated with vleis, pans and springs which are richly fossiliferous, including fossil plant material and aquatic snails and frogs.

Plant material and root casts are associated with palaeosols and surfaces. Trace fossils are common and vary from insect burrows, termitaria, mole burrows and tracks of animals. In unconsolidated sands animal tracks are recognized in section by abrupt disturbances of the dune lamination. Where sands are sufficiently firm larger burrows may occur such as those made by aardvarks. These may be occupied by hyaenas whose bone-collecting behaviour results in concentrations of bones of antelopes and carnivores in the lairs.

4 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 w.r.t. 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.

Although coastal aeolianites 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.

The fossil bones that have been found in the coastal aeolianites are of profound scientific value, raising international interest in the region. The aeolianites have been a prime source of information on Quaternary faunas and archaeology of southern Africa.

5 IMPACT ASSESSMENT

This impact assessment refers to the occurrence of sparse, high value vertebrate fossil bone material in the affected Schelm Hoek Formation and pertains to the construction phases. It applies to both Option 1 and Option 2.

5.1 FATAL FLAWS

There are no fatal flaws or predetermined NO-GO areas. The palaeontological heritage resources in the project area are in the subsurface where their locations, nature and size cannot be determined beforehand. Thus pre-construction fatal flaws predicated on fossil content are not a consideration. Although unlikely, it could be that a major find is uncovered during construction. It should then be evaluated as to an appropriate mitigation strategy.

5.2 EXTENTS

The physical extent of impacts on potential palaeontological resources relates directly to the extents of subsurface disturbance, *i.e*. SITE-SPECIFIC or LOCAL. However, unlike an impact that has a defined spatial extent (*e.g*. loss of a portion of a habitat), the consequences of an important fossil find are of international scientific significance.

5.3 INTENSITY

Magnitude of impact relates to the palaeontological sensitivities of the formations (Appendix 2). Overall the palaeontological sensitivity of coastal deposits is HIGH (Almond & Pether, 2008) due to previous fossil bone finds of high scientific importance. However, in consideration of the relatively limited depth of bulk earthworks and that a major fossil find of international significance is not expected, the palaeontological sensitivity is rated as LOW. For the purposes of this report it is assumed that the vertebrate fossils (bones) that may be destroyed/lost (or found) would be additions to the to the latest Quaternary fauna of the region.

5.4 *DURATION*

The initial duration of the impact is shorter term and primarily related to the period over which infrastructural 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. The duration of impact is this LONG TERM.

5.5 *PROBABILITY*

The likelihood of impact is POSSIBLE.

5.6 *CONFIDENCE*

The level of confidence in the magnitudes and probability of impacts is HIGH.

5.7 *STATUS OF THE IMPACT*

Negative without mitigation, positive with mitigation.

5.8 *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 evolution of the southern African fauna, the past palaeoenvironments and the contexts of our prehistoric ancestors.

5.9 *SUMMARY RATINGS TABLE*

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6 RECOMMENDATIONS

A practical monitoring and mitigation programme must be implemented during the Construction Phases of the proposed housing development. Buried archaeological material beneath coversands is common in coastal settings. Recommendations for palaeontological mitigation are affected by those for archaeological mitigation. In most cases, when monitoring and inspection of excavations is recommended in the Archaeological Impact Assessment, separate monitoring for fossil occurrences is not necessary.

6.1 MONITORING

Interventions are particularly required if fossil bones are turned up during earth works. These are rare and valuable and every effort should be made to spot them and effect rescue of them. However, it is not usually practical for a specialist or a designated monitor to be continuously present during the Construction Phase.

It is therefore proposed that personnel involved in the making of excavations keep a lookout for fossil material during digging. The field supervisor/foreman and workers involved in digging excavations must be informed of the need to watch for fossil bones and buried potential 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 developer/owner who will contact the palaeontologist contracted to be on standby in the case of fossil finds.

Appendix 3 outlines monitoring by construction personnel and general Fossil Find Procedures for various scenarios. In the event of possible fossil and/or archaeological finds, the contracted archaeologist or palaeontologist must be contacted. For possible fossil finds, the palaeontologist will assess the information and liaise with the developer and the ECO and a suitable response will be established.

6.2 MITIGATION SUMMARY FOR THE CONSTRUCTION PHASE EMP

<table>
<tr><td colspan="3">OBJECTIVE: To see and rescue fossil material that may be exposed in the excavations made for installation of the housing infrastructure.</td></tr>
<tr><td></td><td colspan="2"></td></tr>
<tr><td>Project components</td><td colspan="2">Foundation excavations, trenches for sanitation & drainage, spoil from excavations.</td></tr>
<tr><td>Potential impact</td><td colspan="2">Loss of fossils by their being unnoticed and/ or destroyed.</td></tr>
<tr><td>Activity/ risk source</td><td colspan="2">All bulk earthworks.</td></tr>
<tr><td>Mitigation: target/ objective</td><td colspan="2">To facilitate the likelihood of noticing fossils and ensure appropriate actions in terms of the relevant legislation.</td></tr>
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</table>

Mitigation: Action/ control	Responsibility	Timeframe
Inform staff of the need to watch for potential fossil bone occurrences.	The Client, SRK, the ECO & contractors.	Pre-construction.
Inform staff of the procedures to be followed in the event of fossil bone occurrences.	ECO/specialist.	Pre-construction.
Monitor for presence of fossil bones	Contracted personnel and ECO, monitoring archaeologist.	Construction.
Liaise on nature of potential finds and appropriate responses.	ECO and specialist.	Construction.
Excavate main finds, inspect pits & record and sample excavations.	Specialist.	Construction.
Obtain permit from ECPHRA for bone finds.	Specialist.	Construction
Performance Indicator	Reporting of and liaison about possible fossil finds. Fossils noticed and rescued. Scientific record of fossil contexts and temporary exposures in earthworks.	

7 APPLICATION FOR A PALAEONTOLOGICAL PERMIT

A permit from the Eastern Cape Heritage Resources Agency (ECPHRA) 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 will be made to ECPHRA immediately. The application requires details of the registered owner/s of the property, their permission and a site-plan map.

All fossils found must be deposited at a SAHRA-approved institution, *e.g*. the Albany Museum.

8 REPORTING

Should fossils be found a detailed report on the occurrence/s must be submitted. This report is in the public domain and copies of the report must be deposited at the ECPHRA and the curatorial institution (*e.g.* the Albany Museum. It must fulfil the reporting standards and data requirements of these bodies.

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10 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.

AIA: Archaeological Impact Assessment.

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.

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.

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.

ESA: Early Stone Age. The archaeology of the Stone Age between 2 000 000 and 250 000 years ago.

EIA: Environmental Impact Assessment.

EMP: Environmental Management Plan.

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.

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. 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).

HIA: Heritage Impact Assessment.

LSA: Late Stone Age. The archaeology of the last 20 000 years associated with fully modern people.

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”.

Midden: A pile of debris, normally shellfish and bone that have accumulated as a result of human activity.

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 Quaternary definition below). 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.

MSA: Middle Stone Age. The archaeology of the Stone Age between 20-300 000 years ago associated with early modern humans.

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.

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.

SAHRA: South African Heritage Resources Agency – the compliance authority, which protects national heritage.

Stone Age: The earliest technological period in human culture when tools were made of stone, wood, bone or horn. Metal was unknown.

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).

10.1 GEOLOGICAL TIME SCALE TERMS (YOUNGEST TO OLDEST).

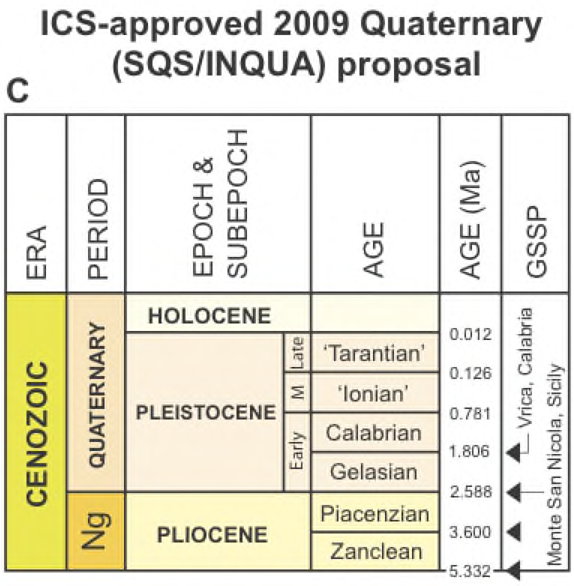
ka: Thousand years or kilo-annum (10^3 years). Implicitly means “ka ago” *i.e*. duration from the present, but “ago” is omitted. The “Present” refers to 1950 AD. Not used for durations not extending from the Present. For a duration only “kyr” is used.

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.

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.

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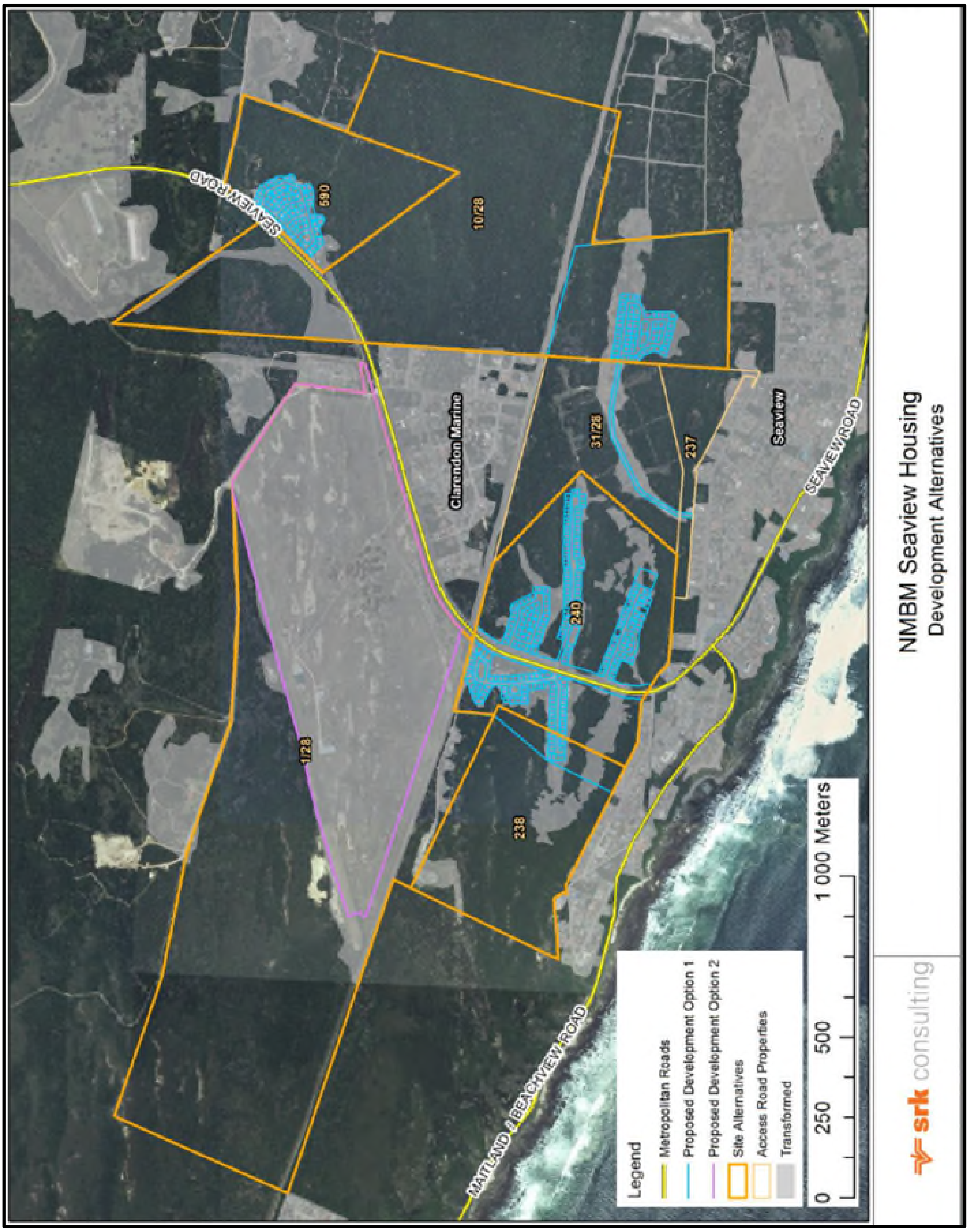
11 APPENDIX 1. PROPOSED HOUSING SITES



12 APPENDIX 2. 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 3 - FOSSIL FIND PROCEDURES

In the context under consideration, it is improbable that fossil finds will require declarations of permanent “no go” zones. At most a temporary pause in activity at a limited locale may be required. The strategy is to rescue the material as quickly as possible.

The procedures suggested below are in general terms, to be adapted as befits a context. They are couched in terms of finds of fossil bones that usually occur sparsely, such as in the aeolian deposits. However, they may also serve as a guideline for other fossil material that may occur.

Bone finds can be classified as two types: isolated bone finds and bone cluster finds.

13.1 ISOLATED BONE FINDS

In the process of digging the excavations, isolated bones may be spotted in the hole sides or bottom, or as they appear on the spoil heap. By this is meant bones that occur singly, in different parts of the excavation. If the number of distinct bones exceeds 6 pieces, the finds must be treated as a bone cluster (below).

Response by personnel in the event of isolated bone finds

- **Action 1:** An isolated bone exposed in an excavation or spoil heap must be retrieved before it is covered by further spoil from the excavation and set aside.
- **Action 2:** The site foreman and ECO must be informed.
- **Action 3:** The responsible field person (site foreman or ECO) must take custody of the fossil. The following information to be recorded:
    - Position (excavation position).
    - Depth of find in hole.
    - Digital image of hole showing vertical section (side).
    - Digital image of fossil.
- **Action 4:** The fossil should be placed in a bag (*e.g.* a Ziplock bag), along with any detached fragments. A label must be included with the date of the find, position info., depth.
- **Action 5:** ECO contacts the standby archaeologist and/or palaeontologist. ECO to describe the occurrence and provide images asap. by email.

Response by Palaeontologist in the event of isolated bone finds

The palaeontologist will assess the information and liaise with the developer, the environmental consultant and the ECO and a suitable response will be established.

13.2 Bone Cluster Finds

A bone cluster is a major find of bones, *i.e*. several bones in close proximity or bones resembling part of a skeleton. These bones will likely be seen in broken sections of the sides of the hole and as bones appearing in the bottom of the hole and on the spoil heap.

Response by personnel in the event of a bone cluster find

- **Action 1:** Immediately stop excavation in the vicinity of the potential material. Mark (flag) the position and also spoil that may contain fossils.
- **Action 2:** Inform the site foreman and the ECO.
- **Action 3:** ECO contacts the standby archaeologist and/or palaeontologist. ECO to describe the occurrence and provide images asap. by email.

Response by Palaeontologist in the event of a bone cluster find

The palaeontologist will assess the information and liaise with the developer and the environmental consultant and a suitable response will be established. It is likely that a Field Assessment by the palaeontologist will be carried out asap.

It will probably be feasible to "leapfrog" the find and continue the excavation farther along, or proceed to the next excavation, so that the work schedule is minimally disrupted. The response time/scheduling of the Field Assessment is to be decided in consultation with developer/owner and the environmental consultant.

The field assessment could have the following outcomes:

- If a human burial, the appropriate authority is to be contacted. The find must be evaluated by a human burial specialist to decide if Rescue Excavation is feasible, or if it is a Major Find.
- If the fossils are in an archaeological context, an archaeologist must be contacted to evaluate the site and decide if Rescue Excavation is feasible, or if it is a Major Find.
- If the fossils are in a palaeontological context, the palaeontologist must evaluate the site and decide if Rescue Excavation is feasible, or if it is a Major Find.

13.3 Rescue Excavation

Rescue Excavation refers to the removal of the material from the "design" excavation. This would apply if the amount or significance of the exposed material appears to be relatively circumscribed and it is feasible to remove it without compromising contextual data. The time span for Rescue Excavation should be reasonably rapid to avoid any or undue delays, *e.g*. 1-3 days and definitely less than 1 week.

In principle, the strategy during mitigation is to "rescue" the fossil material as quickly as possible. The strategy to be adopted depends on the nature of the occurrence, particularly the density of the fossils. The methods of collection would depend on the preservation or fragility of the fossils and whether in loose or in lithified sediment. These could include:

- On-site selection and sieving in the case of robust material in sand.
- Fragile material in loose/crumbly sediment would be encased in blocks using Plaster-of Paris or reinforced mortar.

If the fossil occurrence is dense and is assessed to be a "Major Find", then carefully controlled excavation is required.

13.4 *MAJOR FINDS*

A Major Find is the occurrence of material that, by virtue of quantity, importance and time constraints, cannot be feasibly rescued without compromise of detailed material recovery and contextual observations.
A Major Find is not expected.

Management Options for Major Finds
In consultation with the developer and the environmental consultant, the following options should be considered when deciding on how to proceed in the event of a Major Find.

Option 1: Avoidance

Avoidance of the major find through project redesign or relocation. This ensures minimal impact to the site and is the preferred option from a heritage resource management perspective. When feasible, it can also be the least expensive option from a construction perspective.

The find site will require site protection measures, such as erecting fencing or barricades. Alternatively, the exposed finds can be stabilized and the site refilled or capped. The latter is preferred if excavation of the find will be delayed substantially or indefinitely. Appropriate protection measures should be identified on a site-specific basis and in wider consultation with the heritage and scientific communities.

This option is preferred as it will allow the later excavation of the finds with due scientific care and diligence.

Option 2: Emergency Excavation

Emergency excavation refers to the "no option" situation wherein avoidance is not feasible due to design, financial and time constraints. It can delay construction and emergency excavation itself will take place under tight time constraints, with the potential for irrevocable compromise of scientific quality. It could involve the removal of a large, disturbed sample by excavator and conveying this by truck from the immediate site to a suitable place for "stockpiling". This material could then be processed later.

Consequently, emergency excavation is not a preferred option for a Major Find.

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