PALAEONTOLOGICAL IMPACT ASSESSMENT
(Desktop Study)

PROPOSED ISIVUNGUVUNGU WIND FARM SALDANHA

ISIVUNGUVUNGU WIND ENERGY CONVERTERS (PTY.) LTD. WIND ENERGY FACILITY, SALDANHA BAY, WESTERN 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

AURECON SOUTH AFRICA (PTY) LTD
1 Century City Drive, Waterford Precinct, Century City, 7441
PO Box 494, Cape Town, 8000
Tel: 021 481 2467
Cell: 084 251 1884
Email: Rene.Stewart@aurecongroup.com

December 2011

CONTENTS

---oooOOOooo---

SUMMARY

Isivunguvungu Wind Energy Converters (IWEC) is proposing the construction of a wind energy facility (WEF) on Remainder 129 of the Farm Yzervarkensrug, Farm 195/2 Jakkalskloof and Farm 1132 (the current ArcelorMittal: Saldanha Works steel manufacturing plant), near Saldanha, Western Cape. The proposed WEF would consist of 6 wind turbines with a total capacity of approximately 15 MW. The associated infrastructure includes an 11kV powerline; 6 transformers, a temporary site office, construction of a new road between the turbines and widening of the existing gravel road. The footprint of the project will be ±2.68 ha and the size of the property for the proposed development is ±115ha. All the wind turbines and associated infrastructure will be constructed on a portion of the Remainder 129 of the Farm Yzervarkensrug and 195/2 of the Farm Jakkalskloof; a portion of the 11kV powerline will be constructed on Farm 1132. (Figures 1 & 2).

Aurecon South Africa (Pty) Ltd has been appointed to undertake the Basic Assessment Report (BAR) process as required by the National Environmental Management Act.

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

The deeper excavations to be made are the main concern, *viz*. the foundations for the wind towers. The design specifics of the foundations of the wind turbine towers are not yet available. It is assumed that the dimensions of the excavations for foundations will be typical, *i.e*. with sides 15-20 m in length and depth of 3-4 m. Each finished excavation of these dimensions exposes between ~400 to ~600 m^2 of subsurface section in its sides and bottom. Much more section is exposed incrementally during the digging of the excavation.

The cabling trenches, although probably quite narrow and shallow (~1.0 m deep), are about 2.2 km in length and involve ~2200 m^3 of material. The footings of the overhead transmission line pylons are likely to be minor in scale and have the least likelihood of fossil finds, although not altogether absent.

Beneath a thin cover of sand, the project site is underlain by calcareous aeolianites (old dune sands) and calcretes ("surface limestones") of the **Langebaan Formation** (Figure 3). These strata do not appear to be very fossiliferous to the cursory eye, but the fossils that have been found are of profound scientific value, raising international interest in the region. The Langebaan Formation aeolianites have been a prime source of information on Quaternary faunas and archaeology. It is possible that older Quaternary "raised beach" deposits of the **Velddrif Formation** bearing shell fossils may also be encountered in the excavations.

Monitoring by on-site personnel and field inspections by a palaeontologist/trained fossil excavator are recommended during construction of excavations. Appendices 1 and 2 outline monitoring by construction personnel and a general Fossil Find Procedures.

It is recommended that Ms Pippa Haarhoff, manager of the West Coast Fossil Park, react to the reporting of chance finds by on-site personnel and also carry out field inspections at appropriate stages in the making of the excavations. Ms Haarhoff will liaise with Aurecon, I-WEC and their contractors to carry out the inspections and liaise with the appointed palaeontologist w.r.t. nature of exposures, fossil finds and in the compilation of the report.

At least one inspection of the turbine excavations by the appointed palaeontologist must be carried out, the purpose of which is to record the nature of the exposed strata, look for small-fossil content and to take representative samples.

---oooOOOooo---

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).

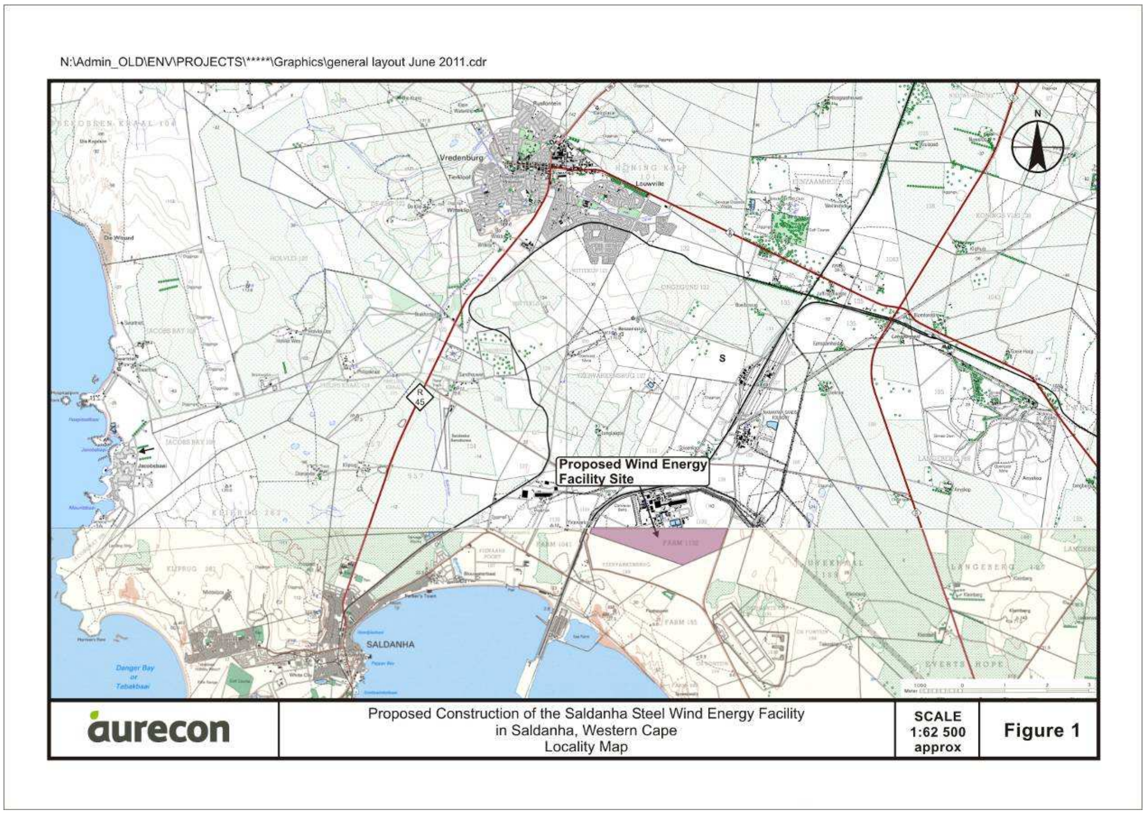
Membership Of Professional Bodies

- 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.
- Heritage Western Cape. Member, Permit Committee for Archaeology, Palaeontology and Meteorites.
- Accredited member, Association of Professional Heritage Practitioners, Western Cape.

---oooOOOooo---

1 INTRODUCTION

Isivunguvungu Wind Energy Converters (IWEC) is proposing the construction of a wind energy facility (WEF) on Remainder 129 of the Farm Yzervarkensrug, Farm 195/2 Jakkalskloof and Farm 1132 (the current ArcelorMittal: Saldanha Works steel manufacturing plant), near Saldanha, Western Cape. The proposed WEF would consist of 6 wind turbines with a total capacity of approximately 15 MW. The associated infrastructure includes an 11kV powerline; 6 transformers, a temporary site office, construction of a new road between the turbines and widening of the existing gravel road. The footprint of the project will be ±2.68 ha and the size of the property for the proposed development is ±115ha. All the wind turbines and associated infrastructure will be constructed on a portion of the Remainder 129 of the



Farm Yzervarkensrug and 195/2 of the Farm Jakkalskloof; a portion of the 11kV powerline will be constructed on Farm 1132 (Figures 1 & 2). Aurecon South Africa (Pty) Ltd has been appointed to undertake the Basic Assessment Report (BAR) process as required by the National Environmental Management Act.

This assessment forms part of the Heritage Impact Assessment in the BA 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.

Figure 1. Location of the proposed Isivunguvungu WEF, showing wind turbines (WT) 1-6. Supplied by Aurecon. Extract 1:50000 topo-cadastral sheet 3218CA_CC_2003_ED5_GEO.TIF (Chief Directorate: Surveys and Mapping).

The proposed Isivunguvungu Wind Farm Saldanha consists of only 6 wind turbines. I-WEC, a subsidiary of DCD-Dorbyl, has acquired licences and technology transfer agreements to locally manufacture 2.5 MW wind turbines and rotor blades from German wind energy conversion technology specialist Aerodyn Energiesysteme (Hancock, 2011).

The 6 wind turbines proposed will generate up to 15 MW and will be linked by underground cabling. Overhead powerlines, approximately 2.2 km, will then traverse the property and a further length of approximately 2.4 km underground cable will connect to the Eskom grid at the Saldanha Steel substation (Figures 1 & 2).

The main purposes of this palaeontological assessment are to:

- Outline the nature of possible 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 bulk 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)* and embodied in the Agreed Terms of Reference for the appointed heritage assessment/mitigation practitioner.

Included herein is a general fossil-finds procedure for the appropriate responses to the discovery of paleontological materials during construction of the foundation excavations of the turbine towers.

Figure 2. Simulated oblique aerial view of the site, looking south. Underground cabling trenches shown in yellow, overhead connection shown in cyan. From Google Earth.

2 APPLICABLE LEGISLATION

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

According to the Act (Sect. 35), it is an offence to destroy, damage, excavate, alter or remove from its original place, or collect, any archaeological, palaeontological and historical material or object, without a permit issued by the South African Heritage Resources Agency (SAHRA) or applicable Provincial Heritage Resources Agency, *viz*. Heritage Western Cape (HWC).

Notification of SAHRA or the applicable Provincial Heritage Resources Agency is required for proposed developments exceeding certain dimensions (Sect. 38).

3 THRESHOLDS

For the evaluation of the palaeontological impact it is the extent/scale of the deeper excavations to be made that are the main concern, mainly the foundations for the wind towers, the trenches for connecting cabling and foundation trenches for buildings. Allied to this is the fossil potential of the formations that are excavated, varying from nil to high.

The design specifics of the foundations of the wind turbine towers are not yet available. However, these are large turbines (between 70m to 80m towers, with 46.9m to 50.3m blades) (Hancock, 2011). It is assumed that the dimensions of the excavations for foundations will be typical, *i.e*. with sides 15-20 m in length and depth of 3-4 m.

Each finished excavation of these dimensions exposes between ~400 to ~600 m^2 of subsurface section in its sides and bottom. Much more section is exposed incrementally during the digging of the excavation. The cabling trenches, although probably quite narrow and shallow (~1.0 m deep?), are about 2.2 km in length. The footings of the overhead transmission line pylons are likely to be minor in scale and have the least likelihood of fossil finds, although not altogether absent.

As elucidated below, the affected subsurface of the site has a distinct probability of containing fossils that will be exposed during earth works.

4 APPROACH AND METHODOLOGY

4.1 AVAILABLE INFORMATION

The main information for the area is Visser & Schoch (1972, 1973) and the accompanying geological map, the relevant part of which is reproduced as Figure 3. Other references are cited in the normal manner and included in the References section.

Quarries in the surrounding area, such as those in the dune cordon to the west of the site and near Namakwa Sands Smelter, as well as trenches made on the property in the recent past for cabling and pipes, have shown the nature of the underlying substrata and their fossil potential (Pether, 2009, 2010).

4.2 ASSUMPTIONS AND LIMITATIONS

It is not possible to predict the buried fossil content of an area other than in general terms. The important fossil bone material is sparsely scattered in most deposits and much depends on spotting this material as it is uncovered during digging *i.e.* by monitoring excavations.

5 GEOLOGICAL AND PALAEONTOLOGICAL SETTING

5.1 THE LOCAL GEOLOGY

The older bedrock of the region consists of **Malmesbury Group** shales that along the coast have mostly been eroded away to below sea level. Their origin dates from over 560 Ma (Ma: million years ago, Mega-annum). The Malmesbury shales are intruded by the crystalline “**Cape Granites**” that are now exposed as hills around Vredenburg and Darling. These bedrock formations are not of palaeontological interest.

The wind turbine sites are situated between 11-13 m asl. on the outer edge of the broad, near-flat plain of the Saldanha Embayment. Beneath a thin cover of sand, the whole surrounding area is underlain by calcareous aeolianites (old dune sands) and calcretes (“surface limestones”) of the **Langebaan Formation** (Visser & Schoch, 1973; orange QC unit in Figure 3).

The fossil dunes are evident in the coastal landscape as the ridges, low hills and mounds beneath a capping calcrete crust. The elevated topography of a fossil dune cordon occurs along the edge of the bay and its strata are exposed in the quarry therein (Figure 2). An older remnant of fossil dune ridge, Skurwerug, now houses oil storage tanks (Figures 2 & 3).

The various aeolianites of the Langebaan Formation are different ages, as an “amalgam” of the dune plumes that formed on the coastal plain, at differing places and times. This is reflected in the different ages indicated from fossils found at various places.

Sheets of pale sand have been wind-deposited, in geologically-recent times, over the wide surrounding area. This is Surface Unit **Q1**, the younger coversand or “white to slightly-reddish sandy soil” (Visser & Toerien, 1971; Visser & Schoch, 1973).

Surface **Unit Q2** is characterized by its surface manifestation as the distinct “heuweltjiesveld”, the densely dot-patterned landscape of low hillocks that are termitaria made by *Microhodotermes viator*. It is an older soil developed on earlier coversands. The patterned surface around the turbine sites resembles Q2 “heuweltjiesveld” (Figure 2), or at least a more established vegetation community.

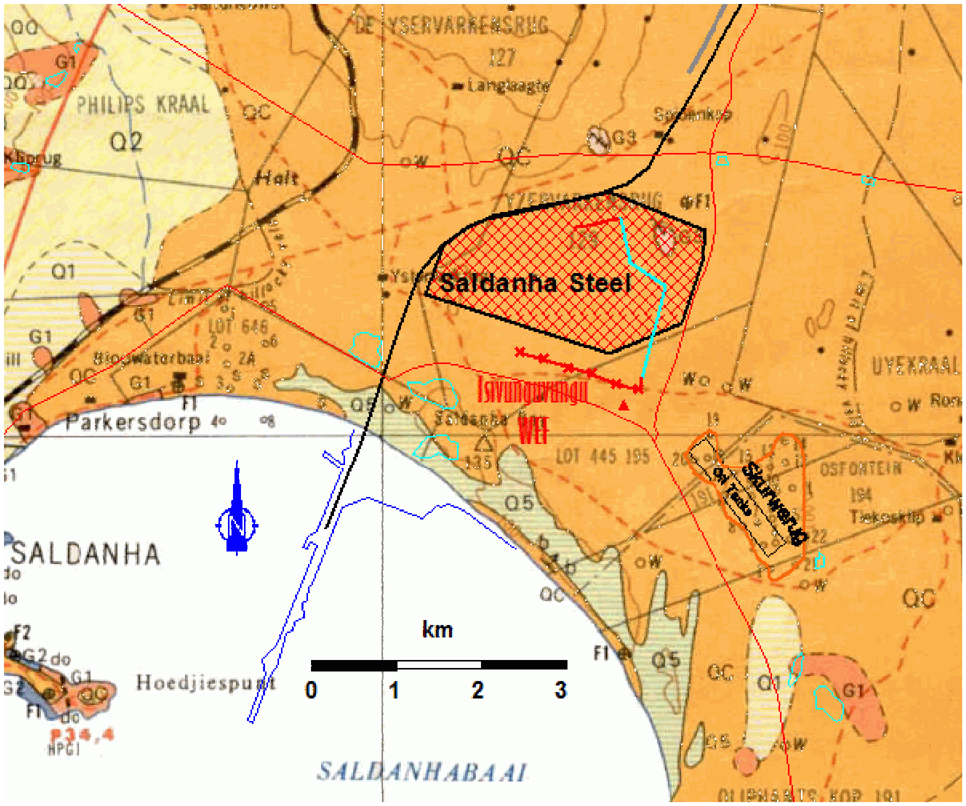


Figure 3. Geology of the project area. From Visser & Schoch (1972), 1:125000 Map Sheet 255: 3217D & 3218C (St Helenabaai), 3317B & 3318A (Saldanhabaai). Legend below in order of youngest to oldest formations.

Q5: Recent windblown sands and dunes along the beach are mapped as unit Q5. Prominent dune plumes extend north from sandy beaches. Called the **Witzand Formation**.
Q1: Another surface unit is the recent soil-unit Q1, white to slightly-reddish sandy soil, which is mainly a stabilized sand sheet blanketing the underlying geology.
Q2: An older surface unit Q2, shallow sandy soil with heuweltjies (heuweltjiesveld), occurs inland the coast. Incipient calcretes occur in Q2. It overlies the Langebaan "Limestone" Formation.
QC: The **Langebaan "Limestone" Formation**, aeolianite Unit QC, is underlain mainly by marine deposits of Pliocene age (**Varswater** & **Uyekraal** fms).
G1, G2, G3, G4 and **G5** are outcrops of various bedrock granites of the Cape Granite Suite.

The latest addition of dunes to the coastal plain is Unit **Q5** (Figure 3), otherwise known as the **Witzand Formation** (Rogers, 1980), for obvious reason. These are sands blown from the beach in the last few thousand years and added to the fossil dune cordon or "sand wall" parallel to the coast, or have blown further as dune plumes transgressing a few kilometres inland.

The Langebaan Formation is underlain by older marine and estuarine deposits, usually as shelly gravels and muddy sands, respectively. In the Saldanha Steel area the underlying marine deposits are the **Uyekraal Shelly Sand Formation** (Rogers, 1983) (Figure 4). Although the adjacent Uyekraal farm is the "type area" of the Uyekraal Formation, there is no type section available and the Uyekraal Fm. is known only from boreholes in this area. These reveal a buried calcrete, beneath of which is green-hued, shelly, gravelly sand, with phosphatic casts (steinkerns) of molluscs and shark teeth

(Rogers, 1982, 1983). At various places around Saldanha Bay are exposures of shelly marine deposits with Pliocene assemblages and these are the eroded fringes of the Uyekraal Formation (Leentjiesklip, Hoedjiespunt peninsula, Diazville lower quarry) (Figure 4). On the basis of extinct fossil shells, the Uyekraal Fm. is correlated with the Hondeklip Fm. of Namaqualand, deposited during the mid-Pliocene 3.0-3.4 Ma (Pether *et al.*, 2000). As in Namaqualand, this formation underlies the outer several km of the coastal plain. In the Saldanha area it extends from just west of the West Coast Fossil Park.

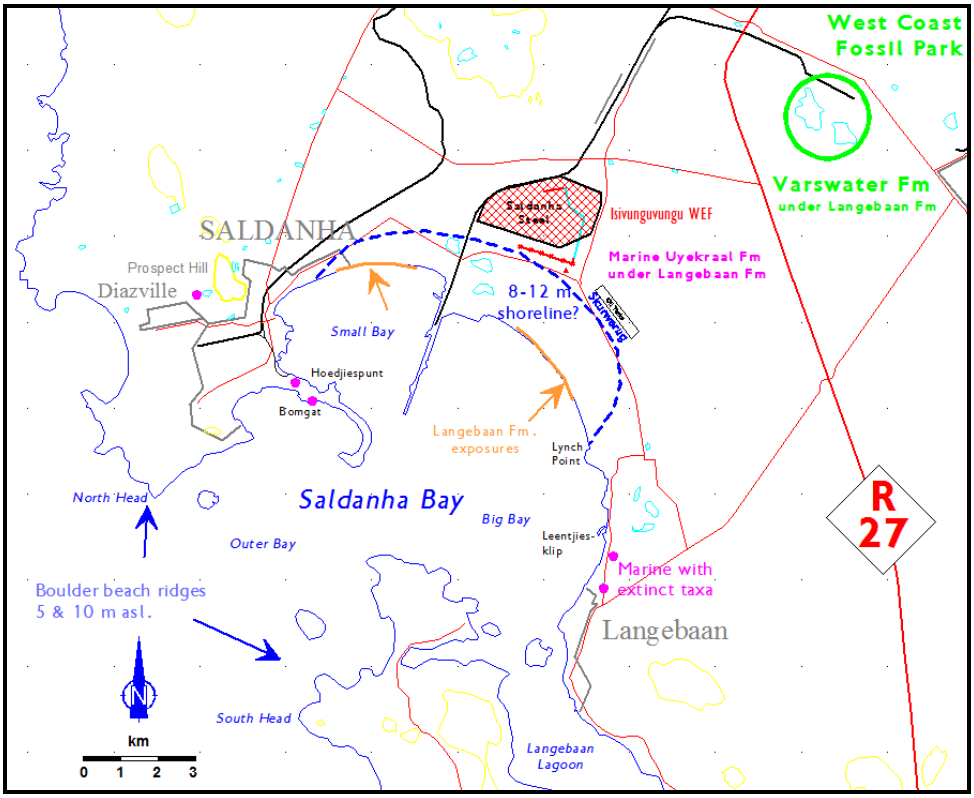


Figure 4. Aspects of the marine stratigraphy of the Saldanha Bay area.

Some vertebrate fossils have previously been obtained from deep excavations at Saldanha Steel (Roberts, 1997). At least some of these are reworked from older formations, such as the Varswater Fm (5-4 Ma) exposed at the West Coast Fossil Park.

“Raised beaches” of the **Velddrif Formation** occur along the coast below ~15 m asl. These were deposited during the Quaternary Period. Most of the Velddrif Formation deposits that are exposed date to the Last Interglacial (LIG) about 125 ka (ka: thousand years ago) and are found up to ~8 m asl. due to storm deposition, but the mean sea level was about 5-6 m asl. The LIG is also known as Marine Isotope Stage 5e (MIS 5e).

Farther inland, higher-lying marine terrace deposits up to 12-15 m asl. may relate to an older interglacial high sea level around 400 ka (MIS 11). These older raised beaches are very poorly known and could well differ in age from place to place, or be composites.

Hendey & Cooke (1985) described a fossil suid skull (bushpig) found in the Skurwerug fossil dune plume, during construction of the “fuel oil tank farm”. The Skurwerug suid dates the Langebaan Formation aeolianite there to the early Quaternary ~1.2 Ma. This provides a minimum age for the underlying marine deposits beneath the Skurwerug area. Hendey & Cooke (1985) also argued that the Skurwerug dune plume may be associated with an early Quaternary palaeoshoreline at ~8-12 m asl.

5.2 EXPECTED PALAEONTOLOGY

5.2.1 Fossils in aeolian settings

Many fossils are associated with old, buried surfaces in the aeolianites (palaeosurfaces), usually formed during wetter or less windy periods, with reduced rates of sand accumulation and with soil formation showing the surface stability. The common fossils include shells of extinct land snails, fossil tortoises, ostrich incl. egg fragments and generally sparsely scattered bones. Conversely “blowout” erosional palaeosurfaces may carry fossils concentrated by the removal of sand by the wind.

Thick calcretes develop beneath long-lived surfaces on old formations. The thick calcrete is normally polyphase in origin and may disguise within it discrete, small phases of sand deposition separated by cryptic palaeosurfaces on which fossils may occur. Fossils in cemented aeolianites and calcretes are quite difficult to spot as they are usually coated with white limey deposit (Figure 5) and do not stand out well amongst the nodules and generally bumpiness of a fresh exposure.

The bone concentrations most commonly found are due to hyaenas. The bones often occur in the lairs of hyaenas, such as tunnels made into the softer material beneath a calcrete “roof” (Figure 6). These most often occur on slopes where some erosion of the calcrete, producing overhangs and crevices, has facilitated the making of a burrow. Burrows made by aardvarks are also exploited by hyaenas. Hyaena lairs can be found at depth in the aeolian deposits, where they relate to buried palaeosurfaces.

Dissolution hollows formed by water locally ponding and dissolving the calcrete are another site of local fossil trapping. These can also be exploited to make burrows and lairs. These dissolution features are called “karst” and surprisingly deep “pipes” can form in this manner, usually filled with reddened sediment. Such dissolution pipes can directly trap small animals and accumulate fossils. The fossil concentrations in animal lairs and dissolution features are “superimposed” into an older, cementing aeolianite.

Figure 5. Example of fossil antelope jaw from a shallow trench into the calcrete capping of the Langebaan Formation. Image courtesy André Carstens.

Figure 6. Fossil bone concentration (circled) in the infill of a cavity below the calcrete capping of the Langebaan Formation.

Hollows between dunes (interdune areas) are the sites of ponding of water seeping from the dunes, leading to the deposits of springs and small vleis. These are usually muddy, with plant fossils, but being waterholes, are usually richly fossiliferous. Due to the erosional truncation of the Langebaan Formation at the present coast, it is exposed in the intertidal zone of the beach fringing the farm Spreeuwal, to the south of the project area (Figure 3). These beds are fossiliferous, with large mammal bones and some MSA artefacts (Avery & Klein, 2009). Small mammals, birds, reptiles, amphibians, freshwater gastropods and ostracods also occur. The preserved environment is a wetland or vlei. The larger mammal component includes extinct species and others not recorded historically in the Western Cape. These "Spreeuwal Beds" illustrate the palaeoenvironments that are a typically interbedded in the lower parts of the Langebaan Formation.

5.2.2 "Raised beach" deposits

It is possible that older Quaternary "raised beach" deposits bearing shell fossils may be encountered in the excavations. No marine deposits are visible in the section of Langebaan Formation dune-cordon aeolianite exposed in the quarry to the west and they must lie at greater depth there. Possible early Quaternary marine deposits should be closer to the surface at the lower elevations of 11-13 m asl. at the turbine sites.

5.2.3 Buried archaeological material

It is possible that archaeological material may occur locally within the thin, loose sand cover covering the capping calcrete of the aeolianite. This is indicated by "out of place' marine shell (limpets, mussels), pottery pieces and quartz or silcrete stone tools. Buried archaeological material may also occur on top of the calcrete or in crevices and solution pits in it. Early and Middle Stone Age artefacts and associated fossil bones are found within and below the capping calcretes.

6 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, <u>provided that efforts are made to watch out for and rescue the fossils</u>. Fossils and significant observations will be lost in the absence of management actions to mitigate such loss this loss of the opportunity to recover them and their contexts when exposed at a particular site is irreversible.

The status of the potential impact for palaeontology is not neutral or negligible.

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

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

7 SIGNIFICANCE

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

Past discoveries show that the fossil potential within and beneath coversands, dunes and in aeolianites can be very significant. The most well-studied is Elandsfontein, where blowouts of the coversand exposed thousands of underlying fossil bones and Stone Age tools, the occurrence of which is associated with a fossil vlei formed due to higher water tables in the past (Klein *et al*., 2007). Notably, prior to the wind erosion of coversands at Elandsfontein, there would have been no indication of the fossil wealth just below, which included a cranium of the pre-modern human *Homo heidelbergensis*.

At Geelbek Dunefield the deflation hollows located between the wind-blown, actively-mobile sand dunes are a source of mammalian fossils and Stone Age tools, with more being constantly exposed (Kandel *et al*., 2003). Examples of hyaena bone accumulations in dens within the partly-lithified dune rocks are the Sea Harvest and Hoedjiespunt sites in Saldanha Bay. Hoedjiespunt is the find site of fossil teeth of a hominid in deposits 200-300 ka old. The Sea Harvest site produced an essentially modern human tooth that is older than 40 ka. Both sites provided considerable samples of the faunas of those times, thanks to the brown hyaenas.

The general significance of coastal-plain fossils involves:

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

8 IMPACT ASSESSMENT

8.1 NATURE OF THE IMPACT

8.1.1 Extents

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

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

8.1.2 Duration

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

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

8.1.3 Intensity

Thus the potential impact of bulk earth works on fossil resources is high in the absence of mitigation. As mentioned, it is quite likely that scientifically valuable fossils may be lost in spite of mitigation.

8.1.4 Probability

The likelihood of impact is medium *i.e*. it is likely to occur under most conditions.

8.1.5 Confidence

The level of confidence of the probability and intensity of impact is medium to high.

8.2 RATING OF THE IMPACT

The ratings in the table below are according to the methodology in Appendix 3. Such methodologies are for environmental impacts, but the “magnitude” section has been adapted for fossil geoheritage impact.

Table 2. Impact Ratings

Nature		
Construction activities (excavations) will result in a negative direct impact on the probable fossil content of the affected subsurface. 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. Conversely, construction excavations 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. There remains a medium to high risk of valuable fossils being lost in spite of management actions to mitigate such loss.		
Impact on Fossil Resource	**Without mitigation**	**With mitigation**
Extent	3-5 (regional-international)	3-5 (regional-international)
Duration	5 (permanent loss)	5 (part loss, part gain, perm.)
Magnitude	10 (destruction)	6 (partly rescued)
Probability	3	3
Significance	**54-60**	**42-48**
Status	Negative	Positive
Reversibility	Irreversible	Irreversible
Irreplaceable loss of resources?	Yes	Partly
Can impacts be mitigated?	Partly	
Mitigation:	Monitoring and inspection of construction-phase excavations	

The significance without mitigation is high Medium and mid-Medium with mitigation. This reflects the probability of loss of sparse, valuable bone fossils, even with diligent mitigation.

9 RECOMMENDATIONS

The potential impact has a moderate influence upon the proposed project, consisting of implemented mitigation measures recommended below, to be followed during the construction phase.

Monitoring by on-site personnel and field inspections by a palaeontologist/trained fossil excavator are recommended during construction of excavations.

Appendices 1 and 2 outline monitoring by construction personnel and a general Fossil Find Procedures.

It is recommended that Ms Pippa Haarhoff, manager of the West Coast Fossil Park, carry out field inspections at appropriate stages in the making of the excavations. Ms Haarhoff has the requisite experience for seeing and excavating fossil material. She can be available to react to the reporting of chance finds by on-site personnel. As she is closer at hand, this arrangement is more cost-effective, with faster response times.

Ms Haarhoff will liaise with Aurecon and I-WEC and their contractors to carry out the inspections during and at completion of excavations, involving:

- Inspect the exacavations and spoil heaps for fossil content.
- Photographically record occurrences.
- Retrieve fossil bone finds. Given the nature of the deposit, these are expected to be finds of broken bone exposed in chunks of calcrete. All bone-bearing pieces should be collected.
- Liaise with the appointed palaeontologist w.r.t. nature of exposures, fossil finds and in the compilation of the report.

In the event of a significant fossil occurrence, additional geological and palaeontological expertise must be brought to bear in order to more completely record the context.

At least one inspection of the turbine excavations by the appointed palaeontologist must be carried out, the purpose of which is to record the nature of the exposed strata, look for small-fossil content and to take representative samples.

9.1 *MONITORING*

Table 4. Basic measures for the Construction EMP

OBJECTIVE: To see and rescue fossil material that may be exposed in the various excavations made for installation foundations and cabling.		
Project components	Foundation excavations for wind turbines. Trenches for cabling linking turbines and the link to the substation. Spoil from excavations.	
Potential impact	Loss of fossils by their being unnoticed and/ or destroyed.	
Activity/ risk source	All bulk earthworks.	
Mitigation: target/ objective	To facilitate the likelihood of noticing fossils and ensure appropriate actions in terms of the relevant legislation.	
Mitigation: Action/ control	**Responsibility**	**Timeframe**
Inform staff of the need to watch for potential fossil occurrences.	I-WEC, Aurecon, ECO, contractors.	Pre-construction.
Inform staff of the procedures to be	ECO/specialist.	Pre-construction.

followed in the event of fossil occurrences.		
Monitor for presence of fossils	Contracted personnel and ECO.	Construction.
Liaise on nature of potential finds and appropriate responses.	ECO and specialist.	Construction.
Excavate main finds, inspect pits & record selected, key/higher-risk excavations.	Specialist.	Construction.
Obtain permit from HWC for finds.	Specialist.	Construction
Performance Indicator	Reporting of and liaison about possible fossil finds. Fossils noticed and rescued.	
Monitoring	Due effort to meet the requirements of the monitoring procedures.	

10 APPLICATION FOR A PALAEONTOLOGICAL PERMIT

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

A permit has not been applied for prior to the making of excavations. Should fossils be found that require rapid collecting, application for a retrospective palaeontological permit will be made to HWC immediately.

The application requires details of the registered owners of the sites, their permission and a site-plan map.

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

11 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 IZIKO S.A. Museum and Heritage Resources Western Cape. It must fulfil the reporting standards and data requirements of these bodies.

The report will be in standard scientific format, basically:

- A summary/abstract.
- Introduction.

- Previous work/context.
- Observations (incl. graphic sections, images).
- Palaeontology.
- Interpretation.
- Concluding summary.
- References.
- Appendices

The draft report will be reviewed by the client, or externally, before submission of the Final Report.

12 REFERENCES

Avery, G & Klein, R.G. 2009. Spreeuwal: an Upper Pleistocene Wetland on the Western Cape Coast, South Africa. *SASQUA 2009, Programme & Abstracts*, p. 11.

Hancock, T. 2011. Wind turbine maker wants DoE to shed light on local content threshold for onshore wind technologies - 2011/09/26. http://www.l2b.co.za/Global/News/Article/Article.asp?ID=6954

Hendey, Q.B. & Cooke, H.B.S. 1985. *Kolpochoerus paiceae* (Mammmalia, Suidae) from Skurwerug, near Saldanha, South Africa, and its palaeoenvironmental implications. *Annals of the South African Museum* **97**: 9-56.

Kandel, A.W., Felix-Henningsen, P. & Conard, N.J. 2003. An overview of the spatial archaeology of the Geelbek Dunes, Western Cape, South Africa. *British Archaeological Reports International Series* **1163**: 37-44.

Klein, R.G., Avery, G., Cruz-Uribe, K. & Steele, T.E. 2007. The mammalian fauna associated with an archaic hominin skullcap and later Acheulean artifacts at Elandsfontein, Western Cape Province, South Africa. *Journal of Human Evolution* **52**: 164-186.

Pether, J, Roberts, D.L. & Ward, J.D. 2000. Deposits of the West Coast (Chapter 3). In: Partridge, T.C. and Maud, R.R. eds. The Cenozoic of Southern Africa. *Oxford Monographs on Geology and Geophysics No. 40. Oxford University Press*: 33-55.

Pether, J. 2009. Palaeontological Impact Assessment (Desktop Scoping Study) and Chance Find Management Plan. Establishment of a Metal Recovery Plant At Arcelor Mittal Saldanha Works, Saldanha Bay, Western Cape. For Environmental Resources Management SA (ERM). (June).

Pether, J. 2009. Palaeontological Monitoring Report. Establishment Of A Metal Recovery Plant At Arcelor Mittal Saldanha Works, Saldanha Bay, Western Cape. For Environmental Resources Management SA (ERM). (Aug).

Pether, J. 2010. Palaeontological Impact Assessment. Arcelor-Mittal SA Proposed Saldanha Bay LPG Facility Site Selection. For ERM Southern Africa (Pty) Ltd. (Sept.)

Roberts, D.L. 1997. Fossil occurrence at the Saldanha Steel site. Report prepared for Saldanha Steel Project (Pty) Ltd. Pretoria. Council for Geoscience Geological Survey.

Rogers, J. 1980. First report on the Cenozoic sediments between Cape Town and Eland's Bay. *Geological Survey of South Africa Open File* **136**.

Rogers, J. 1982. Lithostratigraphy of Cenozoic sediments between Cape Town and Eland's Bay. *Palaeoecology of Africa* **15**: 121-137.

Rogers, J. 1983. Lithostratigraphy of Cenozoic sediments on the coastal plain between Cape Town and Saldanha Bay. *Technical Report of the Joint Geological Survey/University of Cape Town Marine Geoscience Unit* **14**: 87-103.

Visser, H.N. & Schoch, A.E. 1972. Map Sheet 255: 3217D & 3218C (St Helenabaai), 3317B & 3318A (Saldanhabaai). *Geological Survey of South Africa*.

Visser, H.N. & Schoch, A.E. 1973. The geology and mineral resources of the Saldanha Bay area. *Memoir Geological Survey of South Africa* **63**: 156 pp.

Visser, H.N. & Toerien, D.K. 1971. Die geologie van die gebied tussen Vredendal en Elandsbaai. Explanation of Sheet 254: 3118C (Doring Bay) and 3218A (Lambert's Bay). *Geological Survey of South Africa.* 63 pp.

---oooOOOooo---

13 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: Mineralised bones of animals, shellfish, plants and marine animals. A trace fossil is the disturbance or structure produced in sediments by organisms, such as burrows and trackways.

HAWT: Horizontal Axis Wind Turbine.

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.

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

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 whose 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.

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.

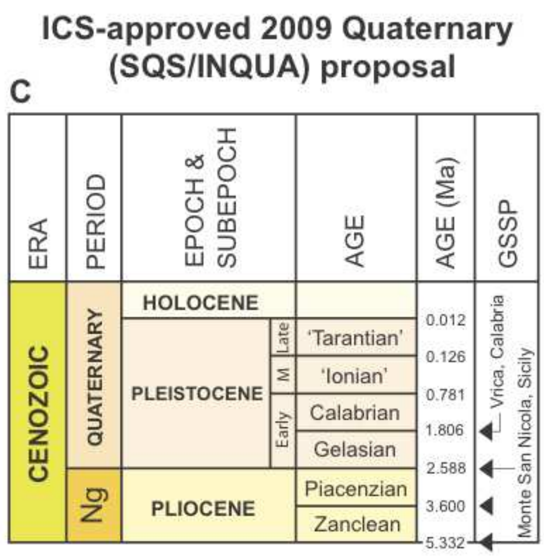
13.1 *GEOLOGICAL TIME SCALE TERMS (YOUNGEST TO OLDEST).*

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. Generally not used for durations not extending from the Present. Sometimes “kyr” is used instead.

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. Generally not used for durations not extending from the Present.

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. The terms early, middle or late in reference to the Quaternary should only be used with lower case letters because these divisions are informal and have no status as divisions of the term Quaternary. The sub-divisions 'Early', 'Middle' or 'Late' apply only to the word Pleistocene. 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.

Jurassic: Period in the Mesozoic Era, 200-145 Ma.

Precambrian: Old crustal rocks older than 542 Ma (pre-dating the Cambrian).

---oooOOOooo---

14 APPENDIX 1 – MONITORING FOR FOSSILS

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

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

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

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

Should the monitoring of the excavations be a stipulation in the Archaeological Impact Assessment, the contracted Monitoring Archaeologist (MA) can also monitor for the presence of fossils and make a field assessment of any material brought to attention. The MA is usually sufficiently informed to identify fossil material and this avoids additional monitoring by a palaeontologist. In shallow coastal excavations, the fossils encountered are usually in an archaeological context.

The MA then becomes the responsible field person and fulfils the role of liaison with the palaeontologist and coordinates with the developer and the Environmental Control Officer (ECO). If fossils are exposed in non-archaeological contexts, the palaeontologist should be summoned to document and sample/collect them.

Other alternatives could be considered, such as the employment of a dedicated monitor for the construction period. For instance, a local person could be detached from or trained by personnel at the West Coast Fossil Park.

14.1 CONTACTS FOR REPORTING OF FOSSIL FINDS.

West Coast Fossil Park

- Pippa Haarhoff: 083 289 6902, 022 766 1606, pippah@iafrica.com

Iziko Museums of Cape Town: SA Museum, 021 481 3800.

- Dr Graham Avery. 021 481 3895, 083 441 0028.
- Dr Deano Stynder. 021 481 3894.

Heritage Western Cape

- Justin Bradfield. 021 483 9543
- Jenna Lavin: 021 483 9685

---oooOOOooo---

15 APPENDIX 2 - 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.

In contrast, fossil shell layers are usually fairly extensive and can be easily documented and sampled (See section 15.5).

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

15.1 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 to inform the developer, the developer 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 and the ECO and a suitable response will be established.

15.2 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 to inform the developer, the developer 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 ECO 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 (see AIA). 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 an palaeontological context, the palaeontologist must evaluate the site and decide if Rescue Excavation is feasible, or if it is a Major Find.

15.3 RESCUE EXCAVATION

Rescue Excavation refers to the removal of the material from the just 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.

15.4 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 developer/owner 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.

15.5 EXPOSURE OF FOSSIL SHELL BEDS

Response by personnel in the event of intersection of fossil shell beds

- **Action 1:** The site foreman and ECO must be informed.
- **Action 2:** The responsible field person (site foreman or ECO) must record the following information:
    - Position (excavation position).
    - Depth of find in hole.
    - Digital image of hole showing vertical section (side).
    - Digital images of the fossiliferous material.
- **Action 3:** A generous quantity of the excavated material containing the fossils should be stockpiled near the site, for later examination and sampling.
- **Action 4:** ECO to inform the developer, the developer 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 fossil shell bed finds
The palaeontologist will assess the information and liaise with the developer and the ECO and a suitable response will be established. This will most likely be a site visit to document and sample the exposure in detail, before it is covered up.

---oooOOOooo---

16 APPENDIX 3 – RATING THE SIGNIFICANCE OF IMPACTS

The Nature: A description of what causes the effect, what will be affected and how it will be affected.

The Extent: Whether the impact will be local (limited to the immediate area or site of development) or regional, and a value between 1 and 5 will be assigned as appropriate (with 1 being low and 5 being high).

The Duration: Whether the lifetime of the impact will be of:
- very short duration (0-1 years) assigned a score of 1.
- short duration (2-5 years) assigned a score of 2.
- medium-term (5-15 years) - assigned a score of 3.
- long term (> 15 years) - assigned a score of 4.
- permanent - assigned a score of 5.

The Magnitude: Quantified on a scale of 0-10, where:
- 0 is negligible - no effect on fossil geoheritage.
- 2 is minor and will not result in an impact – similar fossils available elsewhere.
- 4 is low and will cause a slight impact - similar fossils available elsewhere, but rare and quality specimens desirable.
- 6 is moderate and will result in an impact – expected fossils sparse and thus quite rare and scientifically important.
- 8 is high – high loss of rare material, only partial mitigation possible.
- 10 is very high - complete loss of known rare material.

The Probability: The likelihood of the impact actually occurring. Probability will be estimated on a scale of 1-5, where
- 1 is very improbable (probably will not happen).
- 2 is improbable (some possibility, but low likelihood).
- 3 is probable (distinct possibility).
- 4 is highly probable (most likely).
- 5 is definite (impact will occur regardless of any prevention measures).

The Significance: Determined through a synthesis of the characteristics described above and can be assessed as low, medium or high.
The significance S is calculated by combining the criteria in the following formula: S=(E+D+M)P
- E = Extent
- D = Duration
- M = Magnitude
- P = Probability

The significance weightings for each potential impact are as follows:
- < 30 points: Low (would not have a direct influence on the decision to develop in the area).
- 30-60 points: Medium (could influence the decision to develop in the area unless it is effectively mitigated).
- > 60 points: High (must have an influence on the decision process to develop in the area).

The Status: Positive, negative or neutral.

Reversibility: The degree to which the impact can be reversed.

Irreplaceable loss of resources: The degree to which the impact may cause irreplaceable losses.

Degree to which the impact can be mitigated.

---oooOOOooo---