Draft EIA Report for the Proposed Construction, Operation and Decommissioning of a Seawater Reverse Osmosis Plant and Associated Infrastructure in the Saldanha Bay Region, Western Cape

DRAFT EIA REPORT

Appendix 10-3

Heritage (incl Archaeology, Palaeontology & Visual)

Palaeontology Specialist Study

Contents

LIST OF TABLES

LIST OF FIGURES

APPENDIX 10.3 – PALAEONTOLOGICAL SPECIALIST STUDY

SUMMARY

The longest corridor traverses (i.e. those from Danger Bay to the Besaansklip Reservoir) affect the Langebaan Formation aeolianites and the calcrete palaeosols formed in them. The main "bulk" of aeolianites is not very fossiliferous, but fossil bones from the Langebaan Formation have been a prime source of information on past (different) Quaternary faunas and archaeology.

Most of the finds are expected to be sporadic occurrences of **Low** (local) significance, but significant bone concentrations occur in certain contexts. Depending on the nature of the discovery, the significance may escalate to **High** (international interest), such as finds of unexpected or new species or hominid finds. The pipeline corridors to Danger Bay also cross the Prospect Hill Formation aeolianites and calcretes.

Rare fossil fragments, particularly fossil eggshell fragments of an extinct ostrich, show that these aeolianites are much older than the Langebaan Formation aeolianites. These were found in hillside calcrete exposures and further finds are now of **High** (international) significance.

The raised beaches of the Velddrif formation fringe the coast. At Danger Bay Outfall, the south western discharge crosses two raised beach ridges. The shell fossils are usually abundant and are of **Low** (local) significance. The crossing point at Big Bay may cross fossil bone-bearing deposits that locally crop out in the intertidal zone, of **High** significance.

Impacts to palaeontological resources were found to be of potentially **High** (even international) significance in palaeontological terms, although their sparse distribution warrants only **Medium** significance overall. *Note that the presence of fossils in the subsurface does not have an a priori influence on the decision to proceed with the development.*

However, mitigation measures are essential. The key activity will be that the contracted palaeontologist carry out field inspections at appropriate stages in the making of the excavations, particularly in the Prospect Hill and Velddrif formations. The aim of field inspection is to examine a representative sample of the various deposits exposed in the excavations, recording context, fossil content and to take samples.

It is probable that sparse, valuable bone fossils will go undetected, even with the most diligent mitigation practicable. On the other hand, the finding and recovery fossils will have a positive impact ranging from local to international in extent, depending on the nature of the finds.

DECLARATION OF INDEPENDENCE

In terms of Chapter 5 of the National Environmental Management Act of 1998 specialists involved in Impact Assessment processes must declare their independence. I, J. Pether, do hereby declare that I am financially and otherwise independent of the client and their consultants, and that all opinions expressed in this document are substantially my own.

J Pether

Table 1. Affected formations of the Sandveld Group in the study area.

FORMATION	Age and description	Sensitivity
WITZAND - Q5	Holocene and recently active dune fields and cordons <~12 ka.	Mainly archaeological sites.
SPRINGFONTYN - Q1 & Q2	Quaternary to Holocene, mainly quartzose dune and sandsheet deposits, interbedded palaeosols, basal fluvial deposits <~2 Ma.	Fossil bones very sparse, local to high signif. Basal fluvial deposits locally – high signif.
VELDDRIF - VD	Quaternary raised beaches & estuarine deposits, <~1.2 Ma. Sea-levels below ~15 m asl.	Shell fossils common, local signif. Fossil bones very sparse, high signif.
LANGEBAAN - LB	Late Pliocene to Late Quaternary aeolianites <~3 Ma to ~60 ka.	Fossil bones mod. common, local to high signif.
PROSPECT HILL - PH	Late Miocene aeolianite 12-9 Ma?	Fossils very sparse – high signif.

The longest traverses affect the Langebaan Formation aeolianites and the calcrete palaeosols formed in them (Annexure 10.3.3). The main "bulk" of aeolianites is not very fossiliferous, but fossil bones from the Langebaan Formation formation have been a prime source of information on past (different) Quaternary faunas and archaeology. Most of the finds are expected to be sporadic occurrences of "local" significance, but significant bone concentrations occur in certain contexts. Depending on the nature of the discovery, the significance may escalate to high (international interest), such as finds of unexpected or new species or hominid finds.

The pipeline corridors to Danger Bay also cross the Prospect Hill Formation aeolianites and calcretes. Rare fossil fragments, particularly fossil eggshell fragments of an extinct ostrich, show that these aeolianites are much older than the Langebaan Formation aeolianites. These were found in hillside calcrete exposures and further finds are now of high (international) significance.

The "raised beaches" of the Velddrif formation fringe the coast. At Danger Bay the SW discharge crosses two raised beach ridges. The shell fossils are usually abundant and are of local significance. The crossing point at Big Bay may cross fossil bone-bearing deposits that locally crop out in the intertidal zone, of high significance.

The pipeline corridors to Danger Bay cross 3-4 km of Springfontyn Formation coversands and soils. The fossil potential is low and material that occurs in it is likely to be in an archaeological context.

Note that the presence of fossils in the subsurface does not have an *a priori* influence on the decision to proceed with the development. However, mitigation measures are essential. It is probable that sparse, valuable bone fossils will go undetected, even with the most diligent mitigation practicable. On the other hand, the finding and recovery fossils will have a positive impact ranging from local to international in extent, depending on the nature of the finds.

Table 2. Summary Impact Ratings

NATURE		
Impact on Fossil Resource	**Without mitigation**	**With mitigation**
Extent	Site specific	Site specific
Duration	Permanent loss	Permanent (part loss, part gain)
Intensity	High (destruction)	Medium (partly rescued)
Probability	Probable	Probable
SIGNIFICANCE	**MEDIUM**	**MEDIUM**
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	

Monitoring by on-site personnel and field inspections by a palaeontologist/trained fossil excavator are recommended during construction of excavations. Once pegged, the pipeline routes across the Prospect Hill and Velddrif formations must be inspected for possible exposed fossils. It is recommended that the contracted palaeontologist carry out field inspections at appropriate stages in the making of the excavations, particularly in the Prospect Hill and Velddrif formations.

Appendices 1 and 2 outline monitoring by construction personnel and a general Fossil Find Procedures for inclusion in the Construction Phase EMP. In the event of fossil finds, the appointed palaeontologist will assess the information and liaise with the manager and the ECO and a suitable response will be established. If an important find, a field inspection must be undertaken to document and sample fossiliferous strata that may be exposed.

When a site and pipeline routes are chosen, the mitigation recommendations can be amended to be more specific. The contracted palaeontologist will liaise with the CSIR and the WCDM and their contractors about the specifics of setting up a monitoring and inspection programme.

1 INTRODUCTION

Developments in the Saldanha area have resulted in a growing demand for potable water that projects into the future. The West Coast District Municipality (WCDM) is therefore proposing to construct and operate a sea water desalination plant in the Saldanha Bay area using Sea Water Reverse Osmosis technology (SWRO) to generate ~25 000 m^3 of potable water per day.

WorleyParsons South Africa (Pty) Ltd., a provider of engineering, procurement and construction management services (EPCM), has been commissioned by WCDM to oversee the project process, including the Environmental Impact Assessment (EIA) process that forms part of the feasibility studies. On behalf of the WCDM, WorleyParsons has appointed the Council for Scientific and Industrial Research (CSIR) as the independent environmental assessment practitioner for the proposed project.

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 undertaken during the construction phase.

Notably, palaeontological interventions happen once fossil material is exposed at depth, *i.e.* once the EIA process is done and construction commences. Unless formations bearing rare fossils crop out at a project site, palaeontological concerns do not usually impede developments. The main purposes of this palaeontological assessment are to:

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

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 mitigation practitioner. Included herein is a general fossil-finds procedure for the appropriate responses to the discovery of paleontological materials during construction-phase bulk earth works.

1.1 PROPOSED PROJECT COMPONENTS AND LOCATIONS

The project components and the alternative options under consideration are illustrated in Figure 1. A sea water reverse-osmosis desalination plant (SWROP) includes the intake and discharge marine pipelines and pumps, the SWROP itself, a holding reservoir for the desalinated seawater, the pipeline to transfer the latter to the municipal reservoir on the flank of Besaansklip and connections to the local electricity grid.

The Preferred site, called Site 4, is situated near the shoreline at Danger Bay, with 1 intake and 2 brine discharge pipelines (Figure 1). The freshwater pipeline will link to the Besaansklip Reservoir via either the Jacobsbaai Road Corridor or the Afrisam Corridor. There are two route options to link the SWROP to the Jacobsbaai Road Corridor (Western and Eastern).

Figure 1/…

Figure 1. Project components and alternative options. Spatial data provided by the CSIR, viewed in Google Earth

The Alternative site is Site 1 at the ArcelorMittal Saldanha Steel plant. Here there are 2 sites under consideration for the SWROP location, Western and Eastern. The intake and discharge pipelines are located in Big Bay and the pipe routes associated with the alternative sites are shown (Figure 1).

Other options under consideration are the routings of the brine discharge from the chosen Site 1 SWROP location to Danger Bay, instead of back to Big Bay, via either the Jacobsbaai Road Corridor or the Afrisam Corridor.

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 of remove from its original place, or collect, any archaeological, palaeontological and historical material or object, without a permit issued by the South African Heritage Resources Agency (SAHRA) or applicable Provincial Heritage Resources Agency, *viz*. Heritage Western Cape (HWC).

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

3 THRESHOLDS

The areal scale of subsurface disturbance and exposure of the SWROP and the pipelines exceeds 300 m in linear length and 5000 m^2. In terms of the NHRA 25 (1999) Section 38 (1), the proposed project must be assessed for heritage impacts (an HIA) that includes assessment of potential palaeontological heritage (a PIA).

For the evaluation of palaeontological impacts it is the extent/scale of the bulk earth works that are the main concern. The main impacts relate to the pipeline routes to the seawater intakes and brine discharge points and the freshwater routes to the Besaansklip reservoir. The pipes will be shallowly buried along existing servitudes, road reserves or cadastral boundaries. Thus parts of the routes will be in previously disturbed subsurface, while other parts will involve excavation of “fresh ground”.

The footprint of the SWROP site is about 5000 m^2 and relatively small (70 X 70 m). Bulk earth works involved in the foundations for the plant and ancillary infrastructure are expected to be “standard” and quite shallow. Specifications for the earth works involved in the permeate (freshwater) holding reservoir are not yet available, as are specifications for possible sludge-handling dams and spill limitation measures.

Although the excavations will be generally shallow (<2 m deep), the subsurface of the area has a distinct probability of containing fossils that will be exposed during earth works, as is elucidated below.

4 TERMS OF REFERENCE

Review of provided plans and data on proposed development, *e.g.*, location of footprints and scale of bulk earth works envisaged.

Desktop review of all relevant palaeontological and geological literature and application of specialist knowledge of the proposed area.

Identify and rank sensitivities of fossil heritage within project area with respect to the proposed development.

Make specific recommendations for palaeontological mitigation, for inclusion in the Construction EMP, including a "Fossil Finds Procedure".

5 APPROACH AND METHODOLOGY

5.1 AVAILABLE INFORMATION

Early geological and palaeontological work in the Saldanha Bay area described the calcareous aeolianites, their basal marine beds and occurrences of phosphatic deposits (Du Toit, 1917; Wybergh, 1919, 1920; Haughton, 1932a,b). The overall perspective on the surface geology in this area has been provided by Visser & Schoch (1973) and the accompanying map. They document valuable observations from the earlier phosphate exploration phase. Further details of the "Langebaan" or "Coastal Limestones" are provided by Siesser (1970, 1972).

Mining of the phosphatic deposits led to the discovery of fossil-rich "bone beds" at Langebaanweg (LBW) which is now an internationally significant palaeontological site renowned for its prolific, diverse and exceptionally well preserved Mio-Pliocene vertebrate faunas. Scientific papers that refer to the LBW faunas number in the several hundred.

The exposures provided by mining and exploratory drilling greatly expanded the knowledge of the stratigraphy and fossil record of the area (Tankard 1974a,b, 1975a,b,c; Dingle *et al.*, 1979; Hendey, 1981a,b,c and many earlier publications). Kensley (1972, 1977) described the taxa and palaeoenvironmental significance of the invertebrates present in the Gravel and Quartzose Sand members of the Varswater Formation. Just recently, Roberts *et al.* (2011) produced a valuable review of the literature pertaining to the LBW site, citing 176 references.

Rogers (1980, 1982, 1983) reviewed and described the wider-scale geology of the Saldanha coastal plain, *viz*. gross bedrock topography, sediment thicknesses and lithostratigraphy, as revealed by a Department of Water Affairs drilling programme. Useful reviews and summaries that include the geology and palaeontology around Saldanha are Dingle *et al.* (1983), Hendey (1983a,b,c), Hendey and Dingle (1990), Pether *et al.* (2000) and Roberts *et al.* (2006).

The point of departure is the geological map of the area *viz*. 1:125000 Sheet 255 and the accompanying explanation (Visser & Schoch (1972, 1973). The relevant part of the geological map is reproduced as Figure 2. Since then, ongoing research has added various refinements of the geology, but the map remains essentially valid.

The later research contributions relevant to this assessment are cited in the normal manner as references in the text and are included in the References section.

5.2 ASSUMPTIONS AND LIMITATIONS

The assumption is that the fossil potential of the formations underlying the site (Langebaan and Springfontyn formations) will be typical of that found in the region and more specifically, similar to that already discovered nearer to the site. Scientifically important fossil bone material is expected to be sparsely scattered in these deposits and much depends on spotting this material as it is uncovered during digging *i.e.* by monitoring excavations.

A limitation on predictive capacity exists in that it is not possible to predict the buried fossil content of an area or formation other than in such general terms. Certain processes/agents can produce significant concentrations of fossil bones, but the possibility of these specific buried palaeoenvironments being present is only hinted at by the general setting of a site.

6 GEOLOGICAL AND PALAEONTOLOGICAL SETTING

6.1 THE BEDROCK

The older bedrock of the region consists of **Malmesbury Group** shales. Their origin dates from over 560 Ma (Ma: million years ago, Mega-annum), when mainly muddy sediments were deposited on the margins of an ancient ocean. The ocean basin subsequently was compressed by tectonic forces and the Malmesbury sediments were transformed to shales and were then intruded by molten magma that cooled to form the crystalline "**Cape Granites**". These bedrock formations are not of palaeontological interest.

6.2 THE OLDER SANDVELD GROUP

During the early history of the coastal plain it was deeply eroded by courses of the ancestral Berg River and the soft Malmesbury shales along the coast have mostly been eroded away to below sea level, while the hard granites form the hills. The deposits of that overlie this erosion surface are much younger than the bedrock, being of Cenozoic age. These various formations are grouped together as the **Sandveld Group**.

During the early Miocene about 20 Ma, rising sea level caused the rivers in the valleys to "back up", filling the valleys with river (fluvial) sediments and peat beds with plant fossils. This fluvial valley fill is the **Elandsfontyn Formation**, the oldest formation of the Sandveld Group of coastal deposits. It is not exposed, being deeply covered by marine deposits and ancient dunes.

Eventually, by ~16 Ma during the Mid-Miocene Climatic Optimum, enough of the Antarctic ice cap had melted to raise sea level to the extent that the coastal plain was submerged as a shallow sea and the granite hills were islands upon which seabirds roosted, their guano leaching into and phosphatizing the granites. This ancient shoreline is now uplifted to ~100 m asl. and in places along the West Coast is marked by marine gravels occurring seaward of a prominent slope "nick" or even vertical "fossil" sea cliffs. However, to the writer's knowledge, *in situ* mid-Miocene marine deposits at high elevations have not been exposed or recognized in the Saldanha area. Notwithstanding, phosphatic, ostensibly marine deposits are recognized in boreholes and just to the north of Elandsfontein extend to 90 m asl. (borehole S22, Rogers, 1980). Should the age of these deposits indeed prove to mid-Miocene, precedence dictates that it is named the **Saldanha Formation.**

At lower elevations further seaward, marine deposits of Pliocene age drape the bedrock and older sediments on the coastal plain. These include two formations, *viz*. the early Pliocene **Varswater Formation** and the mid-Pliocene "**Uyekraal Formation**". The type area of the former is the exposures at the West Coast Fossil Park where the fossils from the upper part show that the age of the deposits is about 5 Ma and that the origin of the deposits is related to the early Pliocene sea level high that reached 50-60 m asl.

Sea level rose again in the middle Pliocene (~3.0 Ma) to a level now ~30 m asl. The associated marine deposits underlie the flat plain extending west from the West Coast Fossil Park. Rogers (1983) named the marine deposits the Uyekraal Shelly Sand Member of the Bredasdorp Formation. It has a capping hardpan calcrete, beneath which is green-hued shelly, gravelly sand with phosphatic casts (steinkerns) of molluscs and shark teeth (Rogers, 1982, 1983). Note that the Uyekraal Shelly Sand Member is not formally recognized and is subsumed in the Varswater Formation, but it is deserving of being called the "**Uyekraal Formation**", Sandveld Group.

The aforementioned fossiliferous marine deposits are generally too deeply buried beneath old dune deposits (aeolianites) to be intersected in shallow excavations.

6.3 THE YOUNGER SANDVELD GROUP

Aeolianites or “dune rocks/fossil dunes” overlie the marine deposits of the coastal plain, *i.e.* the “Saldanha”, upper Varswater and Uyekraal formations. They rest on wind-deflation erosion surfaces formed on the marine deposits and are comprised of calcareous sand reworked from the marine deposits by wind and also blown off the beaches of the receding sea levels. The calcareous aeolianites are evident in the coastal landscape as the ridges, low hills and mounds beneath a capping calcrete crust.

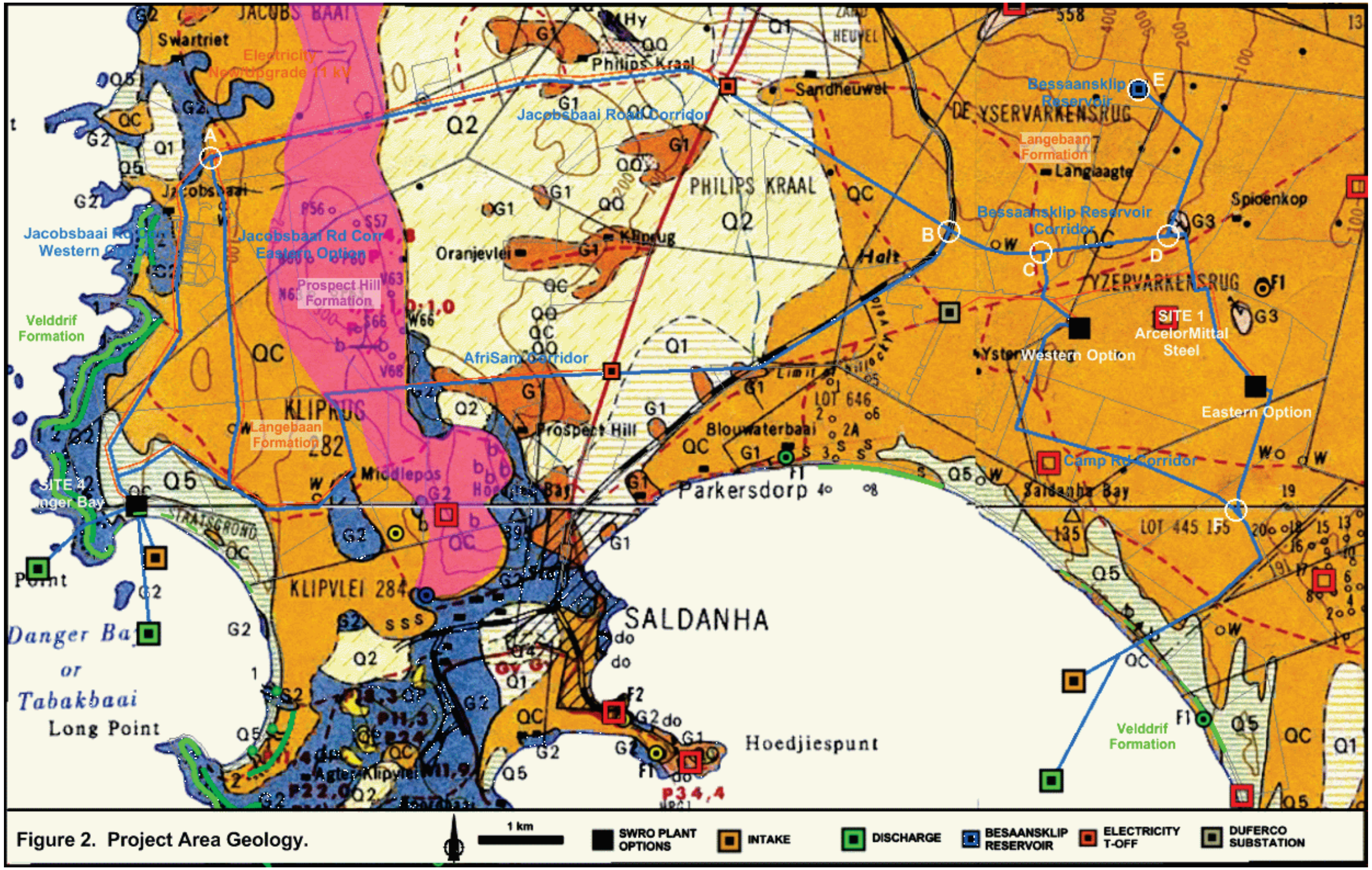
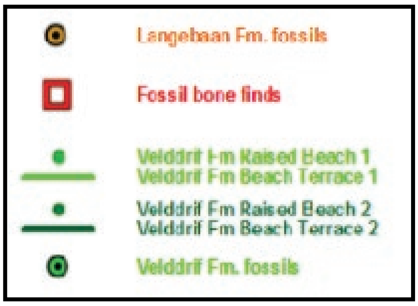


Figure 2. Surface geology of the study area. Extract from Visser & Schoch (1972), 1:125000 Map Sheet 255: 3217D & 3218C (St Helenabaai), 3317B & 3318A (Saldanhabaai). Viewed as overlay in Google Earth. Legend below in order of youngest to oldest formations.

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.
QC: The **Langebaan "Limestone" Formation**, aeolianite Unit QC, is underlain mainly by marine deposits of Pliocene age (**Varswater** & **Uyekraal** fms).
The **Prospect Hill Formation.** Part of the Langebaan Fm between Saldanha Bay and Paternoster has now been separated as this new formation, due to fossil finds indicating that it is significantly older than the other aeolianites included in the Langebaan Formation.
G1, G2, G3, G4 and **G5** are outcrops of various bedrock granites of the Cape Granite Suite.



Much of the aeolianite sand is tiny fragments of shell. The cementing of this "calcarenite" is generally quite weak, but much denser cementing has taken place in the uppermost part of the fossil dunes in the form of a "carapace" or capping of calcrete (Figure 4). The calcrete is a type of cemented soil called a pedocrete, formed in the near-surface by evapo-transpiration after the dunes became inactive and were vegetated.

The aeolianites contain further calcretes and leached *terra rosa* soils at depth, attesting to a number of periods of reduced rates of sand accumulation, surface stability and soil formation. There are more marked breaks between periods of sand accumulation, shown by erosion surfaces or very thick calcretes formed over a long time.

The dune plumes accumulated episodically, under the influence of climate (windiness, rainfall) and available sand source areas (sea-level position, sediment supply), with erosion and re-deposition of previous dunes also taking place in some areas, separated by periods of stability and soil formation.

6.3.1 The Prospect Hill Formation - aeolianite

The inner aeolianite ridge stretching north from Saldanha Bay up the coast to near Paternoster has been found to have fossil eggshell fragments of extinct ostriches (*Diamantornis wardi*) and extinct land snail forms (Roberts & Brink, 2002). *Diamantornis wardi* is dated as Miocene 10-12 Ma in the Namib Desert (Senut & Pickford, 1995) and, based on dated occurrences in East Africa and Arabia, an age of 12-9 Ma is indicated. These aeolianites, previously belonging to the Langebaan Formation, are now called the Prospect Hill Formation (Figure 2), due to the significantly older age indicated by the fossils (Roberts & Brink, 2002; Roberts *et al*., 2006). Separation of this aeolianite as a distinct formation is also justified by it being lithologically distinct from the younger aeolianites that abut it.

6.3.2 The Langebaan Formation - aeolianites

Most of the calcareous aeolianites of the west coast of the southern Cape are included in the Langebaan Formation or “Langebaan Limestones” (Figure 2, deep yellow, QC). The Langebaan Fm. thus includes various aeolianites of 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 (see below).

Of course, the aeolianites must be younger than the underlying “foundation” of marine deposits. Potentially the oldest Miocene aeolianites would overlie mid-Miocene Saldanha Fm., mid-Pliocene and younger aeolianites would overlie the Varswater Fm. and early Quaternary and younger aeolianites would overlie the Uyekraal Fm. The youngest Langebaan Fm. aeolianites postdate the Velddrif Formation (see below) and are as young as ~60 ka. In the case of the younger, Quaternary dunes, the most favourable sand supply conditions seem to have prevailed at sea levels below present, in the range of 10-40 m bsl.

6.3.3 The Springfontyn Formation

The Springfontyn Formation is an informal category that accommodates the mainly non-calcareous, windblown sand sheets and dunes that have covered parts of the landscape during the Quaternary. Its areal extent is depicted on the geological map in pale yellow hues wherein Visser & Schoch (1972, 1973) differentiate the coversands by their surface appearance into 2 surficial units, **Q2** (older cover) and **Q1** (younger cover). The Springfontyn Fm. consists of the sequences beneath these “coversands”, *i.e*. SubQ2 and SubQ1.

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*. Its true areal extent is not immediately appreciated as it laps onto bedrock and onto the Langebaan Fm., but for the purposes of geological mapping these overlap areas are not shown. It is also apparent that Q2 underlies large areas now covered by Q1.

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

Surface Unit Q1 is a younger "coversand" geological unit and is "white to slightly-reddish sandy soil" (Visser & Toerien, 1971; Visser & Schoch, 1973). These are patches of pale sand deposited in geologically-recent times. In places these sands are undergoing semi-active transport and locally have been remobilized into active sandsheets and dunes.

Chase & Thomas (2007) have cored Q1 coversands in a regional survey of various settings along the West Coast and applied optically stimulated luminescence (OSL) dating techniques to establish the timing of sand accumulation. Their results indicate several periods of deposition of Q1 during the last 100 ka, with activity/deposition at 63–73, 43–49, 30–33, 16–24 and 4–5 ka. Notably, underlying sands produced dates from ~150 to ~600 ka, reflecting the accumulation of Unit Q2 in the middle Quaternary.

The Springfontyn Formation aeolianites date from at least ~600 ka, if not older and, in parts, may be of similar ages as parts of the Langebaan Fm., but derived from less calcareous sources and/or deposited in settings more prone to subsequent groundwater leaching in water tables. The reworking of older coastal-plain deposits was likely the major sediment source. It is also possible that decalcified marine sands have not been recognized as marine in origin, especially if only encountered in boreholes, and been included in the Springfontyn Fm.

6.3.4 The Witzand Formation - aeolian

The latest addition of dunes to the coastal plain is shown in Figure 2 as **Unit Q5**, called "Holocene dunes" and otherwise known as (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.

6.3.5 The Velddrif Formation – marine and estuarine

After ~2.6 Ma the Earth went into "Ice House" mode (the Quaternary Period) and major ice caps formed in the polar regions, subtracting water from the oceans. During Ice Ages sea levels fluctuated at positions mainly below present (Figure 3) and coastal rivers eroded their valleys to deeper levels. These now-submerged shorelines were also the source of the sand for further additions to the Langebaan Formation in the form of dune plumes blown far inland.

During the Quaternary period there were brief intervals of global warming (interglacials), of which the present time is an example, when sea levels were similar to the present level or several metres above or below present level. The higher sea levels are the Quaternary "raised beaches" found at low elevations (<15 m asl.) around the coast, where they are exposed in cliffs beneath dune rocks, on top of low marine platforms fringing the coast and within the lower reaches of valleys, *e.g*. the Berg River. They comprise the Velddrif Formation (Figure 2).

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). In Figure 2 the LIG deposits are shown as the lower "Raised Beach 1" and "Beach Terrace 1".

Farther inland are higher-lying marine terrace deposits up to 12-15 m asl. This older raised beach is very poorly known and it is possible that beach deposits of differing ages are preserved from place to place. It is probable that most of such occurrences relate to an older interglacial high sea level around 400 ka (MIS 11). In Figure 2 these older deposits are shown as the upper "Raised Beach 2" and "Beach Terrace 2".

Deposits relating to the MIS 7 interglacial about 200 ka are often found interbedded in the bases of the Langebaan Formation aeolianite seacliffs and exposed in the intertidal zone and below sea level. 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.

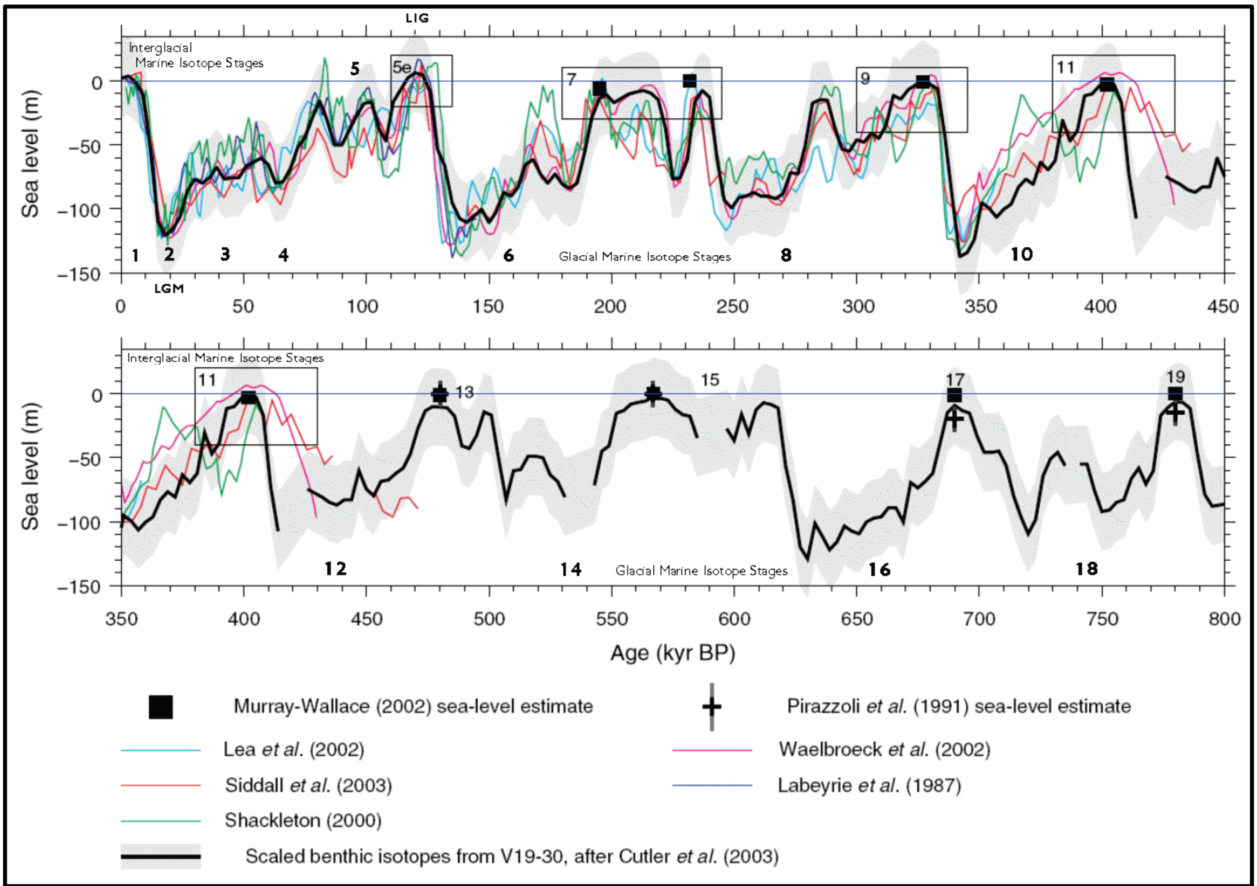


Figure 3. Sea level history for the middle and late Quaternary, showing glacial/interglacial Marine Isotope Stages. From Siddall et al., 2007.

7 EXPECTED PALAEONTOLOGY

7.1.1 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.

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 4). 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.

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, with concentrations of large mammal bones due to predator activity, including Stone Age hunters.

Figure 4. Fossil bone concentration (circled) in the infill of a cavity below the calcrete capping of the Langebaan Formation.

Particularly thick calcretes formed in the upper aeolianite often underlie flatter areas on the coastal plain. Such thick calcrete develops beneath long-lived surfaces on the aeolianite, where increments of deposition have been small and the "fossil" dune topography is subdued. The thick calcrete is polyphase in origin and disguised within it are 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 aforegoing applies primarily to the highly calcareous Langebaan Formation, within which fossil bones are well preserved. In contrast, the Springfontyn Formation is mainly quartz sands and pedogenic muds and few fossils have been found. Notwithstanding, it has clearly accumulated episodically over a considerable time span and thus will include palaeosurfaces with bone fossils and other settings such as vlei deposits with considerable fossil potential.

7.1.2 Buried archaeological material

It is possible that buried archaeological material may occur locally within or below the thin, loose Q1 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.

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

7.2 PALAEONTOLOGY OF THE VELDDRIF FORMATION.

The shelly fauna of the open-coast, LIG parts of the Velddrif Formation (Figure 6) is mainly modern and thus its palaeontological sensitivity is moderate and of local significance overall. Nevertheless, faunal changes are present and surprises occur. Furthermore, rare bones may be spotted in the deposits, such as those of marine mammals (cetaceans and seals) and seabirds.

The LIG deposits that occur in protected embayment settings at various locations around the coast of the western and southern Cape are of particular interest due to the occurrence of several species of exotic fossil shells of West African origin, today found living in the tropics along the Angolan coast and farther northwards. The taxonomy of these exotic or "extralimital" species has been dealt with in Kilburn & Tankard (1975) and Kensley (1974, 1985a,b).

To account for the occurrence of the West African species, Tankard (1975a) suggested that, during the LIG, shallow-water coastal embayments were more numerous due to the higher sea-level. Water temperature in the sheltered embayments was warmer than at present due to increased insolation, but open-coast sea-temperatures were similar to the present day regime. Postulating a poleward shift of the LIG South Atlantic Anticyclone relative to its present mean position, he suggested a concomitant southward shift of isotherms and the West African molluscan province, bringing tropical taxa closer to the Cape. Periodic southward incursions of tropical (Angolan) water carried the larvae of tropical taxa through the environmental barrier of Benguela upwelling, to warm embayments along the LIG coast. Further southward dispersal could have been accomplished by inshore southward currents developed during westerly winds associated with the passage of mid-latitude cyclones.

The episodic southward incursions of tropical Angolan water into the northern Benguela invoked by Tankard (1975a) have subsequently become known as Benguela *Niños* (Shannon *et al*., 1986). The molluscan evidence therefore suggests that oceanographic conditions in the LIG northern Benguela involved frequent or extended Benguela *Niño*-type situations.

The older, higher Velddrif Fm. units ~8-15 m asl. are poorly exposed and practically unstudied.

Figure 6. Velddrif Formation near Velddrif showing open-coast, shelly beach deposits.

8 NATURE OF THE IMPACT OF BULK EARTH WORKS ON FOSSILS

Fossils are rare objects, often preserved due to unusual circumstances. This is particularly applicable to vertebrate fossils (bones), which tend to be sporadically preserved and have high value 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.

9 SIGNIFICANCE

The fossils that have been found in the Langebaan Fm. aeolianites are of profound scientific value, raising international interest in the region. The Langebaan Fm. aeolianites have been a prime source of information on Quaternary faunas and archaeology.

At the Diazville lower quarry, Langebaan Fm. aeolianite overlying the mid-Pliocene, marine Uyekraal Formation enclosed vertebrate material indicative of a late Pliocene or younger age (Roberts & Brink, 2002) (Diazville Member). The fossil suid (bushpig) from Skurwerug dates the fossil dune-plume there to the early Pleistocene ~1.2 Ma (Hendey & Cooke, 1985).

At Elandsfontein a fossil interdunal vlei was exposed by deflation, the large number of fossil bones and ESA tools indicate an age of ~600 ka (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). The older aeolianites surrounding Geelbek dunefield exhibit three sequential calcretes which are dated at ~250, ~150 and ~65 ka, *i.e*. stability/soil formation during glacial periods (Felix-Henningsen et al., 2003).

At Kraalbaai the aeolianite with human tracks preserved in it (Kraal Bay Member) is dated to 117-79 ka (Roberts & Berger, 1997). Dating of aeolianites near Cape Town by luminescence methods shows accumulation during MIS 7 and MIS 5 (interglacials), with calcrete formation in the intervening glacial (ice age) periods (Roberts *et al*., 2009).

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.

At Spreeuwal on the shore of Big Bay, Velddrif Fm. (MIS 7) coastal fossil vlei deposits are exposed in the intertidal zone and contain large mammal bones and some MSA artefacts (Avery & Klein, 2009). The larger mammal component includes extinct species and others not recorded historically in the Western Cape. Small mammals, birds, reptiles, amphibians, freshwater gastropods and ostracods also occur.

The application of dating techniques to shells, such as amino-acid racemisation, requires spatially-distributed samples, from many localities, to build a comparative database. The shells may not be interesting from a fossil enthusiast's point of view as rare species, but they contain a geochemical record of environmental conditions at the time they lived, preserved in stable isotopes and trace elements. Bulk earth works into the Velddrif Formation, that create significant exposure, must be mitigated by sampling and recording.

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.

The formations affected by the pipeline routes are summarised below, with a brief indication of their palaeontological sensitivity.

Table 1. Surface formations of the Sandveld Group in the study area.

FORMATION	Age and description	Sensitivity
WITZAND - Q5	Holocene and recently active dune fields and cordons <~12 ka.	Mainly archaeological sites.
SPRINGFONTYN - Q1 & Q2	Quaternary to Holocene, mainly quartzose dune and sandsheet deposits, interbedded palaeosols, basal fluvial deposits <~2 Ma.	Fossil bones very sparse, local to high signif. Basal fluvial deposits locally – high signif.
VELDDRIF - VD	Quaternary raised beaches & estuarine deposits, <~1.2 Ma. Sea-levels below ~15 m asl.	Shell fossils common, local signif. Fossil bones very sparse, high signif.
LANGEBAAN - LB	Late Pliocene to Late Quaternary aeolianites <~3 Ma to ~60 ka.	Fossil bones mod. common, local to high signif.
PROSPECT HILL - PH	Late Miocene aeolianite 12-9 Ma?	Fossils very sparse – high signif.

In Annexure 10.3.3 the length of the various pipeline route traverses across the formations is provided.

10 IMPACT ASSESSMENT

This impact assessment refers to the occurrence of sparse, “high value” fossil bone material in the affected formations and pertains to the construction phase. The operational and decommissioning phases do not involve adverse impacts on palaeontological heritage.

10.1 NATURE OF THE IMPACT

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.

10.2 EXTENTS

The physical extent of impacts on potential palaeontological resources relates directly to the extents of subsurface disturbance, *i.e*. site specific.

Notwithstanding, 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.

10.3 DURATION

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.

10.4 INTENSITY

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

10.5 PROBABILITY

The likelihood of impact is medium *i.e*. it is likely to occur under most conditions, particularly in view of the length of pipeline trenches.

10.6 REVERSIBILITY

The loss of fossil material such as rare fossil bone is irreversible.

10.7 IRREPLACEABILITY

The loss of fossil material such as rare fossil bones is irreplaceable.

10.8 STATUS OF THE IMPACT

Negative without mitigation, positive with mitigation (refer to Section8).

10.9 CONFIDENCE

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

10.10 SIGNIFICANCE

In terms of the provided rating methodology, the significance is Medium both with and without mitigation. This reflects the probability of loss of sparse, valuable bone fossils, even with diligent mitigation.

Note that the presence of fossils in the subsurface does not have an *a priori* influence on the decision to proceed with the development. However, mitigation measures are essential. It is probable that sparse, valuable bone fossils will go undetected, even with the most diligent mitigation practicable. On the other hand, the finding and recovery fossils will have a positive impact ranging from local to international in extent, depending on the nature of the finds.

Table 2. Summary Impact Ratings

NATURE		
Impact on Fossil Resource	**Without mitigation**	**With mitigation**
Extent	Site specific	Site specific
Duration	Permanent loss	Permanent (part loss, part gain)
Intensity	High (destruction)	Medium (partly rescued)
Probability	Probable	Probable
SIGNIFICANCE	**MEDIUM**	**MEDIUM**
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	

11 RECOMMENDATIONS

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

Monitoring by on-site personnel and field inspections by a palaeontologist/trained fossil excavator are recommended during construction of excavations. Once pegged, the pipeline routes across the Prospect Hill and Velddrif formations must be inspected for possible exposed fossils.

Appendices 1 and 2 outline monitoring by construction personnel and a general Fossil Find Procedures for inclusion in the Construction Phase EMP. In the event of fossil finds, the appointed palaeontologist will assess the information and liaise with the manager and the ECO and a suitable response will be established. If an important find, a field inspection must be undertaken to document and sample fossiliferous strata that may be exposed.

It is recommended that the contracted palaeontologist carry out field inspections at appropriate stages in the making of the excavations, particularly in the Prospect Hill and Velddrif formations. The aim of field inspection is to examine a representative sample of the various deposits exposed in the excavations, recording context, fossil content and to take samples.

When a site and pipeline routes are chosen, the mitigation recommendations can be amended to be more specific. The contracted palaeontologist will liaise with the CSIR and the WCDM and their contractors about the specifics of setting up a monitoring and inspection programme.

11.1 MONITORING

Table 3. 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, trenches for pipes, 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**
Inspect routes across Prospect Hill and Velddrif fms.	WCDM, the CSIR and specialist.	Pre-construction
Inform staff of the need to watch for potential fossil occurrences.	WCDM, the CSIR, the ECO & contractors.	Pre-construction.
Inform staff of the procedures to be followed in the event of fossil occurrences.	ECO/specialist.	Pre-construction.
Monitor for presence of fossils	Contracted personnel and ECO, monitoring archaeologist.	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.	

12 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.

13 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.

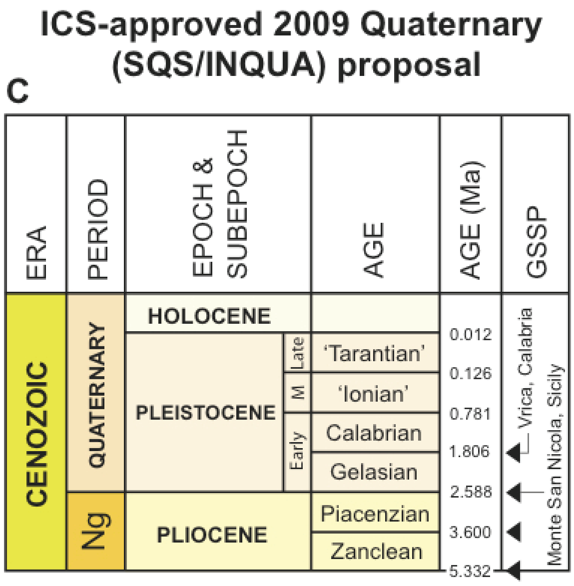
13.1 GEOLOGICAL TIME SCALE TERMS (YOUNGEST TO OLDEST).

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).

14 ANNEXURE 10.3.1 – 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 Archaeo-logical Impact Assessment, the contracted Monitoring Archaeologist (MA) can also monitor for the presence of fossils and make a field assessment of any material brought to attention. The MA is 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

15 ANNEXURE 10.3.2 - 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.

16 ANNEXURE 10.3.3 – PIPELINE ROUTE OPTIONS BY FORMATION TRAVERSED

SITE 4 DANGER BAY

DANGER BAY BEACH TO SWROP

PIPELINE SECTION	SW BRINE PIPE		SOUTH INTAKE		SOUTH BRINE	
Formation	VD	Q5	VD	Q5	VD	Q5
Metres traversed	230	440	?	160	?	160

FROM DANGER BAY SWROP VIA WESTERN CORRIDOR & JACOBSBAAI ROAD TO RESERVOIR (E)

Formation	PH	LB	Q2	Q1	Q5
Metres traversed	1280	11950	4260	1460	1170

FROM DANGER BAY SWROP VIA EASTERN CORRIDOR & JACOBSBAAI ROAD TO RESERVOIR (E)

Formation	PH	LB	Q2	Q1	Q5
Metres traversed	1280	12600	4260	1460	1830

FROM DANGER BAY SWROP VIA AFRISAM CORRIDOR TO RESERVOIR E

Formation	PH	LB	Q2	Q1	Q5
Metres traversed	1300	10662	2800	1600	2220

FROM NODE B VIA BESAANSKLIP CORRIDOR TO BESAANSKLIP RESERVOIR (E)

Section	B - C	C -D	D - E	TOTAL
Formation	LB	LB	LB	LB
Metres traversed	1250	1600	2300	5150

SITE 1 ARCELORMITTAL

BIG BAY BEACH TO NODE F TO WESTERN OPTION SWROP

Formation	LB	VD	Q5
Metres traversed	6620	?	630

FROM WESTERN OPTION SWROP TO NODE C TO RESERVOIR (E)

Formation	LB
Metres traversed	5074

BIG BAY BEACH TO NODE F TO EASTERN OPTION SWROP

Formation	LB	VD	Q5
Metres traversed	3660	?	630

FROM EASTERN OPTION SWROP TO NODE D TO RESERVOIR (E)

Formation	LB
Metres traversed	4830

FROM WESTERN OPTION VIA JACOBSBAAI ROAD & WESTERN CORRIDOR & TO DANGER BAY SWROP

Formation	PH	LB	Q2	Q1	Q5
Metres traversed	1280	9224	4260	1460	1170

FROM WESTERN OPTION VIA JACOBSBAAI ROAD & EASTERN CORRIDOR & TO DANGER BAY SWROP

Formation	PH	LB	Q2	Q1	Q5
Metres traversed	1280	9874	4260	1460	1830

FROM WESTERN OPTION VIA AFRISAM ROAD TO DANGER BAY SWROP

Formation	PH	LB	Q2	Q1	Q5
Metres traversed	1300	7936	2800	1600	2220

FROM EASTERN OPTION VIA JACOBSBAAI ROAD & WESTERN CORRIDOR & TO DANGER BAY SWROP

Formation	PH	LB	Q2	Q1	Q5
Metres traversed	1280	12180	4260	1460	1170

FROM EASTERN OPTION VIA JACOBSBAAI ROAD & EASTERN CORRIDOR & TO DANGER BAY SWROP

Formation	PH	LB	Q2	Q1	Q5
Metres traversed	1280	12830	4260	1460	1830

FROM EASTERN OPTION VIA AFRISAM ROAD TO DANGER BAY SWROP

Formation	PH	LB	Q2	Q1	Q5
Metres traversed	1300	10892	2800	1600	2220