PALAEONTOLOGICAL IMPACT ASSESSMENT

SAND MINING ON ERVEN 653, 657 & 658 OF SCHAAP KRAAL, PHILIPPI AREA
CITY OF CAPE TOWN METROPOLITAN MUNICIPALITY
WYNBERG MAGISTERIAL DISTRICT, WESTERN CAPE PROVINCE

By

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Client

RAPICORP 122 (PTY) Ltd
Oakland Urban Development Project

11 October 2012

HWC Case No: 120807JL05E. Auto Ids: 1951 - 2031
DMR Reference: WC30/5/1/2/2/10016MR

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SUMMARY

The context of this report is an application for a mining right for sand mining by RAPICORP 122 (Pty) Ltd. on erven 653, 657 and 658 of Schaap Kraal, near Philippi (Figure 1). It takes place in a wider context of the proposed Oakland Urban Development Project (Oakland) on 22 properties on Schaap Kraal (Figure 1) that are owned by RAPICORP. Urban Dynamics Western Cape Inc. has been appointed by RAPICORP as the project managers to undertake the EIA and other legal requirements for the proposed mining and development projects.

The proposed mine layout is shown in Appendix 4 and the mining proposal involves a minimum of 1 million loose cubic metres of sand to be mined over 15 years at 250m^3 per day. Figure 3 shows the proposed mining method. The use of a long-reach excavator will enable wet extraction to 9 m depth. Alternatively, the sand below the water table could be dredged to 9 m depth (Site Plan, 2012). At the end of the life of the mine it is proposed to integrate the flooded pits into the urban environment as an aquatic feature linked with the stormwater runoff system (Appendix 5).

The proposed mining involves the dune sands of the Witzand Formation and the underlying leached sands of the upper Springfontyn Formation. The calcrete and calcareous dune rock of the Langebaan Formation does not occur in the mining right application area, but may be encountered in the eastern part of the Oakland urban project area (Figure 5).

The expected fossil contexts relate to the processes and environments of the coastal dunefield. Although the fossil potential of aeolianites is overall low, the fossils that have been found in the coastal aeolianites are of profound scientific value as a prime and ongoing source of information on Quaternary faunas and archaeology. The fossil content varies from the occasional isolated find (apparently), to spectacular abundances in certain contexts.

Notwithstanding, in view of the overall low fossil potential, it is proposed that only a basic degree of mitigation is required for the proposed sand mine. It is recommended that an alert for the uncovering of fossil bone, archaeological implements and fossil plant/peaty material, be included in the Mining EMP for the 15-year continuous mining operation. Particular attention must be paid to oversize material “waste” that is screened off during preparation of the product as fossil content will be revealed in this process.

Appendices 1 and 2 outline monitoring by mine personnel and general Fossil Find Procedures. This is a general guideline, to be adapted to circumstances. The Fossil Find Procedures also apply to the proposed Oakland Urban Development.

In the event of possible fossil and/or archaeological finds, the contracted archaeologist or palaeontologist must be contacted. For possible fossil finds, the palaeontologist will assess the information and liaise with the developer and the ECO and a suitable response will be established.

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The author, John Pether, 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).
- Analysis of the shelly macrofauna of modern samples e.g. for environmental surveys.

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.

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1 INTRODUCTION

This application for a mining right for sand mining takes place in the context of the proposed Oakland Urban Development Project (Oakland) which consolidates 22 properties on Schaap Kraal (Figure 1) that are owned by **RAPICORP 122 (Pty) Ltd** (RAPICORP). Historically, the vicinity was also known as Montagu's Gift. Included in the proposed project is this parallel application for sand mining on three erven, *viz*. 653, 657 and 658. **Urban Dynamics Western Cape Inc**. has been appointed by RAPICORP as the project managers to undertake the EIA i.t.o. the NEMA, the urban planning i.t.o. the LUPO and this mining right application i.t.o. the MPRDA. Cindy Postlethwayt is the appointed Heritage Consultant and this report forms part of the Heritage Assessment.

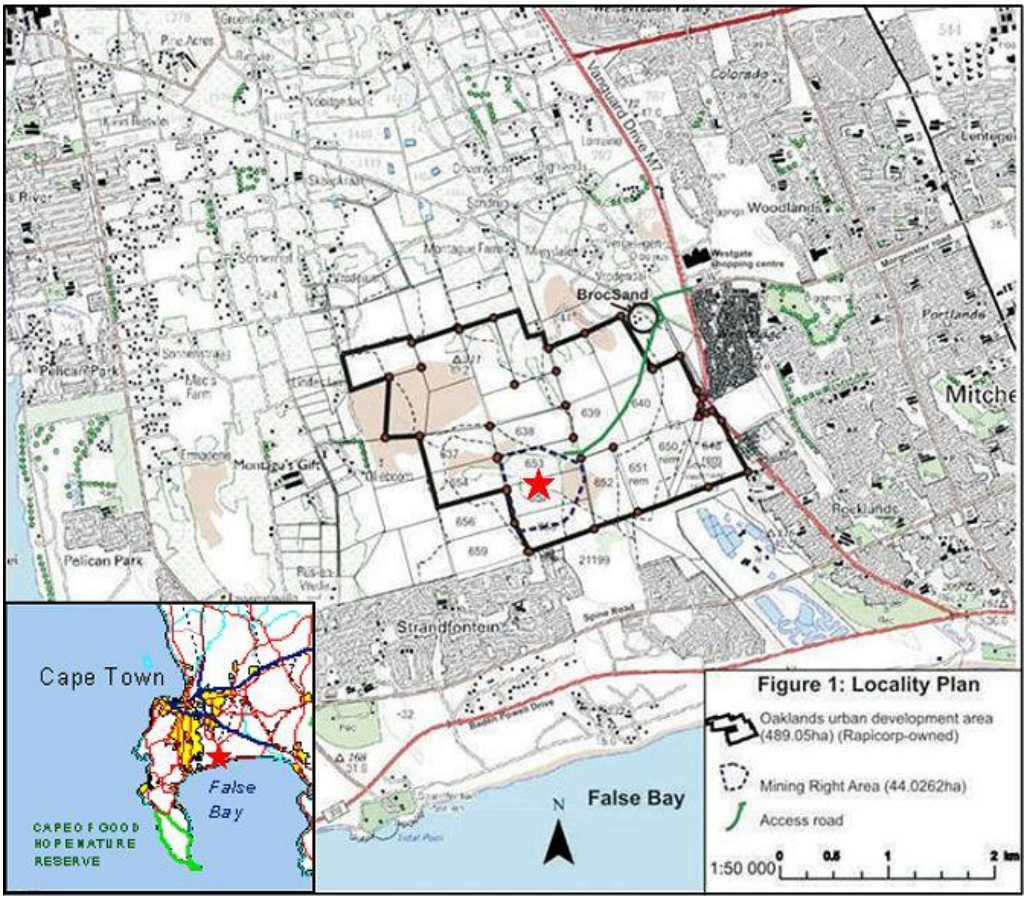

Figure 1. Mining right application for construction-sand mining on Schaap Kraal farm. Adapted from supplied map (from 1:50000 topo-cadastral map 3418BA - Chief Directorate: Surveys & Mapping.)

Extensive sand mining has already taken place in the area which has been the main source of construction sands for Cape Town. The Oakland project area largely encompasses the largest patch of remaining resource identified by Cole (2011) and ongoing mining by Brocsand and Afrimat occurs on adjacent properties (Figure 2 and Appendix 3).

The area is also adjacent to the identified remaining resource area for "clean" silica sands for industrial use (glass and foundry sands) (Figure 2) (Cole, 2011). The actual extent of the silica sands closely underlying the surface soil is considerably larger, extending northwards beneath the suburbs to the Pinelands area. The identified remaining resource area is unfortunately also the remaining Philippi Horticultural Area of market gardens close to the city markets.

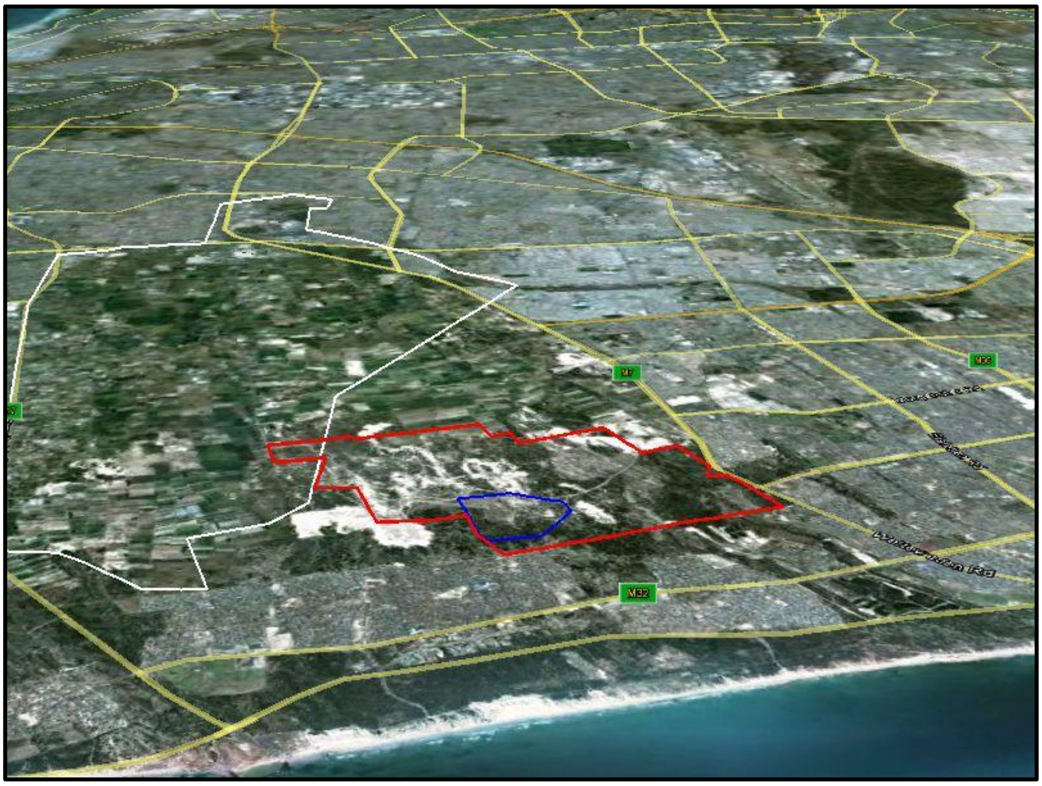

Figure 2. Simulated oblique aerial view of the project area from Google Earth. White outline indicates remaining extent of high-grade silica sand in the shallow subsurface.

These are competing interests in the area for consideration by the planners of the proposed development. As the area has been identified as a resource area for building and silica sands, Rapicorp obtained prospecting rights and carried out a prospecting programme in order to establish the location of remaining viable sand resources (Site Plan, 2012).

A limitation that applies to both post-mining horticultural use and post-mining urban development is that the maximum depth of sand extraction may not exceed 1.5 m above the winter water table. The previous sand mining (Appendix 3) has already lowered much of the Oakland project area to about this level. Consequently, the sand available for such dry-sand mining is now limited to the remaining dune ridges. Site Plan (2012) concludes that further significant sand extraction necessarily involves "wet" mining below the water table. The prospecting shows that high-grade glass sand does not occur in the project area. The proposed mine location in the southwestern corner of Oakland is based on the exploration results that indicate suitable sand grades for construction purposes, consideration of mining techniques and costs, competing sources and post-mining integration into the proposed urban development environment.

The proposed mine layout is shown in Appendix 4 and the mining proposal involves a minimum of 1 million loose cubic metres of sand to be mined over 15 years at 250m^3 per day. Figure 3 shows the proposed mining method. The use of a long-reach excavator will enable wet extraction to 9 m depth. Alternatively, the sand below the water table could be dredged to 9 m depth (Site Plan, 2012). At the end of the life of the mine it is proposed to integrate the flooded pits into the urban environment as an aquatic feature linked with the stormwater runoff system (Appendix 5).

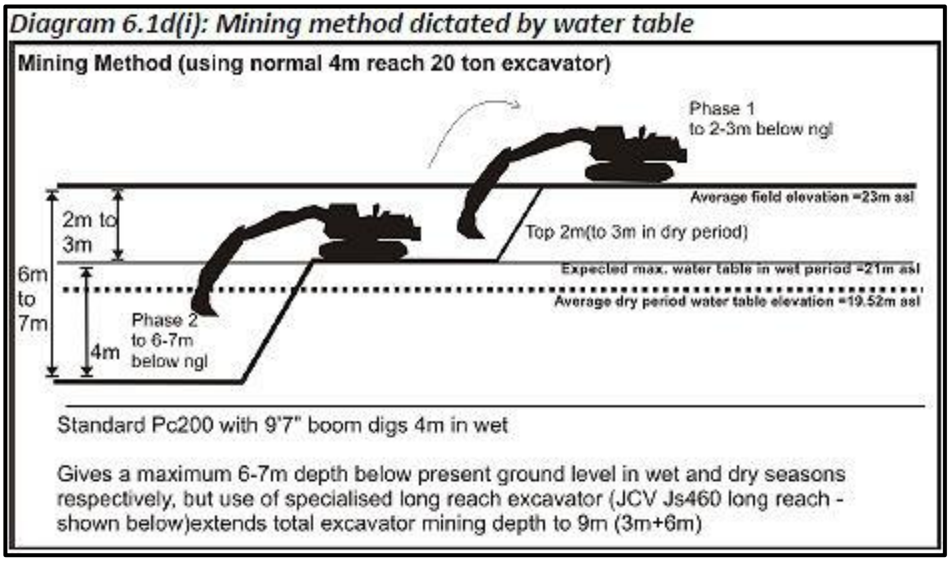

Figure 3. Mining method. From Site Plan, 2012.

Although the context of this report is the mining right application, due to the general nature of fossil potential prediction, it can be considered applicable to the bulk earth works involved in the installation of infrastructure for the urban development as well.

The main purposes of this palaeontological assessment are to:

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

Palaeontological interventions mainly happen once fossil material is exposed at depth, *i.e*. once the EIA process is done and mining commences. The action plans and protocols for palaeontological mitigation must therefore be *included in the Environmental Management Plan (EMP)* for the sand mine.

Included herein is a general fossil-finds procedure for the appropriate responses to the discovery of paleontological materials during sand mining.

The coastal-plain bedrock is composed of weathered shale of the **Tygerberg Formation** (**Malmesbury Group**): highly deformed and metamorphosed deep-sea turbidites that are ~600 Ma (Mega-annum - million years old). The soft shales have been deeply eroded to below sea level (Figure 4A) and the project area is lies above an ancient, buried valley eroded below 20 m bsl. in which a greater thickness of sediments occurs (Figure 4B). Granites of the **Cape Granite Suite** have intruded the Malmesbury Group and form topographic highs, such as the granites that outcrop from beneath Grassy Park (Figure 5) and which form Seal Island in False Bay. These bedrock formations have no intrinsic palaeontological potential.

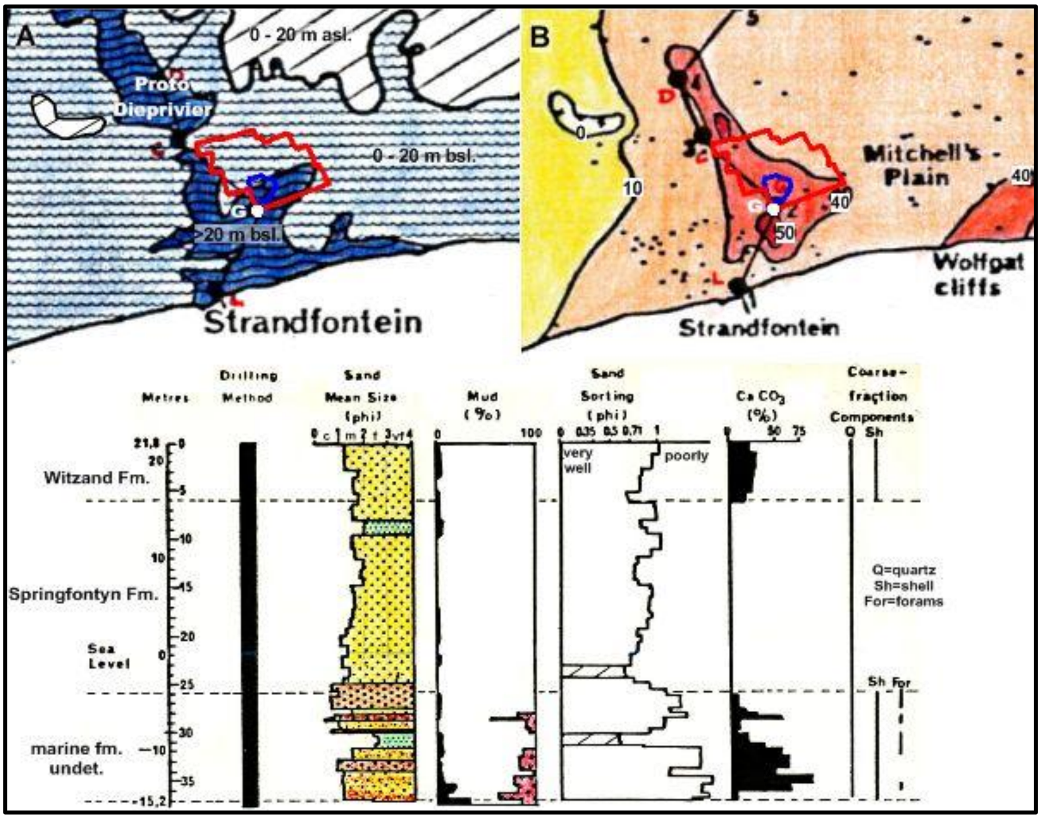

Figure 4. Approximate bedrock topography (A) and sediment thickness (B) beneath the project area and graphic log of borehole Flats G. From Rogers, 1980.

Formations of the Cenozoic **Sandveld Group** overlie the bedrock. The oldest of these is the **Elandsfontyn Formation**, of Miocene age, which consists of poorly-sorted medium to coarse fluviatile quartz sands. It is preserved within the palaeovalley and was encountered in borehole Flats C (Figure 4), near the northwestern corner of the project area. Further seawards it has been eroded away and the channel hosts a shelly marine formation. The Elandsfontyn Formation is too deep to be intersected by the proposed mining.

The coastal plain has been inundated by the sea at various times. During the global warming of the Mid-Miocene Climatic Optimum ~16 Ma, 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. 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 (Pether *et al*., 2000; Roberts *et al*., 2006).

At lower elevations 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. The equivalent deposits on the Namaqualand Coast comprise the “50 m Package” or Avontuur Formation (informal).

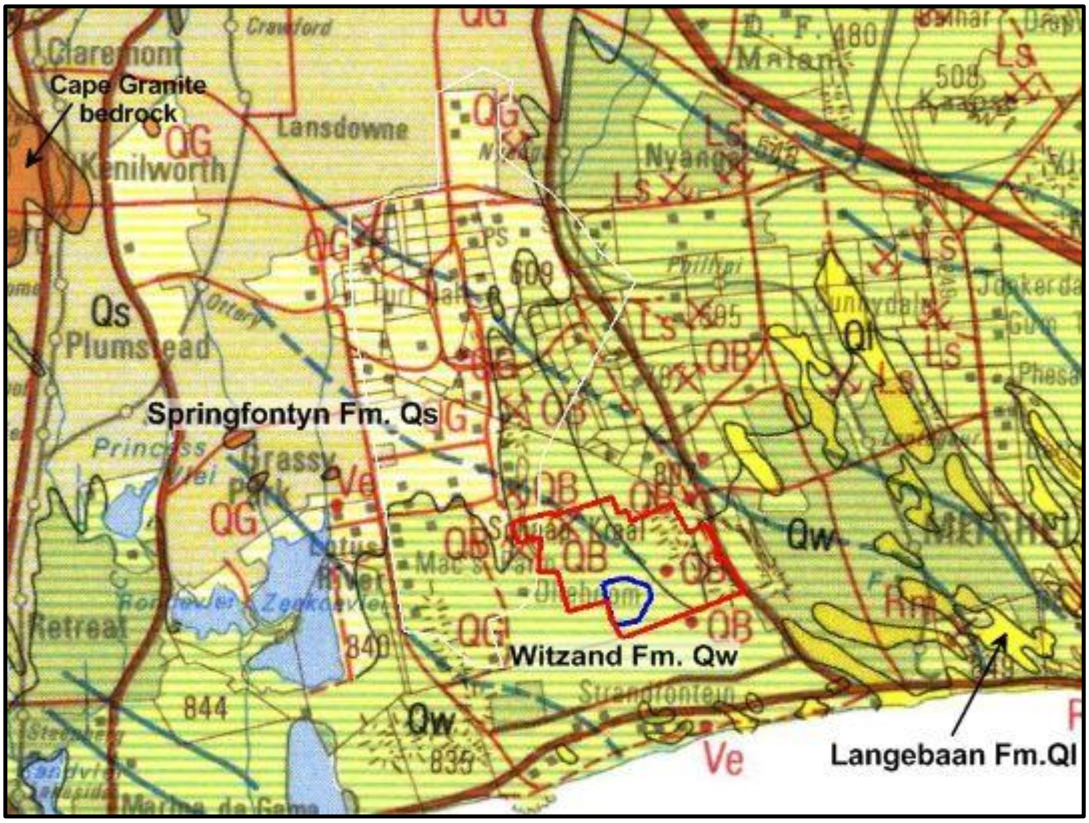

Figure 5. Surface geology of the project area. White polygon outlines remaining high-silica sands. Extract of 1:250 000 Geological Series map, Sheet 3318 Cape Town. 1990. Council for Geoscience, Pretoria.

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 (the latter now superceded by the Sandveld Group). Note that the Uyekraal Shelly Sand Member is not formally recognized and is subsumed in the Varswater Formation, but it is deserving of separate recognition as the “Uyekraal Formation”, Sandveld Group. The equivalent deposits on the Namaqualand Coast comprise the “30 m Package” or Hondeklipbaai Formation (informal).

During the high sea level stages in the Miocene and Pliocene epochs, the Cape Flats was inundated by the sea, forming the "Cape Strait" between the mainland and the Cape Peninsula mountains. The last time this occurred was during the Mid-Pliocene Warm Period ~3 Ma (Figure 6). When the sea level regressed from the highstand, shallow-marine deposits were left draping the coastal plain. These extensive Pliocene marine deposits, with their distinct fossil shell faunas of warm-water species and extinct species, are well-preserved elsewhere around the coast, but have not been recognized on the Cape Flats.

Figure 6. Present topography "flooded" to a level of ~30 m asl., approximately illustrating the "Cape Strait" during the mid-Pliocene Warm Period ~3 Ma.

A clue to this anomaly is found at Ysterplaat where, beneath a capping lateritic soil of koffieklip ("die ysterplaat"), are several metres of white glass sand. The leached, sugary-textured, largely structureless, white sand deposit is ostensibly the Springfontyn Formation (see below). However, a very localized occurrence of fossil shells, uniquely preserved as films of carbon lining cavities formed the dissolving away of the original shells, shows that the glass sand at Ysterplaat is marine in origin and is of Pliocene age and probably equivalent to the Uyekraal Formation or 30 m Package (~3 Ma) (personal observations).

The borehole “Flats G” encountered ~11 m of shelly marine deposits beneath leached silica sands of the Springfontyn Formation (Figure 4). Rogers (1980) provisionally referred these deposits to the marine Varswater Formation, but they may equally be the extension of the Uyekraal formation below current sea level. Close to the coast, the marine water table extending inland would have excluded overlying acidic terrestrial groundwater from dissolving the shell content of the marine deposits. Alternatively, they may be the deposits of subsequent earlier Quaternary shorelines as there were many highstands during that time that were just below current sea level. The age of these marine deposits beneath the project area can only be resolved by the recovery of their fossil content. Unfortunately, they are too deep to be intersected by the proposed mining.

Large areas of the coastal plains, including the Cape Flats, are underlain by the **Springfontyn Formation** (**Qs**) (Figure 5). Its manifestation at the surface is as “light grey sandy soil” (Theron, 1984). The Springfontyn Formation is generally used as an informal category that accommodates non-calcareous, windblown sand sheets and dunes that have covered parts of the landscape during the Quaternary. This refers to the upper parts of the formation, below which are leached sands, usually structureless, with local lenses of peaty sands and clays formed in marshy or vlei environments (Rogers, 1980). In places the sand is variously stained by Fe-oxides, with orange to reddish-brown hues. The Springfontyn Formation includes the very leached glass sands closely underlying the Philippi area.

Much of the Springfontyn Formation is considered to be aeolian in origin, involving windblown sand sheets and dunes, with interdunal vleis in places. The erosion and reworking of older coastal-plain deposits, such as the widespread marine formations, was likely the major sediment source. As mentioned above, there is clear evidence that the formation also includes leached, altered Pliocene marine deposits. Where the formation is thick, the cryptic marine deposits will form the lower part.

Locally fluvial deposits will be present where larger drainages issued from the surrounding hills/mountains, with some terminating “blind” in swamps. Such muddy and peaty marsh deposits are a feature of the formation at inland locations such as beneath Epping. Fossil wood, including large tree trunks of yellowwoods (*Afrocarpus*) and pieces of Clanwilliam cedar (*Widdringtonia*) have been found in excavations at Crawford and Maitland, very likely in fluvial deposits. The fluvial sediments deposited on the Cape Flats would also have supplied sands for subsequent aeolian redistribution. Colluvial/slopewash inputs are expected near hillslope topography.

The leached Springfontyn Formation sands are overlain by cemented calcareous aeolianites of the **Langebaan Formation** (**Ql**) (Figure 5). Near the coast the Langebaan Formation manifests as “fossil” dune ridges which have a capping of calcrete or “surface limestone”. Small examples occur to the south of the project area and an extensive area of fossil dune ridges occurs immediately to the east (Figure 5). However, most of the Langebaan Formation on the Cape Flats is concealed beneath loose white dune sands of the Witzand Formation. Its true extent is shown by the locations of numerous limestone quarries where the capping calcrete has been exploited in the past as a source of limestone for cement and for road material (Ls and Rm (red) in Figure 5). The calcrete, beneath loose white sands, extends beneath Cape Town International Airport as far north as Bellville.

The nature of the Langebaan Formation aeolianite is well illustrated by the section exposed in the cliffs at Wolfgat near Swartklip. This has been described in detail by Roberts *et al*. (2009), together with OSL-dating results. In the intertidal zone, lensoid peaty and muddy beds with terrestrial bones and aquatic shells represent the deposits of coastal vleis. These are overlain by ~50 m of aeolianite dated to ~230 ka in the middle Quaternary, which is capped by an advanced calcrete palaeosol which has a weathered surface. This middle Quaternary generation of dunes advanced northwards over the Springfontyn leached sands, extending to the vicinity of Bellville. A later generation of aeolianite dune ridges, dated to ~130 ka, advanced over the earlier calcrete-capped generation, but did not extend as far inland, instead forming high dune ridges closer to the coast.

On the South Coast, the equivalent of the Langebaan Formation is the Waenhuiskrans Formation aeolianites. OSL dates reveal that their deposition occurred at times around 67–80, 88–90, 104–128, 160–189 and >200 ka, during interglacial and intermediate sea-level high stands (Bateman *et al*., 2004).

The latest addition of dunes to the coastal plain is the loose white sands of the **Witzand Formation** (**Qw**) (Figure 5). These sands have blown inland as far as the older part of the Langebaan Formation. Most of the sand was probably blown from False Bay during the early Holocene 12-8 ka, when the shoreline was further south and was approaching its present level after the last ice age, with the dunes ramping over the cliffed Langebaan Formation. Further addition of sand and reworking of earlier sand is ongoing. These calcareous Witzand sands have been the main source of construction sand.

3 EXPECTED PALAEONTOLOGY

The proposed mining involves the dune sands of the Witzand Formation and the underlying leached sands of the upper Springfontyn Formation. The calcrete and calcareous dune rock of the Langebaan Formation does not occur in the mining right application area, but may be encountered in the eastern part of the Oakland urban project area (Figure 5).

The expected fossil contexts relate to the processes and environments of the coastal dunefield. Although the fossil potential of aeolianites is overall low, the fossils that have been found in the coastal aeolianites are of profound scientific value, raising international interest in the region. The aeolianites have been a prime and ongoing source of information on Quaternary faunas and archaeology. The fossil content varies from the occasional isolated find (apparently), to spectacular abundances in certain contexts.

3.1 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, moles, 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.

Trace fossils are an important feature of aeolianites. Most commonly there are root traces or actual "petrified" roots that are associated with palaeosols. Calcretised termitaria, termite burrows and a variety of other insect traces occur. Spoor or vertebrate trackways, ascribed to elephants, rhino, antelopes, equids, carnivores, tortoises and prehistoric humans have been recorded from aeolianites at various localities on the coast of South Africa.

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.

In calcreted aeolianites, 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". 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. Similarly, porcupines also accumulate bones in their lairs. 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.

The uppermost part of Langebaan-type aeolianites is richer in artefacts and associated fossil bones and shell than the underlying dune, due to prolonged surface stability/slowed accumulation, together with the more productive, attractive environment consequent upon colonization by vegetation. The latter also promoted the subsequent evolution of the well-developed, capping calcrete palaeosol. The hard surface of the capping calcrete itself is another palaeosurface upon which younger material becomes concentrated, for instance, by deflation away of "now lost generations" of dune sands.

Although the young Witzand Formation is not cemented into an aeolianite "dune rock", fossils occur in similar contexts. However, such content is most noticeable as anthropogenic LSA sites that are surficial or shallowly subsurface. It is quite possible that earlier, more-deeply buried occupation sites may occur, as well as non-anthropogenic fossil occurrences. In several instances in the past, bones of elephant, rhino, hippo, bushpig *etc*. have been uncovered in Witzand Formation dunes on the coastal plains, during sand mining and developments. The palaeosurface on top of the Springfontyn Formation, beneath the Witzand sands, has higher fossil and archaeological potential. Haughton (1933) records a find of a human skull associated with stone artefacts in this context at a location near Philippi.

The decalcified Springfontyn Formation has low fossil potential, but some fossil bones of terrestrial mammals have evidently been found in this formation and suggest a middle Quaternary age (Hendey, quoted in Rogers, 1980). As mentioned, lignified and "coalified" plants, tree stumps and logs have been found at several places in the Springfontyn Formation and are the most common fossil remains encountered (Theron, 1984). However, some of the occurrences of thick peats and clays mentioned in the literature in fact relate to the much older, underlying Elandsfontyn Formation (Miocene).

4 RECOMMENDATIONS

An Archaeological Impact Assessment has been done for the proposed Oakland Urban Development Project (Kaplan, 2007). This recommended that: "Bulk earthworks must be monitored by a professional archaeologist, during the Construction Phase of the proposed development. Alternatively, monitoring can be undertaken by a suitably qualified Environmental Control Officer (ECO) subject to training by the archaeologist, and approval by Heritage Western Cape." This applies to the installation of urban development infrastructure and foundations.

Similarly, in view of the overall low fossil potential, it is proposed that only a basic degree of mitigation is required for the proposed sand mine.

It is recommended that an alert for the uncovering of fossil bone, archaeological implements and fossil plant/peaty material, be included in the Mining EMP for the 15-year continuous mining operation.

Particular attention must be paid to oversize material "waste" that is screened off during preparation of the product as fossil content will be revealed in this process.

Appendices 1 and 2 outline monitoring by mine personnel and general Fossil Find Procedures. This is a general guideline, to be adapted to circumstances. The Fossil Find Procedures also apply to the proposed Oakland Urban Development.

In the event of possible fossil and/or archaeological finds, the contracted archaeologist or palaeontologist must be contacted. For possible fossil finds, the palaeontologist will assess the information and liaise with the developer and the ECO and a suitable response will be established.

5 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).

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

The application requires details of the registered owner/s of the property, their permission and a site-plan map.

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

6 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

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8 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.

ECO: Environmental Control Officer.

EIA: Impact Assessment.

EMP: Environmental Management Plan.

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

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 track or footprint of a fossil animal that is preserved in stone or consolidated sediment.

Heritage: That which is inherited and forms part of the National Estate (Historical places, objects, fossils as defined by the National Heritage Resources Act 25 of 1999).

HIA: Heritage Impact Assessment.

i.t.o.: in terms of.

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".

LUPO: Land Use Planning Ordinance 15 of 1985.

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

MPRDA: Mineral and Petroleum Resources Development Act 28 of 2002.

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

NEMA: National Environmental Management Act (Act 107 of 1998 as amended in 2010).

OSL: Optically stimulated luminescence. One of the radiation exposure dating methods based on the measurement of trapped electronic charges that accumulate in crystalline materials as a result of low-level natural radioactivity from U, Th and K. In OSL dating of aeolian quartz and feldspar sand grains, the trapped charges are zeroed by exposure to daylight at the time of deposition. Once buried, the charges accumulate and the total radiation exposure (total dose) received by the sample is estimated by laboratory measurements. The level of radioactivity (annual doses) to which the sample grains have been exposed is measured in the field or from the separated minerals containing radioactive elements in the sample. Ages are obtained as the ratio of total dose to annual dose, where the annual dose is assumed to have been similar in the past.

Palaeontology: The study of any fossilised remains or fossil traces of animals or plants which lived in the geological past and any site which contains such fossilised remains or traces.

Palaeosol: An ancient, buried soil 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.

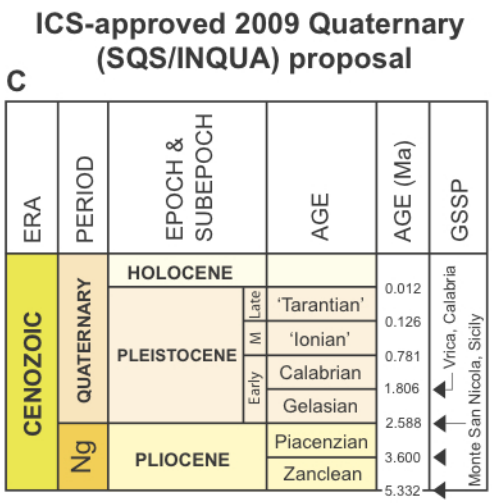
Stone Age: The earliest technological period in human culture when tools were made of stone, wood, bone or horn. Metal was unknown.

w.r.t.: with respect to.

8.1 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.

Pliocene: Epoch from 5.3-2.6 Ma.

Miocene: Epoch from 23-5 Ma.

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9 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.

9.1 CONTACTS FOR REPORTING OF FOSSIL FINDS.

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

- Dr Romala Govender: 021 481 3895, 083 441 0028.

Heritage Western Cape

- Troy Smuts: 021 483 9543
- Jenna Lavin: 021 483 9685

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10 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.

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

10.1 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.

10.2 *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.

10.3 *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.

10.4 *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.

10.5 *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.

10.6 EXPOSURE OF FOSSIL WOOD AND PEATS

As for 10.5 above.

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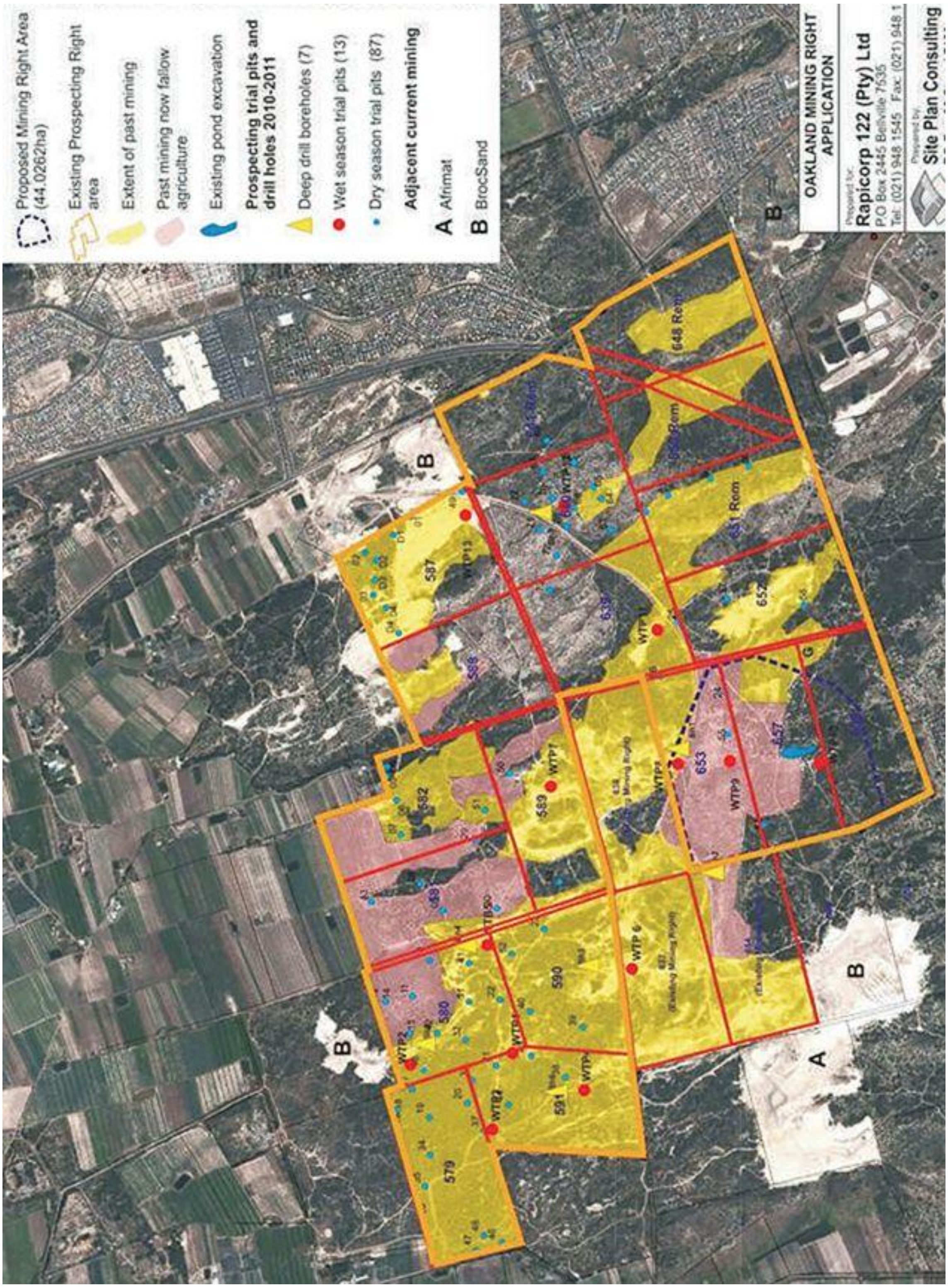
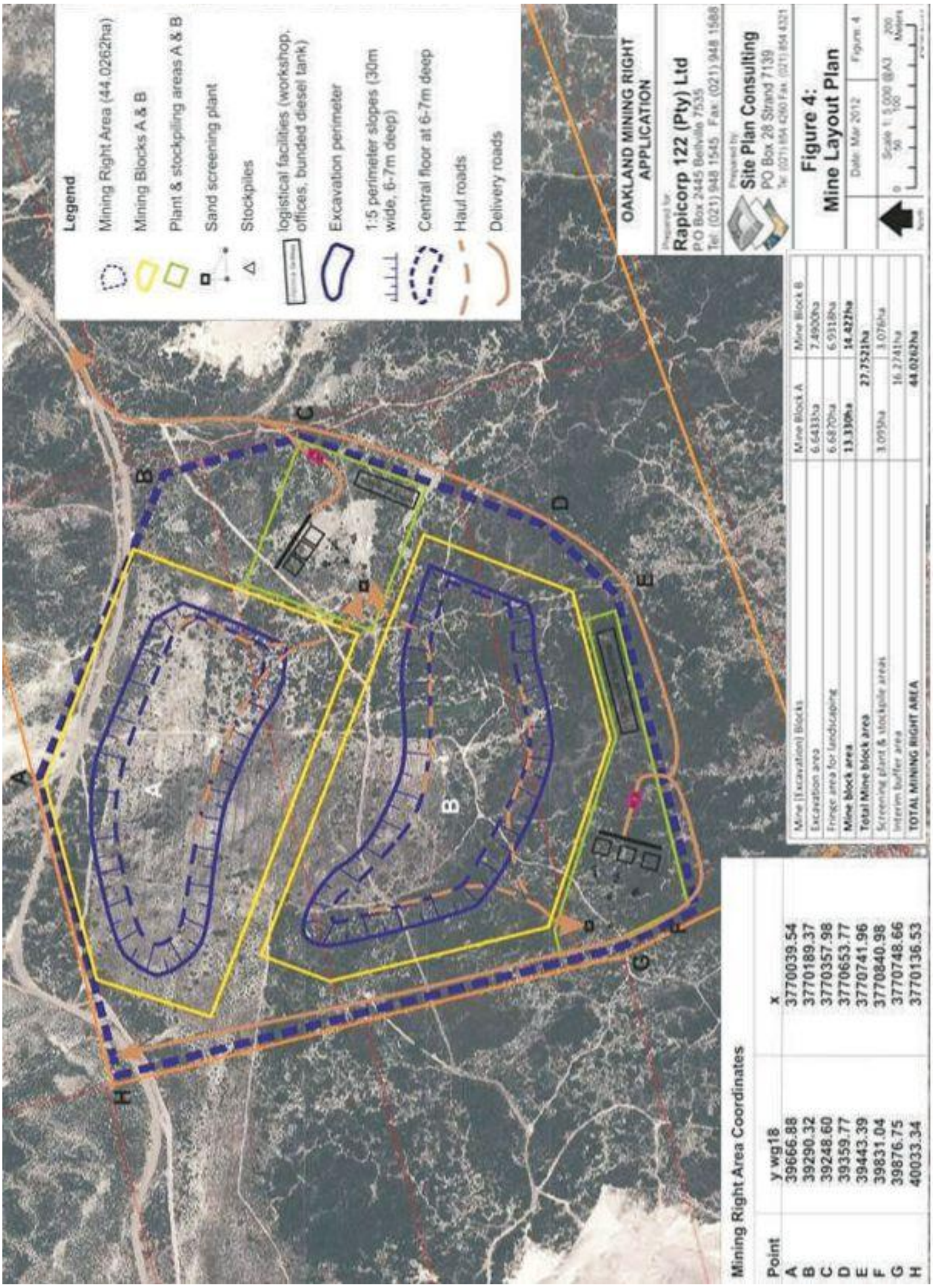
11 APPENDIX 3 – PREVIOUS MINING



12 APPENDIX 4 – MINE LAYOUT



13 APPENDIX 5 – POST MINING URBAN INTEGRATION