PALAEONTOLOGICAL IMPACT ASSESSMENT
(Desktop Study)

PROPOSED REZONING, SUBDIVISION AND RESIDENTIAL DEVELOPMENT: ERF 3122, HARTENBOS, MOSSEL BAY, WESTERN CAPE PROVINCE

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

Prepared at the Request of
Dr Peter Nilssen
Centre for Heritage & Archaeological Resource Management
PO Box 176, Great Brak River, 6525 |
Tel. (044) 620 4936 / 082 783 5896
peter@carm.co.za – www.carm.co.za

For
Mr Schalk Cilliers, ATKV-Hartenbos Strandoord
C/o Mr Werner Kock Tel: (044) 601 7200, Fax: (044) 695 0770, e-mail: wernerk@atkv.org.za

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SUMMARY

This assessment has been prepared at the request of Dr Peter Nilssen of the Centre for Heritage & Archaeological Resource Management, on behalf of Mr Schalk Cilliers, ATKV-Hartenbos Strandoord. The context is a proposed residential development on Erf 3122, a property of ~59 ha that is on a hill overlooking Hartenbos, just north of Mossel Bay (Figures 1 and 2).

The main purposes of this palaeontological assessment are to:

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

The hill upon which Erf 3122 is situated consists of Buffelskloof Formation alluvial fan conglomerates. In the east, the road corridor just extends onto the overlying sand and siltstones of the fluvio-deltaic lower Hartenbos Formation. These formations are the upper two in the late Jurassic to early Cretaceous Uitenhage Group.

The Buffelskloof Formation has low fossil potential, but it is comparable to the Enon Formation wherein identifiable teeth and bones are occasionally found. Fossil wood is the most common fossil material and includes lignified or petrified larger pieces such as logs. The likelihood of a major fossil occurrence in the Buffelskloof Formation is low. The Hartenbos Formation will only be encountered in a limited area in the east, but trenches for services may traverse that area and encounter fossil plant material. Fossil plant material is usually more abundant and easily collected. There seems little likelihood of fossiliferous marine deposits equivalent to the De Hoopvlei Formation being preserved on the dissected hill.

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

Monitoring by on-site personnel is recommended during construction of excavations. Appendices 1 and 2 outline monitoring by construction personnel and a general Fossil Find Procedures. 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. Should potential fossil material be found, it is proposed that Dr Peter Nilssen could be contracted to carry out the initial field assessment and liaise with the palaeontologist as to its context, significance and appropriate actions.

DECLARATION

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.

The author does not have any financial interest in the undertaking of the activity, other than the remuneration for the compilation of this report.

1 INTRODUCTION

This assessment has been prepared at the request of Dr Peter Nilssen of the Centre for Heritage & Archaeological Resource Management, on behalf of Mr Schalk Cilliers, ATKV-Hartenbos Strandoord.

The context is a proposed residential development on Erf 3122, a property of ~59 ha that is on a hill overlooking Hartenbos, just north of Mossel Bay (Figures 1 and 2).

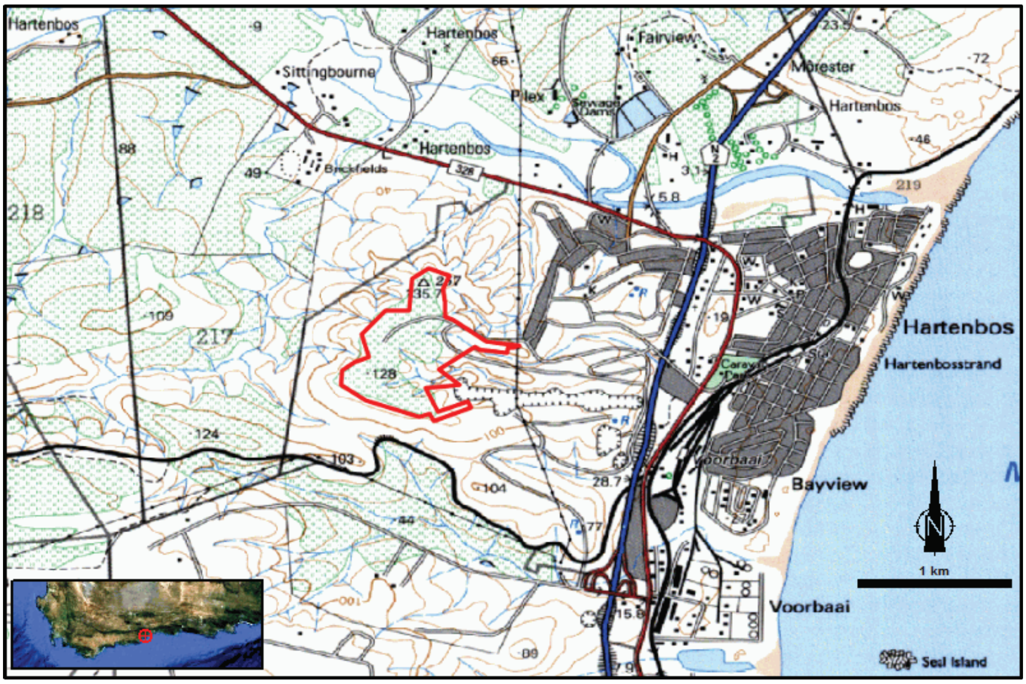

Figure 1. Location of the proposed development on Erf 3122. Extract of 1:50 000 3422AA_1998_ED3_GEO.TIF. Chief Directorate: Surveys & Mapping.

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.

The proposed residential development includes the following:

- 173 units - single residential units ranging from 600 to 880m^2.
- 182 units - group housing units ranging from 300 to 380m^2.
- 162 units - retirement complex.
- Business area - 4500m^2
- Community hall - 5276m^2.
- Sports Field - 7436m^2.
- Associated bulk services and roads.

The main purposes of this palaeontological assessment are to:

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

The report also includes a general fossil finds procedure for the appropriate responses to the discovery of paleontological materials during construction of excavations.

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 exceeds 300 m in linear length and 5000 m^2 (NHRA 25 (1999), Section 38 (1)). It must therefore be assessed for heritage impacts (an HIA) that includes assessment of potential palaeontological heritage (a PIA).

For the evaluation of the palaeontological impact it is the extent/scale of the deeper excavations to be made that are the main concern, mainly the sections exposed by site levelling, trenches for electricity, water, telecoms and sewerage infrastructure, foundations of buildings and excavations for sewerage pump stations, stormwater management system, fuel tanks, dams *etc*. Allied to this is the fossil potential of the formations that are excavated, varying from none to high.

4 APPROACH AND METHODOLOGY

4.1 AVAILABLE INFORMATION

The main information for the area is from Malan & Viljoen (1990) and Viljoen and Malan (1993) and the relevant geological maps, parts of which are reproduced in Figures 3 and 4. Other references are cited in the normal manner and included in the References section.

4.2 ASSUMPTIONS AND LIMITATIONS

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

Specific details of geological sections in the area, such as geotechnical/engineering reports showing sections exposed in test pits, are not readily available. Some site-specific information is available in the form of images of shallow excavations acquired during the AIA survey and usefully reproduced in the AIA report (Nilssen, 2010).

5 GEOLOGICAL AND PALAEONTOLOGICAL SETTING

5.1 THE LOCAL GEOLOGY

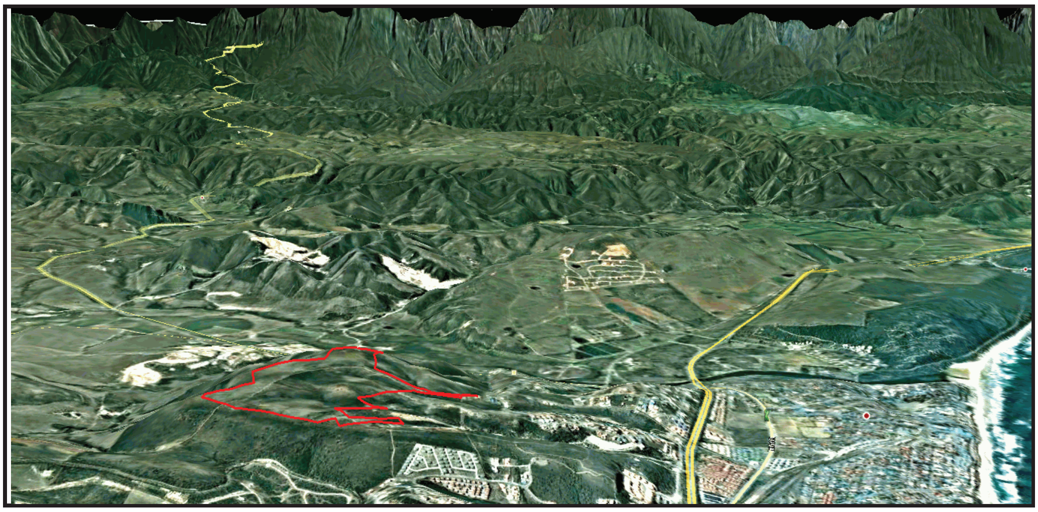

Figure 2. Setting of Erf 3122, Hartenbos. Simulated oblique aerial view from Google Earth.

Erf 3122 is situated on a hill west of Hartenbos and encompasses the hilltop and its eastern slopes, the latter dissected by the headwaters of a number of drainages (Figure 2). Elevations range from 96-137 m asl. and the hill has a flattish summit mainly about 125 m asl.

The bedrock in this region is comprised of cemented sedimentary rocks of the Cape Supergroup. Table Mountain Group (TMG) sandstones (quartzites) and shales, deposited 470-400 Ma (Ordovician and Silurian periods) are the most prominent in the landscape (Figure 3, purple hues). Bokkeveld Group (Dg, blue) shales occur locally in synclinal valleys and the high, inner "Coastal Platform" in this region is underlain by the Maalgaten Granites (pink). These rocks are of no concern here.

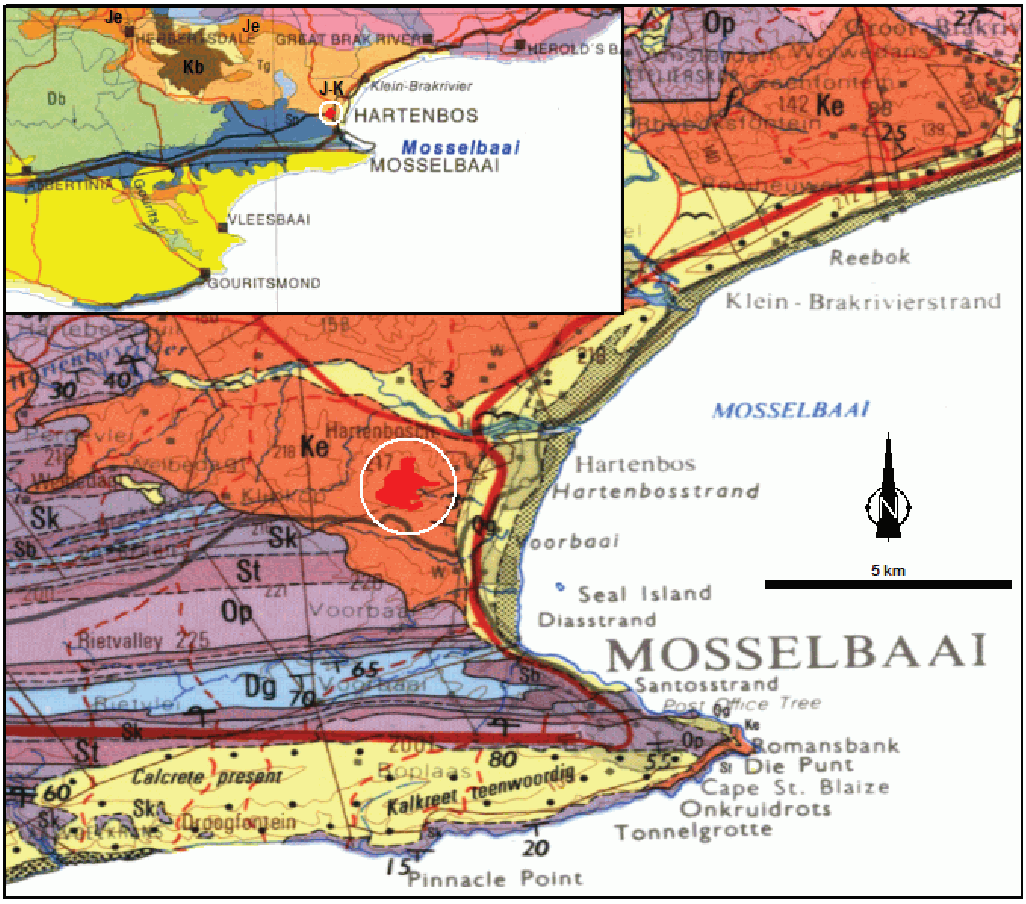

Figure 3. Extract of 1:250 000 Geological Series 3322 Oudtshoorn. Council for Geoscience (Geological Survey), Department of Mineral & Energy Affairs, 1979. Inset: Extract from Geological Map of the RSA and Kingdoms of Lesotho and Swaziland. 1997. Council for Geoscience.

The Cape Supergroup rocks were extensively disrupted by faulting during the breakup of supercontinent Gondwana and a "fresh" suite of sediments filled the basins so created. The South Coast of South Africa is rather unique compared to the other coastal stretches in that deposits that date from the breakup of Gondwana are much more extensively preserved onshore there than elsewhere. Along the West and East coasts, sediment eroded from the interior was mainly deposited offshore in the opening Atlantic and Indian oceans. Along the South Coast, the pattern of crustal stretching and faulting was more complex and many local basins were formed that are now onshore. These late Jurassic and early Cretaceous sediments, deposited between about 155 Ma and 134 Ma (Ma – million years ago), are called the **Uitenhage Group**, as they are best exposed in the Algoa area. Erf 3122 is situated on Uitenhage Group deposits (Figure 3, Ke – dark orange hue).

This early Cretaceous landscape was quite rugged, with high areas forming long capes between the downfaulted segments of crust, into which coastal river floodplains debouched at the head of extensive arms of the sea. Several volcanoes studded the landscape. The lowermost deposits filling the fault-bounded basins, called the **Enon Formation**, are overwhelming conglomerates eroded from the high ground above fault scarps by rivers (Figure 4). Farther downslope from these coarse alluvial fans were sandy and muddy flood plains of the rivers, called the **Kirkwood Formation**. At the new coast were deltas, estuaries and marine embayments, the environments in which the mainly marine **Sundays River Formation** sediments were deposited.

Subsequent to the compilation of the 1979 geological map shown in Figure 3, further mapping of the Uitenhage Group has improved the boundaries of the various formations and also resulted in the recognition of more formations. The inset in Figure 3 shows more detail in the Herbertsdale-Mossel Bay Basin where the Enon (Je) and Kirkwood (J-K) formations are indicated separately, along with a new formation, the **Buffelskloof Formation** (**Kb**). Significantly this formation overlies strata of the Enon and Kirkwood formations that have been tilted northwards, indicating another phase of tectonic activity and movement on the prominent faults. The Buffelskloof Formation is a pale conglomerate derived from the TMG and was deposited, like the Enon, in mountain-slope alluvial fan and braided-stream settings.

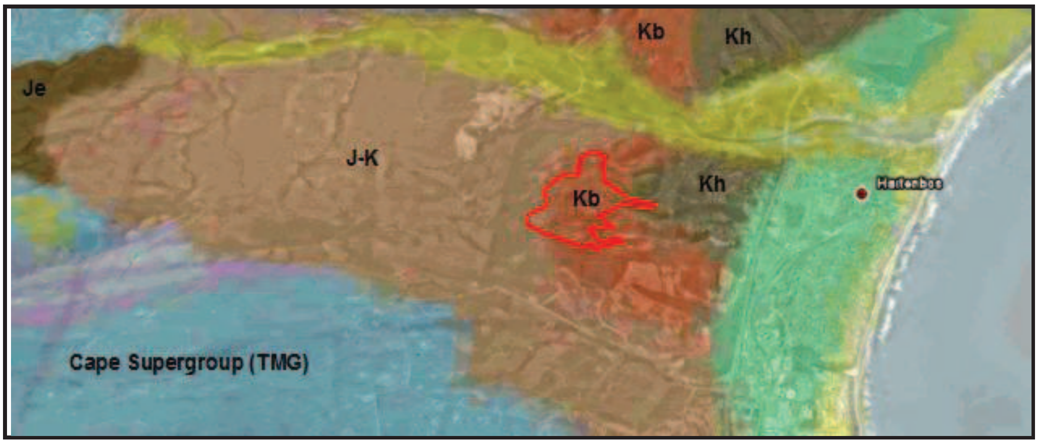

Figure 4. Detail of the Uitenhage Group in the Hartenbos area. Formations: Je – Enon; J-K – Kirkwood; Kb – Buffelskloof; Kh – Hartenbos. Earlier and later Quaternary deposits shown in green and yellow hues, respectively.

Overlying the Buffelskloof Formation to the seaward (east) in this area is another formation that has quite recently been defined, *viz*. the Hartenbos Formation. Figure 4 shows the additional detail. The Hartenbos Formation consists of sandy and muddy/clayey beds and is considered to represent fluvio-deltaic deposition. The lower sandstones contain silicified fossil wood.

The subsequent geological history of the region involves coastal-plain marine platform development and shallow-marine deposits that relate to periods of high sea level during the Cenozoic Era. In Figure 2 the high, old “Coastal platform” can be seen in the background. It dates back to the early Cenozoic or Paleogene times. In the Knysna region, Marker (1987) has recorded marine benches below the Coastal Platform, eroded at 120-140, 90, 60 and 30 m asl. This is in broad accord with the general sea level history preserved as actual marine formations elsewhere on the coast (*e.g.* De Hoopvlei and Alexandria formations). Marine deposits have been recognized in similar topography in the Plettenberg Bay area, relating to sea levels reaching ~100, ~60 and ~ 30 m asl. (Butzer & Helgren, 1972). These sea levels are very similar to those seen on the West Coast, where they are dated to ~16-15 Ma (late Early Miocene), ~5-4 Ma (early Pliocene) and 3.5-3.0 Ma (mid-Pliocene), respectively (Pether *et al*., 2000).

The Erf 3122 hilltop, along with other local summits in the range of 120-140 m asl., represent the remnants of a younger marine platform that has been dissected and reduced. This 120-140 m asl. platform was probably fashioned during high sea levels of the Mid-Miocene Climatic Optimum, 16-14 Ma.

5.2 EXPECTED PALAEONTOLOGY

The hill upon which Erf 3122 is situated consists of Buffelskloof Formation conglomerates. In the east, the road corridor just extends onto the lower Hartenbos Formation.

No fossils have hitherto been found in the Buffelskloof Formation (Almond & Pether, 2008). Petrified wood and other fossil plant material is found in the lower parts of the Hartenbos Formation. Notwithstanding, these formation are basically similar to the Enon and Kirkwood formations (resp.), in which fossils do occur.

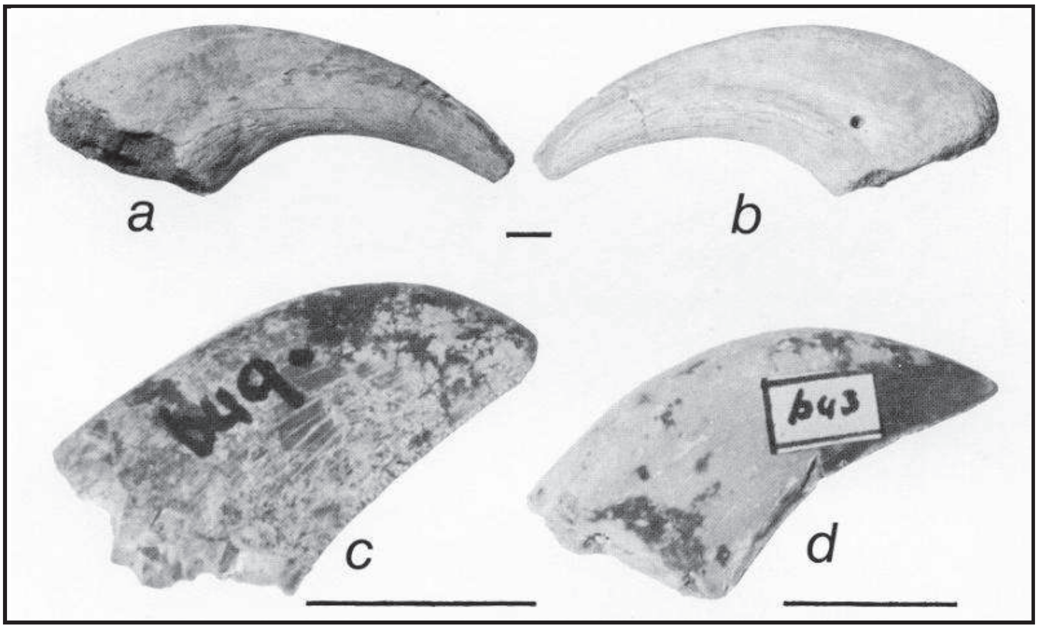

Figure 5. Examples of dinosaur talons (top) and teeth (bottom) that could be found in the Buffelskloof Formation. All scale bars are 1 cm. From Mateer, 1987.

Fossils are very scarce in the Enon Formation; transported bone fragments, isolated teeth (Figure 5) and lignified wood have been found. There is a similar low probability of comparable fossils being found on Erf 3122 in the Buffelskloof Formation.

The Kirkwood Formation used to be called “The Variegated Marls and Wood Beds” (Du Toit, 1954). The former referred to sandstones and mudstones of various pink, red and greenish hues; the latter to yellow sandstones and greenish clays that contain much fossil wood and plant remains, including logs of silicified wood, tree trunks and lignite seams. The “Wood Beds” are lithologically similar to the yellowish and greenish silts and sands of the Hartenbos Formation.

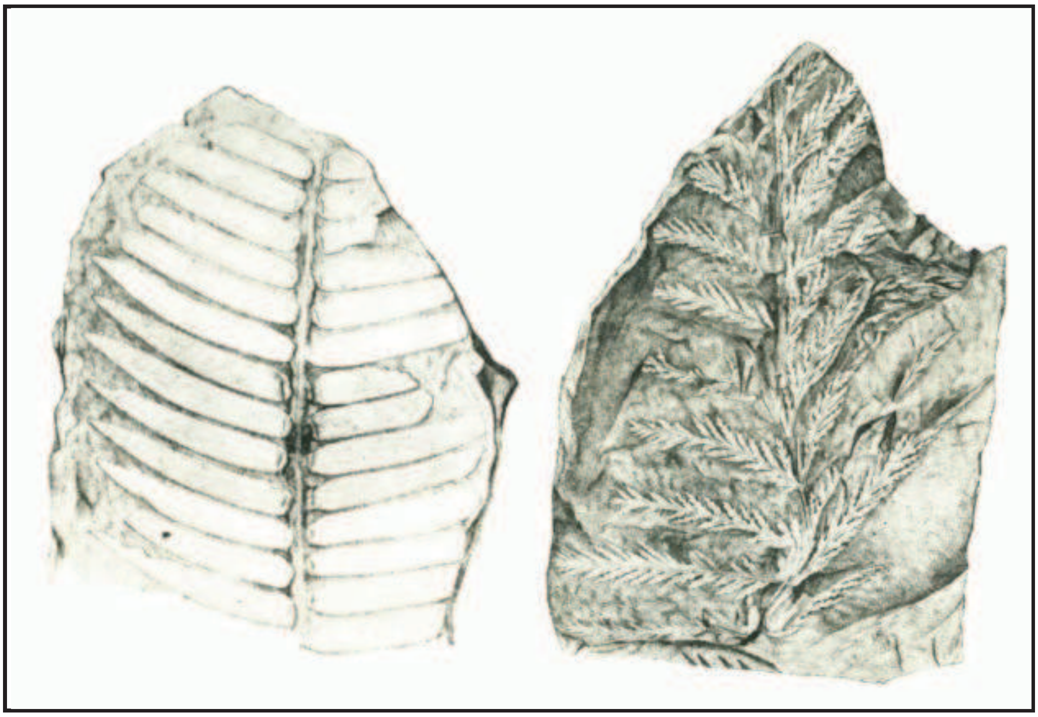

Figure 6. Early Cretaceous plant fossils from the Kirkwood Formation . Left: The cycad Zamites. Right: The fern Onychiopsis. From Du Toit, 1954.

These "Wood Beds" are palaeobotanically famous and have yielded a diverse flora dominated by woody gymnosperms (conifers and cycads) as well as bryophytes and pteridophytes such as ferns (Figure 6) (Seward, 1903; Haughton, 1928, 1935; Engelbrecht *et al*., 1962; Anderson & Anderson, 1985; Bamford, 1986; MacRae, 1999; Almond *et al.*, 2008). Plant microfossils include pollens, spores, cuticular fragments and amber (Scott, 1971, 1976a, 1976b; Gomez *et al*., 2002).

Cretaceous dinosaurs have been collected from the Kirkwood Formation of the Algoa Basin since 1845 when the "Cape Iguanodon was discovered, now called *Paranthodon africanus.* In addition to *Paranthodon,* the dinosaur fauna comprises several giant sauropods including *Algoasaurus*, primitive iguanodontians and a small coelurosaur therapod *Nqwebasaurus* (Figure 7) (Broom, 1904; Hoffman, 1966; Galton & Coombs, 1981; De Klerk, 2000; De Klerk *et al*., 1997, 1998, 2000; Forster *et al*., 1995; Forster & De Klerk, 2008; De Klerk, 2008). Other Kirkwood vertebrate fossils include material of crocodiles, turtles, sphenodontid and other lizards, mammals and garfish. Invertebrate fossils are represented by freshwater and estuarine molluscs and ostracods (Haughton, 1935; McLachlan & McMillan, 1976; Dingle *et al*., 1983; MacRae, 1999; Rich *et al*., 1983; Ross *et al*., 1999).

***Figure 7.** Left: Algoasaurus, a large sauropod dinosaur. From McCarthy & Rubidge (eds.), 2005. Top right: Nqwebasaurus, a small predatory dinosaur of turkey size with large claws and the earliest-known coelurosaur from Africa. Otherwise known as "Kirky". Yates, Easy Science, es_2007_09. Bottom right: Paranthodon africanus, Kirkwood Formation. From McCarthy & Rubidge (eds.), 2005.*

The Hartenbos Formation is not as well exposed as the Kirkwood Formation in the Algoa area and it is feasible that excavations into it could turn up valuable fossils.

***Figure 8.** Example of De Hoopvlei Formation shelly conglomerate exposed on hilltop near Klein Brak River. From Viljoen & Malan, 1993.*

Remnants of Cenozoic marine deposits are locally preserved on the flanks and tops of the coastal hills formed on the Uitenhage Group sequence. For instance, on Vaalevalley 219 next to the Klein Brak Rivier, a marine deposit with fossil shells occurs on top of a hill at 120 m asl., overlying the Hartenbos

Formation. Other occurrences in the Mossel Bay area are exposures of shelly marine conglomerate along the 60 m asl. contour (Viljoen & Malan, 1993).

However, marine deposits have not been mapped in the vicinity of Erf 3122. None were noticed during the detailed archaeology survey of the erf. It is probable that the marine deposits once present have been flushed off. However, cemented remnants could occur. In addition to greater rounding, sorting and closer clast packing than the alluvial conglomerates, shell fossils might be preserved, or less conspicuously, moulds of shells.

6 NATURE OF THE IMPACT OF BULK EARTH WORKS ON FOSSILS

Fossils are rare objects, often preserved due to unusual circumstances. This is particularly applicable to vertebrate fossils (bones), which tend to be sporadically preserved and have high value w.r.t. palaeoecological and biostratigraphic (dating) information. Such fossils are non-renewable resources. Provided that no subsurface disturbance occurs, the fossils remain sequestered there.

When excavations are made they furnish the “windows” into the coastal plain depository that would not otherwise exist and thereby provide access to the hidden fossils . The impact is positive for palaeontology, provided that efforts are made to watch out for and rescue the fossils. Fossils and significant observations will be lost in the absence of management actions to mitigate such loss this loss of the opportunity to recover them and their contexts when exposed at a particular site is irreversible.

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

Although the Buffelskloof and Hartenbos formations are apparently not very fossiliferous, it is quite possible that fossiliferous material could occur. The very scarcity of fossils makes for the added importance of watching for them.

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

7 SIGNIFICANCE

The general significances 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.

Fossil plants and rare specimens of dinosaurs found hitherto in Uitenhage Group sediments suggest that much remains to be discovered about extinct life here in southern Africa during the early Cretaceous.

8 IMPACT ASSESSMENT

8.1 NATURE OF THE IMPACT

8.1.1 Extents

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

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

8.1.2 Duration

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

In the longer term, development “sterilizes” the palaeontological heritage resource potential within its extents, as the subsurface is “sealed” beneath roads, buildings and urban gardens.

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

8.1.3 Intensity

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

8.1.4 Probability

The likelihood of impact is medium *i.e.* it is likely to occur under most conditions. The fragmentary, smaller fossil material is not seen readily during earthmoving due to adhering mud and it is a distinct possibility that the sparse fossils will be lost. This must be ongoing at quarrying sites. However, the likelihood of a major fossil occurrence in the Buffelskloof Formation is low.

8.1.5 Confidence

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

8.2 SUMMARY TABLE

Nature Construction activities (excavations) will result in a negative direct impact on the probable fossil content of the affected subsurface. Fossils and significant observations will be lost in the absence of management actions to mitigate such loss. This loss of the opportunity to recover them and their contexts when exposed at a particular site is irreversible. Conversely, construction excavations furnish the "windows" into the coastal plain depository that would not otherwise exist and thereby provide access to the hidden fossils. The impact is positive for palaeontology, provided that efforts are made to watch out for and rescue the fossils. There remains a medium to high risk of valuable fossils being lost in spite of management actions to mitigate such loss.		
Impact on Fossil Resource	**Without mitigation**	**With mitigation**
Extent	3-5 (regional-international)	3-5 (regional-international)
Duration	5 (permanent loss)	5 (part loss, part gain, perm.)
Magnitude	6 (destruction)	4 (partly rescued)
Probability	2	2
SIGNIFICANCE	**30**	**26**
Status	Negative	Positive
Reversibility	Irreversible	Irreversible
Irreplaceable loss of resources?	Yes	Partly
Can impacts be mitigated?	Partly	
Mitigation:	Monitoring of construction-phase excavations	

(See Appendix 3 for explanation)

9 RECOMMENDATIONS

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

The Buffelskloof Formation has low fossil potential, but it is comparable to the Enon Formation wherein identifiable teeth and bones are occasionally found. Fossil wood is the most common fossil material and includes lignified or petrified larger pieces such as logs.

The Hartenbos Formation will only be encountered in a limited area in the east, but trenches for services may traverse that area and encounter fossil plant material. Fossil plant material is usually more abundant and easily collected.

There seems little likelihood of fossiliferous marine deposits equivalent to the De Hoopvlei Formation being preserved on the dissected hill.

Monitoring by on-site personnel is recommended during construction of excavations. Appendices 1 and 2 outline monitoring by construction personnel and a general Fossil Find Procedures. Should potential fossil material be found, it is proposed that Dr Peter Nilssen could be contracted to carry out the initial field assessment.

9.1 MONITORING

OBJECTIVE: To see and rescue fossil material that may be exposed in the various excavations made for foundations, services and drainage.		
Project components	All bulk earthworks.	
Potential impact	Loss of fossils by their being unnoticed and/ or destroyed.	
Activity/ risk source	All bulk earthworks.	
Mitigation: target/ objective	To facilitate the likelihood of noticing fossils and ensure appropriate actions in terms of the relevant legislation.	
Mitigation: Action/ control	**Responsibility**	**Timeframe**
Inform staff of the need to watch for potential fossil occurrences.	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.	Construction.
Liaise on nature of potential finds and appropriate responses.	ECO and specialists.	Construction.
Inspect, document and collect any significant finds.	Specialist.	Construction.
Obtain permit from HWC for finds.	Specialist.	Construction
Performance Indicator	Reporting of and liaison about possible fossil finds. Fossils noticed and rescued.	
Monitoring	Due effort to meet the requirements of the monitoring procedures.	

10 APPLICATION FOR A PALAEONTOLOGICAL PERMIT

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

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

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

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

11 REPORTING

Should fossils be found a detailed report on the occurrence/s must be submitted. This report is in the public domain and copies of the report must be deposited at the IZIKO S.A. Museum and Heritage Resources Western Cape. It must fulfil the reporting standards and data requirements of these bodies.

The report will be in standard scientific format, basically:

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

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

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13 GLOSSARY

~ (tilde): Used herein as “approximately” or “about”.

Aeolian: Pertaining to the wind. Refers to erosion, transport and deposition of sedimentary particles by wind. A rock formed by the solidification of aeolian sediments is an aeolianite.

AIA: Archaeological Impact Assessment.

Alluvium: Sediments deposited by a river or other running water.

Archaeology: Remains resulting from human activity which are in a state of disuse and are in or on land and which are older than 100 years, including artefacts, human and hominid remains and artificial features and structures.

asl.: above (mean) sea level.

Bedrock: Hard rock formations underlying much younger sedimentary deposits.

Calcareous: sediment, sedimentary rock, or soil type which is formed from or contains a high proportion of calcium carbonate in the form of calcite or aragonite.

Calcrete: An indurated deposit (duricrust) mainly consisting of Ca and Mg carbonates. The term includes both pedogenic types formed in the near-surface soil context and non-pedogenic or groundwater calcretes related to water tables at depth.

Clast: Fragments of pre-existing rocks, *e.g.* sand grains, pebbles, boulders, produced by weathering and erosion. Clastic – composed of clasts.

Colluvium: Hillwash deposits formed by gravity transport downhill. Includes soil creep, sheetwash, small-scale rainfall rivulets and gullying, slumping and sliding processes that move and deposit material towards the foot of the slopes.

Coversands: Aeolian blanket deposits of sandsheets and dunes.

Duricrust: A general term for a zone of chemical precipitation and hardening formed at or near the surface of sedimentary bodies through pedogenic and (or) non-pedogenic processes. It is formed by the accumulation of soluble minerals deposited by mineral-bearing waters that move upward, downward, or laterally by capillary action, commonly assisted in arid settings by evaporation. Classified into calcrete, ferricrete, silcrete.

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

EIA: Environmental Impact Assessment.

EMP: Environmental Management Plan.

Ferricrete: Indurated deposit (duricrust) consisting predominantly of accumulations of iron sesquioxides, with various dark-brown to yellow-brown hues. It may form by deposition from solution or as a residue after removal of silica and alkalis. Like calcrete it has pedogenic and groundwater forms. Synonyms are laterite, iron pan or “koffieklip”.

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

Fm.: Formation.

Fossil: Mineralised bones of animals, shellfish, plants and marine animals. A trace fossil is the track or footprint of a fossil animal that is preserved in stone or consolidated sediment.

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

HIA: Heritage Impact Assessment.

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

LIG: Last Interglacial. Warm period 128-118 ka BP. Relative sea-levels higher than present by 4-6 m. Also referred to as Marine Isotope Stage 5e or “the Eemian”.

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

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

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

Palaeosol: An ancient, buried soil whose composition may reflect a climate significantly different from the climate now prevalent in the area where the soil is found. Burial reflects the subsequent environmental change.

Palaeosurface: An ancient land surface, usually buried and marked by a palaeosol or pedocrete, but may be exhumed by erosion (*e.g.* wind erosion/deflation) or by bulk earth works.

Peat: partially decomposed mass of semi-carbonized vegetation which has grown under waterlogged, anaerobic conditions, usually in bogs or swamps.

Pedogenesis/pedogenic: The process of turning sediment into soil by chemical weathering and the activity of organisms (plants growing in it, burrowing animals such as worms, the addition of humus *etc.*).

Pedocrete: A duricrust formed by pedogenic processes.

PIA: Palaeontological Impact Assessment.

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

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

13.1 GEOLOGICAL TIME SCALE TERMS (YOUNGEST TO OLDEST).

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

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

Holocene: The most recent geological epoch commencing 11.7 ka till the present.

Pleistocene: Epoch from 2.6 Ma to 11.7 ka. Late Pleistocene 11.7–135 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.

Neogene: Period that includes the Miocene and Pliocene.

Oligocene: Epoch from 34-23 Ma.

Eocene: Epoch from 56-34 Ma.

Paleocene: Epoch from 65-56 Ma.

Paleogene: Period that includes the Paleocene, Eocene and Oligocene.

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).

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14 APPENDIX 1 – MONITORING FOR FOSSILS

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

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

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

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

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

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

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15 APPENDIX 2 - FOSSIL FIND PROCEDURES

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

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

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

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.
- 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 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 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.

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

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

The Duration: Whether the lifetime of the impact will be of:

- very short duration (0-1 years) assigned a score of 1
- short duration (2-5 years) assigned a score of 2
- medium-term (5-15 years) - assigned a score of 3
- long term (> 15 years) - assigned a score of 4
- permanent - assigned a score of 5

The Magnitude: Quantified on a scale of 0-10, where:

- 0 is small and will have no effect on the environment
- 2 is minor and will not result in an impact on processes
- 4 is low and will cause a slight impact on processes
- 6 is moderate and will result in processes continuing but in a modified way
- 8 is high (processes are altered to the extent that they temporarily cease)
- 10 is very high and results in complete destruction of patterns and permanent cessation of processes

The Probability: The likelihood of the impact actually occurring. Probability will be estimated on a scale of 1-5, where

- 1 is very improbable (probably will not happen)
- 2 is improbable (some possibility, but low likelihood)
- 3 is probable (distinct possibility)
- 4 is highly probable (most likely)
- 5 is definite (impact will occur regardless of any prevention measures)

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

- E = Extent
- D = Duration
- M = Magnitude
- P = Probability

The significance weightings for each potential impact are as follows:

- < 30 points: Low (would not have a direct influence on the decision to develop in the area)
- 30-60 points: Medium (could influence the decision to develop in the area unless it is effectively mitigated)
- > 60 points: High (must have an influence on the decision process to develop in the area)

The Status: Positive, negative or neutral.

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

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

Degree to which the impact can be mitigated.

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