The construction and operation of chicken houses

Steve Tshwete Local Municipality, Mpumalanga Province

Farm: Portions 2 & 14 Kopermyn 435 JS and Portions 1 & 2 Kwaggafontein 460 JS, Middelburg

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012 0000040/012 993 3110

Palaeontological Impact Assessment: Phase 1 Field study

Commissioned by: Clean Stream Environmental Services

P.O. Box 647, Witbank, 1035

013 697 5021

2015/05/11

Ref: DARDLEA 17/2/3N-406

B. Executive summary

Outline of the development project: Clean Stream Environmental Services appointed Dr H. Fourie, a palaeontologist, to undertake a Paleontological Impact Assessment (PIA), Phase 1 Field study of the suitability of the proposed new construction and operation of chicken houses (Layer Hens) on the Farms Kopermyn 435 JS and Kwaggafontein 460 JS, Steve Tshwete Local Municipality, Mpumalanga Province.

The applicant, Alzu Enterprises (Pty) Ltd., intends to expand their existing layer hen operation with the addition of seven new facilities, comprising of 2 layer houses each.

The Project includes one Option (see map):

Option 1: Three different sites located south of Middelburg on property belonging to the applicant. The sites are located between the N4 and N11 national roads, south east of Middelburg and marked as the N4 Site, Blue Site and the Green Site.

The **National Heritage Resources Act (Act No. 25 of 1999) (NHRA)** requires that all heritage resources, that is, all places or objects of aesthetic, architectural, historical, scientific, social, spiritual, linguistic or technological value or significance are protected. The Republic of South Africa (RSA) has a remarkably rich fossil record that stretches back in time for some 3.5 billion years and must be protected for its scientific value. Fossil heritage of national and international significance is found within all provinces of the RSA. South Africa's unique and non-renewable palaeontological heritage is protected in terms of the National Heritage Resources Act. According to this act, palaeontological resources may not be excavated, damaged, destroyed or otherwise impacted by any development without prior assessment and without a permit from the relevant heritage resources authority.

The main aim of the assessment process is to document resources in the development area and identify both the negative and positive impacts that the development brings to the receiving environment. The PIA therefore identifies palaeontological resources in the area to be developed and makes recommendations for protection or mitigation of these resources.

For this study, resources such as geological maps, scientific literature, institutional fossil collections, satellite images, aerial maps and topographical maps were used. It provides an assessment of the observed or inferred palaeontological heritage within the study area, with recommendations (if any) for further specialist palaeontological input where this is considered necessary.

A Palaeontological Impact Assessment is generally warranted where rock units of LOW to VERY HIGH palaeontological sensitivity are concerned, levels of bedrock exposure within the study area are adequate; large scale projects with high potential heritage impact are planned; and where the distribution and nature of fossil remains in the proposed area is unknown. The specialist will inform whether further monitoring and mitigation are necessary.

Types and ranges of heritage resources as outlined in Section 3 of the National Heritage Resources Act (Act No.25 of 1999):

(i) objects recovered from the soil or waters of South Africa, including archaeological and palaeontological objects and material, meteorites and rare geological specimens.

This report adheres to the guidelines of Section 38 (1) of the National Heritage Resources Act (Act No. 25 of 1999).

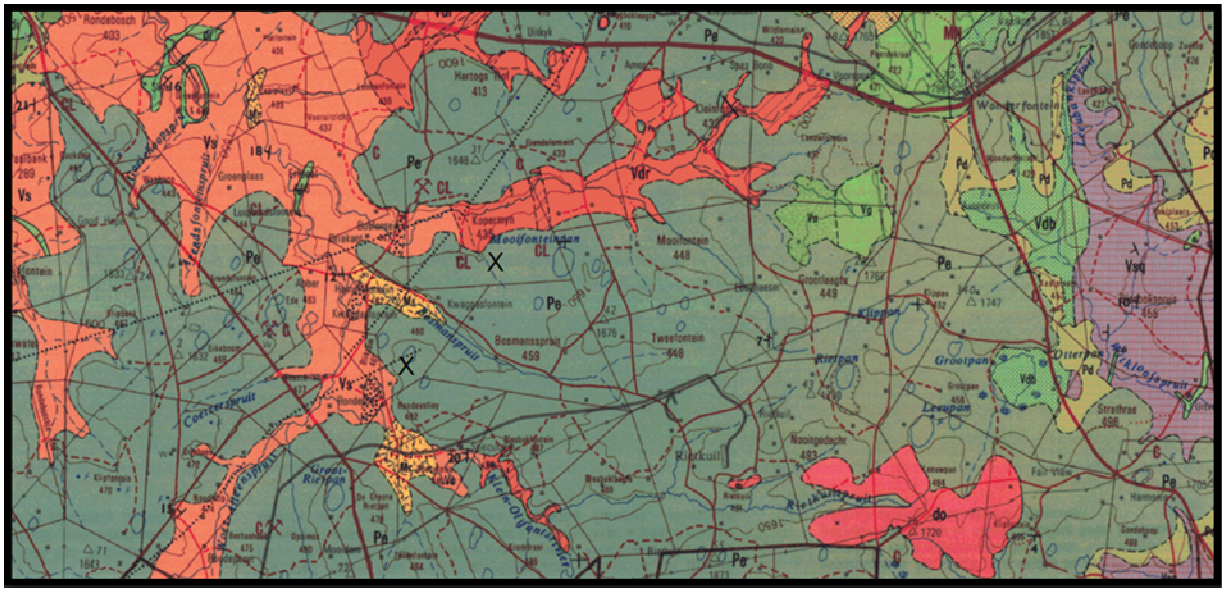
Subject to the provisions of subsections (7), (8) and (9), any person who intends to undertake a development categorised as (a) the construction of a road, wall, power line, pipeline, canal or other similar form of linear development or barrier exceeding 300 m in length; (b) the construction of a bridge or similar structure exceeding 50 m in length; (c) any development or other activity which will change the character of a site (see Section 38); (d) the re-zoning of a site exceeding 10 000 m² in extent; (e) or any other category of development provided for in regulations by SAHRA or a PHRA authority.

This report aims to provide comment and recommendations on the potential impacts that the proposed development could have on the fossil heritage of the area and to state if any mitigation or conservation measures are necessary.

Outline of the geology and the palaeontology:

The geology was obtained from map 1:100 000, Geology of the Republic of South Africa (Visser 1984) and 2528 Pretoria (Walraven 1978).

Figure 1: The geology of the development area.



Legend to Map and short explanation.

Pe – (brown) Sandstone, shaly sandstone, grit, shale, conglomerate and coal near base and top. Vryheid Formation, Ecca Group, Karoo Supergroup. Permian.

Mr – Granophyre, pseudogranophyre, granite porphyry. Rashoop Granophyre Suite, Bushveld Complex.

Vs – (amber) Volcanic rocks, red porphyritic rhyolite. Selonsrivier Formation, Rooiberg Group, Transvaal Supergroup. Vaalian.

Vdr – (orange) Volcanic rocks. Damwal Formation, Rooiberg Group, Transvaal Supergroup. Vaalian.

……. – Linear structure (Landsat and aeromagnetic).

X – Marks the two farms.

Mining activity: CL – Flint fire-clay.

Summary of findings: The Phase 1 Palaeontological Impact Assessment Field study was undertaken towards the end of April 2015 in the summer in dry and warm conditions and the following is reported:

Formations present are part of the Karoo Supergroup. The Karoo Supergroup is renowned for its fossil wealth. The Vryheid Formation (Pe,Pv), Ecca Group is rich in plant fossils such as the *Glossopteris* flora represented by stumps, leaves, pollen and fructifications. This formation is early to mid-Permian (Palaeozoic) in age and consists of sandstone, shaly sandstone, grit, conglomerate, coal and shale. Coal seams are present in the Vryheid Formation within the sandstone and shale layers. Fossils are mainly present in the grey shale which is interlayered between the coal seams. Borehole logs in the coalfields show the following layers; soil, shale and sandstone, shale and sandstone interbedded, sandstone, coal, conglomerate reworked diamictite, Dwyka Tillite, and the Pre-Karoo Basement (Kent 1980, Visser 1989).

The Transvaal Supergroup rocks are represented by the Selonsrivier and Damwal Formations that are Vaalian in age. Both the Selonsrivier and Damwal Formation are present on the Farm Kopermyn. The Selonsrivier Formation is present on the Farm Kwaggafontein together with the younger Bushveld Complex Rashoop Granophyre Suite. Most of the development area is covered by coal fines (Green Site), grass and crops obscuring the underlying geology. The N4 Site has a shallow outcrop of Vryheid Formation sandstone.

Fossils in South Africa mainly occur in rocks of sedimentary nature and not in rocks from igneous or metamorphic nature. Therefore, if there is the presence of Karoo Supergroup strata the palaeontological sensitivity can generally be LOW to VERY HIGH, and here locally **VERY HIGH** for the Vryheid Formation, **LOW** for the Rooiberg Group and **INSIGNIFICANT OR ZERO** for the Rashoop Granophyre Suite (SG 2.2 SAHRA APMHOB, 2012).

Recommendation:

The impact of the development on fossil heritage is **VERY HIGH** and therefore a field survey or further mitigation or conservation measures are necessary for this development (according to SAHRA protocol). A Phase 2 Palaeontological Impact Assessment and or mitigation may be recommended. The overburden and inter-burden consisting of Ecca rocks must be surveyed for fossiliferous outcrops (shale). Special care must be taken during the digging, drilling, blasting and excavating of foundations, trenches, channels and footings and removal of overburden. Protocol is attached (Appendix 2).

During the survey it was found that the farms are directly underlain by Karoo shale, shaly sandstone, grit, conglomerate and sandstone of the Vryheid Formation and is presently used for agriculture (maize crops). Recent structures are absent, but there are layer hen houses nearby. It is located on a gentle sloping topography. The development of layer hen houses includes several projects that will need foundations, footings, channels and trenches to be dug.

The survey was done in the Summer, conditions were dry and warm and as the area is covered by overburden, overgrowth, crops and it is difficult to see outcrops. There is only one option with a high impact. The sandstone may be thick enough to accommodate foundations, but the coal fines present on the Green site should be set aside and inspected for fossils.

The Project includes one Option (see map):

Option 1: Three different sites located south of Middelburg on property belonging to the applicant. The sites are located between the N4 and N11 national roads, south east of Middelburg, and marked as the N4 Site, Blue Site and the Green Site.

Concerns/threats:

1. Threats are earth moving equipment/machinery (front end loaders, excavators, graders, dozers) during construction, the sealing-in or destruction of the fossils by development, vehicle traffic and human disturbance.
2. Mitigation is needed (Appendix 2).
3. No consultation with parties was necessary.

Stakeholders: Developer – Alzu Enterprises (Pty) Ltd, Piet du Toit, Private Bag X251875, Middelburg, 1050, 013 249 8900.

Environmental – Clean Stream Environmental Services, P.O. Box 647, Witbank, 1035, 013 697 5021.

Landowner – Alzu Enterprises (Pty) Ltd.

C. Table of Contents

D. Background information on the project

Report

This report is part of the environmental impact assessment process under the National Environmental Management Act, as amended (Act No. 107 of 1998) (NEMA) and includes Appendix 6 (GN R38282 of 4 December 2014) of the Environmental Impact Assessment Regulations contained in GN R982 of 04 December 2010.

Outline of development

This report discusses and aims to provide the developer with information regarding the location of palaeontological material that will be impacted by the development. In the pre-construction phase it is necessary for the developer to apply for the relevant permit from the South African Heritage Resources Agency (SAHRA / PHRA).

The applicant, Alzu Enterprises (Pty) Ltd., intends to expand their existing layer hen operation with the addition of seven new facilities, comprising of 2 layer houses each. The following is envisaged for each site (Figure 2) (BID document):

N4 Site – located on Portion 2 of the Farm Kopermyn 435 JS. This site will comprise of 2 facilities (i.e. 4 houses) located ±100 m apart. Each house will be 100 m x 12 m in extent and will be able to accommodate 50 000 hens.

Blue Site – located on Portion 14 of the Farm Kopermyn 435 JS. This site will comprise of 2 facilities (i.e. 4 houses) located ±300 m apart. Each house will be 85 m x 10 m in extent and will be able to accommodate 10 000 hens. Two existing facilities (4 chicken houses) are located north of the site.

Green Site – located on Portions 1 and 2 of the Farm Kwaggafontein 460 JS. This site will comprise of three facilities (i.e. 6 houses). The one facility will be located ±1.2 km from the other two facilities. Each house will be 110 m x 10 m in extent and will be able to accommodate 10 000 hens. Six existing facilities (i.e. 12 houses) are located west of the site.

Figure 2: Proposed layout plan (provided by Clean Stream Environmental Services).

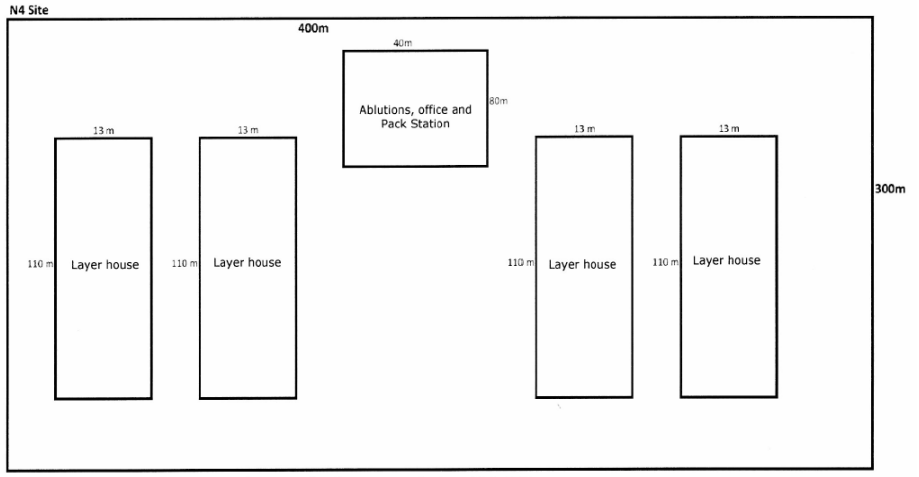


Figure 3.1: Schematic layout of the N4 Site

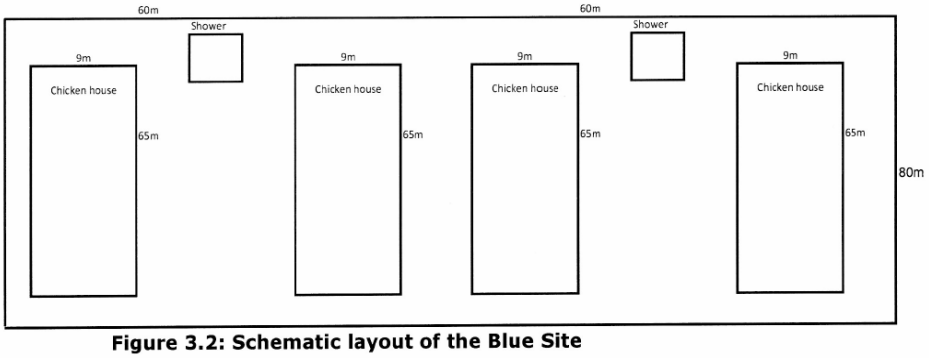


Figure 3.2: Schematic layout of the Blue Site

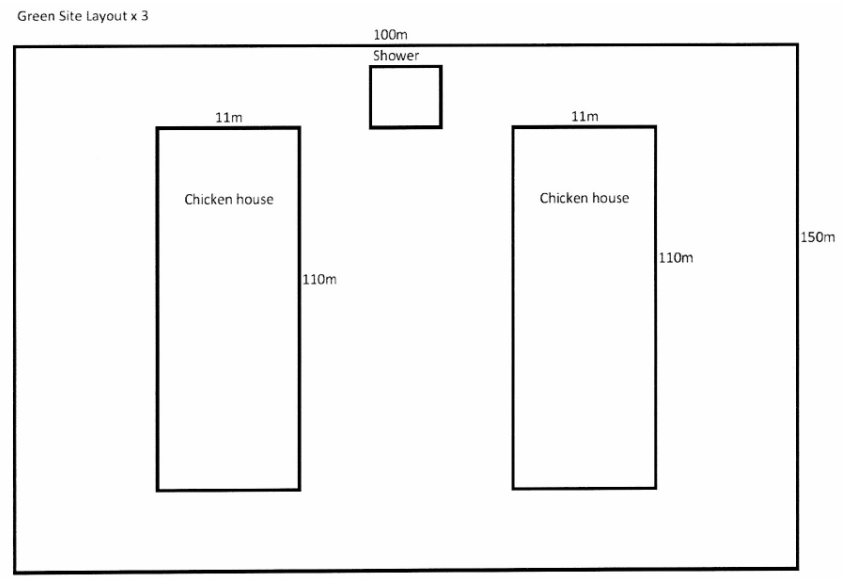


Figure 3.3: Schematic layout of one Green Site facility

The Project includes one Option (see map):

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Rezoning/ and or subdivision of land: None (Agriculture).

Name of developer and consultant: Alzu Enterprises (Pty) Ltd and Clean Stream Environmental Services.

Terms of reference: Dr H. Fourie is a palaeontologist commissioned to do a palaeontological impact assessment: field study to ascertain if any palaeontological sensitive material is present in the development area. This study will advise on the impact on fossil heritage mitigation or conservation necessary, if any.

Dr Fourie obtained a Ph.D from the Bernard Price Institute for Palaeontological Research (now ESI), University of the Witwatersrand. Her undergraduate degree is in Geology and Zoology. She specialises in vertebrate morphology and function concentrating on the Therapsid Therocephalia. For the past nine years she carried out field work in the Eastern Cape. Dr Fourie has been employed at the Ditsong: National Museum of Natural History in Pretoria (formerly Transvaal Museum) for 20 years.

Legislative requirements: South African Heritage Resources Agency (SAHRA) for issue of permits if necessary. National Heritage Resources Act (Act No. 25 of 1999). An electronic copy of this report must be supplied to SAHRA.

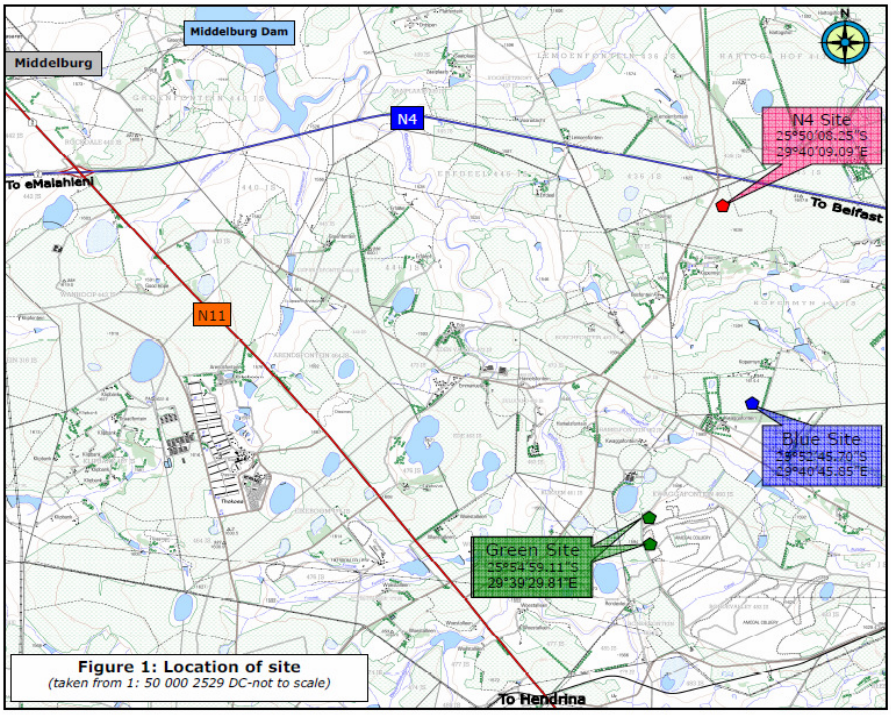
E. Description of property or affected environment

Location and depth:

The new layer houses will be located at three different sites (N4 Site, Blue Site, Green Site) for bio-security reasons. All three sites are located on property belonging to the applicant. The properties are located between the N4 and N11 national roads, south east of Middelburg (Figure 3) (BID document). Depth is determined by the foundations.

The N4 and Blue Sites will be located on cultivated land. The Green Site will be located adjacent to an area that was previously mined by Anglo Coal (now Anglo American).

Figure 3: Topographic map (Clean Stream Environmental Services) showing location.



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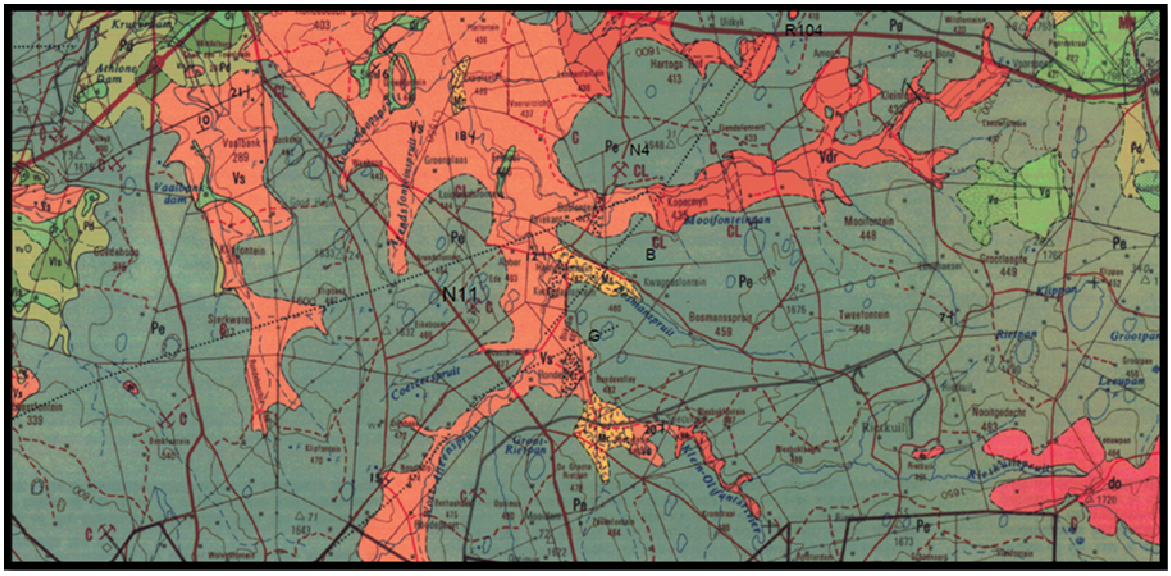
The bulk of the site is underlain by the flat-lying Vryheid Formation of the Ecca Group, Karoo Supergroup sediments covered by corn fields, grassland and coal fines (overburden).

F. Description of the Geological Setting

Description of the rock units:

Large areas of the southern African continent are covered by the Karoo Supergroup. The Ecca Group is early to mid-Permian (545-250 Ma) in age. Sediments of the Ecca group are lacustrine and marine to fluvio-deltaic (Snyman 1996). The Ecca group is known for its coal (mainly the Vryheid Formation) (5 coal seams) and uranium. Coalfields formed due to the accumulation of plant material in shallow and large swampy deltas (see Appendix 1). The Ecca Group conformably overlies the Dwyka Group and is conformably overlain by the Beaufort Group, Karoo Supergroup. It consists essentially of mudrock (shale), but sandstone-rich units occur towards the margins of the present main Karoo basin in the south, west and north-east, with coal seams also being present in the north-east (Kent 1980) (Johnson 2009).

Figure 4: Excerpt of geological map 2528 Pretoria (Walraven 1978).



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……. – Linear structure (Landsat and aeromagnetic).

N4, B, & G – Approximate position of sites (lack of reference points due to old geological maps).

The Vryheid Formation is named after the type area of Vryheid-Volksrust. In the north-eastern part of the basin the Vryheid Formation thins and eventually wedges out towards the south, southwest and west with increasing distance from its source area to the east and northeast (Johnson 2009). The Vryheid Formation consists essentially of sandstone, shale, and subordinate coal beds, and has a maximum total thickness of 500 m. It forms part of the Middle Ecca (Kent 1980). This formation has the largest coal reserves in South Africa. The prodelta sediments are characterised by trace and plants fossils (Snyman 1996).

Coal has always been the main energy source in industrial South Africa. It is in Mpumalanga, south of the N4, that most of the coal-fired power stations are found. Eskom is by far the biggest electricity generator in Africa. Thick layers of coal just below the surface are suited to open-cast mining and where the overlying sediments are too thick, shallow underground mining. In 2003, coal was South Africa's third most valuable mineral commodity and is also used by Sasol for fuel- and chemicals-from-coal (Norman and Whitfield 2006). Grodner and Cairncross (2003) proposed a 3-D model of the Witbank Coalfield to allow easy evaluation of the sedimentary rocks, both through space and time. Through this, one can interpret the environmental conditions present at the time of deposition of the sediments. This can improve mine planning and mining techniques. The Vryheid Formation is underlain by the Dwyka Group and gradually overlain by mudstones (and shale) and sandstones of the Volksrust Formation.

The Bushveld Complex is a massive body of igneous origin and it is intrusive in the Transvaal Supergroup. It is Vaalian in age (2,100 – 1,920 Ma). The Rustenburg Layered Suite is so termed as it is intrusive in origin and the term is to be equivalent to a 'group'. It consists of mafic and ultramafic rocks and is rich in platinum, chrome and vanadium. The layered rocks of the Bushveld Complex are generally believed to be the result of crystals settling out of magma during slow cooling. This region is covered by the 'Bushveld' vegetation. The magmatic events are petrogenetically related to and generally considered part of the whole magmatic evolution of the Complex are, the diabase sills and the Rooiberg Group. The Complex consists of three main units of which the Rashoop Granophyre Suite is one (Kent 1980). The Rashoop Granophyre Suite is present throughout the Bushveld Complex in the form of sills. It consists of granophyre, granite porphyry, granophyre, microgranophyre and pseudogranophyre. All of these are characterised by quartz and orthoclase, with minor hornblende and biotite (Visser 1989).

The Transvaal Supergroup fills an east-west elongated basin in the south-central part of the old Transvaal (now North – West, Gauteng and Mpumalanga Provinces) as far south as Potchefstroom. It is Vaalian in age, approximately 2600 Ma to 2100 Ma. A maximum thickness of the Transvaal Supergroup reaches 2000 m in the north-eastern section. An east-west elongated basin is filled with clastic, volcanic and chemical sedimentary rocks. Three groups based on lithological differences have been established: they are the Rooiberg, Chuniespoort, and Pretoria Groups as well as other smaller groups (Kent 1980). It is the Bushveld Complex that is responsible for the tilting of the Transvaal sediments and the heat of its intrusion having created andalusite crystals (Norman and Whitfield 2006). This Supergroup is underlain by the Ventersdorp, Witwatersrand and Pongola Supergroups, and the Dominion Group. The Rooiberg Group is divided into the Formations Damwal and Selonsrivier in the Loskop dam area (Visser 1989).

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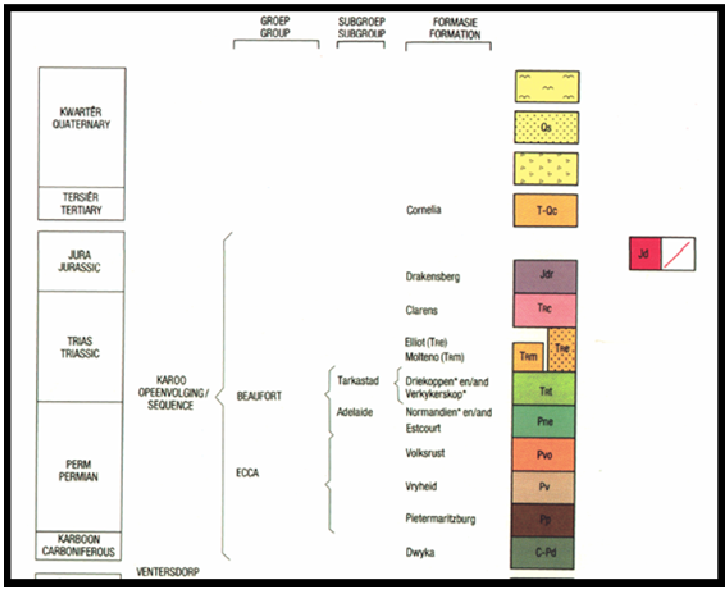
Figure 5: Lithostratigraphic column to show the Ecca Group within the Karoo Supergroup (Muntingh 1992).



Ecca rocks are stable and lend themselves well to developments. It is only unstable in or directly above mining activities (Snyman 1996). The site itself is situated on the flat-lying Vryheid Formation, Ecca Group, Karoo Supergroup. Dolerite dykes do occur throughout the Karoo Supergroup. Structural geological features such as dykes and faults can have a measurable influence on ground water flow and mass transport.

The typical colours for the Vryheid Formation are grey and yellow for the sediments and black for the coal seam. The thickness of the grey shale can vary and this is interlayered with the also variable yellow sandstone and coal seams.

The walk through was done towards the end of April 2015, conditions were dry and warm. Photographs below show the gentle sloping topography. A variety of soil types (overburden and topsoil) are present.

Figure 6: N4 site. Site is currently cultivated. A gravel road to surrounding properties and the N4 national road are located nearby. The site will be used to house commercial laying hens from 18 weeks to 85 weeks of age. A brick house, ablution facilities, a small office, and automated conveyor belt system will be erected. The sandstone bank is indicative of the Vryheid formation. Grit is also present.

Figure 7: Blue site. This site will house chicks from one day old until they are mature enough (18 weeks) to be moved to a free range laying facility. Two brick houses, ablution facilities, and a small office will be erected. View of site with crops.

Figure 8: Green site. This site will house free range laying hens. Brick houses, ablution facilities, and small office will be erected. View of site. There are no existing buildings here, but there are signs of the past mine activities. Presently not utilised, but covered in grass and back fill (overburden).

Figure 9: Green site. View to show the back view of the existing houses, the new facility will be situated where the crop is (not in view).

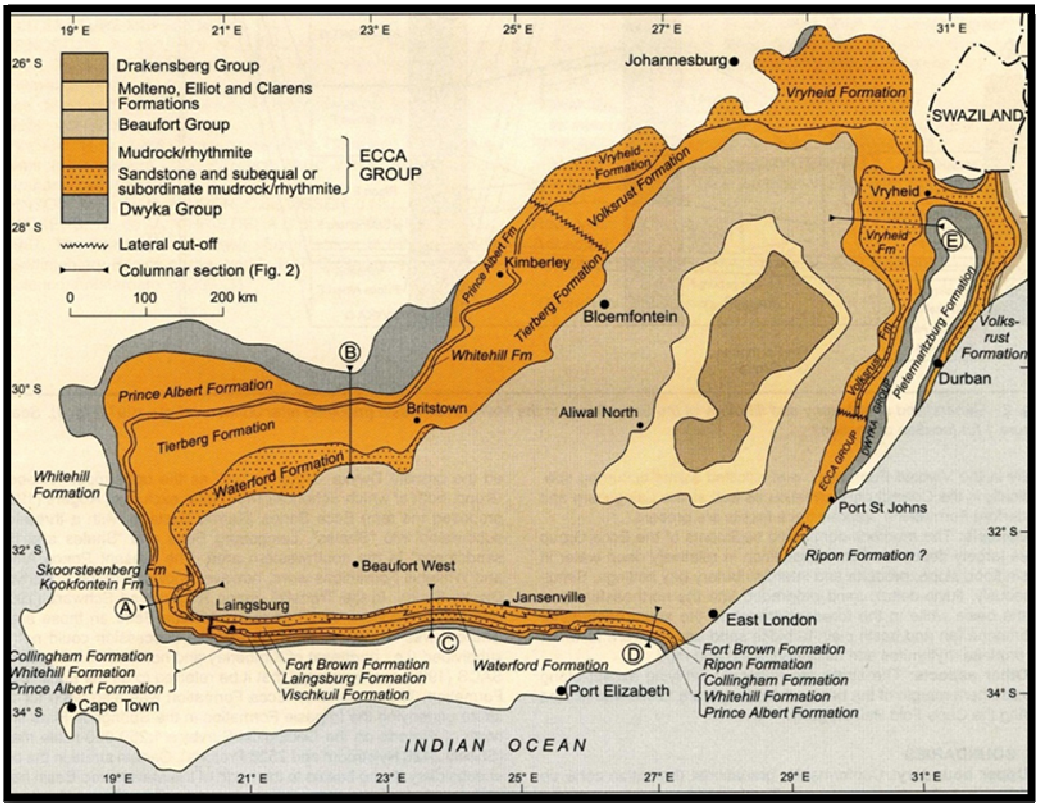
Figure 10: Green site. There is a considerable layer of mine rubble (back fill) on top of a thick layer of overburden. The entire area is covered by sloping rehabilitated areas and mine rubble. This rubble contains coal fines and shale. This shale may contain fossils.

There is some concern with the property due to the presence of the Vryheid Formation. The depth of the Formation can be verified with geological cores. The topsoil, subsoil and overburden must be surveyed for fossils and Mitigation is needed for the shale layer. The shale within the rubble (Green Site) may also contain fossils and should be set aside for a palaeontologist to inspect.

It is recommended to wait for the response from SAHRA on the Phase 1 Field study (this report), and if mitigation is recommended then the SAHRA protocol must be followed. Alternatives will not be feasible as all proposed development portions and surrounding areas are on the Vryheid Formation.

G. Background to Palaeontology of the area

Summary: When rock units of moderate to very high palaeontological sensitivity are present within the development footprint, a desk top and or field scoping (survey) study by a professional palaeontologist is usually warranted. The main purpose of a field scoping (survey) study would be to identify any areas within the development footprint where specialist palaeontological mitigation during the construction phase may be required (SG 2.2 SAHRA AMPHOB, 2012).



Map 1: Extent of the Ecca Group, more specifically the Vryheid Formation and the Volksrust Formation (Johnson 2009).

The Ecca Group may contain fossils of diverse non-marine trace, *Glossopteris* flora, mesosaurid reptiles, palaeoniscid fish, marine invertebrates, insects, and crustaceans (Johnson 2009). *Glossopteris* trees rapidly colonised the large deltas along the northern margin of the Karoo Sea. Dead vegetation accumulated faster than it could decay, and thick accumulations of peat formed, which were ultimately converted to coal. It is only in the northern part of the Karoo Basin that the glossopterids and cordaitales, ferns, clubmosses and horsetails thrived (McCarthy and Rubidge 2005) (Appendix 1).

The Glossopteris flora is thought to have been the major contributor to the coal beds of the Ecca. These are found in Karoo-age rocks across Africa, South America, Antarctica, Australia and India. This was one of the early clues to the theory of a former unified Gondwana landmass (Norman and Whitfield 2006).

Figure 11: Photograph (H. Fourie): Fossil courtesy of Prof. Bamford, The Evolutionary Studies Institute. A Horsetail fern stem.

Fossils in South Africa mainly occur in rocks of sedimentary nature and not in rocks from igneous or metamorphic nature. Therefore, if there is the presence of Karoo Supergroup strata the palaeontological sensitivity is generally LOW to VERY HIGH, but here locally **VERY HIGH** for the Vryheid Formation.

Criteria used (Fossil Heritage Layer Browser/SAHRA):

Rock Unit	Significance/vulnerability	Recommended Action
Vryheid Formation (Pv) (Pe)	VERY HIGH	Field assessment and protocol for finds is required
Rashoop GS, BC	Insignificant or Zero	No action required
Rooiberg Group	LOW	No palaeontological studies are required, however a protocol for finds is required.

Databases and collections: Ditsong: National Museum of Natural History. Evolutionary Studies Institute, University of the Witwatersrand (ESI).

Impact: **VERY HIGH** for the Vryheid Formation. There are significant fossil resources that may be impacted by the development (shale).

H. Description of the Methodology

The palaeontological impact assessment field study was undertaken in April 2015. The walk through of the affected portion was done and photographs (in 7.1 mega pixels) were taken of the site with a digital Canon camera (PowerShot A470). It was not necessary to use a Global Positioning System (GPS) (Garmin eTrex 10) to record fossiliferous finds as the area is covered with topsoil, subsoil, overburden, corn fields, grassland, shrubs and bushes. The walk through did identify the Vryheid Formation, but not the underlying shale. A literature survey is included.

Assumptions and Limitations:-

The accuracy and reliability of the report may be limited by the following constraints:

1. Most development areas have never been surveyed by a palaeontologist or geophysicist.
2. Variable accuracy of geological maps and associated information.
3. Poor locality information on sheet explanations for geological maps.
4. Lack of published data.
5. Lack of rocky outcrops.
6. Insufficient data from developer and exact lay-out plan for all structures.

A Phase 2 Palaeontological Impact Assessment: Mitigation will include:

1. Recommendations for the future of the site.
2. Description of work done (including number of people and their responsibilities.
3. A written assessment of the work done, fossils excavated, not removed or collected and observed.
4. Conclusion reached regarding the fossil material.
5. A detailed site plan.

6. Possible declaration as a heritage site or Site Management Plan.

Mitigation involves planning the protection of significant fossil sites, rock units or other palaeontological resources and/or excavation, recording and sampling of fossil heritage that might be lost during development, together with pertinent geological data. The mitigation may take place before and / or during the construction phase of development. The specialist will require a Phase 2 mitigation permit from the relevant Heritage Resources Authority before a Phase 2 may be implemented.

The Mitigation is done in order to rescue representative fossil material from the study area to allow and record the nature of each locality and establish its age before it is destroyed and to make samples accessible for future research. It also interprets the evidence recovered to allow for education of the public and promotion of palaeontological heritage.

Should further fossil material be discovered during the course of the development (*e. g.* during bedrock excavations), this must be safeguarded, where feasible *in situ,* and reported to a palaeontologist or to the Heritage Resources authority. In situations where the area is considered palaeontologically sensitive (*e. g.* Karoo Supergroup Formations, ancient marine deposits in the interior or along the coast) the palaeontologist might need to monitor all newly excavated bedrock. The developer needs to give the palaeontologist sufficient time to assess and document the finds and, if necessary, to rescue a representative sample.

When a Phase 2 palaeontological impact study is recommended, permission for the development to proceed can be given only once the heritage resources authority has received and approved a Phase 2 report and is satisfied that (a) the palaeontological resources under threat have been adequately recorded and sampled, and (b) adequate development on fossil heritage, including, where necessary, *in situ* conservation of heritage of high significance. Careful planning, including early consultation with a palaeontologist and heritage management authorities, can minimise the impact of palaeontological surveys on development projects by selecting options that cause the least amount of inconvenience and delay.

Three types of permits are available; Mitigation, Destruction and Interpretation. The specialist will apply for the permit at the beginning of the process (SAHRA 2012).

I. Description of significant fossil occurrences

All Karoo Supergroup geological formations are ranked as LOW to VERY HIGH, and here the impact is potentially **VERY HIGH** for the Vryheid Formation, Ecca Group. Rocks of Permian age in South Africa are particularly rich in fossil plants (Rayner and Coventry 1985). The fossils are present in the grey shale interlayered with the coal seams. The fossils are not very rare and also occur in other parts of the Karoo stratigraphy. The pollen of the Greenside Colliery also on the Vryheid formation was the focus of a Ph.D study. It is often difficult to spot the greyish fossils as they are the same colour as the grey shale in which they are present as these coalified compressions have been weathered to leave surface replicas on the enclosing shale matrix. A locality close to Ermelo, also Vryheid Formation, has yielded *Scutum, Glossopteris* leaves, *Neoggerathiopsis* leaves, the lycopod *Cyclodendron leslii,* and various seeds and scale leaves (Prevec 2011).

Fossils likely to be found are mostly plants (Appendix 1) such as '*Glossopteris* flora' of the Vryheid Formation. The aquatic reptile *Mesosaurus* and fossil fish may also occur with marine invertebrates, arthropods and insects. Trace fossils can also be present. The marine bivalve *Megadesmus* is found in the upper part of the Volksrust Formation near Newcastle (Johnson 2009).

During storms a great variety of leaves, fructifications and twigs accumulated and because they were sandwiched between thin films of mud, they were preserved to bear record of the wealth and the density of the vegetation around the pools. They make it possible to reconstruct the plant life in these areas and wherever they are found, they constitute most valuable palaeobotanical records (Plumstead 1963) and can be used in palaeoenvironmental reconstructions.

Details of the location and distribution of all significant fossil sites or key fossiliferous rock units are often difficult to be determined due to thick topsoil, subsoil, overburden and alluvium. Depth of the overburden may vary a lot. The vast coal mining industry provides palaeontologists with fantastic access to coal-associated plant fossils, while simultaneously resulting in the destruction of important National palaeontological heritage.

The threats are:- earth moving equipment/machinery (front end loaders, excavators, graders, dozers) during construction, the sealing-in or destruction of fossils by development, vehicle traffic, and human disturbance. See Description of the Geological Setting (F) above.

J. Recommendation

a. There is no objection (see Recommendation B) to the development, but it was necessary to request a Phase 1 Palaeontological Impact Assessment: Field study to determine whether the development will affect fossiliferous outcrops as the palaeontological sensitivity is **VERY HIGH**. A Phase 2 Palaeontological Mitigation may be required as the Phase 1 Palaeontological Assessment identified a fossiliferous formation (Vryheid Formation). Protocol is attached (Appendix 2).

b. This project may benefit the economy, the growth of the community and social development in general.

c. Preferred choice: The impact on the palaeontological heritage is **VERY HIGH for the Vryheid Formation.** The presence of shale is problematic. Care must be taken during the digging of foundations and removing topsoil, subsoil and overburden (see Executive Summary).

d. The following should be conserved: if any palaeontological material is exposed during digging, excavating, drilling or blasting SAHRA must be notified. All construction activities must be stopped and a palaeontologist should be called in to determine proper mitigation measures.

Sampling and collecting:

Wherefore a permit is needed from the South African Heritage Resources Agency (SAHRA / PHRA).

a. Objections: Cautious. See heritage value and recommendation.

b. Conditions of development: See Recommendation.

c. Areas that may need a permit: Yes.

d. Permits for mitigation: **Needed from SAHRA/PHRA prior to Mitigation**.

K. Conclusions

a. All the land involved in the development was assessed and none of the property is unsuitable for development (see Recommendation B).

b. All information needed for the Phase 1 Palaeontological Impact Assessment and Field scope was provided by the Consultant. All technical information was taken from the Background Information Document provided by Clean Stream Environmental Services, Ms R. J. van Rensburg.

c. Areas that would involve mitigation and may need a permit from the South African Heritage Resources Agency are discussed.

d. The following should be conserved: if any palaeontological material is exposed during digging, excavating, drilling or blasting, SAHRA must be notified. All development activities must be stopped and a palaeontologist should be called in to determine proper mitigation measures. Especially shallow caves.

e. Condition in which development may proceed: It is further suggested that a Section 37(2) agreement of the Occupational, Health and Safety Act 85 of 1993 is signed with the relevant contractors to protect the environment and adjacent areas as well as for safety and security reasons.

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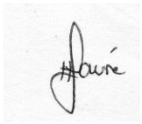
Declaration

I, Heidi Fourie, declare that I am an independent consultant and have no business, financial, personal or other interest in the proposed development project for which I was appointed to do a palaeontological assessment. There are no circumstances that compromise the objectivity of me performing such work.

Heidi Fourie accepts no liability, and the client, by receiving this document, indemnifies Heidi Fourie against all actions, claims, demands, losses, liabilities, costs, damages and expenses arising from or in connection with services rendered, directly or indirectly by the use of the information contained in this document.

This report may not be altered in any way and any parts drawn from this report must make reference to this report.



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Heidi Fourie

2015/05/11

Appendix 1: **Figure 12:** Examples of Vryheid Formation fossils.

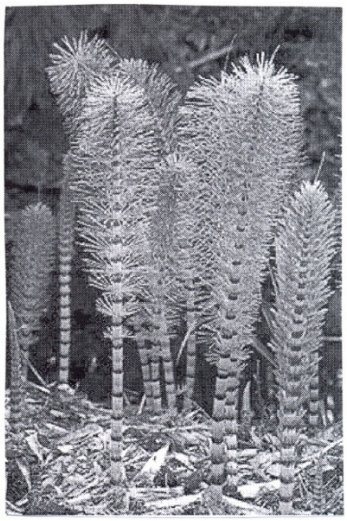
Ecca Group

Vryheid Formation

Glossopteris

Ferns

Horsetails



Clubmosses

Figure 13: Example of a plant fossil (courtesy of the ESI). *Glossopteris* leave.

Appendix 2: **Protocol for finds**

This section covers the recommended protocol for a Phase 2 Mitigation process as well as for reports where the Palaeontological Sensitivity is LOW; this process guides the palaeontologist / palaeobotanist on site and should not be attempted by the layman / developer.

The developer must survey the areas affected by the development and indicate on plan where the construction / development / mining will take place. Trenches have to be dug to ascertain how deep the sediments are above the bedrock (can be a few hundred metres). This will give an indication of the depth of the topsoil, subsoil, and overburden, if need be trenches should be dug deeper to expose the interburden.

Mitigation will involve recording, rescue and judicious sampling of the fossil material present in the layers sandwiched between the geological / coal layers. It must include information on number of taxa, fossil abundance, preservational style, and taphonomy. This can only be done during mining or excavations. In order for this to happen, in case of coal mining operations, the process will have to be closely scrutinised by a professional palaeontologist / palaeobotanist to ensure that only the coal layers are mined and the interlayers (siltstone and mudstone) are surveyed for fossils or representative sampling of fossils are taking place.

The palaeontological impact assessment process presents an opportunity for identification, access and possibly salvage of fossils and add to the few good plant localities. Mitigation can provide valuable onsite research that can benefit both the community and the palaeontological fraternity.

A Phase 2 study is very often the last opportunity we will ever have to record the fossil heritage within the development area. Fossils excavated will be stored at a National Repository.

A Phase 2 Palaeontological Impact Assessment: Mitigation will include (SAHRA) -

1. Recommendations for the future of the site.
2. Description and purpose of work done (including number of people and their responsibilities).
3. A written assessment of the work done, fossils excavated, not removed or collected and observed.
4. Conclusion reached regarding the fossil material.
5. A detailed site plan and map.
6. Possible declaration as a heritage site or Site Management Plan.
7. Stakeholders.
8. Detailed report including the Desktop and Phase 1 study information.
9. Annual interim or progress Phase 2 permit reports as well as the final report.
10. Methodology used.

Mitigation involves planning the protection of significant fossil sites, rock units or other palaeontological resources and/or excavation, recording and sampling of fossil heritage that might be lost during development, together with pertinent geological data. The mitigation may take place before and / or during the construction phase of development. The specialist will require a Phase 2 mitigation permit from the relevant Heritage Resources Authority before a Phase 2 may be implemented.

The Mitigation is done in order to rescue representative fossil material from the study area to allow and record the nature of each locality and establish its age before it is destroyed and to make samples accessible for future research. It also interprets the evidence recovered to allow for education of the public and promotion of palaeontological heritage.

Should further fossil material be discovered during the course of the development (*e. g.* during bedrock excavations), this must be safeguarded, where feasible *in situ,* and reported to a palaeontologist or to the Heritage Resources authority. In situations where the area is considered palaeontologically sensitive (*e. g.* Karoo Supergroup Formations, ancient marine deposits in the interior or along the coast) the palaeontologist might need to monitor all newly excavated bedrock. The developer needs to give the palaeontologist sufficient time to assess and document the finds and, if necessary, to rescue a representative sample.

When a Phase 2 palaeontological impact study is recommended, permission for the development to proceed can be given only once the heritage resources authority has received and approved a Phase 2 report and is satisfied that (a) the palaeontological resources under threat have been adequately recorded and sampled, and (b) adequate development on fossil heritage, including, where necessary, *in situ* conservation of heritage of high significance. Careful planning, including early consultation with a palaeontologist and heritage management authorities, can minimise the impact of palaeontological surveys on development projects by selecting options that cause the least amount of inconvenience and delay.

Three types of permits are available; Mitigation, Destruction and Interpretation. The specialist will apply for the permit at the beginning of the process (SAHRA 2012).

The Palaeontological Society of South Africa (PSSA) does not have guidelines on excavating or collecting, but the following is suggested:

1. The developer needs to clearly stake or peg-out (survey) the areas affected by the mining/ construction/ development operations and dig representative trenches and if possible supply geological borehole data.

2. Fossils likely to occur are for example the fossil plants from the Vryheid Formation, these are present in the grey shale (or any other fossiliferous layer ranked as VERY HIGH or HIGH) or invertebrates from the Volksrust Formation (or any other fossiliferous layer).

3. When clearing topsoil, subsoil or overburden and hard rock (outcrop) is found, the contractor needs to stop all work.

4. A Palaeobotanist / palaeontologist (contact SAHRIS for list) must then inspect the affected areas and trenches for fossiliferous outcrops / layers. The contractor / developer may be asked to move structures, and put the development on hold.

5. If the palaeontologist / palaeobotanist is satisfied that no fossils will be destroyed or have removed the fossils, development and removing of the topsoil can continue.

6. After this process the same palaeontologist / palaeobotanist will have to inspect and offer advice through the Phase 2 Mitigation Process. Bedrock excavations for footings may expose, damage or destroy previously buried fossil material and must be inspected.

7. When permission for the development is granted, the next layer can be removed, if this is part of a fossiliferous layer, then with the removal of each layer of sediment, the palaeontologist / palaeobotanist must do an investigation (a minimum of once every two weeks).

8. At this stage the palaeontologist / palaeobotanist in consultation with the developer / mining company must ensure that a further working protocol and schedule is in place. Onsite training should take place, followed by an annual visit by the palaeontologist / palaeobotanist.

Fossil excavation if necessary during Phase 2:

1. Photography of fossil / fossil layer and surrounding strata.

2. Once a fossil has been identified as such, the task of extraction begins.

3. It usually entails the taking of a GPS reading and recording lithostratigraphic, biostratigraphic, date, collector and locality information.

4. Using Paraloid (B-72) as an adhesive and protective glue, parts of the fossil can be kept together (not necessarily applicable to plant fossils).

5. Slowly chipping away of matrix surrounding the fossil using a geological pick, brushes and chisels.

6. Once the full extent of the fossil / fossils are visible, it can be covered with a plaster jacket (not necessarily applicable to plant fossils).

7. Chipping away sides to loosen underside.

8. Splitting of the rock containing palaeobotanical material should reveal any fossils sandwiched between the layers.

SAHRA does have the following documents in place:

Guidelines to Palaeontological Permiting policy.

Minimum Standards: Palaeontological Component of Heritage Impact Assessment reports.

Guidelines for Field Reports.

Appendix 3:

Table 1: Listing points in Appendix 6 of the Act and position in Report.

Section	Point in Act	Heading
B	1(c)	Outline of development project
	1(d)	Summary of findings
	1(g)	Concerns/threats:
	1(n)i	"
	1(n)ii	"
	1(o)	"
	1(p)	"
D	1(h)	Figures
	1(a)i	Terms of reference
H	1(e)	Description of Methodology
	1(i)	Assumptions and Limitations
I	1(f)	Heritage value
J	1(j)	Recommendation
	1(l)	"
	1(m)	Sampling and collecting
	1(k)	"
Declaration	1(b)	Declaration
Appendix 2	1(k)	Protocol for finds
	1(m)	"
	1(q)	"