The Upgrading of National Route 1 Section 17 Between Westleigh (km 77.8) and Heuningspruit (km 101.6)

Moqhaka Local Municipality, Fezile Dabi District Municipality, Free State Province

Farm: For N1 not applicable, several for Borrow pits and Quarry

Fourie, H. Dr heidicindy@yahoo.com

012 322 7632/012 942 0110 X 1057

Palaeontological Impact Assessment: Amendment

CaseID: 15132

Facilitated by: Tsimba Archaeological Footprints

24 Lawson Mansions, 74 Loveday Street, Johannesburg CBD, 2000

Tel: 061 912 5118

2019/09/16

Ref: Pending

This Amendment addresses the concerns SAHRA raised in the Interim Comment with CaseID: 15132 around the location and National Heritage of the borrow pits.

The applicant has decided not to include the **borrow pits** in the application, therefore this section in the Report falls away.

Field Observation for ***Road*** - The project will fall on the already existing road reserve that has been cleared of all outcrops when the road was constructed. Only a few isolated rocks are present on the road reserve which did not contain any fossils. The few outcrops present in the road cutting (bank 93.8N) were walked to look for fossils, but nothing was found.

Additional Images.


18/09/2019


18/09/2019

Result and conclusion: Adelaide Subgroup – **Very High**. Mostly photographs are not taken if there are no outcrops to be seen. The photographs show the shoulder of the road that will be used for additional lanes. This project was done more than a year ago, even so, the conditions were favourable as the grass were very short. The entire road reserve could be walked and surveyed.

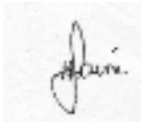
Declaration (disclaimer)

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.

I accept no liability, and the client, by receiving this document, indemnifies me 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.

It may be possible that the Amendment may have missed palaeontological resources in the project area as outcrops are not always present or visible on geological maps while others may lie below the overburden of earth and may only be present once development commences.

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



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Heidi Fourie
2020/12/09

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Moqhaka Local Municipality, Fezile Dabi District Municipality, Free State Province

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Fourie, H. Dr heidicindy@yahoo.com

012 322 7632/012 942 0110 X 1057

Palaeontological Impact Assessment: Phase 1 Field study

Facilitated by: Tsimba Archaeological Footprints

24 Lawson Mansions, 74 Loveday Street, Johannesburg CBD, 2000

Tel: 061 912 5118

2019/09/16

Ref: Pending

B. Executive summary

Outline of the development project: Tsimba Archaeological Footprints has facilitated the appointed of Dr H. Fourie, a palaeontologist, to undertake a Palaeontological Impact Assessment (PIA), Phase 1 Field study of the suitability of the proposed Upgrading of National Route 1 Section 17 Between Westleigh (km 77.8) and Heuningspruit (km 101.6) in the Moqhaka Local Municipality, Fezile Dabi District Municipality, Free State Province .

The applicant, The South African Roads Agency SOC Ltd (SANRAL), proposes to upgrade the National Route 1 Section 17 from Westleigh (km 77.8) to Heuningspruit (km 101.6). The need for the project arose from increased traffic volumes on the N1-17 route and declining Levels of Service on the existing 3-lane carriageway facility.

The Project includes one Alternative (see map):
Alternative 1: A stretch of National Road (N1) outlined in red near the town of Villiers. The length of the road is 23.8 km.

Legal requirements:-

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.

"palaeontological" means any fossilised remains or fossil trace of animals or plants which lived in the geological past, other than fossil fuels or fossiliferous rock intended for industrial use, and any site which contains such fossilised remains or traces.

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.

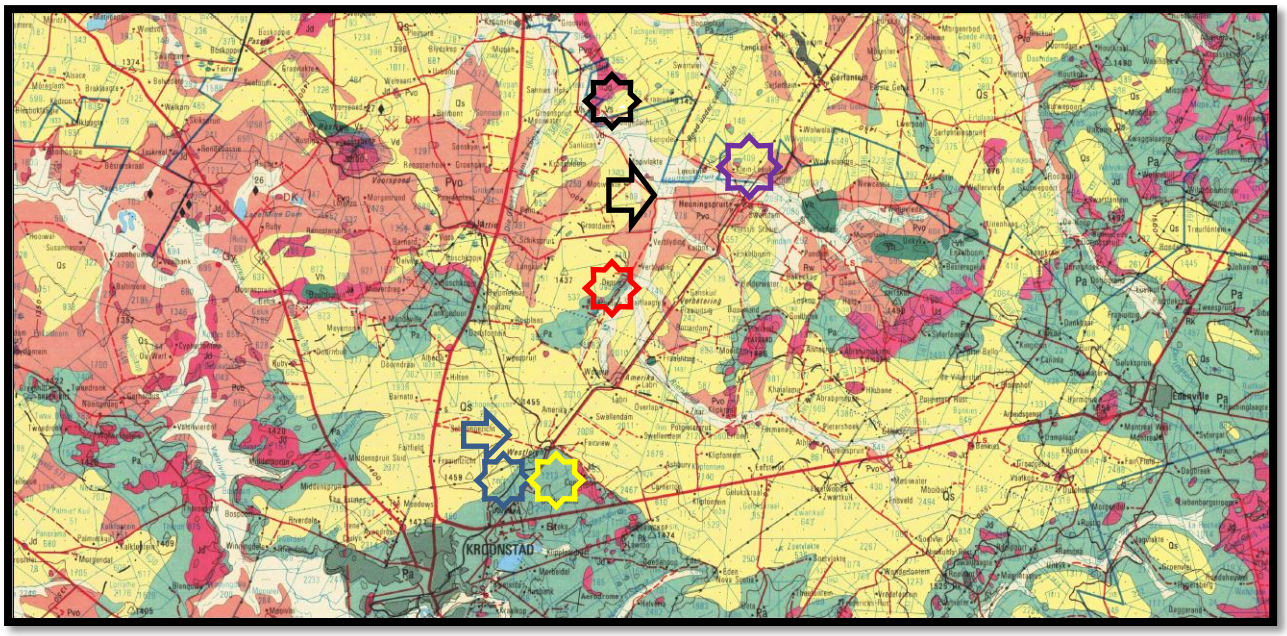
Types and ranges of heritage resources as outlined in Section 3 of the National Heritage Resources Act (Act No.25 of 1999):
(i) (i) objects recovered from the soil or waters of South Africa, including archaeological and palaeontological objects and material, meteorites and rare geological specimens.

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 **(6c)**.

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 2726 Kroonstad, 1:250 000 geological map (Schutte 1986).

Figure 2: The geology of the development area.



Legend to Map and short explanation.
Qs – Aeolian sand (yellow) – Quaternary.
Pa – Sandstone, mudstone, siltstone (green). Adelaide Subgroup, Karoo Supergroup. Early Triassic.
Pvo – Mudstone, siltstone, shale (pink). Volksrust Formation, Ecca Group, Karoo Supergroup. Permian.
…… – (black) Lineament (Possible dyke).
--f— Fault.
┼ - Vertical bed.
┴10˚ - Strike and dip.
→ – Approximate position of road upgrade (black - end, blue - start) (The N1 is not on this old geological map).

Over areas totalling fully 40% of Southern Africa the 'hard rocks', from the oldest to the Quaternary, are concealed by normally unconformable deposits – principally sand, gravel, sandstone, and limestone. Inland deposits are much more extensive than marine deposits and are terrestrial and usually unfossiliferous. Some of

these deposits date back well into the Tertiary, whereas others are still accumulating. Owing to the all-to-often lack of fossils and of rocks suitable for radiometric or palaeomagnetic dating, no clear-cut dividing line between the Tertiary and Quaternary successions could be established (Kent 1980). The alluvium sands were deposited by a river system and reworked by wind action (Snyman 1996).

The Adelaide Subgroup consists of up to three formations (Koonap, Middleton, Balfour). Mudrock predominates with subordinate sandstone and is Upper Permian in age. It overlies the Ecca Group conformably and is overlain by the Katberg Formation of the Tarkastad Subgroup. Siltstone beds are common (Cole *et al.* 2004). The Balfour Formation is distinguished from the Middleton Formation by the lack of 'red' mudstone and is ±2150 m. thick, whereas the Middleton Formation is ±1600 m. thick (sheet info, Kent 1980). The Abrahamskraal and Teekloof Formations also form part of the Adelaide Subgroup (Snyman 1996). Chert is present in the Abrahamskraal Formation. The Adelaide Subgroup has a maximum thickness of 1750 m. in the south (Visser 1989).

Kent (1980) described the Volksrust Formation as the 150-270 m of shale which overlies the Vryheid Formation. The deposition of this formation coincides with that of the Fort Brown and Waterford Formations in the south (Snyman 1996). It occurs from the south of Kwazulu-Natal into the Free State and is concordant (Visser 1989).

Palaeontology – 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 **MODERATE** for the Quaternary, **MODERATE** for the Volksrust Formation, and **VERY HIGH** for the Adelaide Subgroup (SG 2.2 SAHRA APMHOB, 2012).

The Quaternary has a wide range of possible fossil remains, though these are often sparse, such as: mammalian bones and teeth, tortoise remains, ostrich eggshells, non-marine mollusc shells, ostracods, diatoms, and other micro fossil groups, trace fossils (e.g. calcretised termitaria, rhizoliths, burrows, vertebrate tracks), freshwater stromatolites, plant material such as peats, foliage, wood, pollens, within calc tufa. Stromatolite structures range from a centimetre to several tens of metres in size. They are the result of algal growth in shallow water, indicating a very rich growth that would have caused an enrichment in the amount of oxygen in the atmosphere (Groenewald and Groenewald 2014).

The rocks of the Karoo Supergroup are internationally acclaimed for their richness and diversity of fossils. The rocks of the Beaufort Group of South Africa cover approximately one-third of the land surface and have yielded an abundance of well-preserved therapsids and other tetrapods which have been used to subdivide this Group into eight faunal Assemblage Zones.

The Volksrust Formation consists of a monotonous sequence of grey shale and fossils are significant, but very rarely recorded. Fossils include rare temnospondyl amphibian remains, invertebrates, minor coals with plant remains, fish scales, petrified wood, and low-diversity marine to non-marine trace fossil assemblages (Groenewald and Groenewald 2014).

Summary of findings (**6d**): The Phase 1 Palaeontological Impact Assessment Field Study was undertaken in September 2019 in the summer in dry and warm conditions, and the following is reported:

Field Observations - The area is accessible and the road reserve is well maintained. Most of the road reserve was surveyed on foot, although it is dangerous next to the National Road. The site is located on a fairly flat topography with some rocky outcrops (bedrock) and is covered by overburden, vegetation and grass.
Recommendation:

The potential impact of the development on fossil heritage is **VERY HIGH and MODERATE** and therefore a field survey was necessary for this development (according to SAHRA protocol). A Phase 2 Palaeontological Impact Assessment and or Mitigation or conservation may be recommended when fossils are found during construction

The Project includes one Alternative (see map):
Alternative 1: A stretch of National Road (N1) outlined in red near the town of Villiers. The length of the road is 23.8 km.

Other Alternatives will not be feasible due to the existence of the N1 National Road.

Concerns/threats **(6g,6ni,6nii,6o,6p)** to be added to EMPr:

1. Threats are earth moving equipment/machinery (for example haul trucks, front end loaders, excavators, graders, dozers) during construction, the sealing-in, disturbance, damage or destruction of the fossils by development, vehicle traffic, prospecting, mining, and human disturbance.
2. Special care must be taken during the digging, drilling, blasting and excavating of foundations, trenches, channels and footings and removal of overburden not to intrude fossiliferous layers.

The recommendations are:

1. Mitigation may be needed if fossils are found during the construction of road or mining of borrow pits / quarry.
2. No consultation with parties was necessary. The Environmental Control Officer must familiarise him- or herself with the formations present and its fossils.
3. The development may go ahead with caution. The ECO must survey for fossils before and or after blasting, drilling or excavating.
4. The EMPr already covers the conservation of heritage and palaeontological material that may be exposed during construction activities. For a chance find, the protocol is to immediately cease all construction activities, construct a 30 m no-go barrier, and contact SAHRA for further investigation. It is recommended that the EMPr be updated to include the involvement of a palaeontologist for pre-mining training of the ECO or during the digging and excavation phase of the development.
5. The mine should be encouraged to set aside some of the shale / mudstone for future research purposes if mining is done in the Volksrust Formation or Adelaide Subgroup.

Stakeholders: Developer – The South African National Roads Agency SOC Ltd.
Environmental – Tsimba Archaeological Footprints. Tel. 061 912 5118.
Landowner – N/a.

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 R326 of 7 April 2017) of the Environmental Impact Assessment Regulations (see Appendix 2). It also is in compliance with The Minimum Standards for Palaeontological Components of Heritage Impact Assessment Reports, SAHRA, APMHOB, Guidelines 2012, Pg 1-15.

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, The South African Roads Agency SOC Ltd (SANRAL), proposes to upgrade the National Route 1 Section 17 from Westleigh (km 77.8) to Heuningspruit (km 101.6). The need for the project arose from increased traffic volumes on the N1-17 route and declining Levels of Service on the existing 3-lane carriageway facility. The existing road pavement also requires some rehabilitation measures at this stage. The upgrade may be either as a 4-lane undivided single carriageway with a median barrier, or a 4-lane divided dual carriageway road.

1. Road, 4-lane,
2. Realignment of intersection ramps,
3. Bridges, road-over-rail and road-over-river,
4. Culverts, up to nine, and

The Project includes one Alternative (see map):
Alternative 1: A stretch of National Road (N1) outlined in red near the town of Villiers. The length of the road is 23.8 km.
Rezoning/ and or subdivision of land: None.
Name of Developer and Consultant: The South African National Roads Agency SOC Ltd. and Tsimba Archaeological Footprints.
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.
Short *Curriculum vitae:* 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. At present she is curator of a large fossil invertebrate collection, Therapsids, dinosaurs, amphibia, fish, reptiles, and plants at Ditsong: National Museum of Natural History. For the past 13 years she carried out field work in the North West, Western Cape, Northern Cape, Eastern Cape, Limpopo, Mpumalanga, Gauteng and Free State Provinces. Dr Fourie has been employed at the Ditsong: National Museum of Natural History in Pretoria (formerly Transvaal Museum) for 25 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

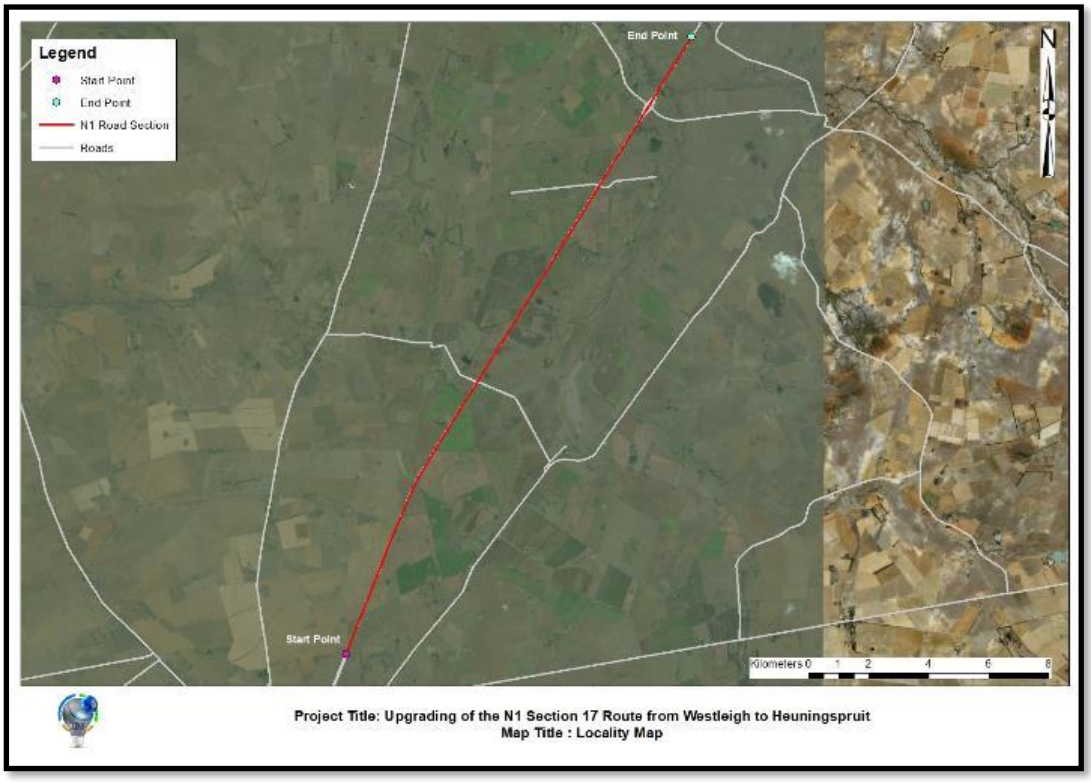
Location and depth:

The Upgrading of National Route 1 Section 17 Between Westleigh (km 77.8) and Heuningspruit (km 101.6) will be situated in the Moqhaka Local Municipality, Fezile Dabi District Municipality, Free State Province.

Depth is determined by the related infrastructure to be developed and the thickness of the formation in the development area as well as depth of the foundations, footings and channels to be developed. Details of the location and distribution of all significant fossil sites or key fossiliferous rock units are often difficult to determine due to thick topsoil, subsoil, overburden and alluvium. Depth of the overburden may vary a lot. Geological maps do not provide depth or superficial cover, it only provides mappable surface outcrops. The depth can be verified with test pit results or drill cores.

The Project includes one Alternative (see map):
Alternative 1: A stretch of National Road (N1) outlined in red near the town of Villiers. The length of the road is 23.8 km.

Figure 1: Google.earth image showing location (Tsimba).



The site is underlain by the Quaternary and Karoo Supergroup Formations covered by vegetation, grass, and trees.

F. Description of the Geological Setting

Description of the rock units:

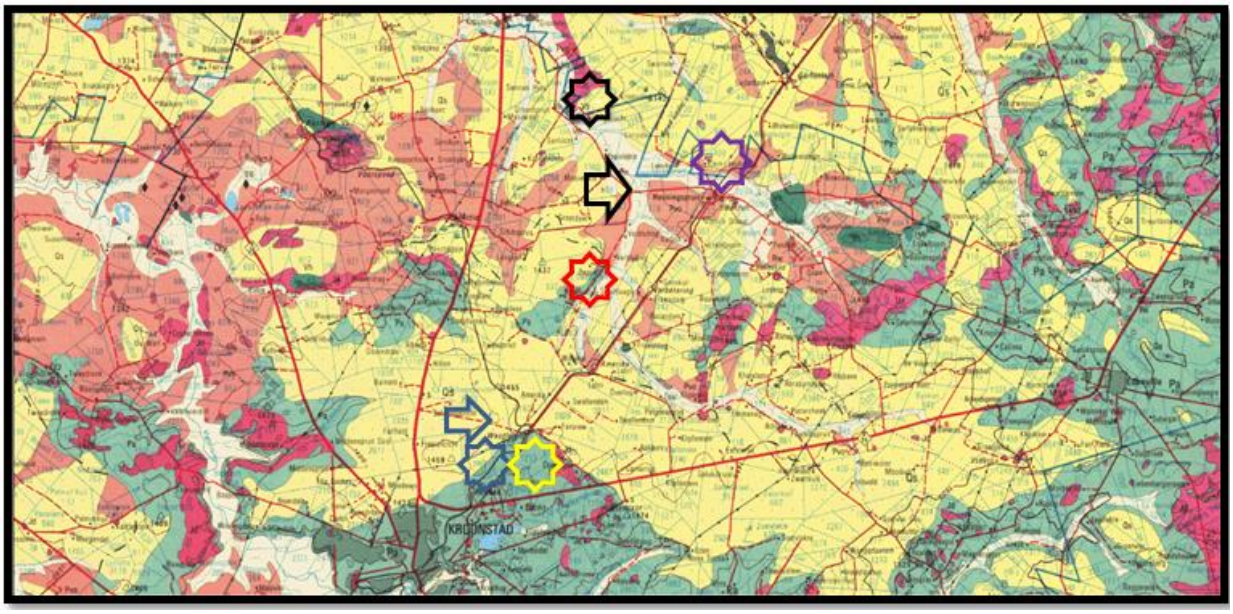
Over areas totalling fully 40% of Southern Africa the 'hard rocks', from the oldest to the Quaternary, are concealed by normally unconformable deposits – principally sand, gravel, sandstone, and limestone. Inland deposits are much more extensive than marine deposits and are terrestrial and usually unfossiliferous. Some of these deposits date back well into the Tertiary, whereas others are still accumulating. Owing to the all-to-often lack of fossils and of rocks suitable for radiometric or palaeomagnetic dating, no clear-cut dividing line between the Tertiary and Quaternary successions could be established (Kent 1980). The alluvium sands were deposited by a river system and reworked by wind action (Snyman 1996).

Large areas of the southern African continent are covered by the Karoo Supergroup (Figures 4, 5, Map 1). It covers older geological formations with an almost horizontal blanket. Several basins are present with the main basin in the central part of south Africa and several smaller basins towards Lebombo, Springbok Flats and Soutpansberg. An estimated age is 150 – 180 Ma. And a maximum thickness of 7000 m is reached in the south. Three formations overlie the Beaufort Group, they are the Molteno, Elliot and Clarens Formations. The Elliot Formation is also known as the Red Beds and the old Cave Sandstone is known as the Clarens Formation. At the top is the Drakensberg Basalt Formation with its pillow lavas, pyroclasts, etc. (Kent 1980, Snyman 1996). The Beaufort Group is underlain by the Ecca Group which lies on the Dwyka Group.

The rocks of the Beaufort Group were deposited by large, northward-flowing, meandering rivers in which sand accumulated, flanked by extensive floodplains where periodic floods deposited mud. Following the end-Permian mass extinction, the meandering rivers were replaced by multi-channelled, braided river systems that deposited sand rather than the silts and muds of the earlier meandering rivers. The sandstone-dominated strata deposited by these braided rivers, known as the Katberg Formation, can be as much as 1000 m. thick. As time passed, the high-energy, braided rivers of the Katberg Formation reverted to a meandering form, possibly reflecting recovery of the vegetation. These sedimentary deposits are the Burgersdorp Formation (McCarthy and Rubidge 2005).

The Tarkastad Subgroup of the Beaufort Group consists of a lower predominantly arenaceous Katberg Sandstone Formation and a predominantly upper argillaceous Burgersdorp Formation (Cole *et al*. 2004, Kent 1980). It is Early Triassic in age. This Subgroup is absent in the west of the basin. A maximum thickness of 900 m can be measured for the Katberg sandstone. Red, bluish and green mudstone, siltstone and fine- to medium-grained sandstone lenses are characteristic of the Burgersdorp Formation. This Subgroup marks the boundary of the Palaeozoic and the Mesozoic (Snyman 1996, Visser 1998). Fossil mammal-like reptiles are present (Norman and Whitfield 2006).

Figure 2: Geology of the development area.



Legend to Map and short explanation.

Qs – Aeolian sand (yellow) – Quaternary.

Pa – Sandstone, mudstone, siltstone (blue). Adelaide Subgroup, Karoo Supergroup. Early Triassic.

Pvo – Mudstone, siltstone, shale (pink). Volksrust Formation, Ecca Group, Karoo Supergroup. Permian.

…… – (black) Lineament (Possible dyke).

--f— Fault.

┼ - Vertical bed.

⊥10˚ - Strike and dip.

→ – Approximate position of road upgrade (black – end, blue –begin).

Mining Activities on Figure:

DK – Kimberlite Ls – Limestone St – Stone aggregate, gravel.

The Adelaide Subgroup consists of up to three formations (Koonap, Middleton, Balfour). Mudrock predominates with subordinate sandstone and is Upper Permian in age. It overlies the Ecca Group conformably and is overlain by the Katberg Formation of the Tarkastad Subgroup. Siltstone beds are common (Cole *et al.* 2004). The Balfour Formation is distinguished from the Middleton Formation by the lack of 'red' mudstone and is ±2150 m. thick, whereas the Middleton Formation is ±1600 m. thick (sheet info, Kent 1980). The Abrahamskraal and Teekloof Formations also form part of the Adelaide Subgroup (Snyman 1996). Chert is present in the Abrahamskraal Formation. The Adelaide Subgroup has a maximum thickness of 1750 m. in the south (Visser 1989).

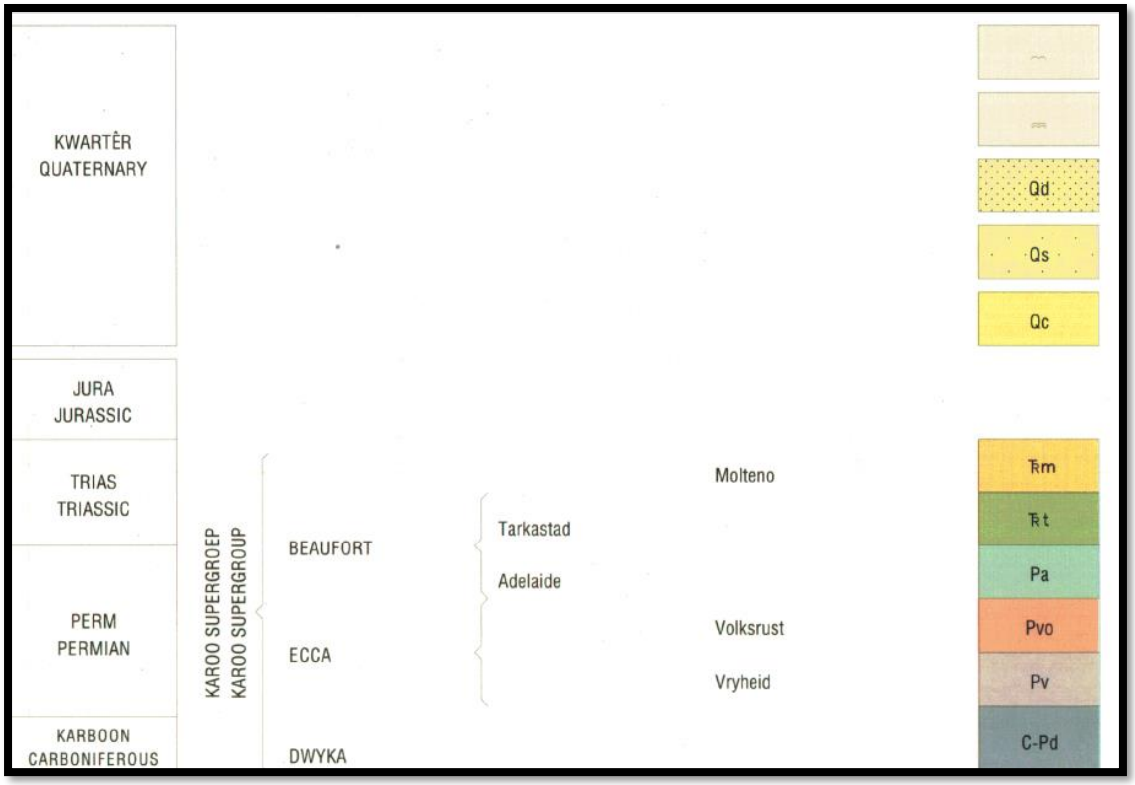
The Ecca Group is early to mid-Permian (545-250 Ma) in age. Sediments of the Ecca group are lacustrine and marine to fluvio-deltaic (Snyman 1996). The Ecca group is known for its coal (mainly the Vryheid Formation) (five coal seams) and uranium. Coalfields formed due to the accumulation of plant material 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).

Kent (1980) described the Volksrust Formation as the 150-270 m of shale which overlies the Vryheid Formation. The deposition of this formation coincides with that of the Fort Brown and Waterford Formations in the south (Snyman 1996). It occurs from the south of Kwazulu-Natal into the Free State and is concordant (Visser 1989).

Very little is written on the Volksrust Formation. It rests conformably on the Vryheid Formation. Fossils consist of fish scales and wood. This formation reaches thicknesses of 170-270 m (Visser 1989). A monotonous sequence of grey shale is present and fossils are significant, but very rarely recorded. Fossils include rare temnospondyl amphibian remains, invertebrates, minor coals with plant remains, petrified wood, and low-diversity marine to non-marine trace fossil assemblages (Groenewald and Groenewald 2014).

The Project includes one Alternative (see map):
Alternative 1: A stretch of National Road (N1) outlined in red near the town of Villiers. The length of the road is 23.8 km.

Figure 4: Lithostratigraphic column of the development area (19).



Dolerite dykes (Jd) 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.

Field Observations.
The area is accessible and the road reserve is well maintained. Most of the road reserve was surveyed on foot, although it is dangerous next to the National Road. The site is located on a fairly flat topography with some rocky outcrops (bedrock) and is covered by overburden, vegetation and grass.

Figure 6: View of road reserve at km 101.6. N (east road reserve) It is easy to see outcrops due to the short grass.

Figure 7: View at km 93.4 – km 92.4 N with Adelaide Subgroup rocks present (road reserve east).

Figure 8: View at road reserve east.

Figure 9: Sandstone bank at km 93.8 N (road reserve west).

Figure 10: Very coarse sandstone at km 93.8 N (road reserve west).

It is recommended to wait for the response from SAHRA on the Phase 1 Field study (this report), and if mitigation is recommended then SAHRA protocol must be followed.

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).

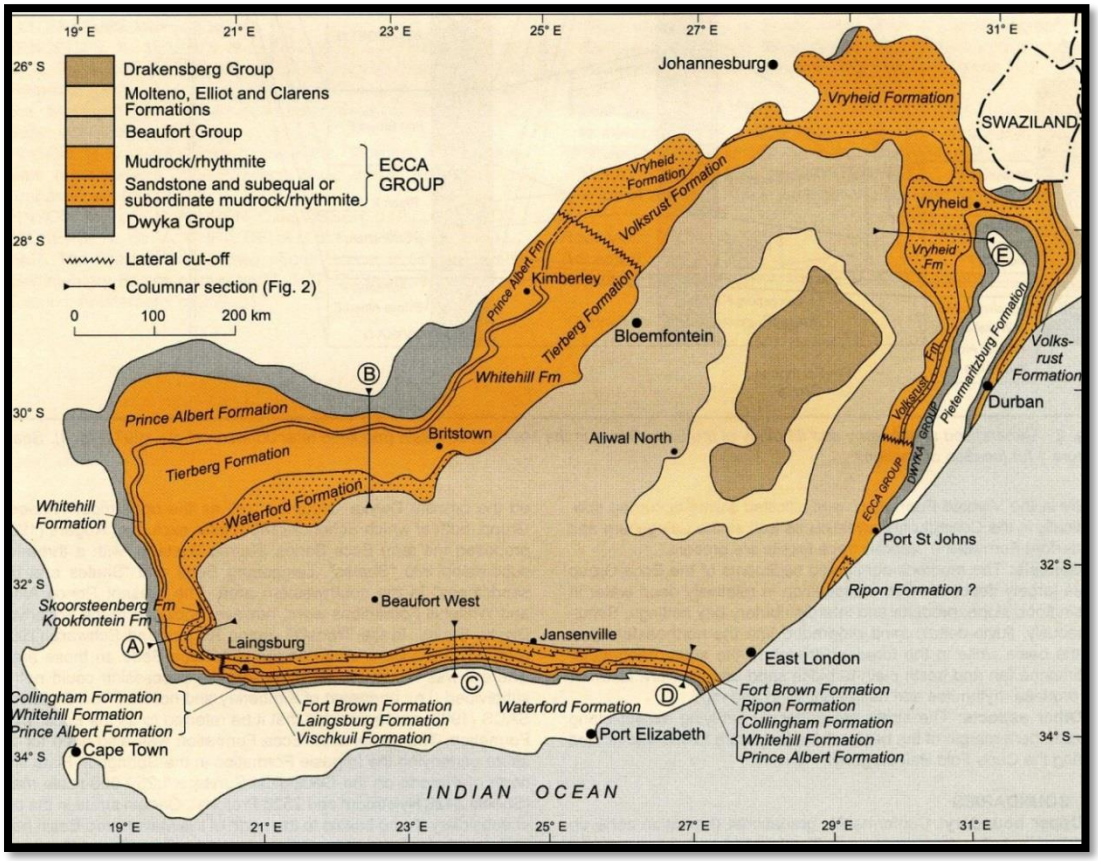
The Cenozoic Era, in which we are presently living, is popularly known as the 'Age of the Mammals'. These fossils are preserved on the river gravel terraces (Cornelia), cave systems (Makapan), coastal plains(Langebaanweg), and basins. The Cenozoic Era of South Africa has been subdivided into six African Land Mammal Ages, namely, Recent, Florisian, Cornelian, Makapanian, Langebaanian, and Namibian (MacRae 1999).

Significant fossil finds in the Free State are recorded from Cenozoic aged superficial deposits at specific localities such as Florisbad, Cornelia and others. The fossils recorded include bones and teeth of mammals, reptiles, fish, freshwater molluscs, petrified wood, trace fossils, rhizoliths and diatom floras (Groenewald and Groenewald 2014).

Very wide range of possible fossil remains, though these are often sparse, such as: mammalian bones and teeth, tortoise remains, ostrich eggshells, non-marine mollusc shells, ostracods, diatoms, and other micro fossil groups, trace fossils (e.g. calcretised termitaria, rhizoliths, burrows, vertebrate tracks), freshwater stromatolites, plant material such as peats, foliage, wood, pollens, within calc tufa. Stromatolite structures range from a centimetre to several tens of metres in size. They are the result of algal growth in shallow water, indicating a very rich growth

that would have caused an enrichment in the amount of oxygen in the atmosphere (Groenewald and Groenewald 2014).

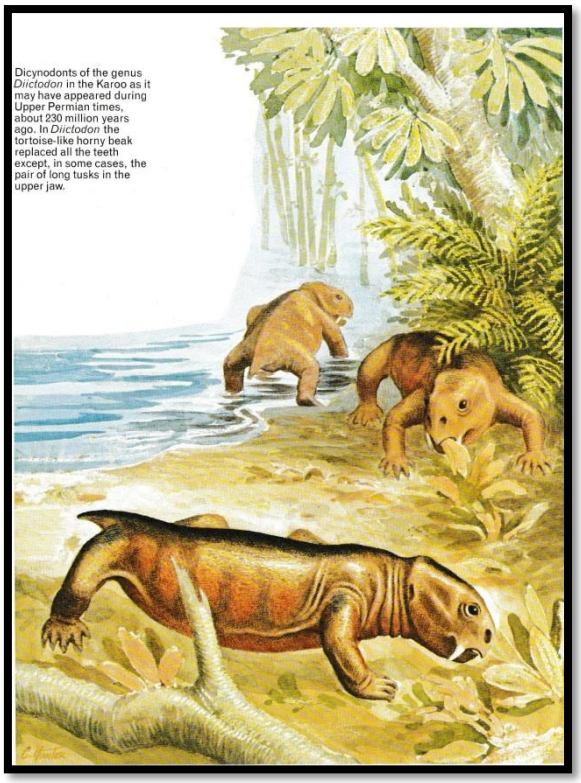
Figure 11: Extent of the Karoo Supergroup (Johnson 2009).



The rocks of the Karoo Supergroup are internationally acclaimed for their richness and diversity of fossils. The rocks of the Beaufort Group of South Africa cover approximately one-third of the land surface and have yielded an abundance of well-preserved therapsids and other tetrapods which have been used to subdivide this Group into eight faunal Assemblage Zones.

Fossil vertebrates are found in the thick mudrock of the Adelaide Subgroup. Fossils of *Diictodon, Ictidosuchops, Gorgonops* and the amphibian *Rhinesuchus* are frequently preserved as articulated skeletons within the mudrock present in the *Daptocephalus* Assemblage Zone (Figure 14). Fossil fish (*Atherstonia*) and the captorhinid *Pareiasaurus* have also been recorded. Other fossils that occur are *Procynosuchus, Tetracynodon, Lycaenops, Ictidorhinus, Dicynodon, Youngina,* to name but a few (Rubidge 1995).

Figure 12: Typical Karoo scene during the Upper Permian times (Cluver 1978).



In 1936 Mr G. Myburgh found mammalian fossil bones on the farm Rankies near Kroonstad. A *Zorrilodontops* fossil (Therocephalia, SAM/K 1392 cranium, postcraium) was found in Edenville, Kroonstad and *Procolophon* and *Lystrosaurus* fossils were found at Colton near Dewetsdorp. A desktop study done (Bamford 2018) south of Kroonstad (near Edenville) omits to report these finds.

Figure 13: Examples of the Zone fossils (Rubidge 1995).

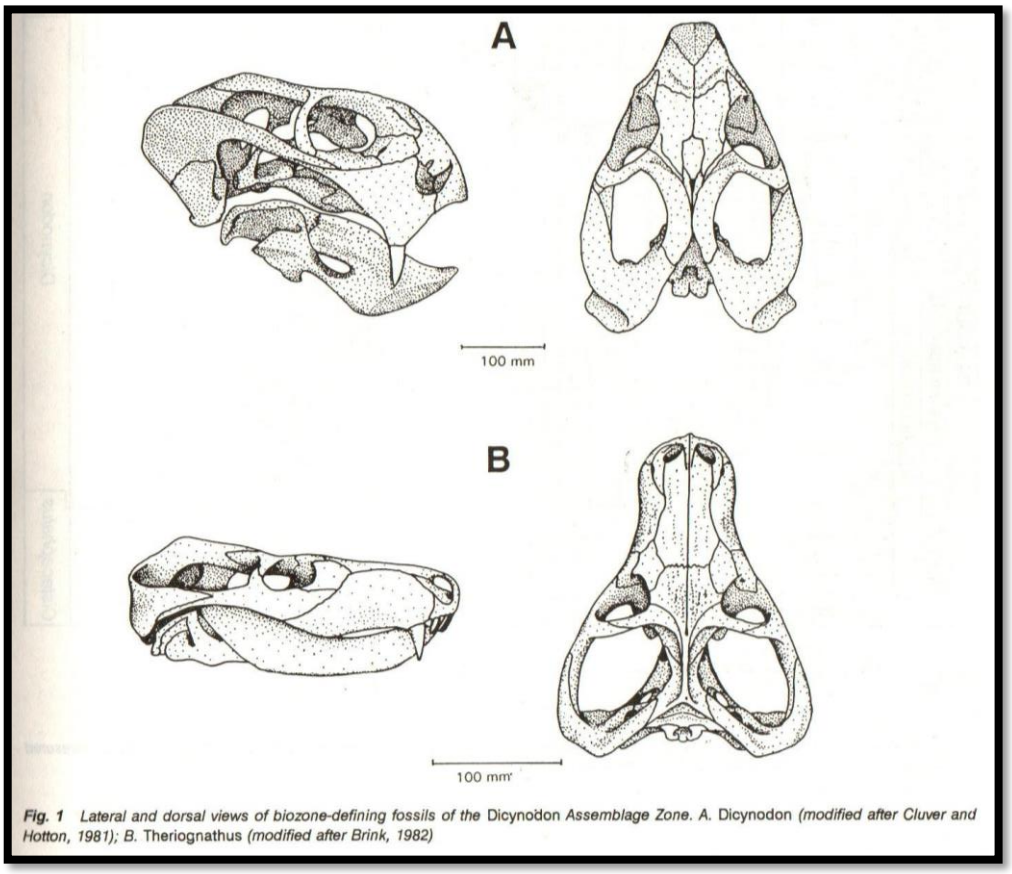


Fig. 1 Lateral and dorsal views of biozone-defining fossils of the Dicynodon *Assemblage Zone. A.* Dicynodon *(modified after Cluver and Hotton, 1981); B.* Theriognathus *(modified after Brink, 1982)*

The Volksrust Formation consists of a monotonous sequence of grey shale and fossils are significant, but very rarely recorded. Fossils include rare temnospondyl amphibian remains, invertebrates, minor coals with plant remains, fish scales, petrified wood, and low-diversity marine to non-marine trace fossil assemblages (Groenewald and Groenewald 2014).

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 **MODERATE** for the Quaternary and the Volksrust Formation, and **VERY HIGH** for the Adelaide Subgroup.

Table 1: Taken from Palaeotechnical Report (Groenewald and Groenewald 2014).

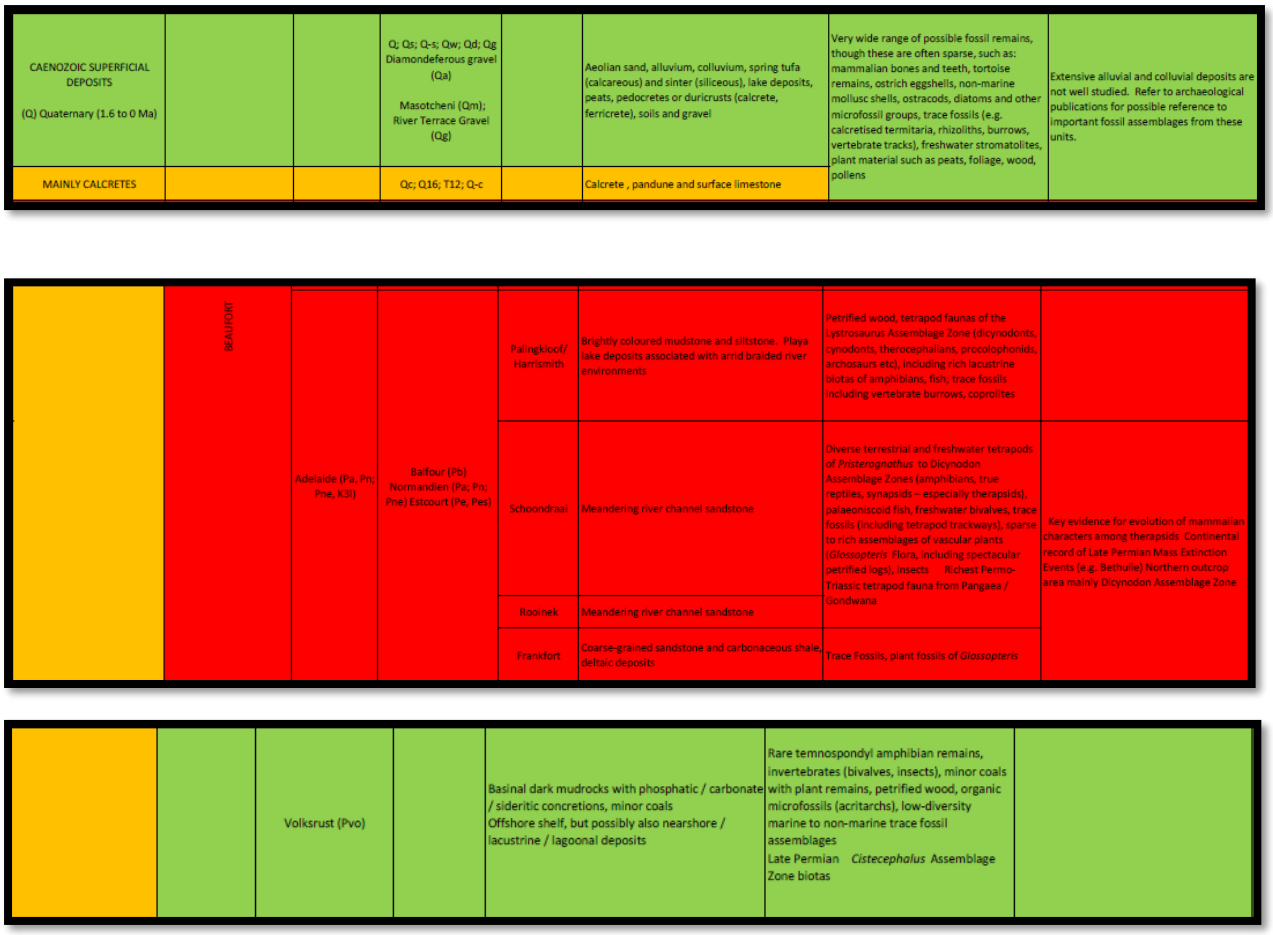


Table 2: Criteria used (Fossil Heritage Layer Browser/SAHRA):

Rock Unit	Significance/vulnerability	Recommended Action
Quaternary	Moderate	Desktop survey and Phase 1 PIA is recommended
Adelaide Subgroup	Very High	Field assessment and protocol for finds is required
Volksrust Formation	Moderate	Desktop survey and Phase 1 PIA is recommended

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

Impact: **MODERATE**, **VERY HIGH** for the Quaternary, Volksrust Formation and Adelaide Subgroup, Beaufort Group, Karoo Supergroup. There are significant fossil resources that may be impacted by the development (mudstone, shale) and if destroyed are no longer available for scientific research or other public good (Almond, *et al.* 2009).

H. Description of the Methodology

The palaeontological impact assessment field study was undertaken on 11 September 2019. The survey 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). Additionally, Google.maps was accessed on a Sony Experia cellular phone. A Global Positioning System (GPS) (Garmin eTrex 10) is used to record fossiliferous finds and outcrops (bedrock) when the area is not covered with topsoil, subsoil, overburden, vegetation, grassland, trees or waste. The survey did identify the Karoo Supergroup. A literature survey is included and the study relied heavily on geological maps.

SAHRA document 7/6/9/2/1 (SAHRA 2012) requires track records/logs from archaeologists not palaeontologists as palaeontologists concentrate on outcrops which may be recorded with a GPS. Isolated occurrences of rocks

usually do not constitute an outcrop. Fossils can occur in dongas, as nodules, in fresh rock exposures, and in riverbeds. Finding fossils require the experience and technical knowledge of the professional palaeontologist, but that does not mean that an amateur can't find fossils. The geology of the region is used to predict what type of fossil and zone will be found in any particular region. Archaeozoologists concentrate on more recent fossils in the quaternary and tertiary deposits.

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. Inaccessibility of site.
7. 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.

The National Heritage Resources Act No. 25 of 1999 further prescribes.

Act No. 25 of 1999. National Heritage Resources Act, 1999.
National Estate: 3 (2) (f) archaeological and palaeontological sites,
(i)(1) objects recovered from the soil or waters of South Africa, including archaeological and palaeontological objects and material, meteorites and rare geological specimens,
Heritage assessment criteria and grading: (a) Grade 1: Heritage resources with qualities so exceptional that they are of special national significance;
(b) Grade 2: Heritage resources which, although forming part of the national estate, can be considered to have special qualities which make them significant within the context of a province or a region; and (c) Grade 3: Other heritage resources worthy of conservation.
SAHRA is responsible for the identification and management of Grade 1 heritage resources.
Provincial Heritage Resources Authority (PHRA) identifies and manages Grade 2 heritage resources.
Local authorities identify and manage Grade 3 heritage resources.

No person may damage, deface, excavate, alter, remove from its original position, subdivide or change the planning status of a provincially protected place or object without a permit issued by a heritage resources authority or local authority responsible for the provincial protection.
Archaeology, palaeontology and meteorites: Section 35.
(2) Subject to the provisions of subsection (8) (a), all archaeological objects, palaeontological material and meteorites are the property of the State.
(3) Any person who discovers archaeological or palaeontological objects or material or a meteorite in the course of development or agricultural activity must immediately report the find to the responsible heritage resources

authority, or to the nearest local authority offices or museum, which must immediately notify such heritage resources authority.

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 Adelaide Subgroup.

A very wide range of possible fossil remains are present in the Quaternary, though these are often sparse, such as: mammalian bones and teeth, tortoise remains, ostrich eggshells, non-marine mollusc shells, ostracods, diatoms, and other micro fossil groups, trace fossils (e.g. calcretised termitaria, rhizoliths, burrows, vertebrate tracks), freshwater stromatolites, plant material such as peats, foliage, wood, pollens, within calc tufa. Stromatolite structures range from a centimetre to several tens of metres in size. They are the result of algal growth in shallow water, indicating a very rich growth that would have caused an enrichment in the amount of oxygen in the atmosphere (Groenewald and Groenewald 2014).

Fossil vertebrates are found in the thick mudrock of the Adelaide Subgroup. Fossils of *Diictodon, Ictidosuchops, Gorgonops* and the amphibian *Rhinesuchus* are frequently preserved as articulated skeletons within the mudrock present in the *Daptocephalus* Assemblage Zone (Figure 16). Fossil fish (*Atherstonia*) and the captorhinid *Pareiasaurus* have also been recorded. Other fossils that occur are *Procynosuchus, Tetracynodon, Lycaenops, Ictidorhinus, Dicynodon, Youngina,* to name but a few (Rubidge 1995).

The Volksrust Formation consists of a monotonous sequence of grey shale and fossils are significant, but very rarely recorded. Fossils include rare temnospondyl amphibian remains, invertebrates, minor coals with plant remains, fish scales, petrified wood, and low-diversity marine to non-marine trace fossil assemblages (Groenewald and Groenewald 2014).

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 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 of the shale is **VERY HIGH and MODERATE**. A Phase 2 Palaeontological Mitigation is only required if the Phase 1 Palaeontological Assessment identified a fossiliferous formation (Karoo Supergroup) and fossils or if fossils are found during construction or mining. Protocol is attached (Appendix 2).
b. This project may benefit the economy, the life expectancy of the community, the growth of the community and social development in general.
c. Preferred choice: No Alternatives are possible.
d. The following should be conserved: if any palaeontological material is exposed during clearing, digging, excavating, drilling or blasting SAHRA must be notified. All construction activities must be stopped, a 30 m no-go barrier constructed and a palaeontologist should be called in to determine proper mitigation measures. A sample of shale / mudstone should be set aside if mined.

Sampling and collecting **(6m,6k)**:
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 provided by Tsimba Archaeological Footprints.
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 (fossils) and adjacent areas as well as for safety and security reasons.

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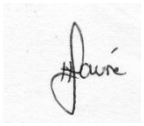
Declaration

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.

I accept no liability, and the client, by receiving this document, indemnifies me 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.

It may be possible that the Phase 1: Palaeontological Impact Assessment may have missed palaeontological resources in the project area as outcrops are not always present or visible while others may lie below the overburden of earth and may only be present once development commences.

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



Heidi Fourie
2019/09/30

Appendix 1: **Protocol for Chance Finds and Management Plan**

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. As part of the Environmental Authorisation conditions, an Environmental Control Officer (ECO) will be appointed to oversee the construction activities in line with the legally binding Environmental Management Programme (EMPr). The EMPr already covers the conservation of heritage and palaeontological material that may be exposed during construction activities. For a chance find, the protocol is to immediately cease all construction activities, construct a 30 m no-go barrier, and contact SAHRA for further investigation. Construction workers must be informed that this is a no-go area. It is recommended that the EMPr be updated to include the involvement of a palaeontologist for pre-construction training of the ECO or during the digging and excavation phase of the development or a site visit once a month during construction. The ECO must visit the site weekly and keep a photographic record.

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. When the route is better defined, it is recommended that a specialist undertake a 'walk through' of the entire road as well as construction areas, including camps and access roads, prior to the start of any construction activities, this may be done in sections.
2. Fossils likely to occur are for example the therapsids from the Middleton Formation, these are present in the mudstone (or any other fossiliferous layer ranked as VERY HIGH or HIGH) or other vertebrates from the Beaufort Group (or any other fossiliferous layer). The palaeontologist needs to survey the overburden, subsoil and topsoil at least once a week.
3. When clearing vegetation, topsoil, subsoil or overburden, 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 week).
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.

This document forms part of the Environmental Monitoring Programme. For practical reasons a palaeontologist/palaeobotanist may be required to be on site once a week. If any fossil material is discovered then a Phase 2 rescue operation may be necessary, and a permit will be required.

The South African Heritage Resources Agency has the following documents in place:
Guidelines to Palaeontological Permitting policy.
Minimum Standards: Palaeontological Component of Heritage Impact Assessment reports.
Guidelines for Field Reports.
Palaeotechnical Reports (Eastern Cape, North West, Northern Cape, Mpumalanga, Gauteng, Western Cape, Free State, Kwazulu Natal, and Limpopo)

Appendix 2:
Table 2: Listing points in Appendix 6 of the Act and position in Report (bold in text).

Section	Point in Act	Heading
B	1(c)	Outline of development project
	1(d)	Summary of findings
	1(g)	Concerns/threats
	1(n)i	Concerns/threats
	1(n)ii	Concerns/threats
	1(o)	Concerns/threats
	1(p)	Concerns/threats
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)	Recommendation

	1(m)	Sampling and collecting
	1(k)	Sampling and collecting
Declaration	1(b)	Declaration
Appendix 1	1(k)	Protocol for finds
	1(m)	Protocol for finds
	1(q)	Protocol for finds