DESKTOP PALAEONTOLOGICAL ASSESSMENT FOR THE PROPOSED BURBREEZE PIPELINE PROJECT, TONGAAT, ETHEKWINI METROPOLITAN MUNICIPALITY, KWAZULU-NATAL PROVINCE.

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EXECUTIVE SUMMARY

Gideon Groenewald undertook a desktop survey, assessing the potential palaeontological impact of the proposed construction by the Water and Sanitation Department of eThekwini Municipality of a 5Mℓ reservoir, to be referred to as the Burbreeze reservoir and a 3 km long DN300 pipeline from Mamba Ridge tie-in to the Burbreeze reservoir in Tongaat, KwaZulu-Natal. The purpose of the project is to increase the supply of potable water to the community.

The study area is underlain by sedimentary rocks of the Permian-aged Pietermaritzburg and Vryheid Formations of the Ecca Group, Karoo Supergroup. Trace fossils are known from the Pietermaritzburg Formation, where fossils are associated with the bedding planes of shales exposed during excavation of trenches or foundations deeper than 1,5m and a Moderate Palaeontological sensitivity is allocated to these rocks. Very rich assemblage of plant fossils, coal beds and significant trace fossils have been described from the Vryheid Formation and a Very High Palaeontological sensitivity is allocated to areas underlain by this formation. A phase 1 PIA is therefore recommended during excavations of infrastructure deeper than 1,5m during the initial phases of the construction.

Recommendations:

1. The EAP and ECO of the project must be informed of the fact that significant trace fossils have been described from the upper Pietermaritzburg Formation and highly significant fossils from the Vryheid Formation. Chance recording of fossils from these rocks will contribute uniquely to our understanding of the palaeo-environments of these regions.
2. All sections of the development that are allocated a Very High Palaeontological sensitivity and where trenching or excavation for infrastructure will be deeper than 1,5m, must be identified during geotechnical surveys. Where the trenches and excavations will reach this depth, a suitably qualified Palaeontologist must be appointed to record and collect the fossils according to SAHRA and AMAFA specifications as part of a Phase 1 Palaeontological Impact Assessment during the initial stages of excavation.
3. These recommendations must form part of the EMP for the project.

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INTRODUCTION

Gideon Groenewald undertook a desktop survey, assessing the potential palaeontological impact of the proposed construction by the Water and Sanitation Department of eThekwini Municipality of a 5Mℓ reservoir, to be referred to as the Burbreeze reservoir and a 3 km long DN 300 pipeline from Mamba Ridge tie-in to the Burbreeze reservoir in Tongaat, KwaZulu-Natal. The purpose of the project is to increase the supply of potable water to the community.

The project will consist of :

(i) an inlet at the existing Jan Roz reservoir
(ii) an inlet to Burbreeze
(iii) an outlet pipeline and
(iv) an overflow pipeline as well as a booster pump station at the existing Jan Roz reservoir site. The overflow pipeline will have one discharge point.

The project area is situated just north of the centre of Tongaat and between the so-called "Mamba Ridge" tie-in point and the proposed Burbreeze Reservoir (Figure 1).

Figure 1 Locality of the proposed project. Pipelines indicated in the image are the Burbreeze pipeline (turqoise), Outlet pipe (yellow), and Overflow pipe (Pink).

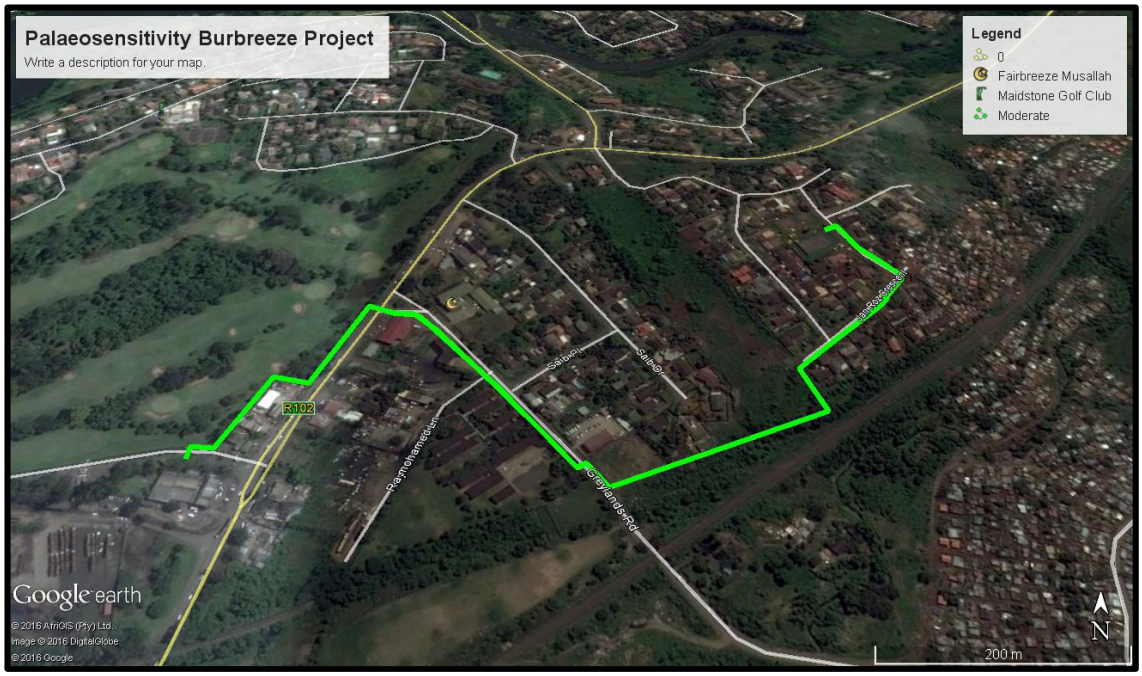

Figure 2 Revised route of pipeline in green

Rerouted configuration of the pipeline to avoid impact on the wetlands is proposed. This rerouting of the pipeline will have no additional impact on the Palaeontological Heritage as was reported during April 2016.

SOUTH AFRICAN NATIONAL HERITAGE RESOURCE ACT NO 25/1999 AND KWAZULU-NATAL HERITAGE ACT NO 4/2008

This Palaeontological Assessment forms part of the Heritage Impact Assessment (HIA) and complies with the requirements of the South African National Heritage Resource Act No 25 of 1999 as well as the KwaZulu-Natal Heritage Act No 4 of 2008. In accordance with Section 38 of the National Resources Act No 25 of 1999 (Heritage Resources Management), a HIA is required to assess any potential impacts to palaeontological heritage within the development footprint.

Categories of heritage resources recognised as part of the National Estate in Section 3 of the Heritage Resources Act, and which therefore fall under its protection, include:

- geological sites of scientific or cultural importance;
- objects recovered from the soil or waters of South Africa, including archaeological and palaeontological objects and material, meteorites and rare geological specimens;

- objects with the potential to yield information that will contribute to an understanding of South Africa's natural or cultural heritage.

METHODOLOGY

Following the "SAHRA APM Guidelines: Minimum Standards for the Archaeological & Palaeontological Components of Impact Assessment Reports" the aims of the palaeontological impact assessment are:

- to identify exposed and subsurface rock formations that are considered to be palaeontologically significant;
- to assess the level of palaeontological significance of these formations;
- to comment on the impact of the development on these exposed and/or potential fossil resources and
- to make recommendations as to how the developer should conserve or mitigate damage to these resources.

In preparing a palaeontological desktop study the potential fossiliferous rock units (groups, formations etc) represented within the study area are determined from geological maps and Google Earth imagery. The known fossil heritage within each rock unit is inventoried from the published scientific literature, previous palaeontological impact studies in the same region and the author's field experience.

The likely impact of the proposed development on local fossil heritage is determined on the basis of the palaeontological sensitivity of the rock units concerned and the nature and scale of the development itself, most notably the extent of bedrock excavation envisaged. The different sensitivity classes used are explained in Table 1 below.

Table 1 Palaeontological sensitivity analysis outcome classification

PALAEONTOLOGICAL SIGNIFICANCE/VULNERABILITY OF ROCK UNITS	
The following colour scheme is proposed for the indication of palaeontological sensitivity classes. This classification of sensitivity is adapted from that of Almond et al (2008, 2009) (Groenewald etal.,2014).	
RED	Very High Palaeontological sensitivity/vulnerability. Development will most likely have a very significant impact on the Palaeontological Heritage of the region. Very high possibility that significant fossil assemblages will be present in all outcrops of the unit. Appointment of professional palaeontologist, desktop survey, phase I Palaeontological Impact Assessment (PIA) (field survey and recording of fossils) and phase II PIA (rescue of fossils during construction) as well as application for collection and destruction permit compulsory.
ORANGE	High Palaeontological sensitivity/vulnerability. High possibility that significant fossil assemblages will be present in most of the outcrop areas of the unit. Fossils most likely to occur in associated sediments or underlying units, for example in the areas underlain by Transvaal Supergroup dolomite where Cenozoic cave deposits are likely to occur. Appointment of professional palaeontologist, desktop survey and phase I Palaeontological Impact Assessment (field survey and collection of fossils) compulsory. Early application for collection permit recommended. Highly likely that a Phase II PIA will be applicable during the construction phase of projects.
GREEN	Moderate Palaeontological sensitivity/vulnerability. High possibility that fossils will be present in the outcrop areas of the unit or in associated sediments that underlie the unit. For example areas underlain by the Gordonia Formation or undifferentiated soils and alluvium. Fossils described in the literature are visible with the naked eye and development can have a significant impact on the Palaeontological Heritage of the area. Recording of fossils will contribute significantly to the present knowledge of the development of life in the geological record of the region. Appointment of a professional palaeontologist, desktop survey and phase I PIA (ground proofing of desktop survey) recommended.
BLUE	Low Palaeontological sensitivity/vulnerability. Low possibility that fossils that are described in the literature will be visible to the naked eye or be recognized as fossils by untrained persons. Fossils of for example small domal Stromatolites as well as micro-bacteria are associated with these rock units. Fossils of micro-bacteria are extremely important for our understanding of the development of Life, but are only visible under large magnification. Recording of the fossils will contribute significantly to the present knowledge and understanding of the development of Life in the region. Where geological units are allocated a blue colour of significance, and the geological unit is surrounded by highly significant geological units (red or orange coloured units), a palaeontologist must be appointed to do a desktop survey and to make professional recommendations on the

	impact of development on significant palaeontological finds that might occur in the unit that is allocated a blue colour. An example of this scenario will be where the scale of mapping on the 1:250 000 scale maps excludes small outcrops of highly significant sedimentary rock units occurring in larger alluvium deposits. Collection of a representative sample of potential fossiliferous material is recommended.
GREY	Very Low Palaeontological sensitivity/vulnerability. Very low possibility that significant fossils will be present in the bedrock of these geological units. The rock units are associated with intrusive igneous activities and no life would have been possible during implacement of the rocks. It is however essential to note that the geological units mapped out on the geological maps are invariably overlain by Cenozoic aged sediments that might contain significant fossil assemblages and archaeological material. Examples of significant finds occur in areas underlain by granite, just to the west of Hoedspruit in the Limpopo Province, where significant assemblages of fossils and clay-pot fragments are associated with large termite mounds. Where geological units are allocated a grey colour of significance, and the geological unit is surrounded by very high and highly significant geological units (red or orange coloured units), a palaeontologist must be appointed to do a desktop survey and to make professional recommendations on the impact of development on significant palaeontological finds that might occur in the unit that is allocated a grey colour. An example of this scenario will be where the scale of mapping on the 1:250 000 scale maps excludes small outcrops of highly significant sedimentary rock units occurring in dolerite sill outcrops. It is important that the report should also refer to archaeological reports and possible descriptions of palaeontological finds in Cenozoic aged surface deposits.

When rock units of moderate to high palaeontological sensitivity are present within the development footprint, a field-based assessment by a professional palaeontologist is usually warranted.

The key assumption for this desktop study is that the existing geological maps and datasets used to assess site sensitivity are correct and reliable. However, the geological maps used were not intended for fine scale planning work and are largely based on aerial photographs alone, without ground-truthing.

These factors may have a major influence on the assessment of the fossil heritage significance of a given development and, without supporting field assessments, may lead to either:

- an underestimation of the palaeontological significance of a given study area due to ignorance of significant recorded or unrecorded fossils preserved there, or
- an overestimation of the palaeontological sensitivity of a study area, for example when originally rich fossil assemblages inferred from geological maps have in fact been destroyed by weathering, or are buried beneath a thick mantle of unfossiliferous “drift” (soil, alluvium etc).

GEOLOGY

The study area is underlain by Permian aged rocks of the Pietermaritzburg and Vryheid Formations of the Ecca Group, Karoo Supergroup (Figure 2).

Ecca Group

Pietermaritzburg Formation (Pp)

As Gondwana, a large super-continent that existed during the Permian, moved north towards toward the equator, thick clay and silt beds were laid down in a large sea that occupied the Karoo Basin in South Africa. These sediments, deposited in deep water, now form the shales of the Pietermaritzburg Formation of the Ecca Group in KZN. The shales of the Pietermaritzburg Formation are easily weathered and often present slope stability problems (Johnson et al, 2009).

Vryheid Formation (Pv)

The Permian aged Vryheid Formation is a thick sequence of sedimentary rocks consisting mainly of coarse-grained sandstone and interbedded black shale. These sandstones and shales were deposited along ancient sandy shorelines behind which lay vast swamplands. Burial of vegetation in the swamps eventually formed coal which is mined at various localities in the outcrop areas of the formation in South Africa (McCarthy and Rubidge, 2005; Johnson et al, 2009).

Revised Route of the pipeline

The revised route of the pipeline falls on the same geological formations as described during April 2016 and there will be no further impact on the Palaeontological Heritage as was reported during April 2016 (Figure 5).

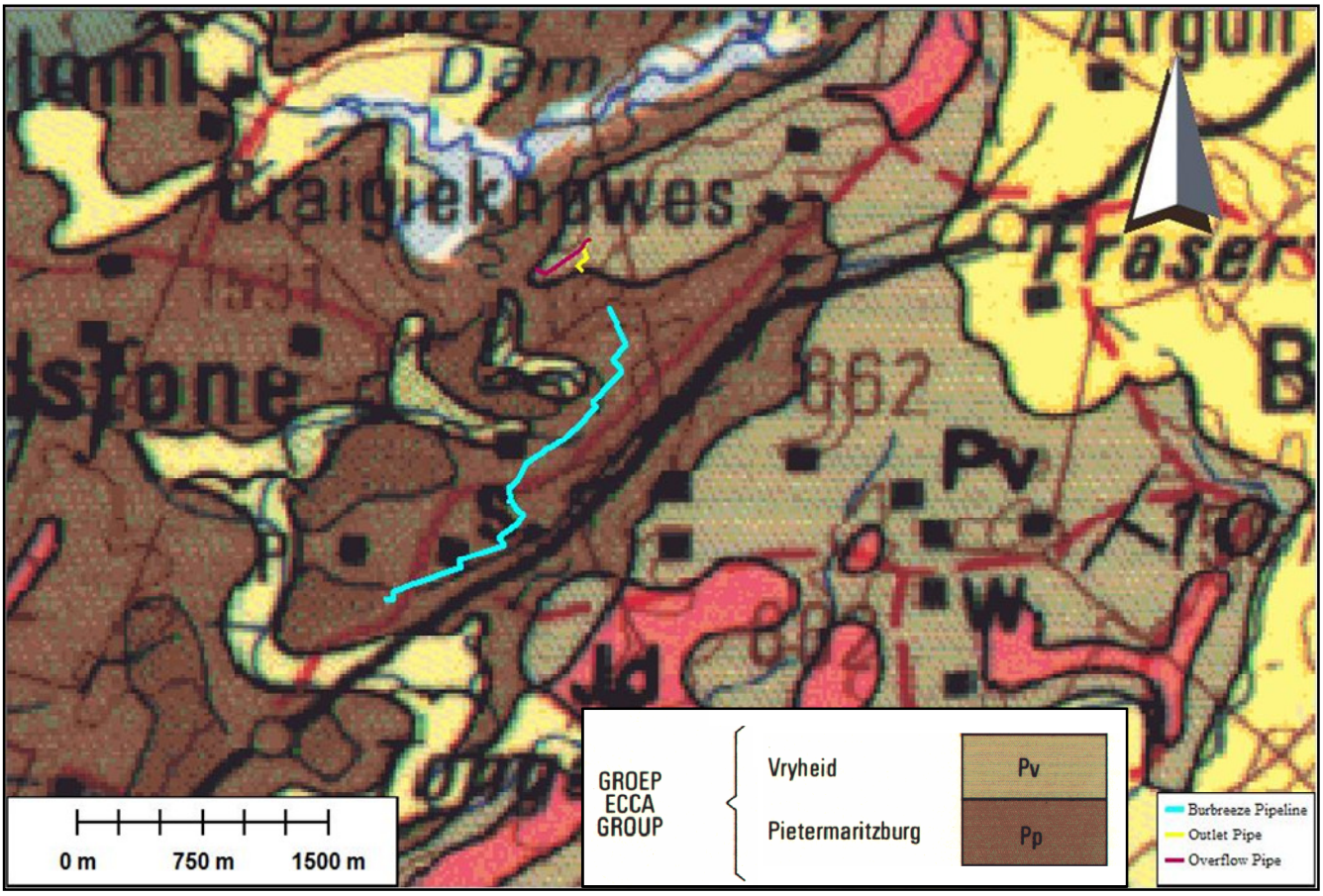

Figure 4 Geology of the study area for the proposed Burbreeze Pipeline

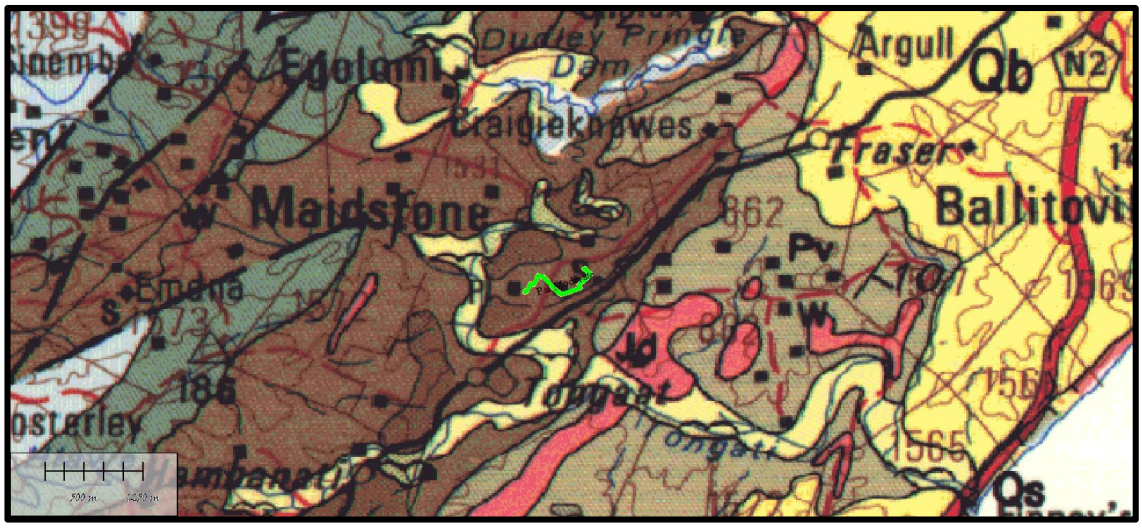

Figure 3 Rerouting of the pipeline will have no effect on the initial impact assessment report of April 2016

PALAEONTOLOGY

Ecca Group

Pietermaritzburg Formation (Pp)

While fossils are generally absent from the Pietermaritzburg Formation, trace fossils have been recorded from the upper layers by Linstrom (1987).

Vryheid Formation (Pv)

The Vryheid Formation is well-known for the occurrence of coal beds that resulted from the accumulation of plant material over long periods of time. Plant fossils described by Bamford (2011) from the Vryheid Formation are; *Azaniodendron fertile, Cyclodendron leslii, Sphenophyllum hammanskraalensis, Annularia sp., Raniganjia sp., Asterotheca spp., Liknopetalon enigmata, Glossopteris > 20 species, Hirsutum 4 spp., Scutum 4 spp., Ottokaria 3 spp., Estcourtia sp., Arberia 4 spp., Lidgetonnia sp., Noeggerathiopsis sp. and Podocarpidites sp.*

According to Bamford (2011), “Little data have been published on these potentially fossiliferous deposits. Around the coal mines there is most likely to be good material and yet in other areas the exposures may be too poor to be of interest. When they do occur fossil plants are usually abundant and it would not be feasible to preserve and maintain all the sites, however, in the interests of heritage and science such sites should be well recorded, sampled and the fossils kept in a suitable institution.”

Although no vertebrate fossils have been recorded from the Vryheid Formation, invertebrate trace fossils have been described in some detail by Mason and Christie (1985). It should be noted, however, that the aquatic reptile, *Mesosaurus*, which is the earliest known reptile from the Karoo Basin, as well as fish (*Palaeoniscus capensis*), have been recorded in equivalent-aged strata in the Whitehill Formation in the southern part of the basin (MacRae, 1999; Modesto, 2006). Indications are that the Whitehill Formation in the main basin might be correlated with the mid-Vryheid Formation. If this assumption proves correct, there is a possibility that Mesosaurus could be found in the Vryheid Formation.

The late Carboniferous to early Jurassic Karoo Supergroup of South Africa includes economically important coal deposits within the Vryheid Formation of Natal. The Karoo sediments are almost entirely lacking in body fossils but

ichnofossils (trace fossils) are locally abundant. Modern sedimentological and ichnofaunal studies suggest that the north-eastern part of the Karoo basin was marine. In KwaZulu-Natal a shallow basin margin accommodated a prograding fluviodeltaic complex forming a broad sandy platform on which coal-bearing sediments were deposited. Ichnofossils include U-burrows (formerly *Corophioides*) which are assigned to ichnogenus *Diplocraterion* (Mason and Christie, 1985).

DISCUSSION

The predicted palaeontological impact of the development is based on the initial mapping assessment and literature reviews. No significant body fossils are known from the Pietermaritzburg Formation but some well-defined trace fossils have been recorded. Very significant fossils has been recorded from the Vryheid Formation and the recording of plant and trace fossils from this part of the Karoo Basin will contribute significantly to our understanding of the palaeo-environments that existed during the Permian times in this part of KwaZulu-Natal.

MANAGEMENT PLAN

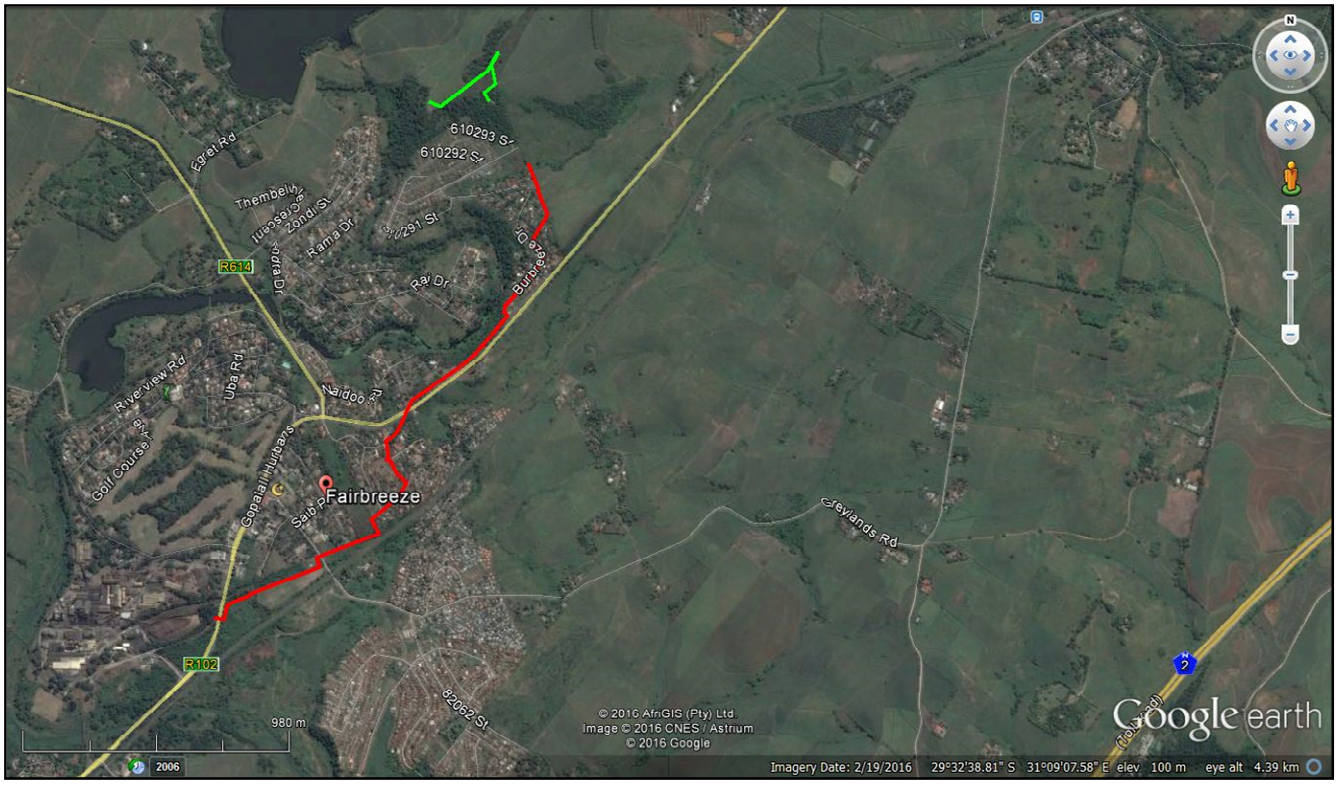

Figure 5 Palaeosensitivity of the proposed project.

The likely impact of the proposed development on local fossil heritage is determined on the basis of the palaeontological sensitivity of the rock units

concerned and the nature and scale of the development itself, most notably the extent of un-weathered bedrock excavation (deeper than 1.5m excavation) envisaged. The different sensitivity classes used are explained in Table 1.

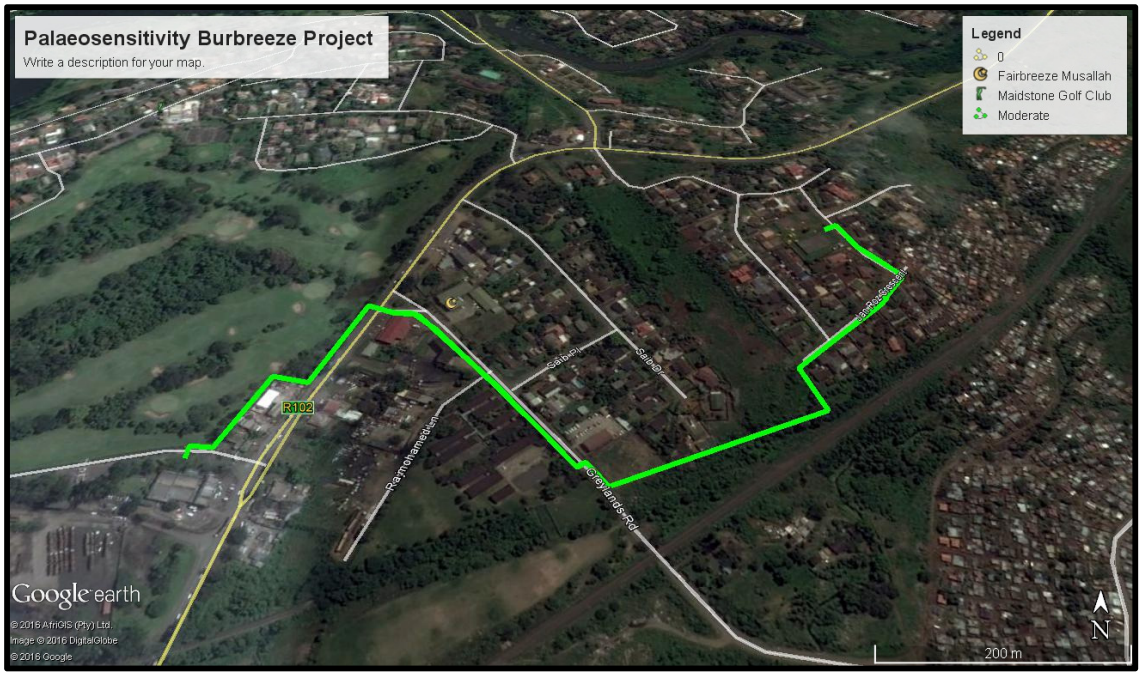

Figure 6 Palaeosensitivity of the geology underlying the rerouted section of the Pipeline falls in a Moderately Sensitive zone for Palaeontological Heritage

The palaeontological sensitivity of the development is related to the specific geology that underlies the development footprints. For the sake of this desktop survey it is assumed that there are significant outcrops on site, and that trenching of up to 2m depth, will in fact expose bedrock of all the geological formations recorded in the desktop survey. Due to the fact that the recording of fossils will have a significant impact on our understanding of the palaeo-environments in this part of the basin, a Moderate Palaeontological sensitivity is allocated to the study area underlain by rocks of the Pietermaritzburg Formation and a Very High Palaeontological sensitivity is allocated to areas underlain by Vryheid Formation sediments. The palaeontological sensitivity of the study area is shown in Figure 3.

CONCLUSION AND RECOMMENDATIONS

The study area is underlain by sedimentary rocks of the Permian-aged Pietermaritzburg and Vryheid Formations of the Ecca Group, Karoo Supergroup. Trace fossils are known from the Pietermaritzburg Formation, where fossils are associated with the bedding planes of shales exposed during excavation of trenches or foundations deeper than 1,5m and a Moderate Palaeontological

sensitivity is allocated to these rocks. Very rich assemblage of plant fossils, coal beds and significant trace fossils have been described from the Vryheid Formation and a Very High Palaeontological sensitivity is allocated to areas underlain by this formation. A phase 1 PIA is therefore recommended during excavations of infrastructure deeper than 1,5m during the initial phases of the construction.

Recommendations:

1. The EAP and ECO of the project must be informed of the fact that significant trace fossils have been described from the upper Pietermaritzburg Formation and highly significant fossils from the Vryheid Formation. Chance recording of fossils from these rocks will contribute uniquely to our understanding of the palaeo-environments of these regions.
2. All sections of the development that are allocated a Very High Palaeontological sensitivity and where trenching or excavation for infrastructure will be deeper than 1,5m, must be identified during geotechnical surveys. Where the trenches and excavations will reach this depth, a suitably qualified Palaeontologist must be appointed to record and collect the fossils according to SAHRA and AMAFA specifications as part of a Phase 1 Palaeontological Impact Assessment during the initial stages of excavation.
3. These recommendations must form part of the EMP for the project.

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QUALIFICATIONS AND EXPERIENCE OF THE AUTHOR

Dr Gideon Groenewald has a PhD in Geology from the University of Port Elizabeth (Nelson Mandela Metropolitan University) (1996) and the National Diploma in Nature Conservation from Technicon RSA (the University of South Africa) (1989). He specialises in research on South African Permian and Triassic sedimentology and macrofossils with an interest in biostratigraphy, and palaeo-ecological aspects. He has extensive experience in the locating of fossil material in the Karoo Supergroup and has more than 20 years of experience in locating, collecting and curating fossils, including exploration field trips in search of new localities in the southern, western, eastern and north-eastern parts of the country. His publication record includes multiple articles in internationally recognized journals. Dr Groenewald is accredited by the Palaeontological Society of Southern Africa (society member for 25 years).

DECLARATION OF INDEPENDENCE

I, Gideon Groenewald, declare that I am an independent specialist consultant and have no financial, personal or other interest in the proposed development, nor the developers or any of their subsidiaries, apart from fair remuneration for work performed in the delivery of palaeontological heritage assessment services. There are no circumstances that compromise the objectivity of my performing such work.

Dr Gideon Groenewald
Geologist