PALAEONTOLOGICAL DESKTOP ASSESSMENT FOR THE PROPOSED NORTHERN AQUEDUCT AUGMENTATION PHASE 5: DURBAN HEIGHTS TO DUFFS ROAD STEEL PIPELINE, WITHIN THE ETHEKWINI MUNICIPALITY, KWAZULU-NATAL

For:

HIA CONSULTANTS

DATE: 14 April 2015

By

GIDEON GROENEWALD

EXECUTIVE SUMMARY

Gideon Groenewald was appointed by PGS Heritage to undertake a desktop survey, assessing the potential palaeontological impact of the Northern Aqueduct Phase 5 project.

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

The study area is mostly underlain by Ordovician to Silurian aged quartzites of the Natal Group, Carboniferous to Permian Aged tillites of the Dwyka Group, Permian aged shales and sandstone of the Ecca Group, Jurassic aged dolerite and Quaternary aged alluvium.

Trace fossils have been recorded from the Dwyka Group and Pietermaritzburg Formation of the Ecca Group, whereas fossils are abundantly known from rocks of the Vryheid Formation, and also from the Ecca Group.

No fossils are expected from the alluvial deposits and the dolerite will not contain fossils.

Recommendation:

1. The Environmental Assessment Practitioner (EAP) and Environmental Control Officer (ECO) of the project must be made aware of the possibility of finding trace fossils in areas underlain by the Dwyka Group and Pietermaritzburg Formation. There is a very high possibility of fossils being present in the areas underlain by the Vryheid Formation.
2. Due to the fact that the presence/absence of fossils will only be recorded during the execution of the excavation activities, it is recommended that a qualified palaeontologist be appointed to compile a Phase 1 PIA report if fossils are recorded during the construction phase of the project.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1. INTRODUCTION

1.1. Background

Gideon Groenewald was appointed by PGS Heritage to undertake a desktop survey, assessing the potential palaeontological impact of the proposed Northern Aqueduct Phase 5 project in KwaZulu-Natal.

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

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.

1.2. Aims and 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. The known fossil heritage within each rock unit is inventoried from the published scientific literature and previous palaeontological impact studies in the same region.

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 fresh bedrock excavation envisaged. The different sensitivity classes used are explained in Table 1.1 below.

Table 1.1 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.	
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 aPhase 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 underly 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. Developer and HIA consultant must take note of possible fossils and make professional recommendations on the impact of development on significant palaeontological finds recorded in the literature. SAHRA must be notified if new fossils are recorded and collection of a representative sample of potential fossiliferous material recommended.

GREY	Very Low Palaeontological sensitivity/vulnerability. Very low to no possibility that 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. Developer and HIA consultant must note archaeological reports for possible descriptions of palaeontological finds in Cenozoic aged surface deposits.

1.3. Scope and Limitations of the Desktop Study

The study will include: i) an analysis of the area's stratigraphy, age and depositional setting of fossil-bearing units; ii) a review of all relevant palaeontological and geological literature, including geological maps, and previous palaeontological impact reports; iii) data on the proposed development provided by the developer (e.g. location of footprint, depth and volume of bedrock excavation envisaged) and iv) where feasible, location and examination of any fossil collections from the study area (e.g. museums).

The key assumption for this scoping 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. There is also an inadequate database for fossil heritage for much of the RSA, due to the small number of professional palaeontologists carrying out fieldwork in RSA. Most development study areas have never been surveyed by a palaeontologist.

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.).

2. DESCRIPTION OF THE PROPOSED DEVELOPMENT

The development entails the construction of an Aqueduct in the northern regions of Durban (Figure 2.1).

Figure 2.1 Locality of Durban North Aqueduct (Grey line)

3. GEOLOGY

Most of the study area is underlain by Ordovician to Silurian-aged quartzites of the Natal Group, Carboniferous to Permian aged tillites of the Dwyka Group, Permian aged shales of the Pietermaritzburg Formation, Permian aged sandstone of the Vryheid Formation of the Karoo Supergroup, Jurassic aged Dolerite and Quaternary aged alluvium (Figure 3.1).

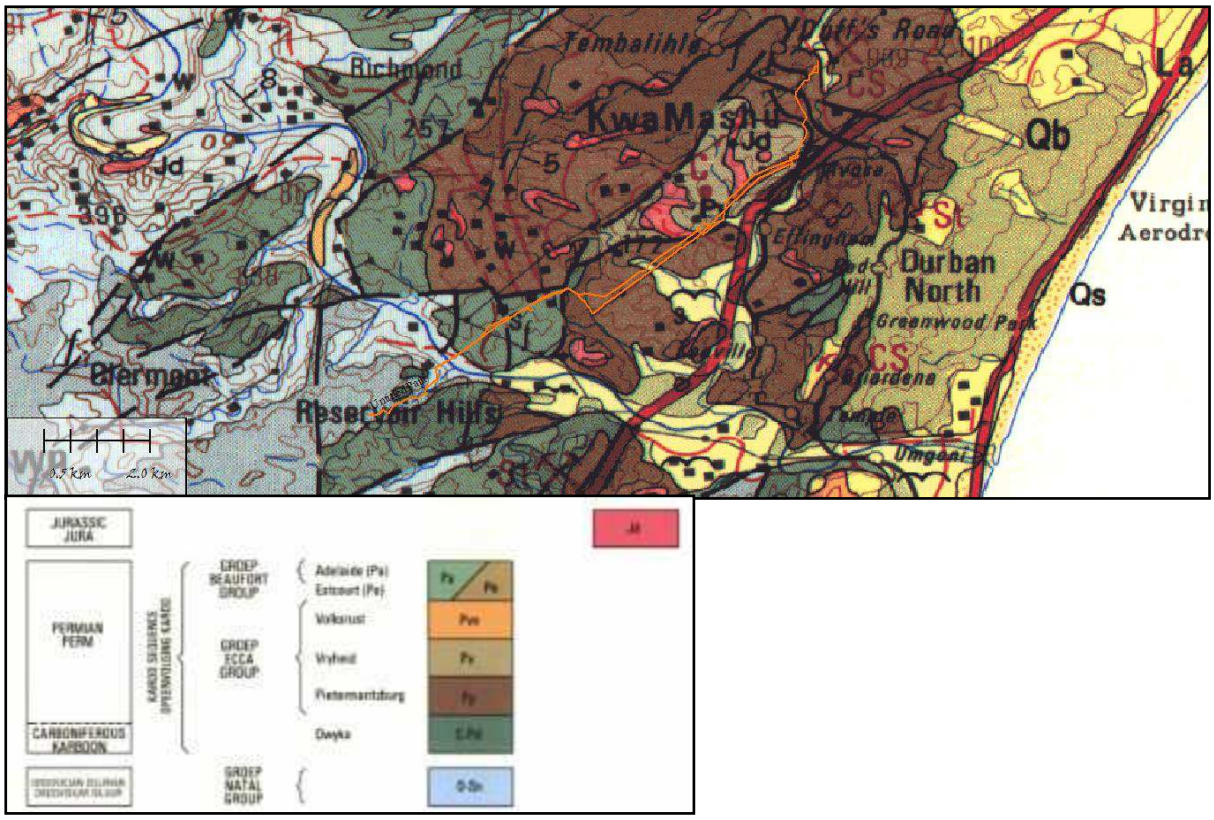

Figure 3.1 Geology of the study area (Pipeline in yellow)

3.1. Natal Group

The Ordovician to Silurian Aged Natal Group consists predominantly of relatively clean quartzite, with minor shale beds.

3.2. Dwyka Group

The Carboniferous to Permian aged Dwyka Formation is an assemblage of diamictites and glacial sediments, consisting of a mixture of fine-grained, poorly sorted sediments ranging from fine-grained silts and shales to sandy shales, with larger dropstones and angular cobbles in places. The deposits represent glacial activity in this part of Gondwanaland during the Carboniferous and Early Permian (Johnson et al, 2006).

3.3. Ecca Group

3.3.1. Pietermaritzburg Formation

The Permian aged Pietermaritzburg Formation consists mainly of dark grey to black shale deposits.

3.3.2. Vryheid Formation

The Permian aged Vryheid Formation consists mainly of coarse-grained sandstone and carbonaceous shale, with some prominent coal beds in many parts of the basin.

3.4. Dolerite

The Jurassic aged dolerite forms part of the main suite of Karoo Dolerite that was intruded during the breakup of Gondwanaland.

3.5. Alluvium

The alluvium deposits are associated with the deposits of the recent rivers in the area.

4. PALAEONTOLOGY OF THE AREA

4.1. Natal Group

No significant fossils have up to date been recorded from the quartzites of the Natal Group

4.2. The Dwyka Group

Trace fossils have been recorded from the fine-grained shales of the Dwyka Group in KwaZulu-Natal (Linstrom, 1987; MacRae, 1999). All of the following could potentially be found in KwaZulu-Natal. Trackways, produced mostly by fish and arthropods (invertebrates), have been recovered in shales from the uppermost Dwyka Formation. Other trace fossils include coprolites (fossilized faeces) of chondrichthyians (sharks, skates and rays).

Body fossils include aranaceous foraminifera and radiolarians (single-celled organisms), bryozoans, sponge spicules (internal support elements of sponges), primitive starfish, orthoceroid nautiloids (marine invertebrates similar to the living Nautilus), goniatite cephalopods (Eoasinites sp.), gastropods (marine snails such as *Peruvispira viperdorfensis*), bivalves (*Nuculopsis* sp., *Phestia* sp., *Aphanaia haibensis*, *Eurydesma mytiloides*), brachiopods (*Attenuatella* sp.) and palaeoniscoid fish such as *Namaichthys schroederi* and *Watsonichthys lotzi*.

Fossil plants have also been found, including lycopods (*Leptophloem australe*), moss, leaves and stems (possibly belonging to a proto-glossopterid flora). Fossil spores and pollens (such as moss, fern and horsetail spores and primitive gymnosperm pollens) as well as fossilized wood probably belonging to primitive gymnosperms have also been recorded from Dwyka deposits (MacRae, 1999; McCarthy and Rubidge, 2005; Groenewald, 2012).

4.3. Ecca Group

4.3.1. Pietermaritzburg Formation

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

4.3.2. Vryheid Formation

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 coalmines 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 (1986). 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, 1986).

4.3.3. Dolerite

Due to its igneous character dolerite will not contain fossils.

4.3.4. Alluvium

No significant fossils have been recorded from the alluvial deposits in this part of KwaZulu-Natal.

5. PALAEONTOLOGICAL SENSITIVITY

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 fresh bedrock excavation envisaged. The different sensitivity classes used are explained in Table 1 above. The palaeontological sensitivity of the study area is shown in Figure 5.1.

The Natal Group is allocated a Low palaeontological sensitivity due to the fact that no fossils have up to date been recorded from this unit.

The Pietermaritzburg Formation and alluvial deposits have been allocated a medium palaeontological sensitivity whereas the areas underlain by dolerite are allocated a very low to non-significant rating for palaeontological sensitivity

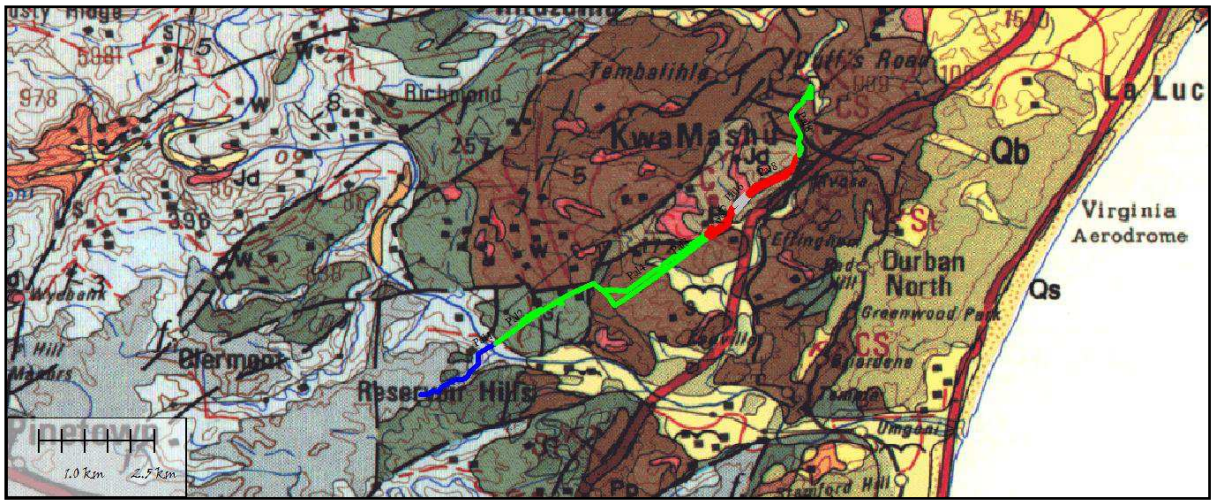

Figure 5.1 Palaeontological sensitivity of the study sites. Colour coding is explained in Table 1.1 above.

6. CONCLUSION AND RECOMMENDATIONS

The study area is mostly underlain by Ordovician to Silurian aged quartzites of the Natal Group, Carboniferous to Permian Aged tillites of the Dwyka Group, Permian aged shales and sandstones of the Ecca Group, Jurassic aged dolerite and Quaternary aged alluvium.

Trace fossils have been recorded from the Dwyka Group and Pietermaritzburg Formation of the Ecca Group, whereas fossils are abundantly known from rocks of the Vryheid Formation, also from the Ecca Group.

No fossils are expected from the alluvial deposits and the dolerite will not contain fossils.

Recommendation:

1. The EAP and ECO of the project must be made aware of the possibility of finding trace fossils in areas underlain by the Dwyka Group and Pietermaritzburg Formation. There is a very high possibility of fossils being present in the areas underlain by the Vryheid Formation.
2. Due to the fact that the presence/absence of fossils will only be recorded during the execution of the excavation activities, it is recommended that a qualified palaeontologist be appointed to compile a Phase 1 PIA report if fossils are recorded during the construction phase of the project.

7. REFERENCES

Bamford M. 2011. Desktop study Palaeontology Ermelo to Empangeni – Eskom powerline. Internal report Bernard Price Institute for Palaeontological Research, University of the Witwatersrand.

Groenewald GH. 2012. Palaeontological Technical Report for KwaZulu-Natal. Internal report – AMAFA.

Johnson MR, Anhausser CR and Thomas RJ. 2009. The Geology of South Africa. Geological Society of South Africa.

MacRae C. 1999. Life Etched in Stone. Geological Society of South Africa, Linden, South Africa.

Mason TR and Christie ADM 1986. Palaeoevironmental significance of ichnogenus *Diplocraterion torell* from the Permian Vryheid Formation of the Karoo Supergroup, South Africa. Palaeogeography, Palaeoclimatology, Palaeoecology 53(3-4):249-265.

McCarthy T and Rubidge BS. 2005. Earth and Life. 333pp. Struik Publishers, Cape Town.

Modesto, SP. 2006. The cranial skeleton of the Early Permian aquatic reptile *Mesosaurus tenuidens* : implications for relationships and palaeobiology. *Zoological Journal of the Linnean Society* 146: 345–368.
Linstrom W. 1987. Die Geologie van die gebied Durban. Explanation Sheet 2930 (1:250 000). Geological Survey of South. Africa.

8. 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 palaeoecological 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).

9. 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