



**DESKTOP PALAEOLOGICAL
HERITAGE IMPACT ASSESSEMENT
REPORT ON THE SITE OF THE
PROPOSED OKHAHLAMBA
LANDFILL PROJECT TO BE
LOCATED ON A PORTION OF THE
FARM REIT VALLEI 3285, KWA
ZULU-NATAL PROVINCE**

5 December 2014

Prepared for:
Heritage Contracts and Archaeological
Consulting CC

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**DESKTOP PALAEOLOGICAL HERITAGE IMPACT ASSESSEMENT REPORT ON
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On Behalf of:

Pravin Amar Development Planners

Prepared By:

Prof B.D. Millstead

EXECUTIVE SUMMARY

The Okhahlamba Local Municipality is proposing the establishment of a landfill facility to be located approximately 7 km south of the town Bergville on a portion of the Farm Reit Vallei 3285, Okhahlamba Local Municipality, Uthukela District Municipality, Bergville Magisterial District, Kwa Zulu-Natal Province. The aerial extent of the project area is approximately 27 ha.

The Okhahlamba Local Municipality has appointed Pravin Amar Development Planners (PADP) to undertake an Environmental Impact Assessment of the proposed project and the subsequent production of an Environmental Management Program (EMPr) for the project. Pravin Amar Development Planners (PADP) has appointed Heritage Contract and Archaeological Consulting CC, as independent consultants, to undertake a Heritage Impact Assessment of the project area. Heritage Contract and Archaeological Consulting CC has contracted BM Geological Services to provide a desktop Palaeontological Heritage Impact Assessment Report in respect of the proposed project that will form part of the final Heritage Impact Assessment Report.

The western portion of the project area is underlain by unfossiliferous rocks of the Karoo Dolerite Suite. Accordingly, the proposed project presents nil possibility of causing any negative impact on the South Africa's palaeontological heritage. In contrast the eastern portion of the project area is underlain by potentially fossiliferous Permian rocks of the Normandien Formation (Adelaide Subgroup). The potential for the proposed project to result in a negative impact upon the palaeontological heritage of the site has been assessed as moderate in the area underlain by the Normandien Formation. The fossils known to be present within the formation elsewhere in South Africa are known to contain highly scientifically and culturally significant fossils, particularly the vertebrate fossil fauna of the *Lystrosaurus* Assemblage Zone and plant macrofossils of the famous *Glossopteris* flora as well as diverse trace fossil assemblages. Any damage caused to the fossil materials that may be present within the strata underlying the project area would be both permanent and irreversible. The following damage mitigation protocols are recommended:

- A thorough examination of the eastern portions of the project area (i.e., those areas underlain by the Normandien Formation should be made by a palaeontologist prior to the commencement of the project as part of a full Palaeontological Impact Assessment Study. This would allow a meaningful evaluation of the presence of potentially fossiliferous strata within that portion of the project area. If fossil materials prove to be present the process would allow the identification of any such fossils that should either be protected completely or could have damage mitigation procedures emplaced to minimise negative impacts.

- If the proposed excavations are planned to extend to the underlying bedrock appropriate line staff of the Okhahlamba Local Municipality such as environmental officers should be trained to identify the types of fossils that may be expected to occur within the Normandien Formation as well as be educated concerning the scientific and cultural importance of those fossils.
- A close examination should be made of all excavations occurring upon the sediments of the Normandien Formation while they are occurring by the trained line staff.
- Should any fossil materials be identified, the particular excavations should be halted and SAHRA informed of the discovery (as required in Section 3.3 above). A palaeontologist should then be mandated to inspect the fossil materials and ascertain their scientific and cultural importance.
- A significant potential benefit of the examination of the excavations associated with the construction of the project is that currently unobservable fossils may be uncovered. As long as the construction process is closely monitored it is possible that potentially significant fossil material may be made available for scientific study.

Should scientifically or culturally significant fossil material exist within the project area any negative impact upon it could be mitigated by its excavation (under permit from SAHRA) by a palaeontologist and the resultant material being lodged with an appropriately permitted institution. In the event that an excavation is impossible or inappropriate the fossil or fossil locality could be protected and the site of any planned construction moved.

The project has been assessed as being socially beneficial, herein, as it would provide a safe and environmentally controlled site for disposal of the municipality's domestic waste materials.

This desktop study has not identified any palaeontological reason to prejudice the progression of the Okhahlamba Local Municipality Landfill Project, subject to the recommended damage mitigation procedures being enacted.

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1 INTRODUCTION

The Okhahlamba Local Municipality is proposing the establishment of a landfill facility to be located approximately 7 km south of the town Bergville on a portion of the Farm Reit Vallei 3285, Okhahlamba Local Municipality, Uthukela District Municipality, Bergville Magisterial District, Kwa Zulu-Natal Province (Figure 1). The aerial extent of the project area is approximately 27 ha.

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2 TERMS OF REFERENCE AND SCOPE OF THE STUDY

The terms of reference for this study were as follows:-

- Conduct a desktop assessment of the potential impact of the proposed project on the palaeontological heritage of the project area.
- Describe the possible impact of the proposed development on the palaeontological heritage of the site, according to a standard set of conventions.
- Quantify the possible impact of the proposed development on the palaeontological heritage of the site, according to a standard set of conventions.
- Provide an overview of the applicable legislative framework.
- Make recommendations concerning future work programs as, and if, necessary.

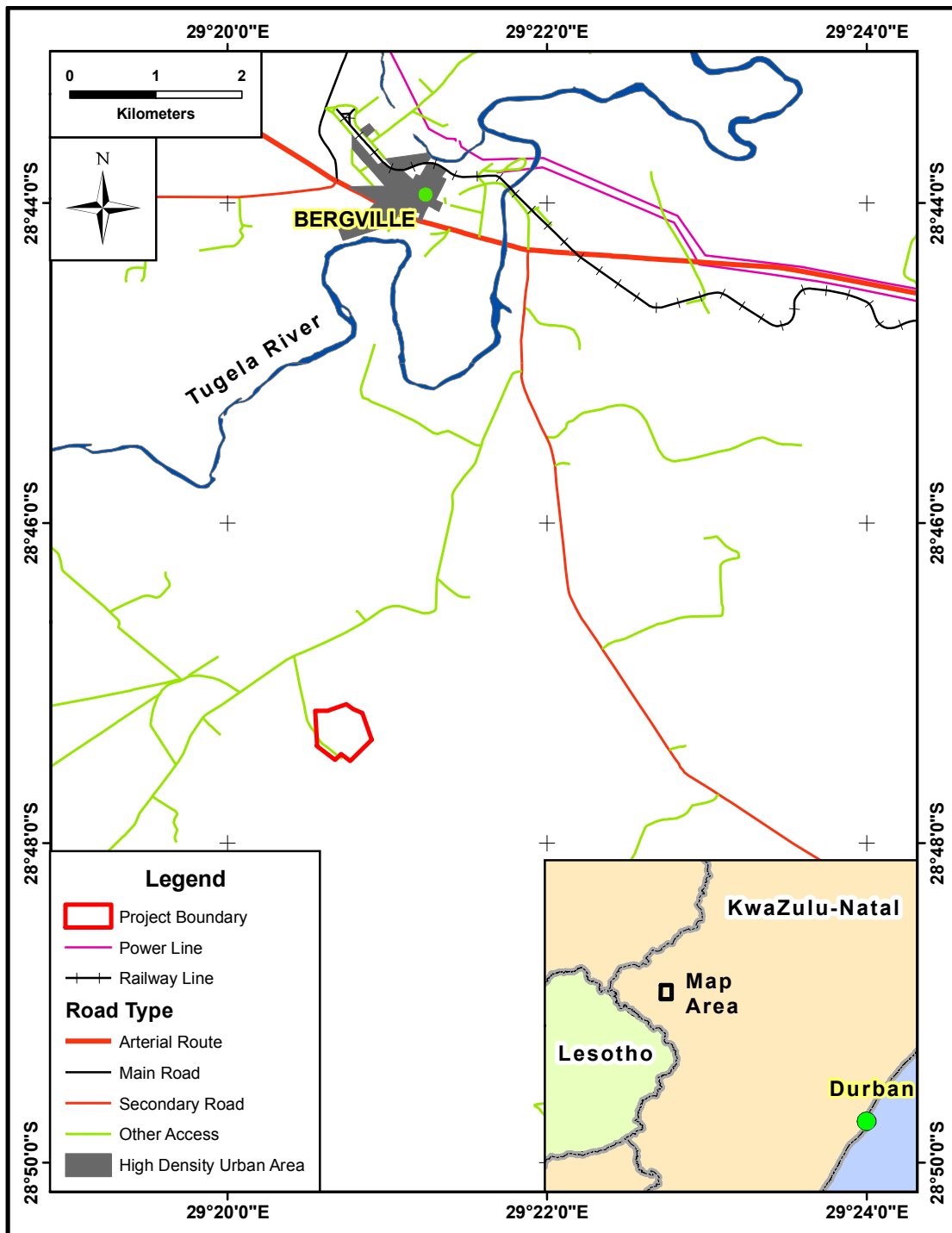


Figure 1: Location map showing the proposed position of the Okhahlamba Municipal Landfill Project.

3 LEGISLATIVE REQUIREMENTS

South Africa's cultural resources are primarily dealt with in two Acts. These are the National Heritage Resources Act (Act 25 of 1999) and the National Environmental Management Act (Act 107 of 1998).

3.1 The National Heritage Resources Act

The following are protected as cultural heritage resources by the National Heritage Resources Act:

- Archaeological artefacts, structures and sites older than 100 years,
- Ethnographic art objects (e.g. prehistoric rock art) and ethnography,
- Objects of decorative and visual arts,
- Military objects, structures and sites older than 75 years,
- Historical objects, structures and sites older than 60 years,
- Proclaimed heritage sites,
- Grave yards and graves older than 60 years,
- Meteorites and fossils,
- Objects, structures and sites of scientific or technological value.

The Act also states that those heritage resources of South Africa which are of cultural significance or other special value for the present community and for future generations must be considered part of the national estate and fall within the sphere of operations of heritage resources authorities. The national estate includes the following:

- Places, buildings, structures and equipment of cultural significance,
- Places to which oral traditions are attached or which are associated with living heritage,
- Historical settlements and townscapes,
- Landscapes and features of cultural significance,
- Geological sites of scientific or cultural importance,
- Sites of Archaeological and palaeontological importance,
- Graves and burial grounds,
- Sites of significance relating to the history of slavery,
- Movable objects (e.g. archaeological, palaeontological, meteorites, geological specimens, military, ethnographic, books etc.).

3.2 Need for Impact Assessment Reports

Section 38 of the Act stipulates that any person who intends to undertake an activity that falls within the following:

- The construction of a linear development (road, wall, power line, canal etc.) exceeding 300 m in length,

- The construction of a bridge or similar structure exceeding 50 m in length,
- Any development or other activity that will change the character of a site and exceed 5 000 m² or involve three or more existing erven or subdivisions thereof,
- Re-zoning of a site exceeding 10 000 m²,
- Any other category provided for in the regulations of SAHRA or a provincial heritage authority.

must at the very earliest stages of initiating such a development, notify the responsible heritage resources authority and furnish it with details regarding the location, nature and extent of the proposed development. If there is reason to believe that heritage resources will be affected by such development, the developer may be notified to submit an impact assessment report. A Palaeontological Impact Assessment (PIA) only looks at the potential impact of the development palaeontological resources of the proposed area to be affected.

3.3 Legislation Specifically Pertinent to Palaeontology*

*Note: Section 2 of the Act defines “palaeontological” material as “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”.

Section 35(4) of this Act specifically deals with archaeology, palaeontology and meteorites. The Act states that no person may, without a permit issued by the responsible heritage resources authority (national or provincial):

- Destroy, damage, excavate, alter, deface or otherwise disturb any archaeological or palaeontological site or any meteorite,
- Destroy, damage, excavate, remove from its original position, collect or own any archaeological or palaeontological material or object or any meteorite,
- Trade in, sell for private gain, export or attempt to export from the Republic any category of archaeological or palaeontological material or object, or any meteorite; or
- Bring onto or use at an archaeological or palaeontological site any excavation equipment or any equipment that assists in the detection or recovery of metals or archaeological and palaeontological material or objects, or use such equipment for the recovery of meteorites,
- Alter or demolish any structure or part of a structure which is older than 60 years as protected.

The above mentioned palaeontological objects may only be disturbed or moved by a palaeontologist, after receiving a permit from the South African Heritage Resources Agency (SAHRA). In order to demolish such a site or structure, a destruction permit from SAHRA will also be needed.

Further to the above point, Section 35(3) of this Act indicates that “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”. Thus, regardless of the granting of any official clearance to proceed with any development based on an earlier assessment of its impact on the Palaeontological Heritage of an area, the development should be halted and the relevant authorities informed should fossil objects be uncovered during the progress of the development.

3.4 The National Environmental Management Act [as amended]

This Act does not provide the detailed protections and administrative procedures for the protection and management of the nation’s Palaeontological Heritage as are detailed in the National Heritage Resources Act, but is more general in its application. In particular Section 2(2) of the Act states that environmental management must place people and their needs at the forefront of its concerns and, amongst other issues, serve their cultural interests equitably. Further to this point section 2(4)(a)(iii) states that disturbances of sites that constitute the nation’s cultural heritage should be avoided, and where it cannot be avoided should be minimised and remedied.

Section 23(1) indicates that a general objective of integrated environmental management is to identify, predict and evaluate the actual and potential impact of activities upon the cultural heritage. This section also highlights the need to identify options for mitigating of negative effects of activities with a view to minimising negative impacts.

In order to give effect to the general objectives of integrated environmental management outlined in the Act the potential impact on cultural heritage of activities that require authorisation or permission by law must be investigated and assessed prior to their implementation and reported to the relevant organ of state. Thus, a survey and evaluation of cultural resources must be done in areas where development projects that will potentially negatively affect the cultural heritage will be performed. During this process the impact on the cultural heritage will be determined and proposals for the mitigation of the negative effects made.

4 RELEVANT EXPERIENCE

Prof Millsteed holds a PhD in palaeontology and has previously been employed as a professional palaeontologist with the Council for Geoscience in South Africa. He is currently the principle of BM Geological Services and has sufficient knowledge of palaeontology and the relevant legislation required to produce this Palaeontological Impact Assessment Report. Dr Millsteed is registered with the South African Council for Natural Scientific Professions (SACNASP), and is a member of the Palaeontological Society of South African and the Geological Society of South Africa.

5 INDEPENDENCE

Prof Millsteed was contracted as an independent consultant to conduct this Palaeontological Heritage Impact Assessment study and shall receive fair remuneration for these professional services. Neither Prof Millsteed nor BM Geological Services has any financial interest either in the Okhahlamba Local Municipality, any of the council's officers or with the proposed landfill project.

6 GEOLOGY AND FOSSIL POTENTIAL

Figure 2 shows that the eastern portion of the project area is underlain by rocks of the Early Permian Normandien Formation (Adelaide Subgroup) while the western half is underlain by Jurassic dolerites of the Karoo Dolerite Suite. A summary of the characteristics of both the Normandien Formation and Karoo Dolerite Suite and their fossiliferous potential follows.

6.1 Normandien Formation, Adelaide Subgroup

6.1.1 Geology

The project area is completely underlain by Late Permian sedimentary rocks of the Normandien Formation, Adelaide Subgroup, Beaufort Group (Figure 2). In the south and central portions of the Main Karoo Basin the Adelaide Subgroup is differentiated into two distinct stratigraphic sequences which are located either side of the line of longitude of 24° east. To the east of that dividing line the Adelaide Subgroup consists of (in order of decreasing stratigraphic age) the Koonap, Middleton and Balfour Formations. To the west of 24° east the Adelaide subgroup is subdivided into a lower Abrahamskraal and an upper Teekloof Formations (South African Committee for Stratigraphy, 1980). In the north-eastern region of the basin only a single formation (the Normandien Formation) is present (Groenewald, 1984, 1990; Figure 3). Thus, it is the rocks of the Normandien Formation that underlie the eastern portions of the project area.

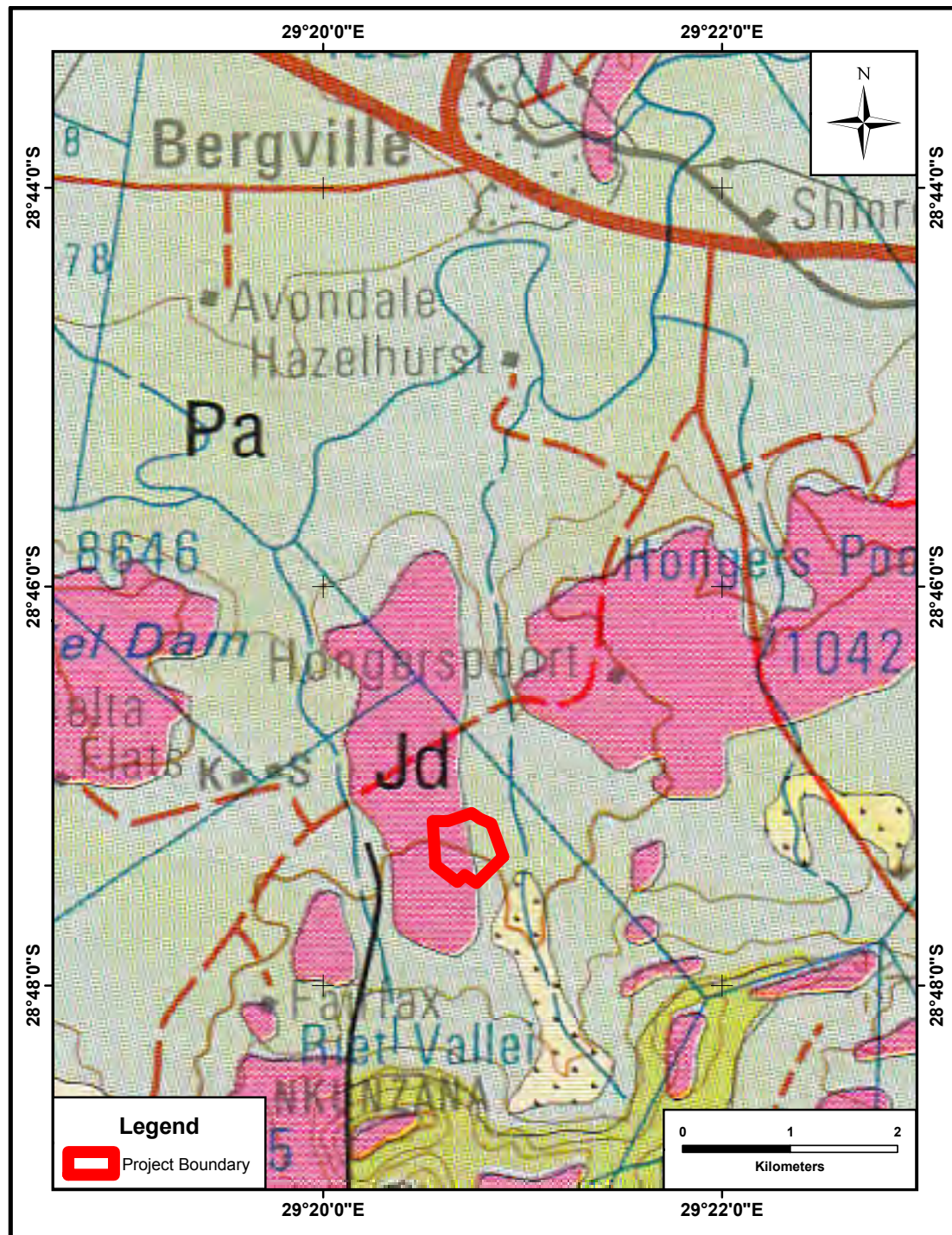


Figure 2: Geology of the area underlying the project area for the proposed Okhahlamba Landfill Facility (red polygon) and its immediate environs. The annotation "Pa" denotes the Normandien Formation while "Jd" denotes the Karoo Dolerite Suite [modified from Geological Survey of South Africa (1998)].

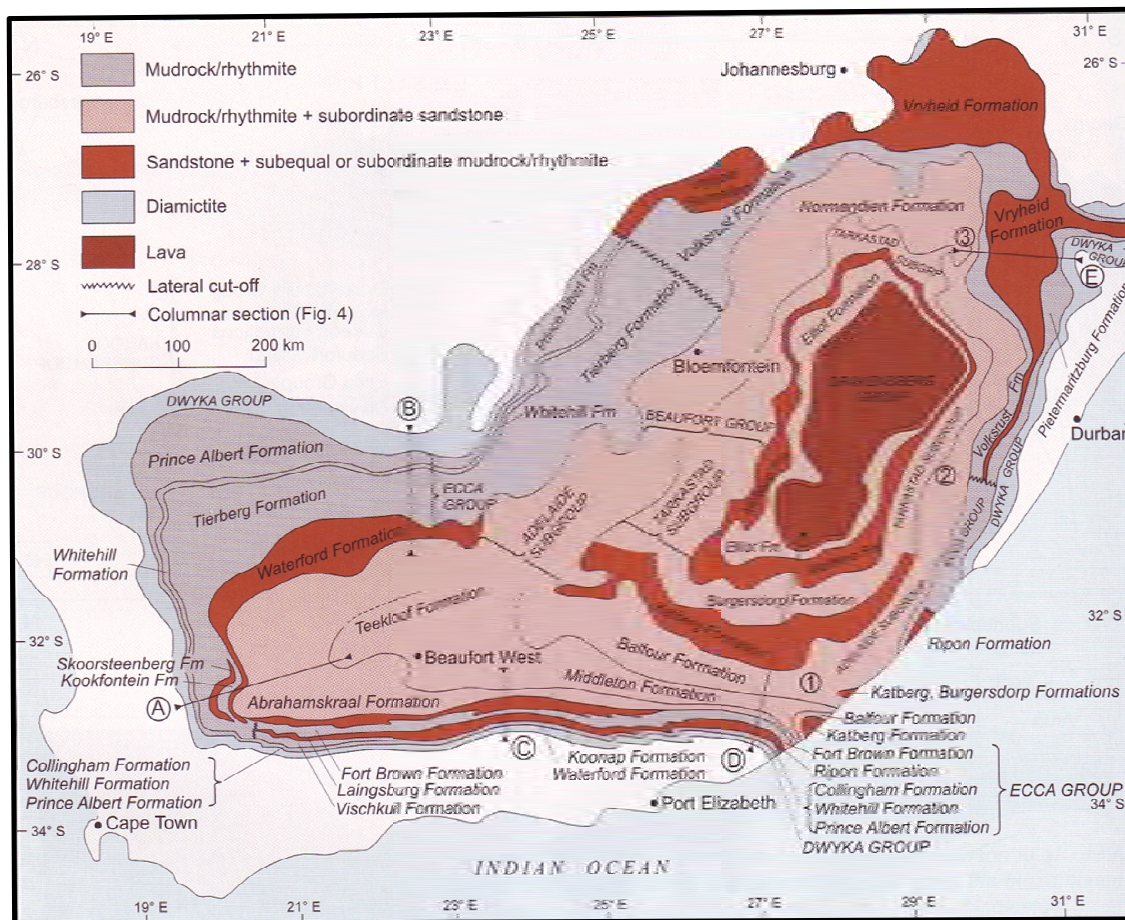


Figure 3: Schematic geological map of the Main Karoo Basin showing the location of the various stratigraphic subdivisions of the Adelaide Subgroup as well as the major lithological characteristics of each major stratigraphic unit (Johnson *et al.*, 2006).

In general the Adelaide Subgroup consists of alternating bluish-grey, greenish-grey or greyish-red mudrocks and grey, very fine- to medium-grained lithofeldspathic sandstones (South African Committee for Stratigraphy, 1980). Sandstones generally constitute 20-30% of the total thickness of the sequence, but maybe as high as 60% and as low as 10%. Deposition within the northern part of the basin varies from that in the remainder of the basin in that coarse to very coarse sandstones or even granulestones are common within the Normandien Formation and the mudstones of the Adelaide Subgroup are generally massive and blocky weathering except in parts of the Normandien Formation and Daggaboersnek Member where horizontal lamination is common and rhythmites are common (Johnson *et al.*, 2006). The sediments of the Normandien Formation are further differentiated from the remainder of the Adelaide Subgroup in that thin coal beds are occasionally present in the lower part (Botha and Linström, 1984; Groenewald, 1984).

Genetically the Normandien Formation differs from the strata coeval in the southern and central portions of the Karoo Basin in that deposition took place within a west to north - westerly fluvial transport system (Cole and Wipplinger, 2001). The depositional system was initially lacustrine and deltaic with progradation to the east and changed upwards into fluvial meandering under drier conditions (Cole and Wipplinger, 2001).

6.1.2 Palaeontological potential

Figure 4 indicates that the project area is underlain by rocks containing vertebrate fossils belonging to the *Lystrosaurus* Assemblage Zone (Groenewald, G.H., and Kitching, J.W., 1995). The vertebrate fossil faunas that constitute the *Lystrosaurus* Assemblage Zone are taxonomically diverse and contain reptile genera belonging to the Captorhinida (*Owenetta* and *Procolophon*), Eosuchia (*Heleosuchus*, *Paliguana*, *Noteosuchus*, *Aenigmatasaurus*, *Prolacerata*, *Proterosuchus* and *Proterosuchus*), Dinocynodontia (*Lystrosaurus* and *Myosaurus*), Therocephalia (*Ericiolacerata*, *Moschorhinus*, *Oliviera*, *Regisaurus*, *Scaloposaurus*, *Tetracynodon* and *Zorillodontops*), Cynodontia (*Galesaurus*, *Platycraniellus* and *Thrinaxodon*). There are also the amphibian genera (*Broomulus*, *Kestrosurus*, *Limnoiketes*, *Lydekkerina*, *Microphoris*, *Putterillia*, *Rhytidosteus* and *Uranocentrodon*) present (Groenewald, G.H., and Kitching, J.W., 1995). There have also been fossil millipedes (the genus cf. *Gymnostrepus*) reported within the palaeoflora, as well as the trace fossil genera *Gyrolithes*, *Histioderma*, *Planolites*, *Scolithus*, *Scoyenia*, *Thalassinoides* and various vertebrate burrows present (Groenewald, G.H., and Kitching, J.W., 1995).

The fossil plant macroflora of the Normandien Formation is taxonomically depauperate compared to the vertebrate assemblage of the *Lystrosaurus* Assemblage Zone. However, it may be expected that this sequence may in general contain plant fossils (including silicified wood) belonging to the famous *Glossopteris* flora (Johnson *et al.*, 2006). Bamford (2004) indicates that this sequence contains the fossil wood genera *Agathoxylon* and *Australoxylon*. Groenewald, G.H., and Kitching, J.W. (1995) also indicate of the fossil wood genera *Dadoxylon* as well as the leaf genera *Glossopteris* and *Schizoneura*.

6.2 Karoo Dolerite Suite

6.2.1 Geology

The dolerites located within the western portion of the project area and the surrounding region represents a series of dykes and/or sills of the Jurassic (approximately 183 million years old; Duncan and Marsh, 2006) Karoo Dolerite Suite.

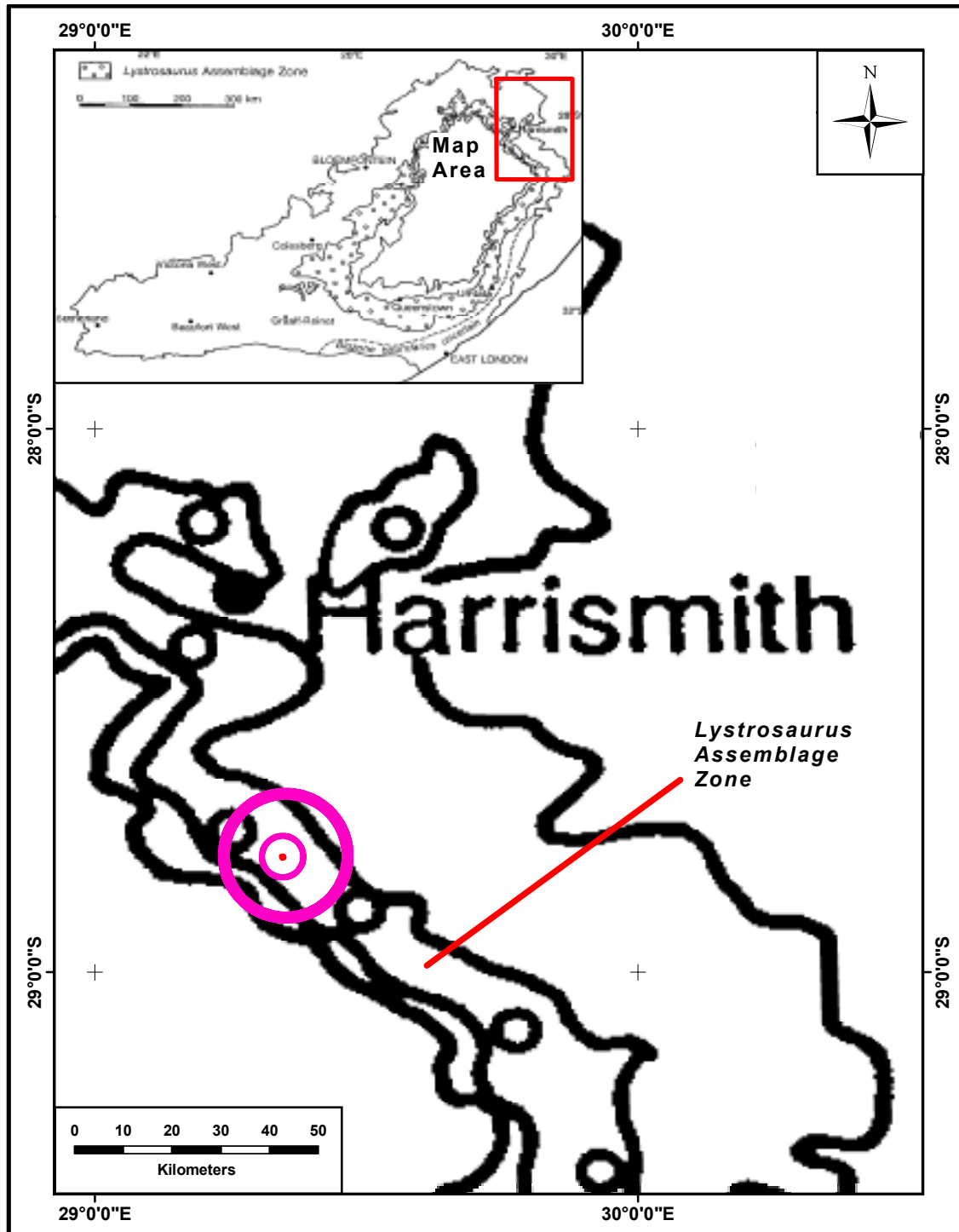


Figure 4: Map showing that the project area (in the centre of the two concentric purple circles) is located upon rocks containing the *Lystrosaurus* Assemblage Zone [modified from Groenewald and Kitching, 1995].

6.2.2 Palaeontological potential

Dolerite is an intrusive igneous rock; as such there is no potential for any fossil material to be located within this rock type.

7 ENVIRONMENT OF THE PROPOSED PROJECT SITE

The site for the proposed Okhahlamba Local Municipality Landfill Project area is relatively large; being approximately 27 ha in aerial extent. Examination of Google earth imagery (Figure 5) indicates that the project area is relatively topographically featureless, but is located between two ephemeral fluvial drainage lines; which coalesce immediately to the north of the project area. These waterways eventually drain northwards into the Tugela River (Figure 7). The land surface of the project area appears to be uncultivated, but the surrounding region has been extensively utilized for agriculture (Figure 6 and 7). Figure 8 shows that the western portions of the project area (underlain by the Karoo dolerites) are vegetated with trees and bushes, while the eastern and northern portions are vegetated with grassland, and appear to have been extensively disturbed by human activity.

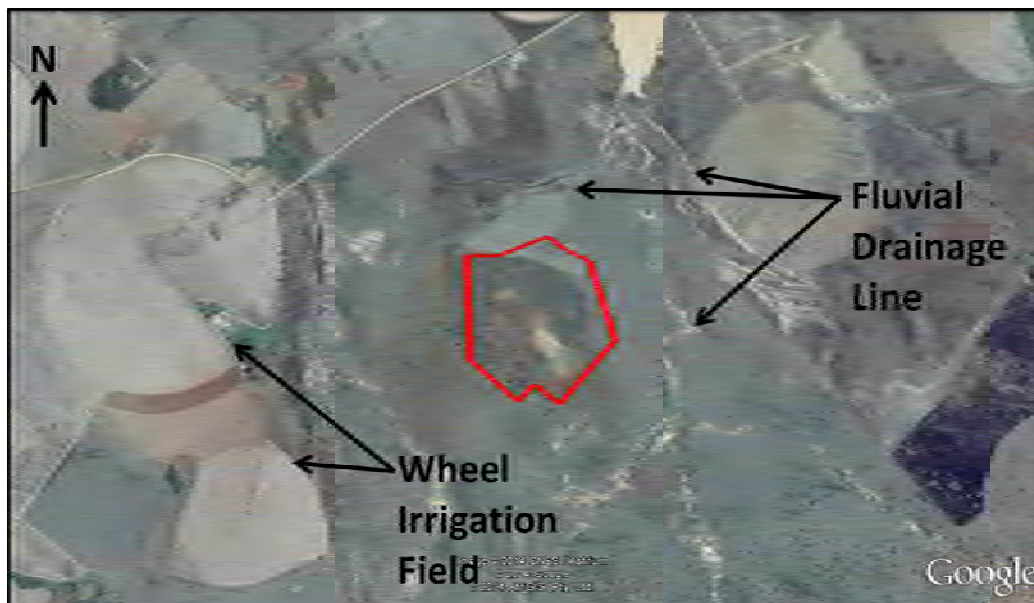


Figure 5: Google earth image showing the project area (red polygon). It is evident that there are two ephemeral fluvial drainage lines located either side of the project area and also that these drainage lines coalesce immediately to the north of the project area. The project area does not appear to have been subject to crop cultivation, but much of the surrounding area is.



Figure 6: Close-up Google earth image of the project area (red polygon). It is evident that there has been some sort of disruption of the land surface in the central and northern-most parts of the project area.

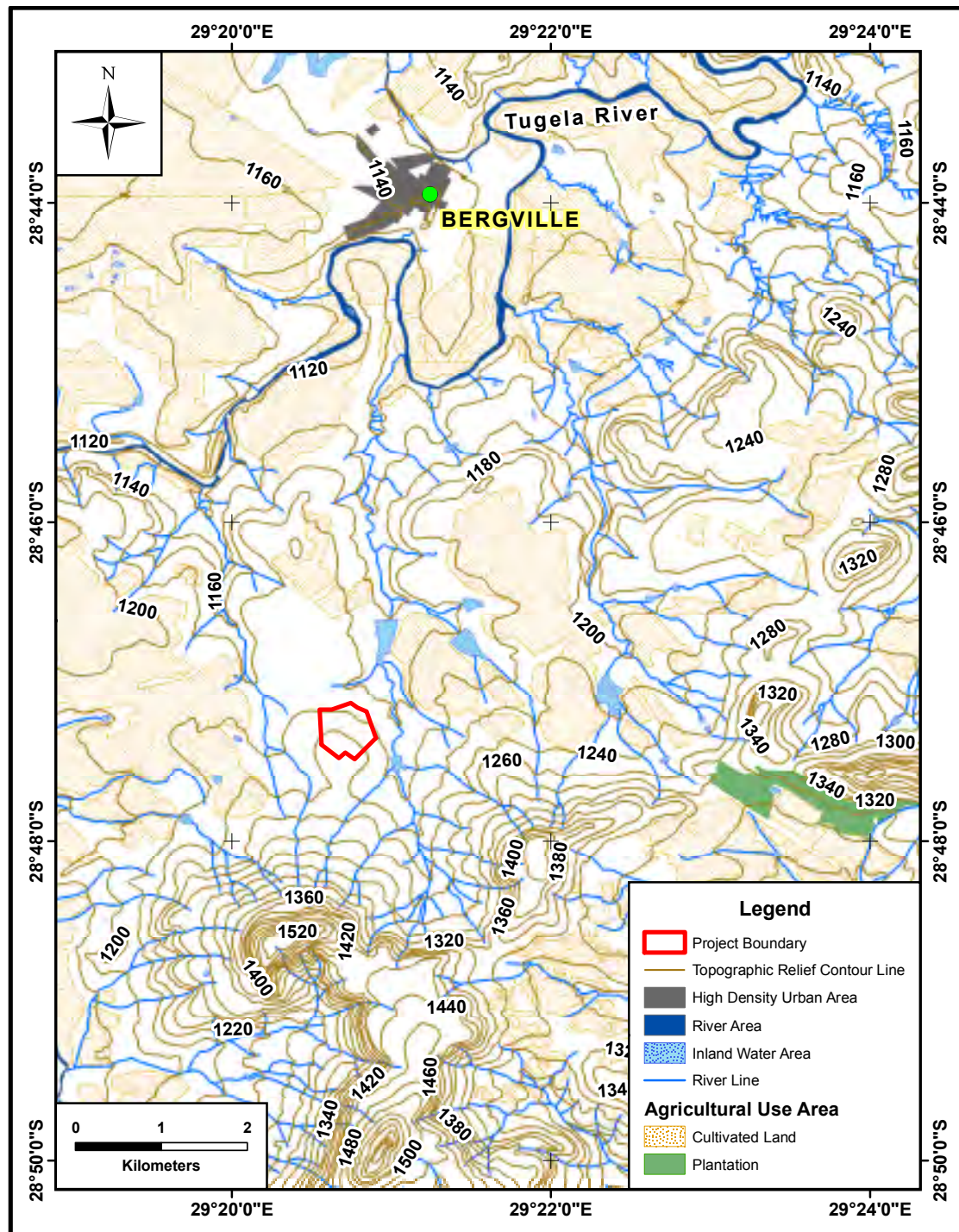


Figure 7: Map of the project area and its immediate environs. The project area lies upon the toe of a northerly sloping hillside. It is evident that the ephemeral fluvial drainage system that surrounds the project area drains into the Tugela River immediately adjacent to Bergville. Much of the area surrounding the proposed landfill site is currently cultivated for agriculture. The topographic contour interval is 20 m.

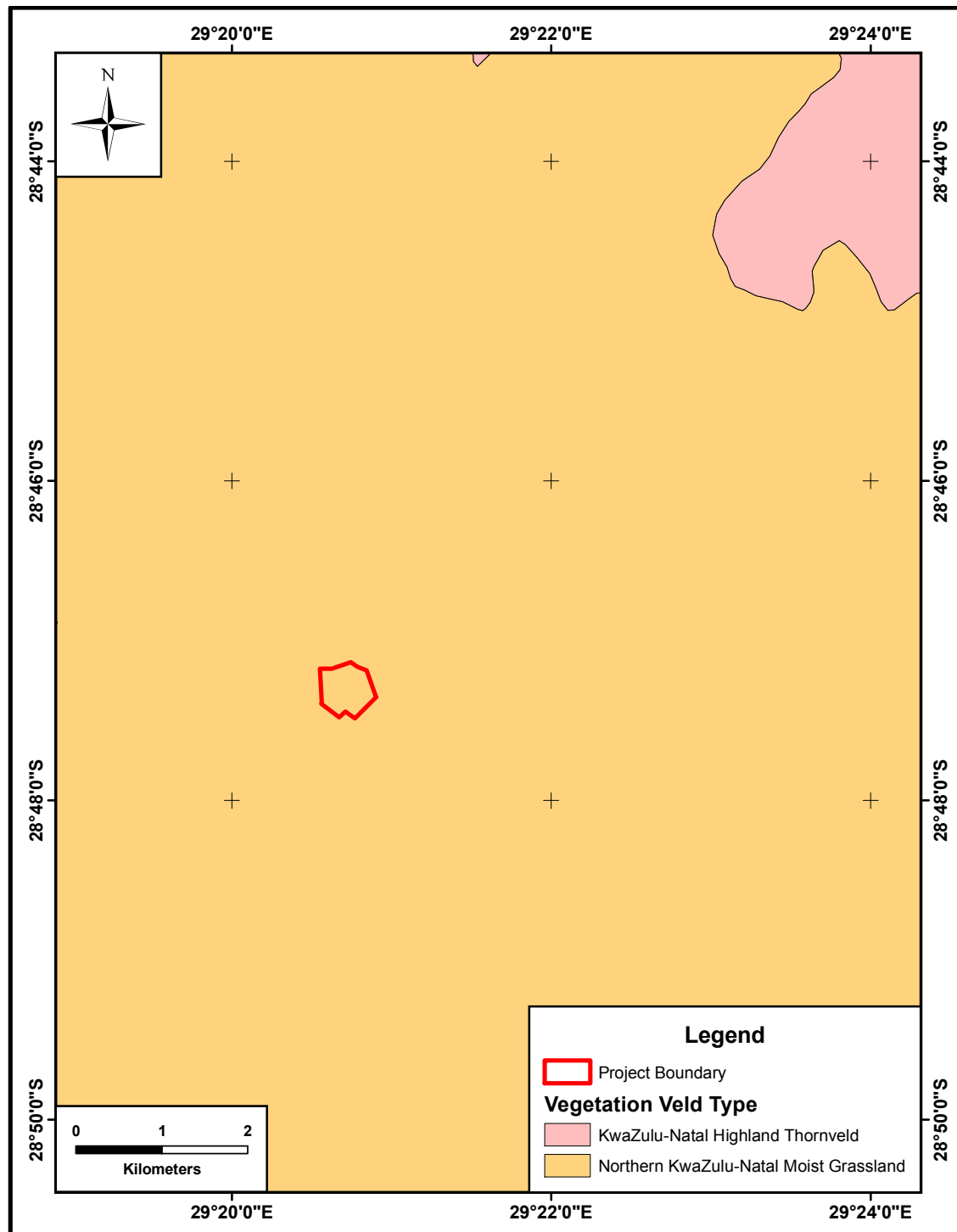


Figure 8: Map of the distribution of the vegetation veld types located beneath the project area and within its immediate environs (after Mucina and Rutherford, 2006).

Figure 5 shows that the project area is located upon the toe of the northern slopes of a significant hill. This figure also reaffirms the observation that the ephemeral drainage lines located either side of the project area coalesce, and drain into the Tugela River immediately adjacent to Bergville.

The natural vegetation cover of the project area consists of the Northern Kwa Zulu-Natal Moist Grassland veld type (Figure 8). The conservation status of the Northern Kwa Zulu-Natal Moist Grassland is described by Mucina and Rutherford (2006) as vulnerable. However, as indicated above it appears from the Google earth imagery that a significant proportion of the project area land surface has been disturbed by human activity and the amount of natural vegetation cover remaining is uncertain.

8 OVERVIEW OF SCOPE OF THE PROJECT

The Okhahlamba Municipal Landfill Project is anticipated to necessitate large scale excavation of the land surface to a depth of several meters. Following the completion of dumping of refuse the excavations would be recovered with the previously excavated soil. It is considered unlikely that significant mining of the underlying solid bedrock will occur as this process would most likely be too expensive. Thus the landfill project will consist of a series of excavations into the soil cover, the building of topsoil stockpiles and the construction of access roads.

8.1 Effect of project on the geology

It may be interpreted from Section 8 above that the development anticipated within the project area could be expected to be restricted to the upper few meters of the land surface, with the deepest anticipated impacts upon the underlying geology resulting from the excavations that will be in filled with refuse. The majority of any impacts will be restricted to the soil cover and the immediate surface of the sub-cropping bedrock.

9 IMPACT ASSESSMENT

The potential impact of the proposed landfill project is categorised according to the criteria outlined below.

9.1 Nature of Impact

The potential negative impacts of the proposed project on the palaeontological heritage of the area are:

- Damage or destruction of fossil materials during the construction of project infrastructural elements to a maximum depth of those excavations. Many fossil taxa

(particularly vertebrate taxa) are known from only a single fossil and, thus, any fossil material is potentially highly significant. Accordingly, the loss or damage to any single fossil can be potentially significant to the understanding of the fossil heritage of South Africa and to the understanding of the evolution of life on Earth in general. Where fossil material is present and will be directly affected by the building or construction of the project's infrastructural elements the result will potentially be the irreversible damage or destruction of the fossil(s).

- Movement of fossil materials during the construction phase, such that they are no longer *in situ* when discovered. The fact that the fossils are not *in situ* would either significantly reduce or completely destroy their scientific significance.
- The loss of access for scientific study to any fossil materials present beneath infrastructural elements for the life span of the existence of those constructions and facilities.

9.2 Extent of impact

The possible extent of the permanent impact of the proposed project on the palaeontological heritage of South Africa is restricted to the damage, destruction or accidental relocation of fossil material caused by the excavations and construction of the necessary infrastructure elements forming part of the project. The possible source of a less permanent negative impact on the palaeontological heritage is the loss of access for scientific research to any fossil materials that become covered by the various infrastructural elements that comprise the project. The **extent of the area of potential impact is, accordingly, categorised as local** (i.e., restricted to the project site).

9.3 Duration of impact

The anticipated duration of the identified potential impact is assessed as potentially **permanent to long term**. This assessment is based on the fact that, in the absence of mitigation procedures (should fossil material be present within the area to be affected) the damage or destruction of any palaeontological materials will be permanent. Similarly, any fossil materials that exist below the landfill will be sterilised for scientific study due to the existence of a thick layer of buried refuse. To subsequently re-excavate the area would require exposure to potential pollutants, toxins and medically dangerous microbial accumulation. The life of the facility is expected to be permanent herein.

9.4 Probability of impact

The sediments of the Normandien Formation are noted for containing an important palaeontological heritage particularly in respect of the vertebrate fossil fauna of the

Lystrosaurus Assemblage Zone and the plant macrofossils of the *Glossopteris* flora as well as trace fossil assemblages. However, the occurrence of fossils within the geological record is erratic in general and the chance of impacting upon most macrofossil types at any particular point within the Normandien Formation is low. It must be noted however, that where plant macrofossils or trace fossils are present within a sequence (as they are elsewhere in the Normandien Formation) they are often in dense accumulations and the probability of a negative impact is accordingly assessed as being **moderate** in the eastern portions of the project area. In the western portions of the area the bedrock consists of Karoo dolerite, which is unfossiliferous; the probability of a negative impact in this area is accordingly categorised as **nil**.

9.5 Significance of the impact

Should the project progress without due care to the possibility of fossils being present within the Normandien Formation the resultant damage, destruction or inadvertent relocation any affected fossils will be permanent and irreversible. The fossil fauna of the *Lystrosaurus* Assemblage Zone provide a unique window into a discrete interval in the evolution of reptiles to mammals and are, accordingly, of the highest scientific significance. Any vertebrate fossils that may occur within the project area are potentially of greater than normal significance due to the general scarcity of fossil materials at surface in Kwa Zulu-Natal because of the high rainfall and generally thick soil cover and because the paleoenvironment of the Normandien Formation differs substantially from those that deposited the remainder of the Adelaide subgroup. Thus, the fossil faunas of the Normandien Formation are more poorly known than those located further to the south in the Main Karoo Basin and may include taxa restricted to this portion of the Karoo Basin. The potential for negative impact on the fossil heritage of the site is accentuated by the fact that often the plant macrofossils and trace fossils that are known to be present in this formation often occur in dense accumulations, and as such, if any negative impact occurs it may well affect many fossils simultaneously. The sediments of the Normandien Formation provide an important window into the evolution the of plant life that constitutes the famous *Glossopteris* flora during this poorly understood interval in the Early Permian within the Main Karoo Basin. Their significance is due to the uniqueness of their terrestrial environments within the basin fill of the Main Karoo Basin at that time. Thus, any fossil materials occurring within the project area are potentially extremely scientifically and culturally significant and any negative impact on them would be of **high significance**.

The scientific and cultural significance of fossil materials is underscored by the fact that many fossil taxa (particularly vertebrate taxa) are known from only a single fossil and, thus, any fossil material is potentially highly significant. Accordingly, the loss or damage to any single fossil can be potentially significant to the understanding of the fossil heritage of South Africa and to the understanding of the evolution of life on Earth in

general. Where fossil material is present and will be directly affected by the construction of project infrastructural elements the result will potentially be the irreversible damage or destruction of the fossil(s).

The certainty of the exact *in situ* location of fossils and their precise location within the stratigraphic sequence is essential to the scientific value of fossils. The movement of any fossil material during the construction of the facility that results in the exact original location of the fossil becoming unknown will either greatly diminish or destroy the scientific value of the fossil.

9.6 Severity / Benefit scale

The proposed project is categorised, herein, as being potentially **beneficial**. This classification is based on the intention that the project will provide a safe and environmentally controlled site for disposal of the municipality's domestic waste materials.

The probability of a negative impact on the palaeontological heritage of the project areas has been categorised as moderate over the eastern portion of the project area (and nil in the western portion underlain by dolerite rocks). However, the implementation of suitable damage mitigation and avoidance protocols, as outlined below, will minimise the probability of any negative impact occurring and ensure that the severity/benefit scale for the project remains positive.

9.7 Status

The proposed project would provide a safe and environmentally controlled site for disposal of the municipality's domestic waste materials. As such, the project is determined as having a **positive status** herein.

10 DAMAGE MITIGATION, REVERSAL AND POTENTIAL IRREVERSABLE LOSS

The degree to which the possible negative effects of the proposed project can be mitigated, reversed or will result in irreversible loss of the palaeontological heritage can be determined as discussed below.

10.1 Mitigation

The following damage mitigation protocols are, however, recommended:

- A thorough examination of the eastern portions of the project area (i.e., those areas underlain by the Normandien Formation (see Figure 2) should be made by

a palaeontologist prior to the commencement of the project as part of a full Palaeontological Impact Assessment Study. This would allow a meaningful evaluation of the presence of potentially fossiliferous strata within that portion of the project area. If fossil materials prove to be present the process would allow the identification of any such fossils that should either be protected completely or could have damage mitigation procedures emplaced to minimise negative impacts.

- If the proposed excavations are planned to extend to the underlying bedrock appropriate line staff of the Okhahlamba Local Municipality such as environmental officers should be trained to identify the types of fossils that may be expected to occur within the Normandien Formation as well as be educated concerning the scientific and cultural importance of those fossils.
- A close examination should be made of all excavations occurring upon the sediments of the Normandien Formation while they are occurring by the trained line staff.
- Should any fossil materials be identified, the particular excavations should be halted and SAHRA informed of the discovery (as required in Section 3.3 above). A palaeontologist should then be mandated to inspect the fossil materials and ascertain their scientific and cultural importance.
- A significant potential benefit of the examination of the excavations associated with the construction of the project is that currently unobservable fossils may be uncovered. As long as the construction process is closely monitored it is possible that potentially significant fossil material may be made available for scientific study.
- Should scientifically or culturally significant fossil material exist within the project area any negative impact upon it could be mitigated by its excavation (under permit from SAHRA) by a palaeontologist and the resultant material being lodged with an appropriately permitted institution. In the event that an excavation is impossible or inappropriate the fossil or fossil locality could be protected and the site of any planned construction moved.

10.2 Reversal of damage

Any damage to, or the destruction of, palaeontological materials or reduction of scientific value due to a loss of the original location is **irreversible**.

10.3 Degree of irreversible loss

Once a fossil is damaged, destroyed or moved from its original position without its geographical position and stratigraphic location being recorded the **damage is irreversible**.

Fossils are usually both scarce and sporadic in their occurrence and the chances of negatively impacting on a fossil in any particular area are low. However, any fossil material is potentially of the greatest scientific and cultural importance. Thus, the potential always exists during construction and excavation within potentially fossiliferous rocks for the permanent and irreversible loss of extremely significant or irreplaceable fossil material. This said, many fossils are incomplete in their state of preservation or are examples of relatively common taxa. As such, just because a fossil is present it is not necessarily of great scientific value. Accordingly, not all fossils are necessary significant culturally or scientifically significant and the potential degree of irreversible loss will vary from case to case. The judgement on the significance of the fossil must be made by an experienced palaeontologist.

11 ASSUMPTIONS, UNCERTAINTIES AND GAPS IN KNOWLEDGE

The information provided within this report was derived from a desktop study of available maps and scientific literature; no direct observation was made of the area as result of a site visit.

12 ENVIRONMENTAL IMPACT STATEMENT

A desktop Palaeontological Impact Assessment Study has been conducted on the location of the proposed Okhahlamba Local Municipality landfill project. The proposed alternative project areas are both moderately large; being approximately 27 ha. However, any negative impacts to the palaeontological heritage of the region will be limited to the footprint area of the required infrastructure and the extent of any impacts is accordingly characterised as local.

The effects of the required construction operations to the geological strata underlying the project area will be restricted to the rocks of the Early Permian Normandien Formation and the Jurassic Karoo Dolerite Suite; the former unit is known to be fossiliferous while the later is unfossiliferous. The probability of the project resulting in a negative impact on the palaeontological heritage of the Karoo dolerites is assessed as being nil as the rocks are unfossiliferous. The probability of the project resulting in a negative impact on the palaeontological heritage of the Normandien Formation has been assessed as moderate. Any negative impact on the fossil materials within the Normandien Formation will potentially be highly significant due to the scientific and cultural importance of many of the fossils that may be expected to be present. However, the social benefits of the project have been classified as beneficial, herein, as the project aims to provide a safe and environmentally controlled site for disposal of the municipality's domestic waste materials. The following damage mitigation protocols are accordingly recommended:

- A thorough examination of the eastern portion of the project area (i.e., those areas underlain by the Normandien Formation (see Figure 2) should be made by a palaeontologist prior to the commencement of the project as part of a full Palaeontological Impact Assessment Study. This would allow a meaningful evaluation of the presence of potentially fossiliferous strata within that portion of the project area. If fossil materials prove to be present the process would allow the identification of any such fossils that should either be protected completely or could have damage mitigation procedures emplaced to minimise negative impacts.
- If the proposed excavations are planned to extend to the underlying bedrock appropriate line staff of the Okhahlamba Local Municipality such as environmental officers should be trained to identify the types of fossils that may be expected to occur within the Normandien Formation as well as be educated concerning the scientific and cultural importance of those fossils.
- A close examination should be made of all excavations while they are occurring by the trained line staff.
- Should any fossil materials be identified, the particular excavations should be halted and SAHRA informed of the discovery (as required in Section 3.3 above). A palaeontologist should then be mandated to inspect the fossil materials and ascertain their scientific and cultural importance.
- A significant potential benefit of the examination of the excavations associated with the construction of the project is that currently unobservable fossils may be uncovered. As long as the construction process is closely monitored it is possible that potentially significant fossil material may be made available for scientific study.
- Should scientifically or culturally significant fossil material exist within the project area any negative impact upon it could be mitigated by its excavation (under permit from SAHRA) by a palaeontologist and the resultant material being lodged with an appropriately permitted institution. In the event that an excavation is impossible or inappropriate the fossil or fossil locality could be protected and the site of any planned construction moved.

The implementation of these protocols will minimise the potential negative impact of the project and ensure that the severity/benefit scale for the project is beneficial.

This desktop study has not identified any palaeontological reason to prejudice the progression of the Okhahlamba Local Municipality Landfill Project, subject to the recommended damage mitigation procedures being enacted.

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