



PALAEONTOLOGICAL IMPACT ASSESSMENT

D3 ENERGY PRODUCTION RIGHT AND
ASSOCIATED INFRASTRUCTURE IN
THE FREE STATE PROVINCE

August 2026

Compiled for Environmental Impact
Management Services



Declaration of Independence

I, Elize Butler, declare that –

General declaration:

- I act as the independent palaeontological specialist in this application
- I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant
- I declare that there are no circumstances that may compromise my objectivity in performing such work;
- I have expertise in conducting palaeontological impact assessments, including knowledge of the Act, Regulations and any guidelines that have relevance to the proposed activity;
- I will comply with the Act, Regulations, and all other applicable legislation;
- I will take into account, to the extent possible, the matters listed in section 38 of the NHRA when preparing the application and any report relating to the application;
- I have no, and will not engage in, conflicting interests in the undertaking of the activity;
- I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority; and - the objectivity of any report, plan, or document to be prepared by myself for submission to the competent authority;
- I will ensure that information containing all relevant facts in respect of the application is distributed or made available to interested and affected parties and the public and that participation by interested and affected parties is facilitated in such a manner that all interested and affected parties will be provided with a reasonable opportunity to participate and to provide comments on documents that are produced to support the application;
- I will provide the competent authority with access to all information at my disposal regarding the application, whether such information is favourable to the applicant or not
- All the particulars furnished by me in this form are true and correct;
- I will perform all other obligations as expected a palaeontological specialist in terms of the Act and the constitutions of my affiliated professional bodies; and
- I realize that a false declaration is an offense in terms of regulation 71 of the Regulations and is punishable in terms of section 24F of the NEMA.



Disclosure of Vested Interest

I do not have and will not have any vested interest (either business, financial, personal, or other) in the proposed activity proceeding other than remuneration for work performed in terms of the Regulations.

PALAEONTOLOGICAL CONSULTANT:

Banzai Environmental (Pty) Ltd

CONTACT PERSON:

Elize Butler

Tel: +27 844478759

Email: info@banzai-group.com

SIGNATURE:



EXECUTIVE SUMMARY

D3 Energy Energy (Pty) Ltd (the “Applicant”) holds an Exploration Right (ER315) for hydrocarbons, granted in terms of Section 80 of the Mineral and Petroleum Resources Development Act (Act 28 of 2002, MPRDA, as amended), and wishes to convert a portion of this Exploration Right area into a **D3 Energy Production Right** (“the project”), located within the Matjhabeng and Masilonyana Local Municipalities, Lejweleputswa District Municipality, Free State Province, near the town of Virginia. The proposed production right application area covers a total of approximately 14 440 hectares. The proposed development entails the extraction and production of helium and methane gas via up to 43 production wells, associated gas gathering pipelines, and a helium recovery and gas processing plant (CNG and/or LNG), together with ongoing exploration activities comprising up to 48 exploration wells and 8 seismic and/or audio-magnetotelluric survey transects with a combined length of approximately 62.5 km. In accordance with the National Environmental Management Act (Act 107 of 1998) (NEMA) and to comply with the National Heritage Resources Act (Act 25 of 1999, Section 38) (NHRA), this Palaeontological Impact Assessment (PIA) is necessary to confirm whether fossil material could potentially be present within the proposed development area, to evaluate the potential impact of the proposed project on palaeontological heritage, and to recommend measures to mitigate possible damage to fossil resources.

The D3 Energy Production Right footprint is underlain by Quaternary sands and alluvium, unfossiliferous Jurassic dolerite, and the Adelaide Subgroup (Beaufort Group, Karoo Supergroup). The PalaeoMap of the South African Heritage Resources Information System (SAHRIS) indicates that the palaeontological sensitivity of the Adelaide Subgroup is Very High, that of the Quaternary sediments is Moderate, and that of the Jurassic dolerite is Zero (Almond and Pether 2008; Almond et al. 2013; Groenewald et al. 2019). Within the wider region, the Adelaide Subgroup hosts the fossiliferous *Daptocephalus* Assemblage Zone, while the overlying Tarkastad Subgroup hosts the *Lystrosaurus declivis* Assemblage Zone. In this north-eastern part of the Karoo Basin, these are represented by the undifferentiated Normandien Formation and by the Verkykerskop and Driekoppen Formations respectively, the lateral equivalents of the Balfour Formation and the Katberg/Burgersdorp Formations recognised further south in the basin (Johnson et al. 2006, after Groenewald 1989). Both zones preserve a well-documented record of Permo-Triassic vertebrate fossils, including dicynodonts, gorgonopsians, therocephalians, and cynodonts (Almond et al. 2013; Groenewald et al. 2019). Palaeontological sensitivity generated by the Department of Forestry, Fisheries and the Environment (DFFE) National Environmental Screening Tool confirms that the proposed production right application area falls within a zone of Very High Palaeontology Theme Sensitivity.

A field-based palaeontological site investigation of the D3 Energy Production Right application area was conducted on 9 June 2026 with four site visits since 2022 (refer to Section 7), comprising a walkdown



and vehicle survey of the development footprint to verify the desktop-based palaeontological sensitivity assessment. No fossiliferous outcrops, *in situ* fossil material, or significant exposures of Adelaide Subgroup bedrock were observed during the site investigation; the ground surface is predominantly covered by grassland (bossieveld), cultivated land, and superficial soil. While these field observations do not confirm the presence of fossil material at surface, they are consistent with the Very High regional palaeontological sensitivity assigned to the Adelaide Subgroup bedrock by the SAHRIS PalaeoMap and the DFFE National Environmental Screening Tool, given that the bedrock, and any fossil material it may contain, is predominantly concealed beneath surface cover rather than confirmed absent. Fossil preservation and exposure within the Karoo Supergroup are inherently unpredictable and sporadic, occurring in isolated pockets rather than uniformly throughout a given rock unit; the absence of surface indications during a single site visit therefore cannot on its own be taken as evidence that the underlying Adelaide Subgroup is unfossiliferous. The Adelaide Subgroup in this part of the Karoo Basin hosts a well-documented regional record of Permo-Triassic vertebrate fossils, and construction-phase excavation, drilling and trenching activities have the potential to expose previously concealed material.

The loss of fossil heritage during construction has a Low pre-mitigation significance for seismic surveying and a High significance for drilling and gas plant construction/gas-gathering infrastructure. After mitigation, these drop to Low and Medium-High respectively (Confidence: High). The difference comes down to disturbance: drilling and trenching leave permanent, largely irreversible ground disturbance, while a seismic survey's footprint is brief and easily reversed. Both ratings sit within the context of the Very High regional geological sensitivity of the Adelaide Subgroup and the scientific value of an intact fossil assemblage. This is balanced against the probability of actually encountering such material: no fossiliferous outcrops or *in situ* fossil material were identified during the site-based verification survey, and fossil occurrence within this unit is, in any case, inherently unpredictable and sporadic rather than uniformly distributed. The construction phase (including seismic surveying, drilling, and trenching for gas gathering pipelines) is the only development phase expected to impact palaeontological heritage, and no significant impacts are anticipated during the operational or decommissioning phases. If the project is not implemented, the study area will remain undisturbed, resulting in a neutral impact on palaeontological heritage; however, the No-Go alternative would also forfeit the associated socio-economic and strategic resource benefits of the project. Proceeding with the project, while resulting in some potential disturbance to fossil heritage, would keep the post-mitigation impact within an acceptable Low to Medium-High range provided the recommended Chance Find Protocol is implemented. Moreover, residual negative impacts from fossil loss would be partially offset by a positive outcome, as any newly discovered, well-recorded, and suitably curated fossil material recovered during construction would enhance the regional palaeontological database and contribute to the broader scientific understanding of the Free State Karoo Basin fossil record. The SAHRIS PalaeoMap indicates that the general palaeontological sensitivity within a 30 km radius of the development ranges from Zero to Very High; given the variable quality of fossil preservation across this



radius, it is difficult to assign a single cumulative sensitivity rating to the project, though cumulative impacts are not expected to exceed the significance assigned to the project footprint itself.

Statement and Reasoned Opinion:

It is recommended that the proposed project receive environmental authorisation. The proposed D3 Energy Production Right and associated infrastructure are thus not considered to be fatally flawed from a palaeontological perspective, provided the Chance Find Protocol is implemented during construction. However, the recommended mitigation measures have to be included within the Environmental Management Programme (EMPr). These recommendations must be implemented in full during the construction phase. Mitigation measures include training of accountable supervisory personnel by a qualified palaeontologist in the recognition of fossil heritage, and are discussed more in detail in Section 10.

Recommendations:

- The Environmental Control Officer (ECO) for this project must be aware that the Adelaide Subgroup (Beaufort Group, Karoo Supergroup) has a **Very High Palaeontological Sensitivity**. The Karoo Supergroup bedrock in the study area is largely concealed due to poor exposure, primarily visible along major drainage lines and some steeper hillslopes.
- **Training of accountable supervisory / resident engineer** by a qualified palaeontologist in the recognition of fossil heritage is thus very important and necessary.
- If palaeontological heritage is uncovered during surface clearing or excavations, the **Chance Find Protocol** included in this report must be implemented immediately. Fossil discoveries must be protected in situ (if possible), and the Environmental Control Officer (ECO) or site manager must report the find to the relevant heritage authority, namely the **South African Heritage Resources Agency (SAHRA)** (111 Harrington Street, Cape Town; PO Box 4637, Cape Town 8000; Tel: 021 462 4502; Fax: 021 462 4509; Web: www.sahra.org.za), and/or the relevant Provincial Heritage Resources Authority – for this project the Free State Heritage Resources Authority (Free State Department of Sport, Arts, Culture and Recreation), so that appropriate mitigation measures, including the recording and collection of fossils by a qualified specialist, can be carried out.
- Before any fossil material can be collected from the development site, the specialist involved would need to apply for a **collection permit from SAHRA**. Fossil material must be **housed in an official collection** (museum or university), while all **reports and fieldwork should meet the minimum standards for palaeontological impact studies proposed by SAHRA (2012)**.



These recommendations should be incorporated into the Environmental Management Programme (EMPr) for the D3 Energy Production Right, as well as included as conditions for Environmental Authorisation.



This Palaeontological Impact Assessment report (as part of the Heritage Impact Assessment), has been compiled considering the National Environmental Management Act (Act 107 of 1998, amended) (NEMA) and Environmental Impact Assessment (EIA) Regulations 2014 as amended, requirements for specialist reports, Appendix 6, as indicated in the table below.

Table 1: Checklist for Specialist studies conformance with Appendix 6 of the EIA Regulations of 2014 (as amended).		
Requirements of Appendix 6 – GN R326 EIA Regulations of 7 April 2017 (as amended)	The relevant section in the report	Comment where not applicable.
1.(1) (a) (i) Details of the specialist who prepared the report	Page ii, Section 2, Appendix 2	-
(ii) The expertise of that person to compile a specialist report, including a curriculum vitae	Section 2, Appendix 2	-
(b) A declaration that the person is independent in a form as may be specified by the competent authority	Page ii	-
(c) An indication of the scope of, and the purpose for which, the report was prepared	Section 3	-
(cA) An indication of the quality and age of base data used for the specialist report	Section 5	-
(cB) a description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change;	Section 8	-
(d) The duration, date and season of the site investigation and the relevance of the season to the outcome of the assessment	Executive Summary, Section 7 & 9	A field-based site investigation was conducted on 9 June 2026 (winter, dry season). Dry-season conditions provided clear ground visibility for the surface walkdown survey and did not adversely affect the outcome of the assessment.
(e) a description of the methodology adopted in preparing the report or carrying out the specialised process inclusive of equipment and modelling used	Section 3	-
(f) details of an assessment of the specifically identified sensitivity of the site related to the proposed activity or activities and its	Executive Summary, Section 7 & 9	The palaeontological sensitivity of the site was assessed via desktop review of the SAHRIS PalaeoMap



Table 1: Checklist for Specialist studies conformance with Appendix 6 of the EIA Regulations of 2014 (as amended).

Requirements of Appendix 6 – GN R326 EIA Regulations of 7 April 2017 (as amended)	The relevant section in the report	Comment where not applicable.
associated structures and infrastructure, inclusive of a site plan identifying site alternatives;		and DFFE National Environmental Screening Tool, and verified by a field-based site investigation conducted on 9 June 2026. No fossiliferous outcrops were identified within the development footprint during the site investigation. A site plan identifying the development footprint is provided in this report (Figure 1).
(g) An identification of any areas to be avoided, including buffers	Executive Summary, Section, 7 & 9	-
(h) A map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers;	Section 5	-
(i) A description of any assumptions made and any uncertainties or gaps in knowledge;	Section 3.1	-
(j) A description of the findings and potential implications of such findings on the impact of the proposed activity, including identified alternatives, on the environment	Executive Summary, Section 7 & 9	-
(k) Any mitigation measures for inclusion in the EMPr	Section 8.8 & 10	-
(l) Any conditions for inclusion in the environmental authorisation	Executive Summary, Section 9	-
(m) Any monitoring requirements for inclusion in the EMPr or environmental authorisation	Executive Summary, Section 8.8 & 10	-



Table 1: Checklist for Specialist studies conformance with Appendix 6 of the EIA Regulations of 2014 (as amended).

Requirements of Appendix 6 – GN R326 EIA Regulations of 7 April 2017 (as amended)	The relevant section in the report	Comment where not applicable.
(n)(i) A reasoned opinion as to whether the proposed activity, activities or portions thereof should be authorised and	Executive Summary, Section 9	-
(n)(iA) A reasoned opinion regarding the acceptability of the proposed activity or activities; and		-
(n)(ii) If the opinion is that the proposed activity, activities or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the EMP, and where applicable, the closure plan	Executive Summary, Section 8.8 & 9	-
(o) A description of any consultation process that was undertaken during the course of carrying out the study	N/A	Not applicable. A public consultation process was handled as part of the Environmental Impact Assessment (EIA) process.
(p) A summary and copies of any comments that were received during any consultation process	N/A	Not applicable. To date, no comments regarding heritage resources that require input from a specialist have been raised.
(q) Any other information requested by the competent authority.	N/A	Not applicable.
(2) Where a government notice by the Minister provides for any protocol or minimum information requirement to be applied to a specialist report, the requirements as indicated in such notice will apply.	Section 3 compliance with SAHRA guidelines	.



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GLOSSARY OF TERMS

Fossil

A fossil is the conserved remains or vestiges of a long-dead organism, typically dating back millions of years. Fossils may consist of mineralised skeletons, shells, or other hard parts of ancient animals and plants, as well as impressions, moulds, and castings that were left in sedimentary rock when the organism's remains decomposed and left an impression. Fossils offer scientists valuable insights into the evolution and biodiversity of ancient species, enabling them to research and comprehend their evolution and biodiversity.

Heritage

That which is inherited and forms part of the National Estate (historical places, objects, fossils as defined by the National Heritage Resources Act No 25 of 1999).

Heritage resources

This means any place or object of cultural significance and can include (but not limited to) as stated under Section 3 of the NHRA,

- 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 natural features of cultural significance.
- geological sites of scientific or cultural importance.
- archaeological and palaeontological sites.
- graves and burial grounds, and
- sites of significance relating to the history of slavery in South Africa.

Palaeontology

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 comprises of fossilised remains or traces of past life.

The term palaeontology derives from the modern Latin palaeontologia, which in turn originates from the Greek words palaios (παλαιός), meaning “ancient,” andontos (ὄντος), meaning “being” or “creature,” combined with the suffix -logia, meaning “study of.” The literal translation is therefore “the study of ancient beings.” In English usage, the British and South African spelling is palaeontology, while the American spelling omits the a after the p, rendering paleontology. In this report the English and South African spelling of Palaeontology will be used.



LIST OF ABBREVIATIONS

amsl	above mean sea level
BA	Basic Assessment
CA	National Competent Authority
CFB	Continental Flood Basalt
CNG	Compressed Natural Gas
DEA	Department of Environmental Affairs
DEAT	Department of Environmental Affairs and Tourism
DFFE	Department of Forestry, Fisheries and the Environment
EA	Environmental Authorisation
EAP	Environmental Assessment Practitioner
ECO	Environmental Control Officer
EMP	Environmental Management Plan
EMPr	Environmental Management Programme
ESO	Environmental Site Officer
ESR	Environmental Scoping Report
GIS	Geographic Information System
GN	Government Notice
GNR	Government Notice Regulation
GPS	Global Positioning System
HDPE	High-Density Polyethylene
HIA	Heritage Impact Assessment
LNG	Liquefied Natural Gas
Ma	Millions of years ago
MMscfd	Million Standard Cubic Feet per Day
MPRDA	Mineral and Petroleum Resources Development Act
NEMA	National Environmental Management Act
NHRA	National Heritage Resources Act
PIA	Palaeontological Impact Assessment
PSA	Pressure Swing Adsorption
PSSA	Palaeontological Society of South Africa
S&EIA	Scoping & Environmental Impact Assessment
SAHRA	South African Heritage Resources Agency
SAHRIS	South African Heritage Resources Information System
ToR	Terms of Reference



1 INTRODUCTION

D3 Energy South Africa (Pty) Ltd ("D3 Energy" or the "Applicant") holds Exploration Right ER315 for hydrocarbons and wishes to convert a portion of this area into a Production Right. Environmental Impact Management Services (Pty) Ltd (EIMS) has been appointed as the Independent Environmental Assessment Practitioner (EAP) to undertake the Scoping and Environmental Impact Assessment (S&EIA) process for the proposed D3 Energy Production Right. Banzai Environmental has, in turn, been commissioned by EIMS to conduct the Palaeontological Impact Assessment (PIA) for the D3 Energy Production Right.

This report focusses on the D3 Energy Production Right application area within the Matjhabeng and Masilonyana Local Municipalities, Free State Province (Figure 1).

1.1 Locality and Project Description

The D3 Energy Production Right application area covers approximately 14 440 hectares within the Matjhabeng and Masilonyana Local Municipalities, Lejweleputswa District Municipality, Free State Province, centred at approximately 28°14'38.37"S, 26°57'54.97"E. The application area is situated in the vicinity of Virginia, Welkom, Hennenman, and Theunissen, and overlaps a portion of D3 Energy's existing Exploration Right (ER315) area (EIMS 2026). The locality of the production right application area is shown in Figure 1.

Table 2: Description of the components of the proposed project

COMPONENT	DESCRIPTION
Production Wells	
Number of Production Wells	Up to 43 production wells, comprising 13 new well locations and 3 existing wells on the Virginia faultline (initial development focus), and a further 27 well locations on the Ventersburg faultline to be drilled as required to maintain the required sales production.
Well Depth	Up to approximately 600 m.
Drilling Activities	- Pre-drilling seismic and/or audio magnetotelluric surveys to optimise well locations for maximum deliverability. - Drilling and completion of wells, followed by ongoing maintenance workovers as required.
Well and Infrastructure Siting	Production wells, gas gathering pipelines and processing plant infrastructure to be located in consultation with landowners and other stakeholders, close to existing fence lines and farm roads/tracks where practically possible, and not in close proximity to housing and major structures.
Gas Gathering and Processing Infrastructure	
Gas Gathering Pipelines	A network of gas gathering pipelines connecting production wells to the central processing facility; pipeline routes designed to minimise



Table 2: Description of the components of the proposed project

COMPONENT	DESCRIPTION
	pipeline length and pressure loss while maintaining required distances from landowner and environmental constraints.
Gas Compression	Provision for field nodal compression, powered by gas in the pipeline, should actual flow rates and pressures differ from the modelling and nodal compression be required. The pipeline network has been designed around a single gas and helium processing plant within the project area to reduce the requirement for nodal compression and the associated environmental footprint.
Helium Recovery and Gas Processing Plant	- A single helium recovery facility (gas or liquid helium) and gas (methane) processing plant (CNG and/or LNG), with an approximate capacity of 3.0 Million Standard Cubic Feet per Day (MMscfd). - Modular-based facility design comprising inlet compression, pretreatment, single-stage membrane separation, Pressure Swing Adsorption (PSA) boost compression, vacuum PSA purification, and helium sales compression and/or liquefaction.
Associated Infrastructure	
Office and Maintenance Workshop	A multipurpose facility to be constructed beside the helium and gas processing facilities, comprising an office for field staff, plant and equipment storage, maintenance facilities, and a storage warehouse, with provision for storage of consumables and spares. During the initial construction phase the facility will also be used to store larger construction equipment, well casing/tubulars, and HDPE pipes.
Roads and Site Access	- Existing roads and tracks to be used wherever possible for well and plant access, upgraded where required due to increased traffic or wet-weather access. - Where access is not available, new access tracks approximately 3,5 m wide will be created and rehabilitated at the end of production.
Water Requirements	- A maximum of 70 000 litres of water per production well (to a depth of approximately 600 m) is required for drilling operations. - Potable water to be obtained locally, by agreement with landowners or the local municipality, in accordance with relevant legal requirements.
Waste Management	- General waste (domestic solid waste, scrap metal, construction waste) to be temporarily stored on site and removed by an approved, licensed waste contractor for disposal at a registered general waste disposal facility. - Hazardous waste (used oil and filters, diesel, lubricants, and grease) to be stored in clearly marked skip bins/containers on a hard, impervious surface, and collected by a licensed contractor for safe disposal or recycling. - Drilling waste (wastewater and drilling mud) to be stored in lined aboveground tanks adjacent to the drill rig for no more than 90 days before removal and disposal at an appropriately licensed waste disposal facility.
Workforce and Accommodation	- The majority of construction workers are expected to be based in the local towns of Welkom, Virginia, and surrounds; specialised non-local contractors will be engaged only where suitably skilled local contractors are not available. - Estimated employment associated with the D3 Energy Production Right (per EIMS review comment) is as follows: Exploration Phase –



Table 2: Description of the components of the proposed project

COMPONENT	DESCRIPTION
	6 permanent and 8 temporary positions; Construction Phase – 30 permanent and 123 temporary positions; Operational Phase – 44 permanent and 30 temporary positions; Closure Phase – 10 permanent and 20 temporary positions.
Construction Period and Project Timeline	- Major construction activities are expected to occur during the initial 5 years of the development, comprising three components: production well drilling, the gas gathering network, and processing plant construction. - An initial multi-well drilling campaign of approximately 15 wells is planned during 2027 and a further 15 wells during 2028; the gas (CNG) and helium separation plant is planned to be ready to accept gas by early 2028. Remaining wells on the Ventersburg faultline will be drilled as required to maintain the required sales production.
Operational Period	The D3 Energy Production Right area has an expected operational life of at least 30 years.
Decommissioning and Closure	To be undertaken in accordance with a rehabilitation, decommissioning and closure plan prepared in terms of the NEMA Financial Provision Regulations (GNR 1147, 2015), aiming to restore affected land to a condition as close as possible to its pre-production state, including the safe sealing/grouting of wells, reshaping of landforms, and re-vegetation.

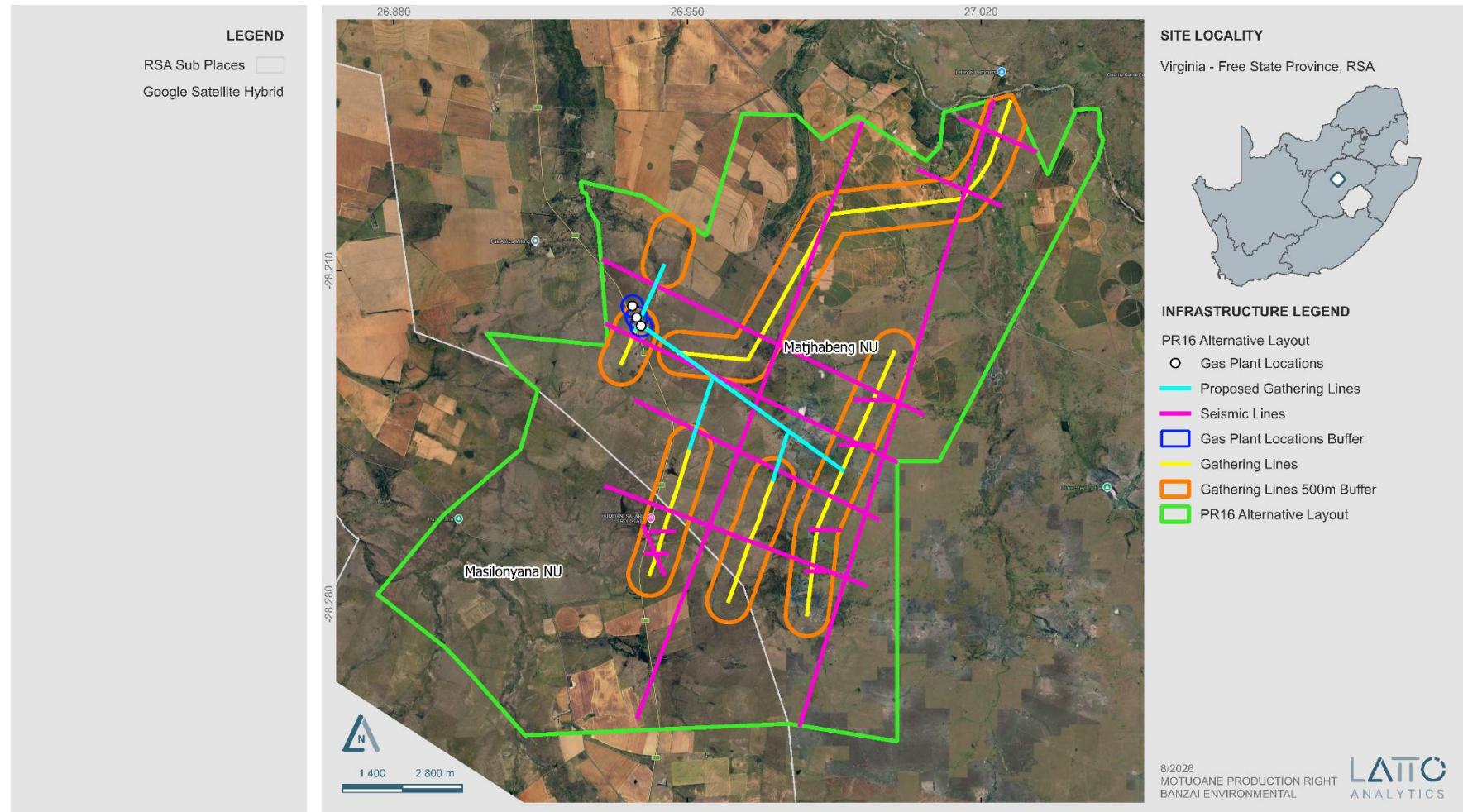


Figure 1: Locality of the D3 Energy Production Right application area within the Matjhabeng and Masilonyana Local Municipalities, Free State Province.



2 SPECIALIST CREDENTIALS

This study has been conducted by Mrs Elize Butler, palaeontologist of Banzai Environmental (Pty) Ltd. She has conducted approximately 900 palaeontological impact assessments for developments in the Free State, KwaZulu-Natal, Eastern, Western, and Northern Cape, Northwest, Gauteng, Limpopo, and Mpumalanga. She has an MSc (*cum laude*) in Zoology (specializing in Palaeontology) from the University of the Free State, South Africa and has been working in Palaeontology for more than thirty years. She has experience in locating, collecting, and curating fossils, including exploration field trips in search of new localities in the Karoo Basin. She has been a member of the Palaeontological Society of South Africa (PSSA) since 2006 and has been conducting PIAs since 2014.

A detailed Curriculum Vitae is provided in **Appendix 2**, and the Specialist Declaration of Independence is included in **Appendix 3** of this report.

3 TERMS OF REFERENCE

This field-based PIA assesses the potential impacts of the proposed development on fossil heritage. This study forms part of the Heritage Impact Assessment Report. According to the “SAHRA Archaeology, Palaeontology and Meteorites (APM) Guidelines: Minimum Standards for the Archaeological and Palaeontological Components of Impact Assessment Reports” the purpose of the PIA is: 1) to identify the palaeontological importance of the rock formations in the footprint; 2) to evaluate the palaeontological magnitude of the formations; 3) to clarify the impact on fossil heritage; and 4) to suggest how the developer might protect and lessen possible damage to fossil heritage.

The palaeontological status of each rock section is calculated, as well as the possible impact of the development on fossil heritage by a) the palaeontological importance of the rocks, b) the type of development and c) the quantity of bedrock removed.

All possible information was consulted to compile a scoping specialist input report, which included the following: DFFE Screening Tool, SAHRIS Palaeosensitivity map, all Palaeontological Impact Assessment reports in the same area; aerial photos and Google Earth images, topographical and geological maps as well as scientific articles of specimens from the development area and Assemblage Zones. A field-based assessment is necessary when the development footprint has a Very High to High paleontological sensitivity. The desktop and the field survey of the exposed rock determine the impact significance of the planned development, and recommendations for further studies or mitigation are made. Destructive impacts on palaeontological heritage usually only occur during the construction phase, while the excavations will change the current topography and destroy or permanently seal in fossils at or below the ground surface. Fossil Heritage will then no longer be accessible for scientific research.



During a site investigation, the palaeontologist surveys the development and tries to determine the density and diversity of fossils in the development area. The palaeontological heritage field research concentrated on analysing certain potentially fossil-rich locations, notably those with good Beaufort Group mudrock exposure. These locations were **predominantly situated along drainage lines, erosion features, gullies, and hillslopes. Documenting all, or even a substantial fraction, of fossil sites within such an extensive region over a limited period of fieldwork is impractical.**

Rock exposures that are investigated usually contain a large portion of the stratigraphic unit, can be accessed easily and comprise of unweathered (fresh) exposed rock. These exposures may be natural (rocky outcrops in streams or riverbanks, cliffs, dongas) but could also be artificial (quarries, open building excavations, and even railway and road cuttings). It is common practice for palaeontologists to log well-preserved fossils (GPS, and stratigraphic data) during field assessment studies.

Mitigation usually precedes construction or may occur during construction when potentially fossiliferous bedrock is exposed. **Mitigation comprises the collection and recording of fossils.** Preceding excavation of any fossils, a permit from SAHRA must be obtained, and the material will have to be housed in a SAHRA approved fossil repository. When mitigation is applied correctly, a **positive impact** is possible as **knowledge of local palaeontological heritage may be increased.**

The fossil potential of the development area was determined by criss-crossing the development footprint and physically investigating bedrock outcrops to determine the lithology and fossil content of the outcrops. Fossils occurring at the surface are very unpredictable, and a representative sample size of the area has been investigated. However, it is important to note that the absence of fossils in a development footprint does not necessarily mean that palaeontological significant material is not present on site (on or beneath ground surface).

The terms of reference of a PIA are as follows:

General Requirements:

- Adherence to the content requirements for specialist reports in accordance with Appendix 6 of the EIA Regulations 2014, as amended,
- Adherence to all applicable best practice recommendations, appropriate legislation and authority requirements,
- Submit a comprehensive overview of all appropriate legislation, guidelines,
- Description of the proposed project and provide information regarding the developer and consultant who commissioned the study,
- Description and location of the proposed development and provide geological and topographical maps,
- Provide palaeontological and geological history of the affected area,



- Identification of sensitive areas to be avoided (providing shapefiles/kmls) in the proposed development,
- Evaluation of the significance of the planned development during the Pre-construction, Construction, Operation, Decommissioning Phases and Cumulative impacts. Potential impacts should be rated in terms of the direct, indirect and cumulative:
 - a. **Direct impacts** are impacts that are caused directly by the activity and generally occur at the same time and at the place of the activity.
 - b. **Indirect impacts** of an activity are indirect or induced changes that may occur as a result of the activity.
 - c. **Cumulative impacts** are impacts that result from the incremental impact of the proposed activity on a common resource when added to the impacts of other past, present or reasonably foreseeable future activities.
- Fair assessment of alternatives (infrastructure alternatives have been provided):
- Recommend mitigation measures to minimise the impact of the proposed development and
- Implications of specialist findings for the proposed development (such as permits, licenses etc).

3.1 Assumptions and Limitations

The focal point of geological maps is the geology of the area, and the sheet explanations of the Geological Maps were not meant to focus on palaeontological heritage. Many inaccessible regions of South Africa have never been reviewed by palaeontologists, and data is generally based on aerial photographs alone. Locality and geological information of museums and universities databases have not been kept up to date and data collected in the past have not always been accurately documented.

Comparable Assemblage Zones in other areas are also used to provide information on the existence of fossils in an area that has not been documented. It is generally assumed that exposed fossil heritage is present within the footprint when using similar Assemblage Zones and geological formations for Desktop studies. The **field assessment** (conducted for this report) will thus improve the accuracy of a desktop assessment. Access to the relevant farms was freely available and it was possible to investigate all areas deemed necessary for the satisfactory completion of the study.

4 LEGAL REQUIREMENTS AND GUIDELINES

Cultural Heritage in South Africa, includes all heritage resources, is protected by the National Heritage Resources Act, 1999 (Act No. 25 of 1999) (NHRA). Heritage resources as defined in Section 3 of the Act include **“all objects recovered from the soil or waters of South Africa, including archaeological and palaeontological objects and material, meteorites and rare geological specimens”**.

The identification, evaluation and assessment of any cultural heritage site, artefact or finds in the South



African context is required and governed by the following legislation:

- National Environmental Management Act, (NEMA), 1998 (Act No. 107 of 1998)
- National Heritage Resources Act (NHRA), 1999 (Act No. 25 of 1999)
- Minerals and Petroleum Resources Development Act (MPRDA), 2002 (Act No. 28 of 2002)
- Notice 320 of the Government Gazette 43110- general requirements for undertaking an initial site sensitivity verification where no specific assessment protocol has been identified.

The next section in each Act is directly applicable to the identification, assessment, and evaluation of cultural heritage resources.

GNR 326 (Government Gazette 38282, 14 December 2014) promulgated under the NEMA Act 107 of 1998

- Basic Assessment Report (BAR) – Regulations 19 and 23
- Environmental Impacts Assessment (EIA) – Regulation 23
- Environmental Scoping Report (ESR) – Regulation 21
- Environmental Management Programme (EMPr) – Regulations 19 and 23

NHRA

- Protection of Heritage Resources – Sections 34 to 36
- Heritage Resources Management – Section 38

MPRDA Regulations of 2014

Environmental reports to be compiled for application of mining right – Regulation 48

- Contents of scoping report – Regulation 49
- Contents of environmental impact assessment report – Regulation 50
- Environmental management programme – Regulation 51
- Environmental management plan – Regulation 52

The NEMA states that an integrated EMP should (23:2 (b)) “...identify, predict and evaluate the actual and potential impact on the environment, socio-economic conditions and cultural heritage”.

In agreement with legislative requirements, EIA rating standards as well as SAHRA policies the following comprehensive and legally compatible PIA report have been compiled.

Palaeontological heritage is exceptional and non-renewable and is protected by the NHRA. Palaeontological resources may not be unearthed, broken, moved, or destroyed by any development without prior assessment and without a permit from the relevant heritage resources authority as per section 35 of the NHRA.



This Palaeontological Impact Assessment forms part of the Heritage Impact Assessment (HIA) and adhere to the conditions of the Act. According to Section 38 (1), an HIA is required to assess any potential impacts to palaeontological heritage within the development footprint where:

- the construction of a road, wall, power line, pipeline, canal or other similar form of linear development or barrier exceeding 300 m in length.
- the construction of a bridge or similar structure exceeding 50 m in length.
- any development or other activity which will change the character of a site—
- Exceeding 5 000 m² in extent; or
- involving three or more existing erven or subdivisions thereof; or
- involving three or more erven or divisions thereof which have been consolidated within the past five years; or
- the costs of which will exceed a sum set in terms of regulations by SAHRA or a provincial heritage resources authority
- the re-zoning of a site exceeding 10 000 m² in extent.
- or any other category of development provided for in regulations by SAHRA or a Provincial heritage resources authority.

5 DESCRIPTION OF THE RECEIVING ENVIRONMENT

The D3 Energy Production Right application area is situated within the Matjhabeng and Masilonyana Local Municipalities, Free State Province, southeast of Welkom and southeast of Virginia. The topography of the greater study area is generally flat to gently undulating, becoming more undulating and hillier towards the east, and can be classified as a lowland with hills; prominent dolerite intrusions give rise to locally resistant, high-standing topographic features (EIMS 2026). Elevations across the wider study area range from approximately 1260 m amsl in low-lying drainage areas to approximately 1695 m amsl along the southern watershed, with gentle to moderate on-site gradients. The mean annual precipitation for the area is estimated at approximately 536 mm/a, and the mean annual temperature is approximately 18.8°C (EIMS 2026). The footprint overlaps the Vaal-Vet Sandy Grassland, Central Free State Grassland, Highveld Alluvial Vegetation, and Winburg Grassy Shrubland vegetation types (Mucina and Rutherford, 2010), which are dominated by Highveld sour grassveld species with scattered low shrubs; surface exposure of bedrock is consequently limited, being largely confined to drainage lines, erosion gullies, and disturbed ground such as existing well pads and access roads.

A field-based palaeontological site investigation of the D3 Energy Production Right application area was conducted on 9 June 2026. Representative site photographs illustrating ground conditions, surface cover, and the absence of fossiliferous outcrops within the footprint are presented in Section 7.



5.1 Geological overview of the Proposed Project

The geology of the D3 Energy Production Right application area near Virginia, in the Free State, is depicted on the 1:250 000 Winburg 2826 (1998) Geological Map (Council for Geoscience, Pretoria) (**Figure 2**). The D3 Energy footprint is underlain by Quaternary sands and alluvium (Qs, yellow), unfossiliferous Jurassic dolerite (Jd, red), and the Adelaide Subgroup (Pa, Beaufort Group, Karoo Supergroup). On this map sheet the Beaufort Group is mapped only at subgroup level, as the Adelaide Subgroup (Pa) and the overlying Tarkastad Subgroup (Tt), without further formation-level subdivision. The wider map sheet also depicts, in ascending stratigraphic order, the Tierberg Formation of the Eccia Group (Pt); the Triassic Molteno (Trm), Elliot (Tre) and Clarens (Trc) Formations; and the Jurassic Drakensberg Formation lavas (Jdb), together with intrusive Jurassic dolerite (Jd) and, in the south-west of the sheet, Ventersdorp Supergroup basement of the Platberg Group (Rietgat and Makwassie Formations) (Council for Geoscience, 1998). The PalaeoMap of the South African Heritage Resources Information System (SAHRIS) (**Figure 4, Table 5**) indicates that the Palaeontological Sensitivity of the Adelaide Subgroup is **Very High (red)**, that of the Quaternary sediments is **Moderate (green)**, while the Palaeontological Sensitivity of the Jurassic dolerite is **Zero (grey)** (Almond and Pether, 2008; Almond et al., 2013; Groenewald et al., 2019). The proposed footprint is classified as having a **Very High Palaeontology Theme Sensitivity** in the Department of Forestry, Fisheries and the Environment (DFFE) National Web-Based Screening Tool (**Figure 5**).

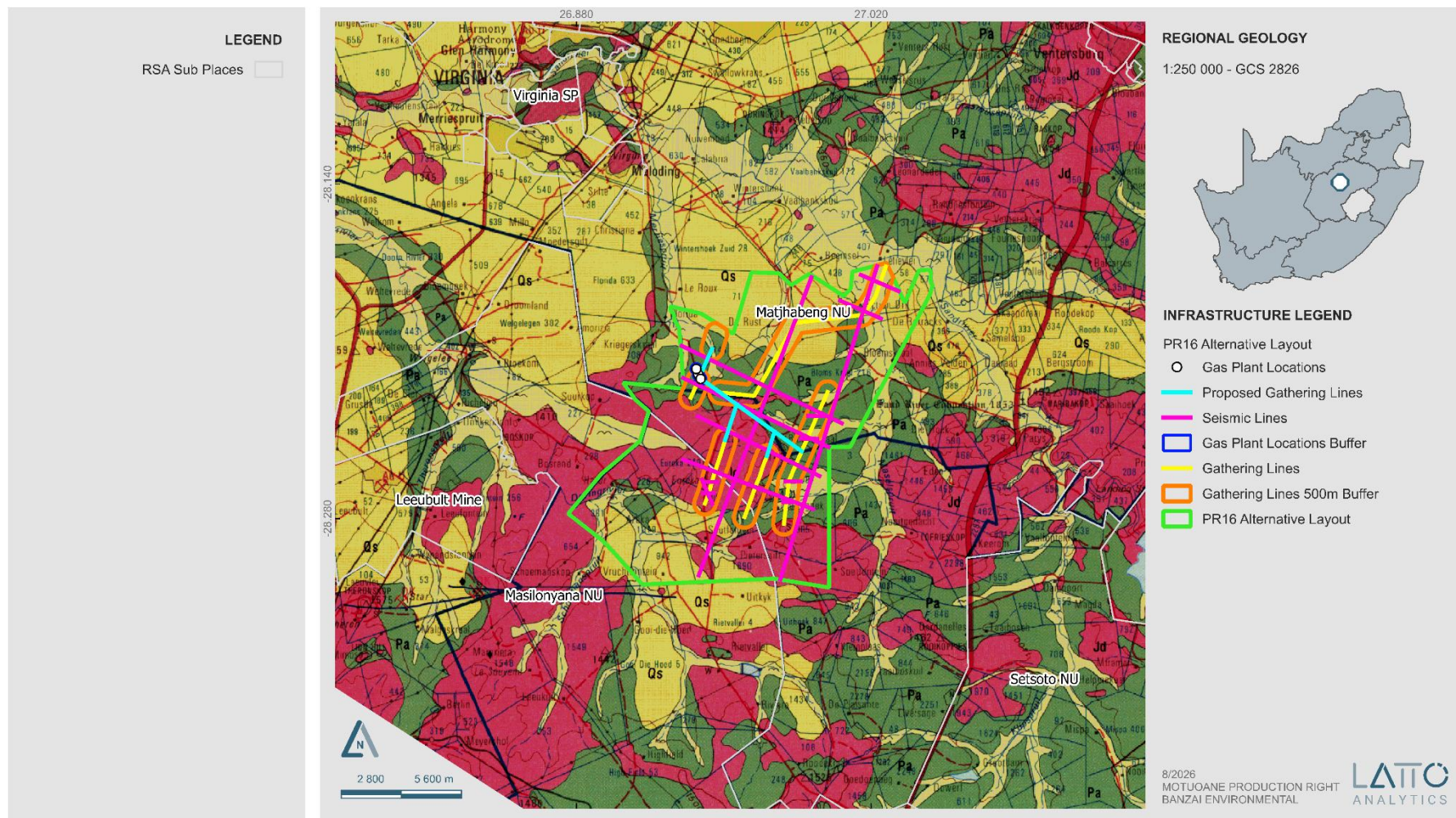


Figure 2: Extract of the 1:250 000 Winburg 2826 (1998) Geological Map (Council for Geoscience, Pretoria) indicating the geology of the D3 Energy Production Right application area. The footprint is underlain by the Adelaide Subgroup (Pa, Beaufort Group, Karoo Supergroup), Quaternary sands and alluvium (Qs, yellow), and unfossiliferous Jurassic dolerite (Jd, red).



The Jurassic dolerite present in the development forms part of the Karoo Igneous Province, one of the world's classic continental flood basalt (CFB) provinces. This Suite was formed approximately 183 million years ago (Early Jurassic, Toarcian) and consists of intrusive and extrusive rocks that occur over a large area (Duncan and Marsh, 2006). Generally, the flood basalts do not contribute to prominent volcanic structures but instead are formed by successive eruptions from a set of fissures that form sub-horizontal lava flows (sills and dikes) varying in thickness. This lava caps the landscape on which they erupted. As the Karoo is an old flood basalt province it is today preserved as erosional fragments of a more extensive lava cap that covered much of southern Africa in the geological past. It is estimated that the Karoo lava outcrop currently covering at least 140 000 km², was larger in the past [$\sim 2\,000\,000\text{ km}^2$ (Cox 1970, 1972)]. The Karoo Igneous Province can be divided into the Lebombo and the Drakensberg Groups (Table 4). The Igneous Province contains a large volume of flood basalts as well as silicic volcanic rocks. These units consist of rhyodacite and rhyolitic magma and crop out along the Lebombo monocline. Individual units span up to 60 km and sometimes show massive pyroclastic structures and are thus classified as rheoignimbrites. The basal lava flows typically overlie the Clarens Formation (Upper Karoo Supergroup). In some regions, erosional unconformities are observed prior to volcanism. Early interactions of magma with groundwater produced phreatomagmatic and volcaniclastic deposits (Lock et al., 1974), while evidence of aqueous environments during eruption is provided by the occurrence of pillow lavas, hyaloclastite breccias, and interbedded fluviatile sandstones in basal volcanic units (Eales et al., 1984).

Table 3: Formal stratigraphic units of the Karoo Igneous Province

Group	Formation	Dominant Rock Type(s)	Notes
Drakensberg Group	Lesotho	Basalt	Main flood basalts in Lesotho, Free State, Eastern Cape
	Barkly East	Basalt	Upper basalt flows, preserved in Eastern Cape uplands
Lebombo Group	Movene	Basalt	Lower flows of the Lebombo Monocline
	Mbuluzi	Rhyolite	Silicic volcanic unit
	Jozini	Rhyodacite	Silicic volcanic unit
	Sabie River	Basalt	Preserved along Sabie River valley
	Letaba	Picritic basalt	Mg-rich basalts, often at the base



Group	Formation	Dominant Rock Type(s)	Notes
	Mashikiri	Nephelinite	Localised alkaline volcanic centres

The Beaufort Group floodplains are internationally renowned for recording the early diversification of land vertebrates and provide one of the world's most complete evolutionary transitions from early "reptiles" to mammals. The Beaufort Group, the third major subdivision of the Karoo Supergroup, overlies the Ecca Group and consists mostly of mudrocks alternating with sandstones, deposited from the Middle Permian to the Early Triassic (Johnson et al., 2006). The Group is subdivided into the Adelaide Subgroup and the overlying Tarkastad Subgroup, with biostratigraphic assemblage zones erected on faunal content (Figure 3; Rubidge, 1995; Smith et al., 2020). In the D3 Energy study area, the succession is represented by the Adelaide Subgroup, within which the Daptocephalus Assemblage Zone (DaAZ) is recognised. The DaAZ is characterised by the dicynodont Daptocephalus leoniceps, with associated taxa including the therocephalian Theriognathus microps and the cynodont Procynosuchus delaharpeae (Smith et al., 2020). This zone records peak vertebrate diversity in the Beaufort Group, with dicynodonts, gorgonopsians, therocephalians and cynodonts well represented, alongside less common reptiles, amphibians, fishes and *Glossopteris* plant fossils (Smith et al., 2020). The DaAZ extends through the upper part of the Normandien Formation—the undifferentiated equivalent, in this part of the basin, of the uppermost Oudeberg Member up through the Daggaboersnek, Ripplemead, Elandsberg and lower Palingkloof members of the Balfour Formation recognised further south (Viglietti, 2020; Johnson et al., 2006) and directly precedes the Permo–Triassic boundary, one of the most significant extinction events in Earth history (Smith et al., 2020).



Age	Gp	West of 24° E		East of 24° E	Free State / KwaZulu-Natal	Vertebrate Assemblage Zones	Vertebrate Subzones
JURASSIC	STORMBERG			Drakensberg Gp	Drakensberg Gp	Massospondylus	
				Clarens Fm	Clarens Fm		
				upper Elliot Fm	upper Elliot Fm		
				lower Elliot Fm	lower Elliot Fm	Scalenodontoides	
TRIASSIC	Tarkastad Subgp			Molteno Fm	Molteno Fm	Cynognathus	Cricodon-Ufudocyclops
				Burgersdorp Fm	Driekoppen Fm		Trirachodon-Kannemeyeria
							Langbergia-Gargainia
				Katberg Fm	Verkykerskop Fm	Lystrosaurus declivis	
				Palingkloof M.		Daptocephalus	
				Elandsberg M.	Harrismith M.		Lystrosaurus maccaigi-Moschorhinus
				Ripplemead M.	Schoondraai M.		
				Daggaboersnek M.	Rooinekke M.		Dicynodon-Theriongnathus
				Oudeberg M.	Frankfort M.		
						Cistecephalus	
PERMIAN	BEAUFORT	Adelaide Subgp	Teekloof Fm	Steenkampsvlakte M.		Endothiodon	Tropidostoma-Gorgonops
				Oukloof M.			Lycosuchus-Eumotosaurus
				Hoedemaker M.	Middleton Fm	Tapinocephalus	Diictodon-Styracocephalus
				Poortjie M.			Eosimops-Glanosuchus
				Abrahamskraal Fm	Koonap Fm	Eodicynodon	
				Waterford Fm	Waterford Fm		
				Tierberg/Fort Brown	Fort Brown		

Figure 3: Generalised biostratigraphy of the Beaufort Group (Adelaide and Tarkastad subgroups) of the Karoo Supergroup, showing vertebrate assemblage zones recognised west and east of 24°E and in the Free State/KwaZulu-Natal region (after Rubidge, 1995). The D3 Energy study area falls within the Daptocephalus Assemblage Zone.

The Permo–Triassic boundary extinction event is succeeded by the *Lystrosaurus declivis* Assemblage Zone of the overlying Tarkastad Subgroup—represented in this area by the Driekoppen Formation, equivalent to the Katberg/Burgersdorp Formations further south (Groenewald 1989, in Johnson et al., 2006), which signifies the recovery interval following this event and is characterised by the predominance of the dicynodont *Lystrosaurus* and the reptile *Procolophon*, while taxa such as gorgonopsians and biarmosuchians became extinct (Smith et al. 2020). In the south, the Tarkastad Subgroup comprises a lower, sandstone-dominated Katberg Formation and an upper, mudstone-dominated Burgersdorp Formation; in this north-eastern part of the basin these are instead represented by the Verkykerskop Formation (lower, sandstone-rich) and the Driekoppen Formation (upper, almost entirely mudstone) (Groenewald 1989, in Johnson et al., 2006); sandstones are moderately sorted, fine- to medium-grained and crossbedded, while the mudstones are predominantly red in colour, with greenish-grey mudstone also present (Johnson et al., 2006). The *Lystrosaurus declivis* Assemblage Zone spans the upper part of the Normandien Formation and the overlying Driekoppen Formation—equivalent to the upper Palingkloof Member of the Balfour Formation and the overlying Katberg Formation further south and is of particular



significance as it records the survival and recovery of terrestrial vertebrates from the end-Permian mass extinction (Smith et al., 2020).

Two species dominate the *Lystrosaurus declivis* Assemblage Zone, namely the small to medium-sized herbivorous dicynodonts *Lystrosaurus murrayi* and *Lystrosaurus declivis*. Smaller, less common insectivorous and faunivorous taxa are also represented, including the cynodonts *Galesaurus*, *Platycraniellus* and *Thrinaxodon*, the therocephalians *Olivierosuchus*, *Promoschorhynchus* and *Regisaurus*, small parareptiles such as *Procolophon*, and the larger carnivores *Moschorhinus* and *Proterosuchus*. Vertebrate fossils of this zone are mostly found in mudrock units between channel sandstones, with well-preserved, often articulated skull and skeleton material, including burrow casts (Day, 2013).

The Cenozoic superficial deposits are the youngest geological units, formed during the last ~2.6 million years. These mostly unconsolidated sediments—clay, sand, silt, and gravel—occur as thin, discontinuous patches and include channel, floodplain, and stream deposits. Palaeoclimatic fluctuations during the Cenozoic, and especially the Quaternary (last 1.8 Ma), influenced river flow, sedimentation, and vegetation patterns (Hunter et al., 2006; Maud, 2012; Barnosky, 2005; Tooth et al., 2004). Fossil assemblages in these deposits are generally rare and low in diversity but can include mammalian teeth, bones, horn cores, reptile skeletons, ostrich eggshell fragments, microfossils, non-marine mollusc shells, plant material (foliage, wood, pollen, peats), and trace fossils such as vertebrate tracks, burrows, termite mounds, and rhizoliths (Barnosky, 2005; Tooth et al., 2004). Partially calcretised older alluvium often overlies dolerite intrusions, while gravelly colluvial and eluvial deposits mantle low-relief hillslopes and plateaus across the Free State interior.

The Quaternary Era is also known as the “Age of the Mammals” and is preserved on coastal plains (Langebaanweg), cave systems (Makapan), and river gravel terraces (Cornelia), as well as other basins. These deposits have been subdivided in six African Land Mammal Ages, namely Recent, Florisian, Cornelian, Makapanian, Langebaanian, and Namibian (MacRae, 1999). Quaternary deposits best known in the Free State is the Florisbad and Cornelia localities. Fossils recovered from these sites include teeth and bones of mammals, fish, reptiles, freshwater mollusks, trace fossils, wood, rhizoliths and diatom floras (Groenewald and Groenewald, 2014).

The Virginia/Welkom District is known for the presence of fluvial deposits along the present river courses that are terrestrial sediments and includes diatomite (diatom deposits), calcareous tufa, pedocretes, peats, spring deposits, soils and gravel and other Tertiary calcrete deposits, that is very important for understanding the Early and Late Pliocene period in this region (De Ruiter et al., 2010). The late Cenozoic (Plio-Pleistocene) floodplain deposits (overbank sediments) found near the Sand, Doring-, Vals- and Vet River systems including pan sites, contain confined but abundant mammal vertebrate fossil sites. In 1955, Meiring, described an in situ proboscidian fossil (mammoth), comprising of a lower molar, large part of a tusk as well as a proximal portion of an ulna from the Sand River near Virginia. This specimen



was found in pebbly channel-fill sediments about 40m above the current riverbed. Originally described as *Archidiskodon scotti* (Meiring, 1955) this specimen was later assigned to the Pliocene species *Mammuthus subplanifrons* (Coppens et al., 1978). Later investigations uncovered diverse fauna that include amphibians, birds, fish, reptiles, as well as several proboscideans, perissodactyls and artiodactyls from the same site (De Ruiter et al., 2010).

Terrace gravels above the Vet River, southwest of Welkom have uncovered Pliocene fossils while surveys along the Doring, Vals, Sand and Vet Rivers produced moderately fossiliferous overbank sediments and erosional gullies that comprise of a variety of Quaternary-aged mammals (Brink et al., 1999; De Ruiter et al., 2011). Ancient pan sites, for example near Whites, produced rich Quaternary-aged mammal fossil remains. Quaternary fossils are usually very rare but may also include mammalian teeth and bone, ostrich eggshells, tortoise remains, ostracods, diatoms, and reptilian skeletons; trace fossils include burrows, vertebrate tracks, rhizoliths as well as calcretised termitaria (termite heaps). Plant remains include foliage, peat, wood, and pollens. Microfossils and vertebrate remains are often found in Quaternary deposits near water courses and drainage lines.

5.2 Palaeontological Sensitivity of the Proposed Site

The SAHRIS PalaeoMap (Figure 4, Table 5) indicates that the D3 Energy Production Right application area is underlain by sediments with a Very High (red), Moderate (green), and Zero (grey) Palaeontological Sensitivity, corresponding respectively to the Adelaide Subgroup, the Quaternary sands and alluvium, and the Jurassic dolerite. The DFFE National Web-Based Screening Tool (Figure 5) similarly indicates a Very High Palaeontology Theme Sensitivity for the footprint. The Very High Palaeontological Sensitivity of the SAHRIS PalaeoMap thus corresponds with the Very High rating of the DFFE Screening Tool. A field-based site investigation was conducted for this Project on 9 June 2026 (Section 7).

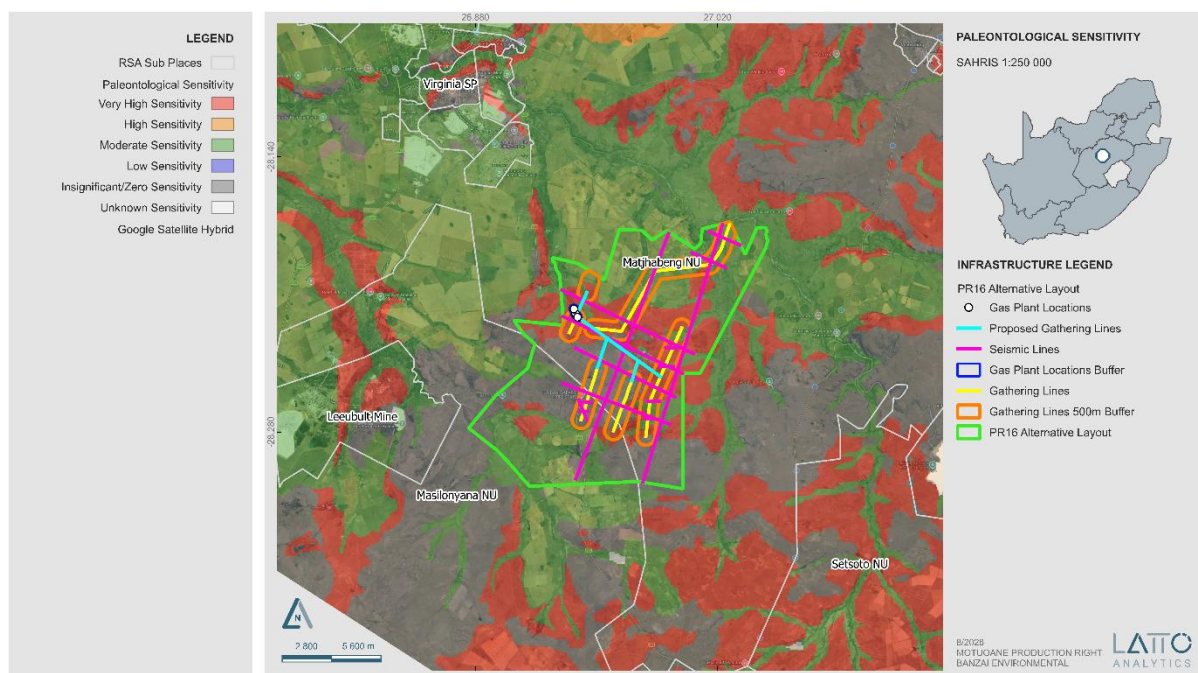
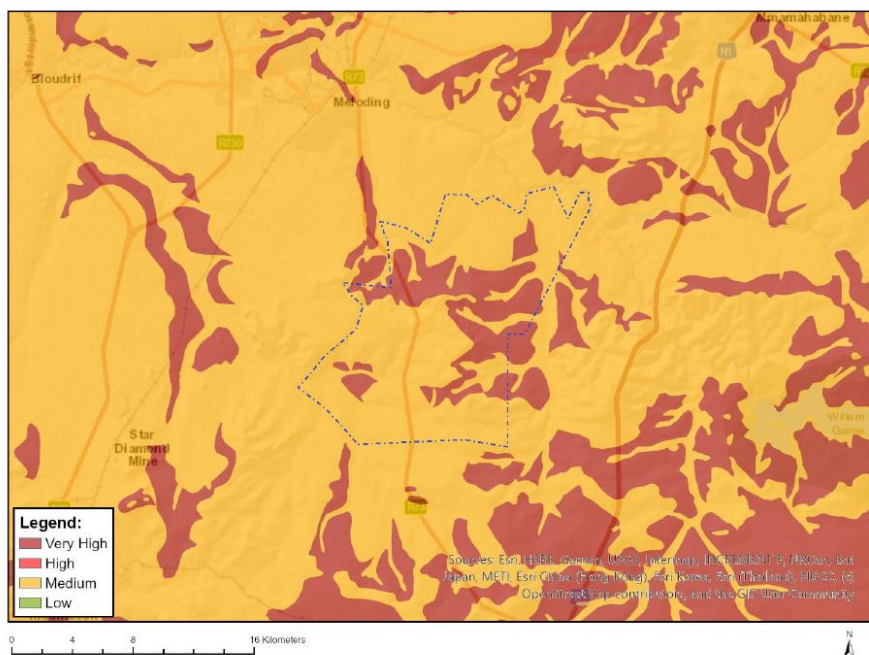


Figure 4: Extract from the SAHRIS PalaeoMap (South African Heritage Resources Information System) showing the Palaeontological Sensitivity of the D3 Energy Production Right application area. The footprint is rated Very High (red, Adelaide Subgroup), Moderate (green, Quaternary sediments) and Zero (grey, Jurassic dolerite).

Table 4: Palaeontological Sensitivity according to the SAHRIS PalaeoMap (Almond et al, 2013; SAHRIS website)		
Colour	Sensitivity	Required Action
RED	VERY HIGH	Field assessment and protocol for finds is required
ORANGE/YELLOW	HIGH	Desktop study is required and based on the outcome of the desktop study; a field assessment is likely
GREEN	MODERATE	Desktop study is required
BLUE	LOW	No palaeontological studies are required however a protocol for finds is required
GREY	INSIGNIFICANT/ZERO	No palaeontological studies are required
WHITE/CLEAR	UNKNOWN	These areas will require a minimum of a desktop study. As more information comes to light, SAHRA will continue to populate the map.

MAP OF RELATIVE PALEONTOLOGY THEME SENSITIVITY



Very High sensitivity	High sensitivity	Medium sensitivity	Low sensitivity
X			

Sensitivity Features:

Sensitivity	Feature(s)
Medium	Features with a Medium paleontological sensitivity
Very High	Features with a Very High paleontological sensitivity

Figure 5: Extract from the DFFE National Web-Based Environmental Screening Tool report for the D3 Energy Production Right application area, indicating a Very High Palaeontology Theme Sensitivity for the footprint.

Based on the desktop assessment, supported by the findings of the field-based site investigation conducted on 9 June 2026 (Section 7), it is concluded that the Adelaide Subgroup underlying the D3 Energy footprint carries a Very High potential for fossil heritage of scientific and conservational interest, while the overlying Quaternary sediments carry a Moderate potential and the Jurassic dolerite is unfossiliferous (Zero). No fossiliferous outcrops or exposed bedrock were identified during the site investigation; this is consistent with the generally poor surface exposure of the Adelaide Subgroup within the footprint and does not preclude the presence of fossil material at depth. Should fossil material be exposed during clearing or excavation, the Chance Find Protocol (Section 10 of this report) must be implemented immediately. The recommendations of this report should be incorporated into the project Environmental Management Programme (EMPr).

6 ADDITIONAL INFORMATION CONSULTED

In compiling this report the following sources were consulted:



- Geological map 1:100 000, Geology of the Republic of South Africa (Visser 1984)
- 1: 50 000 scale topographic maps.
- Palaeosensitivity map on SAHRIS (South African Heritage Resources Information System) website.
- DFFE Screening tool of the study area
- A Google Earth kmz files and background information on the proposed development was supplied by EIMS, as received from the developer, namely, D3 Energy South Africa (Pty) Ltd.
- 1:250 000 Winburg 2826 (1998) Geological Map (Council for Geoscience, Pretoria), covering the D3 Energy Production Right application area.

The geological and palaeontological context of the Adelaide Subgroup (Beaufort Group, Karoo Supergroup) in this part of the Free State Province was instead assessed with reference to the published geological literature, the SAHRIS PalaeoMap, and the DFFE National Web-Based Screening Tool, as set out in Section 5 above, and verified by a field-based site investigation conducted on 9 June 2026, as set out further in the Site Visit section below.

7 SITE VISIT

A field-based palaeontological site investigation was conducted on 9 June 2026 by Banzai Environmental, comprising a walkdown and motor vehicle survey of the D3 Energy Production Right application footprint to verify the desktop-based palaeontological sensitivity assessment presented in Section 5. No fossiliferous outcrops, in situ fossil material, or significant exposures of the Adelaide Subgroup bedrock were identified within the footprint during the site investigation. The ground surface across the study area is predominantly covered by grassland (bossieveld), cultivated (maize) land, and superficial soil, limiting surface exposure (Figures 6 to 9). These site investigation findings are consistent with, and support, the desktop-based assessment presented above.



Figure 6: Banzai Environmental site identification signage at a field verification point within the application footprint (GPS: -28.234047, 26.992597).



Figure 7: Site access track and signage at a verified survey point, showing dry grassland cover with no exposed outcrops (GPS: -28.221001, 27.024429).



Figure 8: Low-relief grassland (bossieveld) terrain typical of the footprint, with soil and grass cover and no rock outcrops or fossil material observed (GPS: -28.232464, 26.998614).



Figure 9: Cultivated (maize) land within the footprint at a verified survey point; the ground surface and any potential outcrops are obscured by crop cover (GPS: -28.175783, 26.974455).



8 ASSESSMENT OF IMPACTS

8.1 Sensitivities identified by the DFFE National Web-Based Screening Tool.

As indicated in Section 5 the Screening Tool shows that the study area falls in an area of Very High (dark red) Palaeontological Sensitivity for the majority of the footprint, in agreement with the SAHRIS PalaeoMap. On that basis, a pre-mitigation significance of Low is allocated to seismic surveying and High to drilling and gas plant construction/gas-gathering infrastructure for the D3 Energy Production Right Development – the difference tracking how long each activity disturbs the ground for and how reversible that disturbance is, not any difference in the underlying geological sensitivity, which is uniform across the footprint. This is set within the context of the Very High regional geological sensitivity of the Adelaide Subgroup and the potential scientific consequence of disturbing an intact fossil assemblage, balanced against the probability of encountering such material: no fossiliferous outcrops or in situ material were identified during the field-based site investigation conducted on 9 June 2026 (Section 7), and fossil preservation and exposure within this unit is in any case inherently unpredictable and sporadic rather than uniformly distributed.

8.2 Summary of Issues identified during the Public Consultation Phase

No comments or issues related to palaeontological impacts were raised during the public consultation process.

8.3 Sensitivity Analysis Summary Statement

The Very High Palaeontological Sensitivity of the DFFE Screening Tool is supported by the SAHRIS PalaeoMap, which similarly indicates a Very High Palaeontological Sensitivity for the Adelaide Subgroup underlying the majority of the footprint. A field-based site investigation was conducted on 9 June 2026 (Section 7); no fossiliferous outcrops were identified within the development footprint. No impacts are expected during the Planning, Operational and Decommissioning Phases of the D3 Energy Production Right project.



Construction-phase activities associated with the D3 Energy Production Right comprise three main components, namely seismic surveying, drilling, and gas plant construction and associated gas-gathering infrastructure. All three involve excavation, drilling and/or trenching within the same underlying Adelaide Subgroup geology across the same development footprint, but they are not equivalent in how much ground they disturb or for how long: seismic surveying is brief and largely reversible, while drilling and gas plant construction/gas-gathering infrastructure leave a permanent, high-magnitude footprint that is effectively irreversible. The impact assessment for each activity is therefore presented individually below, with significance ratings differentiated accordingly.

Table 5: Rating of Impacts Construction Phase - D3 Energy Production Right, Seismic Surveying

Impact	Impact Criteria		Significance and Ranking (Pre-Mitigation)	Potential mitigation measures	Significance and Ranking (Post-Mitigation)	Confidence Level
SUMMARY OF ASSESSMENTS OF IMPACTS TO PALAEOONTOLOGICAL RESOURCES DURING THE CONSTRUCTION PHASE – SEISMIC SURVEYING						
Loss of fossil Heritage	Status	Negative	Low	Implement the Chance Find Protocol (as captured in Section 10 of this report) as well as the training of accountable supervisory personnel by a qualified palaeontologist.	Low – post-mitigation Probability drops to Improbable (1); $S = C \times P = -1.5 \times 1 = -1.5$. Priority = Cumulative Impact (Low, 1) + Irreplaceable Loss (Low, 1) = 2, giving a Prioritisation Factor (PF) of 1.0. Final Significance (FS) = $S \times PF = -1.5 \rightarrow$ Low.	High
	Spatial Extent	Activity (1)				
	Duration	Immediate (<1 year) (1)				
	Magnitude	Low (2)				
	Reversibility	Reversible without incurring significant time and cost (2)				
	Consequence	-1.5 (low overall consequence)				
	Probability (Pre-Mitigation)	Low probability (2)				



	Irreplaceable Loss of Resources	Low – unlikely to result in irreplaceable loss of resources (1)				
	Cumulative Impact	Low – unlikely to result in spatial/temporal cumulative change (1)				

Table 6: Rating of Impacts Construction Phase - D3 Energy Production Right, Drilling

Impact	Impact Criteria		Significance and Ranking (Pre-Mitigation)	Potential mitigation measures	Significance and Ranking (Post-Mitigation)	Confidence Level
SUMMARY OF ASSESSMENTS OF IMPACTS TO PALAEOONTOLOGICAL RESOURCES DURING THE CONSTRUCTION PHASE – DRILLING						
Loss of fossil Heritage	Status	Negative	High	Implement the Chance Find Protocol (as captured in Section 10 of this report) as well as the training of accountable supervisory personnel by a qualified palaeontologist.	Medium-High – post-mitigation Probability drops to Low probability (2); $S = C \times P = -4.0 \times 2 = -8.0$. Priority = Cumulative Impact (High, 3) + Irreplaceable Loss (High, 3) = 6, giving a Prioritisation Factor (PF) of 1.5. Final Significance (FS) = $S \times PF = -12.0 \rightarrow$ Medium-High.	High
	Spatial Extent	Activity (1)				
	Duration	Permanent (>65 years) (5)				
	Magnitude	Very high (5)				
	Reversibility	Irreversible (5)				
	Consequence	-4.0 (high overall consequence)				
	Probability (Pre-Mitigation)	High probability (4)				
	Irreplaceable Loss of Resources	High – may result in irreplaceable loss of resources of high value (3)				



	Cumulative Impact	High – highly probable/definite spatial/temporal cumulative change (3)				
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Table 7: Rating of Impacts Construction Phase - D3 Energy Production Right, Gas Plant Construction and Gas-Gathering Infrastructure

Impact	Impact Criteria		Significance and Ranking (Pre-Mitigation)	Potential mitigation measures	Significance and Ranking (Post-Mitigation)	Confidence Level
SUMMARY OF ASSESSMENTS OF IMPACTS TO PALAEOONTOLOGICAL RESOURCES DURING THE CONSTRUCTION PHASE – GAS PLANT CONSTRUCTION AND GAS-GATHERING INFRASTRUCTURE						
Loss of fossil Heritage	Status	Negative	High	Implement the Chance Find Protocol (as captured in Section 10 of this report) as well as the training of accountable supervisory personnel by a qualified palaeontologist.	Medium-High – post-mitigation Probability drops to Low probability (2); $S = C \times P = -4.0 \times 2 = -8.0$. Priority = Cumulative Impact (High, 3) + Irreplaceable Loss (High, 3) = 6, giving a Prioritisation Factor (PF) of 1.5. Final Significance (FS) = $S \times PF = -12.0 \rightarrow$ Medium-High.	High
	Spatial Extent	Activity (1)				
	Duration	Permanent (>65 years) (5)				
	Magnitude	Very high (5)				
	Reversibility	Irreversible (5)				
	Consequence	-4.0 (high overall consequence)				
	Probability (Pre-Mitigation)	High probability (4)				
	Irreplaceable Loss of Resources	High – may result in irreplaceable loss of resources of high value (3)				
	Cumulative Impact	High – highly probable/definite spatial/temporal cumulative change (3)				



Cumulative Impacts

REFs in the D3 Energy Production Right development area (30 km range) will have a Low Palaeontological Sensitivity. If all the mitigation measures are carried out, a conservative estimate of the Cumulative impacts on fossil Heritage will be Low significance.



Impact	Impact Criteria		Significance and Ranking (Pre-Mitigation)	Potential mitigation measures	Significance and Ranking (Post-Mitigation)	Confidence Level
CUMULATIVE IMPACT DURING CONSTRUCTION PHASE						
Loss of fossil Heritage	Status	Negative	Low	Chance Find Protocol as well as the training of accountable supervisory personnel by a qualified palaeontologist	Low	High
	Spatial Extent	Site specific				
	Duration	Permanent				
	Consequence	Moderate				
	Probability	Unlikely				
	Reversibility	Non-reversible				
	Irreplaceability	Irreplaceable				



8.4 Overall Impact Rating

For the construction phase, pre-mitigation significance is Low for seismic surveying and High for drilling and gas plant construction/gas-gathering infrastructure — a difference driven by the duration, magnitude, and reversibility of disturbance rather than by any variation in the Very High Palaeontological Sensitivity recorded on the SAHRIS Palaeomap, which applies across the footprint as a whole. After mitigation these fall to Low and Medium-High respectively. The same pattern holds for cumulative impacts, where post-mitigation significance likewise ranges from Low to Medium-High depending on the activity.

8.5 Impact Summary

Table 8: Overall Impact Significance (Post Mitigation)	
Phase	Overall Impact Significance
Construction	Low to Medium-High
Operational	No impact
Decommissioning	No Impact
Nature of Impact	Overall Impact Significance
Cumulative – Construction	Low to Medium-High
Cumulative – Operational	No Impact
Cumulative – Decommissioning	No Impact

8.6 Technology Options

Regardless of the specific technology option ultimately selected, the disturbance footprint associated with seismic surveying, drilling, well-pad construction, and gas plant and gas-gathering infrastructure construction is expected to remain broadly similar, as each activity disturbs the same underlying Adelaide Subgroup geology across the same development footprint. The choice of technology is therefore not expected to materially influence the nature or significance of potential impacts to palaeontological heritage, which are determined primarily by the extent and depth of ground disturbance rather than the specific technology employed.

8.7 No-go Alternative

If the projects were not implemented, then the study area would stay as it currently is (impact significance of neutral in most cases but moderate negative for built heritage). Although the heritage impacts with implementation would generally be greater than the existing impacts, the loss of socio-economic benefits is more significant and suggests that the No-Go option is less desirable in heritage terms.



8.8 EMPr Inputs

Table 8 below provides the mitigation measures and the proposed methods for monitoring the implementation. These measures should be included in the EMPr in conjunction with the Chance Fossil Find Procedure outlined in Section 10.



Table 9: Proposed management actions and approach to monitoring

Impact	Mitigation/ Management Outcome	Impact Management Action	Monitoring		
			Method	Frequency	Responsibility
PLANNING AND DETAILED ENGINEERING DESIGN PHASE (PRE-CONSTRUCTION PHASE)					
No impact on fossil heritage	N/A	▪ N/A	▪ N/A	▪ N/A	▪ N/A
CONSTRUCTION PHASE					
Loss of fossil heritage	Safeguarding, recording, and sampling of palaeontological materials encountered or exposed during construction (Chance Fossil Finds)	▪ ECO for this project must be informed that the Adelaide Subgroup (Beaufort Group, Karoo Supergroup) has a Very High Palaeontological Sensitivity. ▪ Accountable supervisory personnel must be trained by a qualified palaeontologist in the recognition of fossil heritage. ▪ If Palaeontological Heritage is uncovered during surface clearing and excavations, the Chance Fossil Finds Protocol (included in Section 11 of this report) should be implemented immediately. ▪ The ECO must familiarize themselves with the Chance Fossils Finds Protocol and ensure that it is kept on file on site. ▪ Fossil discoveries must be protected in situ (if possible), and the Environmental Control Officer (ECO) or site manager must report the find to the relevant heritage authority, namely the South African Heritage Resources Agency (SAHRA) (111 Harrington Street, Cape Town; PO Box 4637, Cape Town 8000; Tel: 021 462 4502; Fax: 021 462 4509; Web: www.sahra.org.za) ▪ Before any fossil material can be collected from the development site, the specialist involved must apply for a collection permit	▪ Conduct the relevant training and ensure that training records are kept on file. ▪ Ensure that the Chance Fossil Finds Protocol is implemented if any fossiliferous deposits are exposed or during chance fossil finds. Undertake inspections and report any non-compliance. ▪ The immediate area of the fossil find must be safeguarded with security tape / fence / sand bags if necessary.	▪ Ongoing during the construction phase	▪ ECO and Contractor



Impact	Mitigation/ Management Outcome	Impact Management Action	Monitoring		
			Method	Frequency	Responsibility
		from SAHRA. Fossil material must be housed in an official collection (museum or university), while all reports and fieldwork should meet the minimum standards for palaeontological impact studies proposed by SAHRA (2012).			
OPERATION PHASE					
No impact on fossil heritage	N/A	▪ N/A	▪ N/A	▪ N/A	▪ N/A
DECOMMISSIONING PHASE					
No impact on fossil heritage	N/A	▪ N/A	▪ N/A	▪ N/A	▪ N/A



8.9 Conclusion and Impact Statement

Before mitigation, the significance of the impact ranges from Low for seismic surveying up to High for drilling and gas plant construction/gas-gathering infrastructure. Mitigation brings these down to Low and Medium-High respectively.

8.10 Legislative and Permit Requirements

It is required to submit a PIA as part of a Heritage Impact assessment to the SAHRA. The costs for submitting a Review of an impact assessment report related to an application for Environmental Authorisation made in terms of legislation other than NHRA will be R3800 without a NID application.

9 FINDINGS AND RECOMMENDATIONS

The majority of the D3 Energy Production Right application area is underlain by Permian-aged sediments of the Adelaide Subgroup (Beaufort Group, Karoo Supergroup), with smaller areas underlain by Quaternary sands and alluvium and by Jurassic dolerite. The PalaeoMap of the South African Heritage Resources Information System (SAHRIS) indicates that the preliminary Palaeontological Sensitivity of the Adelaide Subgroup is Very High, that of the Quaternary sediments is Moderate while that of the Jurassic dolerite is Zero, as it is igneous in origin and thus unfossiliferous. Palaeontological Sensitivity generated by the Department of Forestry, Fisheries and the Environment (DFFE) National Environmental Web-Based Screening Tool similarly indicates that the application area has a Very High Palaeontological Sensitivity.

According to the National GIS Palaeontological Databases, the broader Beaufort Group of the Karoo Supergroup in the Free State is regarded as highly fossiliferous, hosting Permian-Triassic *Daptocephalus* Assemblage Zone vertebrate fossils. A field-based palaeontological site investigation of the D3 Energy Production Right application area was conducted on 9 June 2026 (Section 7); no fossiliferous outcrops or in situ fossil material were identified within the development footprint during this investigation.

For the construction phase of the D3 Energy Production Right and associated infrastructure, pre-mitigation significance has been allocated as Low for seismic surveying and High for drilling and gas plant construction/gas-gathering infrastructure. The gap between them comes down to how much longer and more permanently drilling and gas-gathering infrastructure disturb the ground compared with a seismic survey, set against the Very High regional geological sensitivity of the Adelaide Subgroup and the potential scientific consequence of disturbing an intact fossil assemblage, balanced against the probability of encountering such material: no fossiliferous outcrops or in situ material were identified during the field-based site investigation conducted on 9 June 2026 (Section 7), and fossil preservation and exposure within this unit is in any case inherently unpredictable and sporadic rather than uniformly



distributed. The construction phase is expected to be the only development phase with the potential to impact palaeontological heritage, and no significant impacts are expected during the Planning, Operational and Decommissioning Phases. If the project is not implemented, the application area will remain undisturbed, resulting in a neutral impact on palaeontological heritage; however, the No-Go alternative would also forgo the associated socio-economic benefits of the Project. Proceeding with the Project, while resulting in some potential disturbance to fossil heritage, can be brought down to a Low to Medium-High post-mitigation impact through implementation of the Chance Find Protocol (Section 10), which is considered an acceptable outcome. Any newly discovered, well-recorded, and suitably curated fossil material recovered during construction would enhance the regional palaeontological database and contribute to the broader scientific understanding of South Africa's fossil heritage.

Statement and Reasoned Opinion:

It is recommended that the proposed project receive an environmental authorisation. The proposed D3 Energy Production Right and associated infrastructure are thus not fatally flawed from a palaeontological perspective, on the basis of the desktop assessment and field-based site investigation conducted. However, the recommended mitigation measures have to be included within the Environmental Management Programme (EMPr). These recommendations must be implemented in full during the construction phase. Mitigation measures include training of accountable supervisory personnel by a qualified palaeontologist in the recognition of fossil heritage and implementation of the Chance Find Protocol, and are discussed in more detail in Section 10.

Recommendations:

- The Environmental Control Officer (ECO) for this project must be informed that the Adelaide Subgroup (Beaufort Group, Karoo Supergroup) has a **Very High Palaeontological Sensitivity**. The Karoo Supergroup bedrock in the study area is largely concealed due to poor exposure, primarily visible along major drainage lines and some steeper hillslopes.
- **Training of accountable supervisory personnel** by a qualified palaeontologist in the recognition of fossil heritage is thus very important and necessary.
- If palaeontological heritage is uncovered during surface clearing or excavations, the **Chance Find Protocol** included in this report must be implemented immediately. Fossil discoveries must be protected in situ (if possible), and the Environmental Control Officer (ECO) or site manager must report the find to the relevant heritage authority, namely the **South African Heritage Resources Agency (SAHRA)** (111 Harrington Street, Cape Town; PO Box 4637, Cape Town 8000; Tel: 021 462 4502; Fax: 021 462 4509; Web: www.sahra.org.za), so that appropriate mitigation measures, including the recording and collection of fossils by a qualified specialist, can be carried out.
- Before any fossil material can be collected from the development site, the specialist involved would need to apply for a **collection permit from SAHRA**. Fossil material must be **housed in an**



official collection (museum or university), while all reports and fieldwork should meet the minimum standards for palaeontological impact studies proposed by SAHRA (2012).

These recommendations should be incorporated into the Environmental Management Programme (EMPr) for the D3 Energy Production Right, as well as included as conditions for Environmental Authorisation.

10 CHANCE FINDS PROTOCOL

A following procedure will only be followed if fossils are uncovered during excavation.

10.1 Background

A fossil is the naturally preserved remains (or traces) of plants or animals embedded in rock. These plants and animals lived in the geologic past millions of years ago. Fossils are extremely rare and irreplaceable. By studying fossils, it is possible to determine the environmental conditions that existed in a specific geographical area millions of years ago.

This informational document is intended for workmen and foremen on construction sites. It describes the actions to be taken when mining or construction activities accidentally uncovers fossil material.

It is the responsibility of the Environmental Control Officer (ECO) or site manager of the project to train the workmen and foremen in the procedure to follow when a fossil is accidentally uncovered. In the absence of the ESO, a member of the staff must be appointed to be responsible for the proper implementation of the chance find protocol as not to compromise the conservation of fossil material.

10.2 Legislation

Cultural Heritage in South Africa (includes all heritage resources) is protected by the **National Heritage Resources Act (Act 25 of 1999) (NHRA)**. According to Section 3 of the Act, all Heritage resources include "all objects recovered from the soil or waters of South Africa, including archaeological and palaeontological objects and material, meteorites and rare geological specimens".

Palaeontological heritage is unique and non-renewable and is protected by the NHRA and are the property of the State. It is thus the responsibility of the State to manage and conserve fossils on behalf of the citizens of South Africa. Palaeontological resources may not be excavated, broken, moved, or destroyed



by any development without prior assessment and without a permit from the relevant heritage resources authority as per section 35 of the NHRA.

10.3 Chance Find Procedure

- If a chance find is made the person responsible for the find must immediately **stop working** and all work that could impact that finding must cease in the immediate vicinity of the find.
- The person who made the find must immediately **report** the find to their direct supervisor which in turn must report the find to their manager and the ECO or site manager. The ECO or site manager must report the find to the relevant Heritage authority, namely **South African Heritage Resources Agency (SAHRA)** (111 Harrington Street, Cape Town; PO Box 4637, Cape Town 8000; Tel: 021 462 4502; Fax: 021 462 4509; Web: www.sahra.org.za), so that appropriate mitigation measures, including the recording and collection of fossils by a qualified specialist, can be carried out.
- The information to the Heritage Agency must include photographs of the find, from various angles, as well as the GPS coordinates.
- A preliminary report must be submitted to the Heritage Agency within **24 hours** of the find and must include the following: 1) date of the find; 2) a description of the discovery and a 3) description of the fossil and its context (depth and position of the fossil), GPS co-ordinates.
- Photographs (the more the better) of the discovery must be of high quality, in focus, accompanied by a scale. It is also important to have photographs of the vertical section (side) where the fossil was found.
- Upon receipt of the preliminary report, the Heritage Agency will inform the ESO (or site manager) whether a rescue excavation or rescue collection by a palaeontologist is necessary.
- The site must be secured to protect it from any further damage. **No attempt** should be made to remove material from their environment. The exposed finds must be stabilized and covered by a plastic sheet or sand bags. The Heritage agency will also be able to advise on the most suitable method of protection of the find.
- In the event that the fossil cannot be stabilized the fossil may be collected with extreme care by the ECO or site manager. Fossils finds must be stored in tissue paper and in an appropriate box while due care must be taken to remove all fossil material from the rescue site.
- Once the Heritage Agency has issued the written authorization, the developer may continue with the development on the affected area.

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APPENDIX 1: ASSESSMENT METHODOLOGY

The impact significance rating methodology, as presented herein and utilised for all EIMS Impact Assessment Projects, is guided by the requirements of the NEMA EIA Regulations 2014 (as amended). The approach may be altered or substituted on a case-by-case basis if the specific aspect being assessed requires such- such instances require prior EIMS Project Manager approval. The broad approach to the significance rating methodology is to determine the significance (S) of an environmental risk or impact by considering the consequence (C) of each impact (comprising Nature, Extent, Duration, Magnitude, and Reversibility) and relating this to the probability/ likelihood (P) of the impact occurring. The S is determined for the pre- and post-mitigation scenario. In addition, other factors, including cumulative impacts and potential for irreplaceable loss of resources, are used to determine a prioritisation factor (PF) which is applied to the S to determine the overall final significance rating (FS). The impact assessment will be applied to all identified alternatives.

Determination of Significance

The final significance (FS) of an impact or risk is determined by applying a prioritisation factor (PF) to the post-mitigation environmental significance. The significance is dependent on the consequence (C) of the particular impact and the probability

(P) of the impact occurring. Consequence is determined through the consideration of the Nature (N), Extent (E), Duration (D), Magnitude (M), and Reversibility (R) applicable to the specific impact.

For the purpose of this methodology the consequence of the impact is represented by:

$$C = \frac{(E + D + M + R) * N}{4}$$

Each individual aspect in the determination of the consequence is represented by a rating scale as defined in **Table** below.

Criteria for Determining Impact Consequence

Aspect	Score	Definition
Nature	- 1	Likely to result in a negative/ detrimental impact
	+1	Likely to result in a positive/ beneficial impact
Extent	1	Activity (i.e. Highly localised, limited to the area applicable to the specific activity)
	2	Site (i.e. within the development property or site boundary, or the area within a few hundred meters of the site)
	3	Local (i.e. beyond the site boundary within the Local administrative boundary (e.g. Local Municipality) or within consistent local geographical features, or the area within 5 km of the site)



	4	Regional (i.e. Far beyond the site boundary, beyond the Local administrative boundaries within the Regional administrative boundaries (e.g. District Municipality), or extends into different distinct geographical features, or extends between 5 and 50 km from the site).
	5	Provincial / National / International (i.e. extends into numerous distinct geographical features, or extends beyond 50 km from the site).
Duration	1	Immediate (<1 year, quickly reversible)
	2	Short term (1-5 years, less than project lifespan)
	3	Medium term (6-15 years)
	4	Long term (15-65 years, the impact will cease after the operational life span of the project)
	5	Permanent (>65 years, no mitigation measure of natural process will reduce the impact after construction/ operation/ decommissioning).
Magnitude/ Intensity	1	Minor (where the impact affects the environment in such a way that natural, cultural and social functions and processes are not affected)
	2	Low (where the impact affects the environment in such a way that natural, cultural and social functions and processes are slightly affected, or affected environmental components are already degraded)
	3	Moderate (where the affected environment is altered but natural, cultural and social functions and processes continue albeit in a modified way; moderate improvement for +ve impacts; or where change affects area of potential conservation or other value, or use of resources).
	4	High (where natural, cultural or social functions or processes are altered to the extent that it will temporarily cease; high improvement for +ve impacts; or where change affects high conservation value areas or species of conservation concern)
	5	Very high / don't know (where natural, cultural or social functions or processes are altered to the extent that it will permanently cease, substantial improvement for +ve impacts; or disturbance to pristine areas of critical conservation value or critically endangered species)
Reversibility	1	Impact is reversible without any time and cost.

	2	Impact is reversible without incurring significant time and cost.
	3	Impact is reversible only by incurring significant time and cost.
	4	Impact is reversible only by incurring very high time and cost.
	5	Irreversible Impact.



Once the C has been determined, the significance is determined in accordance with the standard risk assessment relationship by multiplying the C and the P. Probability is rated/ scored as per Table below.

It is noted that both environmental risks as well as environmental impacts should be identified and assessed. Environmental Risk can be regarded as the potential for something harmful to happen to the environment, and in many instances is not regarded as something that is expected to occur during normal operations or events (e.g. unplanned fuel or oil spills at a construction site). Probability and likelihood are key determinants or variables of environmental risk. Environmental Impact can be regarded as the actual effect or change that happens to the environment because of an activity and is typically an effect that is expected from normal operations or events (e.g. vegetation clearance from site development results in loss of species of concern). Typically, the probability of an unmitigated environmental impact is regarded as highly likely or certain (management and mitigation measures would ideally aim to reduce this likelihood where possible). In summary, environmental risk is about what could happen, while environmental impact is about what does happen.

Probability/ Likelihood Scoring

Probability	1	Improbable (Rare, the event may occur only in exceptional circumstances, the possibility of the impact materialising is very low as a result of design, historic experience, or implementation of adequate corrective actions; <5% chance).
	2	Low probability (Unlikely, impact could occur but not realistically expected; >5% and <20% chance).
	3	Medium probability (Possible, the impact may occur; >20% and <50% chance).
	4	High probability (Likely, it is most probable that the impact will occur- > 50 and <90% chance).
	5	Definite (Almost certain, the impact is expected to, or will, occur, >90% chance).

The result is a qualitative representation of relative significance associated with the impact.

Significance is therefore calculated as follows:

$$S = C \times P$$

Determination of Significance

	5- Very High ¹	5	10	15	20	25
	4- High	4	8	12	16	20
	3- Medium	3	6	9	12	15
	2- Low	2	4	6	8	10
	1- Very low	1	2	3	4	5



¹ In the event that an impact or risk has very high or catastrophic consequences, but the likelihood/ probability is low, then the resultant significance would be Low-medium. This does in certain instances detract from the relative important of this impact or risk and must consequently be flagged for further specific consideration, management, mitigation, or contingency planning

	1- Improbable	2- Low	3- Medium/ Possible	4- High/ Probable	5- Highly likely/ Definite
Probability					

The outcome of the significance assessment will result in a range of scores, ranging from 1 through to 25. These significance scores are then grouped into respective classes as described in Table below.

Significance Scores

S Score	Description
≤4.25	Low (i.e. where this impact is unlikely to be a significant environmental risk/ reward).
>4.25, ≤8.5	Low-Medium (i.e. where the impact could have a significant environmental risk/ reward).
>8.5, ≤13.75	High-Medium (i.e. where the impact could have a significant environmental risk/ reward).
>13.75	High (i.e. where the impact will have a significant environmental risk/ reward).

The impact significance will be determined for each impact without relevant management and mitigation measures (pre-mitigation significance), as well as post implementation of relevant management and mitigation measures (post-mitigation significance). This allows for a prediction in the degree to which the impact can be managed/mitigated.

Impact Prioritization

Further to the assessment criteria presented in the section above, it is necessary to consider each potentially significant impact in terms of:

Cumulative impacts; and

The degree to which the impact may cause irreplaceable loss of resources.

To ensure that these factors are considered, an impact prioritisation factor (PF) will be applied to each impacts' post-mitigation significance (post-mitigation). This prioritisation factor does not aim to detract from the significance ratings but rather to focus the attention of the decision-making authority on the higher priority/significance issues and impacts. The PF will be applied to the post-mitigation significance based on the assumption that relevant suggested management/mitigation impacts are implemented.

Table 5: Criteria for Determining Prioritisation



Cumulative Impact (CI)	Low (1)	Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is unlikely that the impact will result in spatial and temporal cumulative change.
	Medium (2)	Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is probable that the impact will result in spatial and temporal cumulative change.
	High (3)	Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is highly probable/ definite that the impact will result in spatial and temporal cumulative change.
	Low (1)	Where the impact is unlikely to result in irreplaceable loss of resources.

Irreplaceable Loss of Resources (LR)	Medium (2)	Where the impact may result in the irreplaceable loss (cannot be replaced or substituted) of resources but the value (services and/or functions) of these resources is limited.
	High (3)	Where the impact may result in the irreplaceable loss of resources of high value (services and/or functions).

The value for the final impact priority is represented as a single consolidated priority, determined as the sum of each individual criteria represented in Table 5. The impact priority is therefore determined as follows:

$$\text{Priority} = CI + LR$$

The result is a priority score which ranges from 2 to 6 and a consequent PF ranging from 1 to 1.5 (Refer to Table below).

Determination of Prioritisation Factor

Priority	Prioritisation Factor
2	1
3	1.125
4	1.25
5	1.375
6	1.5

In order to determine the final impact significance (FS), the PF is multiplied by the post-mitigation significance scoring. The ultimate aim of the PF is an attempt to increase the post mitigation environmental risk rating by a factor of 0.5, if all the priority attributes are high (i.e. if an impact comes out with a high medium environmental risk after the conventional impact rating, but there is significant cumulative impact potential and significant potential for irreplaceable loss of resources, then the net result would be to upscale the impact to a higher significance).

Final Environmental Significance Rating



Significance Rating	Description
<-25	Very High (Impacts in this class are extremely significant and pose a very high environmental risk. In certain instances these may represent a fatal flaw. They are likely to have a major influence on the decision and may be difficult or impossible to mitigate. Offset's may be necessary.
<-13.75 to -25	High negative (These impacts are significant and must be carefully considered in the decision-making process. They have a high environmental risk or impact and require extensive mitigation measures).
-8.5 to -13.75	Medium-High negative (i.e. Impacts in this class are more substantial and could have a significant environmental risk. They may influence the decision to develop in the area and require more robust mitigation measures).
<-4.25 to <-8.5	Medium- Low negative (i.e. These impacts are slightly more significant than low impacts but still do not pose a major environmental risk. They might require some mitigation measures but are generally manageable).

Significance Rating	Description
-1 to -4.25	Low negative (i.e. Impacts in this class are minor and unlikely to have a significant environmental risk. They do not influence the decision to develop in the area and are typically easily mitigated.
0	No impact
1 to 4.25	Low positive
>4.25 to <8.5	Medium-Low positive
8.5 to 13.75	Medium-High positive
>13.75	High positive

The significance ratings and additional considerations applied to each impact will be used to provide a quantitative comparative assessment of the alternatives being considered. In addition, professional expertise and opinion of the specialists and the environmental consultants will be applied to provide a qualitative comparison of the alternatives under consideration. This process will identify the best alternative for the proposed project.

Nature	-1	Likely to result in a negative/ detrimental impact	CONSEQUENCE	ENVIRONMENT
	1	Likely to result in a positive/ beneficial impact		
Extent	1	Activity (i.e. Highly localised, limited to the area applicable to the specific activity)		



	2	Site (i.e. within the development property or site boundary, or the area within a few hundred meters of the site)		
	3	Local (i.e. beyond the site boundary within the Local administrative boundary (e.g. Local Municipality) or within consistent local geographical features, or the area within 5 km of the site)		
	4	Regional (i.e. Far beyond the site boundary, beyond the Local administrative boundaries within the Regional administrative boundaries (e.g. District Municipality), or extends into different distinct geographical features, or extends between 5 and 50 km from the site).		
	5	Provincial / National / International (i.e. extends into numerous distinct geographical features, or extends beyond 50 km from the site).		
Duration	1	Immediate (<1 year, quickly reversible)		
	2	Short term (1-5 years, less than project lifespan)		
	3	Medium term (6-15 years)		
	4	Long term (15-65 years, the impact will cease after the operational life span of the project)		
	5	Permanent (>65 years, no mitigation measure of natural process will reduce the impact after construction/ operation/ decommissioning).		
Magnitude/ Intensity	1	Minor (where the impact affects the environment in such a way that natural, cultural and social functions and processes are not affected)		
	2	Low (where the impact affects the environment in such a way that natural, cultural and social functions and processes are slightly affected, or affected environmental components are already degraded)		
	3	Moderate (where the affected environment is altered but natural, cultural and social functions and processes continue albeit in a modified way; moderate improvement for +ve impacts; or where change affects area of potential conservation or other value, or use of resources).		
	4	High (where natural, cultural or social functions or processes are altered to the extent that it will temporarily cease; high improvement for +ve impacts; or where change affects high conservation value areas or species of conservation concern)		
	5	Very high / don't know (where natural, cultural or social functions or processes are altered to the extent that it will permanently cease, substantial improvement for +ve impacts; or disturbance to pristine areas of critical conservation value or critically endangered species)		



Reversibility	1	Impact is reversible without any time and cost.		
	2	Impact is reversible without incurring significant time and cost.		
	3	Impact is reversible only by incurring significant time and cost.		
	4	Impact is reversible only by incurring prohibitively high time and cost.		
	5	Irreversible Impact		
Probability	1	Improbable (Rare, the event may occur only in exceptional circumstances, the possibility of the impact materialising is very low as a result of design, historic experience, or implementation of adequate corrective actions; <5% chance).	PROBABILITY	
	2	Low probability (Unlikely, impact could occur but not realistically expected; >5% and <20% chance).		
	3	Medium probability (Possible, the impact may occur; >20% and <50% chance).		
	4	High probability (Likely, it is most probable that the impact will occur- > 50 and <90% chance).		
	5	Definite (Almost certain, the impact is expected to, or will, occur, >90% chance).		
Cumulative Impact	1	Low: Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is unlikely that the impact will result in spatial and temporal cumulative change.	PRIORITISATION FACTOR	
	2	Medium: Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is probable that the impact will result in spatial and temporal cumulative change.		
	3	High: Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is highly probable/definite that the impact will result in spatial and temporal cumulative change.		
Irreplaceable loss of resources	1	Low: Where the impact is unlikely to result in irreplaceable loss of resources.		
	2	Medium: Where the impact may result in the irreplaceable loss (cannot be replaced or substituted) of resources but the value (services and/or functions) of these resources is limited.		
	3	High: Where the impact may result in the irreplaceable loss of resources of high value (services and/or functions).		
Degree of Confidence	Low	<30% certain of impact prediction		
	Medium	>30 and < 60% certain of impact prediction		
	High	>60% certain of impact prediction		



APPENDIX 2: CURRICULUM VITAE E. BUTLER

PROFESSION: Palaeontologist

YEARS' EXPERIENCE: 30 years in Palaeontology

EDUCATION: University of the Orange Free State
B.Sc Botany and Zoology, 1988

University of the Orange Free State
B. Sc (Hons) Zoology, 1991

University of the Free State
M. Sc. *Cum laude* (Zoology), 2009

Dissertation title: The postcranial skeleton of the Early Triassic non-mammalian Cynodont *Galesaurus planiceps*: implications for biology and lifestyle.

EMPLOYMENT HISTORY

Research Assistant	National Museum, Bloemfontein 1993 – 1997
Principal Research Assistant and Collection Manager	National Museum, Bloemfontein 1998–2022
Banzai Environmental	2016 to present

Elize Butler has conducted approximately **900** Palaeontological Impact Assessments for developments in the Free State, KwaZulu-Natal, Eastern, Northern and Western Cape, Northwest, Gauteng, Limpopo, and Mpumalanga. She has an MSc (*cum laude*) in Zoology (specializing in Palaeontology) from the University of the Free State, South Africa. She has experience in locating, collecting, and curating fossils. She has been a member of the Palaeontological Society of South Africa (PSSA) since 2006 and has been conducting PIAs since 2014.

MEMBERSHIP

Palaeontological Society of South Africa (PSSA) 2006-currently.
A full CV is available on request.