



BANZAI
ENVIRONMENTAL

PALAEONTOLOGICAL IMPACT ASSESSMENT

TETRA4 PRODUCTION RIGHT
EXTENSION PROJECT

July 2024

COMPILED FOR: EIMS



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.

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SIGNATURE:

**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	The relevant section in the report	Comment where not applicable
1.(1) (a) (i) Details of the specialist who prepared the report	Page ii and Section 2 of Report – Contact details and company and Appendix A	-
(ii) The expertise of that person to compile a specialist report including a curriculum vita	Section 2 – refer to Appendix A	-
(b) A declaration that the person is independent in a form as may be specified by the competent authority	Page ii of the report	-
(c) An indication of the scope of, and the purpose for which, the report was prepared	Section 4 – Methods and Terms of Reference	-
(cA) An indication of the quality and age of base data used for the specialist report	Section 5 – Geological and Palaeontological history	-
(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, 7 & 11	



(e) A description of the methodology adopted in preparing the report or carrying out the specialised process inclusive of equipment and modelling used	Section 4- Approach and Methodology	-
(f) Details of an assessment of the specifically identified sensitivity of the site related to the proposed activity or activities and its associated structures and infrastructure, inclusive of a site plan identifying site alternative	Executive Summary, 7 & 9	
(g) An identification of any areas to be avoided, including buffers	Executive Summary, 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 – Geological and Palaeontologic al history	
(i) A description of any assumptions made and any uncertainties or gaps in knowledge	Section 4.1 – Assumptions and Limitation	-
(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, 9	
(k) Any mitigation measures for inclusion in the EMPr	Section 10	
(l) Any conditions for inclusion in the environmental authorisation	Section 10	
(m) Any monitoring requirements for inclusion in the EMPr or environmental authorisation	Section 10	
(n)(i) A reasoned opinion as to whether the proposed activity, activities or portions thereof should be authorised and	Executive Summary & 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 EMPr, and where applicable, the closure plan	Executive Summary & 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) and Environmental Management Plan (EMP) 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	



EXECUTIVE SUMMARY

Tetra4 (the Applicant) appointed Environmental Impact Management Services (Pty) Ltd (EIMS) to undertake the necessary application for Environmental Authorization (EA) to the Petroleum Agency of South Africa (PASA - the competent authority), to extend natural gas production operations within an existing Production Right (PASA Reference: 12/4/1/07/2/2), in the Matjhabeng and Masilonyana Local Municipalities, near the town of Virginia in the Free State.

Banzai Environmental was in turn commissioned by EIMS to conduct the Palaeontological Impact Assessment (PIA) to assess the palaeontology of the proposed Tatra4 Extension. In accordance with the National Environmental Management Act 107 of 1998 (NEMA) and to comply with the National Heritage Resources Act (No 25 of 1999, section 38) (NHRA), this PIA is necessary to confirm if fossil material could potentially be present in the planned development area, to evaluate the potential impact of the proposed development on the Palaeontological Heritage and to mitigate possible damage to fossil resources

The Tetra4 footprint is underlain by Quaternary sands (yellow and alluvium), unfossiliferous Jurassic dolerite, the Adelaide Subgroup (Beaufort Group, Karoo Supergroup), the Volksrust Formation and the Allanridge Formation (Ventersdorp Supergroup). **However, the drilling collars is only located in the Quaternary sediments, Jurassic dolerite and the Adelaide Subgroup.** 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 Volksrust Formation is High, and that of the Quaternary sediments is Moderate, while the Palaeontological Sensitivity of the Allanridge Formation is Low and that of the Jurassic Dolerite is Zero (Almond and Pether, 2009; Almond *et al.*, 2013, Groenewald *et al.* 2014). The suggested location is classified as having a Medium Palaeontology Theme Sensitivity in the DFFE Screening Report. Updated Geology (2014, Council of Geosciences) refined the geological map and indicates that the proposed development is underlain by alluvium, colluvium, eluvium and gravel as well as Karoo dolerite.

A site-specific field survey of the Balfour Formation (High Palaeontological Sensitivity) was conducted on foot and by motor vehicle on 28 June 2024. No fossiliferous outcrop was detected in the proposed development. The site investigation as well as desktop research (National Database and published data) concluded that **fossil heritage of scientific and conservational interest in the development area is relatively rare and of low scientific and conservational value.** Data indicates that fossil sites are generally rare, sporadic and unpredictable. A **low significance** has thus been allocated to the development footprint. **This is in disagreement with the Very High Sensitivity allocated to the development area by the**



SAHRIS Palaeontological Sensitivity Map and DFFE Screening Tool as no fossils were detected during the site investigation.

In terms of palaeontological impacts, **a Medium Palaeontological Significance has been allocated for impacts associated with the construction phase of the Tetra4 Extension Project pre-mitigation and a low significance post mitigation.** The drilling phase will be the only development phase with the potential of impacting Palaeontological Heritage, and **no significant impacts are expected to impact the Operational and Decommissioning phases.** As the No-Go Alternative considers the option of 'do nothing' and maintaining the status quo, it will have a Neutral impact on the Palaeontological Heritage of the development. **The Cumulative impacts of the development is considered to be Medium pre- mitigation and Low post mitigation, and falls within the acceptable limits for the project.** It is therefore considered that the proposed development will not lead to damaging impacts on the palaeontological resources of the area. **The construction of the Tetra4 Extension development may thus be permitted in its whole extent, as the development footprint is not considered sensitive in terms of palaeontological resources.** It is consequently recommended that **no further palaeontological heritage studies, ground truthing and/or specialist mitigation are required, pending the discovery of newly discovered fossils.**

If fossil remains are discovered during any phase of construction, either on the surface or exposed by excavations the **Chance Find Protocol** of the EMPr must be implemented by the ECO/site manager in charge of these developments. These discoveries ought to be protected (if possible, *in situ*) and the ECO/site manager must report to SAHRA (Contact details: SAHRA, 111 Harrington Street, Cape Town. PO Box 4637, Cape Town 8000, South Africa. Tel: 021 462 4502. Fax: +27 (0)21 462 4509. Web: www.sahra.org.za) so that mitigation (recording and collection) can be carry out by a paleontologist.

Preceding any collection of fossil material, the specialist would need to apply for a collection permit from SAHRA. Fossil material must be curated in an accredited collection (museum or university collection), while all fieldwork and reports should meet the minimum standards for palaeontological impact studies suggested by SAHRA.

These recommendations should be incorporated into the updated Environmental Management Programme (EMPr) for the Tetra4 Extension Project in the Free State Province.



TABLE OF CONTENT

1 INTRODUCTION	16
1.1 PROPOSED PRODUCTION RIGHT EXTENSION PROJECT	17
2. QUALIFICATIONS AND EXPERIENCE OF THE AUTHOR.....	22
3. LEGISLATION	22
3.1 NATIONAL HERITAGE RESOURCES ACT (25 OF 1999).....	22
4. METHODS AND TERMS OF REFERENCE	24
4.1 ASSUMPTIONS AND LIMITATIONS.....	26
5. GEOLOGICAL AND PALAEONTOLOGICAL HISTORY	26
6. ADDITIONAL INFORMATION CONSULTED	55
7. SITE INVESTIGATION	56
8. ASSESSMENT METHODOLOGY	57
8.1 METHOD OF ENVIRONMENTAL ASSESSMENT	57
9. FINDINGS AND RECOMMENDATIONS	59
10. MITIGATION AND EMPR REQUIREMENTS	61
10.1 LEGISLATION	61
10.2 CHANCE FIND PROCEDURE.....	61
11. BIBLIOGRAPHY.....	63



TABLE OF FIGURES

Figure 1: Cluster 1 and Cluster 2 locality in relation to the Production Right area.....	18
Figure 2: Site locality of the proposed Tetra 4 Project.....	19
Figure 3: ER32 (V2) Production Right Extension (north of Welkom).	20
Figure 4: ER 94 (V7) Production Right Extension (north of Theunissen).....	21
Figure 5: Extract of the 1:250 000 Kroonstad 2726 (2000) and Winburg 2826 (1998) Geological map (Council of Geoscience, Pretoria) indicating that the study area is underlain by Quaternary sands (Qs, yellow and alluvium, yellow single bird figure), unfossiliferous Jurassic dolerite (Jd, red), the Adelaide Subgroup (Pa, Beaufort Group, Karoo Supergroup), the Volksrust Formation (Pvo, Ecca Group) and the Allanridge Formation (Ra, Ventersdorp Supergroup)	32
Figure 6: Extract of the 1:250 000 Kroonstad 2726 Geological map (2000) (Council of Geoscience, Pretoria) indicating that the ER32 study area is underlain by Quaternary sands (yellow, Qs) and alluvium (yellow, single bird figure) and the Allanridge Formation (Ventersdorp Supergroup).	33
Figure 7: Extract of the 1:250 000 Winburg 2826 Geological map (1998) (Council of Geoscience, Pretoria) indicating that the ER94 study area is underlain by Quaternary sands (yellow, Qs), The Adelaide Subgroup (Pa, green) and Jurassic dolerite Jd, red).	34
Figure 8: Extract of the 1 in 250 000 SAHRIS PalaeoMap (Council of Geosciences, Pretoria) indicting the Very High (red), High (orange) Moderate (green), Low (blue) and Zero (grey) Palaeontological Sensitivity of the proposed Tetra4 expansion the Free State.	37
Figure 9: Palaeontological Sensitivity of the Northern portion of the Tetra4 Expansion in the Free State by the National Environmental Web-based Screening Tool indicates a High (red) and Medium (yellow), Palaeontological Sensitivity.	39
Figure 10: Palaeontological Sensitivity of the North B portion of the Tetra4 Expansion in the Free State by the National Environmental Web-based Screening Tool indicates a High (red) and Medium (yellow), Palaeontological Sensitivity.	40
Figure 11: Palaeontological Sensitivity of the North C portion of the Tetra4 Expansion in the Free State by the National Environmental Web-based Screening Tool indicates a Medium (yellow), Palaeontological Sensitivity.	41
Figure 12: Palaeontological Sensitivity of the North D portion of the Tetra4 Expansion in the Free State by the National Environmental Web-based Screening Tool indicates a High (red) and Medium (yellow), Palaeontological Sensitivity.	42
Figure 13: Palaeontological Sensitivity of the North E portion of the Tetra4 Expansion in the Free State by the National Environmental Web-based Screening Tool indicates a High (red) and Medium (yellow), Palaeontological Sensitivity.	43



Figure 14: Palaeontological Sensitivity of the North F portion of the Tetra4 Expansion in the Free State by the National Environmental Web-based Screening Tool indicates a Medium (yellow), Palaeontological Sensitivity.....	44
Figure 15: Palaeontological Sensitivity of the South A portion of the Tetra4 Expansion in the Free State by the National Environmental Web-based Screening Tool indicates a Very High (deep red) and Medium (yellow), Palaeontological Sensitivity.....	45
Figure 16: Updated Geology (Council of Geosciences, Pretoria) indicates that the proposed study area is underlain by the alluvium, colluvium, eluvium and gravel (n-qg), Karoo Dolerite (jd), the Balfour Formation (pbf, Beaufort Group), Volksrust Formation (pvo) as well as the Allanridge Formation (anal, Ventersdorp Supergroup).....	46
Figure 17: Vertebrate biozonation range chart for the Main Karoo Basin of South Africa.....	47
Figure 18: Lateral and dorsal views of skull of the dicynodont <i>Daptocephalus leoniceps</i> , the main biozone defining fossil (Image taken from Viglietti, 2020) and dorsal views (Image taken from Viglietti, 2020).	48
Figure 19: Skulls of the biozone defining fossils of the <i>Dicynodon-Therapsid</i> Subzone in lateral and dorsal views. <i>Dicynodon lacerticeps</i> (top), <i>Therapsid microps</i> (bottom) (Image taken from Viglietti, 2020).....	49
Figure 20: Biozone defining fossils of the <i>Lystrosaurus maccaigi</i> - <i>Moschorhinus</i> Subzone. The skulls of the <i>Lystrosaurus maccaigi</i> (top) and <i>Moschorhinus kitchingi</i> (bottom) in lateral (Image taken from Viglietti, 2020).....	50
Figure 21: Lateral and dorsal views of the index taxa defining the <i>Lystrosaurus declivis</i> Assemblage Zone. (top) <i>Lystrosaurus declivis</i> , (centre) <i>Thrinaxodon liorhinus</i> , (bottom) <i>Procolophon trigoniceps</i> (Image taken from Botha and Smith, 2020).	51
Figure 22: Reconstruction of <i>Lystrosaurus</i> sp.	52
Figure 23: Synchrotron scan of a burrow cast from the Early Triassic indicates an injured temnospondyl amphibian (<i>Broomistega</i>) that sheltered in a burrow occupied by an aestivating therapsid (<i>Thrinaxodon</i>) Image taken from Fernandez, et al., 2013.....	54
Figure 24: General view over the footprint indicate, a flat topography with no rocky outcrops visible.	56
Figure 25: Dolerite outcrops in close proximity of the Balfour Formation.	57



LIST OF TABLES

<i>Table 1: Checklist for Specialist studies conformance with Appendix 6 of the EIA Regulations of 2014 (as amended).</i>	iv
<i>Table 2: Legend to the 1:250 000 Kroonstad 2726 Geological map (2000) (Council of Geoscience, Pretoria).</i>	35
<i>Table 3: Legend to the 1:250 000 Winburg 2826 Geological map (1998) (Council of Geoscience, Pretoria).</i>	36
<i>Table 4: Palaeontological Sensitivity according to the SAHRIS PalaeoMap (Almond et al, 2013; SAHRIS website).</i>	38

APPENDIX 1: CV



GLOSSARY OF TERMS

Fossil

A fossil is the preserved remnants or vestiges of a long-dead organism, generally from millions of years ago. Fossils can be mineralized skeletons, shells, or other hard pieces of ancient animals and plants, as well as impressions, moulds, and casts left in sedimentary rock when the organism's remains decomposed and left an impression. Fossils provide valuable insights into the evolution and biodiversity of ancient species, allowing scientists to study and understand 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.



LIST OF ABBREVIATIONS

BA	Basic Assessment
DEA	Department of Environmental Affairs
DFFE	Department of Forestry, Fisheries and the Environment
DMRE	Department of Mineral Resources and Energy
CA	National Competent Authority
EA	Environmental Authorizatoion
ECO	Environmental Control Officer
EMPr	Environmental Management Programme
ESO	Environmental Site Officer
HIA	Heritage Impact Assessment
Ma	Millions of years ago
NEMA	National Environmental Management Act
NHRA	National Heritage Resources Act
PIA	Palaeontological Impact Assessment
PSSA	Palaeontological Society of South Africa
SAHRA	South African Heritage Resources Agency
SAHRIS	South African Heritage Resources Information System
S&EIA	Scoping & Environmental Impact Assessment
ToR	Terms of Reference



1 INTRODUCTION

Tetra4 is the operator and holder of existing Exploration Rights (ERs) and a Production Right (PR), in the Matjhabeng and Masilonyana Local Municipalities, in terms of the Mineral and Petroleum Resources Development Act (No. 28 of 2002 - MPRDA). In 2012, a Production Right (Ref: 12/4/1/07/2/2) was granted which spans approximately 187 000 hectares for the development of natural gas (Helium and Methane) production operations around the town of Virginia in the Free State Province. Within the approval of the Production Right, the 2010 Environmental Management Programme (EMPr) was approved which is applicable to a large portion of the Production Right area (Figure 1).

The activities in the Production Right include:

- Continued exploration activities;
- Drilling and establishment of further production wells throughout the entire production area (260 production wells);
- Installation of intra-field pipelines throughout the entire production area (~500km);
- Installation of boosters and main compressors; and
- Central gas processing plant (not approved in the original EIA and approved EMPr).

On 21 September 2017, the Department of Mineral Resources and Energy (DMRE) issued an integrated environmental authorisation ("Cluster 1 EA") (reference: 12/04/07) to Tetra4 in terms of the NEMA. The Cluster 1 EA (as amended by Cluster 1 EA amendments dated 26 August 2019 and 1 September 2020) authorises the development of "Cluster 1" of the Project. In this EA approval, various new wells and pipelines, booster and compressor stations, a Helium and LNG Facility and associated infrastructure was approved which comprises the first gas field for development within the approved Production Right area. The Cluster 1 EA also authorises certain waste management activities as per the List of Waste Management Activities (Government Notice 921, as amended) published under the National Environmental Management: Waste Act 59 of 2008 (NEMWA).

On 13 July 2023, the Department of Mineral Resources and Energy (DMRE) issued an integrated environmental authorisation ("Cluster 2 EA") (reference: 12/04/007) to Tetra4 in terms of the NEMA. The Cluster 2 EA authorises the development of "Cluster 2" of the Project. The Cluster 2 EA authorised up to 300 new production wells, gas transmission pipelines and associated infrastructure, 3 compressor stations and an additional new combined Liquid Natural Gas (LNG) and Liquid Helium (LHe) plant ("LNG/LHe Plant") and associated infrastructure, as well as powerlines as part of the Cluster 2 expansion of the Project in order to meet the future production requirements. The Cluster 2 EA also authorises certain waste management activities as per the List of Waste Management Activities (Government



Notice 921, as amended) published under the National Environmental Management: Waste Act 59 of 2008 (NEMWA).

1.1 Proposed Production Right Extension Project

Tetra4 was granted two Exploration Rights (ER32 and ER94) in 2015/2016 which span combined area of approximately 18 700 hectares for the development of natural gas (Helium and Methane) exploration operations near the towns of Theunissen / Winburg and Odendaalsrus / Allanridge in the Free State Province. Further to the above project history and resource tenure background, Tetra4 now wishes to consolidate the two ERs into the greater PR area. The consolidation of the ERs into the PR area will include the drilling of up to 18 exploration wells. This consolidation will incorporate ~78 farm portions near the towns of Theunissen and Winburg in the south of the PR area and Odendaalsrus and Allanridge in the north of the PR area (comprising the Exploration Rights) into the Production Right. The ER32 located north of the Production Right is approximately 7.2 km Northwest of Welkom and the ER94 to the south of the Production Right is approximately 19.2 km South of Virginia. An MPRDA Section 102 application shall be lodged to consolidate ER 32 and ER 94 (with associated exploration activities) into the Production Right and this process will also require an Environmental Authorisation application in terms of the National Environmental Management Act (Act 107 of 1998).

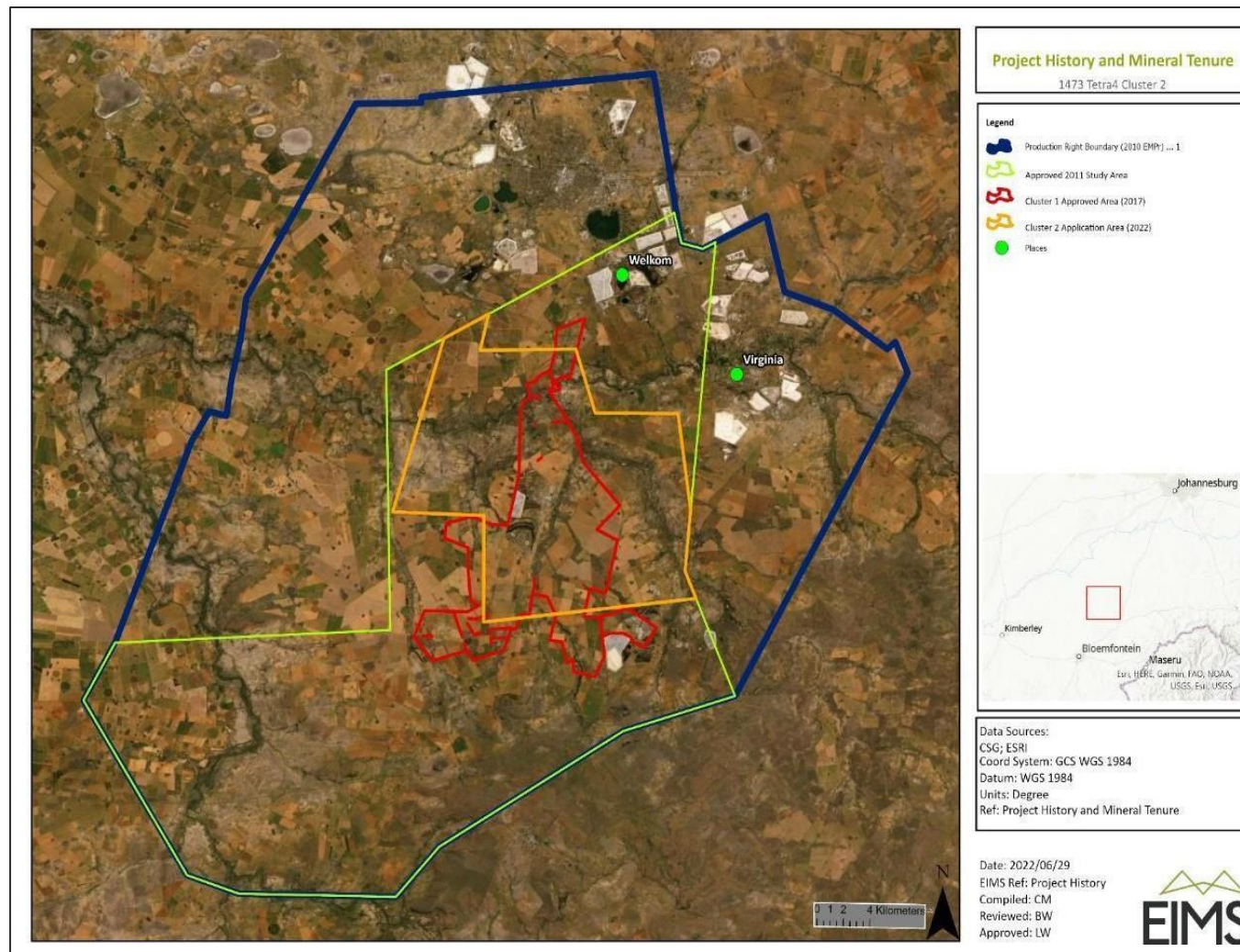


Figure 1: Cluster 1 and Cluster 2 locality in relation to the Production Right area.

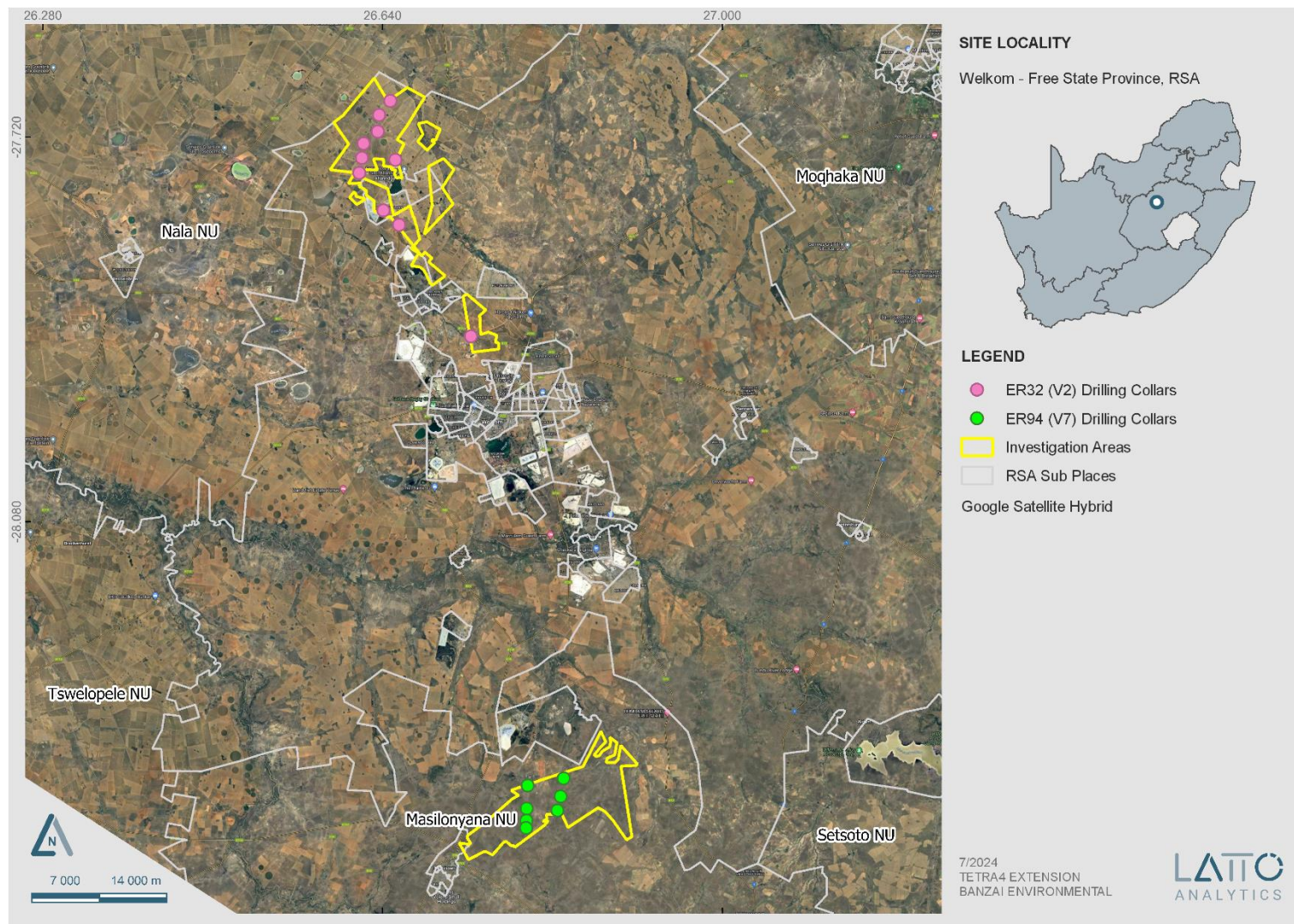


Figure 2: Site locality of the proposed Tetra 4 Project.

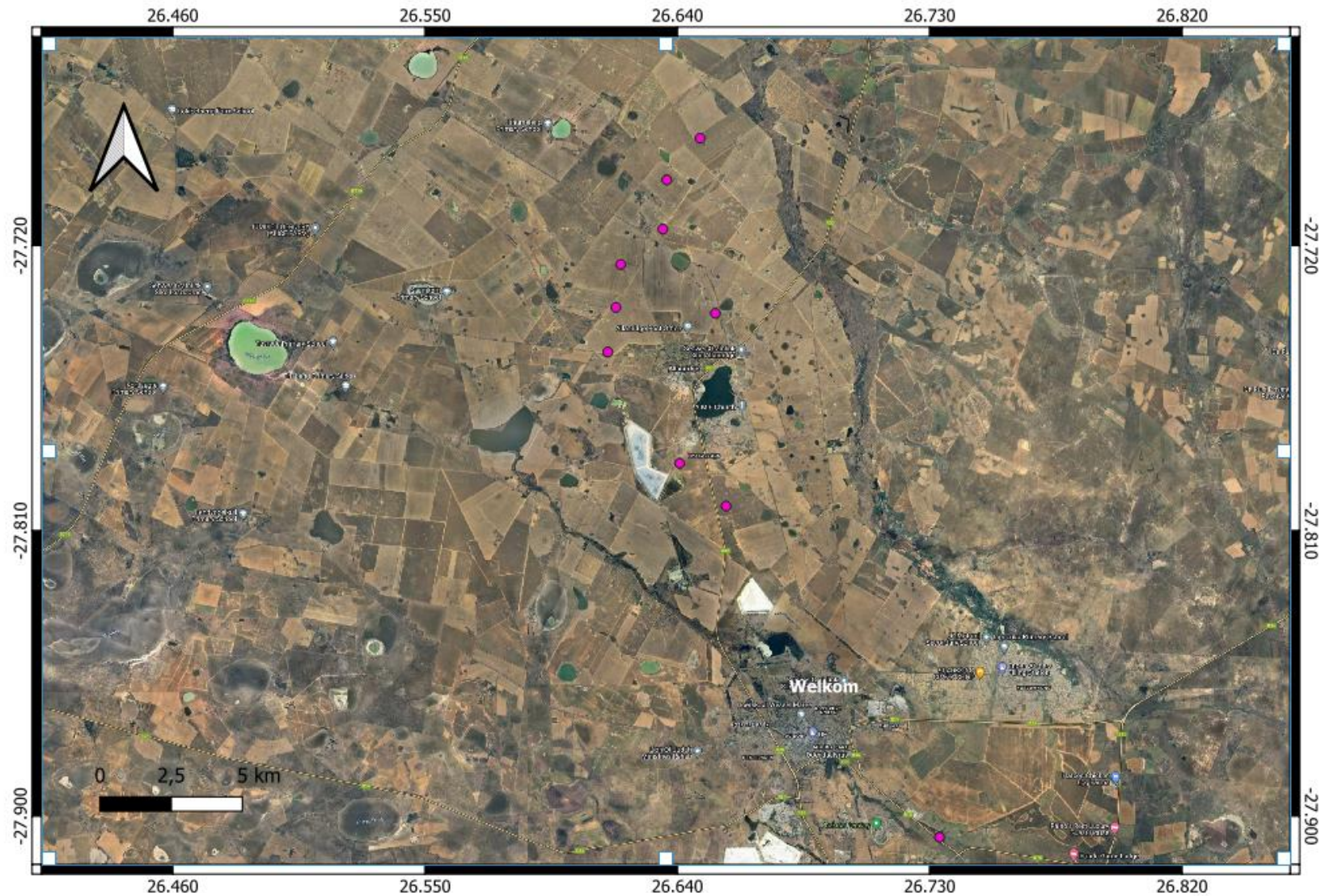


Figure 3: ER32 (V2) Production Right Extension (north of Welkom).

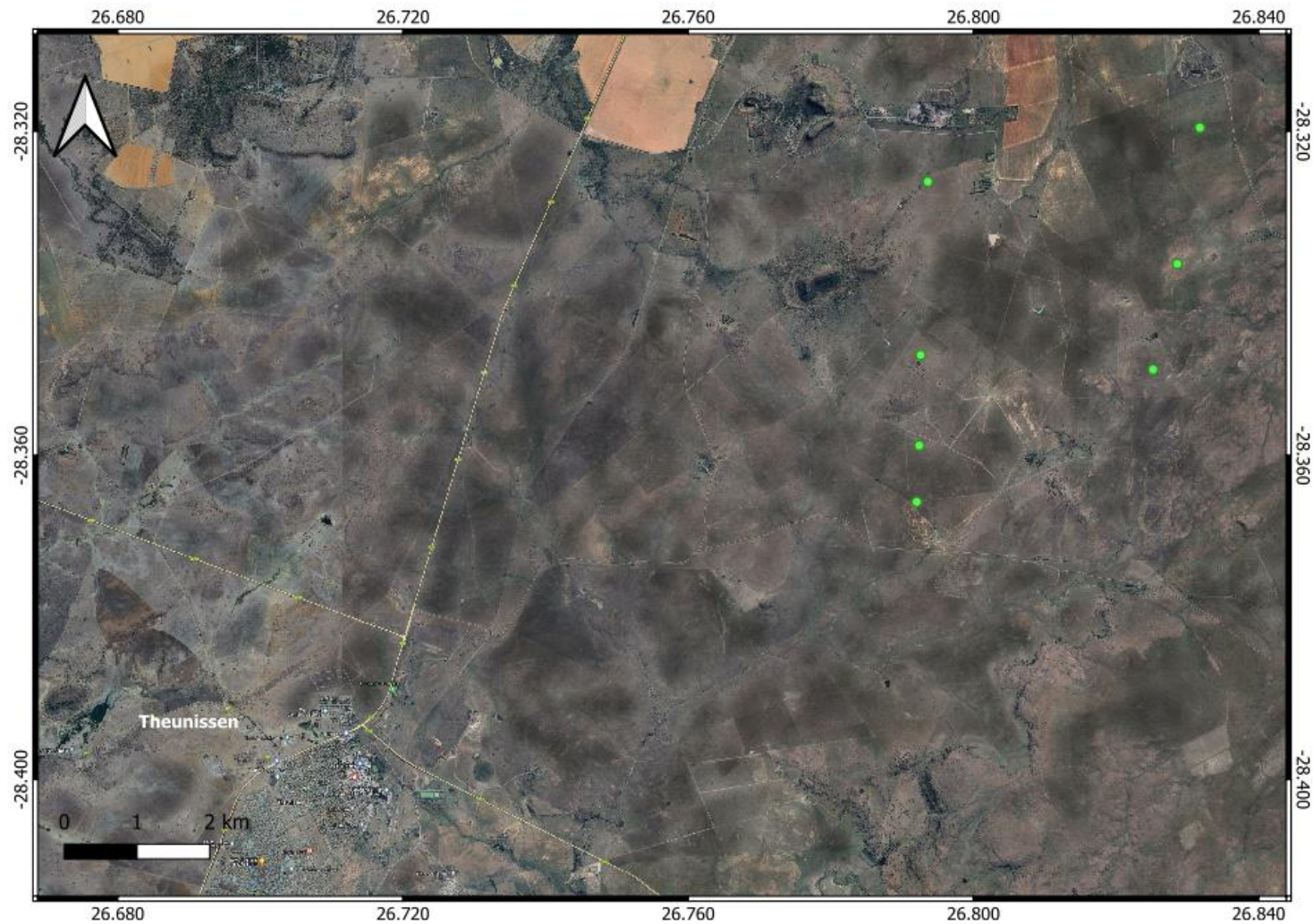


Figure 4: ER 94 (V7) Production Right Extension (north of Theunissen).



2. QUALIFICATIONS AND EXPERIENCE OF THE AUTHOR

This study has been conducted by Mrs Elize Butler. She has conducted approximately 750 palaeontological impact assessments for developments in the Free State, KwaZulu-Natal, Eastern, 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 twenty-eight 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.

3. LEGISLATION

3.1 National Heritage Resources Act (25 of 1999)

Cultural Heritage in South Africa, includes all heritage resources, is protected by the National Heritage Resources Act (Act 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) Act 107 of 1998
- National Heritage Resources Act (NHRA) Act 25 of 1999
- Minerals and Petroleum Resources Development Act (MPRDA) Act 28 of 2002
- Notice 648 of the Government Gazette 45421- 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 982 (Government Gazette 38282, 14 December 2014) promulgated under the National Environmental Management Act (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

National Heritage Resources Act (NHRA) Act 25 of 1999

- 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 (No 107 of 1998) 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 and 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.

4. METHODS AND TERMS OF REFERENCE

This Palaeontological Assessment is part of the HIA Report. The PIA's goals are to: 1) identify the palaeontological significance of the rock formations in the footprint; 2) evaluate the palaeontological magnitude of the formations; 3) clarify the impact on fossil heritage; and 4) make recommendations for how the developer might protect and minimize potential harm to fossil heritage, according to the "SAHRA APM Guidelines: Minimum Standards for the Archaeological and Palaeontological Components of Impact Assessment Reports".

Calculations of the palaeontological state of each rock segment and the potential impact of development on fossil history take into account the palaeontological status of the rocks, the type of development, and the amount of bedrock removed.

The Provisional DFFE Screening Tool, the SAHRIS Palaeosensitivity map, all Palaeontological Impact Assessment reports for the same area, Google Earth images, topographical and geological maps, as well as academic articles about specimens from the development area and Assemblage Zones, are all used to create scoping reports.

When the development footprint has a moderate to high palaeontological sensitivity, a field-based assessment is necessary. A desktop or field assessment of the exposed rock is used to evaluate the significance of the proposed development's impact, and recommendations for more research or mitigation are made. Excavations for the project often only take place during the building phase, changing the terrain and destroying or permanently encasing fossils at or below the ground surface. Then, access to Fossil Heritage will no longer be available for academic study.

When doing a site investigation, a palaeontologist examines the local development as well as the quantity and variety of fossils found there. This can be demonstrated by looking at representative fossiliferous rock exposures (most igneous and metamorphic rocks are not fossiliferous, whereas sedimentary rocks contain fossil heritage). Examined rock exposures frequently contain a sizeable portion of the stratigraphic unit, which is primarily made up of recently exposed (unweathered) rock. These exposures



may be man-made (such as quarries, open building excavations, even railway and road cuttings) or natural (such as cliffs, and dongas as well as rocky outcrops along stream or river banks). It is usual practice for palaeontologists to record well-preserved fossils (GPS, and stratigraphic data) during field assessment examinations.

Although mitigation is often done prior to construction, it may take place if potentially fossiliferous bedrock is revealed. Fossil collection and documentation are examples of mitigation. A permit from SAHRA must be obtained before beginning any fossil excavation, and the material must be stored at an authorized facility. When mitigation is properly used, it is possible to have a positive impact by raising awareness of the palaeontological past of the area.

By physically evaluating bedrock outcrops to determine their lithology and fossil richness and crisscrossing the development footprint, one can assess an area's fossil potential. Because the presence of fossils at the surface is so unexpected, an average sample size of the region is investigated. To be clear, however, the lack of fossils in a development footprint does not automatically suggest that there is no palaeontologically important material present on the site (on or below the 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;
- Describe of the proposed project and provide information regarding the developer and consultant who commissioned the study;
- Describe location of the proposed development and provide geological and topographical maps
- Provide palaeontological and geological history of the affected area;
- Identify sensitive areas to be avoided (providing shapefiles/kmls) in the proposed development;
- Evaluate 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
- Detail the implications of specialist findings for the proposed development (such as permits, licenses etc).

4.1 Assumptions and Limitations

The geology of the area is the focal point of geological maps, and the sheet explanations of the Geological Maps were not intended to focus on palaeontological heritage. Many inaccessible areas of South Africa have never been examined by palaeontologists, and data is typically dependent solely on aerial pictures. Locality and geological information in museums and university databases is out of date, and data acquired in the past is not always adequately documented.

Comparable Assemblage Zones in other places are also used to provide information on the existence of fossils in areas that have not before been recorded. When similar Assemblage Zones and geological formations are used for Desktop studies, it is commonly assumed that exposed fossil exists within the footprint. As a result, **this field assessment will improve the accuracy of the desktop evaluation.**

5. GEOLOGICAL AND PALAEONTOLOGICAL HISTORY

The geology of the proposed Tetra4 near Virginia in the Free State is depicted on the 1:250 000 Kroonstad 2726 (2000) and Winburg 2826 (1998) (Council of Geoscience, Pretoria) (**Figure 5-7, Table 2-3**). The Tetra4 footprint is underlain by Quaternary sands (Qs, yellow and alluvium, yellow single bird figure), unfossiliferous Jurassic dolerite (Jd, red), the Adelaide Subgroup (Pa, Beaufort Group, Karoo Supergroup), the Volksrust Formation (Pvo,) and the Allanridge Formation (Ra, Ventersdorp Supergroup). **However, the drilling collars is only located in the Quaternary sediments, Jurassic dolerite and the Adelaide Subgroup.**

The PalaeoMap of the South African Heritage Resources Information System (SAHRIS) (**Figure 8, Table 4**) indicates that the Palaeontological Sensitivity of the Adelaide Subgroup is Very High (red), that of the Volksrust Formation is High (orange), and that of the Quaternary sediments is Moderate (green), while the Palaeontological Sensitivity of the Allanridge Formation is Low (blue) and that of the that of the Jurassic Dolerite is Zero (grey) (Almond and Pether, 2009; Almond *et al.*, 2013, Groenewald et al 2014).



The suggested location is classified as having a Medium (yellow) Palaeontology Theme Sensitivity in the DFFE Screening Report (**Figure 9-15**). Updated Geology (2014, Council of Geosciences) refined the geological map and indicates that the proposed development is underlain by alluvium, colluvium, eluvium and gravel (n-qq) as well as Karoo dolerite (jd) (**Figure 16**).

Superficial sediments are represented by the Pleistocene to Recent superficial deposits and consist of alluvium, downwashed surface gravels, pedocretes, and sandy soils. These sediments are most probably of Low Palaeontological Significance but could contain mammalian teeth, bones and horn cores, reptile skeletons and fragments of ostrich eggs. Microfossils, non-marine mollusc shells are also known from Quaternary deposits. Plant material such as foliage, wood, pollens, and peats are recovered as well as trace fossils like vertebrate tracks, burrows, termitaria (termite heaps/ mounds) and rhizoliths (root casts). Reworked Stone Age artifacts have been found in Quaternary alluvium. Most of the superficial deposits are unconsolidated sediments and consist of clay, gravel, sand, silt, that form relatively thin, discontinuous patches of sediments or larger spreads onshore. These sediments comprise of channel, floodplain and stream deposits, talus gravels and glacial drift sediments. Quaternary deposits are very important because palaeoclimatic changes are reflected in the different geological formations (Hunter et al., 2006). Most geomorphologic features in southern Africa were formed during the climate fluctuations in the Quaternary Era (Maud, 2012). Barnosky (2005) indicated that various warming and cooling events occurred in the Quaternary but states that climatic changes during the Quaternary, specifically the last 1.8 Ma, were the most drastic climate changes relative to all climate variations in the past. Climate variations that occurred in the Quaternary were both drier and wetter than the present and resulted in changes in river flow patterns, sedimentation processes and vegetation variation (Tooth et al., 2004).

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 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, pear, wood, pollens. Microfossils and vertebrate remains are often found in Quaternary deposits near water courses and drainage lines.

The Karoo igneous province is one of the worlds classic continental basalt (CFB) provinces. This province consists of intrusive and extrusive rocks that occur over a large area (Duncan et al, 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 dykes) 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 covered at least 140 000 km² while it was larger in the past [~2 000 000 km² (Cox 1970, 1972)].

The Karoo Igneous Province contains a large volume of flood basalts as well as silicic volcanic rocks. These units are comprised of rhyodacite and rhyolitic magma and crops 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 lavas lie conformable on the Clarens Formation but in specific localities sandstone erosion occurred before the volcanic eruptions took place. Lock et al (1974) found evidence in the Eastern Cape that in the early stages of volcanism magma interacted with ground water to produce volcanoclastic deposits as well as phreatic and phreatomagmatic diatremes. Eales et al (1984) also found evidence of aqueous environments during early volcanism by the existence of pillow lavas and associated hyaloclastite breccias and thin lenses of fluvatile sandstones interbedded with the lowermost magmas.



Karoo sandstones, mudstones, and shales, was deposited under fluvial environments of the Adelaide Subgroup (Beaufort Group). The Beaufort Group is the third of the main subdivisions of the Karoo Supergroup. The Beaufort group overlays the Ecca Group and consists essentially of sandstones and shales, deposited in the Karoo Basin from the Middle Permian to the early part of the Middle Triassic periods and was deposited on land through alluvial processes. The Beaufort Group covers a total land surface area of approximately 200 000 km² in South Africa and is the first fully continental sequence in the Karoo Supergroup and is divided into the Adelaide subgroup and the overlying Tarkastad subgroup (**Figure 17**). The Adelaide subgroup rocks are deposited under a humid climate that allowed for the establishment of wet floodplains with high water tables and are interpreted to be fluvio-lacustrine sediments. The Adelaide Subgroup is approximately 5 000m thick in the southeast, but this decreases to about 800m in the centre of the basin which decreases to about 100 to 200m in the north.

The Adelaide Subgroup contains alternating greyish-red, bluish-grey, or greenish grey mudrocks in the southern and central parts of the Karoo Basin with very fine to medium-grained, grey lithofeldspathic sandstones. Thicker sandstones of the Adelaide are usually multi-storey and usually have cut-and-fill features. The sandstones are characterized internally by horizontal lamination together with parting lineation and less frequent trough crossbedding as well as current ripple lamination. The bases of the sandstone units are extensive beds, while ripple lamination is usually confined to thin sandstones towards the top of the thicker units. The mudrocks of the Adelaide Subgroup usually have massive and blocky weathering. Sometimes desiccation cracks and impressions of raindrops are present. In the mudstones of the Beaufort Group calcareous nodules and concretions occur throughout.

The flood plains of the Beaufort Group (Karoo Supergroup) are internationally renowned for the early diversification of land vertebrates and provide the worlds' most complete transition from early "reptiles" to mammals. The Beaufort Group is subdivided into a series of biostratigraphic units based on its faunal content (Kitching 1977, 1978; Keyser *et al*, 1977, Rubidge 1995, Smith *et al*, 2020; Viglietti 2020) (**Figure 17**). A portion of the proposed development is underlain by the Balfour Formation (**Figure 17**) which is divided in the *Daptocephalus* (DAZ) which in turn is divided in the upper (younger) *Lystrosaurus maccaigi* - *Moschorhinus* and lower (older) *Dicynodon-Theriognathus* Subzones (**Figure 18-21**; Viglietti, 2020).

The dicynodont, *Daptocephalus leoniceps* is the main biozone defining fossil of the *Daptocephalus* Assemblage Zone (**Figure 18**). The *Daptocephalus* Assemblage Zone (DaAZ) is characterised by the co-occurrence of the dicynodontoid *Daptocephalus leoniceps*, the therocephalian *Theriognathus microps*, and the cynodont *Procynosuchus delaharpeae*. The DaAZ comprise of two subzones representing the two distinct faunal assemblages in this assemblage zone. The *Dicynodon -Theriognathus* Subzone (in co-occurrence with *Daptocephalus*) is present in the lower *Daptocephalus* Assemblage Zone while the *Lystrosaurus maccaigi* – *Moschorhinus kitchingi* Subzone (**Figure 19**) is present in the upper DaAZ. The defining taxa of the latter subzone is *L. maccaigi*, *Daptocephalus* and *Moschorhinus*. This Zone is characterized by the co-occurrence of the two therapsids namely *Dicynodon* and *Theriognathus* (**Figure**



20). The *Daptocephalus* Assemblage Zone of the Beaufort Group shows the greatest vertebrate diversity and includes numerous well-preserved genera and species of dicynodonts, biarmosuchians, gorgonopsian, therocephalian and cynodont therapsid Synapsida. Captorhinid Reptilia are also present while eosuchian Reptilia, Amphibia and Pisces are rarer in occurrence. Trace fossils of vertebrates and invertebrates as well as *Glossopteris* flora plants have also been described.

The *Daptocephalus* Assemblage Zone (AZ) expands into the lower Palingkloof of the Upper Balfour Formation. The lower Palingkloof Member is of special importance as it precedes the Permo-Triassic Extinction Event which destroyed the vertebrate fauna and extinguished the diverse glossopterid plants. The lower *Lystrosaurus* declivis AZ forms part of the Katberg Formation. Fauna and flora from this assemblage zone is rare as few genera survived the Permo-Triassic Extinction Event. The *Lystrosaurus* declivis AZ is characterized by the dicynodont, *Lystrosaurus*, and captorhinid reptile, *Procolophon*, biarmosuchian and gorgonopsian Therapsida that did not survive into the *Lystrosaurus* Assemblage Zone although the therocephalian and cynodont Therapsida are present in moderate quantities. Captorhinid Reptilia is reduced, but this interval is characterised by a unique diversity of oversized amphibians while fossil fish, millipedes and diverse trace fossils have also been recorded.

The proposed development is also underlain by the Volksrust Formation (Ecca Group). This Formation is mostly an argillaceous unit that overlies the Vryheid Formation of the Beaufort Group. This Formation is about 150-270 m thick and deposits correlate with that of the Fort Brown and Waterford Formations in the south (Snyman 1996). The Volksrust Formation consists of basinal grey to black, silty shale with thin, usually bioturbated, siltstone or sandstone lenses and beds, particularly towards its upper and lower boundaries. Thin phosphate and carbonate beds and concretions are relatively common. These deposits may also be lacustrine or even lagoonal (Cairncross et al 1998). This sequence contains important fossils but are rarely recorded. Fossils from the Volksrust Formation include rare temnospondyl amphibian remains, invertebrates, petrified wood, and low-diversity marine to non-marine trace fossil assemblages. Minor coals with plant remains have been found in this Formation. The bivalve *Megadesmus* has been documented from the Volksrust Formation (Bamford 2011).

Four basins developed on the Kaapvaal Craton about 3000 to 2100 million years ago. The Ventersdorp Supergroup was the third Basin to develop and provides an exceptional volcano-sedimentary supracrustal record. The Ventersdorp Supergroup comprises of the biggest and most wide-spread system of volcanic rocks in the Kaapvaal Craton.

The best exposures of the Ventersdorp Supergroup are in the North West Province, Northern Cape Province as well as Gauteng and southern Botswana. This Supergroup consists of the Klipriviersberg Group (oldest) which is overlain by the Platberg Group, followed by the sedimentary Bothaville Formation (Rb) and the volcanic Allanridge Formation (Ra) (uppermost Ventersdorp unit, youngest Formation and represented in the Tetra4 expansion footprint). The Allanridge Formation comprises mostly of light-greenish grey porphyritic lava, dark-green amygdaloidal lava, and pyroclastic rocks. The lavas are



approximately 2700 million years old and comprise of basaltic andesites. The Allanridge Formation is not known to be fossiliferous.

The Platberg Group is subdivided in four formations i.e., the Kameeldoorns-, Goedgenoeg-, Makwassie-, and Rietgat Formations (Rr). These formations consist of heterogeneous rock varying from chemical and classic sediments, to felsic and mafic volcanics. These rocks were deposited in linear vault troughs during graben development (Visser et al, 1975-1976, Buck, 1980). These deep intermontane grabens formed in older underlying andesitic terranes and formed areas of debris and scree flows as well as alluvial fan deposits. In these fine-grained chemical and terrigenous sediments, ooids and stromatolites accumulated under lacustrine conditions (Buck, 1980). In time fluvial processes prevailed causing widespread prograding of alluvial fans across basins. The Rietgat Formation consists of alternating sedimentary and volcanic rocks which varies in thickness across the basin.

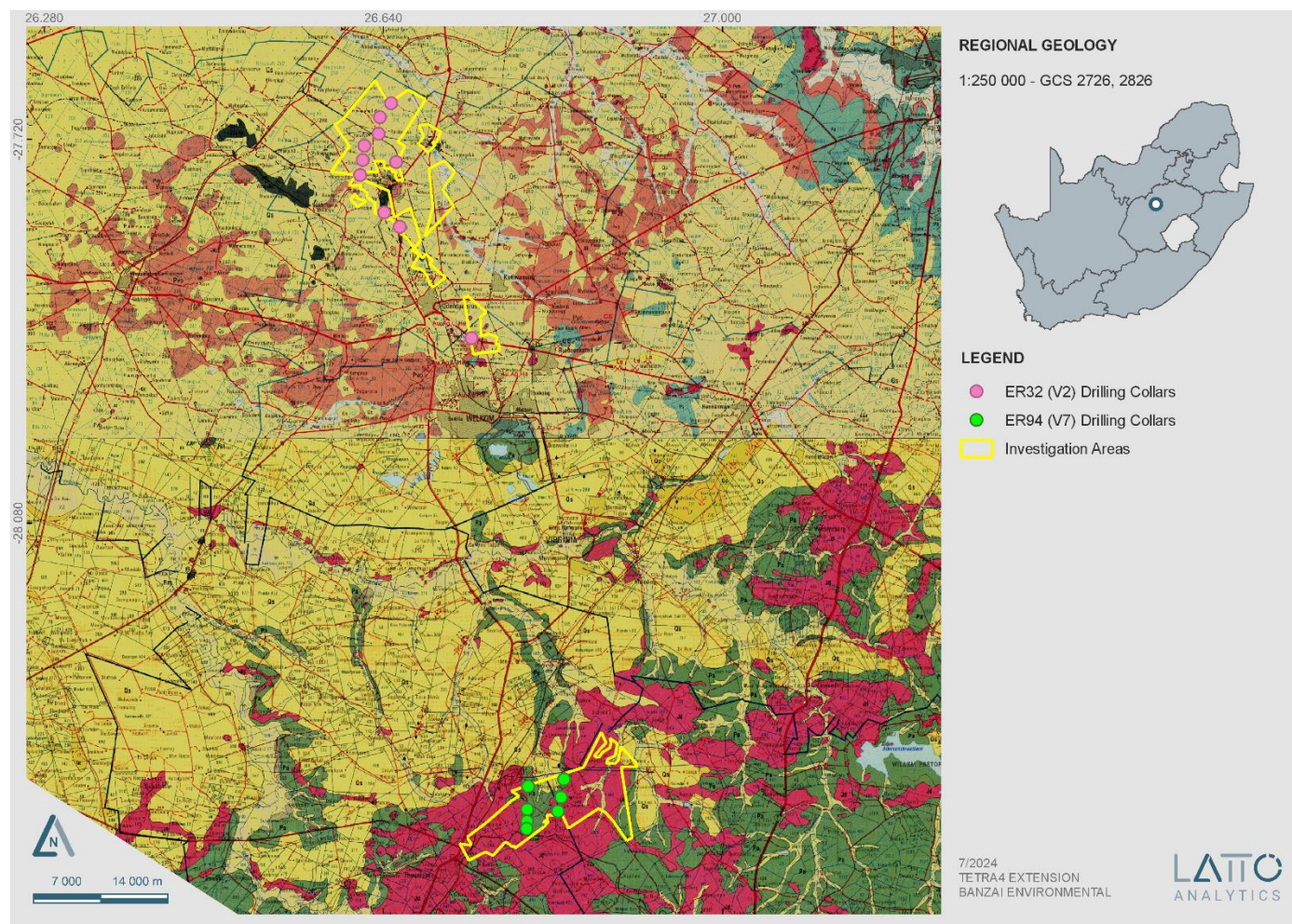


Figure 5: Extract of the 1:250 000 Kroonstad 2726 (2000) and Winburg 2826 (1998) Geological map (Council of Geoscience, Pretoria) indicating that the study area is underlain by Quaternary sands (Qs, yellow and alluvium, yellow single bird figure), unfossiliferous Jurassic dolerite (Jd, red), the Adelaide Subgroup (Pa, Beaufort Group, Karoo Supergroup), the Volksrust Formation (Pvo, Eccia Group) and the Allanridge Formation (Ra, Ventersdorp Supergroup)

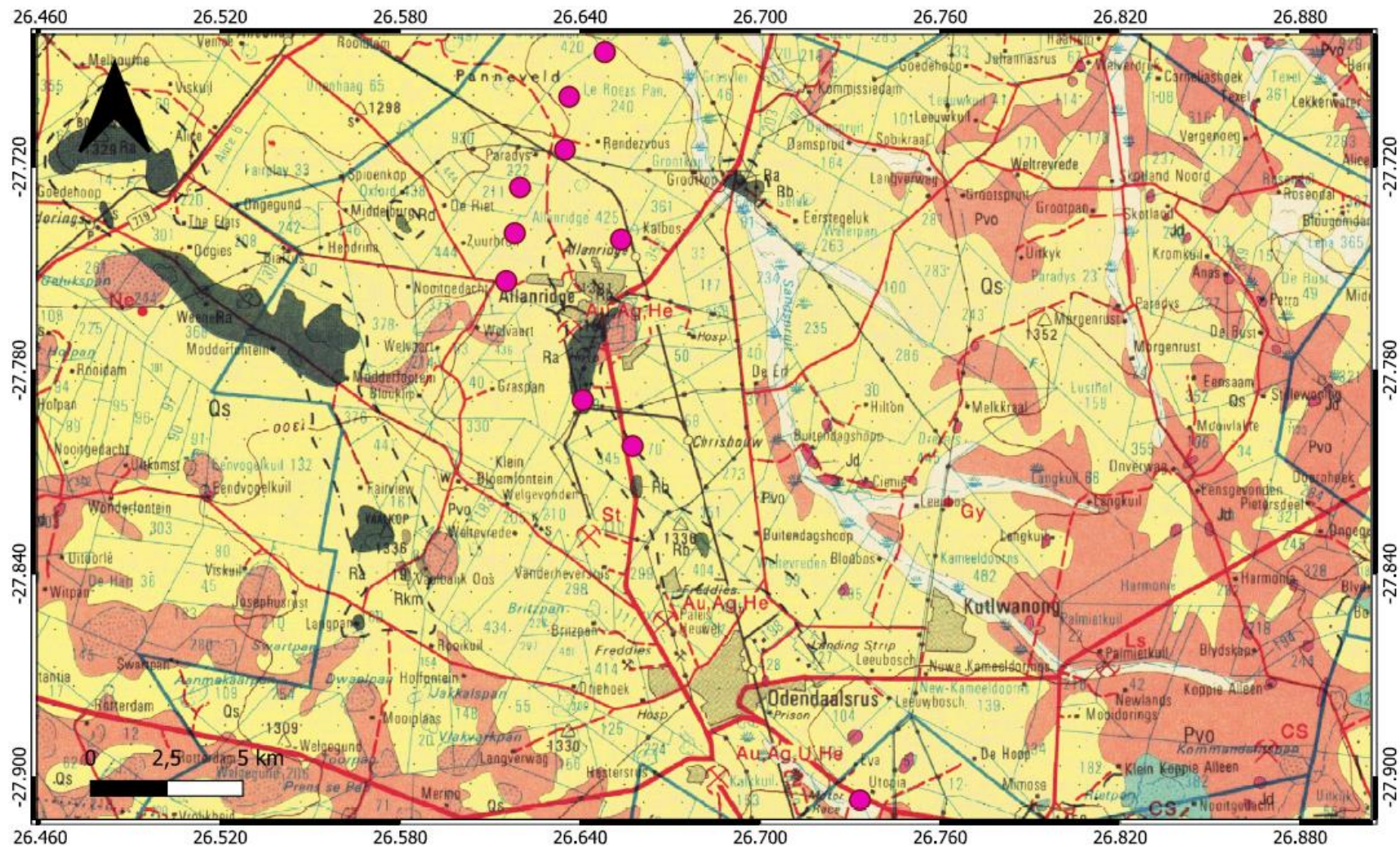


Figure 6: Extract of the 1:250 000 Kroonstad 2726 Geological map (2000) (Council of Geoscience, Pretoria) indicating that the ER32 study area is underlain by Quaternary sands (yellow, Qs) and alluvium (yellow, single bird figure) and the Allanridge Formation (Venterdorp Supergroup).

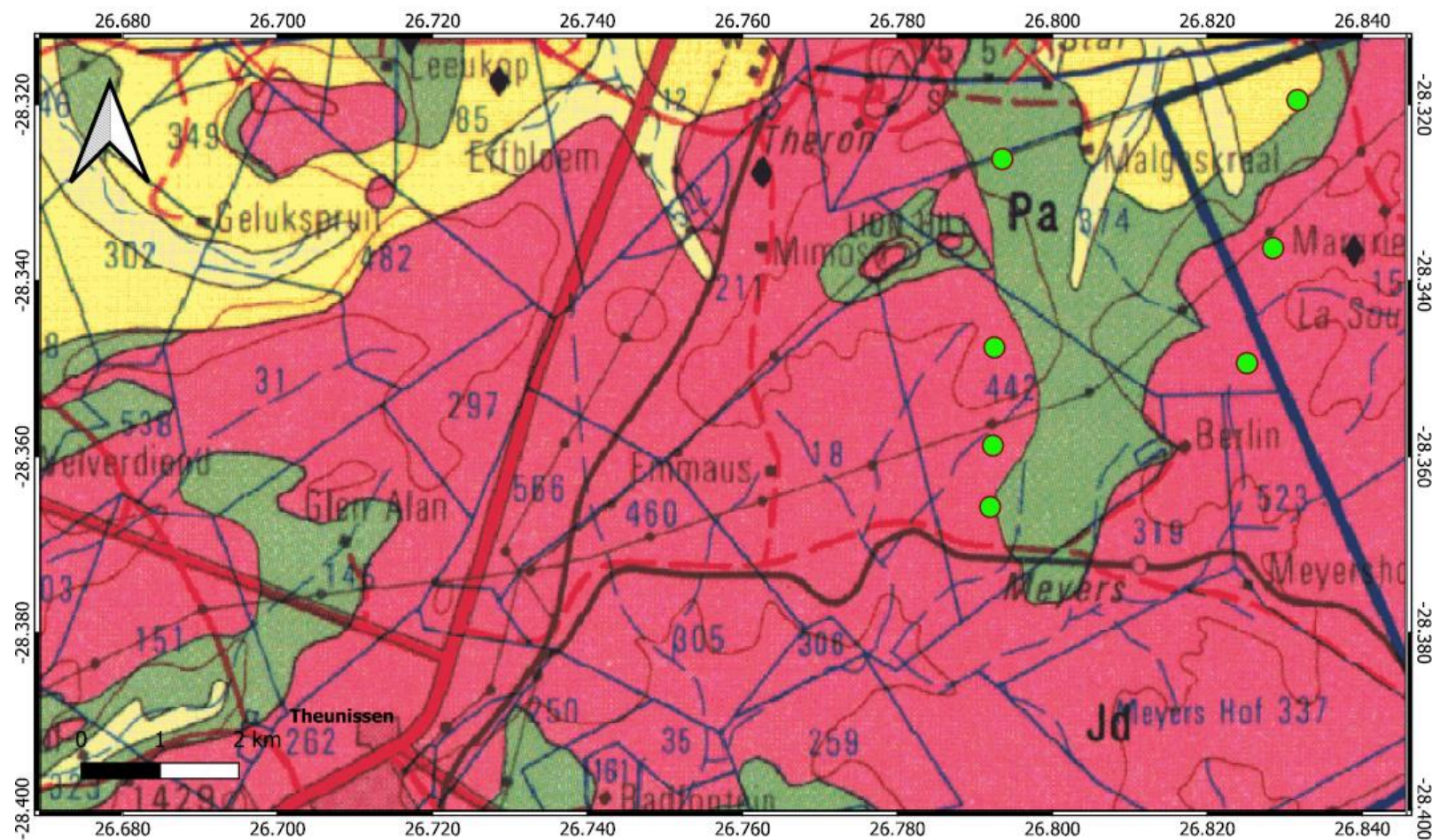


Figure 7: Extract of the 1:250 000 Winburg 2826 Geological map (1998) (Council of Geoscience, Pretoria) indicating that the ER94 study area is underlain by Quaternary sands (yellow, Qs), The Adelaide Subgroup (Pa, green) and Jurassic dolerite Jd, red).

**Table 2: Legend to the 1:250 000 Kroonstad 2726 Geological map (2000) (Council of Geoscience, Pretoria).**

GEOLOGIESE LEGENDE / GEOLOGICAL LEGEND					
SEDIMENTÊRE EN VULKANIESE GESTEENTES SEDIMENTARY AND VOLCANIC ROCKS				INTRUSIEWE GESTEENTES INTRUSIVE ROCKS	
GROEP GROUP	SUBGROEP SUBGROUP	FORMASIE FORMATION		FORMASIE FORMATION	
KWARTÊR QUATERNARY					Alluvium Alluvium
					Rivierterrasgruis River terrace gravel
			Qd	Qc	Kalksteen, toefa Limestone, tufa
			Qs	Qd	Duinsand Dune sand
			Qc	Qs	Eoliese sand Aeolian sand
JURA JURASSIC				Jd	Doleriet Dolerite
TRIAS TRIASSIC				Rm	Grofkorrelrige sandsteen Coarse-grained sandstone
PERM PERMIAN	KAROO SUPERGROEP KAROO SUPERGROUP	BEAUFORT		Rt	Fynkorrelrige sandsteen, rooi moddersteen, mangaanryke kleipilkonglomeraat Fine-grained sandstone, red mudstone, manganiferous clay-pellet conglomerate
			Tarkastad	Pa	Sandsteen, moddersteen, sliestein Sandstone, mudstone, siltstone
			Adelaide	Pv	Sandsteen, sliestein, skalie Sandstone, siltstone, shale
KARBOON CARBONIFEROUS	ECCA	Vryheid		Pvo	Moddersteen, sliestein, skalie Mudstone, siltstone, shale
				C-Pd	Diamiktiet, konglomeraat, sandsteen, moddersteen, skalie Diamictite, conglomerate, sandstone, mudstone, shale



Table 3: Legend to the 1:250 000 Winburg 2826 Geological map (1998) (Council of Geoscience, Pretoria).

SEDIMENTÊRE EN VULKANIESE GESTEENTES SEDIMENTARY AND VOLCANIC ROCKS					INTRUSIEWE GESTEENTES INTRUSIVE ROCKS				
	SUPERGROEP SUPERGROUP	GROEP GROUP	SUBGROEP SUBGROUP	FORMASIE FORMATION					
KWARTÊR QUATERNARY						~ Alluvium; verkalkte alluvium en riviergruis Alluvium; calcified alluvium and river gravel			
				Qs	Qs	Sand; rooi en grys eoliese duinesand Sand; red and grey aeolian dune sand			
				Qc	Qc	Kalkreet en oppervlakkalksteen Calcrete and surface limestone			
JURA JURASSIC	KAROO	BEAUFORT		Drakensberg	Jdb	Jd	Jdb Basaltiese lawa; ondergeskikte fynkorrelrige sandsteen Basaltic lava; subordinate fine-grained sandstone		
				Clarens	Tc	Tc	Fyn- tot baie fynkorrelrige lig-oranje tot pienk sandsteen Fine- to very fine-grained pale-orange to pink sandstone		
			Elliot	Tie	Tie	Rooi slikssteen en moddersteen, ondergeskikte baie fynkorrelrige sandsteen Red siltstone and mudstone, subordinate very fine-grained sandstone			
			Molteno	Tm	Tm	Baie grof- tot mediumkorrelrige sandsteen, ondergeskikte moddersteen Very coarse- to medium-grained sandstone, subordinate mudstone			
				Tt	Tt	Fyn- tot mediumkorrelrige, geel en kakiekleurige sandsteen; rooi, pers, blou en groen moddersteen Fine- to medium-grained, yellow and khaki-coloured sandstone; red, purple, blue green mudstone			
TRIAS TRIASSIC						Pa	Pa	Baie fyn- tot grofkorrelrige, gelerige wit en wit sandsteen; blougrys moddersteen en skalie; ondergeskikte konglomeraat Very fine- to coarse-grained, buff white and white sandstone; blue-grey mudstone and shale; subordinate conglomerate	
		PERM PERMIAN					Pt	Pt	Grys tot swart skalie, ondergeskikte liggrys, fynkorrelrige sandsteen Grey to black shale, subordinate light-grey, fine-grained sandstone
RANDIUM RANDIAN		VENTERSDORP	PLATBERG		Rietgat	Rri			
				Makwassie	Rm				
SWAZIUM SWAZIAN						ZA			

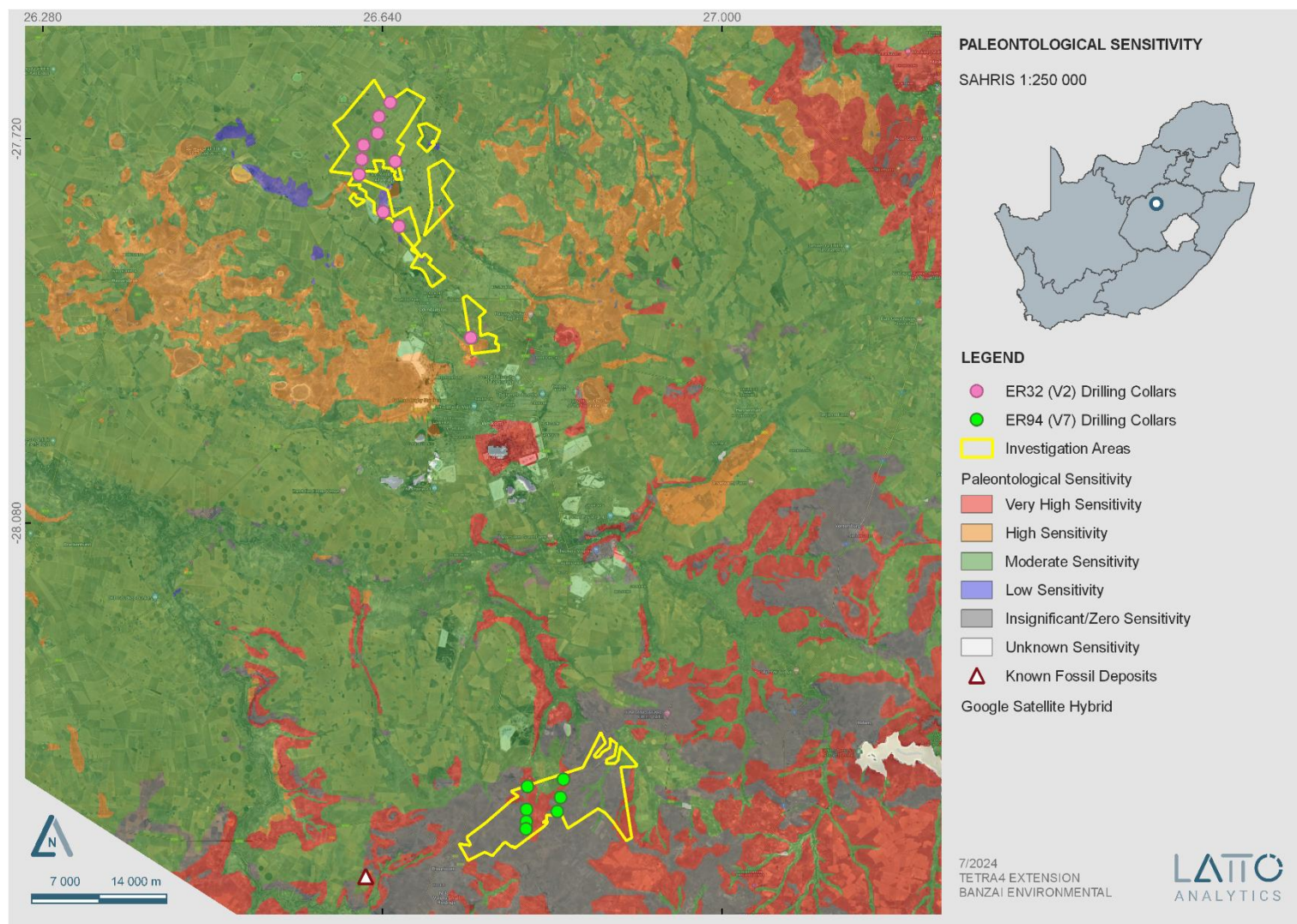


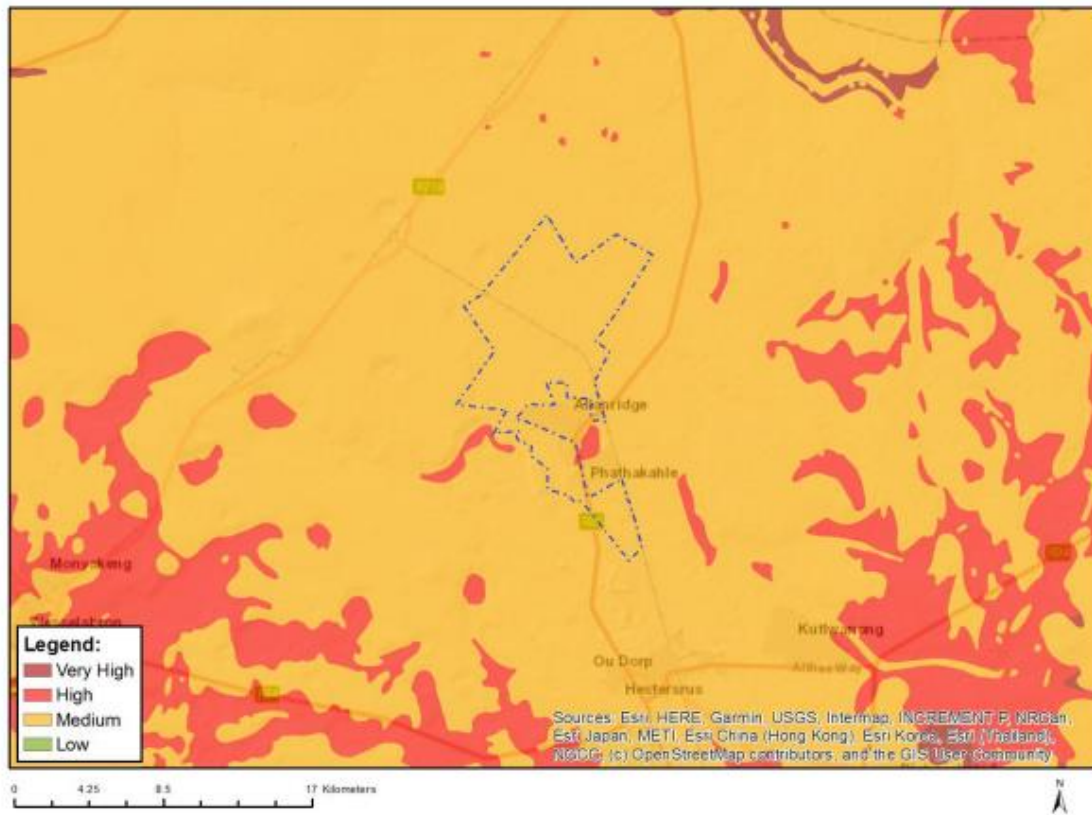
Figure 8: Extract of the 1 in 250 000 SAHRIS PalaeoMap (Council of Geosciences, Pretoria) indicating the Very High (red), High (orange) Moderate (green), Low (blue) and Zero (grey) Palaeontological Sensitivity of the proposed Tetra4 expansion the Free State.

**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.

The SAHRIS Palaeosensitivity map (Figure 8, Table 4) indicates that the proposed development is underlain by sediments with a Very High (red), High (orange), Moderate (green), Low (blue) and Zero (grey) Palaeontological Sensitivity, while the DFFE Screening Tool indicates a small portion in the south with a Very High (deep red) Palaeontological Sensitivity. Areas with a Medium Palaeontological Sensitivity is also crossed (Figure 9-15). The Very High Palaeontological Sensitivity of the SAHRIS PalaeoMap thus corresponds with the Very High DFFE Screening tool. A site investigation conducted on foot and motor vehicle on 28 June 2024 did not detect any fossiliferous outcrops in the development footprint. The Palaeontological Sensitivity of the SAHRIS PalaeoMap and DFFE Screening tool is thus contested with a LOW sensitivity, based on actual conditions in the field in June 2024

MAP OF RELATIVE PALEONTOLOGY THEME SENSITIVITY



Very High sensitivity	High sensitivity	Medium sensitivity	Low sensitivity
	X		

Sensitivity Features:

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

Figure 9: Palaeontological Sensitivity of the Northern portion of the Tetra4 Expansion in the Free State by the National Environmental Web-based Screening Tool indicates a High (red) and Medium (yellow), Palaeontological Sensitivity.

MAP OF RELATIVE PALEONTOLOGY THEME SENSITIVITY



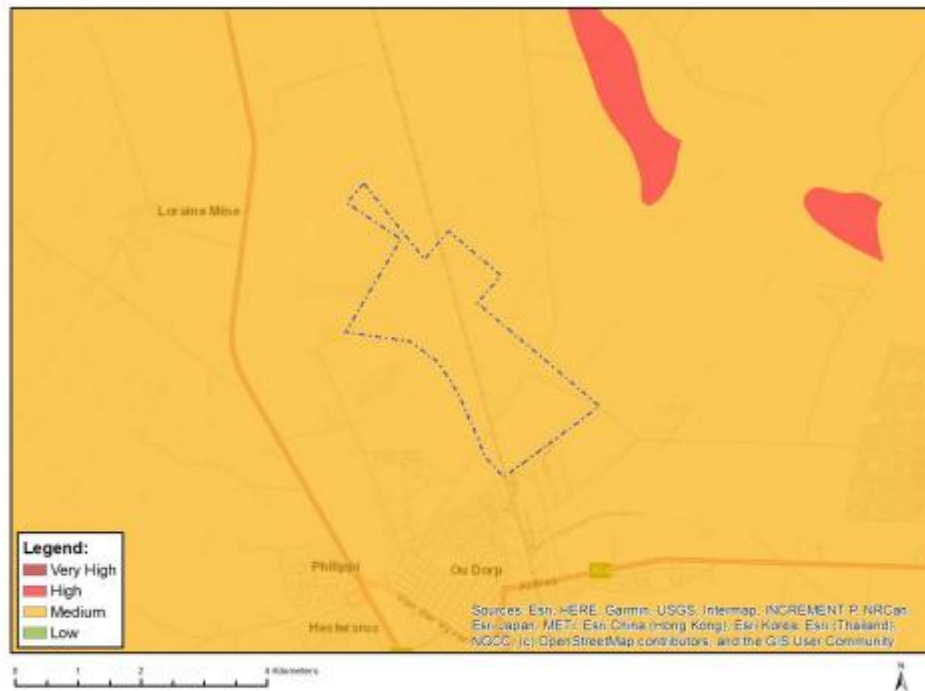
Very High sensitivity	High sensitivity	Medium sensitivity	Low sensitivity
	X		

Sensitivity Features:

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

Figure 10: Palaeontological Sensitivity of the North B portion of the Tetra4 Expansion in the Free State by the National Environmental Web-based Screening Tool indicates a High (red) and Medium (yellow), Palaeontological Sensitivity.

MAP OF RELATIVE PALEONTOLOGY THEME SENSITIVITY



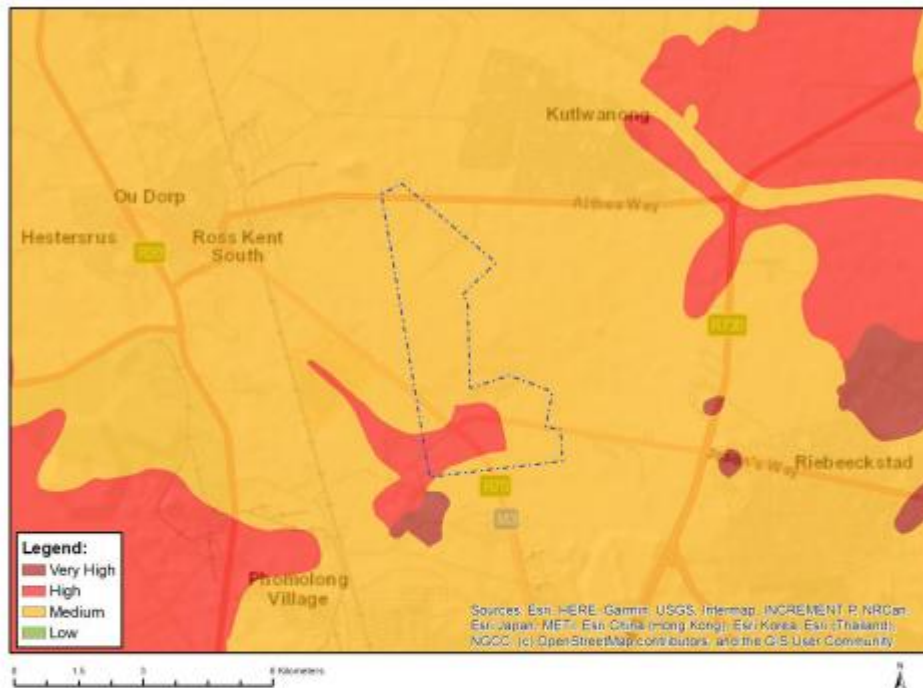
Very High sensitivity	High sensitivity	Medium sensitivity	Low sensitivity
		X	

Sensitivity Features:

Sensitivity	Feature(s)
Low	Features with a Low paleontological sensitivity
Medium	Features with a Medium paleontological sensitivity

Figure 11: Palaeontological Sensitivity of the North C portion of the Tetra4 Expansion in the Free State by the National Environmental Web-based Screening Tool indicates a Medium (yellow), Palaeontological Sensitivity.

MAP OF RELATIVE PALEONTOLOGY THEME SENSITIVITY



Very High sensitivity	High sensitivity	Medium sensitivity	Low sensitivity
	X		

Sensitivity Features:

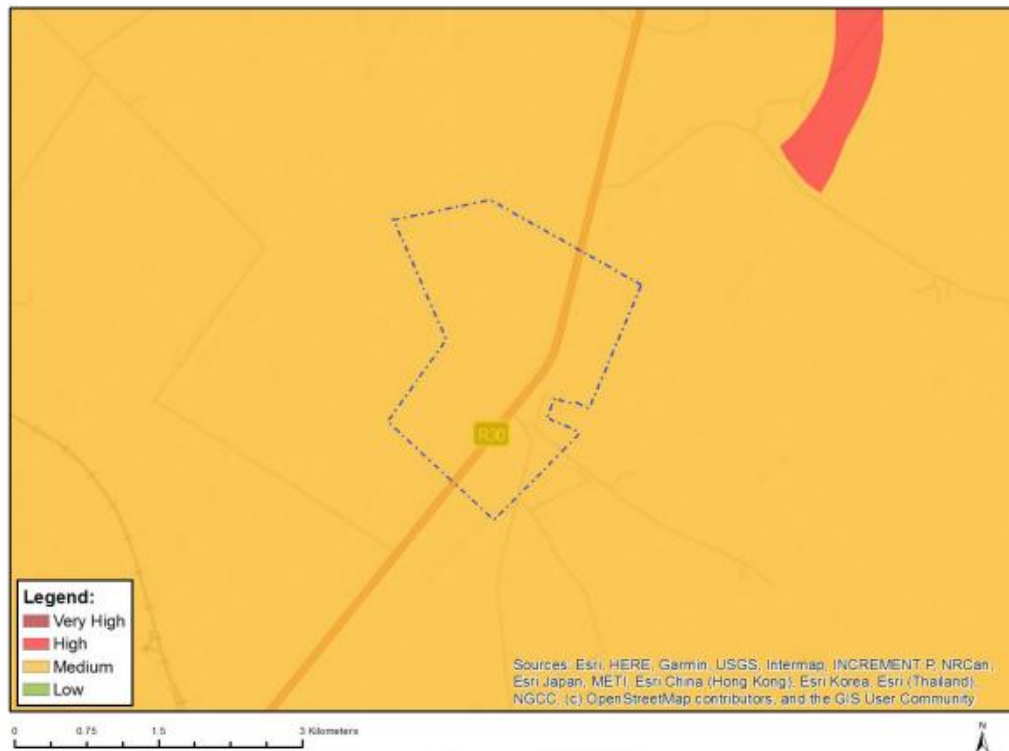
Sensitivity	Feature(s)
High	Features with a High paleontological sensitivity
Medium	Features with a Medium paleontological sensitivity

Figure 12: Palaeontological Sensitivity of the North D portion of the Tetra4 Expansion in the Free State by the National Environmental Web-based Screening Tool indicates a High (red) and Medium (yellow), Palaeontological Sensitivity.

Sensitivity Features:

Figure 13: Palaeontological Sensitivity of the North E portion of the Tetra4 Expansion in the Free State by the National Environmental Web-based Screening Tool indicates a High (red) and Medium (yellow), Palaeontological Sensitivity.

MAP OF RELATIVE PALEONTOLOGY THEME SENSITIVITY



Very High sensitivity	High sensitivity	Medium sensitivity	Low sensitivity
		X	

Sensitivity Features:

Sensitivity	Feature(s)
Low	Features with a Low paleontological sensitivity
Medium	Features with a Medium paleontological sensitivity

Figure 14: Palaeontological Sensitivity of the North F portion of the Tetra4 Expansion in the Free State by the National Environmental Web-based Screening Tool indicates a Medium (yellow), Palaeontological Sensitivity.

[illegible]

Sensitivity Features:

Figure 15: Palaeontological Sensitivity of the South A portion of the Tetra4 Expansion in the Free State by the National Environmental Web-based Screening Tool indicates a Very High (deep red) and Medium (yellow), Palaeontological Sensitivity.

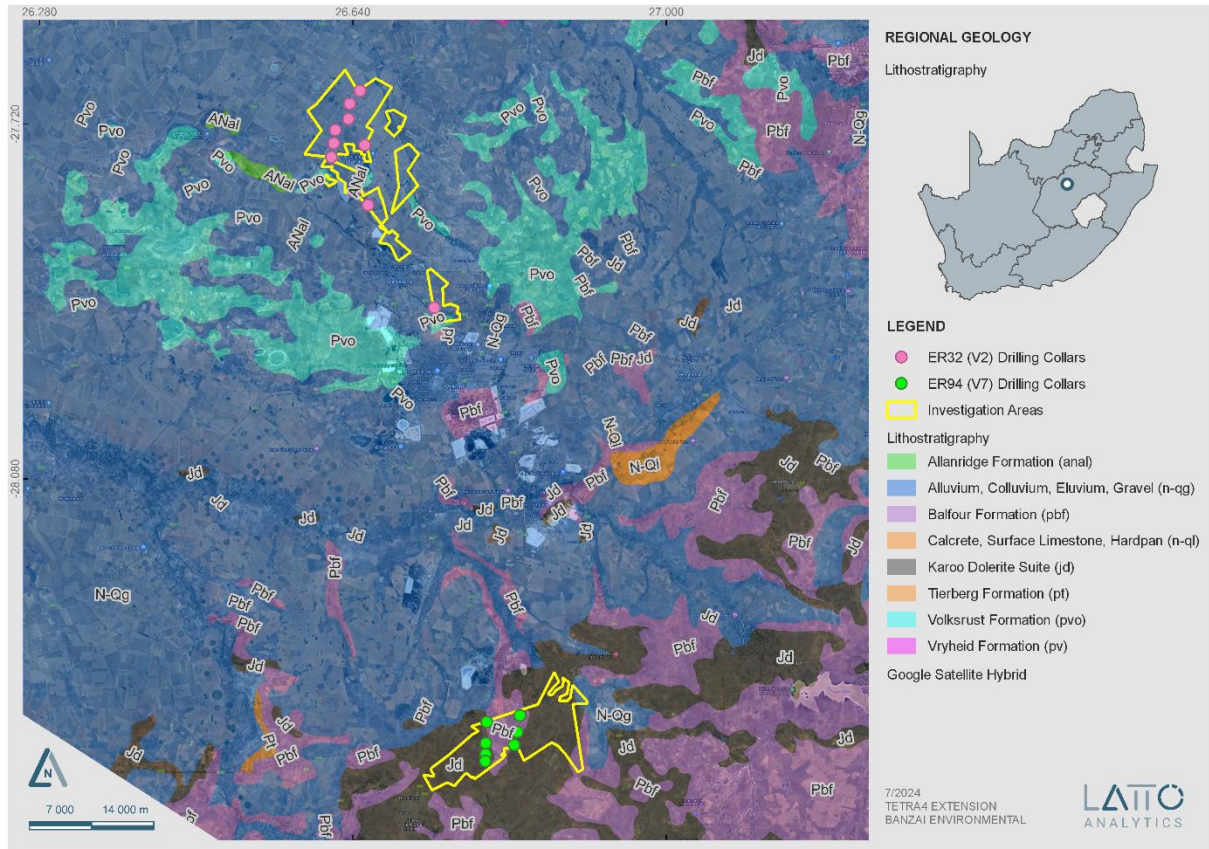


Figure 16: Updated Geology (Council of Geosciences, Pretoria) indicates that the proposed study area is underlain by the alluvium, colluvium, eluvium and gravel (n-qg), Karoo Dolerite (jd), the Balfour Formation (pbf, Beaufort Group), Volksrust Formation (pvo) as well as the Allanridge Formation (anal, Ventersdorp Supergroup).



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		
				Clarens Fm	Clarens Fm	Massospondylus	
				upper Elliot Fm	upper Elliot Fm		
				lower Elliot Fm	lower Elliot Fm		
TRIASSIC	Tarkastad Subgp			Molteno Fm	Molteno Fm	Scalenodontoides	
				Burgersdorp Fm	Driekoppen Fm	Cynognathus	Cricodon-Ufudocyclops Trirachodon-Kannemeyeria Langbergia-Gargainia
				Katberg Fm	Verkykerskop Fm	Lystrosaurus declivis	
				Palingkloof M.			
				Elandsberg M.	Harrismith M.		Lystrosaurus maccaigi-Moschorhinus
				Ripplemead M.	Schoondraai M.		
				Daggaboersnek M.	Rooinekke M.		Dicynodon-Theriongnathus
				Oudeberg M.	Frankfort M.		
PERMIAN	BEAUFORT	Adelaide Subgp	Teekloof Fm	Steenkampsvlakte M.			
				Oukloof M.			
				Hoedemaker M.			
				Poortjie M.			
				Abrahamskraal Fm	Koonap Fm		
ECCA				Waterford Fm	Waterford Fm		
				Tierberg/Fort Brown	Fort Brown		

Figure 17: Vertebrate biozonation range chart for the Main Karoo Basin of South Africa.

Solid lines indicate known ranges, dotted lines indicate suspected but not confirmed ranges, single dot represents the stratigraphic position of the taxa that have only been recovered from a single bed.

Wavy lines indicate unconformities. (PLYCSR=Pelycosauria and MAMMFES+Mammaliaformes. Gp=group, Subgp-Subgroup, Fm=Formation, M=Member)

The geology of the proposed development is indicated by the blue polygon

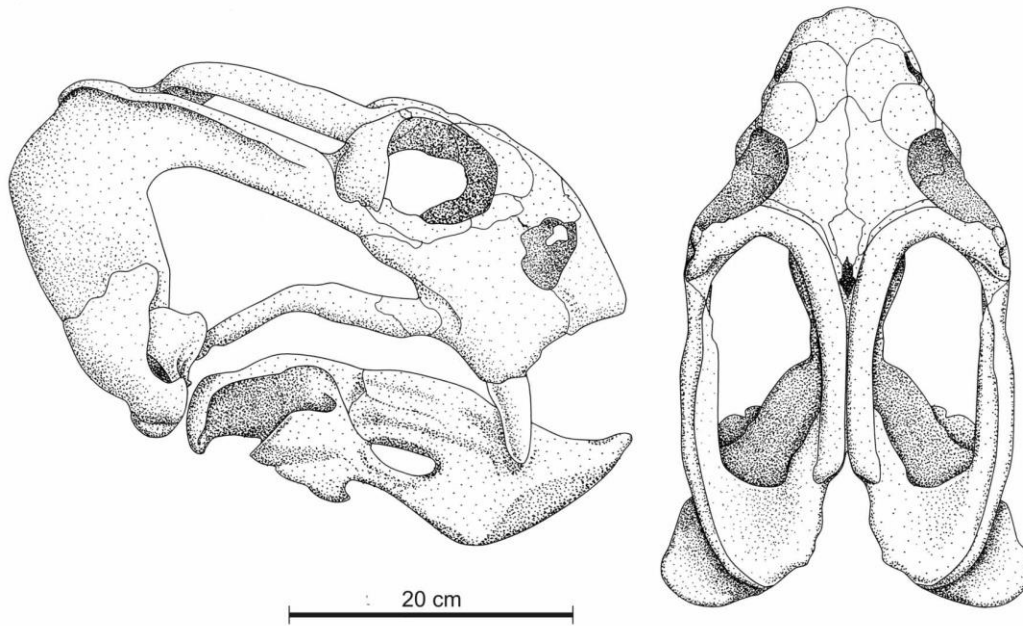


Figure 18: Lateral and dorsal views of skull of the dicynodont *Daptocephalus leoniceps*, the main biozone defining fossil (Image taken from Viglietti, 2020) and dorsal views (Image taken from Viglietti, 2020).

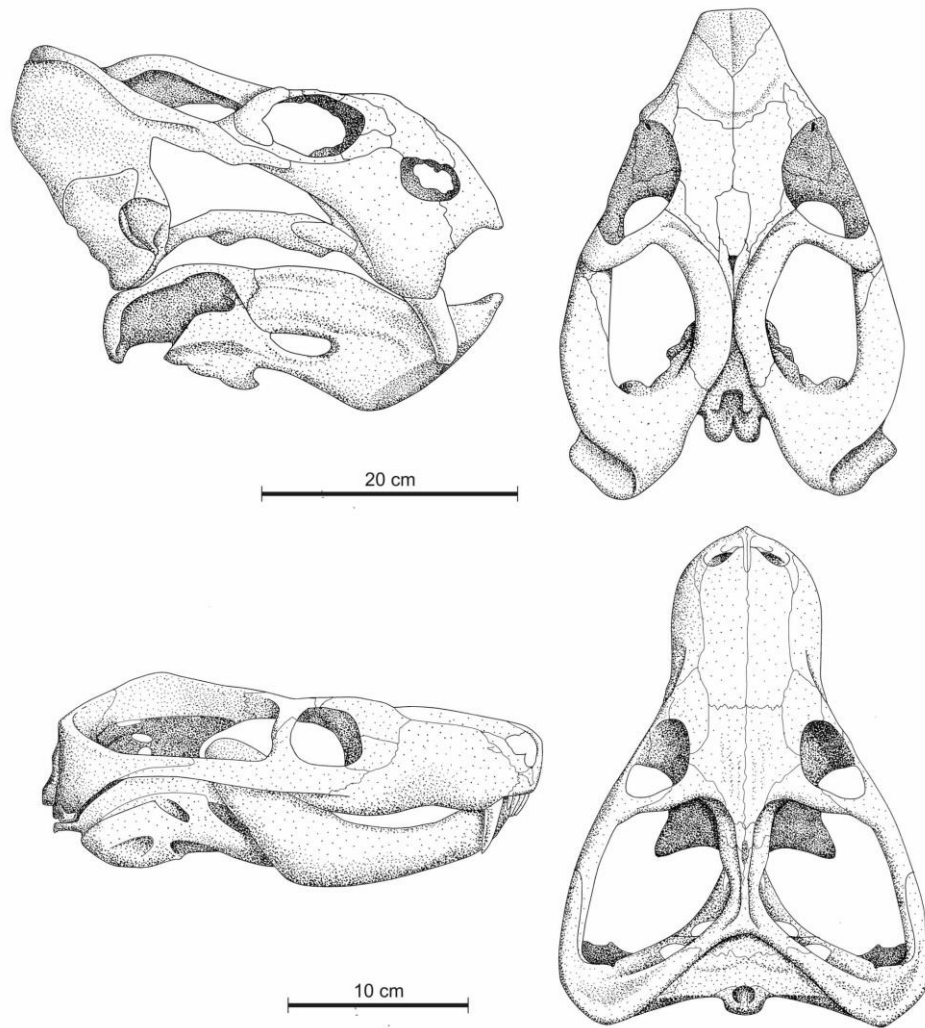


Figure 19: Skulls of the biozone defining fossils of the Dicynodon-Theriognathus Subzone in lateral and dorsal views. *Dicynodon lacerticeps* (top), *Theriognathus microps* (bottom) (Image taken from Viglietti, 2020).

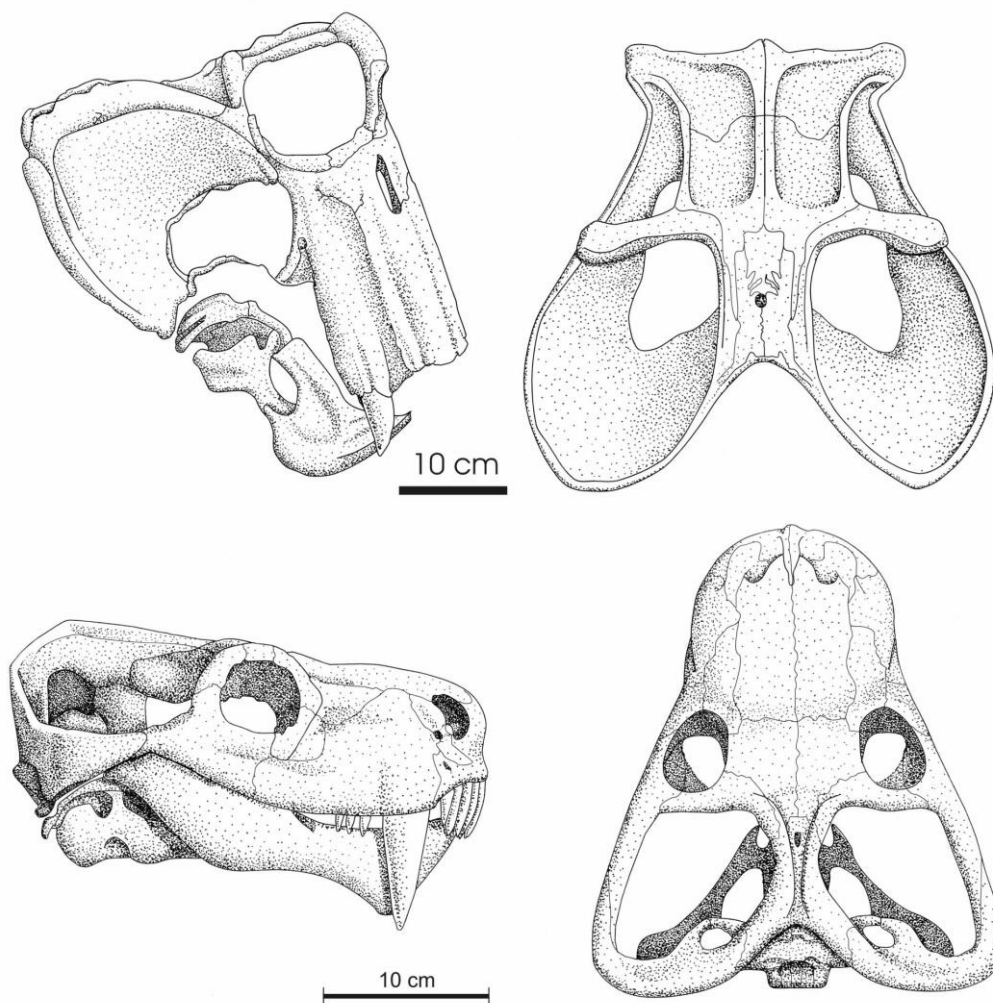


Figure 20: Biozone defining fossils of the *Lystrosaurus maccaigi*- *Moschorhinus* Subzone. The skulls of the *Lystrosaurus maccaigi* (top) and *Moschorhinus kitchingi* (bottom) in lateral (Image taken from Viglietti, 2020).

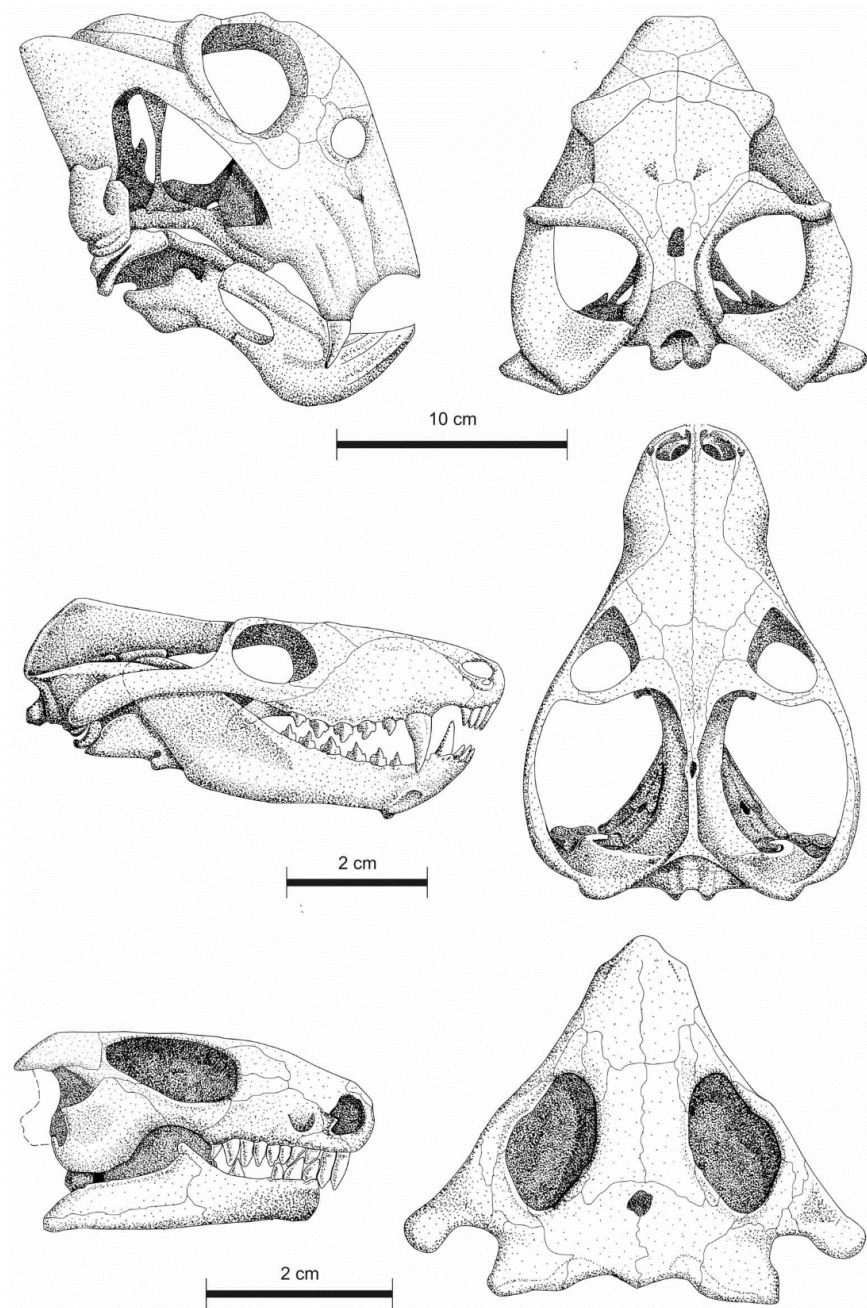


Figure 21: Lateral and dorsal views of the index taxa defining the *Lystrosaurus declivis* Assemblage Zone. (top) *Lystrosaurus declivis*, (centre) *Thrinaxodon liorhinus*, (bottom) *Procolophon trigoniceps* (Image taken from Botha and Smith, 2020).

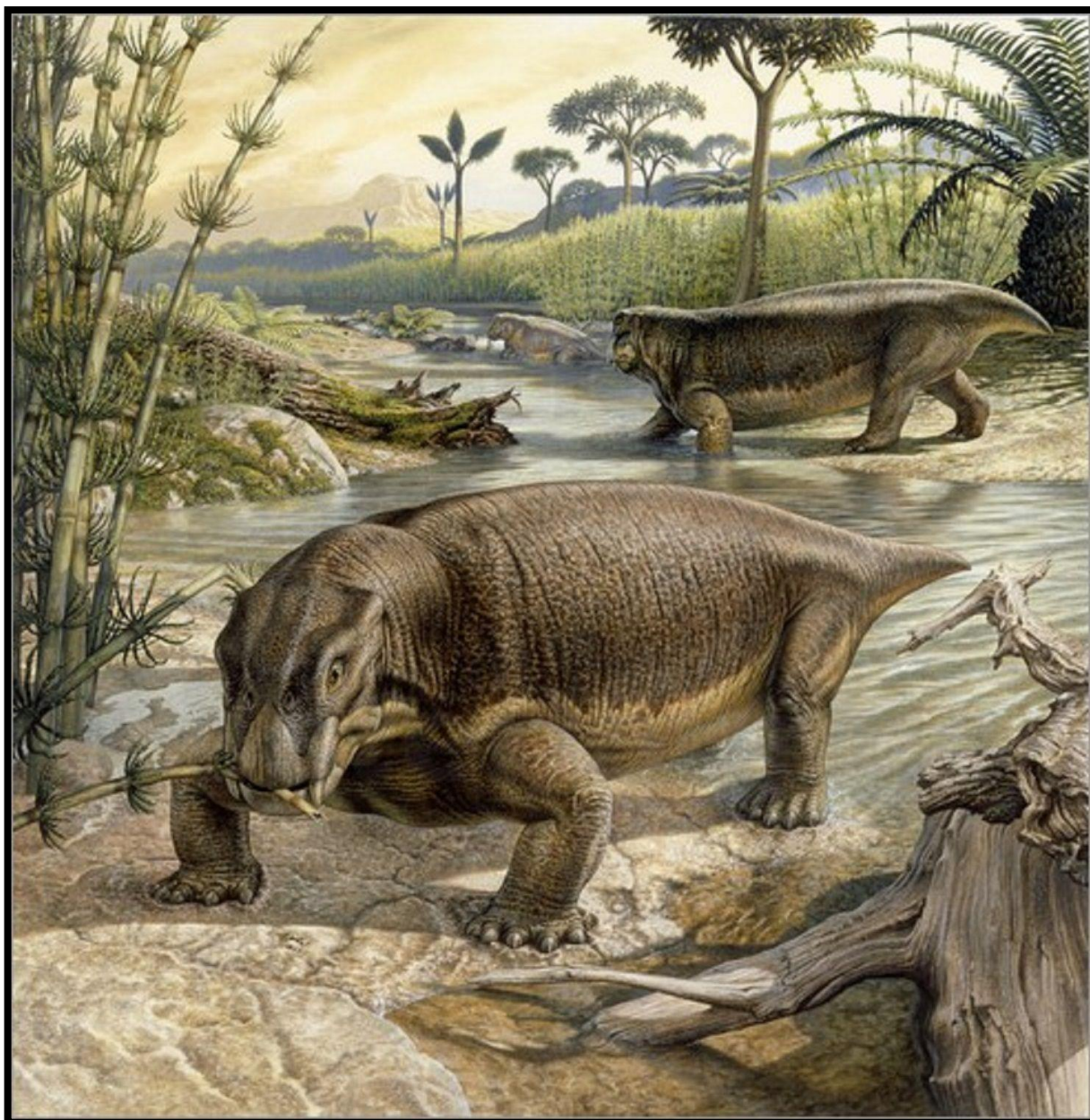


Figure 22: Reconstruction of *Lystrosaurus* sp.

<https://i.pinimg.com/564x/ac/7b/13/ac7b132d1d9882e6d9f9af804820a21e.jpg>

The Triassic Katberg Formation of the Tarkastad Subgroup (**Figure 11**) comprises of a lower Katberg (sandstone-rich) and upper Burgersdorp Formation (mudstone-rich). The Katberg Formation is an arenaceous unit which comprise of 90-95% of sandstone and 5 to 10% of mudstone. In the southern parts of the basin the Tarkastad Subgroup is 2000m thick and reduces to 800m in the centre of the basin thinning to 150m in the northern part of the basin (Groenewald, 1989). The sandstones of this Subgroup are moderately sorted, fine to medium grained, crossbedded, horizontally laminated and ripple cross laminated varying in colour from pale olive or greenish grey tabular subarkose sandstones. The mudstones are horizontally laminated or structureless horizontally laminated, and thick to medium



bedded. Mudstones are minor green to red in colour. Thin mudstone beds occur, with red mudstone beds growing in abundance towards the upper border of the formation as it grades into the Burgersdorp Formation (Johnson, 1976; Johnson et al. 2006). The Burgersdorp Formation is mostly argillaceous and can be interpreted as a meandering fluvial to lacustrine deposit (Johnson et al, 2006; Groenewald, 1996).

The Vertebrate Assemblage Zone present in the Katberg Formation is the *Lystrosaurus declivis* Assemblage Zone (AZ) (Botha & Smith, 2020). In the western part of the basin this biozone spans the upper Palingkloof Member (Balfour Formation) as well as the overlying Katberg Formation. This Assemblage Zone (AZ) is of particular importance as it records the survival and recovery from the end-Permian mass extinction. The argillaceous Palingkloof Member (Balfour Formation) is found in the lower *Lystrosaurus declivis* Assemblage Zone. Olive-grey and massive maroon-bedded siltstone interbedded with minor sandstones with sharp flat basal and upper contacts characterizes the Palingkloof Member. Gastaldo et al., (2020) found that the upper Palingkloof Member is not older than 252.24 +/-0.1 while Botha et al (2020) found that it may be as young as 251.7+/-0.3.

Two species dominate the *Lystrosaurus declivis* AZ namely the small to medium-sized herbivorous dicynodonts *Lystrosaurus murrayi* and *Lystrosaurus declivis* (**Figure 20-22**). These species are small to medium-sized herbivores. Similarly abundant in this biozone is smaller, less common insectivores and faunivorous taxa. Insectivores include *Galesaurus*, *Platycraniellus* and *Thrinaxodon* while theropods are represented by *Olivierosuchus*, *Promoschorhynchus* and *Regisaurus*. Small parareptiles include *Colleta*, *Saurodektes*, *Sauropareion*, *Phonodus* and *Procolophon* while euryptiles are represented by migrant taxa for example *Heleosuchus*, *Noteosuchus*, and *Prolacerta*. The large carnivores include the saber-toothed *Moschorhinus* as well as the long-snouted archosauromorph *Proterosuchus*. After the end-Permian mass extinction, small temnospondyl taxa like *Broomistega*, *Lydekkerina*, and *Micropholis* is abundantly found (Botha et al, 2020). This terrestrial biozone is well-known in the west of Gondwana with closely related species present in Antarctica and India.

Vertebrate fossils are mostly found in the mudrock units between channel sandstones in the *Lystrosaurus declivis* Assemblage Zone. Specimens are well preserved and articulated skull and skeleton specimens have been abundantly found. Several bonebeds have been recorded. A common contributor to the floodplain bonebeds is juvenile *Lystrosaurus declivis* that most probably died due to severe drought conditions (Smith and Botha, 2005, Viglietti et al., 2013, Smith and Botha-Brink, 2014). Numerous positively identified skeletons have been identified in burrows in this Assemblage Zone (Bordy et al., 2011; Botha-Brink, 2017, Damiani et al., 2003, Kitching, 1977; Modesto and Botha-Brink, 2010; Smith and Botha-Brink, 2014). Synchrotron scanning made it possible for Fernandez, et al., 2013 to describe a burrow cast from the Early Triassic of the Karoo (**Figure 23**). This scan depicts a unique mixed-species association of an injured temnospondyl amphibian (*Broomistega*) sheltering in a burrow inhabited by an aestivating *Thrinaxodon*.

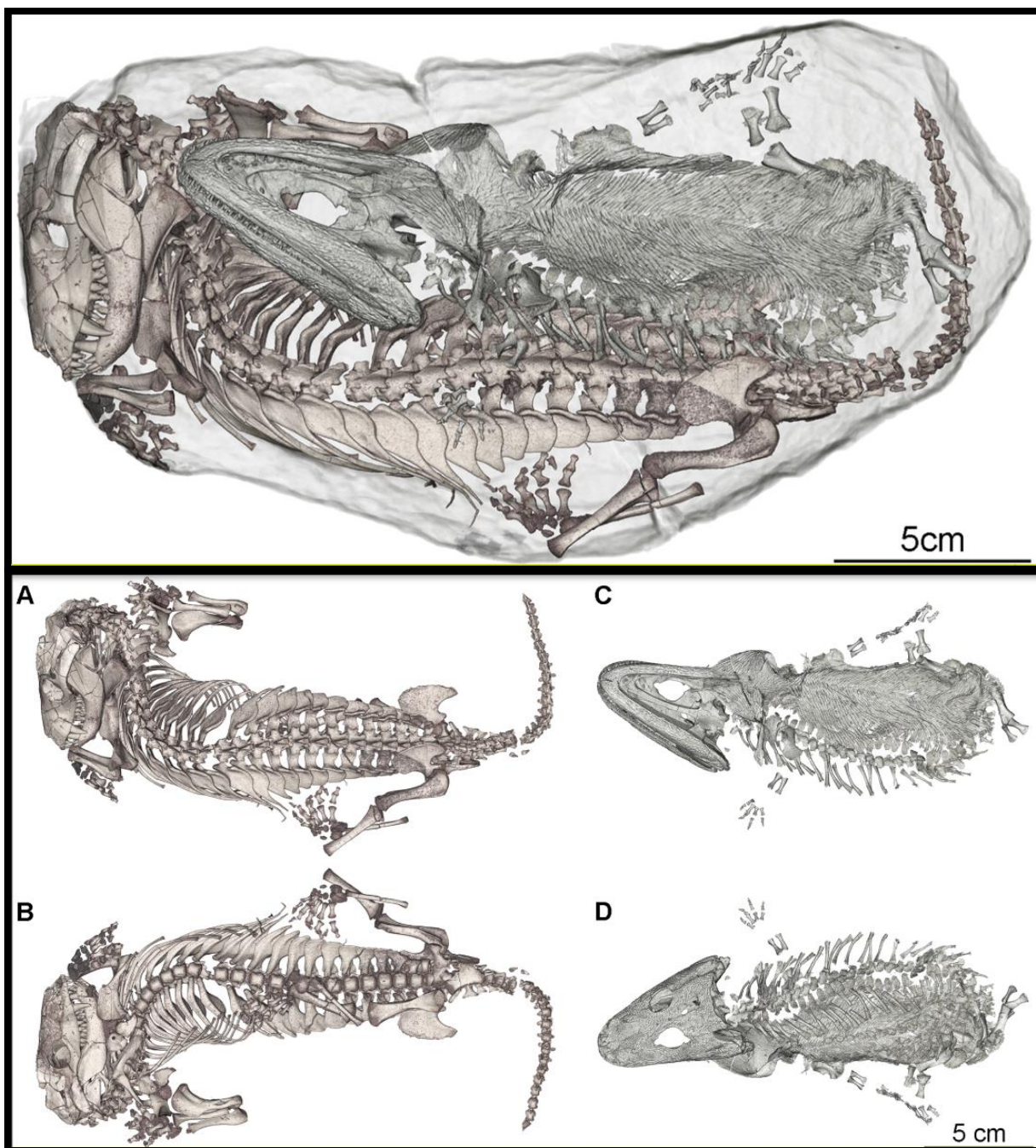


Figure 23: Synchrotron scan of a burrow cast from the Early Triassic indicates an injured temnospondyl amphibian (*Broomistega*) that sheltered in a burrow occupied by an aestivating therapsid (*Thrinaxodon*) Image taken from Fernandez, et al., 2013.



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)
- A Google Earth map with polygons of the proposed development was obtained from Landscape Dynamics
- Google Earth® satellite imagery.
- 1:250 000 Winburg 2826 Geological map (1998) Geological Map (Council for Geosciences, Pretoria)
- 1:250 000 Kroonstad 2726 Geological map (2000) Geological Map (Council for Geosciences, Pretoria)
- Updated geology of the proposed development (2014, Council for Geosciences, Pretoria).
- Palaeosensitivity map on SAHRIS (South African Heritage Resources Information System) website
- Department of Forestry, Fisheries and the Environment Screening tool report
- The combined National Palaeontological Databases of the Museums and Universities of Southern Africa.
- Published geological and palaeontological literature as well as PIAs in the area that includes
 - Almond, J.E. 2022. Proposed Khauta Solar PV Cluster and Associated Grid Connections near Welkom, Matjhabeng Local Municipality, Free State Province.
 - Bamford, M. 2023. Palaeontological Impact Assessment for the proposed Virginia Solar Park, SE of Virginia, Free State Province - Corona Solar Park.
 - Butler. E., 2022. Palaeontological Impact Assessment for the proposed Merapi PV plant phase 4 (46MW) on a site near Welkom, Mantsopa Local Municipality of Thabo Mofutsanyana District Municipality, Free State Province.
 - Butler. E., 2022. Palaeontological Impact Assessment for the proposed Doornrivier Solar 1, southwest of Matjhabeng (formerly Virginia) in the Free State
 - Butler. E., 2022. Palaeontological Impact Assessment (PIA) to assess Nyala Solar near Virginia in the Free State Province
 - Butler. E., 2022. Palaeontological Impact Assessment (PIA) to assess the Nyarhi Solar Power Plant (SPP) near Viljoenskroon in the Free State.
 - Butler. E., 2022. Palaeontological Impact Assessment (PIA) to assess Oryx Solar Power Plant near Virginia, in the Free State Province.
 - Butler. E., 2022. Palaeontological Impact Assessment (PIA) to assess Phofu Solar Power Plant (SPP) near Viljoenskroon, Free State Province.
 - Butler. E., 2022. Palaeontological Impact Assessment (PIA) to assess the Proposed Mokolobane Photovoltaic Solar Energy Facility near Welkom, Free State Province.
 - Butler. E., 2022. Palaeontological Impact Assessment (PIA) to assess proposed Lengana Solar Power Plant (SPP) near Welkom, in the Free State Province.

- No site investigation was conducted for this Project as the Palaeontological Sensitivity of the area is Moderate.

7. SITE INVESTIGATION

A site-specific field survey of the Palaeontologically Highly Sensitive Balfour Formation (Adelaide Subgroup) present in the ER94 site was conducted on foot and by motor vehicle on **28 June May 2024**. According to Mucina and Rutherford (2006), the study area is located in the Central Sandy Bushveld. Plains dominate the area, with some scattered, slightly uneven rolling plains and hills. Mainly low-tussock grasslands with a high karroid content. *Themeda triandra* dominates this vegetative unit. Heavy grazing and unpredictable rainfall have led to poor *T. triandra* cover and an increase in *Elionurus muticus*, *Cymbopogon pospischilii*, and *Aristida congesta*.

The Balfour Formation in this area does not exhibit rocky outcrops and thus no fossils were identified.



Figure 24: General view over the footprint indicate, a flat topography with no rocky outcrops visible.



Figure 25: Dolerite outcrops in close proximity of the Balfour Formation.

8. ASSESSMENT METHODOLOGY

8.1 Method of Environmental Assessment

An assessment of the impact significance of the proposed Tetra4 Project indicates that development is underlain Quaternary sands (Qs, yellow and alluvium, yellow single bird figure), unfossiliferous Jurassic dolerite (Jd, red), the Adelaide Subgroup (Pa, Beaufort Group, Karoo Supergroup), the Volksrust Formation (Pvo, Eccu Group) and the Allanridge Formation (Ra, Ventersdorp Supergroup).

Nature of the Impact

The proposed development will entail the drilling of additional boreholes

Geographical extent of the impact

Impacts on fossil heritage will only occur during the construction phase of the development when new excavations into fresh potentially fossiliferous bedrock takes place. The extent of the area of potential impact is thus limited to the project site.



Sensitive areas

The proposed development is underlain The Tetra4 footprint is underlain by Quaternary sands (Qs, yellow and alluvium, yellow single bird figure), unfossiliferous Jurassic dolerite (Jd, red), the Adelaide Subgroup (Pa, Beaufort Group, Karoo Supergroup), the Volksrust Formation (Pvo,) and the Allanridge Formation (Ra, Ventersdorp Supergroup). **Note that the drilling collars is only located in the Quaternary sediments, Jurassic dolerite and the Adelaide Subgroup.**

Duration of the Impact

The expected duration of the impact is potentially permanent too long term. In the absence of mitigation procedures (and if fossils are present in the development area) the harm or destruction of palaeontological heritage will be permanent.

Potential Significance of the Impact

The destruction/damage of fossil heritage in the development, will be permanent and irreversible. Any fossil heritage in the development area is considered to be of scientific and culturally significant and thus any negative impact on the fossil heritage will be highly significant.

Severity/ Beneficial scale

From a Palaeontological Point of view the development of the proposed Tetra4 Expansion may be beneficial, as the excavations may uncover fossils hidden beneath the surface and would have remained unknown to science.

Intensity of impact occurring

Probable significant impacts on palaeontological heritage during the construction phase are low.

Probability

According to the Geology of the proposed development, fossil heritage can be found in the proposed development

Mitigation

If fossil heritage is present in the development footprint any negative or detrimental impact on these fossils can be mitigated by describing and collecting of the well-preserved fossils (by a professional palaeontologist). **Mitigation measures recommended in this report is the same as in the original EMPr.** Mitigation should take place after vegetation clearance and before the ground is levelled for construction. A SAHRA permit will be required for fossil collection and the fossil heritage must be housed in an accredited institution (university or museum). If fossil heritage cannot be excavated a buffer could be placed around the fossil heritage thus protecting the fossils and fossil locality.



Degree of irreversible Loss

Impacts on fossil heritage are generally irreversible. Scientifically all well-documented records and palaeontological studies of any fossils exposed during construction would represent a positive impact. The possibility of a negative impact on the palaeontological heritage of the area can be reduced by the implementation of adequate mitigation procedures. If mitigation is undertaken the benefit scale for the project will be beneficial.

Irreplaceable loss

Fossil heritage may be present in the fossiliferous sediments underlaying the development. Significant loss of fossil heritage may be limited by taking a precautionary approach.

Impact Summary

Environmental parameter	Issues	Rating prior to mitigation	Average	Rating post mitigation	Average
Planning Phase: Tetra4 Expansion	No Impact		No Impact		
Construction Stage: Tetra4 Expansion	Destroy or permanently seal-in fossils at or below the surface that are then no longer available for scientific study	-13	Negative Medium impact	6	Low positive
Operational Phase: Tetra4 Expansion	No impact		No impact		No impact
Decommissioning: Tetra4 Expansion	No impact	No impact	No impact	No impact	No impact

9. FINDINGS AND RECOMMENDATIONS

The Tetra4 footprint is underlain by Quaternary sands (yellow and alluvium), unfossiliferous Jurassic dolerite, the Adelaide Subgroup (Beaufort Group, Karoo Supergroup), the Volksrust Formation and the Allanridge Formation (Ventersdorp Supergroup). **However, the drilling collars is only located in the Quaternary sediments, Jurassic dolerite and the Adelaide Subgroup.** 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 Volksrust Formation is High, and that of the Quaternary sediments is Moderate), while the Palaeontological Sensitivity of the Allanridge Formation is Low and that of the Jurassic Dolerite is Zero (Almond and Pether, 2009; Almond *et al.*, 2013, Groenewald *et al.* 2014). The suggested location is classified as having a Medium Palaeontology Theme Sensitivity in the DFFE Screening Report. Updated Geology (2014, Council of Geosciences) refined the geological map and indicates that the proposed development is underlain by alluvium, colluvium, eluvium and gravel as well as Karoo dolerite.

A site-specific field survey of the Balfour Formation (High Palaeontological Sensitivity) was conducted on foot and by motor vehicle on 28 June 2024. No fossiliferous outcrop was detected in the proposed development. The site investigation as well as desktop research (National Database and published data) concluded that **fossil heritage of scientific and conservational interest in the development area is relatively rare and of low scientific and conservational value**. Data indicates that fossil sites are generally rare, sporadic and unpredictable. A **low significance** has thus been allocated to the development footprint. **This is in disagreement with the Very High Sensitivity allocated to the development area by the SAHRIS Palaeontological Sensitivity Map and DFFE Screening Tool as no fossils were detected during the site investigation.**

In terms of palaeontological impacts, **a Medium Palaeontological Significance has been allocated for impacts associated with the construction phase of the Tetra4 Extension Project pre-mitigation and a low significance post mitigation**. The drilling phase will be the only development phase with the potential of impacting Palaeontological Heritage, and **no significant impacts are expected to impact the Operational and Decommissioning phases**. As the No-Go Alternative considers the option of 'do nothing' and maintaining the status quo, it will have a Neutral impact on the Palaeontological Heritage of the development. **The Cumulative impacts of the development is considered to be Medium pre- mitigation and Low post mitigation, and falls within the acceptable limits for the project**. It is therefore considered that the proposed development will not lead to damaging impacts on the palaeontological resources of the area. **The construction of the Tetra4 Extension development may thus be permitted in its whole extent, as the development footprint is not considered sensitive in terms of palaeontological resources**. It is consequently recommended that **no further palaeontological heritage studies, ground truthing and/or specialist mitigation are required, pending the discovery of newly discovered fossils**.

If fossil remains are discovered during any phase of construction, either on the surface or exposed by excavations the **Chance Find Protocol** of the EMP must be implemented by the ECO/site manager in charge of these developments. These discoveries ought to be protected (if possible, *in situ*) and the ECO/site manager must report to SAHRA (Contact details: SAHRA, 111 Harrington Street, Cape Town. PO Box 4637, Cape Town 8000, South Africa. Tel: 021 462 4502. Fax: +27 (0)21 462 4509. Web: www.sahra.org.za) so that mitigation (recording and collection) can be carried out by a paleontologist.



Preceding any collection of fossil material, the specialist would need to apply for a collection permit from SAHRA. Fossil material must be curated in an accredited collection (museum or university collection), while all fieldwork and reports should meet the minimum standards for palaeontological impact studies suggested by SAHRA.

These recommendations should be incorporated into the updated Environmental Management Programme (EMPr) for the Tetra4 Extension Project in the Free State Province.

10. MITIGATION AND EMPr REQUIREMENTS

The naturally preserved remnants (or traces) of plants or animals imbedded in rock are known as fossils. These plants and animals existed millions of years ago in the geologic past. Fossils are incredibly valuable and difficult to replace. It is possible to identify the environmental conditions that occurred in a certain geographical area millions of years ago by analysing fossils.

This fact sheet is intended for construction workers and foremen. It describes what to do if fossil material is discovered accidentally during drilling.

It is the responsibility of the project's Environmental Site Officer (ESO) or site manager to train the workers and foremen on **what to do** if a fossil is accidentally discovered. In the absence of the ESO, a member of staff must be designated to be accountable for the effective application of the chance discovery protocol so that the conservation of fossil material is not jeopardized.

If fossils are discovered during excavation, the following method shall be followed.

10.1 Legislation

Cultural Heritage in South Africa (includes all heritage resources) is protected by the **National Heritage Resources Act (Act No 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**”.

The NHRA protects and owns the state's palaeontological legacy, which is unique and non-renewable. It is consequently the responsibility of the state to manage and protect fossils on behalf of South African citizens. According to Section 35 of the NHRA, palaeontological resources may not be excavated, broken, transferred, or destroyed by any development without previous assessment and a permit from the relevant heritage resources authority.

10.2 Chance Find Procedure



- If a chance find is made, the person responsible for the find must immediately stop working, and all work in the immediate vicinity of the find must stop as well.
- The individual who discovered the item must immediately notify his or her direct supervisor, who must then notify his or her management and the ESO or site manager. The ECO or site manager must notify the relevant Heritage Agency (South African Heritage Resources Agency, SAHRA) of the discovery. (Contact information: SAHRA, 111 Harrington Street, Cape Town, South Africa. PO Box 4637, Cape Town 8000, South Africa. Fax: +27 (0)21 462 4509. Tel: 021 462 4502. Web address: www.sahra.org.za). Photographs of the find from various perspectives, as well as GPS coordinates, must be submitted to the Heritage Agency.
- Within 24 hours of the discovery, a preliminary report must be sent to the Heritage Agency, which must include the following: 1) the date of finding; 2) a description of the discovery; and 3) a description of the fossil and its context (depth and position of the fossil), as well as GPS coordinates.
- Photographs of the discovery (the more the merrier) must be of high quality, in focus, and accompanied by a scale. Photographs of the vertical part (side) where the fossil was discovered are also required.
- Upon receipt of the preliminary report, the Heritage Agency will notify the ESO (or site manager) whether a palaeontologist rescue excavation or collection is required.
- The place must be guarded to prevent future damage. There should be no attempt to remove material from their environment. Stabilize the exposed items and cover them with a plastic sheet or sand bags. The Heritage organization will also be able to advise on the best way to protect the find.
- If the fossil cannot be stabilized, the ESO (site manager) may carefully collect the fossil.
- Once the Heritage Agency has received the written authorization, the developer may continue with the development on the affected area.
- Fossil finds must be placed in tissue paper and in an appropriate box while necessary care must be taken to remove any fossil material from the rescue site.

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APPENDIX 1

CURRICULUM VITAE

PROFESSION: Palaeontologist
YEARS' EXPERIENCE: 30 years in Palaeontology
EDUCATION: B.Sc Botany and Zoology, 1988
University of the Orange Free State

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

Management Course, 1991
University of the Orange Free State

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

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

MEMBERSHIP

Palaeontological Society of South Africa (PSSA) 2006-currently

EMPLOYMENT HISTORY

Part time Laboratory assistant	Department of Zoology & Entomology University of the Free State Zoology 1989-1992
Part time laboratory assistant	Department of Virology University of the Free State Zoology 1992
Research Assistant	National Museum, Virginia 1993 – 1997
Principal Research Assistant and Collection Manager	National Museum, Virginia 1998–2022

TECHNICAL REPORTS

Butler, E. 2014. Palaeontological Impact Assessment of the proposed development of private dwellings on portion 5 of farm 304 Matjesfontein Keurboomstrand, Knysna District, Western Cape Province. Virginia.



- Butler, E. 2014. Palaeontological Impact Assessment for the proposed upgrade of existing water supply infrastructure at Noupoot, Northern Cape Province. 2014. Virginia.
- Butler, E. 2015. Palaeontological impact assessment of the proposed consolidation, re-division, and development of 250 serviced erven in Nieu-Bethesda, Camdeboo local municipality, Eastern Cape. Virginia.
- Butler, E. 2015. Palaeontological impact assessment of the proposed mixed land developments at Rooikraal 454, Vrede, Free State. Virginia.
- Butler, E. 2015. Palaeontological exemption report of the proposed truck stop development at Palmiet 585, Vrede, Free State. Virginia.
- Butler, E. 2015. Palaeontological impact assessment of the proposed Orange Grove 3500 residential development, Buffalo City Metropolitan Municipality East London, Eastern Cape. Virginia.
- Butler, E. 2015. Palaeontological Impact Assessment of the proposed Gonubie residential development, Buffalo City Metropolitan Municipality East London, Eastern Cape Province. Virginia.
- Butler, E. 2015. Palaeontological Impact Assessment of the proposed Ficksburg raw water pipeline. Virginia.
- Butler, E. 2015. Palaeontological Heritage Impact Assessment report on the establishment of the 65 mw Majuba Solar Photovoltaic facility and associated infrastructure on portion 1, 2 and 6 of the farm Witkoppies 81 HS, Mpumalanga Province. Virginia.
- Butler, E. 2015. Palaeontological Impact Assessment of the proposed township establishment on the remainder of portion 6 and 7 of the farm Sunnyside 2620, Virginia, Mangaung metropolitan municipality, Free State, Virginia.
- Butler, E. 2015. Palaeontological Impact Assessment of the proposed Woodhouse 1 photovoltaic solar energy facilities and associated infrastructure on the farm Woodhouse729, near Vryburg, North West Province. Virginia.
- Butler, E. 2015. Palaeontological Impact Assessment of the proposed Woodhouse 2 photovoltaic solar energy facilities and associated infrastructure on the farm Woodhouse 729, near Vryburg, North West Province. Virginia.
- Butler, E. 2015. Palaeontological Impact Assessment of the proposed Orkney solar energy farm and associated infrastructure on the remaining extent of Portions 7 and 21 of the farm Wolvehuis 114, near Orkney, North West Province. Virginia.
- Butler, E. 2015. Palaeontological Impact Assessment of the proposed Spectra foods broiler houses and abattoir on the farm Maiden Manor 170 and Ashby Manor 171, Lukhanji Municipality, Queenstown, Eastern Cape Province. Virginia.
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- Butler, E. 2016. Recommendation from further Palaeontological Studies: Proposed Construction of the Modikwa Filling Station on a Portion of Portion 2 of Mooihoek 255 Kt, Greater Tubatse Local Municipality, Limpopo Province. Virginia.
- Butler, E. 2016. Recommendation from further Palaeontological Studies: Proposed Construction of the Heidedal filling station on Erf 16603, Heidedal Extension 24, Mangaung Local Municipality, Virginia, Free State Province. Virginia.
- Butler, E. 2016. Recommended Exemption from further Palaeontological studies: Proposed Construction of the Gunstfontein Switching Station, 132kv Overhead Power Line (Single or Double



Circuit) and ancillary infrastructure for the Gunstfontein Wind Farm Near Sutherland, Northern Cape Province. Savannah South Africa. Virginia.

Butler, E. 2016. Palaeontological Impact Assessment of the proposed Galla Hills Quarry on the remainder of the farm Roode Krantz 203, in the Lukhanji Municipality, division of Queenstown, Eastern Cape Province. Virginia.

Butler, E. 2016. Chris Hani District Municipality Cluster 9 water backlog project phases 3a and 3b: Palaeontology inspection at Tsomo WTW. Virginia.

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Butler, E. 2016. Palaeontological Impact Assessment of the proposed upgrading of the main road MR450 (R335) from Motherwell to Addo within the Nelson Mandela Bay Municipality and Sunday's River valley Local Municipality, Eastern Cape Province. Virginia.

Butler, E. 2016. Palaeontological Impact Assessment construction of the proposed Metals Industrial Cluster and associated infrastructure near Kuruman, Northern Cape Province. Savannah South Africa. Virginia.

Butler, E. 2016. Palaeontological Impact Assessment for the proposed construction of up to a 132kv power line and associated infrastructure for the proposed Kalkaar Solar Thermal Power Plant near Kimberley, Free State and Northern Cape Provinces. PGS Heritage. Virginia.

Butler, E. 2016. Palaeontological Impact Assessment of the proposed development of two burrow pits (DR02625 and DR02614) in the Enoch Mgijima Municipality, Chris Hani District, Eastern Cape.

Butler, E. 2016. Ezibeleni waste Buy-Back Centre (near Queenstown), Enoch Mgijima Local Municipality, Eastern Cape. Virginia.

Butler, E. 2016. Palaeontological Impact Assessment for the proposed construction of two 5 Mw Solar Photovoltaic Power Plants on Farm Wildebeestkuil 59 and Farm Leeuwbosch 44, Leeudoringstad, North West Province. Virginia.

Butler, E. 2016. Palaeontological Impact Assessment for the proposed development of four Leeuwberg Wind farms and basic assessments for the associated grid connection near Loeriesfontein, Northern Cape Province. Virginia.

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Butler, E. 2016: Palaeontological desktop assessment of the establishment of the proposed residential and mixed-use development on the remainder of portion 7 and portion 898 of the farm Knopjeslaagte 385 Ir, located near Centurion within the Tshwane Metropolitan Municipality of Gauteng Province. Virginia.

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Butler, E. 2017. Palaeontological Impact Assessment of The Proposed Development of The New Open Cast Mining Operations on The Remaining Portions Of 6, 7, 8 And 10 Of the Farm Kwaggafontein 8 In the Carolina Magisterial District, Mpumalanga Province. Virginia.

Butler, E. 2017. Palaeontological Desktop Assessment for the Proposed Development of a Wastewater Treatment Works at Lanseria, Gauteng Province. Virginia.

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- Butler, E. 2017. Palaeontological Impact Assessment of the proposed development of the new open cast mining operations on the remaining portions of 6, 7, 8 and 10 of the farm Kwaggafontein 8 10 in the Albert Luthuli Local Municipality, Gert Sibande District Municipality, Mpumalanga Province. Virginia.
- Butler, E. 2017. Palaeontological Impact Assessment of the proposed mining of the farm Zandvoort 10 in the Albert Luthuli Local Municipality, Gert Sibande District Municipality, Mpumalanga Province. Virginia.
- Butler, E. 2017. Palaeontological Desktop Assessment for the proposed Lanseria outfall sewer pipeline in Johannesburg, Gauteng Province. Virginia.
- Butler, E. 2017. Palaeontological Desktop Assessment of the proposed development of open pit mining at Pit 36W (New Pit) and 62E (Dishaba) Amandelbult Mine Complex, Janfrederikzimb, Limpopo Province. Virginia.
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- Butler, E. 2017. Palaeontological Desktop Assessment of the proposed development of the new open cast mining operations of the Impunzi mine in the Mpumalanga Province. Virginia.
- Butler, E. 2017. Palaeontological Desktop Assessment of the construction of the proposed Viljoenskroon Munic 132 KV line, Vierfontein substation and related projects. Virginia.
- Butler, E. 2017. Palaeontological Desktop Assessment of the proposed rehabilitation of 5 ownerless asbestos mines. Virginia.
- Butler, E. 2017. Palaeontological Desktop Assessment of the proposed development of the Lephalale coal and power project, Lephalale, Limpopo Province, Republic of South Africa. Virginia.
- Butler, E. 2017. Palaeontological Impact Assessment of the proposed construction of a 132KV powerline from the Tweespruit distribution substation (in the Mantsopa local municipality) to the Driedorp rural substation (within the Naledi local municipality), Free State province. Virginia.
- Butler, E. 2017. Palaeontological Desktop Assessment of the proposed development of the new coal-fired power plant and associated infrastructure near Makhado, Limpopo Province. Virginia.
- Butler, E. 2017. Palaeontological Impact Assessment of the proposed construction of a Photovoltaic Solar Power station near Collett substation, Middelburg, Eastern Cape. Virginia.
- Butler, E. 2017. Palaeontological Impact Assessment for the proposed township establishment of 2000 residential sites with supporting amenities on a portion of farm 826 in Botshabelo West, Mangaung Metro, Free State Province. Virginia.
- Butler, E. 2017. Palaeontological Desktop Assessment for the proposed prospecting right project without bulk sampling, in the Koa Valley, Northern Cape Province. Virginia.
- Butler, E. 2017. Palaeontological Desktop Assessment for the proposed Aroams prospecting right project, without bulk sampling, near Aggeneys, Northern Cape Province. Virginia.
- Butler, E. 2017. Palaeontological Impact Assessment of the proposed Belvior aggregate quarry II on portion 7 of the farm Maidenhead 169, Enoch Mgijima Municipality, division of Queenstown, Eastern Cape. Virginia.
- Butler, E. 2017. PIA site visit and report of the proposed Galla Hills Quarry on the remainder of the farm Roode Krantz 203, in the Lukhanji Municipality, division of Queenstown, Eastern Cape Province. Virginia.
- Butler, E. 2017. Palaeontological Impact Assessment of the proposed construction of Tina Falls Hydropower and associated power lines near Cumbu, Mthlontlo Local Municipality, Eastern Cape. Virginia.



- Butler, E. 2017. Palaeontological Desktop Assessment of the proposed construction of the Mangaung Gariep Water Augmentation Project. Virginia.
- Butler, E. 2017. Palaeontological Impact Assessment of the proposed Belvoir aggregate quarry II on portion 7 of the farm Maidenhead 169, Enoch Mgijima Municipality, division of Queenstown, Eastern Cape. Virginia.
- Butler, E. 2017. Palaeontological Impact Assessment of the proposed construction of the Melkspruit-Rouxville 132KV Power line. Virginia.
- Butler, E. 2017. Palaeontological Desktop Assessment of the proposed development of a railway siding on a Portion of portion 41 of the farm Rustfontein 109 is, Govan Mbeki local municipality, Gert Sibande district municipality, Mpumalanga Province. Virginia.
- Butler, E. 2017. Palaeontological Impact Assessment of the proposed consolidation of the proposed Ilima Colliery in the Albert Luthuli local municipality, Gert Sibande District Municipality, Mpumalanga Province. Virginia.
- Butler, E. 2017. Palaeontological Desktop Assessment of the proposed Extension of the Kareerand Tailings Storage Facility, associated borrow pits as well as a storm water drainage channel in the Vaal River near Stilfontein, North West Province. Virginia.
- Butler, E. 2017. Palaeontological Desktop Assessment of the proposed construction of a filling station and associated facilities on the Erf 6279, district municipality of John Taolo Gaetsewe District, Ga-Segonyana Local Municipality Northern Cape. Virginia.
- Butler, E. 2017. Palaeontological Desktop Assessment of the proposed of the Lephalale Coal and Power Project, Lephalale, Limpopo Province, Republic of South Africa. Virginia.
- Butler, E. 2017. Palaeontological Desktop Assessment of the proposed Overvaal Trust PV Facility, Buffelspoort, North West Province. Virginia.
- Butler, E. 2017. Palaeontological Impact Assessment of the proposed development of the H₂ Energy Power Station and associated infrastructure on Portions 21; 22 And 23 of the farm Hartebeestspruit in the Thembisile Hani Local Municipality, Nkangala District near Kwamhlanga, Mpumalanga Province. Virginia.
- Butler, E. 2017. Palaeontological Impact Assessment of the proposed upgrade of the Sandriver Canal and Klippan Pump station in Welkom, Free State Province. Virginia.
- Butler, E. 2017. Palaeontological Impact Assessment of the proposed upgrade of the 132kv and 11kv power line into a dual circuit above ground power line feeding into the Urania substation in Welkom, Free State Province. Virginia.
- Butler, E. 2017. Palaeontological Desktop Assessment of the proposed Swaziland-Mozambique border patrol road and Mozambique barrier structure. Virginia.
- Butler, E. 2017. Palaeontological Impact Assessment of the proposed diamonds alluvial & diamonds general prospecting right application near Christiana on the remaining extent of portion 1 of the farm Kaffraria 314, registration division HQ, North West Province. Virginia.
- Butler, E. 2017. Palaeontological Desktop Assessment for the proposed development of Wastewater Treatment Works on Hartebeesfontein, near Panbult, Mpumalanga. Virginia.
- Butler, E. 2017. Palaeontological Desktop Assessment for the proposed development of Wastewater Treatment Works on Rustplaas near Piet Retief, Mpumalanga. Virginia.
- Butler, E. 2018. Palaeontological Impact Assessment for the Proposed Landfill Site in Luckhoff, Letsemeng Local Municipality, Xhariep District, Free State. Virginia.
- Butler, E. 2018. Palaeontological Impact Assessment of the proposed development of the new Mutsho coal-fired power plant and associated infrastructure near Makhado, Limpopo Province. Virginia.
- Butler, E. 2018. Palaeontological Impact Assessment of the authorisation and amendment processes for Manangu mine near Delmas, Victor Khanye local municipality, Mpumalanga. Virginia.
- Butler, E. 2018. Palaeontological Desktop Assessment for the proposed Mashishing township establishment in Mashishing (Lydenburg), Mpumalanga Province. Virginia.
- Butler, E. 2018. Palaeontological Desktop Assessment for the Proposed Mlonzi Estate Development near Lusikisiki, Ngquza Hill Local Municipality, Eastern Cape. Virginia.
- Butler, E. 2018. Palaeontological Phase 1 Assessment of the proposed Swaziland-Mozambique border patrol road and Mozambique barrier structure. Virginia.
- Butler, E. 2018. Palaeontological Desktop Assessment for the proposed electricity expansion project and Sekgame Switching Station at the Sishen Mine, Northern Cape Province. Virginia.



- Butler, E. 2018. Palaeontological field assessment of the proposed construction of the Zonnebloem Switching Station (132/22kV) and two loop-in loop-out power lines (132kV) in the Mpumalanga Province. Virginia.
- Butler, E. 2018. Palaeontological Field Assessment for the proposed re-alignment and de-commissioning of the Firham-Platrand 88kv Powerline, near Standerton, Lekwa Local Municipality, Mpumalanga province. Virginia.
- Butler, E. 2018. Palaeontological Desktop Assessment of the proposed Villa Rosa development In the Buffalo City Metropolitan Municipality, East London. Virginia.
- Butler, E. 2018. Palaeontological field Assessment of the proposed Villa Rosa development In the Buffalo City Metropolitan Municipality, East London. Virginia.
- Butler, E. 2018. Palaeontological desktop assessment of the proposed Mookodi – Mahikeng 400kV line, North West Province. Virginia.
- Butler, E. 2018. Palaeontological Desktop Assessment for the proposed Thornhill Housing Project, Ndlambe Municipality, Port Alfred, Eastern Cape Province. Virginia.
- Butler, E. 2018. Palaeontological desktop assessment of the proposed housing development on portion 237 of farm Hartebeestpoort 328. Virginia.
- Butler, E. 2018. Palaeontological desktop assessment of the proposed New Age Chicken layer facility located on holding 75 Endicott near Springs in Gauteng. Virginia.
- Butler, E. 2018 Palaeontological Desktop Assessment for the development of the proposed Leslie 1 Mining Project near Leandra, Mpumalanga Province. Virginia.
- Butler, E. 2018. Palaeontological field assessment of the proposed development of the Wildealskloof mixed use development near Virginia, Free State Province. Virginia.
- Butler, E. 2018. Palaeontological Field Assessment of the proposed Megamor Extension, East London. Virginia
- Butler, E. 2018. Palaeontological Impact Assessment of the proposed diamonds Alluvial & Diamonds General Prospecting Right Application near Christiana on the Remaining Extent of Portion 1 of the Farm Kaffraria 314, Registration Division HQ, North West Province. Virginia.
- Butler, E. 2018. Palaeontological Impact Assessment of the proposed construction of a new 11kV (1.3km) Power Line to supply electricity to a cell tower on farm 215 near Delporthshoop in the Northern Cape. Virginia.
- Butler, E. 2018. Palaeontological Field Assessment of the proposed construction of a new 22 kV single wood pole structure power line to the proposed MTN tower, near Britstown, Northern Cape Province. Virginia.
- Butler, E. 2018. Palaeontological Exemption Letter for the proposed reclamation and reprocessing of the City Deep Dumps in Johannesburg, Gauteng Province. Virginia.
- Butler, E. 2018. Palaeontological Exemption letter for the proposed reclamation and reprocessing of the City Deep Dumps and Rooikraal Tailings Facility in Johannesburg, Gauteng Province. Virginia.
- Butler, E. 2018. Proposed Kalabasfontein Mine Extension project, near Bethal, Govan Mbeki District Municipality, Mpumalanga. Virginia.
- Butler, E. 2018. Palaeontological Desktop Assessment for the development of the proposed Leslie 1 Mining Project near Leandra, Mpumalanga Province. Virginia.
- Butler, E. 2018. Palaeontological Desktop Assessment of the proposed Mookodi – Mahikeng 400kV Line, North West Province. Virginia.
- Butler, E. 2018. Environmental Impact Assessment (EIA) for the Proposed 325mw Rondekop Wind Energy Facility between Matjiesfontein and Sutherland in the Northern Cape Province.
- Butler, E. 2018. Palaeontological Impact Assessment of the proposed construction of the Tooverberg Wind Energy Facility, and associated grid connection near Touws River in the Western Cape Province. Virginia.
- Butler, E. 2018. Palaeontological impact assessment of the proposed Kalabasfontein Mining Right Application, near Bethal, Mpumalanga.
- Butler, E., 2019. Palaeontological Desktop Assessment of the proposed Westrand Strengthening Project Phase II.
- Butler, E., 2019. Palaeontological Field Assessment for the proposed Sirius 3 Photovoltaic Solar Energy Facility near Upington, Northern Cape Province
- Butler, E., 2019. Palaeontological Field Assessment for the proposed Sirius 4 Photovoltaic Solar Energy Facility near Upington, Northern Cape Province
- Butler, E., 2019. Palaeontological Field Assessment for Heuningspruit PV 1 Solar Energy Facility near Koppies, Ngwathe Local Municipality, Free State Province.



- Butler, E., 2019. Palaeontological Field Assessment for the Moeding Solar Grid Connection, North West Province.
- Butler, E., 2019. Recommended Exemption from further Palaeontological studies for the Proposed Agricultural Development on Farms 1763, 2372 And 2363, Kakamas South Settlement, Kai! Garib Municipality, Mgcawu District Municipality, Northern Cape Province.
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- Butler, E., 2019. Palaeontological Desktop Assessment for the Proposed Waste Rock Dump Project at Tshipi Borwa Mine, near Hotazel, Northern Cape Province:
- Butler, E., 2019. Palaeontological Exemption Letter for the proposed DMS Upgrade Project at the Sishen Mine, Gamagara Local Municipality, Northern Cape Province
- Butler, E., 2019. Palaeontological Desktop Assessment of the proposed Integrated Environmental Authorisation process for the proposed Der Brochen Amendment project, near Groblershoop, Limpopo
- Butler, E., 2019. Palaeontological Desktop Assessment of the proposed updated Environmental Management Programme (EMPr) for the Assmang (Pty) Ltd Black Rock Mining Operations, Hotazel, Northern Cape
- Butler, E., 2019. Palaeontological Desktop Assessment of the proposed Kriel Power Station Lime Plant Upgrade, Mpumalanga Province
- Butler, E., 2019. Palaeontological Impact Assessment for the proposed Kangala Extension Project Near Delmas, Mpumalanga Province.
- Butler, E., 2019. Palaeontological Desktop Assessment for the proposed construction of an iron/steel smelter at the Botshabelo Industrial area within the Mangaung Metropolitan Municipality, Free State Province.
- Butler, E., 2019. Recommended Exemption from further Palaeontological studies for the proposed agricultural development on farms 1763, 2372 and 2363, Kakamas South settlement, Kai! Garib Municipality, Mgcawu District Municipality, Northern Cape Province.
- Butler, E., 2019. Recommended Exemption from further Palaeontological Studies for Proposed formalisation of Gamakor and Noodkamp low-cost Housing Development, Keimoes, Gordonia Rd, Kai !Garib Local Municipality, ZF Mgcawu District Municipality, Northern Cape Province.
- Butler, E., 2019. Recommended Exemption from further Palaeontological Studies for proposed formalisation of Blaauwskop Low-Cost Housing Development, Kenhardt Road, Kai !Garib Local Municipality, ZF Mgcawu District Municipality, Northern Cape Province.
- Butler, E., 2019. Palaeontological Desktop Assessment of the proposed mining permit application for the removal of diamonds alluvial and diamonds kimberlite near Windsorton on a certain portion of Farm Zoelen's Laagte 158, Registration Division: Barkly Wes, Northern Cape Province.
- Butler, E., 2019. Palaeontological Desktop Assessment of the proposed Vedanta Housing Development, Pella Mission 39, Khâi-Ma Local Municipality, Namakwa District Municipality, Northern Cape.
- Butler, E., 2019. Palaeontological Desktop Assessment for The Proposed 920 KWP Groenheuwel Solar Plant Near Augrabies, Northern Cape Province
- Butler, E., 2019. Palaeontological Desktop Assessment for the establishment of a Super Fines Storage Facility at Amandelbult Mine, Near Janfrederikzimbi, Limpopo Province
- Butler, E., 2019. Palaeontological Impact Assessment for the proposed Sace Lifex Project, Near Emalahleni, Mpumalanga Province
- Butler, E., 2019. Palaeontological Desktop Assessment for the proposed Rehau Fort Jackson Warehouse Extension, East London
- Butler, E., 2019. Palaeontological Desktop Assessment for the proposed Environmental Authorisation Amendment for moving 3 Km of the Merensky-Kamení 132KV Powerline
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