BANZAI ENVIRONMENTAL

PALAEONTOLOGICAL IMPACT ASSESSMENT

PROPOSED 5 MW BOSTON HYDRO POWER GENERATION SCHEME AND ASSOCIATED GRID INFRASTRUCTURE, IN THE FREE STATE PROVINCE

March 2023

COMPILED FOR:

CES – ENVIRONMENTAL AND SOCIAL

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 favorable 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 favorable 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: 

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

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

Requirements of Appendix 6 – GN R326 EIA Regulations of 7 April 2017	**The relevant section in the report**	**Comment where not applicable.**
1.(1) (a) (i) Details of the specialist who prepared the report	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 2**	-
(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	-
(cA) An indication of the quality and age of base data used for the specialist report	Section 5 –	-
(cB) a description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change;	Section 10	-
(d) The duration, date and season of the site investigation and the relevance of the season to the outcome of the assessment	Section 1;9 & 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 7	-

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.**
(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;	Section 1;10	-
(g) An identification of any areas to be avoided, including buffers	Section 1 & 11	-
(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 Palaeontological history	-
(i) A description of any assumptions made and any uncertainties or gaps in knowledge;	Section 7.1	-
(j) A description of the findings and potential implications of such findings on the impact of the proposed activity, including identified alternatives, on the environment	Section 1, 10 &11	-
(k) Any mitigation measures for inclusion in the EMPr	Section 11	-
(l) Any conditions for inclusion in the environmental authorisation	Section 1 and 11, 12	-
(m) Any monitoring requirements for inclusion in the EMPr or environmental authorisation	Section 1 and 11, 12	-

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.**
(n)(i) A reasoned opinion as to whether the proposed activity, activities or portions thereof should be authorised and	Section 1 and 11	-
(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	Section 1 and 11	-
(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 Programme (EMPr) process.
(p) A summary and copies of any comments that were received during any consultation process	N/A	Not applicable. To date, no

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.**
		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

Banzai Environmental was appointed by CES – ENVIRONMENTAL AND SOCIAL ADVISORY SERVICES to conduct the Palaeontological Impact Assessment (PIA) to assess the proposed Boston Hydro Power Generation Scheme and associated grid infrastructure near Clarence in the Free State Province. To comply with the National Heritage Resources Act (No 25 of 1999, section 38) (NHRA), this PIA is necessary to verify 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 proposed Boston Hydro Power Project and associated grid infrastructure is underlain by Quaternary alluvium, and the Late Triassic to Early Jurassic Molteno and Elliot Formations of the Stormberg Group (Karoo Supergroup). The PalaeoMap of the South African Heritage Resources Information System indicates that the Palaeontological Sensitivity of the Quaternary alluvium is moderate, while that of the Molteno and Eliot Formations is Very High (Almond and Pether, 2009; Almond *et al*., 2013).

A site-specific field survey of the development footprint was conducted on foot and by motor vehicle in March 2023. No visible evidence of fossiliferous outcrops was found, although the area is well known for its well-preserved dinosaur fossils. An overall medium palaeontological significance is allocated to the development footprint. It is thus considered that the proposed development will not lead to detrimental impacts on the palaeontological reserves of the area. And the construction of the development may thus be authorised in its whole extent.

It is thus recommended that:

- The Environmental Control Officer (ECO), responsible for the development should be aware of the possibility of finding fossils in the Elliot and Molteno Formations of the Stormberg Group (Karoo Supergroup).
- Training of accountable supervisory personnel (Environmental site Officer, ESO) by a qualified palaeontologist in the recognition of fossil heritage is necessary.
- If Palaeontological Heritage is uncovered during surface clearing and excavations the Chance find Protocol attached should be implemented immediately. These discoveries ought to be protected (if possible, *in situ*) and the ECO must report to SAHRA (South African Heritage Research Agency, 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). The information to the Heritage Agency must include photographs of the find, from various angles, as well as the GPS co-ordinates) so that correct mitigation (recording and collection) can be carry out by a paleontologist.

Before any fossil material can be collected from the development site the specialist involved would need to apply for a collection permit from SAHRA. Fossil material must be housed in an official collection (museum or university), while all reports and fieldwork should meet the minimum standards for palaeontological impact studies proposed by SAHRA (2012). 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.

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Curriculum Vitae Elize Butler

1 INTRODUCTION

Boston Hydro Power Plant (Pty) Ltd intends on developing and operating a hydropower plant utilising water from the Ash River (which originates from Lesotho via the Lesotho Highlands Water Project (LHWP). The site is approximately 20km south of the town of Bethlehem in the jurisdiction of the Dihlabeng Municipal District in the Free State Province. The plant will be located on Portion 1 of the farm Boston 40 RD and a portion of the farm Kruisvallei 190.

Boston Hydro is a 5MW run-of-river hydro power project located on the Ash River, near Clarens in the Free State province of South Africa. The scheme will comprise a concrete diversion weir and an embankment and intake structure on the left bank. The intake to the hydropower works comprise a concrete intake structure with a coarse screen/trash rack and a radial gate. A concrete transition leads to a trapezoidal headrace canal followed by a reinforced concrete forebay and reject structure. The reject structure is equipped with an active spillway gate and a set of steel fine trash racks before the inlet to the 4.2 x 4.2 m square reinforced concrete penstock (approx. length of 100 m). The penstock leads to a surface power station housing one horizontal Kaplan type turbine and generator; which discharges to the river through a tailrace channel.

Power will be evacuated via a 22kV overhead powerline from Boston to the Eskom Node substation via the Stortemelk hydropower plant. The power evacuation scope will include the construction of a new 2.3 km long overhead powerline from Boston to Stortemelk and upgrading of the existing powerline from Stortemelk to Node over distance of 9km.

The 22kV Boston-Stortemelk-Node powerline will therefore be 11.3 km in total length, utilizing Chickadee conductor, built on wooden pole structures with H-pole and double wood structures, and include ADSS for fiber communications.

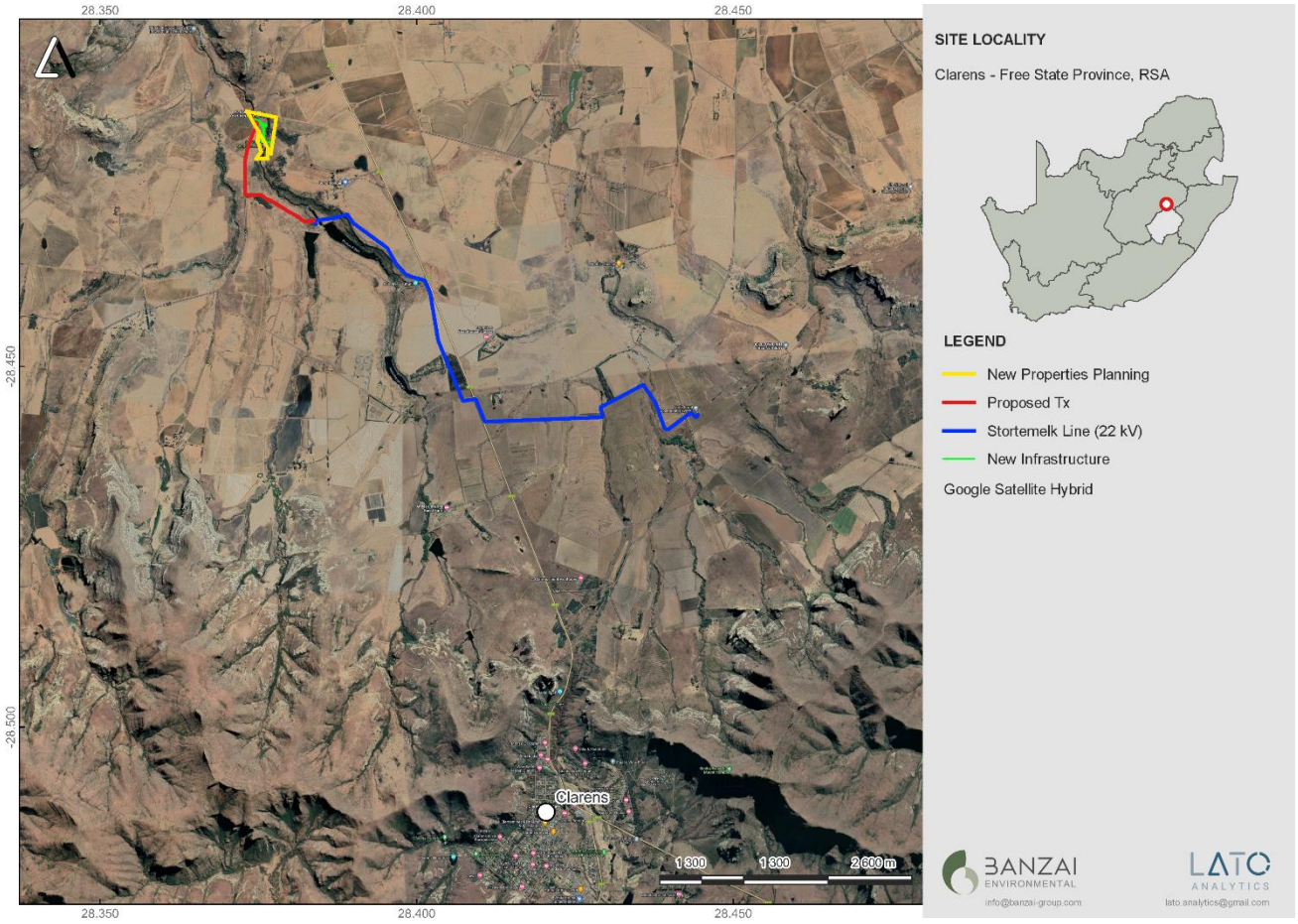


***Figure 1**: Location of the proposed Boston Hydro and grid development near Clarence in the Eastern Free State. The grid connection is indicated in red and blue.*

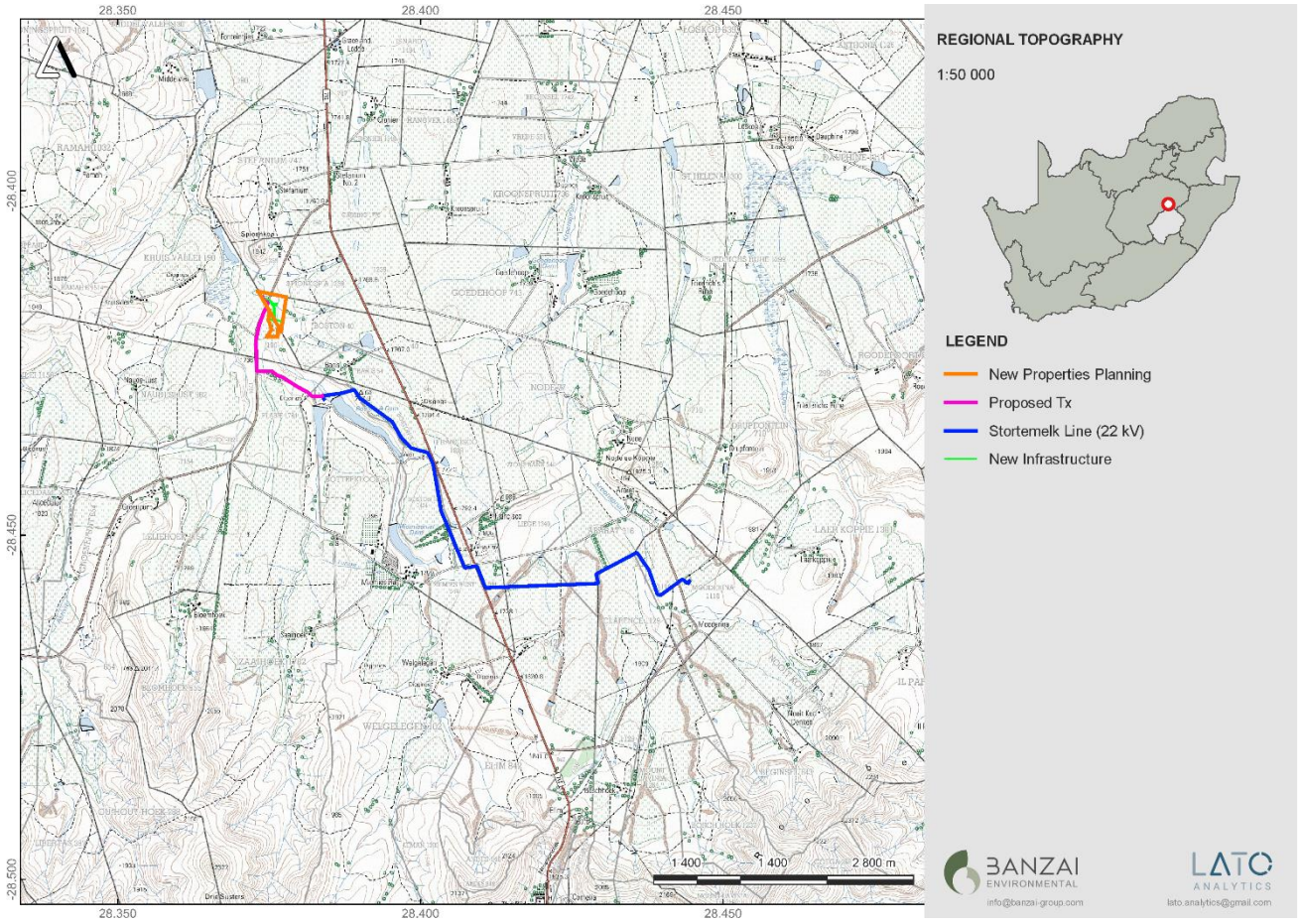


Figure 2: *Regional Topography of the proposed development.*

2 QUALIFICATIONS AND EXPERIENCE OF THE AUTHOR

This present study has been conducted by Mrs Elize Butler. She has conducted approximately 400 palaeontological impact assessments for developments in the Free State, KwaZulu-Natal, Eastern, Central, 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-five years. She has experience in locating, collecting, and curating fossils. She has been a member of the Palaeontological Society of South Africa (PSSA) since 2006 and has been conducting PIAs since 2014.

A curriculum vitae is included in Appendix 1 of this specialist input report.

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 m^2 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 OBJECTIVE

The aim of a Palaeontological Impact Assessment (PIA) is to decrease the effect of the development on potential fossils at the development site.

According to the "SAHRA APM Guidelines: Minimum Standards for the Archaeological and Palaeontological Components of Impact Assessment Reports" the purpose of the PIA is: 1) to identify the palaeontological importance of the rock formations in the footprint; 2) to evaluate the palaeontological magnitude of the formations; 3) to clarify the impact on fossil heritage; and 4) to suggest how the developer might protect and lessen possible damage to fossil heritage.

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

When the development footprint has a moderate to high palaeontological sensitivity a field-based assessment is necessary. The desktop and the field survey of the exposed rock determine the impact significance of the planned development and recommendations for further studies or mitigation. Destructive impacts on palaeontological heritage usually only occur during the construction phase while the excavations will change the current topography and destruct or permanently seal-in fossils at or below the ground surface. Fossil Heritage will then no longer be accessible for scientific research.

During a site investigation the palaeontologist does not only survey the development but also tries to determine the density and diversity of fossils in the development area. This is confirmed by examining representative exposures of fossiliferous rocks (sedimentary rocks contain fossil heritage whereas igneous and metamorphic rocks are mostly unfossiliferous). Rock exposures investigated usually contains a large portion of the stratigraphic unit, can be accessed easily and comprise of unweathered (fresh) exposed rock. These exposures may be natural (rocky outcrops in stream or river banks, cliffs, dongas) but could also be artificial (quarries, open building excavations and even railway and road cuttings). It is common practice for palaeontologist to log well-preserved fossils (GPS, and stratigraphic data) during field assessment studies.

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

The fossil potential of the development area was determined by criss-crossing the development footprint and by physically investigating the bedrock outcrops to determine the lithology and fossil content of the outcrops. Selected potentially fossiliferous sites (e.g., along drainage lines, hillslopes and erosion gullies) were specifically inspected. Fossil sites are usually discovered by chance and a representative subsample is more achievable. However, it is important to note that the absence of fossils in a development footprint does not necessarily mean that palaeontological significant material is not present on site (on or beneath ground surface).

The terms of reference of a PIA are as follows:

General Requirements:

- Adherence to the content requirements for specialist reports in accordance with Appendix 6 of the EIA Regulations 2014, as amended.
- Adherence to all applicable best practice recommendations, appropriate legislation, and authority requirements.
- Submit a comprehensive overview of all appropriate legislation, guidelines.
- Description of the proposed project and provide information regarding the developer and consultant who commissioned the study.
- Description and location of the proposed development and provide geological and topographical maps.
- Provide Palaeontological and geological history of the affected area.
- Identification sensitive areas to be avoided (providing shapefiles/kml's) in the proposed development.
- Evaluation of the significance of the planned development during the Pre-construction, Construction, Operation, Decommissioning Phases and Cumulative impacts. Potential impacts should be rated in terms of the direct, indirect, and cumulative:
    a. Direct impacts are impacts that are caused directly by the activity and generally occur at the same time and at the place of the activity.
    b. Indirect impacts of an activity are indirect or induced changes that may occur as a result of the activity.
    c. Cumulative impacts 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:
- Recommend mitigation measures to minimise the impact of the proposed development; and
- Implications of specialist findings for the proposed development (such as permits, licenses etc).

5 GEOLOGICAL AND PALAEONTOLOGICAL HISTORY

The geology of the Boston Hydro Power Scheme and associated grid connection is indicated on the 1:250 000 Harrismith 2828 (Verster, 1998) Geological map (Council of Geoscience, Pretoria) (Figure 3; Table 2). According to this map the proposed development is underlain by the Late Triassic Molteno (TRm; orange) and Elliot (TRe, red) Formations of the Stormberg Group (Karoo Supergroup). Small areas along the grid connection are also underlain by Quaternary alluvium.

Updated Geology (Figure 4) produced by the Council of Geosciences (Pretoria) indicates that the proposed development is underlain by the Molteno and Elliot Formations of the Stormberg Group (Karoo Supergroup) and does not indicate the superficial Quaternary sediments.

The Palaeosensitivity map of the South African Heritage Resources Information System (SAHRIS) indicates that the Palaeontological Sensitivity of the Quaternary alluvium is moderate, while that of the Molteno and Elliot Formations is Very High (Almond and Pether, 2009; Almond *et al*., 2013) (Figure 5; Table 3).

The Quaternary superficial deposits (yellow, single bird figure and scree) are the youngest geological deposits formed during the most recent geological period (approximately 2.6 million years ago to present). 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. The Quaternary deposits are very important because palaeoclimatic changes are reflected in the different geological formations (Hunter et al., 2006). During the climate fluctuations in the Cenozoic Era most geomorphologic features in southern Africa where formed (Maud, 2012). Barnosky (2005) indicated that various warming and cooling events occurred in the Cenozoic but states that climatic changes during the Quaternary Period, 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 Period 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).

Quaternary fossil assemblages are normally rare and low in diversity and occur over a wide-ranging geographic area. These fossil assemblages may in some cases occur in extensive alluvial and colluvial deposits cut by dongas. In the past palaeontologists did not focus on Caenozoic superficial deposits although they sometimes comprise of significant fossil deposits. These fossil assemblages resemble modern animals and may comprise of mammalian teeth, bones and horn corns, 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). Quaternary scree comprises of rubble and will not contain fossils

The Molteno Formation of the Stormberg Group is Late Triassic in age. In its most southern outcrop this formation is about 600m thick and can be divided into five members (Turner, 1975; Christie, 1981) namely [oldest (bottom) to youngest (top)] Bamboesberg, Indwe, Mayaputi, Qiba and Tsomo Members. This Formation becomes thinner and reaches 10m in the far north. The Molteno Formation consists of alternating coarse to medium grained sandstones and grey mudrocks. The characteristic “glittering” look of this Formation is caused by secondary quartz overgrowths. This Formation is known for well-preserved insect and plant fossils with coal seams in places. The

Bamboesberg Member is the basal member in the south while the Indwe Sandstone Member, is the only representative in the north. These Members overlies the Beaufort Group unconformably (Turner, 1975). The Bamboesberg Member is about 130m thick and is a complex succession that becomes finer upwards in the succession and more erosively based. Medium to fine grained sandstone beds is present with thin, lenticular mudrock intercalations. The Indwe Sandstone Member is about 60m thick and consists of course (pebbly) to medium grained sandstones with an erosively based cobble and pebble bed at its base. The Mayaputi Member is thicker than 50 m and is mostly an argillaceous unit while the more than 60m thick Qiba Member consists of fine- to medium-grained sandstone beds associated with thin mudrock partings. The Tsomo Member is about 300m thick and comprise of a recurring pattern of erosively based, coarse-grained to pebbly sandstones (up to 25m thick) grading upwards into mudrock units (up to 60 m thick). The Molteno Formation is known from two sporadically developed coal seams present in the Tsomo Member comprising of thin, lenticular coal seams.

The Dicroidium Flora of Gondwana preserved in the Molteno Formation is known for the richest plant fossils in the world comprising of diverse vascular plant fossils (horsetails, ferns, gymnosperms include ginkgophytes, cycads, conifers, and seed ferns, silicified woods and palynomorphs) insect's groups as well as dinosaur trackways. Other fossils include bivalves, conchostracans, fish as well as invertebrate trace fossils. This Formation is not known to contain vertebrate fossils (Hancox et al 2020).

The Elliot formation is known as the red beds of South Africa and is Upper Triassic and Lower Jurassic in age. This succession comprises of immature, fine- to medium-grained sandstones, mudstone, and siltstone. The strong red-purple-maroon diagenetic colouration is primarily argillaceous lithologies and lacks extensive marker beds. The Elliot Formation is 460 to 480m thick in the south of the Basin and thinness towards the Free State Drakensberg and KwaZulu-Natal where it varies between 28 and 150m. The formation was deposited in a fluviolacustrine environment that consists of two different types of sandstone (lower and upper part of the Formation). These different sandstones were formed by different fluvial depositional styles. The upper part of the Formation comprises of tabular, multi-storey sheet sandstones and associated facies caused by loessic, aeolian ephemeral, fluvial, and playa lake processes (Visser and Botha, 1980; Eriksson, 1984, 1985; Smith et al., 1993; Bordy et al., 2004b). In the lower part of the Formation the sandstones consist of multi-storey, asymmetrical channelfills. Scientists believe that these sediments were deposits in a perennial, moderately meandering fluvial systems (Botha, 1968; Visser and Botha, 1980; Smith et al., 1993; Bordy et al., 2004b). In the distal Drakensberg regions, the lower part of the Formation becomes thinner. This part of the Formation is dominated by an association of seasonal to ephemeral anastomosing rivers with loessic floodplain fines, and semi-arid sheetflood deposits (Eriksson, 1984, 1985). The differences in fluvial style were generated by changes in the tectonic setting (like tectonic pulses and associated subsidence) as well as climatic conditions.

The Elliot Formation is represented by two Assemblage Zones. The *Scalenodontoides* Assemblage Zone (SAZ) is present in the Lower Elliot Formation (Stormberg Group, Karoo Supergroup) (Viglietti et al 2020a) while the *Massospondylus* Assemblage Zone (MAZ) is present in the Upper Elliot Formation (Viglietti et al 2020b). The SAZ is known for the traversodontid cynodont *Scalenodontoides macrodontes*, as well as the sauropodomorphs *Blikanasaurus cromptoni* and *Melanorosaurus readi* (Viglietti et al 2020a). The MAZ is the youngest tetrapod biozone in the Karoo Basin (upper Stormberg Group, Karoo Supergroup). This AZ represents the dinosaurs of southern Gondwana and include the ornithischian *Lesothosaurus diagnosticus,* sauropodomorph *Massospondylus carinatus* as well as the crocodylomorph *Protosuchus haughtoni*, (Viglietti et al 2020b).

This Formation is palaeontologically very important as it is known for its early dinosaur fauna that includes prosauropods, (he richest known sauropodomorphs) (McPhee, McPhee 2017), ornithischians, rare amphibians, turtles, crocodylomorphs, and crocodilians; cynodont therapsids and early mammals as well as fish. Other fossils include crustaceans, insects, woods, as well as tetrapod trackways (ichnofossils) (Bordy *et al*., 2015).

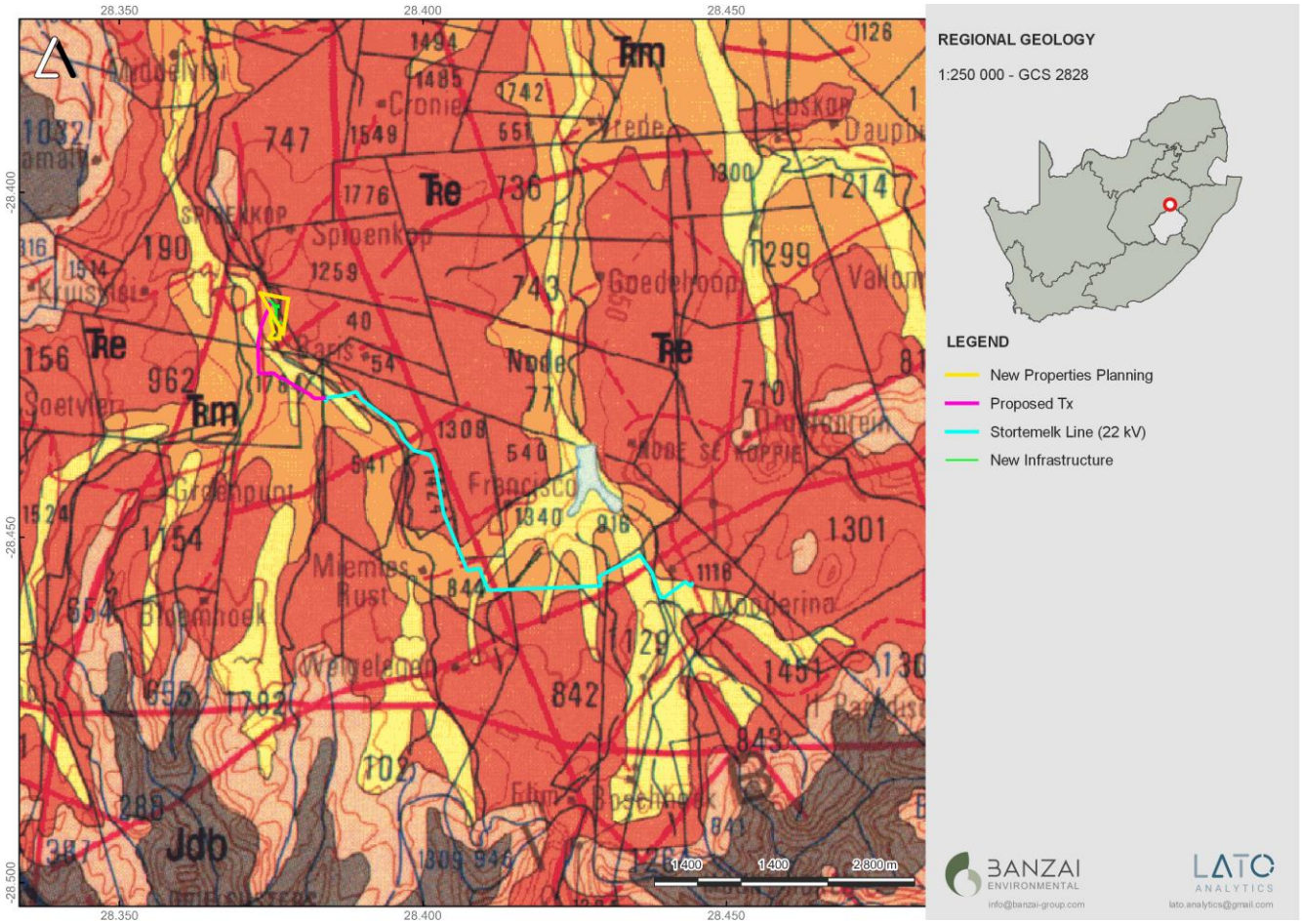


***Figure 3**: Extract of the 1: 250 000 Harrismith 2828 Geological map (1983) (Council of Geoscience, Pretoria) indicating the proposed development in the Eastern Free State. The proposed development is underlain by the Late Triassic Molteno (TRm; orange) and Elliot (TRe, red) Formations of the Stormberg Group (Karoo Supergroup), while as areas along the grid connection is underlain by Quaternary alluvium.*

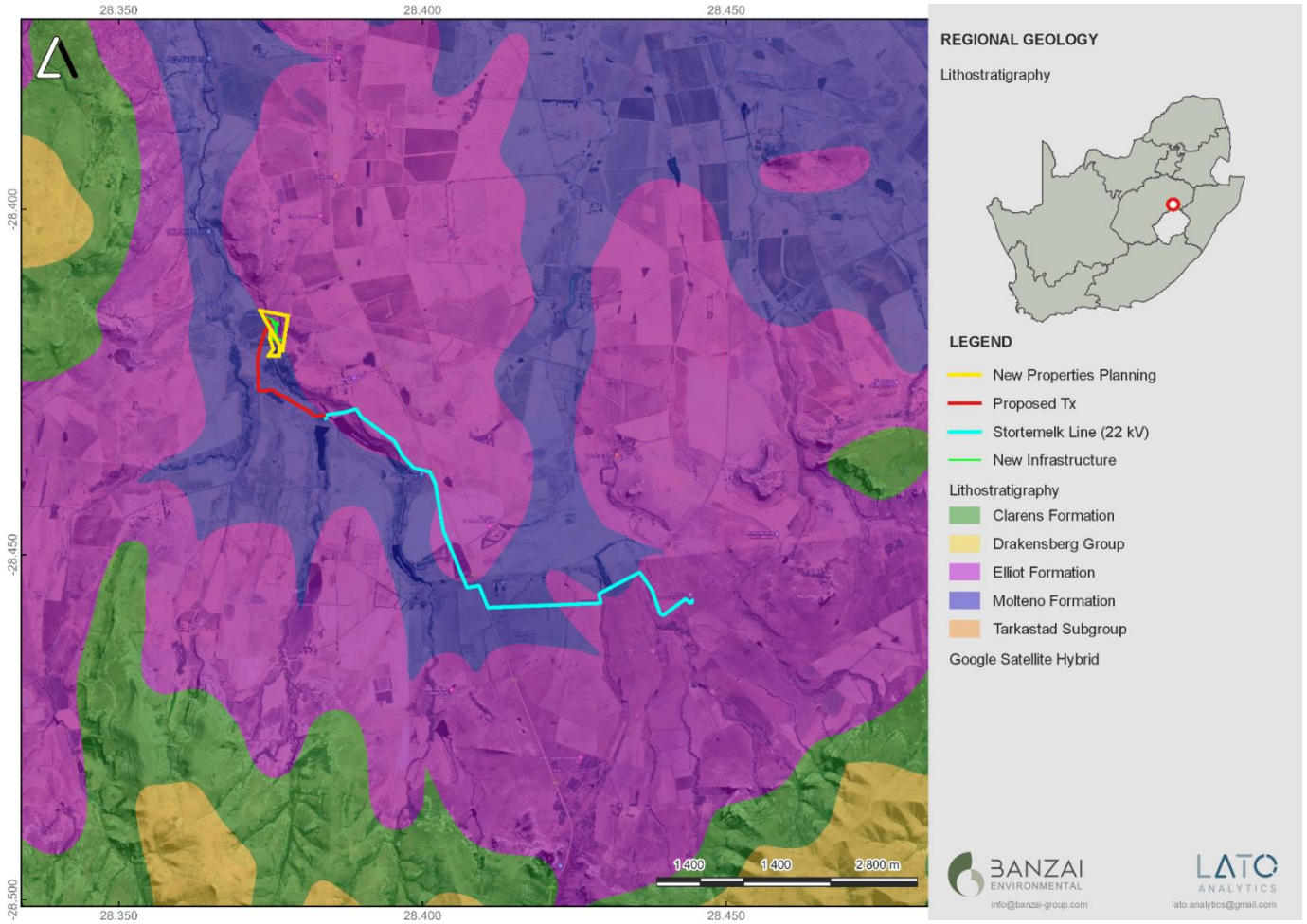
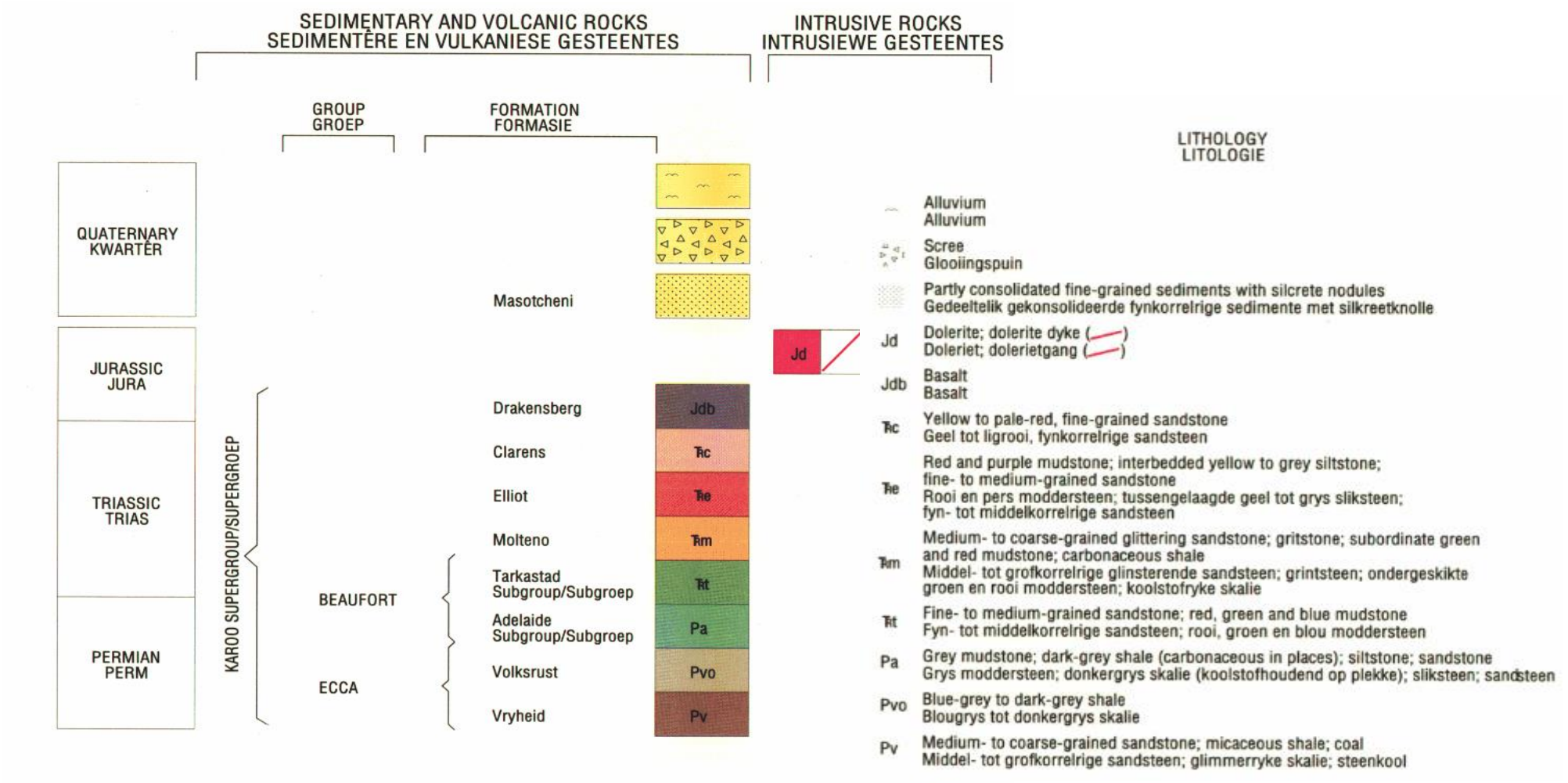


***Figure 4**: Updated geology (Council for Geosciences, Pretoria) indicates that the proposed development is underlain by the Molteno and Elliot Formations of the Stormberg Group (Karoo Supergroup).*

Table 2:Legend of the 1:250 000 Harrismith 2828 (1998) Geological Map (Council for Geosciences, Pretoria).



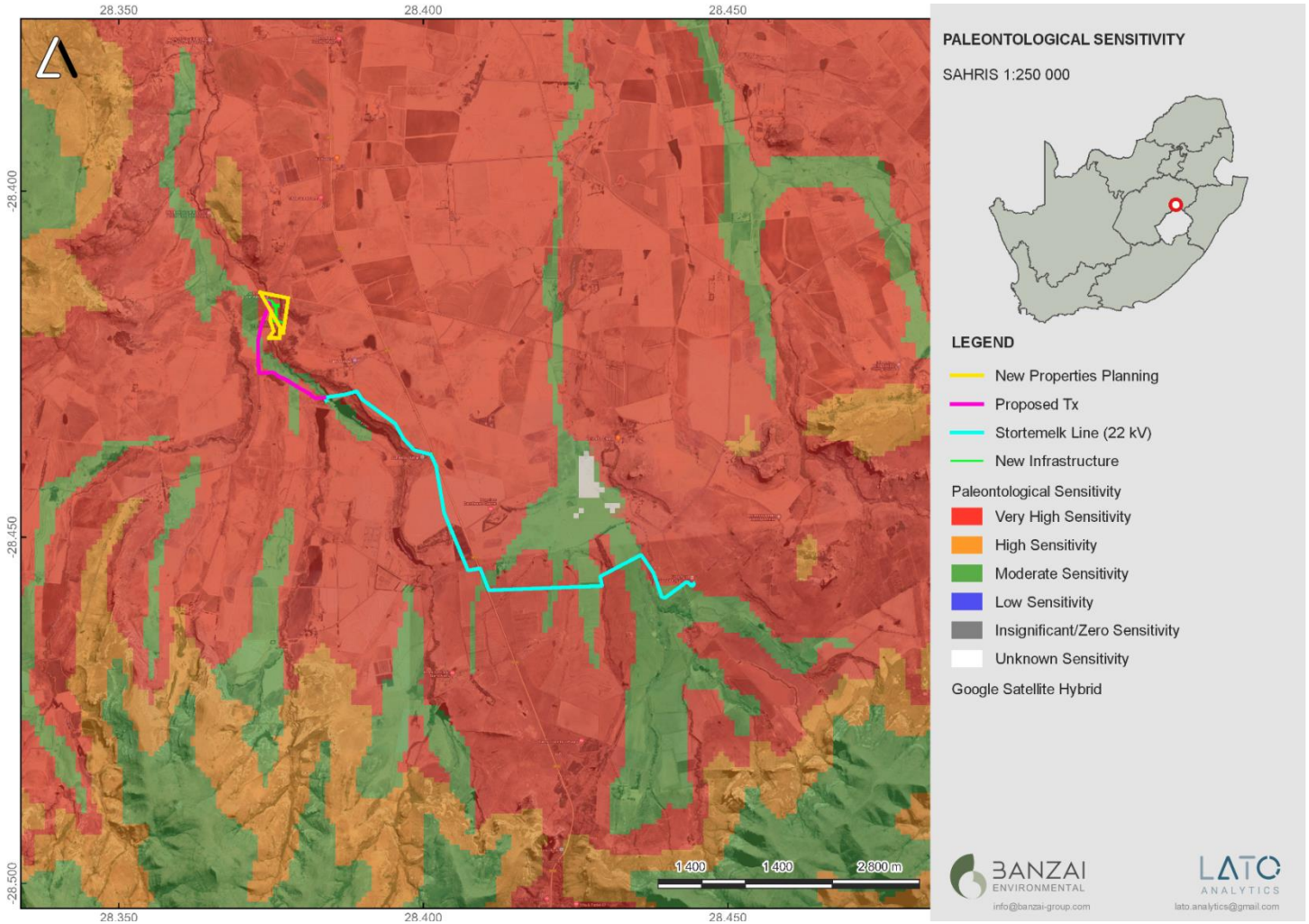


Figure 5: *Extract of the 1:250 000 SAHRIS PalaeoMap (Council of Geosciences, Pretoria) indicating the proposed development in the Free State Province.*

According to the SAHRIS Palaeosensitivity map (**Figure 6)** the proposed development is underlain by sediments of Very High (red) and Moderate (green) Palaeontological Sensitivity.

Table 3: 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.

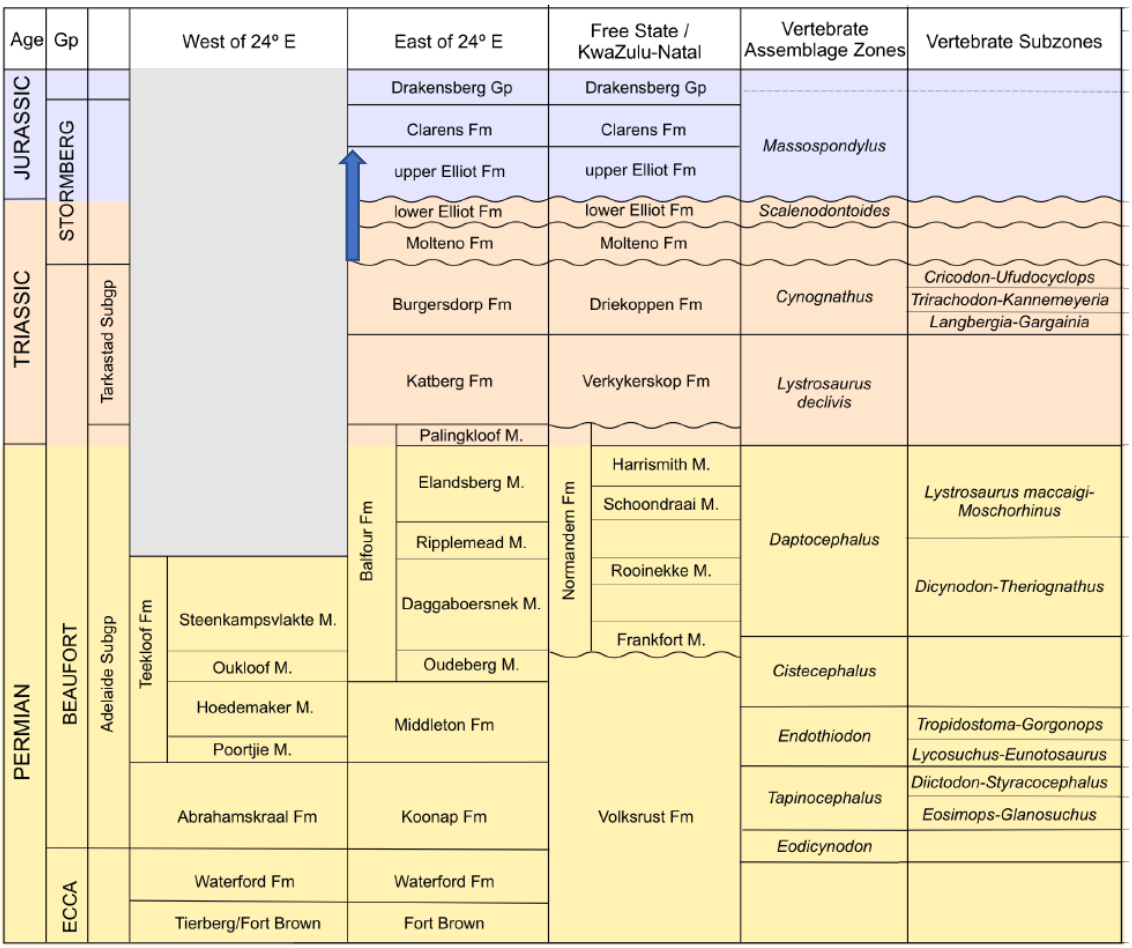


***Figure 6**: Vertebrate biozonation range chart for the Main Karoo Basin of South Africa. (Figure modified from Smith et al, 2020).*

Solid lines indicate known ranges, dotted lines indicate suspected but not confirmed ranges, single dot represents the stratigraphy is position of the taxa that have only been recovered from a single bed. Wavy lines indicate unconformities. (PLYCSR=Pelycosauria and MAMMFMES+Mammaliaformes. Gp=group, Subgp-Supbroup, Fm=Formation, M=Member. Elliot Formation is indicated by the black arrow.

6 GEOGRAPHICAL LOCATION OF THE SITE

The site is approximately 20km south of the town of Bethlehem in the jurisdiction of the Dihlabeng Municipal District in the Free State Province (Figure 1-2).

7 METHODS

The aim of a desktop study is to evaluate the risk to palaeontological heritage in the proposed development. This includes all trace fossils and fossils. All available information is consulted to compile a desktop study and includes Palaeontological impact assessment reports in the same area, aerial photos, and Google Earth images, topographical as well as geological maps. Scientific research articles of research conducted in the area is also sourced and included in the Impact Assessment.

7.1 Assumptions and Limitations

When conducting a PIA several factors can affect the accuracy of the assessment. The focal point of geological maps is the geology of the area, and the sheet explanations were not meant to focus on palaeontological heritage. Many inaccessible regions of South Africa have not been reviewed by palaeontologists and data is generally based on aerial photographs. Locality and geological information of museums and universities databases have not been kept up to date or data collected in the past have not always been accurately documented.

Comparable Assemblage Zones in other areas is used to provide information on the existence of fossils in an area which was not yet been documented. When similar Assemblage Zones and geological formations for Desktop studies is used it is generally assumed that exposed fossil heritage is present within the footprint.

8 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 kmz files of the proposed development was obtained from CES – ENVIRONMENTAL AND SOCIAL ADVISORY SERVICES as well as background information
- 1:250 000 Harrismith 2828 (Verster, 1998) Geological map (Council of Geoscience, Pretoria)
- Updated Geology produced by the Council of Geosciences (Pretoria).

9 SITE VISIT

A one- day overall site-specific field survey of the proposed development was conducted on foot and by motor vehicle during March 2023. No fossiliferous outcrops were identified. No fossiliferous outcrops were detected in the development footprint.

Figure 7: *General view over the development indicates a mountainous area with lush vegetation.*

Figure 9: *Elliot sandstones are abundantly found throughout the development footprint.*

Figure 8: *Thick Quaternary superficial sediments on the riverbanks of the Ash River.*

10 IMPACT ASSESSMENT METHODOLOGY

Impact assessment must take account of the nature, scale and duration of impacts on the environment whether such impacts are positive or negative. Each impact is also assessed according to the following project phases:

- Construction.
- Operation; and
- Decommissioning.

Where necessary, the proposal for mitigation or optimisation of an impact should be detailed. A brief discussion of the impact and the rationale behind the assessment of its significance should also be included. The rating system is applied to the potential impacts on the receiving environment and includes an objective evaluation of the mitigation of the impact. In assessing the significance of each impact, the following criteria is used:

Table 4: The rating system

NATURE		
The Nature of the Impact is the possible destruction of fossil heritage		
GEOGRAPHICAL EXTENT		
This is defined as the area over which the impact will be experienced.		
1	Site	The impact will only affect the site.
2	Local/district	Will affect the local area or district.
3	Province/region	Will affect the entire province or region.
4	International and National	Will affect the entire country.
PROBABILITY		
This describes the chance of occurrence of an impact.		
1	Unlikely	The chance of the impact occurring is extremely low (Less than a 25% chance of occurrence).

2	Possible	The impact may occur (Between a 25% to 50% chance of occurrence).
3	Probable	The impact will likely occur (Between a 50% to 75% chance of occurrence).
4	Definite	Impact will certainly occur (Greater than a 75% chance of occurrence).
DURATION		
This describes the duration of the impacts. Duration indicates the lifetime of the impact as a result of the proposed activity.		
1	Short term	The impact will either disappear with mitigation or will be mitigated through natural processes in a span shorter than the construction phase (0 – 1 years), or the impact will last for the period of a relatively short construction period and a limited recovery time after construction, thereafter it will be entirely negated (0 – 2 years).
2	Medium term	The impact will continue or last for some time after the construction phase but will be mitigated by direct human action or by natural processes thereafter (2 – 10 years).
3	Long term	The impact and its effects will continue or last for the entire operational life of the development, but will be mitigated by direct human action or by natural processes thereafter (10 – 30 years).
4	Permanent	The only class of impact that will be non-transitory. Mitigation either by man or natural process will not occur in such a way or such a time span that the impact can be considered indefinite.
INTENSITY/ MAGNITUDE		
Describes the severity of an impact.		
1	Low	Impact affects the quality, use and integrity of the system/component in a way that is barely perceptible.
2	Medium	Impact alters the quality, use and integrity of the system/component but system/component still

		continues to function in a moderately modified way and maintains general integrity (some impact on integrity).
3	High	Impact affects the continued viability of the system/ component and the quality, use, integrity and functionality of the system or component is severely impaired and may temporarily cease. High costs of rehabilitation and remediation.
4	Very high	Impact affects the continued viability of the system/component and the quality, use, integrity and functionality of the system or component permanently ceases and is irreversibly impaired. Rehabilitation and remediation often impossible. If possible rehabilitation and remediation often unfeasible due to extremely high costs of rehabilitation and remediation.
REVERSIBILITY		
This describes the degree to which an impact can be successfully reversed upon completion of the proposed activity.		
1	Completely reversible	The impact is reversible with implementation of minor mitigation measures.
2	Partly reversible	The impact is partly reversible but more intense mitigation measures are required.
3	Barely reversible	The impact is unlikely to be reversed even with intense mitigation measures.
4	Irreversible	The impact is irreversible, and no mitigation measures exist.
IRREPLACEABLE LOSS OF RESOURCES		
This describes the degree to which resources will be irreplaceably lost as a result of a proposed activity.		
1	No loss of resource	The impact will not result in the loss of any resources.
2	Marginal loss of resource	The impact will result in marginal loss of resources.
3	Significant loss of resources	The impact will result in significant loss of resources.

4	Complete loss of resources	The impact is result in a complete loss of all resources.

CUMULATIVE EFFECT

This describes the cumulative effect of the impacts. A cumulative impact is an effect which in itself may not be significant but may become significant if added to other existing or potential impacts emanating from other similar or diverse activities as a result of the project activity in question.

1	Negligible cumulative impact	The impact would result in negligible to no cumulative effects.
2	Low cumulative impact	The impact would result in insignificant cumulative effects.
3	Medium cumulative impact	The impact would result in minor cumulative effects.
4	High cumulative impact	The impact would result in significant cumulative effects

SIGNIFICANCE

Significance is determined through a synthesis of impact characteristics. Significance is an indication of the importance of the impact in terms of both physical extent and time scale, and therefore indicates the level of mitigation required. The calculation of the significance of an impact uses the following formula:

(**Extent + probability + reversibility + irreplaceability + duration + cumulative effect) x magnitude/intensity = X.**

The summation of the different criteria will produce a non-weighted value. By multiplying this value with the magnitude/intensity, the resultant value acquires a weighted characteristic which can be measured and assigned a significance rating.

Points	Impact significance rating	Description
6 to 28	Negative low impact	The anticipated impact will have negligible negative effects and will require little to no mitigation.
6 to 28	Positive low impact	The anticipated impact will have minor positive effects.
29 to 50	Negative medium impact	The anticipated impact will have moderate negative effects and will require moderate mitigation measures.
29 to 50	Positive medium impact	The anticipated impact will have moderate positive effects.

51 to 73	Negative high impact	The anticipated impact will have significant effects and will require significant mitigation measures to achieve an acceptable level of impact.
51 to 73	Positive high impact	The anticipated impact will have significant positive effects.
74 to 96	Negative very high impact	The anticipated impact will have highly significant effects and are unlikely to be able to be mitigated adequately. These impacts could be considered "fatal flaws".
74 to 96	Positive very high impact	The anticipated impact will have highly significant positive

10.1 Summary of Impact Tables

Loss of fossil heritage will be a negative impact. Only the site will be affected by the proposed development. The expected duration of the impact is assessed as potentially permanent to long term. In the absence of mitigation procedures, the damage or destruction of any palaeontological materials will be permanent. Impacts on palaeontological heritage during the construction phase could potentially occur and are regarded as having a high probability. As fossil heritage will be destroyed the impact is irreversible. The significance of the impact occurring will be high pre-mitigation and medium post-mitigation.

Table 5: Summary of Impact Tables

	Site	Probability	Duration	Magnitude	Reversibility	Irreplicable Loss	Cumulative Effect	Significance
Pre-mitigation	1	2	4	4	4	4	2	68
Post-mitigation	1	2	4	2	4	4	2	32

11 FINDINGS AND RECOMMENDATIONS

The proposed Boston Hydro Power Project and associated grid infrastructure is underlain by Quaternary alluvium, and the Late Triassic to Early Jurassic Molteno and Elliot Formations of the Stormberg Group

(Karoo Supergroup). The PalaeoMap of the South African Heritage Resources Information System indicates that the Palaeontological Sensitivity of the Quaternary alluvium is moderate, while that of the Molteno and Eliot Formations is Very High (Almond and Pether, 2009; Almond *et al*., 2013).

A site-specific field survey of the development footprint was conducted on foot and by motor vehicle in March 2023. No visible evidence of fossiliferous outcrops was found, although the area is well known for its well-preserved dinosaur fossils. An overall medium palaeontological significance is allocated to the development footprint. It is thus considered that the proposed development will not lead to detrimental impacts on the palaeontological reserves of the area. And the construction of the development may thus be authorised in its whole extent.

It is thus recommended that:

- The Environmental Control Officer (ECO), responsible for the development should be aware of the possibility of finding fossils in the Elliot and Molteno Formations of the Stormberg Group (Karoo Supergroup).
- Training of accountable supervisory personnel (ESO) by a qualified palaeontologist in the recognition of fossil heritage is necessary.
- If Palaeontological Heritage is uncovered during surface clearing and excavations the Chance find Protocol attached should be implemented immediately. These discoveries ought to be protected (if possible, *in situ*) and the ECO must report to SAHRA (Contact details: South African Heritage Research Agency, 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). The information to the Heritage Agency must include photographs of the find, from various angles, as well as the GPS co-ordinates/) so that correct mitigation (recording and collection) can be carry out by a paleontologist.

Before any fossil material can be collected from the development site the specialist involved would need to apply for a collection permit from SAHRA. Fossil material must be housed in an official collection (museum or university), while all reports and fieldwork should meet the minimum standards for palaeontological impact studies proposed by SAHRA (2012). 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.

12 CHANCE FINDS PROTOCOL

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

12.1 Legislation

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

Palaeontological heritage is unique and non-renewable and is protected by the NHRA and are the property of the State. It is thus the responsibility of the State to manage and conserve fossils on behalf of the citizens of South Africa. Palaeontological resources may not be excavated, broken, moved, or destroyed by any development without prior assessment and without a permit from the relevant heritage resources authority as per section 35 of the NHRA.

12.2 Background

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

12.3 Introduction

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

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

12.4 Chance Find Procedure

- If a chance find is made the person responsible for the find must immediately stop working and all work that could impact that finding must cease in the immediate vicinity of the find.

- The person who made the find must immediately **report** the find to his/her direct supervisor which in turn must report the find to his/her manager and the ESO or site manager. The ESO or site manager must report the find to the relevant Heritage Agency (South African Heritage Research Agency, 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). The information to the Heritage Agency must include photographs of the find, from various angles, as well as the GPS co-ordinates.
- A preliminary report must be submitted to the Heritage Agency within **24 hours** of the find and must include the following: 1) date of the find; 2) a description of the discovery and a 3) description of the fossil and its context (depth and position of the fossil), GPS co-ordinates.
- Photographs (the more the better) of the discovery must be of high quality, in focus, accompanied by a scale. It is also important to have photographs of the vertical section (side) where the fossil was found.
- Upon receipt of the preliminary report, the Heritage Agency will inform the ESO (or site manager) whether a rescue excavation or rescue collection by a palaeontologist is necessary.
- The site must be secured to protect it from any further damage. **No attempt** should be made to remove material from their environment. The exposed finds must be stabilized and covered by a plastic sheet or sand bags. The Heritage agency will also be able to advise on the most suitable method of protection of the find.
- In the event that the fossil cannot be stabilized the fossil may be collected with extreme care by the ESO (site manager). Fossils finds must be stored in tissue paper and in an appropriate box while due care must be taken to remove all fossil material from the rescue site.
- Once Heritage Agency has issued the written authorization, the developer may continue with the development on the affected area.

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APPENDIX A

ELIZE BUTLER

CURRICULU

M 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, Bloemfontein 1993 – 1997

Principal Research Assistant	National Museum, Bloemfontein
and Collection Manager	1998–2022

TECHNICAL REPORTS

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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. Bloemfontein.
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