Palaeontological Impact Assessment for the proposed Mulilo De Aar grid connection and battery storage project, Northern Cape Province

Desktop Study (Phase 1)

For

ACO Associates

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Expertise of Specialist

The Palaeontologist Consultant: Prof Marion Bamford
Qualifications: PhD (Wits Univ, 1990); FRSSAf, ASSAf
Experience: 31 years research; 3years PIA studies

Declaration of Independence

This report has been compiled by Professor Marion Bamford, of the University of the Witwatersrand, sub-contracted by ACO Associates, Cape Town, South Africa. The views expressed in this report are entirely those of the author and no other interest was displayed during the decision making process for the Project.

Specialist: Prof Marion Bamford

Signature: 

Executive Summary

A palaeontological Impact Assessment was requested for the proposed Mulilo – De Aar grid connection and battery storage facility between several Photovoltaic Facilities and Hydra Substation, east of De Aar, Northern Cape Province. This is part of a large project to generate clean electricity in the Northern Cape.

To comply with the South African Heritage Resources Agency (SAHRA) in terms of Section 38(8) of the National Heritage Resources Act, 1999 (Act No. 25 of 1999) (NHRA), a desktop Palaeontological Impact Assessment (PIA) was completed for the proposed project.

The proposed routes lie on Permian Karoo sediments, Jurassic dolerites and Quaternary sands and alluvium. The dolerite is non-fossiliferous so the proposed SAS2 WEF facility will not impact on the fossil heritage. Parts of Route 2 DA2S Line option 2 part 2 (and Route 1) lie on Quaternary sands with very low impact, and Adelaide Subgroup rocks. The latter is potentially fossiliferous (vertebrates and silicified wood). The DA2S Line option 2 part 1 route and connection to Mulilo De Aar PV are on rocks of the Tierberg Formation (trace fossils and wood fragments). For both strata, the fossils are sporadic and rare and the 132 kV steel monopole structure including foundations and insulators (pole) footprint is so small that the impact would be very small. Since there is a small chance of finding fossils once excavations have commenced, a Fossil Chance Find Protocol should be added to the EMPr. Based on this information it is recommended that no palaeontological site visit is required unless the responsible person on site finds fossils and then a palaeontologist should be called to assess and collect if required.

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1. Background

Mulilo De Aar 2 South (Pty) Ltd ("Mulilo") are seeking approval for grid connection routes and a battery storage facility in Eastern Cape Province.

Grid Connection

Two routes must be assessed for authorisation, (this will allow flexibility to use / not use the battery storage facilities). Mulilo are proposing to construct a **Route 1**: new grid connection transmission power line, approximately 23 km in length, to connect the authorised De Aar 2 South Wind Energy Facility (DA2S WEF) to the Eskom Hydra Substation near De Aar, Northern Cape Province. For approximately 12km from the Eskom Hydra Substation, the proposed line follows approved grid-connection transmission line route for the operational Longyuan Mulilo De Aar 2 North WEF. Thereafter, the proposed new line follows a direct path northeast for a further 11 km up onto the plateau. The entire proposed route for the new line follows and is adjacent to the existing HYD-RO 220kV transmission line; **Route 2:** (part 1 and 2 both required), Part 1 (Connecting various Battery storage facilities (separate BAs) and Part 2 (From the On-site Substation to Via battery storage facilities). The grid connection is for up to 400 kV. The corridor to be assessed is 200m (i.e. 100m either side of all grid lines in the KMZ).

The proposed project will include a 132 kV switching station (100m x 100m). The proposed transmission line would consist of the following infrastructures:

- 132 kV steel monopole structure including foundations and insulators;
- Existing access roads and jeep tracks
- Line and servitude clearances to meet the statutory requirements

Battery Storage Facility (Location to follow)

- Footprint <20 ha
- Height <30m,
- Dangerous / hazardous material <500m³
- Above footprint must include an onsite substation:
  - up to 132kV,
  - 3-bay,
  - 50m x 50m x 30m (H)
  - Substations Buildings to house metering, scada and switchgear, office, spares storage and ablutions.

A Palaeontological Impact Assessment was requested for the project. To comply with the South African Heritage Resources Agency (SAHRA) in terms of Section 38(8) of the National Heritage Resources Act, 1999 (Act No. 25 of 1999) (NHRA), a desktop Palaeontological Impact Assessment (PIA) was completed for the proposed development and is presented herein.

Table 1: Specialist report requirements in terms of Appendix 6 of the EIA Regulations (amended 2017)

	A specialist report prepared in terms of the Environmental Impact Regulations of 2017 must contain:	**Relevant section in report**
ai	Details of the specialist who prepared the report	Appendix B
aii	The expertise of that person to compile a specialist report including a curriculum vitae	Appendix B
b	A declaration that the person is independent in a form as may be specified by the competent authority	Page 1
c	An indication of the scope of, and the purpose for which, the report was prepared	Section 1
ci	An indication of the quality and age of the base data used for the specialist report: SAHRIS palaeosensitivity map accessed – date of this report	Yes
cii	A description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change	Section 5
d	The date and season of the site investigation and the relevance of the season to the outcome of the assessment	N/A
e	A description of the methodology adopted in preparing the report or carrying out the specialised process	Section 2
f	The specific identified sensitivity of the site related to the activity and its associated structures and infrastructure	Section 4
g	An identification of any areas to be avoided, including buffers	N/A
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;	N/A
i	A description of any assumptions made and any uncertainties or gaps in knowledge;	Section 5
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 4
k	Any mitigation measures for inclusion in the EMPr	Appendix A
l	Any conditions for inclusion in the environmental authorisation	N/A
m	Any monitoring requirements for inclusion in the EMPr or environmental authorisation	Appendix A
ni	A reasoned opinion as to whether the proposed activity or portions thereof should be authorised	N/A
nii	If the opinion is that the proposed activity 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	N/A
o	A description of any consultation process that was undertaken during the course of carrying out the study	N/A

p	A summary and copies if any comments that were received during any consultation process	N/A
q	Any other information requested by the competent authority.	N/A

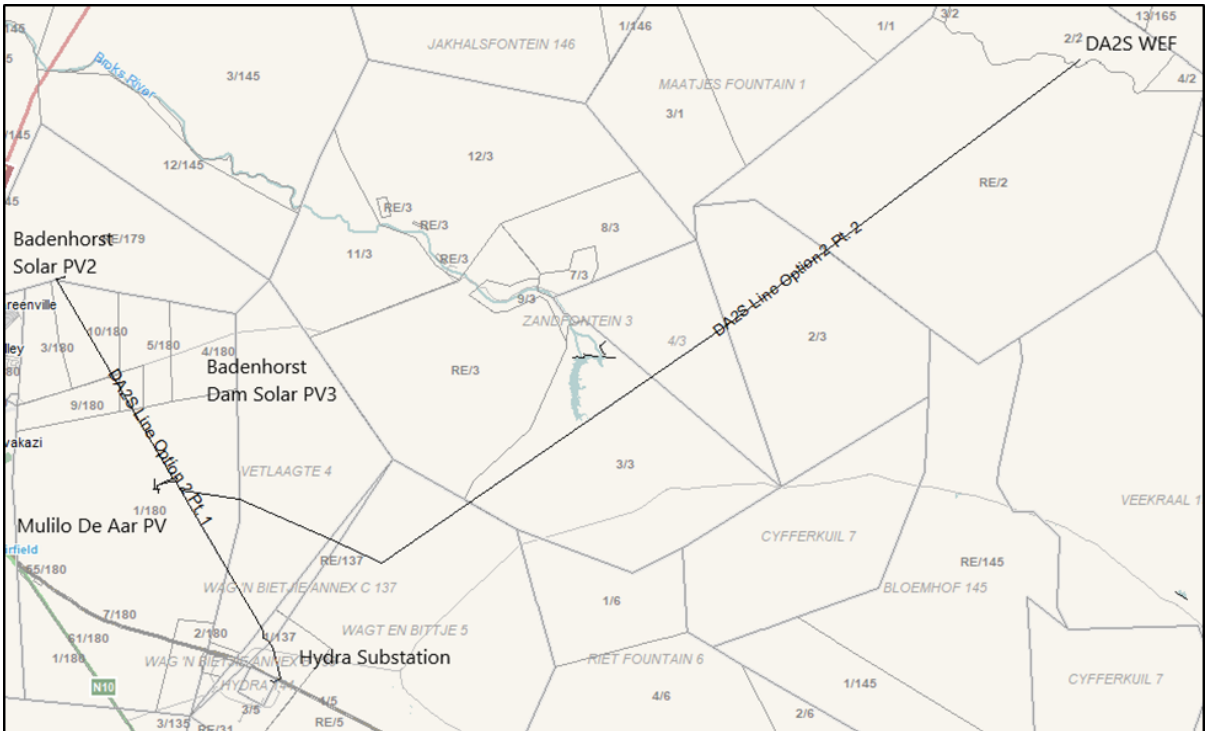

Figure 1: Diagram of the DA2S line Option 2 with part 1 near De Aar and Part 2 heading north eastwards. The proposed battery storage facility WEF is at the northeastern end.

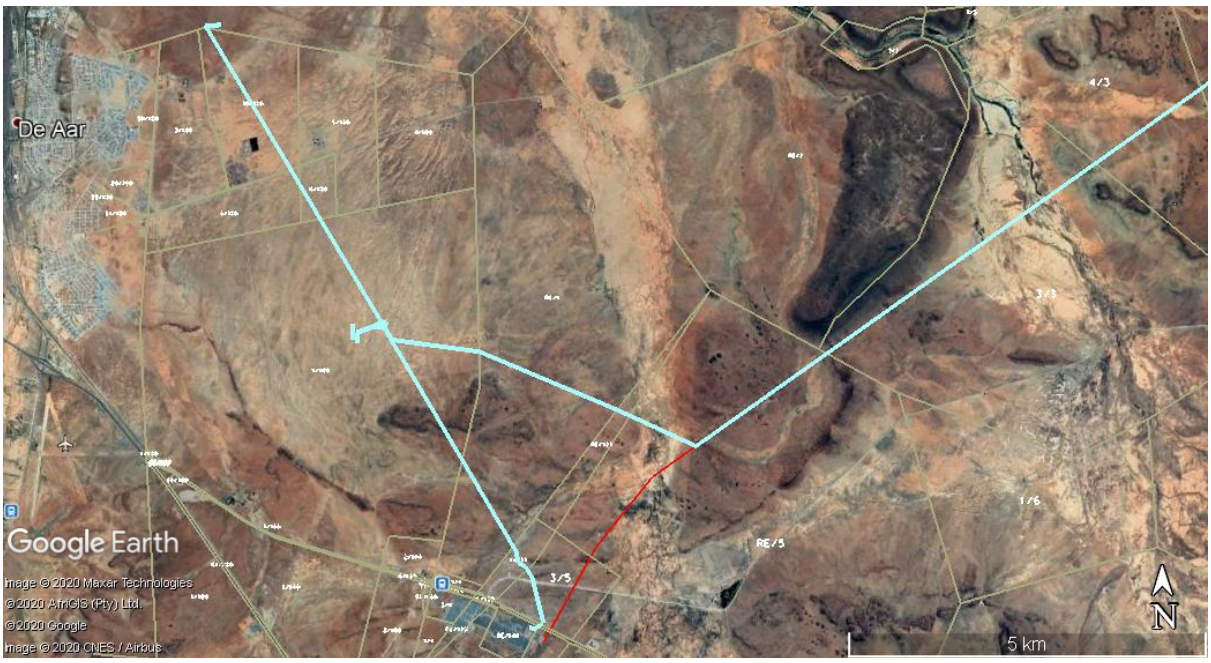

Figure 2: Google Earth map of the proposed routes for the Mulilo De Aar project. The routes near De Aar to connect PVs facilities are shown in blue lines with the red line being a

proposed new connection (here called Route 1 south). Route 2 includes the northwest-southeast route and connections to WEFs.

Figure 3: Google Earth map of the proposed routes for the Mulilo De Aar grid connection project. The routes near De Aar to connect PVs facilities are shown in blue lines with the red line showing a proposed new connection to a potential battery storage facility on the mountain top. (here called Route 1 north). De Aar is off the map to the southwest.

2. Methods and Terms of Reference

The Terms of Reference (ToR) for this study were to undertake a PIA and provide feasible management measures to comply with the requirements of SAHRA.
The methods employed to address the ToR included:

1. Consultation of geological maps, literature, palaeontological databases, published and unpublished records to determine the likelihood of fossils occurring in the affected areas. Sources included records housed at the Evolutionary Studies Institute at the University of the Witwatersrand and SAHRA databases;
2. Where necessary, site visits by a qualified palaeontologist to locate any fossils and assess their importance (*not applicable to this assessment*);
3. Where appropriate, collection of unique or rare fossils with the necessary permits for storage and curation at an appropriate facility (*not applicable to this assessment*); and
4. Determination of fossils' representivity or scientific importance to decide if the fossils can be destroyed or a representative sample collected (*not applicable to this assessment*).

3. Geology and Palaeontology

i. Project location and geological context

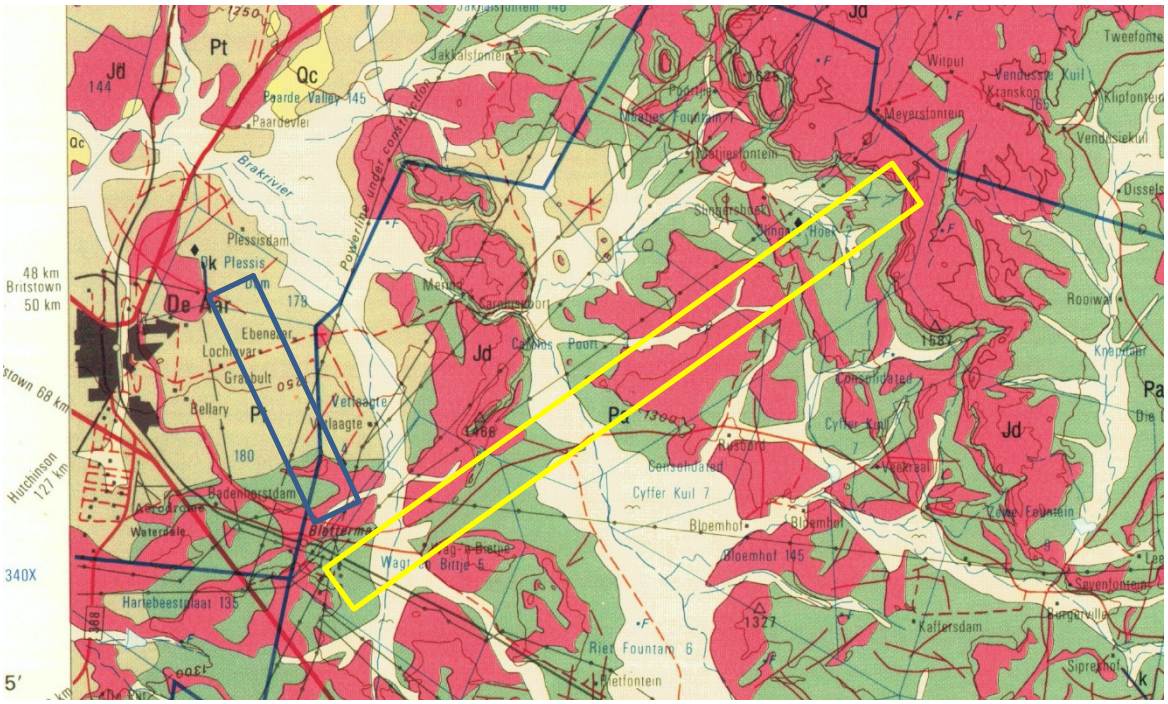

Figure 4: Geological map of the whole are of the proposed Mulilo De Aar project. Within the yellow rectangle, the southwestern end includes the red line from Figure 2 (new connection line) and the northeastern end includes the red line from Figure 3 (proposed battery storage facility). The blue rectangle includes the existing powerline from De Aar to Hydra. Abbreviations of the rock types are explained in Table 2. Map enlarged from the Geological Survey 1: 250 000 map 3024 Colesburg.

Table 2: Explanation of symbols for the geological map and approximate ages (Johnson et al., 2006). SG = Supergroup; Fm = Formation; Ma = million years; grey shading = formations impacted by the project.

Symbol	Group/Formation	Lithology	Approximate Age
Q	Quaternary Kalahari sands	Alluvium, sand, calcrete	Neogene, ca 25 Ma to present
Jd	Jurassic dykes	Dolerite dykes, intrusive	Jurassic, approx. 183 Ma
Pa	Adelaide Subgroup, Beaufort Group, Karoo Supergroup	Blue-grey silty mudstones, sandstones	“middle” Permian, Lower Beaufort Group.
Pt	Tierberg Formation, Ecca Group, Karoo SG	Blue-grey to black mudstones, concretions; siltstones sandstones near the top	“early” Permian, Ecca Group

De Aar is in the north central part of the Karoo Basin and the predominant rocks are those of the Beaufort, middle to late Permian in age. There are large expanses of Jurassic aged dolerite that intruded through the Karoo sediments at the time when Africa was separating from South America and the Drakensberg volcanics erupted. Generally to the south and east are the younger Adelaide

Subgroup rocks. This subgroup has been divided into a number of formations based on lithology and fossil content but in this area the formations are not recognisable. The mudrocks are massive and weather to form blocky material (Johnson et al., 2006)

To the north and west are the slightly older Tierberg Formation (Ecca Group) sediments that are similar to the overlying Adelaide subgroup shales and mudstones. This succession of rocks represents the gradual filling up of the Karoo Basin that was then terminated by the Drakensberg volcanics.

The more weathering-resistant dolerite dykes tend to form the relief in the area, with the mountains to the north and northeast being formed by a huge exposure of dolerite. Smaller dykes show as long lines or circular exposures of dark weathered boulders and rocks

Along some of the water courses much younger sands and alluvium of the Quaternary Kalahari Sands have been deposited (white in the geological map, Figure 4). These sediments have been transported from farther north in the past when there was likely much more rainfall in the system, and more recently with flash flooding. Their composition and origin can be very mixed.

ii. Palaeontological context

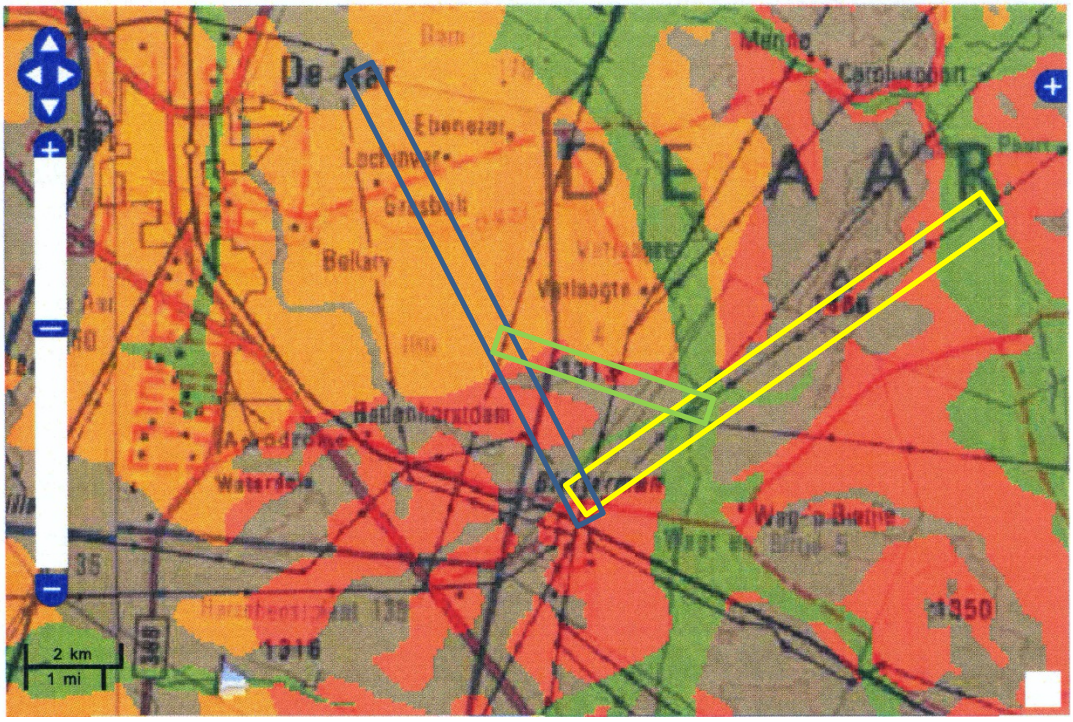

Figure 5: SAHRIS palaeosensitivity map for the site for the proposed Mulilo De Aar project. Route 1 and Route 2 part 2 are shown within the yellow rectangle. Route 2 part 1 within the blue rectangle and existing link/line within the green rectangle. Background colours indicate the following degrees of sensitivity: red = very highly sensitive; orange/yellow = high; green = moderate; blue = low; grey = insignificant/zero.

The Palaeontological Assessment is presented from the location point of view, not the proposed routes and options, because there is a large degree of overlap.

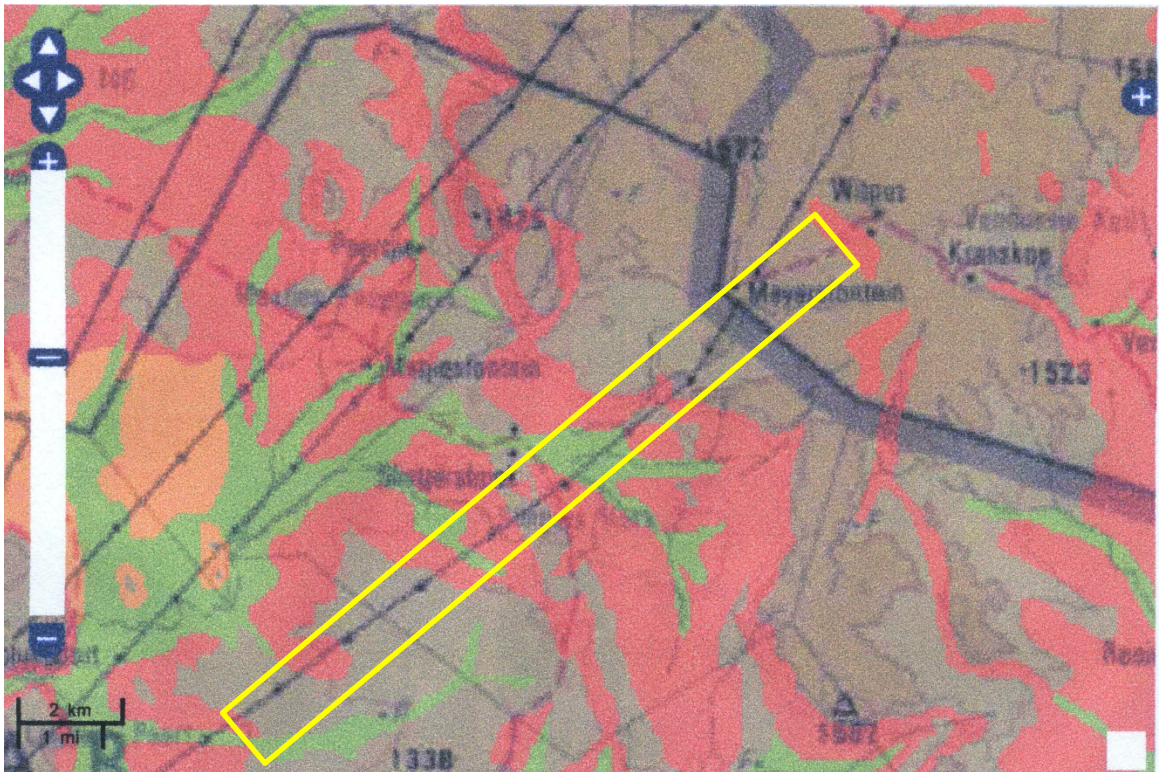

Figure 6: Northeastern section of the De Aar – WEF line with Route 1 and Route 2 part 2 within the yellow rectangle. De Aar is off the map to the southwest. The proposed site for the Battery storage facility is in the uppermost part of the rectangle on the mountain top. See Figure 5 for SAHRIS colour coding.

From the SAHRIS maps above the area is indicated as having the whole range of sensitivities along the various proposed routes. The dolerite has no fossils (grey) because they do not occur in volcanic rocks. As the dykes intrude through the overlying sediments they tend to physically destroy any fossils that might have been in their paths, and the heat can destroy or alter fossils in the near vicinity.

The Quaternary sands (Figure 4) along the water courses are young enough to preserve fossils but by their nature, washed down slopes and streams into rivers, any fossils would have been transported from its site of origin into the river system. The context of the fossils and associated fossils in the assemblage will have been lost. Only robust fossil fragments can survive the journey but their scientific value is greatly reduced because they lack original context. These sediments are indicated as moderately sensitive on the maps (green; Figures 5 and 6).

In contrast, the Ecca and Beaufort rocks are much more likely to preserve fossils. Their distribution, however, is unpredictable but they can be easier to locate on hillsides and slopes. Based on many years of research by geologists and palaeontologists in the Karoo (Rubidge, 1995, 2005; Johnson et al., 2006; Rubidge et al., 2016 and many other references) the lithology and terrestrial flora and vertebrate fauna have been closely correlated, and the fauna used as a biostratigraphic framework. From this and other parts of the Karoo the

Tierberg Formation has produced a number of trace fossils of worm burrows, root casts and invertebrate trackways (van Dijk et al., 2002; Almond, 2013). Fossil plants are rare in this part of the Karoo basin but there are records of fragments of silicified wood from east of De Aar (Almond, 2013).

The Adelaide Subgroup, undifferentiated in this area, can be divided into the Abrahamskraal or Koonap Formations and the Teekloof or Middleton and Balfour Formations. Without fossils it is not possible to distinguish the strata based only on lithology. The relevant assemblage zones are, from the base upwards, the *Eodicynodon, Tapinocephalus, Pristerognathus, Tropidostoma* and *Cistecephalus* zones. Expected vertebrate fossils are a variety of dinocephaleans, gorgons and therocephaleans and some fish. According to Almond's site surveys (Almond 2012a, 2012b, 2012c), vertebrate fossils are rare as there is little exposure.

Potential fossil plants are typical Permian impressions of *Glossopteris* leaves, lycopods, sphenophytes and ferns, and silicified wood (Anderson and Anderson, 1085). Only fossil wood has been seen in the Adelaide Subgroup in this area (Almond, 2012a). The samples have not been collected or identified.

Dr John Almond (Natura Viva) has carried out a number of site visits around De Aar for other aspects of the project (Almond, 2012a, b, c, 2013). He found very few fossils because the area has a large amount of non-fossiliferous dolerite, and the Permian sediments are covered by sand and soil to a large extent.

4. Impact assessment

An assessment of the potential impacts to possible palaeontological resources considers the criteria encapsulated in Table 3:

TABLE 3A: CRITERIA FOR ASSESSING IMPACTS

PART A: DEFINITION AND CRITERIA		
Criteria for ranking of the SEVERITY/NATURE of environmental impacts	**H**	Substantial deterioration (death, illness or injury). Recommended level will often be violated. Vigorous community action.
	M	Moderate/ measurable deterioration (discomfort). Recommended level will occasionally be violated. Widespread complaints.
	L	Minor deterioration (nuisance or minor deterioration). Change not measurable/ will remain in the current range. Recommended level will never be violated. Sporadic complaints.
	L+	Minor improvement. Change not measurable/ will remain in the current range. Recommended level will never be violated. Sporadic complaints.
	M+	Moderate improvement. Will be within or better than the recommended level. No observed reaction.
	H+	Substantial improvement. Will be within or better than the recommended level. Favourable publicity.
Criteria for ranking the DURATION of impacts	**L**	Quickly reversible. Less than the project life. Short term
	M	Reversible over time. Life of the project. Medium term
	H	Permanent. Beyond closure. Long term.
Criteria for ranking the SPATIAL SCALE of impacts	**L**	Localised - Within the site boundary.
	M	Fairly widespread – Beyond the site boundary. Local
	H	Widespread – Far beyond site boundary. Regional/ national
PROBABILITY	**H**	Definite/ Continuous

(of exposure to impacts)	**M**	Possible/ frequent
	L	Unlikely/ seldom

TABLE 3B: IMPACT ASSESSMENT

PART B: ASSESSMENT		
SEVERITY/NATURE	**H**	-
	M	-
	L	-
	L+	The Tierberg Fm sediments might preserve trace fossils of fossil woo fragments; The Adelaide Subgroups rocks might preserve fossil bones; it is less likely to preserve fossil plant impressions. The impact would be low.
	M+	-
	H+	-
DURATION	**L**	-
	M	-
	H	Where manifest, the impact will be permanent.
SPATIAL SCALE	**L**	Since only the possible fossils within the area would be trace fossils and wood fragments from the *Glossopteris* flora in the Tierberg Fm shales and rare vertebrate bones and wood in the Adelaide Subgroup, the spatial scale will be localised within the site boundary.
	M	-
	H	-
PROBABILITY	**H**	**-**
	M	**-**
	L	It is unlikely that any fossils would be found in the loose Quaternary sand; trace fossils and wood fragments might occur in the Tierberg Fm and vertebrate bones and wood in the Adelaide Subgroup rocks. Therefore, a Fossil Chance Find protocol should be added to the eventual EMPr.

Based on the nature of the project, surface activities may impact upon the fossil heritage if preserved in the development footprint. The geological structures suggest that the rocks are the correct age to contain fossils, in particular trace fossils and silicified wood fragments in the Tierberg Formation, in the DAS2 line option 1, part 1. Site visits and PIAs have already been done for the two farms in the area, namely 1/180 and Vetlaagte (Almond, 2012b). Site surveys have also been done for the DAS2 WEF area when the proposed PV facilities on the mountain top were being researched (Almond 2012c). Since roads and access have already been developed along all the routes, and the new poles have a very small footprint, the impact on the fossil heritage is very low. Therefore, a Fossil Chance Find Protocol has been added to this report. Once excavations have commenced for the pole foundations, the responsible person/environmental officer should look out for fossils. Taking account of the defined criteria, the potential impact to fossil heritage resources is extremely low.

5. Assumptions and uncertainties

Based on the geology of the area and the palaeontological record as we know it, it can be assumed that the formation and layout of the dolomites, sandstones, shales and sands are typical for the country and some do contain fossil plant, wood, invertebrate traces and vertebrate material. The sands of the Quaternary period would not preserve fossils in context. From previous site visit PIAs we know that rare traces fossils and fragments of silicified wood occur in the Tierberg Formation (Ecca Group) and silicified wood, trace fossils and bone

fragments occur in the Aldelaide Subgroup rocks. Non- fossiliferous dolerite and sand are widespread.

6. Response to SAHRA Comment (14 September 2022)

In an interim comment on the Draft Basic Assessment report for the proposed new transmission lines, switching station and access road in support of the authorised De Aar 2 South Wind Energy Facility, SAHRA commented that this PIA does not "assess the impact of the proposed developments and their associated activities, including the service roads and new access road".

However, this PIA did assess the areas that will be affected by the transmission line, its service road and the infrastructure related to the transmission substation and switching station (see Figures 5 and 6 above) and only the area affected by the WEF access road shown on Figure 7 below was not assessed.

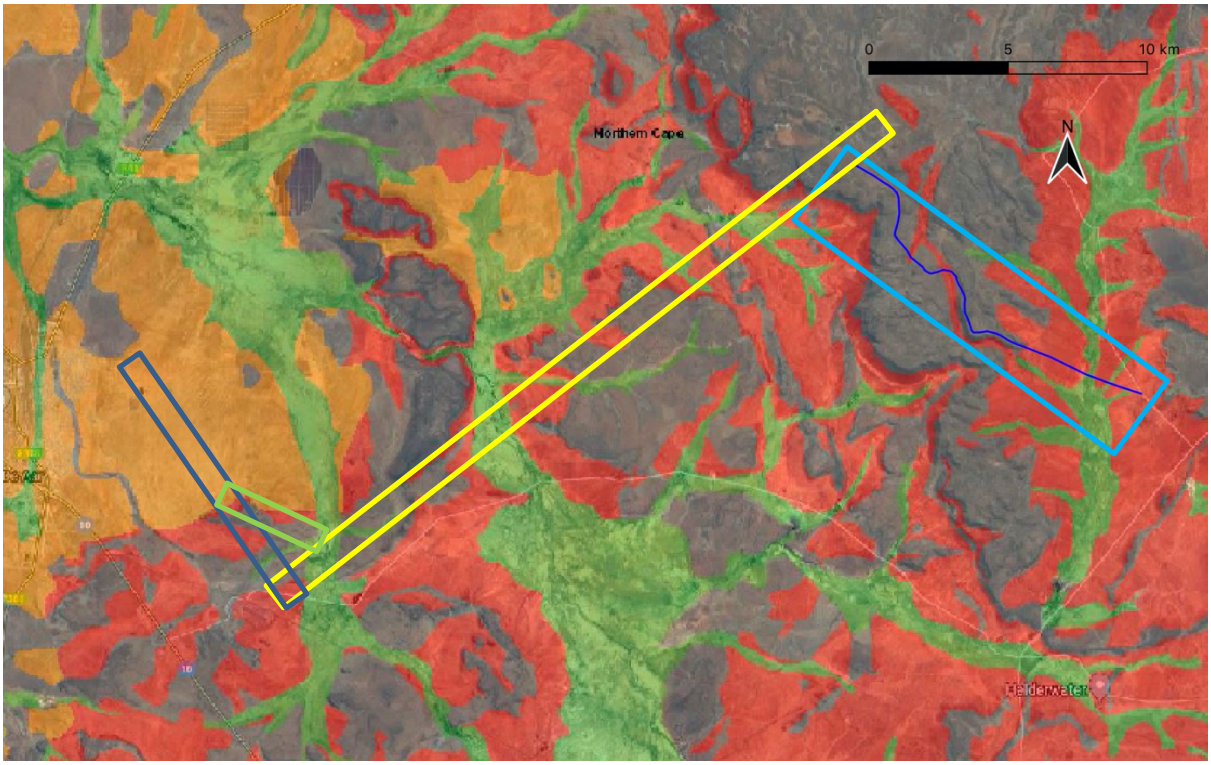

Figure 7: SAHRIS palaeosensitivity map for the site for the proposed Mulilo De Aar project. The transmission lines and infrastructure related to the transmission substation, and switching station previously assessed are within the yellow, green and dark blue rectangles. The proposed access road is the dark blue line within the pale blue rectangle.

More than half the length of the access road will be on non-fossiliferous dolerite so there will be no impact upon fossil heritage.

The south-eastern portion of the access road is partly on the Adelaide Subgroup and partly on Quaternary river alluvium. Although alluvium is considered to be moderately fossiliferous in parts of the country this is dependent on the source rocks of the sands. On the access road

the source rocks are the non-fossiliferous dolerite and the Adelaide subgroup. Since the Adelaide Subgroup has not been divided into its respective formations this implies that there are no fossils present. In practice, the vertebrate palaeontologists source the rocky outcrops to search for *in situ* exposures as any transported rocks (fossils) are out of context and so of limited scientific value for researchers. Therefore, surface finds would be of no value; only below ground *in situ* fossils are of scientific value.

7. Conclusions

Based on experience and the findings from previous palaeontological site visits to the area, it is very unlikely that any fossils would be impacted upon by the foundations for some poles (132 kV steel monopole structure including foundations and insulators) or by the access road because the fossils are sporadic and of common forms. The proposed site for a battery storage facility at DAS2 WEF and more than half the access road is on non-fossiliferous dolerite so would not impact upon the fossil heritage at all. The route between Hydra and this facility (Routes 1 and 2) has several potentially fossiliferous patches but prior field surveys by John Almond show that fossils are rare. The same applies to the DAS2 line option 2 Part 1 – fossils may be present but the footprint is so small that an impact is unlikely on the fossils. Since there is a small chance that fossils may occur in the Quaternary river alluvium, Tierberg Formation and Adelaide Subgroup mudstones and shales, a Fossil Chance Find Protocol should be added to the EMPr: if fossils are found once excavations have commenced then they should be rescued and a palaeontologist called to assess and collect a representative sample, with a SAHRA permit.

8. References

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9. Chance Find Protocol

Monitoring Programme for Palaeontology – to commence once the excavations and associated activities begin.

1. The following procedure is only required if fossils are seen on the surface and when excavations commence.
2. When excavations begin the rocks and must be given a cursory inspection by the environmental officer or designated person. Any fossiliferous material (plants, insects, bone, trace fossils) should be put aside in a suitably protected place. This way the project activities will not be interrupted.

3. Photographs of similar fossil plants must be provided to the developer to assist in recognizing the fossil plants in the shales and mudstones (for example see Figure 1.5). This information will be built into the EMP's training and awareness plan and procedures.
4. Photographs of the putative fossils can be sent to the palaeontologist for a preliminary assessment.
5. If there is any possible fossil material found by the developer/environmental officer/miners then the qualified palaeontologist sub-contracted for this project, should visit the site to inspect the selected material and check the dumps where feasible.
6. Fossil plants or vertebrates that are considered to be of good quality or scientific interest by the palaeontologist must be removed, catalogued and housed in a suitable institution where they can be made available for further study. Before the fossils are removed from the site a SAHRA permit must be obtained. Annual reports must be submitted to SAHRA as required by the relevant permits.
7. If no good fossil material is recovered then no site inspections by the palaeontologist will not be necessary. A final report by the palaeontologist must be sent to SAHRA once the project has been completed and only if there are fossils.
8. If no fossils are found and the excavations have finished then no further monitoring is required.

Appendix A – Examples of fossils from the Permian Karoo.

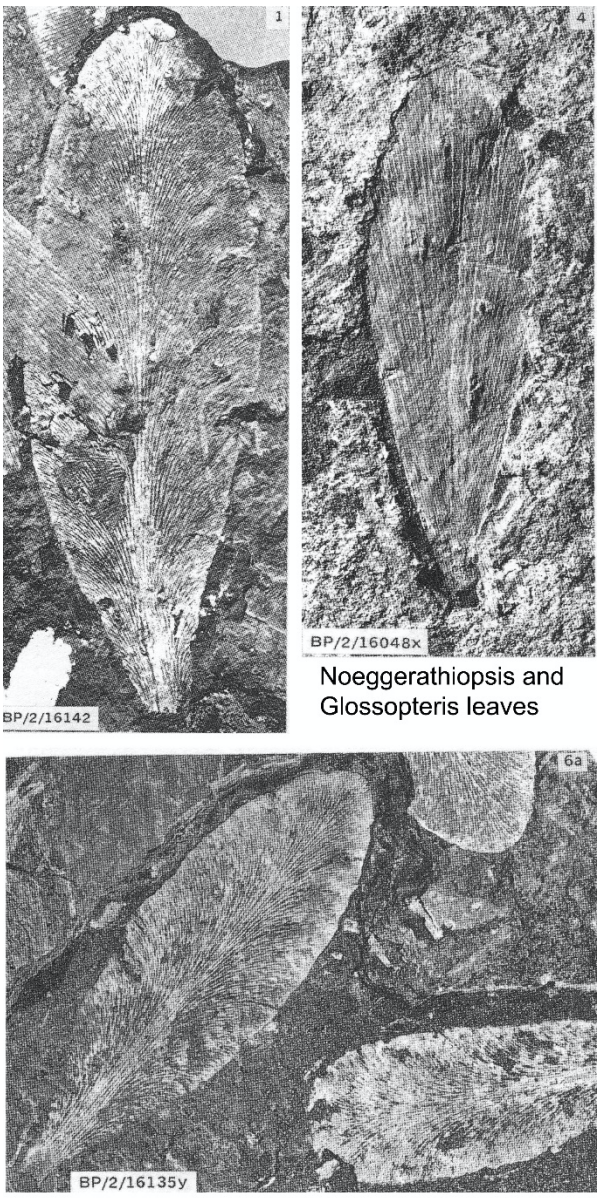

Figure 7: examples of Permian *Glossopteris* leaf impressions.

Figure 8: Vertebrate bones embedded in the mudstone.

Figure 9: a common trace fossil of worm burrows.

Figure 10: piece of silicified wood. Note the knots for branches.

Appendix B – Details of specialist

Curriculum vitae (short) - Marion Bamford PhD
January 2020

I) Personal details

Surname	:	**Bamford**
First names	:	**Marion Kathleen**
Present employment	:	Professor; Director of the Evolutionary Studies Institute. Member Management Committee of the NRF/DST Centre of Excellence Palaeosciences, University of the Witwatersrand, Johannesburg, South Africa-
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ii) Academic qualifications

Tertiary Education: All at the University of the Witwatersrand:
1980-1982: BSc, majors in Botany and Microbiology. Graduated April 1983.
1983: BSc Honours, Botany and Palaeobotany. Graduated April 1984.
1984-1986: MSc in Palaeobotany. Graduated with Distinction, November 1986.
1986-1989: PhD in Palaeobotany. Graduated in June 1990.

iii) Professional qualifications

Wood Anatomy Training (overseas as nothing was available in South Africa):
1994 - Service d'Anatomie des Bois, Musée Royal de l'Afrique Centrale, Tervuren, Belgium, by Roger Dechamps
1997 - Université Pierre et Marie Curie, Paris, France, by Dr Jean-Claude Koeniguer
1997 - Université Claude Bernard, Lyon, France by Prof Georges Barale, Dr Jean-Pierre Gros, and Dr Marc Philippe

iv) Membership of professional bodies/associations

Palaeontological Society of Southern Africa
Royal Society of Southern Africa - Fellow: 2006 onwards
Academy of Sciences of South Africa - Member: Oct 2014 onwards
International Association of Wood Anatomists - First enrolled: January 1991
International Organization of Palaeobotany – 1993+
Botanical Society of South Africa
South African Committee on Stratigraphy – Biostratigraphy - 1997 - 2016
SASQUA (South African Society for Quaternary Research) – 1997+
PAGES - 2008 –onwards: South African representative
ROCEEH / WAVE – 2008+
INQUA – PALCOMM – 2011+onwards

vii) Supervision of Higher Degrees

All at Wits University

Degree	Graduated/completed	Current
Honours	7	0
Masters	10	4
PhD	12	5
Postdoctoral fellows	10	3

viii) Undergraduate teaching
Geology II – Palaeobotany GEOL2008 – average 65 students per year
Biology III – Palaeobotany APES3029 – average 25 students per year
Honours – Evolution of Terrestrial Ecosystems; African Plio-Pleistocene Palaeoecology; Micropalaeontology – average 2-8 students per year.

ix) Editing and reviewing
Editor: Palaeontologia africana: 2003 to 2013; 2014 – Assistant editor
Guest Editor: Quaternary International: 2005 volume
Member of Board of Review: Review of Palaeobotany and Palynology: 2010 –
Cretaceous Research: 2014 –

Journal of African Earth Sciences: 2020 -

Review of manuscripts for ISI-listed journals: 25 local and international journals

x) Palaeontological Impact Assessments

Selected – list not complete:

- Thukela Biosphere Conservancy 1996; 2002 for DWAF
- Vioolsdrift 2007 for Xibula Exploration
- Rietfontein 2009 for Zitholele Consulting
- Bloeddrift-Baken 2010 for TransHex
- New Kleinfontein Gold Mine 2012 for Prime Resources (Pty) Ltd.
- Thabazimbi Iron Cave 2012 for Professional Grave Solutions (Pty) Ltd
- Delmas 2013 for Jones and Wagener
- Klipfontein 2013 for Jones and Wagener
- Platinum mine 2013 for Lonmin
- Syferfontein 2014 for Digby Wells
- Canyon Springs 2014 for Prime Resources
- Kimberley Eskom 2014 for Landscape Dynamics
- Yzermyne 2014 for Digby Wells
- Matimba 2015 for Royal HaskoningDV
- Commissiekraal 2015 for SLR
- Harmony PV 2015 for Savannah Environmental
- Glencore-Tweefontein 2015 for Digby Wells
- Umkomazi 2015 for JLB Consulting
- Ixia coal 2016 for Digby Wells
- Lambda Eskom for Digby Wells
- Alexander Scoping for SLR
- Perseus-Kronos-Aries Eskom 2016 for NGT
- Mala Mala 2017 for Henwood
- Modimolle 2017 for Green Vision
- Klipoortjie and Finaalspan 2017 for Delta BEC
- Ledjadja borrow pits 2018 for Digby Wells
- Lungile poultry farm 2018 for CTS
- Olienhout Dam 2018 for JP Celliers
- Isondlo and Kwasobabili 2018 for GCS
- Kanakies Gypsum 2018 for Cabanga
- Nababeep Copper mine 2018
- Glencore-Mbali pipeline 2018 for Digby Wells
- Remhoogte PR 2019 for A&HAS
- Bospoort Agriculture 2019 for Kudzala
- Overlooked Quarry 2019 for Cabanga
- Richards Bay Powerline 2019 for NGT
- Eilandia dam 2019 for ACO

- Eastlands Residential 2019 for HCAC
- Fairview MR 2019 for Cabanga
- Graspan project 2019 for HCAC
- Lieliefontein N&D 2019 for Enviropro
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xi) Research Output

Publications by M K Bamford up to December 2019 peer-reviewed journals or scholarly books: over 140 articles published; 5 submitted/in press; 8 book chapters.
Scopus h-index = 27; Google scholar h-index = 32; -i10-index = 80
Conferences: numerous presentations at local and international conferences.

xii) NRF Rating

NRF Rating: B-2 (2016-2020)
NRF Rating: B-3 (2010-2015)
NRF Rating: B-3 (2005-2009)
NRF Rating: C-2 (1999-2004)