PALAEONTOLOGICAL SPECIALIST STUDY

In terms of Section 38(8) of the NHRA for a

Proposed Development of the Pixley Park REF and associated infrastructure near De Aar

Prepared by

CTS HERITAGE

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In Association with

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EXECUTIVE SUMMARY

Mulilo is proposing the development of up to 4 x 100MW PV facilities on a site near de Aar. The projects will all connect to the new Vetlaagte Main Transmission Substation (MTS) via the Wag 'n Bietjie MTS. The 4 projects are referred to as Carolus PV, Fountain PV, Rietfontein PV and Wagt PV and will have a combined output of 700MW.

According to the SAHRIS Palaeosensitivity Map (Figure 4a), the area proposed for development is underlain by sediments of moderate and very high paleontological sensitivity. The purpose of this desktop palaeontological study is to satisfy the requirements of section 38(8), and therefore section 38(3) of the National Heritage Resources Act (Act 25 of 1999) in terms of impacts to archaeological resources.

Based on previous surveys in the area, the presence of superficial deposits (probable Pleistocene to Recent age) covering the fossiliferous sediments (Ecca and Beaufort Groups), as well as the extensive network of intrusive dolerite dykes and sills that bake (thermally metamorphose) adjacent mudrocks, it is anticipated that the impact of the development will mainly be **LOW to MODERATE.**

There are no objections on palaeontological heritage grounds. Any fossil finds, most likely in the Adelaide Subgroup sediments and Quaternary Sands, are to be reported by the developer. Should important fossil material be found during excavations, the attached Fossil Finds Procedure must be implemented (Appendix 1).

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1. INTRODUCTION

1.1 Background Information on Project

Mulilo is proposing the development of up to 4 x PV facilities on a site near de Aar. The projects will all connect to the new Vetlaagte Main Transmission Substation (MTS) via the Wag 'n Bietjie MTS. The grid connection infrastructure would include the following:

» Onsite 132kV switching station - 100m x 100m and 30m height
» 132kV Overhead Power Line (OHPL) – 30m height from the switching station to the MTS within a 200m grid corridor
» Extension of the 132kV Busbar at the MTS
» 132kV Feeder Bay at the MTS
» Extension of the 400kV Busbar at the MTS
» 400/132kV Transformer at the MTS
» Access Road to switching station and along the powerline route up to the MTS
» Generic electrical infrastructure EMPs

Property details are as follows:

» Farm Wag 'n Bietjie 5
» Portion 1 of Farm Riet Fountain 6
» Portion 3 & 4 of Farm Carolus Poort 3

The 4 projects are referred to as Carolus PV, Fountain PV, Rietfontein PV and Wagt PV and will have a combined output of 700MW.

1.2 Description of Property and Affected Environment

The farm, Vetlaagte 4, lies 5.5 km east of the town of De Aar and about 2km north of the large Hydra substation. A number of renewable energy projects, particularly solar PV farms, have been proposed immediately surrounding this development and three completed solar farms lie north and northwest of Vetlaagte 4 such as De Aar Solar and Paarde Valley. A completed 144MW wind farm lies on the plateau north east of the development and can be seen from parts of Vetlaagte. An existing powerline as well as the various solar PV panels and infrastructure are clustered on the southern end of the development area. Much of the eastern half of Vetlaagte is similarly flat with only a few very small dolerite outcrops. The western half of Vetlaagte is rockier and hilly with two clusters of dolerite outcrops split either side of a jeep track.

The farms are currently used for grazing by sheep and a few farm kraals, dams and windmills were observed. The vegetation is typical of the Karoo and the grassland was dense enough over much of the site to hamper visibility of archaeological material lying on the surface. Some small scale crop agricultural production is placed at the Vetlaagte farmhouse complex which lies on the banks of a floodplain running north - south past the eastern end of the study area. A few (currently dry) farm dams were evident that appear to be in a state of disuse within the floodplain.

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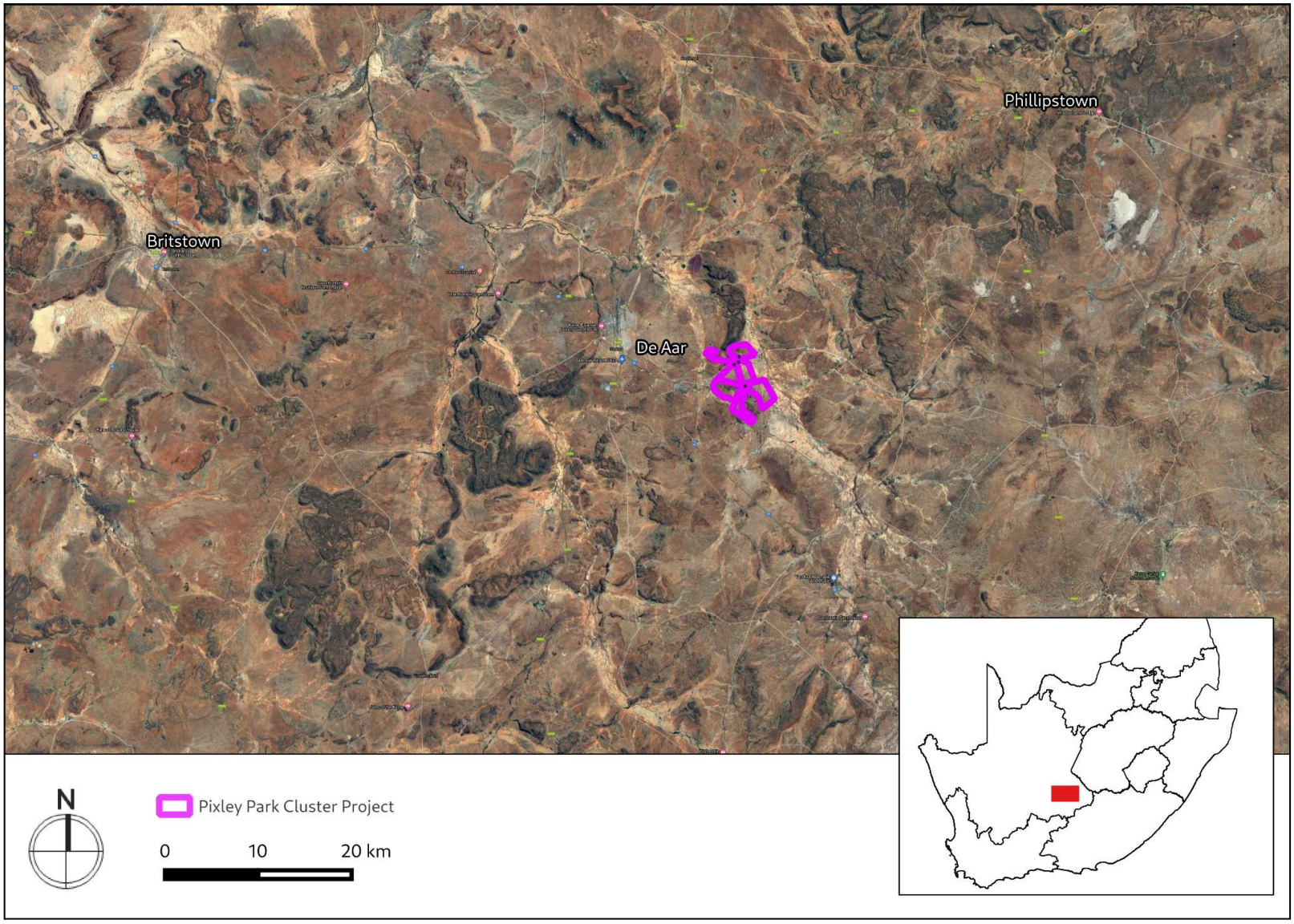

Figure 1.1: Close up satellite image indicating proposed location of study area

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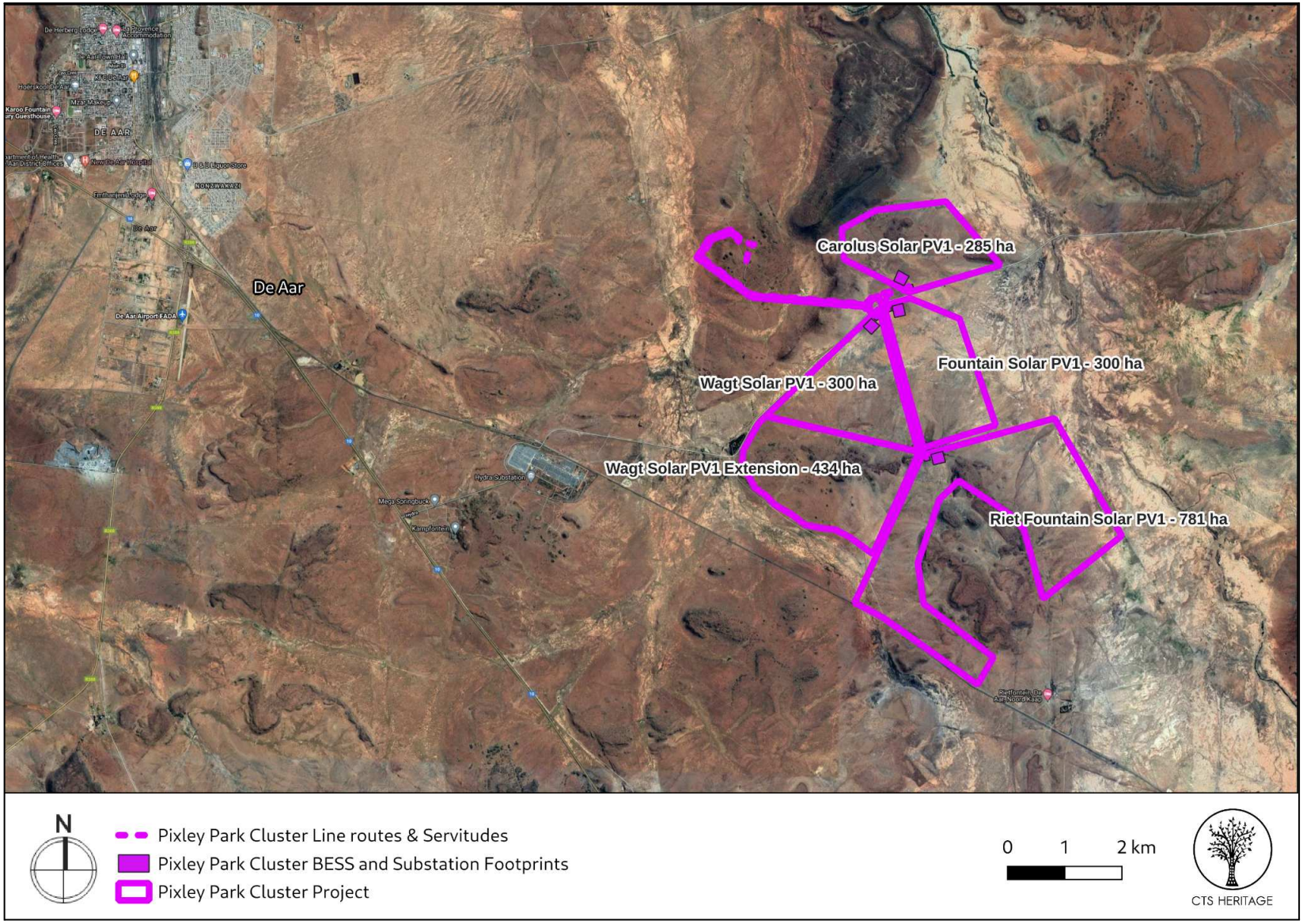

Figure 1.2: Study Area

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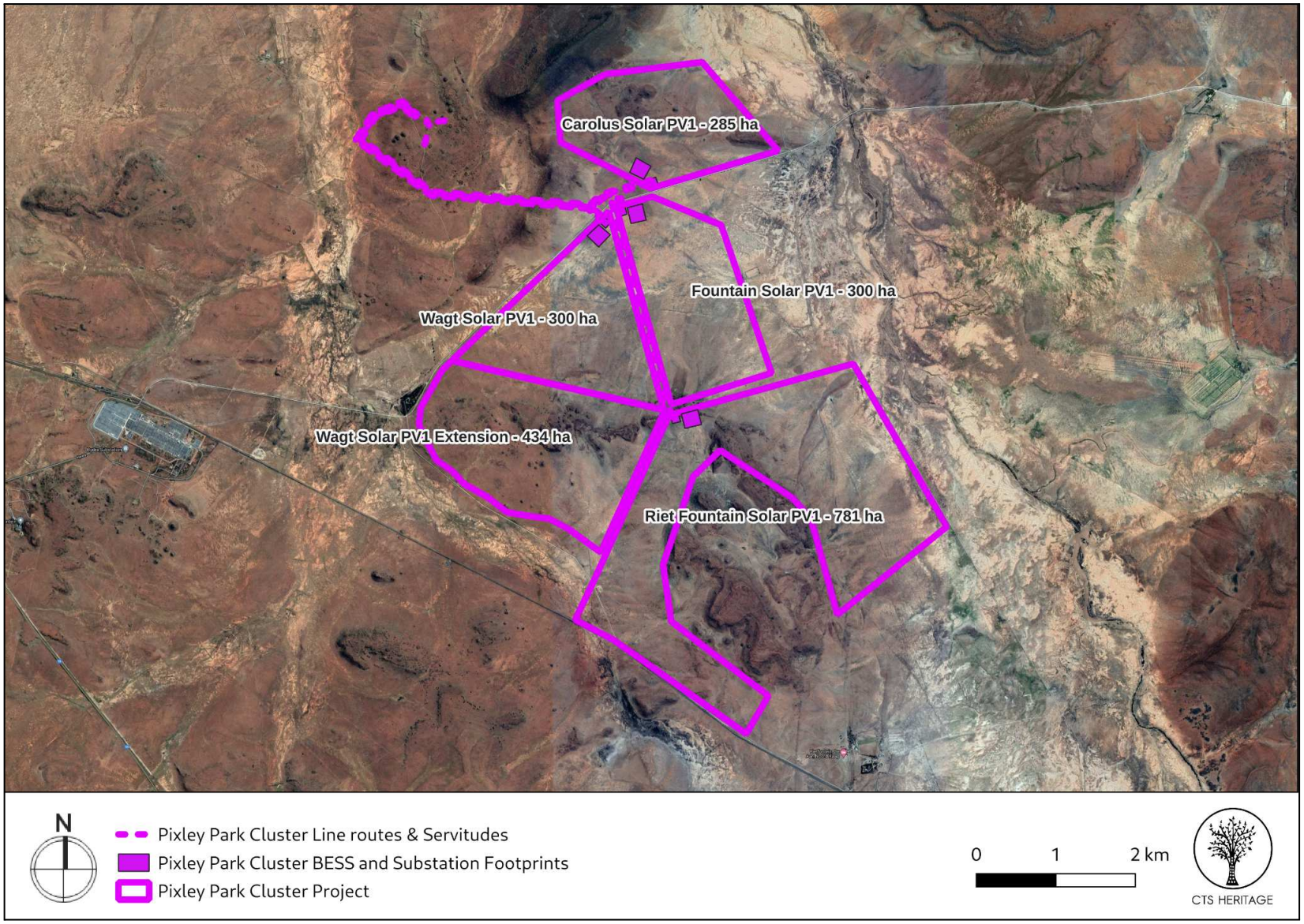

Figure 1.3: Study Area

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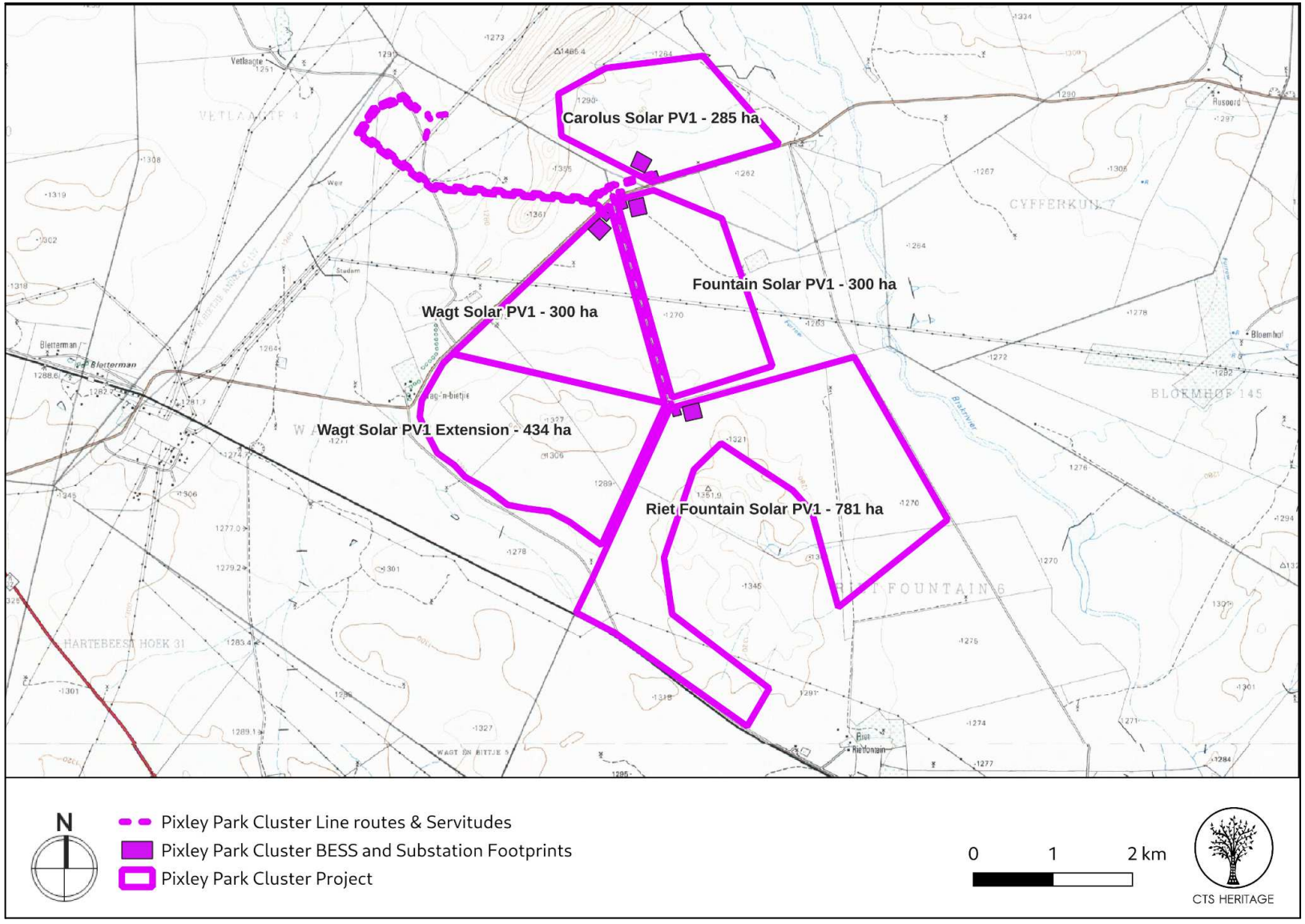

Figure 1.4: Study Area reflected on the 1:50 000 Topo Map

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2. METHODOLOGY

2.1 Purpose of Palaeontological Study

According to the SAHRIS Palaeosensitivity Map (Figure 4a), the area proposed for development is underlain by sediments of moderate and very high paleontological sensitivity. The purpose of this desktop palaeontological study is to satisfy the requirements of section 38(8), and therefore section 38(3) of the National Heritage Resources Act (Act 25 of 1999) in terms of impacts to archaeological resources.

2.2 Summary of steps followed

- Primary research literature was consulted for detailed accounts of the geology and palaeontological representation across the study area. References of these primary research articles are provided.
- Geological maps (provided at various scales by CTS heritage and the South African Council for Geosciences) were consulted to identify represented geological contexts within the study area.
- Where possible, other Palaeontological Impact Assessments were consulted to provide additional information on local geomorphological, geological and palaeontological contexts. These often provide valuable additional information to primary research publications and formal geological maps, which can lack resolution at a local scale and it is important that discussions regarding alternative stratigraphic attributions of exposed rocks are noted and considered.

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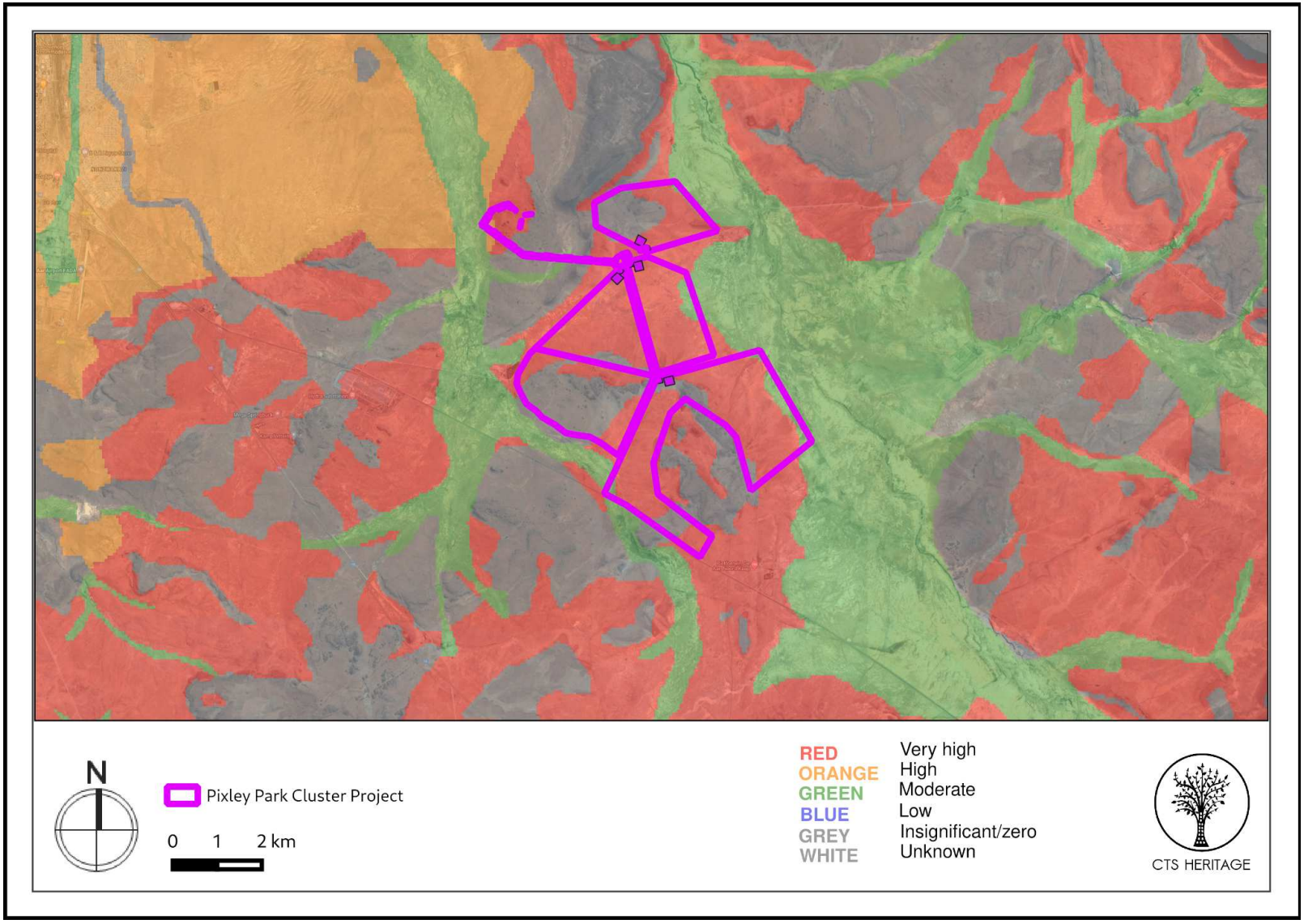

Figure 2: Palaeontological sensitivity of the development area from the SAHRIS PalaeoMap

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3. SITE SENSITIVITY

According to the extract from the Council for GeoSciences Map 3024 for Colesburg, the development area is underlain by Jurassic Dolerite, the Tierberg Formation of the Ecca Group and the Adelaide Subgroup of the Beaufort Group as well as Quaternary sands associated with the drainage lines.

As part of the process completed in 2012 for the approved neighbouring Vetlaagte Solar Energy Facility, Almond completed a field-based palaeontological assessment. Almond (2012) found that "The potentially fossiliferous sediments of the Late Palaeozoic Karoo Supergroup (Ecca and Lower Beaufort Groups) that underlie the study area are almost entirely mantled in a thick layer of superficial deposits of probable Pleistocene to Recent age. These include various soils, gravels and – at least in some areas - a well-developed calcrete hardpan. The upper Ecca Group bedrocks in the northern portion of the study area contain locally abundant fossil wood (of palaeontological interest for dating and palaeoenvironmental studies), as well as low diversity non-marine trace fossil assemblages typical of the Waterford Formation, rather than the Tierberg Formation as mapped. No vertebrate fossils and only scattered woody plant impressions of the Permian Glossopteris Flora were observed within the Lower Beaufort Group rocks that are very poorly exposed in the southern portion of the Vetlaagte study area. Trace fossils, silicified wood and rare vertebrate remains (therapsids, parareptiles) of the Middle Permian Pristerognathus Assemblage Zone have recently been recorded from this succession in the De Aar region (Almond 2010b). Extensive dolerite sills and dykes of the Early Jurassic Karoo Dolerite Suite intruding the Karoo Supergroup sediments are entirely unfossiliferous, as are rare intrusive kimberlite pipe rocks of Cretaceous age. The diverse superficial deposits within the three study areas (e.g. soils, gravels, alluvium, calcrete hardpans) are of low palaeontological sensitivity as a whole . Abundant fragments of reworked fossil wood material of Ecca provenance occur widely within subsurface and surface gravels overlying the Ecca Group outcrop area."

Almond (2012) concludes that "The construction of new access roads and transmission lines in this region are likewise considered to be of low significance as far as fossil heritage is concerned... In view of the overall low significance of the proposed development on palaeontological heritage resources, it is concluded that no further palaeontological heritage studies or specialist mitigation are required for these small PV projects, pending the exposure of any substantial fossil remains (e.g. vertebrate bones and teeth, large blocks of petrified wood) during the construction phase."

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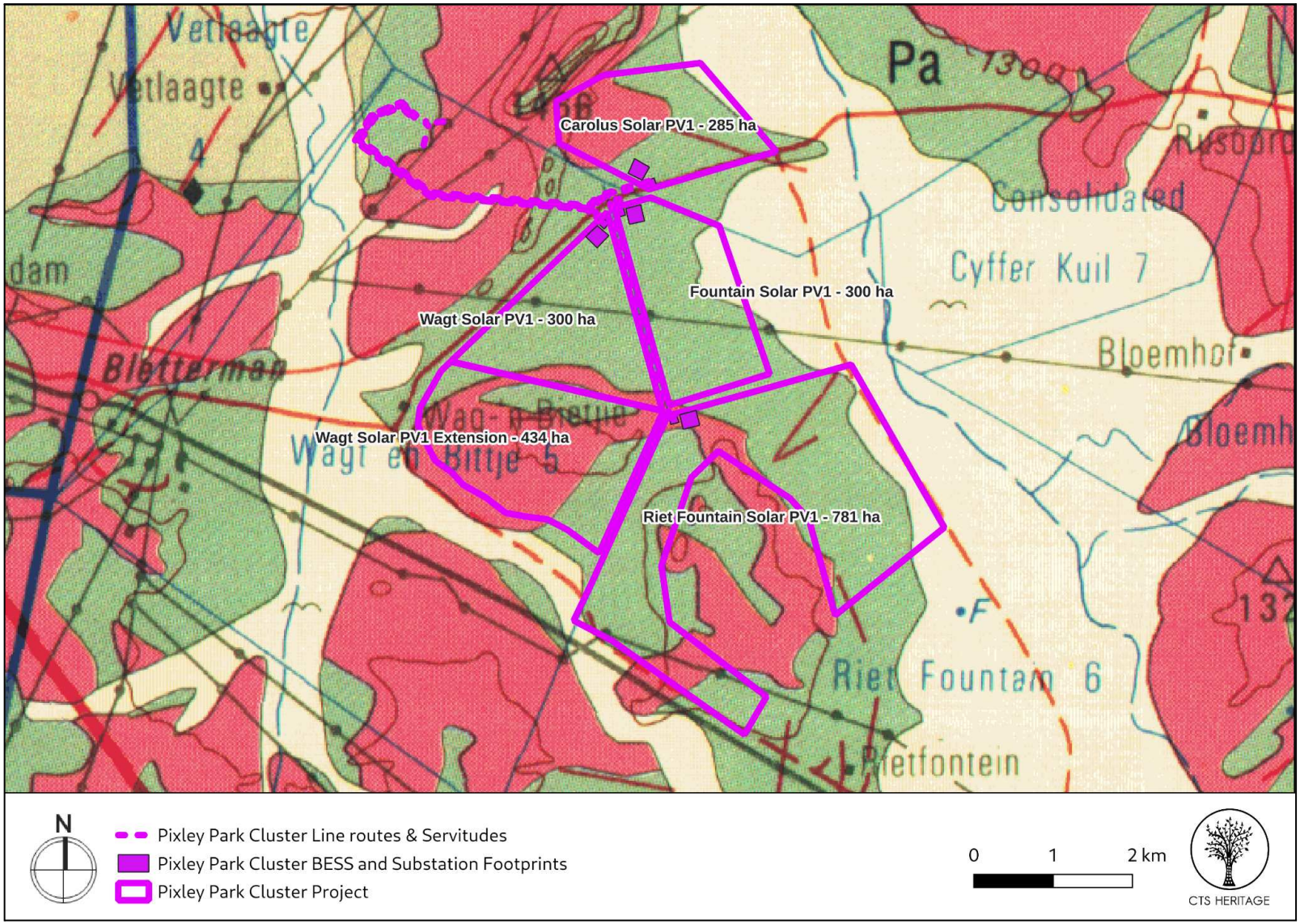

Figure 3. Geology Map. Extracted from the Council for GeoSciences Map 3024 for Colesburg indicating that the development area is underlain by Jd: Jurassic Dolerite (red), Pt (lighter green): Tierberg Formation of the Ecca Group and Pa (darker green): Adelaide Subgroup of the Beaufort Group

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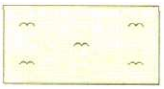
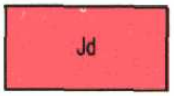
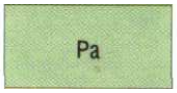
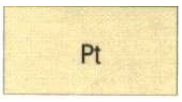
Table 1: Geological Summary Table

Geological unit	Age	Lithology	Symbol on figure 3	Fossil heritage	Palaeontological sensitivity (almond and pether, 2008)	Recommended mitigation
Quaternary	2.58 mya to 0 mya	Alluvium and debris		Calcretised insect burrows (including termites) and root casts (rhizoliths), ostrich egg shells (S*truthio*), shells of land snails (e.g. *Trigonephrus*), bivalves and gastropods (e.g. *Corbula*, *unio*) and ostracods (seed shrimps), charophytes (stonewort algae), diatoms, stromatolites, mammalian ichnofossils	Moderate	Any fossil finds to be reported by developer
Jurassic dolerite	200 mya	Intrusive dolerite		None	Insignificant/Zero	No action required
Adelaide Subgroup - Beaufort Group - Karoo Supergroup	262 mya to 251 mya	Blue-grey silty mudstone, subordinate brownish-red mudstone; sandstone		Rich fossil tetrapod assemblage (including amphibians, pan-testudines, therapsids, pisces); fossil plants (including *Glossopteris,* lycopods, sphenophytes, ferns, silicified wood)	Very High	Any fossil finds to be reported by developer
Tierberg Formation - Ecca Group - Karoo Supergroup	273 mya to 269.5 mya	Blue-grey to black shale with carbonate-rich concretions; subordinate siltstone and sandstone in upper part		Rare microvertebrate fossils (including fish scales and teeth); plant fossils (including leaves and petrified wood); abundant trace fossils (including burrows, arthropod trackways)	High	Any fossil finds to be reported by developer

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4. IDENTIFICATION OF HERITAGE RESOURCES

4.1 Underlying geology of development area

The geological context of the proposed development area is characterised by Quaternary sands, Jurassic Dolerite (Jd), the Permian Adelaide Subgroup (Pa) of the Beaufort Group (Karoo Supergroup), and the Permian Tierberg Formation (Pt) of the Ecca Group (Karoo Supergroup) (see table 1 for summary).

- The Northwest most corner of the development area (Pixley Park Cluster Line Routes and Servitude) traverses a small 180 m (East to West) by 500 m (North to South) area of the oldest deposit in the area, the Tierberg Formation (Ecca Group, Karoo Supergroup) (figure 3). This fine sediments of this formation were accumulated in the middle Permian (approximately 273 to 269.5 mya) (Johnson, Anhauesser & Thomas, 2006; Fildani *et al.*, 2009; Belica *et al.*, 2017; Groenewald, Day & Rubidge, 2019). The depositional environment of this unit has been described as restricted, brackish water (corresponding to offshore, quiet environments below wave base) (Johnson *et al.*, 1996; Almond, 2013; Groenewald *et al.*, 2022). The mudrock-dominated Tierberg Formation consists of dark, well-laminated shales, carbonate-rich concretions, and subordinate thin and fine-grained sandstones (table 1) (Johnson, Anhauesser & Thomas, 2006; Almond, 2013). Previous survey work 7.5 km North-West of the Pixley Park PV area suggested that the Tierberg Formation in the area rather corresponds to the overlying Waterford Formation (top of the Ecca Group defined by shallow shelf, storm-dominated, sandstone-rich facies) (Almond, 2013).
- The majority of the Pixley Park PV development area is geologically represented by the Adelaide Subgroup (Beaufort Group, Karoo Supergroup). This unit was deposited in the middle to upper Permian (approximately 262 to 251 mya) (Groenewald *et al.*, 2022). This subgroup is subdivided into the Abrahamskraal and Teekloof formations in the South-West part of the Karoo basin, and the Abrahamskraal, Middleton and Balfour formations in the South-East part of the basin (Johnson *et al.*, 1996). In some areas of the country, including the Pixley Park PV area, the representation and distribution of Adelaide Subgroup stratigraphic divisions is unresolved (Almond, 2021; Groenewald *et al.*, 2022). The sedimentary change from Ecca to Beaufort Group reflects a shift from subaqueous conditions to subaerial fluvial environments (Groenewald *et al.*, 2022), in which the Adelaide Subgroup was formed through fluvial processes relating to large-scale meandering river systems (Johnson, Anhauesser & Thomas, 2006; Almond, 2021). The sediments of the Adelaide Subgroup comprise fine-grained overbank mudrocks and subordinate lenticular channel sandstones (Almond, 2013; Almond, 2021).
- The entire proposed project area is abundantly intruded by an extensive network of igneous Jurassic Dolerite sills and dykes (part of the Karoo Igneous Province of Southern Africa). These were formed through crustal doming and stretching during the break-up of Gondwana, (Johnson, Anhauesser & Thomas, 2006; Almond, 2013).
- Finally, superficial Quaternary (<2.5 mya) to Recent alluvial deposits are represented at the Eastern border of the Pixey Park PV area. These cover the slopes of the dolerite ridges, valley sides and dry riverbeds (such as the Brakriver on the West of the proposed project area) (Johnson, Anhauesser & Thomas, 2006; Almond, 2013; Almond, 2021). Recent surveys in the area including 7.5 km North-West and 22 km South-East of the Pixley Park PV project area found that the local Quaternary sands are fine-grained, pale brown to orange-brown sandy to

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gravelly alluvial deposits (up to several meters in thickness) of various ages related to the Brakrivier and associated channels and tributaries (Almond, 2013; Almond, 2021).

4.2 Palaeontological Sensitivity of the Development Area

- The Palaeontological Sensitivity of the **Tierberg Formation** is classified as **High Risk** by SAHRIS (figure 2). The most abundant fossils from the formation are trace fossils. These include approximately ten ichnogenera including invertebrate burrows (e.g. *Planolites, Palaeophycus*), arthropod trackways (e.g. *Umfolozia*), and fish swimming trails (e.g. *Undichna*). Rare microvertebrate remains (fish scales and teeth) in calcareous concretions as well as plant fossils (leaves and petrified wood) have also been recovered (Van Dijk, Channing & Van Den Heever, 2002; Almond, 2008; Almond, 2013). If the Tierberg Formation exposures in the area are instead Waterford Formation deposits, these sediments have yielded poorly preserved tetrapod remains (possibly temnospondyl), microvertebrates (fish scales), fish coprolites, non-marine bivalves, trace fossils (e.g. invertebrate burrows *Scoyenia*,), and plant fossils (e.g. petrified wood and *Glossopteris*) (Rubidge, Hancox & Catuneanu, 2000; Johnson, Anhauesser & Thomas, 2006; Almond, 2013).
- The Palaeontological Sensitivity of the **Adelaide Subgroup** is classified as **Very High Risk** by SAHRIS (figure 2). The unit contains a highly diverse tetrapod assemblage and three Assemblage Zones: the *Tapinocephalus*, *Endothiodon*, and *Cistecephalus* Assemblage Zones (Day & Rubidge, 2020; Day & Smith, 2020; Rubidge & Day, 2020). These have yielded amphibian fossils (including temnospondyls like *Rhinesuchus*), Pan-testudines (e.e. *Eunotososaurus*), therapsids (including biarmosuchians, anomodonts, gorgonopsians and therocephalians) as well as fish (e.g. *Namaichthys*). Plant fossils (including petrified wood, plant remains, leaf & stem impressions), non-marine molluscs, and trace fossils (trackways, invertebrate burrows, coprolites) have also been recovered in the Adelaide Subgroup (Johnson, Anhauesser & Thomas, 2006; Bordy & Prevec, 2008; Bordy, Linkermann & Prevec, 2011; Bamford, Cairncross & Lombard, 2020; Almond, 2021). Previous surveys in the area (22 km South-East of current proposed area) have reported that "Due to the generally very poor exposure of Lower Beaufort Group (Adelaide Subgroup) bedrocks in the region between De Aar and Hanover, there have been very few identifiable vertebrate or other fossil finds here. Fragmentary skeletal remains of small-bodied therapsids, mainly dicynodonts, as well as of the small tortoise-like reptile *Eunotosaurus* have been recorded from the Lower Beaufort Group near De Aar […] (Day *et al.*, 2013) but these belong to a slightly older horizon within the Lower Beaufort Group than those in the present study area. Associated fossils near De Aar include scrappy plant remains – mainly sphenophyte ferns and well-preserved silicified wood – as well as low-diversity trace fossil assemblages." (Almond, 2021).
- The Palaeontological Sensitivity of the **Jurassic Dolerite** is classified as **Insignificant/Zero** by SAHRIS (figure 2). The igneous intrusive origin of the Jurassic dolerite dykes makes it unlikely that they contain fossils.
- The Palaeontological Sensitivity of the **Quaternary deposits** is classified as **Moderate** by SAHRIS (figure 2). Although present, the fossil record of the Quaternary Sands is sporadic and not very diverse. Aeolian dunes are not likely to preserve fossil material, however, calcretisation of burrows (including termites) and root casts (rhizoliths) can occur. Fossils that have been recorded include ostrich egg shells (*Struthio*), shells of land snails (e.g. *Trigonephrus*), bivalves and gastropods (e.g. *Corbula*, *Unio*) and snails, ostracods (seed shrimps),

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charophytes (stonewort algae), diatoms (microscopic algae within siliceous shells) and stromatolites (laminated microbial limestones). The Mokolanen clacretes have also yielded calcretised burrows (including termites), root casts (rhizoliths) as well as mammalian ichnofossils (Malherbe, 1984; Almond & Pether, 2008). Previous surveys in the area (22 km South-East of current proposed area) have yielded petrified wood fossils reworked from Permian sedimentary deposits, but no vertebrate or invertebrate fossils (Almond, 2021). It is worth noting that the Quaternary deposits may contain stone tools from various lithic industries and these should be the subject of further specialist assessment.

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5. ASSESSMENT OF THE IMPACT OF THE DEVELOPMENT

5.1 Assessment of impact to Palaeontological Resources

Based on previous surveys in the area, the presence of superficial deposits (probable Pleistocene to Recent age) covering the fossiliferous sediments (Ecca and Beaufort Groups), as well as the extensive network of intrusive dolerite dykes and sills that bake (thermally metamorphose) adjacent mudrocks, it is anticipated that the impact of the development will mainly be **LOW to MODERATE.**

6. CONCLUSION AND RECOMMENDATIONS

There are no objections on palaeontological heritage grounds. Any fossil finds, most likely in the Adelaide Subgroup sediments and Quaternary Sands, are to be reported by the developer. Should important fossil material be found during excavations, the attached Fossil Finds Procedure must be implemented (Appendix 1).

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7. REFERENCES

Heritage Impact Assessments				
Nid	**Report Type**	**Author/s**	**Date**	**Title**
104804	PIA Desktop	John E Almond	01/09/2012	Palaeontological specialist assessment: desktop study PROPOSED RENOSTERBERG SOLAR PV AND WIND ENERGY FACILITIES NEAR DE AAR, NORTHERN CAPE PROVINCE
133536	Palaeontological Specialist Reports	John E Almond	01/07/2013	PALAEONTOLOGICAL SPECIALIST STUDY
133536	Palaeontological Specialist Reports	John E Almond	01/07/2013	PALAEONTOLOGICAL SPECIALIST STUDY
163982	Palaeontological Specialist Reports		31/08/2013	Palaeontological specialist assessment: combined desktop and field study: Proposed development PV Solar Facility near De Aar, Northern CApe Province
256408	Palaeontological Specialist Reports	John E Almond	16/07/2013	Palaeontological Specialist Study: Combined Desktop and Field-based Assessments - Proposed Photovoltaic (Solar) Energy Facilities on Badenhorst Dam Farm near De Aar, Northern Cape
49843	PIA Phase 1	John E Almond	01/05/2012	PALAEONTOLOGICAL SPECIALIST STUDY: COMBINED DESKTOP AND FIELD-BASED ASSESSMENTS Proposed solar power generation facilities on the remaining extent of the farm Vetlaagte No. 4, De Aar, Northern Cape Province
58989	PIA Desktop	James Brink	10/08/2012	A Palaeontological Desktop Study of the Area to be Affected by the Proposed Photovoltaic Power Project on Portion 3 of Farm Hartebeestplaats 135

Additional Relevant Literature Cited:

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