PALAEONTOLOGICAL IMPACT ASSESSMENT

NCORA RENEWABLE ENERGY FACILITY, FORMER TRANSKEI, EASTERN CAPE, RSA

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SUMMARY

Inno Wind (Pty) Ltd. is seeking authorisation to construct a renewable energy facility (comprising up to 18 wind turbines and 10 Ha photovoltaic panels) at a site near Ncora Dam, in the former Transkei, Eastern Cape Province. The area to be developed is underlain by rocks of the upper part of the Tarkastad Subgroup, i.e. the Burgersdorp Formation. Early to Middle Triassic rocks of the Karoo Supergroup in other parts of South Africa have been extensively studied for their rich and diverse vertebrate fauna and associated trace fossils, as well as a low diversity but highly significant fossil plant assemblages. These sequences also record a critical time in Earth's history, i.e. the recovery period following the greatest mass extinction event ever to have occurred.

Although little fossil material was recovered during a cursory field examination of the site (including undiagnostic bone fragments, fossilized roots and stems, trace fossils), this was at least partly due to a lack of extensive rock exposure in the region – a factor of rapid weathering and dense vegetation cover. Compared to other parts of the Karoo Basin, further west, relatively few fossils have been documented from the Burgersdorp Formation in the vicinity of the study area, and in fact from all of the eastern parts of the Eastern Cape. There is every indication that this is due to a lack of prior investigations, and the region has great palaeontological potential.

The Burgersdorp Formation in this area is therefore considered to be of **high palaeontological significance/sensitivity**, although **fossil densities** may be **low** and of **sporadic occurrence**. Because of the sensitivity of these rocks, mitigation measures that should be considered by the applicant and competent authority are as follows: any excavation that exposes fresh Burgersdorp Formation bedrock during development of the site must be closely monitored by the responsible Environmental Control Officer (ECO). Any fossil occurrences must be reported to SAHRA and/or a qualified palaeontologist for further assessment and excavation.

Impact significance rating table as per CES template (see PIA Appendix I for definitions)

SIGNIFICANCE RATING							
Rock Unit	**Temporal Scale**	**Spatial Scale**	**Degree of confidence**	**Impact severity**		**Overall Significance**	
				with mitigation	**without mitigation**	**with mitigation**	**without mitigation**
Burgersdorp Formation	permanent	international	possible	beneficial	very severe	beneficial	high negative

(cont.)

Damage to or destruction of any fossil during construction would be a **highly negative, permanent impact**. Discovery of fossils during excavation, followed by effective mitigation in collaboration with a palaeontologist, would result in the curation of new and important fossil material – therefore the development **could potentially have a positive**, **beneficial impact** on South Africa's palaeontological heritage.

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INTRODUCTION

Inno Wind (Pty) Ltd., a French company specialising in wind generated energy, plan to develop a renewable energy facility on rural communal land near Ncora Dam, in the former Transkei, Eastern Cape, South Africa. The envisaged facility comprises up to 18 wind turbines and 10 Ha of photovoltaic panels. Coastal & Environmental Services (CES) were appointed by InnoWind (Pty) Ltd as Environmental Assessment Practitioner (EAP) to conduct the Environmental Impact Assessment (EIA). Umlando cc. was contracted by CES to perform the heritage impact component of the assessment, and the current study represents the palaeontological component (palaeontological impact assessment - PIA) of the heritage impact assessment (HIA). The purpose of this PIA is to identify exposed and potential palaeontological heritage on the site of the proposed development, to assess the impact the development may have on this resource, and to make recommendations as to how this impact might be mitigated.

Relevant Legislation

Protection of South Africa's environmental resources is regulated by the Department of Environmental Affairs (DEA), in part through the National Environmental Management Act ("NEMA" Act 107 of 1998). In accordance with the Act, developers must apply to the competent authority for approval of their plans, which is subject to an assessment of the anticipated impacts these activities will have on the environment. Activities are categorised according to the 2010 *Government Listing Notices 1 (GN R544), 2 (GN R545) & 3 (GN R546)* issued by the DEA. In cases where impact is considered to be minimal (*Listing Notices 1 & 3*), the applicant is required to submit a basic assessment report with their application. When a greater degree of disturbance is expected *(Listing Notice 2)*, then a more rigorous, two-tiered assessment may be required, comprising a Scoping Report, followed by a full Environmental Impact Assessment (EIA).

The Ncora Renewable Energy development is subject to assessment in terms of the following listed activities (extracted from the relevant CES scoping report, 2011):

Activity No (s)		Required assessment	Listed activity
GN R544	10	Basic Assessment	The construction of facilities or infrastructure for the transmission and distribution of electricity outside urban areas or industrial complexes with a capacity of more than 33 but less than 275 kilovolts
GN R545	1	EIA	The construction of facilities or infrastructure for the generation of electricity where the electricity output is 20 megawatts or more
GN R545	15	EIA	Physical alteration of undeveloped, vacant or derelict land for residential, retail, commercial, recreational, industrial or institutional use where the total area to be transformed is 20 hectares or more.
GN R546	14	Basic assessment	The clearance of an area of 5 hectare or more of vegetation where 75% or more of the vegetative cover constitutes indigenous vegetation in all areas outside urban areas (in the Eastern Cape).

Because the proposed development triggers two listed activities from GN R545, the Ncora Renewable Energy Development is subject to the requirement for both a Scoping Assessment and full EIA.

The primary piece of legislation protecting *national heritage* in South Africa, is the **South African Heritage Resources Act (Act No. 25) of 1999**. In accordance with Section 38 (Heritage Resources Management) of the act, developers must apply to the relevant authority (South African Heritage Resources Agency - SAHRA) for authorisation to proceed with their planned activities. This application must be accompanied by documentation detailing the expected impact this will have on national heritage in particular.

Categories of heritage resources recognised as part of the National Estate in Section 3 of the Heritage Resources Act, and which therefore fall under its protection, include:

- geological sites of scientific or cultural importance;
- objects recovered from the soil or waters of South Africa, including archaeological and palaeontological objects and material, meteorites and rare geological specimens;
- objects with the potential to yield information that will contribute to an understanding of South Africa's natural or cultural heritage.

To address concerns relating to the protection of these particular heritage resources, a Heritage Impact Assessment (HIA) is a required component of the EIA, to assess any potential impacts to archaeological and palaeontological heritage within the development footprint. This report represents the palaeontological component of the HIA.

PROPOSED DEVELOPMENT

According to the draft scoping report issued by CES, the proposed development is a renewable energy facility incorporating both wind and solar technologies.

Wind Farm. Involving the construction of multiple wind turbines along the ridges indicated in Fig. 2, and comprising the following elements:

- temporary construction platform (22 m x 35 m)
- 4m wide access roads (for equipment during construction phase)
- concrete foundations to support the wind towers (20 m wide, 3m deep)
- > 4 meter wide internal access roads to each turbine
- underground cables (1 m deep, under access roads) connecting each turbine to the other and to the substation
- small building to house the control instrumentation and interconnection elements, as well as a storeroom for maintenance equipment.

Photovoltaic Park.

Consisting of an array of photovoltaic panels with a total output of 4 MW, covering an estimated footprint of 10 Ha. Each module is 2.6 x 2.2 m in size, and is anchored by means of a small concrete foot. Other infrastructure will include:

- > 4 meter wide internal access roads
- small control cabin at entrance to park
- underground cables

Location of proposed development

The proposed site for the renewable energy facility is a reverse L-shaped strip of land adjacent to the Ncora Dam in the Eastern Cape Province (Figs 1 & 2). The property is rural communal land under the jurisdiction of the Intsika Yethu Local Municipality, which in turn falls under Chris Hani District Municipality.

The north-eastern leg of the site is approximately 9.5 km long with a maximum width of 2.8 km, and the south-western leg is 14 km long with a maximum width of 2 km, and with a total area of about 39 km^2 (Fig. 2).

Topography of the proposed site generally consists of gentle undulating slopes with elevations of up to 1300 m that have been identified as suitable sites for wind generation. Flatter, low-lying areas, mostly adjacent to the Tsomo river have been selected as sites for the photovoltaic arrays (Figs 2 & 3).

AIMS AND METHODS

This report represents the palaeontological component of a Phase 1 HIA, as per the latest version of the SAHRA guidelines (May 2007, revised 2009). The aims of the PIA are to:

1) identify exposed and subsurface rock formations that are considered to be palaeontologically significant;

2) assess the level of palaeontological significance of these formations;

3) conduct fieldwork to assess the immediate risk to exposed fossils, and to document and sample these localities;

3) comment on the impact of the development on these exposed and/or potential fossil resources;

4) make recommendations as to how the developer should conserve or mitigate damage to these resources;

with the purpose of assessing the exposed and potential palaeontological heritage of the area targeted for development.

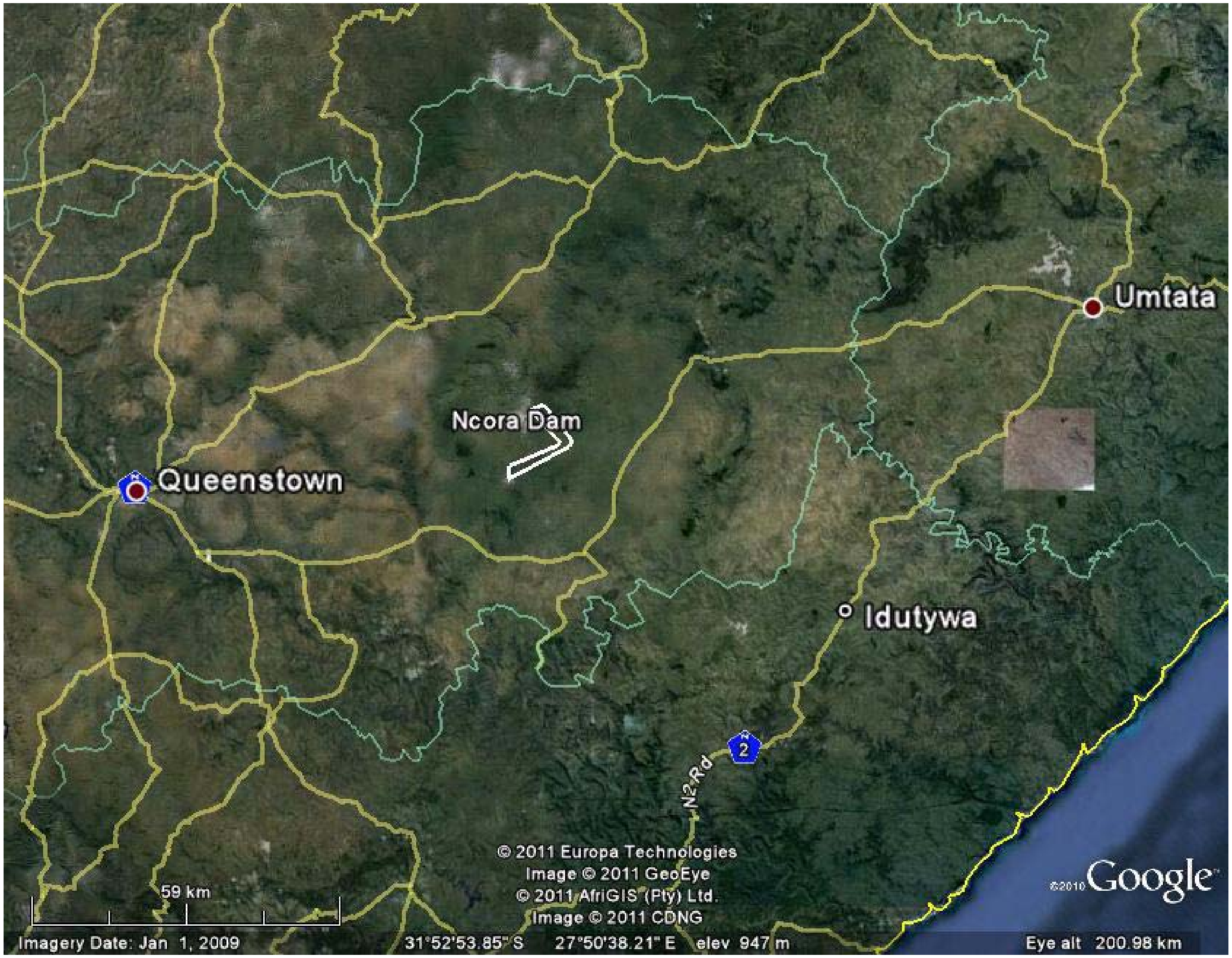

FIG. 1 General location of the proposed Ncora Renewable Energy Project (white outline).

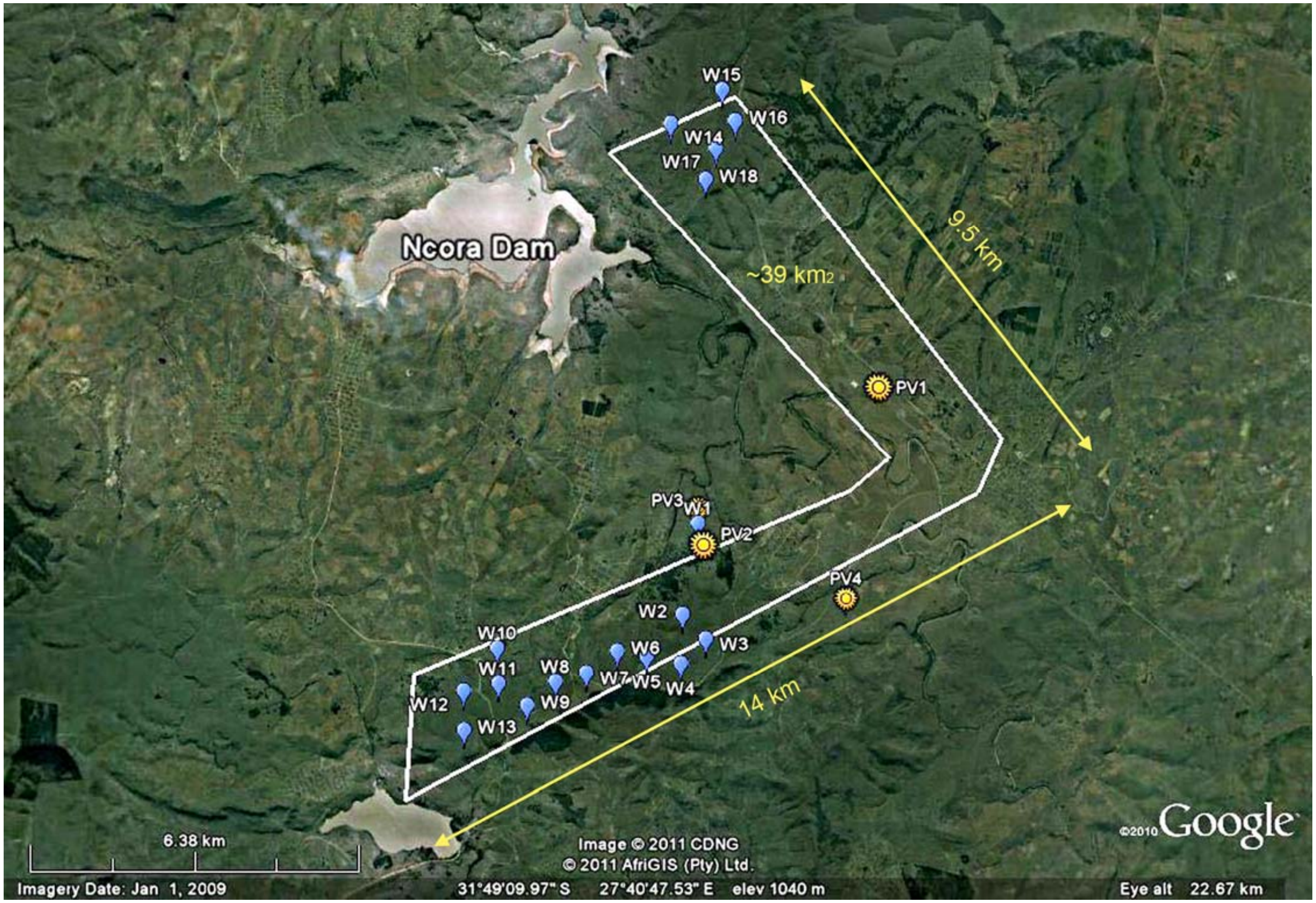

FIG. 2 Location and scale of the Ncora Renewable Energy development

(blue balloons = proposed sites of wind turbines; sun icons = proposed positions of photovoltaic arrays).

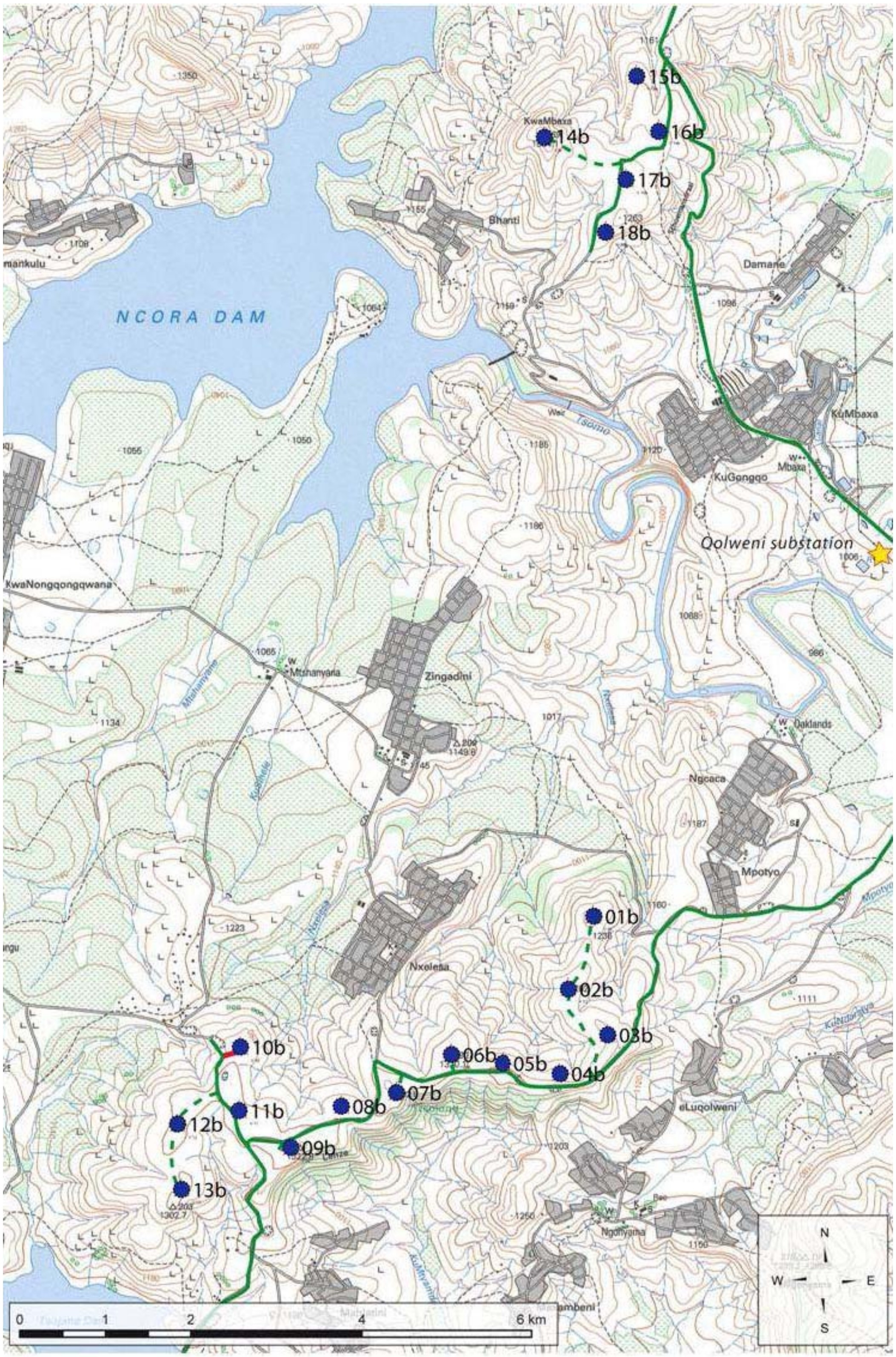

FIG. 3. A 1:50 000 topographic map illustrating a conceptual layout of 18 wind turbines (2MW; blue dots) near Ncora Dam **(extracted from draft scoping report compiled by CES for the Ncora Renewable Energy Facility).**

Using appropriate geological (1:250 000) maps in conjunction with Google Earth, a basic assessment of the topography and geology of the area was made. A review of the literature on the geological formations exposed at surface within the development site, and the fossils that have been associated with these geological strata in the former Transkei and elsewhere in South Africa, was undertaken. Specimen catalogues at the Albany Museum were consulted for additional information in this regard, as were previous PIA reports available on the internet. Dr Emese Bordy (Geology Department, Rhodes University), who is currently involved in detailed geological and palaeontological investigations in the region, provided valuable input.

A field investigation of the site was conducted on 25 February 2011, for the better part of a day, by a team of three (R. Prevec, C.C. Labandeira and J. Hepple), each experienced in looking for fossils. The aims of the fieldwork were to document any exposed fossil material, and to assess the palaeontological potential of the region in terms of the type and extent of rock outcrop in the area.

GEOLOGICAL AND PALAEONTOLOGICAL CONTEXT

Regional and local geology

As indicated by the 1:250 000 geological map of the Queenstown region (3126; Johnson *et al.*, 1979; Fig. 5), the underlying rocks in the area fall within the palaeontologically highly significant **Beaufort Group,** of the Karoo Supergroup, in the south-eastern reaches of the main Karoo Basin.

The entire area was heavily intruded by **dolerite dykes, sills and inclined sheets** during Jurassic times (scattered pink areas in Fig. 5; Jd). Because of the igneous nature of these rocks, they have no palaeontological potential, and are not considered further here.

The Beaufort Group, underlain conformably by the predominantly deep-water mudrocks of the Ecca Group, is characterized as a fluvial succession comprising upward-fining sequences of mudrock and sandstones, the latter mostly representing channel fills (see Hancox & Rubidge, 2001 for overview). The Beaufort Group (see Fig. 4) is divided into two subgroups, viz. the Upper Permian, Adelaide Subgroup and the overlying Lower to Mid-Triassic, Tarkastad Subgroup (yellow-green - Trb, Trk in Fig. 5).

The area targeted for development is underlain by rocks of the **Tarkastad Subgroup** (Trk) (Fig. 5, outline). The Tarkastad Subgroup, which only crops out to the east of 24°E in the main Karoo Basin, consists of two clearly distinguishable formations: the lower predominantly arenaceous (sandy) Katberg Formation (Trk), and the overlying, predominantly argillaceous (shaly) Burgersdorp Formation (Trb) (S.A.C.S., 1980; Johnson, 1984), as indicated in the 1:250 000 geological map of the region (Fig.5), and more clearly, in the 1998 Explanation of the 1:500 000 general hydrogeological map of the Queenstown area (Smart, 1998). The study area is underlain by rocks of the **Burgersdorp Formation**. This assessment has been confirmed by Dr E.M. Bordy (Geology Department, Rhodes University, Grahamstown; pers. comm.) who has worked extensively in the area (Fig. 7; Bordy *et al.*, 2010a,b).

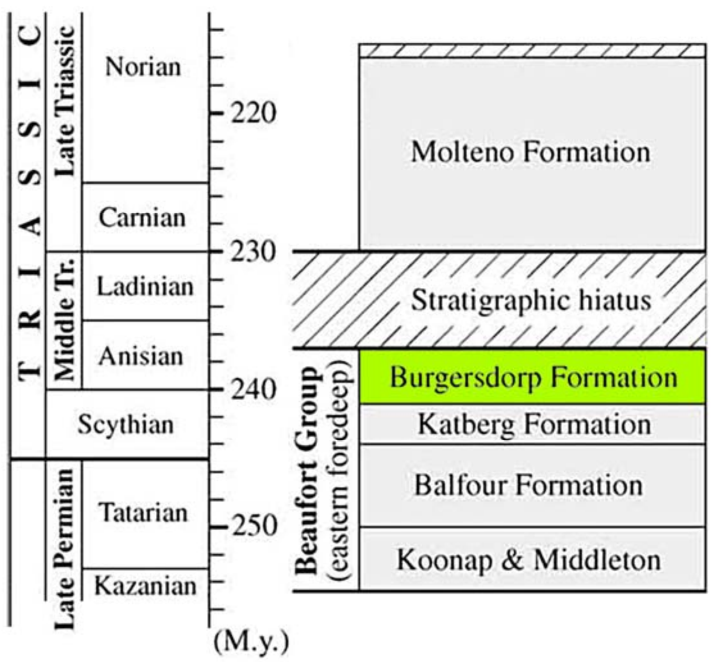

FIG. 4. Major lithostratigraphic subdivisions (Upper Permian to lower Upper Triassic) of the Karoo Supergroup, Main Karoo Basin of South Africa (adapted from Cataneanu *et al.*, 2005).

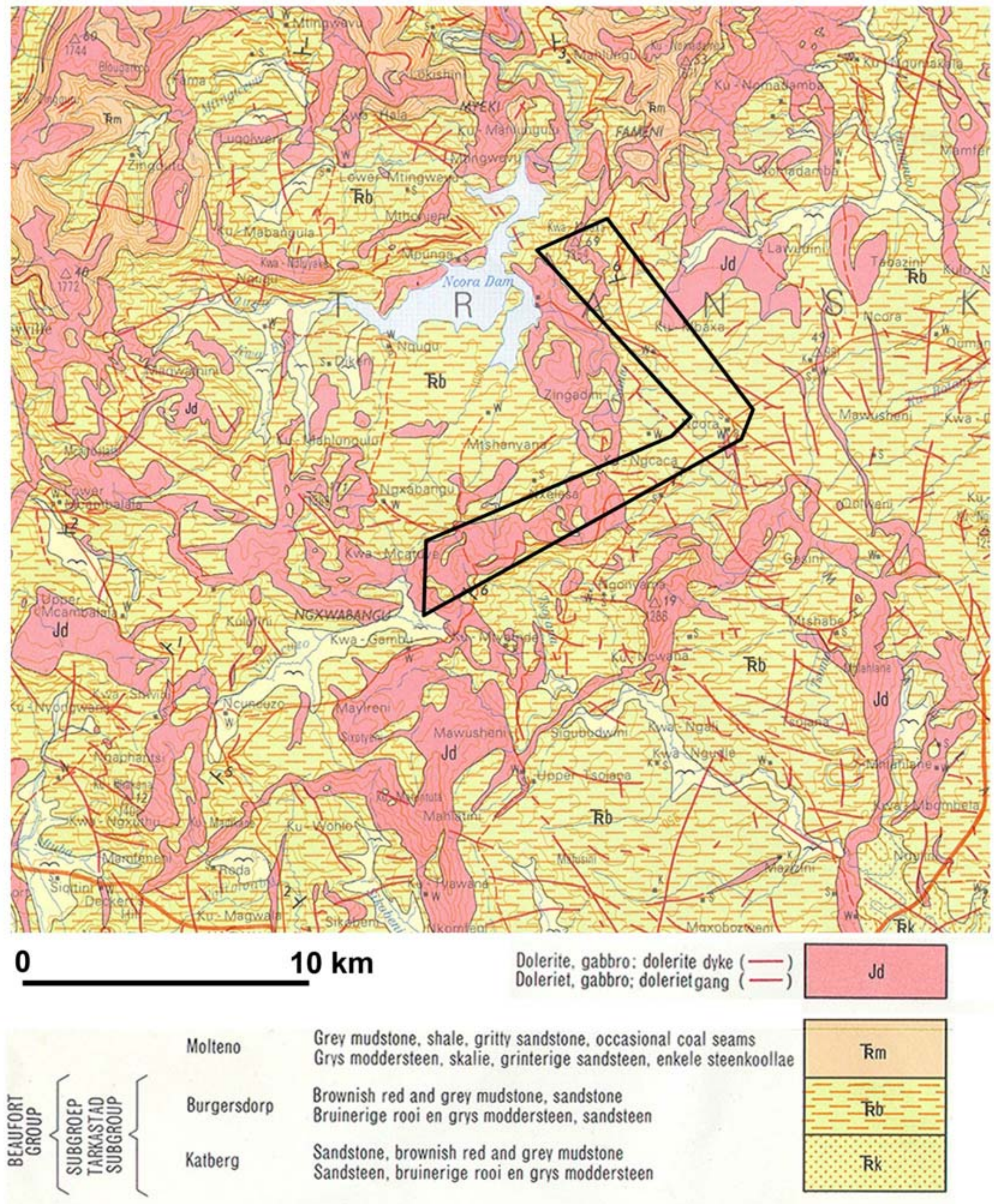

FIG. 5. Regional geology, as mapped in the vicinity of the Ncora Dam.

(extract from the 1:250 000 geological map, 3126 Queenstown; compiled by M.R. A. Marsh, N. Coleman and D. Robertson. 1979; Council for Geoscience, Pretoria)

The upper boundary of the Katberg Formation conformably grades into the Burgersdorp Formation. This transition zone is about 100 m thick, and lies within the uppermost *Lystrosaurus* Assemblage Zone (Neveling, 2004). The lower boundary of the Burgersdorp Formation is arbitrarily defined as the horizon where sandstone:mudstone ratio drops to less than 1:1 (Johnson, 1984). The Burgersdorp Formation therefore constitutes the relatively mudstone-rich upper part of the Tarkastad Subgroup, comprising alternating layers of fine-grained, greenish-grey sandstone and grayish-red mudstone. Sandstone and mudstone sequences generally form upward fining cycles ranging in thickness from a few metres, to tens of metres, the average being around 10 to 20 m (Johnson, 1984). The Burgersdorp Formation is in the region of 600 m thick in the Queenstown area. Lateral extent of most sandstones is in the region of a few hundred meters to a few kilometers before pinching out (Johnson, 1984). The lower boundaries are generally sharp, and rest on scoured surfaces displaying variable degrees of relief. Upper boundaries are always gradational. Average sandstone can be characterized as being moderately sorted, fine grained and lithic (Johnson, 1984). Sandstone generally makes up 20 to 30 per cent of the formation, and is most abundant towards the base and the top.

The Burgersdorp Formation was deposited in a fluvial environment, the sandstones representing channel deposits, and the mudstones overbank floodplain deposits. The high mudstone:sandstone ratio suggests meandering rather than braided stream deposits.

The Beaufort Group as a whole contains few mappable lithological markers and these are diachronous, so biostratigraphic criteria are used to refine further subdivision of the group. The biozones employed are based on the vertebrate fossil remains that are so abundant in these rocks (e.g. Fig. 7). In South Africa there has been a long tradition of vertebrate faunal studies and their biostratigraphic utilization in the Beaufort Group (Broom, 1906; Keyser & Smith 1977-78; Rubidge, 1995; Hancox & Rubidge, 2001; Cataneaunu *et al.*, 2005).

Palaeontological Heritage

The Beaufort Group is internationally recognised as a succession of great palaeontological value. These rocks provide a continuous and abundant record of terrestrial life over a time-span ranging from the Middle Permian to the Middle Triassic, documenting important evolutionary events such as the transition from reptiles to mammals (e.g. Hancox & Rubidge, 2001; McCarthy and Rubidge, 2005), and reflecting the major biotic turmoil associated with the most dramatic extinction event in Earth's history – the Permian/Triassic extinction. This latter event occurred some 251 million years ago, and is marked in the fossil record by a massive turnover of plant and animal species (eg. Erwin 1994; Looy et al., 2001; Smith & Ward, 2001; McCarthy & Rubidge, 2005; Gastaldo *et al.*, 2005; Smith & Botha, 2005).

The Burgersdorp Formation is host to a diverse fossil fauna, widely acknowledged as being one of the most complete terrestrial records of the post-Permian Triassic recovery of animal life in Gondwana. Aside from the fascinating zoological and evolutionary implications of the Beaufort Group fossils, the profuse and continuous fossil record available to palaeontologists has provided them with an opportunity to develop an effective biostratigraphic framework, based primarily on the temporal distributions of therapsids, and allowing for subdivision of the Group into assemblage zones (SACS, 1980; Kitching, 1995; Hancox & Rubidge, 2001; Rubidge, 2005). The base of the Burgersdorp Formation falls within the *Lystrosaurus* AZ, and the upper two thirds falls within the *Cynognathus* Assemblage Zone.

A literature review encompassing all the palaeontological and biostratigraphic research conducted on the Beaufort Group is beyond the scope of this report. However, tetrapod faunas are dominated in terms of diversity and abundance by **therapsids** (so-called 'mammal-like reptiles'), while **temnospondyls** (amphibians) are also abundant. Other animal fossils include a variety of **fish** (Kitching, 1995; Bender & Hancox, 2004), **trace fossils** and **freshwater molluscs** (*Unio karrooensis,* Kitching, 1995).

In the Queenstown area in particular, the therapsids *Lystrosaurus* and *Thrinaxodon* are common in the lower parts of the Burgersdorp Formation, and within the Cynognathus Assemblage Zone the therapsid herbivores *Kannemeyeria*, *Diademedon* and *Bauria cynops* have been found, as well as the carnivorous *Cynognathus* and the large crocodile-like amphibian *Erythrosuchus* (Johnson, 1984).

Typically, vertebrate fossils of the *Cynognathus* AZ are not abundant, and occur mainly as dispersed and isolated specimens in mudrocks and are commonly associated with calcareous concretions. They may also be found in fine to medium-grained sandstone lenses, and fragmentary specimens may be locally concentrated in bone-beds in mudrock or at the base of lenticular sandstones (Kitching, 1963, 1995).

Important **plant fossils** are known from the Burgersdorp Formation, recording the first established flora following the Permian-Triassic mass extinction. Collections of this material are lodged at Iziko Museum in Cape Town, and at the Bernard Price Institute, University of the Witwatersrand. The floras that have been documented are of low diversity and the fossils are in most cases sparse and widely scattered on the bedding planes of yellow, buff to light olive-grey, fine to medium feldspathic, cross-bedded sandstones (Brown, 1859-1920 (unpub. diaries); Du Toit, 1927; Anderson & Anderson, 1983, 1985, 1989; Gastaldo *et al.*, 2005).

Thirteen genera have been recorded including the lycopsid *Gregicaulis*, sphenopsid *Calamites,* ferns *Asterotheca* and *Cladophlebis,* peltasperms *Lepidopteris*, corystosperm *Dicroidium*, conifer *Sewardistrobus* as well as the ginkgophytes *Ginkgoites* and *Sphenobaiera*, and cycads *Pseudoctenis* and *Nilssoniopteris*. The latter two represent the earliest occurring cycads on record in Gondwana (Anderson & Anderson, 1985; Grauvogel-Stamm & Ash, 2005). Leaves are generally preserved as impressions, stems as casts and moulds. Fossilised wood is rare, but has been found in the past (*Agathoxylon, Podocarpoxylon*; Bamford, 2004). Historically, the two most productive localities (in terms of floral diversity and size of collections) are in the Aliwal North and Lady Frere districts (Anderson & Anderson, 1985; Gastaldo *et al*., 2005). Localities closest to the Ncora site are at Lady Frere and Glen Grey (Fig. 6).

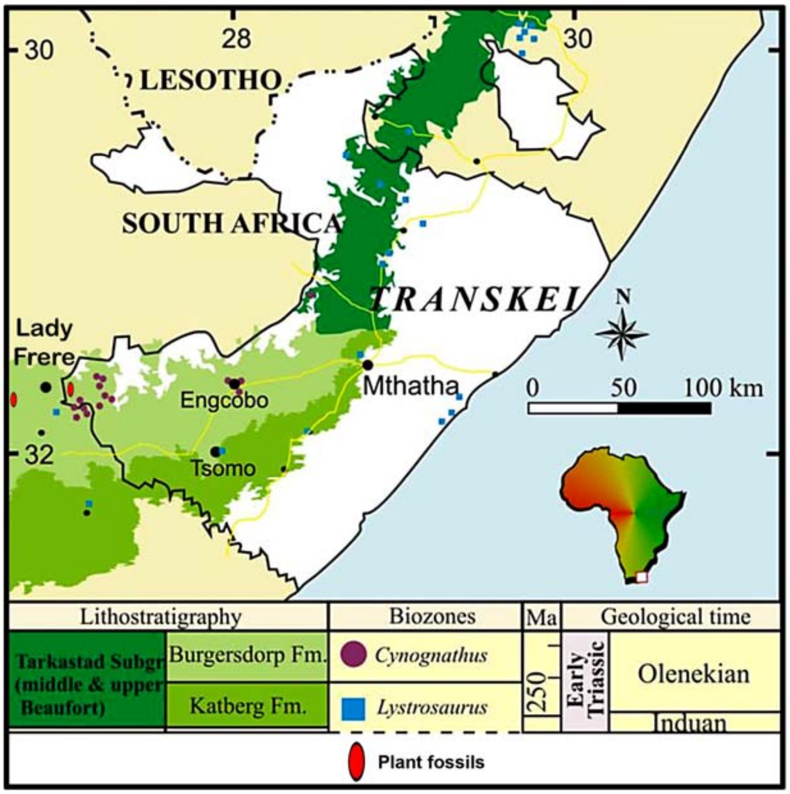

FIG. 6. Recorded occurrences in the eastern parts of the Eastern Cape of index fossils *Lystrosaurus* and *Cynognathus* (used in the subdivision of the Tarkastad Subgroup), and two plant fossil localities [Graphic created by Bordy (2010a); reproduced here with permission and minor modification; data generated from literature and museum catalogues].

FIELD EXAMINATION OF DEVELOPMENT SITE

The proposed Ncora Renewable Energy Facility, involves the construction of up to 18 wind turbines and 4 photovoltaic arrays at various sites within a reverse L-shaped area to the east, south-east and south of the Ncora Dam.

The rolling highlands are well vegetated with heavily grazed grassland and some forest areas on the steeper escarpments. Generally, there is little in the way of rock exposure, although in some cases the more severe of the abundant erosion gullies in the area exposed bedrock. The single available day for fieldwork did not allow for the examination of all exposures within the large area of study (in particular the abundant erosion gullies so typical of the area due to widespread overgrazing). Instead, a broader survey was conducted, targeting larger exposures.

The most informative outcrops in the north-eastern limb of the site (Figs 9-13) took the form of road cuttings (locales 1, 2, Figs 9, 10a), large erosion gullies (locale 1, 2, Figs 10b, 11a-c, 12, 13a-c), and shale quarries mined for road surfacing material (locale 1, Figs 10b, 11d-e). Road cuttings in locale 1, in the north-eastern part of the site contained a higher proportion of sandstone, perhaps reflecting proximity to the upper boundary of the formation (Fig. 9). In this part of the site, the erosion-resistant sandstones as well as dolerites contribute to the formation of highland topography.

Investigation of the bedrock in these locations, yielded little fossil material, including a few possible surface traces on ripple-marked sandstone (Fig.12c,d), and abundant root fossils and rhizoconcretions in red mudrocks (Figs 12b, 13c) which appear to be mostly palaeosols in overbank floodplain settings - an ideal lithology for the preservation of fossil bone, although not for diagnostic plant fossil material.

The most palaeontologically interesting deposits were encountered in the central part of the site, at locale 3, at the juncture between the two limbs, and where the road crosses the Tsomo River (Figs 8, 13d-f, 14). In this area, there is extensive exposure of typical Burgersdorp Formation mudrock, both along the banks of the Tsomo River, and the road cuttings to the east of the river crossing. Here sphenopsid stems, roots, and two small bone fragments were found. The bones were postcranial fragments a few cm in length (Fig 14). Both the vertebrate remains and plants were too fragmentary to be diagnostic and were left *in situ*.

The south-western limb of the site is dominated by highlands resulting from the presence of densely concentrated, abundant dolerite sills and dykes (Figs 8, 14). Dolerite tends to be more resistant to erosion than the host rocks of the Burgersdorp Formation (mostly mudrocks) and has therefore been the primary factor in shaping the hilly topography of the region. This is in contrast to the north-eastern limb, where thicker sandstone deposits also apparently contribute to the topography. The planned excavations for the wind turbines, which would be positioned specifically on the hills for maximum exposure to prevailing winds, will probably only intersect doleritic bedrock in the SW limb, and would therefore require no mitigation in terms of potential palaeontological heritage.

FIG. 7. North-eastern limb of the site for the proposed Ncora Dam Renewable Energy Facility: best exposures of the potentially fossiliferous sandstones and red mudrocks of the Burgersdorp Formation were found in locales 1 and 2, along road cuttings and within erosion gullies.

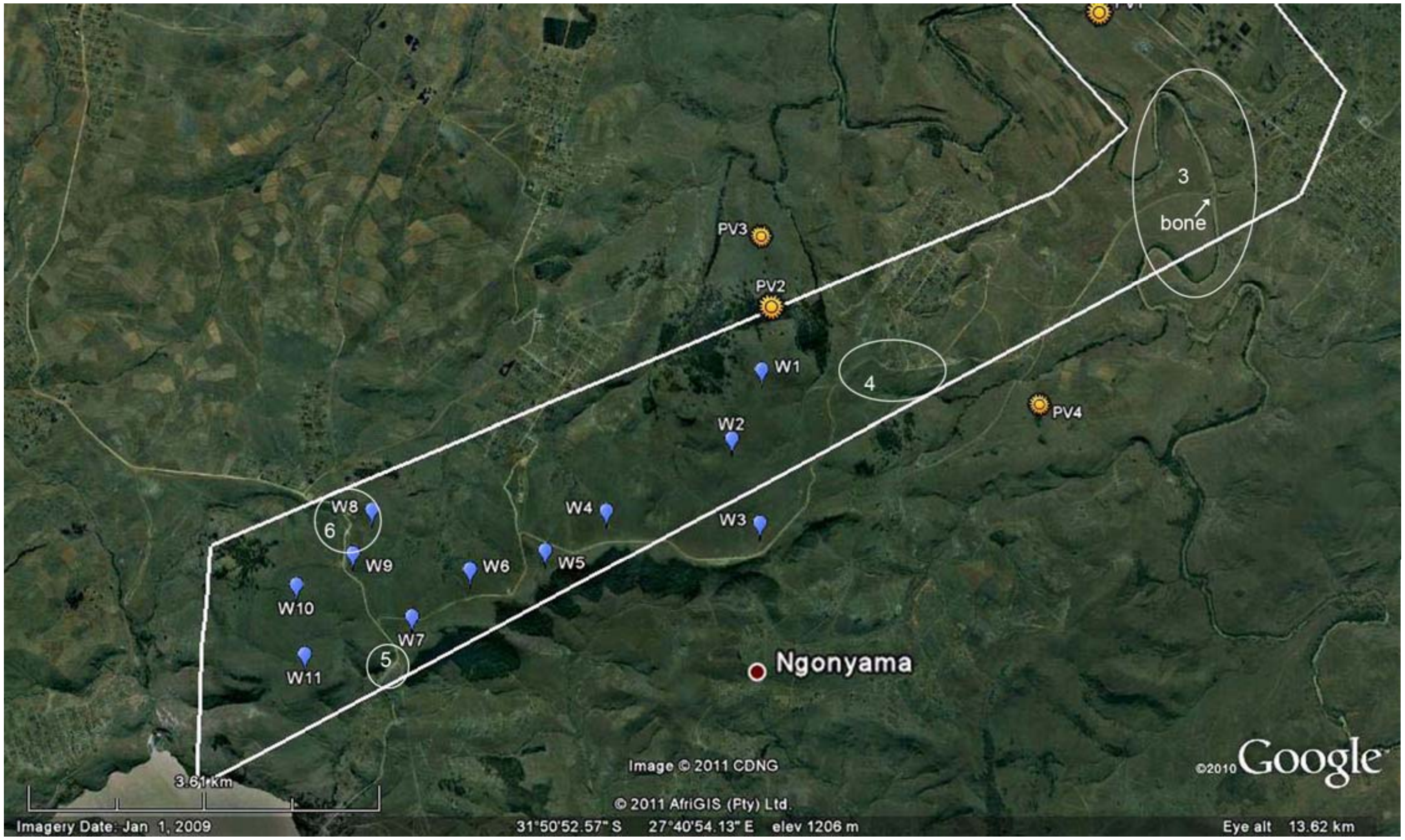

FIG. 8. South-western limb of the site of the proposed Ncora Dam Renewable Energy Facility: most of the exposures observed towards the south-west were dolerite.

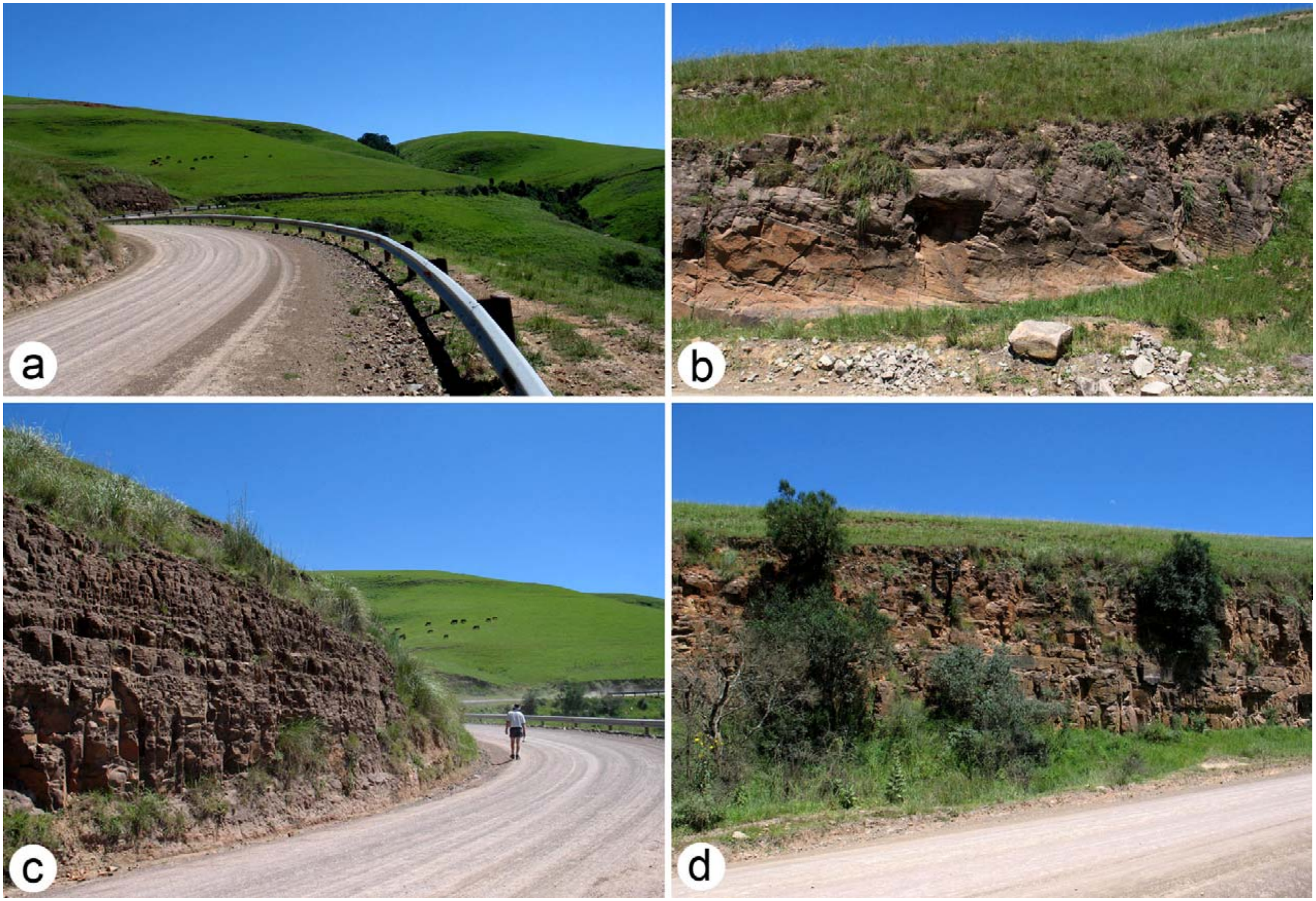

FIG. 9. North-eastern reaches of the proposed site for the Ncora Renewable Energy Facility: road cuttings with a relatively high proportion of sand and siltstone – uppermost portion of the Burgersdorp Formation.

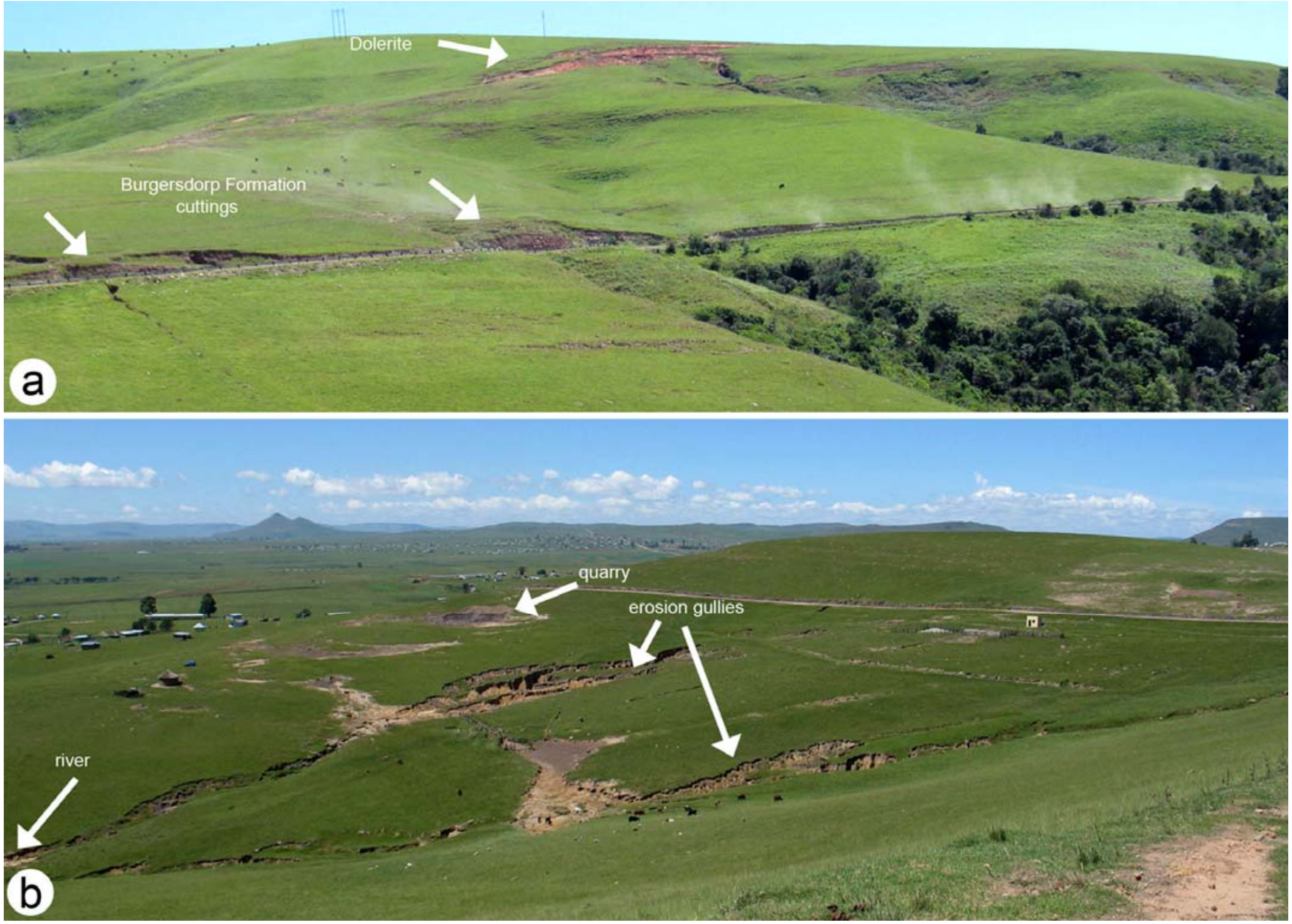

FIG. 10. North-eastern reaches of the proposed site for the Ncora Renewable Energy Facility: (a) view to the north-west, showing dolerite caps on the highland areas, and Burgersdorp Formation outcrops along the road; (b) view to the south-east, showing a road quarry, typical erosion gullies, and the position of the stream bed figured below.

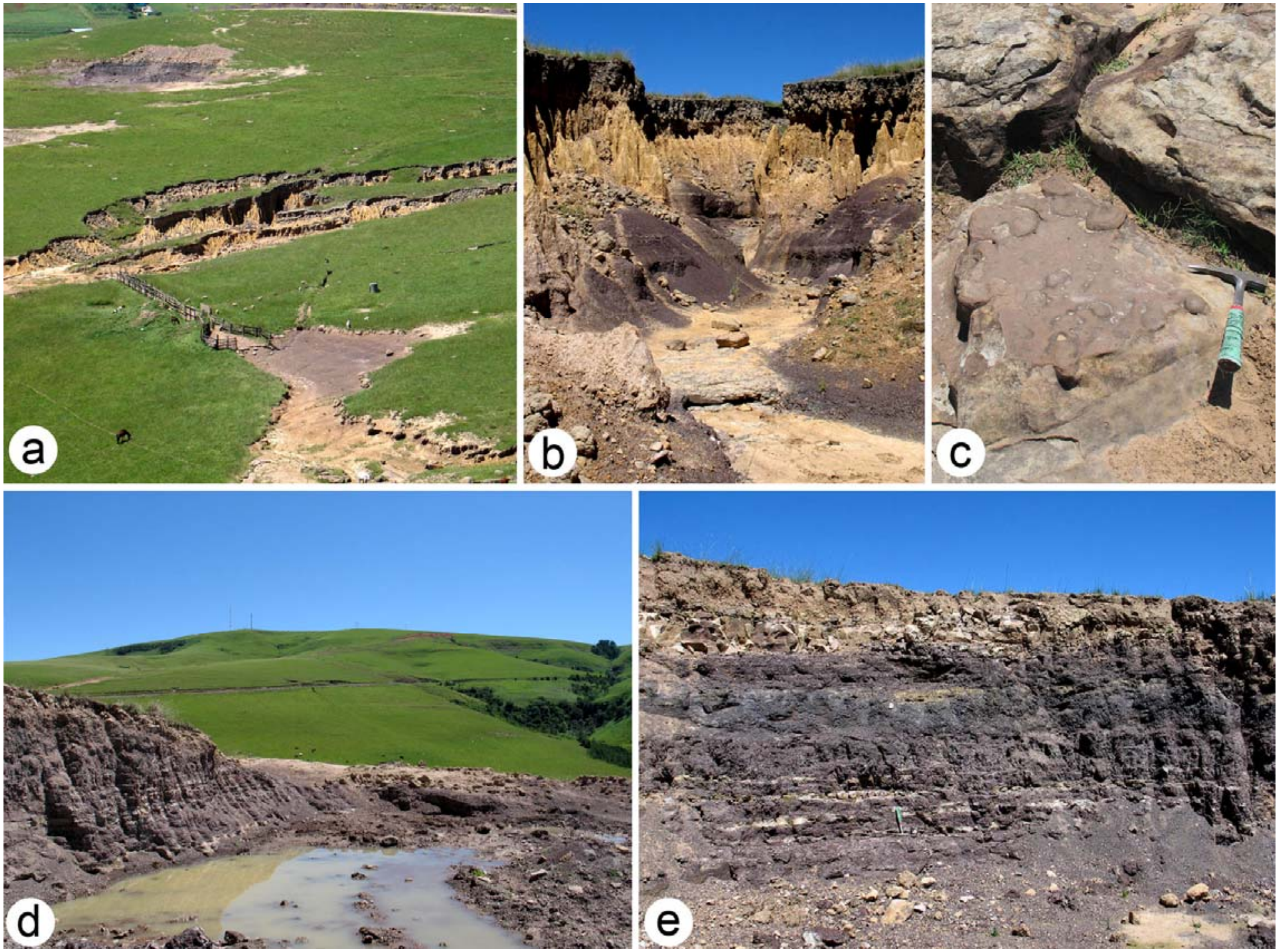

FIG. 11. North-eastern reaches of the proposed site for the Ncora Renewable Energy Facility: road quarry (a, d, e) and erosion gully exposing typical reddish/maroon Burgersdorp Formation bedrock (a, b); (c) sandstone with nodules.

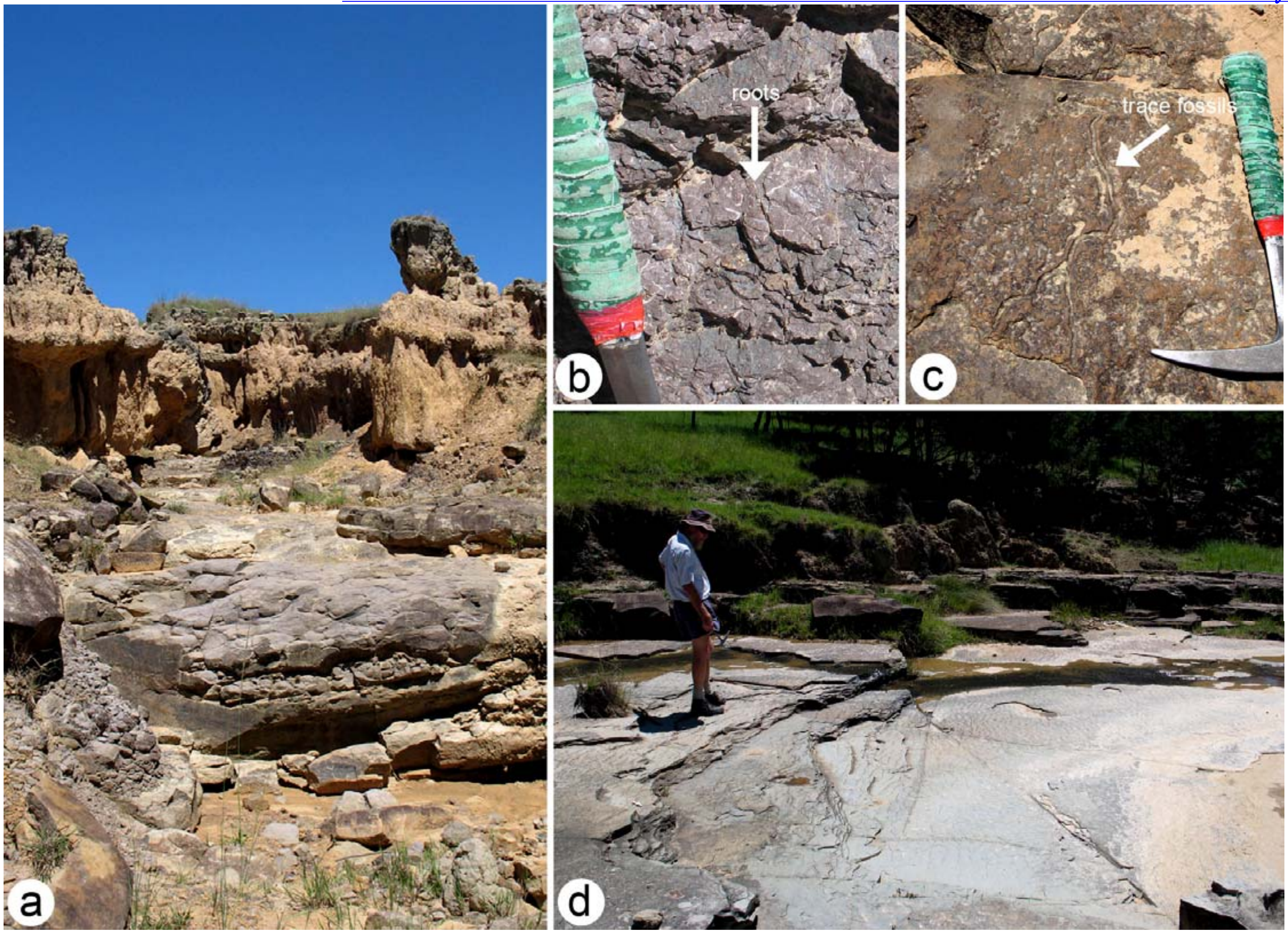

FIG. 12. North-eastern reaches of the proposed site for the Ncora Renewable Energy Facility: (a) sandstone exposures and (b) fossil roots in erosion gully (in previous figure); (c) sinusoidal trace fossils in sandstone and sandstones with ripplemarks exposed in a stream bed downstream from erosion gullies in previous figure.

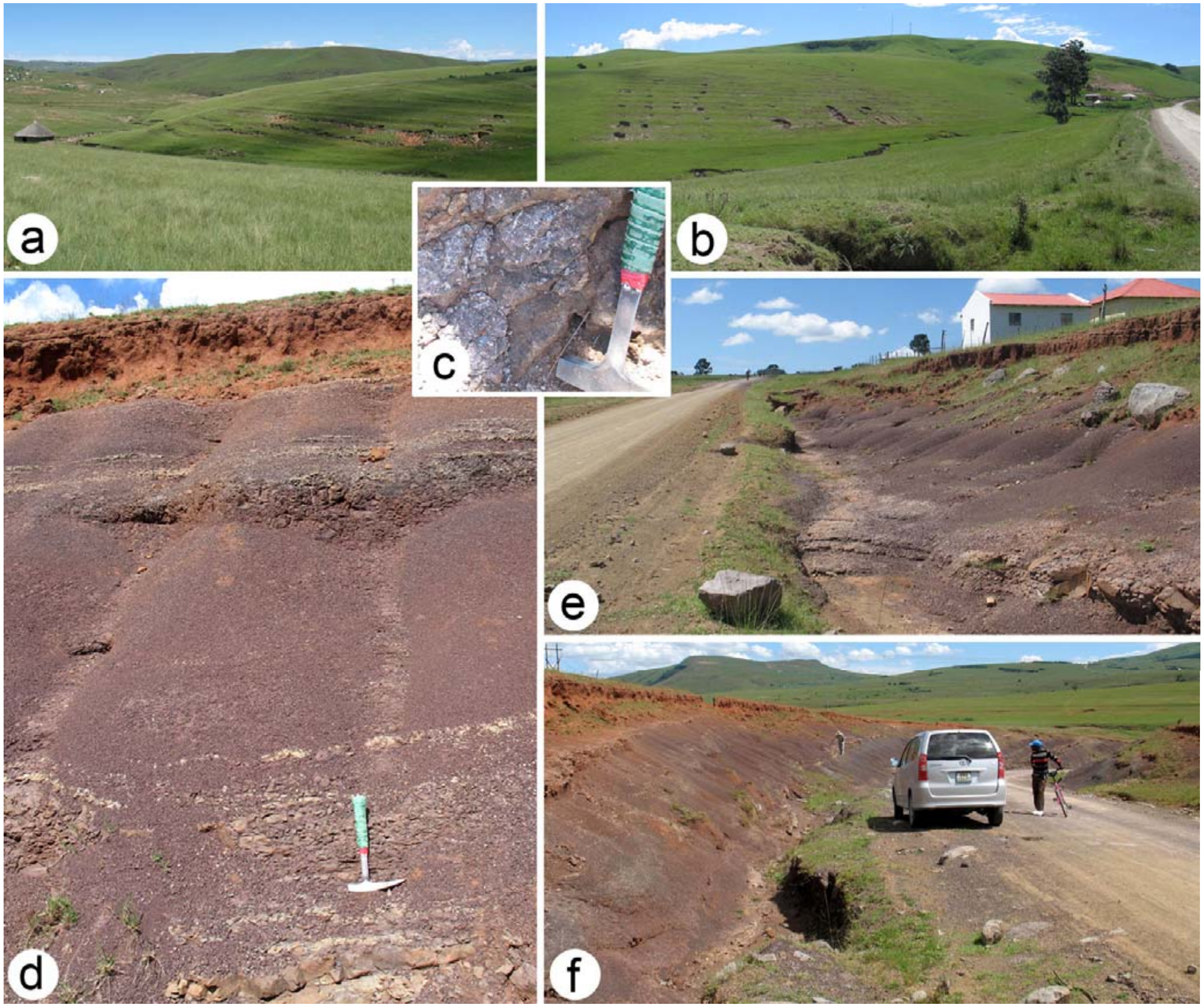

FIG. 13. North-eastern reaches of the proposed site for the Ncora Renewable Energy Facility: (a) and (b) – erosion gullies at locale 2; (c) fossil roots in erosion gully; (d-f) red/maroon outcrops of the Burgersdorp Formation in road cuttings near the Tsomo River crossing at locale 3.

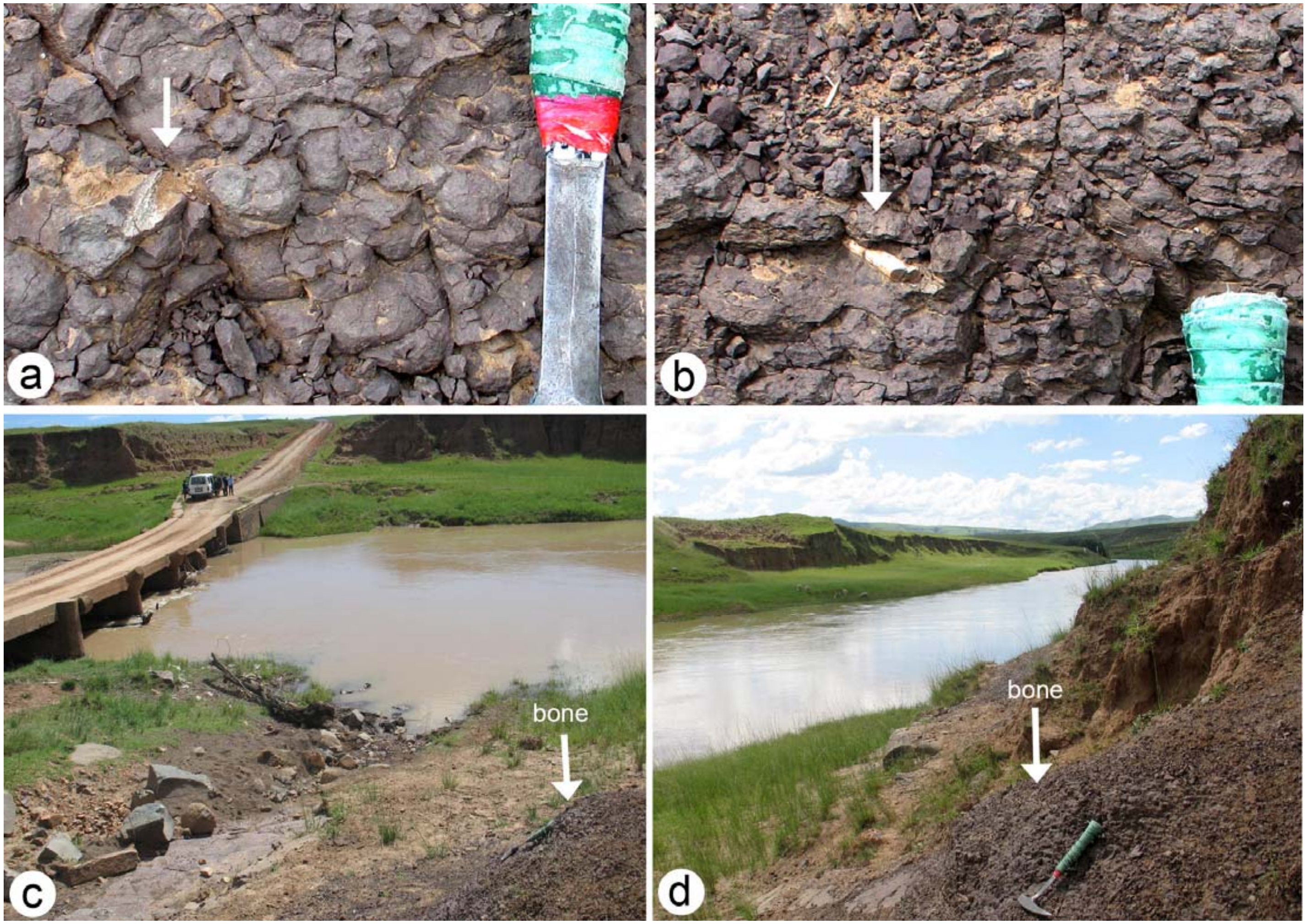

FIG. 14. South-eastern corner of the proposed site for the Ncora Renewable Energy Facility: (a) and (b) small, undiagnostic tetrapod bone fragments; (c-d) location of bone, in the road cutting/river bank on the eastern side of the bridge crossing the Tsomo river at locale 3; Burgersdorp Fm rock exposures along the Tsomo River are extensive and have great palaeontological potential.

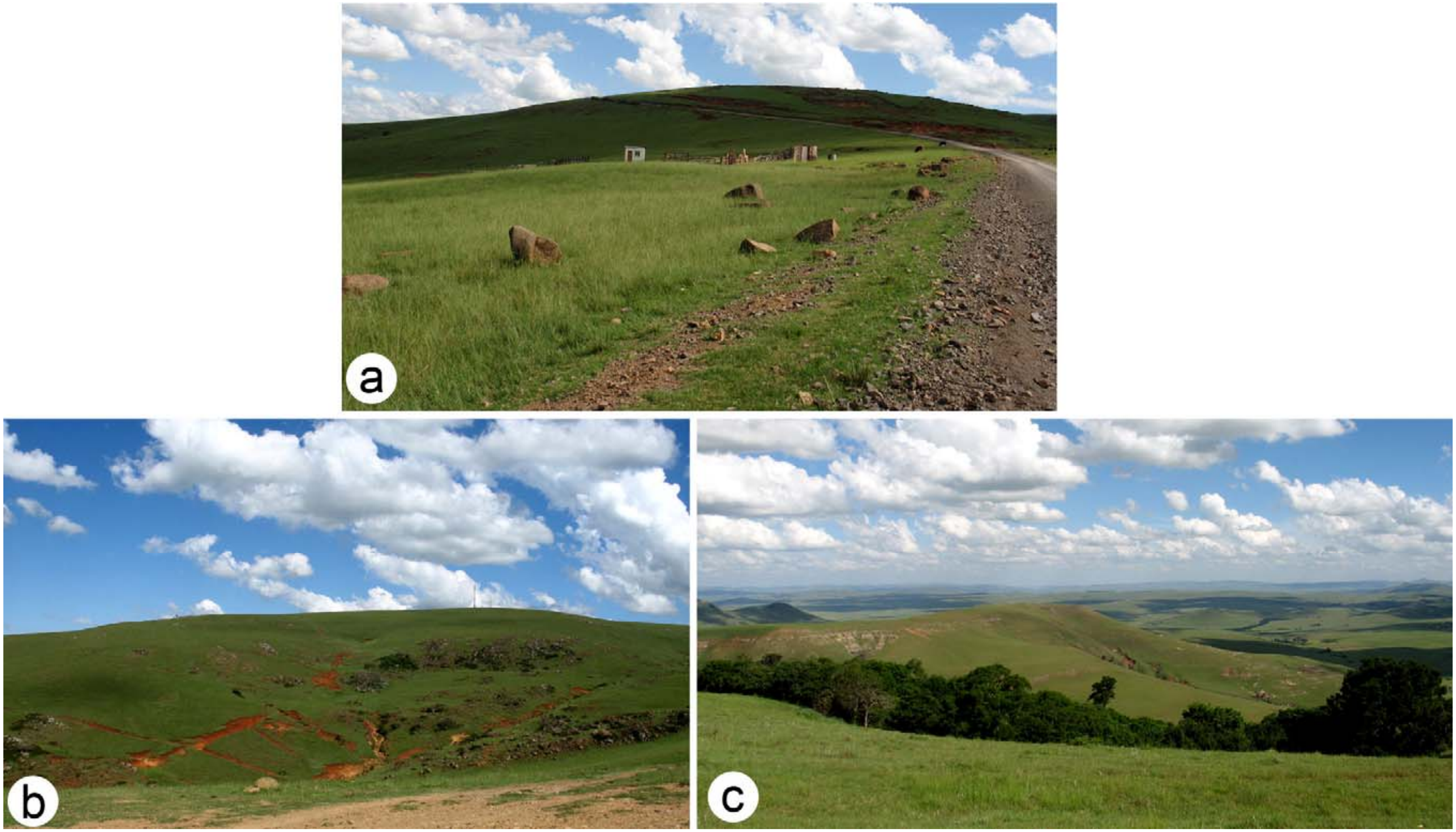

FIG. 15. South-western limb of the proposed site for the Ncora Renewable Energy Facility: (a) Rolling grassy highlands – almost all hills with dolerite caps, although as seen in (c), Burgersdorp Formation sandstones and mudrocks also crop out on the slopes.

PREDICTED IMPACT OF PROPOSED DEVELOPMENT

The proposed development, involving the installation of wind turbines, photovoltaic arrays and infrastructure including roads and buildings, has the potential to impact directly on fossil heritage, as construction will inevitably require excavation of bedrock (Tables 1, 2). However, depending on the effectiveness of the management plan set in place, this could have a positive impact palaeontologically.

The region is highly weathered, and rock exposures are few and of poor quality, making exploration for fossils labour intensive and low yield. If excavations of fresh bedrock are adequately monitored during the course of the proposed development, then any fossil discovery made in the process could be seen as facilitating a significant scientific advancement.

The 1:250 000 geological map of the region (Fig. 5) and field investigations of the development site indicate that much of the highland area is underlain by dolerite, a rock type resistant to erosion and therefore commonly responsible for the creation of elevated areas in the topography of the region. This rock type is devoid of fossil potential, and therefore any excavations into dolerite do not require monitoring or mitigation in terms of palaeontological heritage. However, some hills in the region may also be attributed to the presence of erosion-resistant sandstones of the Burgersdorp Formation. These are interbedded with mud- and siltstones that do have potential to yield fossils.

Since planned construction of individual turbines is restricted to highland areas, there is little chance of these activities exposing the potentially fossiliferous sandstones and mudrocks of the Burgersdorp Formation (particularly wind turbines in the south-western part of the site), but the construction of access roads and building foundations may well result in the excavation of palaeontologically significant bedrock, particularly near the Tsomo River.

Table 1: Palaeontological significance of geological units present on site

GEOLOGICAL UNIT				ROCK TYPE AND AGE	FOSSIL HERITAGE	VERTEBRATE BIOZONE	PALAEON-TOLOGICAL SENSITIVIY	RECOMMENDED MITIGATION
	DRAKENSBERG GROUP			dolerite dykes and sills (igneous intrusives)	none	none	**NIL**	none
KAROO SUPERGROUP	BEAUFORT GROUP	Tarkastad Subgroup	**Burgersdorp Formation**	predominantly argillaceous MIDDLE TRIASSIC (Olenekian to Anisian)		*Cynognathus* AZ *Lystrosaurus* AZ	**High sensitivity**	regular monitoring of any excavations into bedrock; in the event of fossils being encountered, excavation should cease until a palaeontologist can assess, extract and document the find
			Katberg Formation	medium to coarse-grained sandstone dominated EARLY TRIASSIC (Induan, Scythian Stage)		*Lystrosaurus* AZ		N/A

Table 2: Significance rating table as per CES template (see PIA Appendix I for definitions)

SIGNIFICANCE RATING							
Rock Unit	**Temporal Scale** (duration of impact)	**Spatial Scale** (area in which impact will have an effect)	**Degree of confidence** (confidence with which one has predicted the significance of an impact)	**Impact severity** (severity of negative impacts, or how beneficial positive impacts would be)		**Overall Significance** (The combination of all the other criteria as an overall significance)	
				with mitigation	**without mitigation**	**with mitigation**	**without mitigation**
Burgersdorp Formation	permanent	international	possible	beneficial	very severe	beneficial	high negative

Explanation: There is a **possibility** that fossils could be encountered during excavation of non-doleritic bedrock within the development footprint, although these fossils are apparently rare. These fossils would be of **international significance**. If effective mitigation measures were in place at the time of exposure, and they were successfully excavated for study, this would represent a **beneficial** impact. Alternatively, if fossil specimens were destroyed in the absence of adequate monitoring during construction activities, this would represent a **permanent, very severe, highly negative** impact on South Africa's palaeontological heritage.

That said, the possibility of encountering fossils in the region is fairly low in any small, localized region. Within the Burgersdorp Formation in this region, there is no way of assessing the likelihood of encountering fossils during excavation. As evidenced in other areas with exposures of Burgersdorp Formation rocks, fossils may be apparently absent or very scarce over large areas, or it is possible to encounter locally dense accumulations.

To summarize, fossils within the Ncora site could be characterized as **rare, but highly significant**, and any damage to, or loss of, these fossils due to inadequate mitigation would be a **highly negative palaeontological impact.** However, exposure and subsequent reporting of fossils (that would otherwise have remained undiscovered) to a qualified palaeontologist for excavation, could be seen as a **beneficial palaeontological impact**.

RECOMMENDATIONS/ MITIGATION

It should be emphasised that palaeontological impact of a development can be divided into two types – (1) destruction or disturbance of fossils already exposed on the surface (prior exposure through natural weathering processes or through previous excavations); (2) exposure and/or damage of subsurface fossils due to excavation into fresh bedrock.

When the potential exists for new fossils to be exposed through excavations, it is the responsibility of the on-site Environmental Control Officer (ECO) to monitor excavation activities and report the occurrence of any fossiliferous material to SAHRA and an appropriate palaeontological expert, to allow the material to be thoroughly assessed, recorded and professionally excavated or sampled.

It should also be noted that it is not just the actual bone/plant material/shell etc. itself that is of interest and importance to a palaeontologist. Increasingly, scientists appreciate the value of information evident in the immediate vicinity of fossils that is not necessarily inherent to the fossil itself, such as the geology of the host rock stratum, the orientation of individual fossil organs, organism associations, preservational aspects etc. These types of information can provide important clues about past environments, and can help to place fossils within their original context. These types of information can be lost through indiscriminate sampling by untrained personnel.

Additionally, fossil extraction can be a delicate process, employing great skill and experience, and it is not always easy to determine the physical extent of an individual specimen. During excavation, when any contact is made with underlying bedrock, the responsible ECO must regularly inspect the freshly exposed rock for fossil evidence. Any finds must be reported to SAHRA and the Albany Museum, Grahamstown, so that they can be inspected by a qualified palaeontologist at the earliest opportunity and, if necessary, be adequately sampled or removed for curation and study. If feasible, the exposed fossil material should be photographed (with a scale), covered over with loose sediment (or otherwise protected from the elements), and the site carefully recorded (GPS reading/ 1:50 000 map/aerial photograph). ***The responsible ECO should immediately report the find to SAHRA and/or an appropriately qualified palaeontologist.***

Once detailed plans elucidating precise positions of the turbines and associated infrastructure have been finalized, it will save the developers much time and effort were they to establish, during the initial geotechnical study of the construction phase, whether the excavations will intersect dolerite or sedimentary successions. If sedimentary rocks underlie the localized developmental footprint, then the responsible ECO must regularly monitor the excavations for the presence of fossils. If the footprint is underlain by dolerite, no monitoring would be required for palaeontological mitigation purposes.

CONCLUSIONS

The Burgersdorp Formation is known internationally as the source of important and diverse fossil animals and plants. Although these fossils are fairly rare in the study area, they have the potential to improve our understanding of the life and geology of a critical time in Earth's history. The site earmarked for development near Ncora Dam has accordingly been assigned a **palaeontological sensitivity rating of high** (Tables 1 and 2).

Many of the highland areas earmarked for wind turbine construction appear to be underlain by unfossiliferous dolerite intrusions, and would not require any monitoring during construction. However, many of the hillsides, as well as the low-lying regions (particularly near the Tsomo River) are underlain by Burgersdorp Formation sandstones and shales, which potentially harbour fossils. Any excavations into bedrock of the Burgersdorp Formation will require careful and regular monitoring by the ECO, for the presence of fossils. A geologist should be consulted prior to commencement of construction, to assess the nature of the underlying bedrock.

Developments in the Eastern Cape could make a significant contribution to the science through the excavation into underlying bedrock that would otherwise have remained covered by vegetation and soil – **provided that adequate monitoring and reporting procedures are adopted during excavation.**

If any fossils are exposed during construction, the Environmental Control Officer must be notified. The ECO should also make regular surveys of the excavation site so that any exposed fossils can be appropriately protected, and the discovery reported to a local palaeontologist for removal.

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QUALIFICATIONS & EXPERIENCE OF THE AUTHOR

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Declaration of Independence

I, Rosemary Prevec, declare that I am an independent specialist consultant and have no financial, personal or other interest in the proposed development, nor the developers or any of their subsidiaries, apart from fair remuneration for work performed in the delivery of palaeontological heritage assessment services. There are no circumstances that compromise the objectivity of my performing such work.

Dr Rosemary Prevec
Palaeontologist

PIA APPENDIX I: EXPLANATION OF RISK AND SIGNIFICANCE RATINGS
(Compiled by CES)

Table A1: Criteria used to rate the significance of an impact

Significance Rating Table	
Temporal Scale (The duration of the impact)	
Short term	Less than 5 years (Many construction phase impacts are of a short duration).
Medium term	Between 5 and 20 years.
Long term	Between 20 and 40 years (From a human perspective almost permanent).
Permanent	Over 40 years or resulting in a permanent and lasting change that will always be there.
Spatial Scale (The area in which any impact will have an affect)	
Individual	Impacts affect an individual.
Localised	Impacts affect a small area of a few hectares in extent. Often only a portion of the project area.
Project Level	Impacts affect the entire project area.
Surrounding Areas	Impacts that affect the area surrounding the development
Municipal	Impacts affect either the Local Municipality, or any towns within them.
Regional	Impacts affect the wider district municipality or the province as a whole.
National	Impacts affect the entire country.
International/Global	Impacts affect other countries or have a global influence.
Degree of Confidence or Certainty (The confidence with which one has predicted the significance of an impact)	
Definite	More than 90% sure of a particular fact. Should have substantial supportive data.
Probable	Over 70% sure of a particular fact, or of the likelihood of that impact occurring.
Possible	Only over 40% sure of a particular fact, or of the likelihood of an impact occurring.
Unsure	Less than 40% sure of a particular fact, or of the likelihood of an impact occurring.

Table A2: The severity rating scale

Impact severity (The severity of negative impacts, or how beneficial positive impacts would be on a particular affected system or affected party)	
Very severe	**Very beneficial**
An irreversible and permanent change to the affected system(s) or parties which cannot be mitigated. For example the permanent loss of land.	A permanent and very substantial benefit to the affected system(s) or parties, with no real alternative to achieving this benefit. For example the vast improvement of sewage effluent quality.
Severe	**Beneficial**
Long term impacts on the affected system(s) or parties that could be mitigated. However, this mitigation would be difficult, expensive or time consuming, or some combination of these. For example, the clearing of forest vegetation.	A long term impact and substantial benefit to the affected system(s) or parties. Alternative ways of achieving this benefit would be difficult, expensive or time consuming, or some combination of these. For example an increase in the local economy.
Moderately severe	**Moderately beneficial**
Medium to long term impacts on the affected system(s) or parties, which could be mitigated. For example constructing the sewage treatment facility where there was vegetation with a low conservation value.	A medium to long term impact of real benefit to the affected system(s) or parties. Other ways of optimising the beneficial effects are equally difficult, expensive and time consuming (or some combination of these), as achieving them in this way. For example a 'slight' improvement in sewage effluent quality.
Slight	**Slightly beneficial**
Medium or short term impacts on the affected system(s) or parties. Mitigation is very easy, cheap, less time consuming or not necessary. For example a temporary fluctuation in the water table due to water abstraction.	A short to medium term impact and negligible benefit to the affected system(s) or parties. Other ways of optimising the beneficial effects are easier, cheaper and quicker, or some combination of these.
No effect	**Don't know/Can't know**
The system(s) or parties are not affected by the proposed development.	In certain cases it may not be possible to determine the severity of an impact.

Table A3: The rating of overall significance

Overall Significance (The combination of all the above criteria as an overall significance)	
VERY HIGH NEGATIVE	**VERY BENEFICIAL**
These impacts would be considered by society as constituting a major and usually permanent change to the (natural and/or social) environment, and usually result in **severe** or **very severe** effects, or **beneficial** or **very beneficial** effects. **Example:** The loss of a species would be viewed by informed society as being of VERY HIGH significance. **Example:** The establishment of a large amount of infrastructure in a rural area, which previously had very few services, would be regarded by the affected parties as resulting in benefits with VERY HIGH significance.	
HIGH NEGATIVE	**BENEFICIAL**
These impacts will usually result in long term effects on the social and/or natural environment. Impacts rated as HIGH will need to be considered by society as constituting an important and usually long term change to the (natural and/or social) environment. Society would probably view these impacts in a serious light. **Example:** The loss of a diverse vegetation type, which is fairly common elsewhere, would have a significance rating of HIGH over the long term, as the area could be rehabilitated. **Example:** The change to soil conditions will impact the natural system, and the impact on affected parties (such as people growing crops in the soil) would be HIGH.	
MODERATE NEGATIVE	**SOME BENEFITS**
These impacts will usually result in medium to long term effects on the social and/or natural environment. Impacts rated as MODERATE will need to be considered by society as constituting a fairly important and usually medium term change to the (natural and/or social) environment. These impacts are real but not substantial. **Example:** The loss of a sparse, open vegetation type of low diversity may be regarded as MODERATELY significant.	
LOW NEGATIVE	**FEW BENEFITS**
These impacts will usually result in medium to short term effects on the social and/or natural environment. Impacts rated as LOW will need to be considered by the public and/or the specialist as constituting a fairly unimportant and usually short term change to the (natural and/or social) environment. These impacts are not substantial and are likely to have little real effect. **Example:** The temporary change in the water table of a wetland habitat, as these systems is adapted to fluctuating water levels. **Example:** The increased earning potential of people employed as a result of a development would only result in benefits of LOW significance to people who live some distance away.	
NO SIGNIFICANCE	
There are no primary or secondary effects at all that are important to scientists or the public. **Example:** A change to the geology of a particular formation may be regarded as severe from a geological perspective, but is of NO significance in the overall context.	
DON'T KNOW	
In certain cases it may not be possible to determine the significance of an impact. For example, the primary or secondary impacts on the social or natural environment given the available information. **Example:** The effect of a particular development on people's psychological perspective of the environment.	