PALAEONTOLOGICAL SPECIALIST STUDY

In terms of Section 38(8) of the NHRA

Improvement of National Route R63 Sections 15 and 16 from Bisho (km 5.8) to the N6 Bridge Intersection (km 1.0), Amatole Municipality, Eastern Cape Province

Prepared by

John E. Almond PhD (Cantab.)

***Natura Viva* cc, CAPE TOWN**

and

CTS HERITAGE

In Association with

Terreco

April 2018

THE INDEPENDENT PERSON WHO COMPILED A SPECIALIST REPORT OR UNDERTOOK A SPECIALIST PROCESS

I, **Dr John Edward Almond**, as the appointed independent specialist hereby declare that I:

- act/ed as the independent specialist in this application;
- regard the information contained in this report as it relates to my specialist input/study to be true and correct, and
- do not have and will not have any financial interest in the undertaking of the activity, other than remuneration for work performed in terms of the NEMA, the Environmental Impact Assessment Regulations, 2010 and any specific environmental management Act;
- have and will not have no vested interest in the proposed activity proceeding;
- have disclosed, to the applicant, EAP and competent authority, any material information that have or may have the potential to influence the decision of the competent authority or the objectivity of any report, plan or document required in terms of the NEMA, the Environmental Impact Assessment Regulations, 2010 and any specific environmental management Act;
- am fully aware of and meet the responsibilities in terms of NEMA, the Environmental Impact Assessment Regulations, 2010 (specifically in terms of regulation 17 of GN No. R. 543) and any specific environmental management Act, and that failure to comply with these requirements may constitute and result in disqualification;
- have ensured that information containing all relevant facts in respect of the specialist input/study was distributed or made available to interested and affected parties and the public and that participation by interested and affected parties was facilitated in such a manner that all interested and affected parties were provided with a reasonable opportunity to participate and to provide comments on the specialist input/study;
- have ensured that the comments of all interested and affected parties on the specialist input/study were considered, recorded and submitted to the competent authority in respect of the application;
- have ensured that the names of all interested and affected parties that participated in terms of the specialist input/study were recorded in the register of interested and affected parties who participated in the public participation process;
- have provided the competent authority with access to all information at my disposal regarding the application, whether such information is favorable to the applicant or not; and
- am aware that a false declaration is an offence in terms of regulation 71 of GN No. R. 543.

John E. Almond

Dr John E. Almond
***Natura Viva* cc, CAPE TOWN**

Date
16 April 2018

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EXECUTIVE SUMMARY

The proposed road development involves the improvement of a 23.7 km-long sector of National Route R63 Sections 15 and 16 from Bisho (km 5.8) to the N6 Bridge Intersection (km 1.0) near Kei Road, situated in the Amathole Municipality, Eastern Cape Province (Fig. 1). The proposal involves the upgrading of the existing road, including five culverts and three bridges, and will also entail exploitation of road material from six proposed borrow pits and three quarries.

The R63 project area, including the associated borrow pit and quarry sites, is underlain by Late Permian fluvial sedimentary rocks of the Balfour Formation (Lower Beaufort Group, Karoo Supergroup) which are extensively intruded by Early Jurassic dolerite bodies of the Karoo Dolerite Suite. Bedrock exposure levels are generally very poor outside road cuttings, deeper erosion gullies, borrow pits and quarries. Both the sedimentary and igneous bedrocks in the study area are deeply weathered in this part of the Eastern Cape coastal interior, with several meters of near-surface saprolite (*in situ* weathered bedrock). For this reason, comparatively few vertebrate and petrified wood fossils or trace fossil assemblages have previously been recorded here. The only potential fossil material observed during the present 2-day palaeontological field survey comprises a few *possible* inclined sandstone vertebrate burrow casts that were noted in the BP16 study area. However, these equivocal structures show no diagnostic fossil burrow features (*e.g.* peripheral scratch marks) and they may well represent abiogenic load casts. No special conservation or mitigation measures are therefore proposed for this site.

The overall impact significance of the R63 (Sections 15 & 16) road project, including the associated quarry / borrow pits as well as the proposed culvert and bridge improvements, is evaluated as *very low* as far as palaeontology is concerned. Unless significant new fossil finds (*e.g.* well-preserved vertebrate remains, petrified wood) are made during the construction phase of the development, further specialist palaeontological studies or mitigation are not regarded as warranted for this project. The Environmental Control Officer (ECO) for the project should be alerted to the potential for, and scientific significance of, new fossil finds during the construction phase of the development. They should familiarise themselves with the sort of fossils concerned through museum displays (*e.g.* Amatole Museum, King William's Town, East London Museum) and accessible, well-illustrated literature (*e.g.* MacRae 1999).

Should important new fossil remains - such as vertebrate bones and teeth, petrified wood, plant-rich fossil lenses or dense fossil burrow assemblages - be exposed during construction, the responsible Environmental Control Officer should alert ECPHRA (*i.e.* The Eastern Cape Provincial Heritage Resources Authority. Contact details: Mr Sello Mokhanya, 74 Alexander Road, King Williams Town 5600; smokhanya@ecphra.org.za) as soon as possible. This is so that appropriate action can be taken in good time by a professional palaeontologist at the developer's expense. Palaeontological mitigation would normally involve the scientific recording and judicious sampling or collection of fossil material as well as of associated geological data (*e.g.* stratigraphy, sedimentology, taphonomy). The palaeontologist concerned with mitigation work will need a valid fossil collection permit from ECPHRA and any material collected would

have to be curated in an approved depository (*e.g.* museum or university collection). All palaeontological specialist work should conform to international best practice for palaeontological fieldwork and the study (*e.g.* data recording fossil collection and curation, final report) should adhere as far as possible to the minimum standards for Phase 2 palaeontological studies recently developed by SAHRA (2013). These recommendations are summarized in tabular form in Appendix 3 (Chance Fossil Finds Procedure) and should be incorporated into the Environmental Management Programme (EMPr) for the R63 (Section 15 & 16) road and quarry / borrow pit development.

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CONTENTS

1. INTRODUCTION

1.1 Background Information on Project

This application is for the improvement of National Route R63 Sections 15 and 16 from Bisho (km 5.8) to the N6 Bridge Intersection (km 1.0) near Kei Road, situated in the Amathole Municipality (previously Zwelitsha and King William's Town Magisterial Districts), Eastern Cape Province (Fig. 1). The project covers the last 22.7 km of Section 15 of National Route R63 *plus* the first kilometer of Section 16, *i.e.* a total length of 23.7 km. This section consists of a paved single carriageway rural highway. The proposal involves the upgrading of the existing road, including five culverts and three bridges, and will also entail exploitation of road material from six proposed borrow pits and three quarries (Figs. 2 to 4).

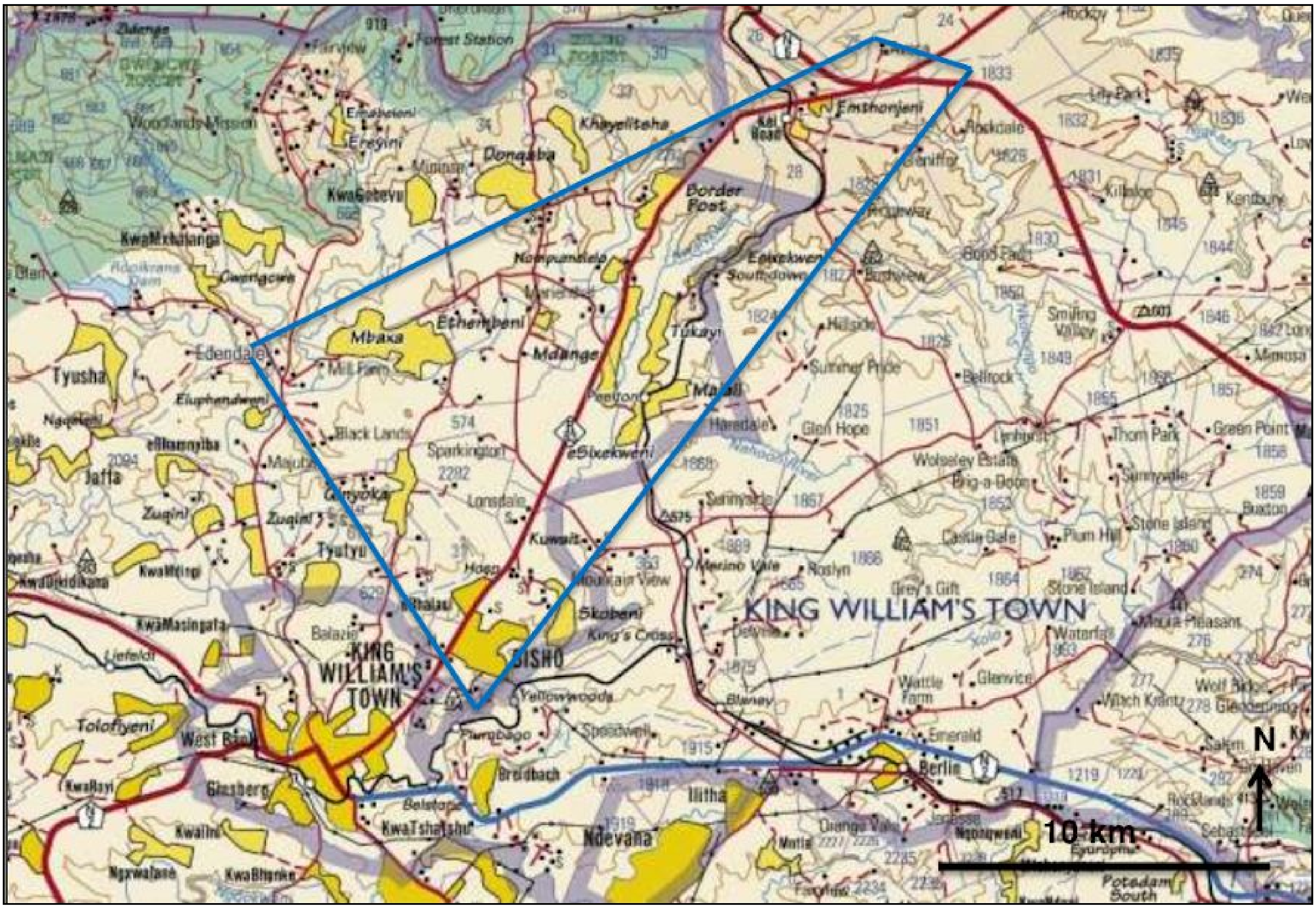

Figure 1: Extract from 1: 250 000 topographical sheet 3226 King William's Town (Courtesy of The Chief Directorate: National Geo-spatial Information, Mowbray) showing the location of the R63 Sections 15 & 16 road project *plus* associated borrow pit and quarry developments to the northeast of King William's Town, between Bisho and the N6 bridge intersection near Kei Road, Amathole Municipality, Eastern Cape Province (blue polygon).

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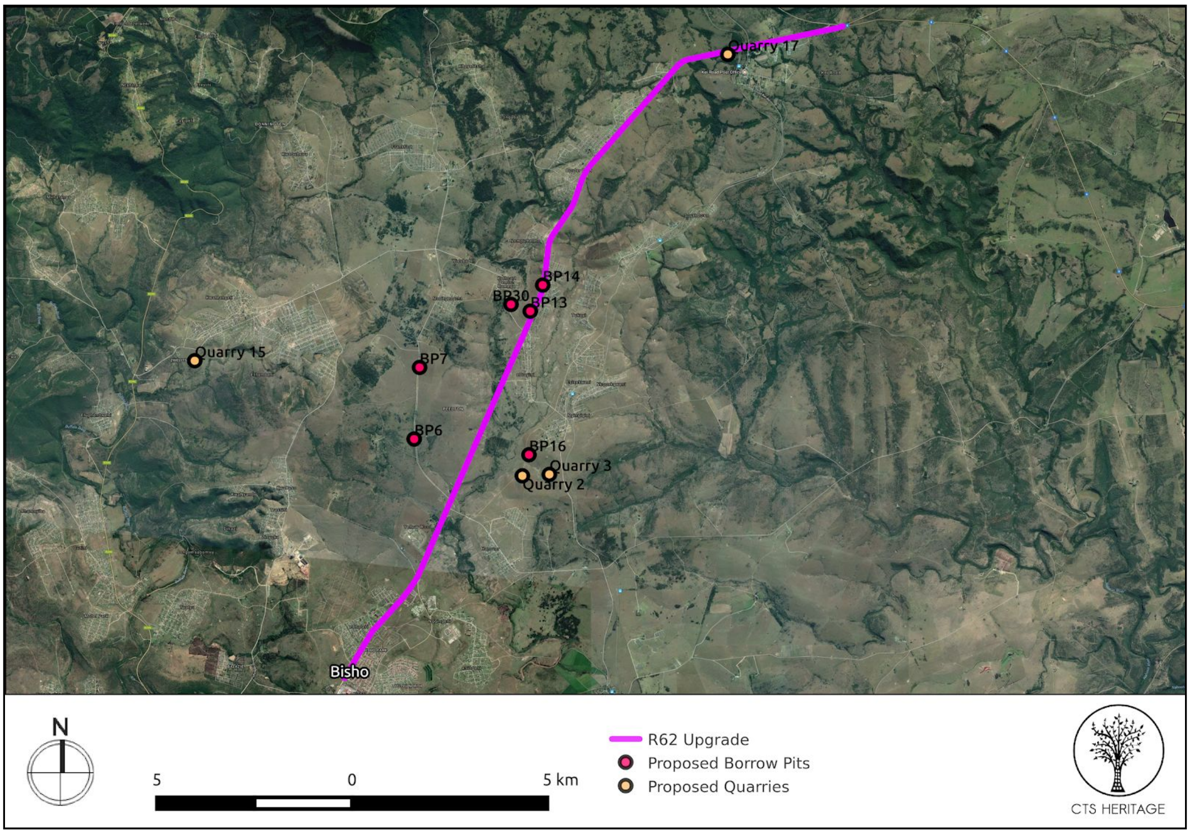

Figure 2: Google Earth© satellite image of the R63 Sections 15 & 16 study area between Bisho and the N6 bridge intersection (purple line) showing the four quarry sites (yellow dots) and six borrow pit sites (red dots). Please see following two figures for more detail.

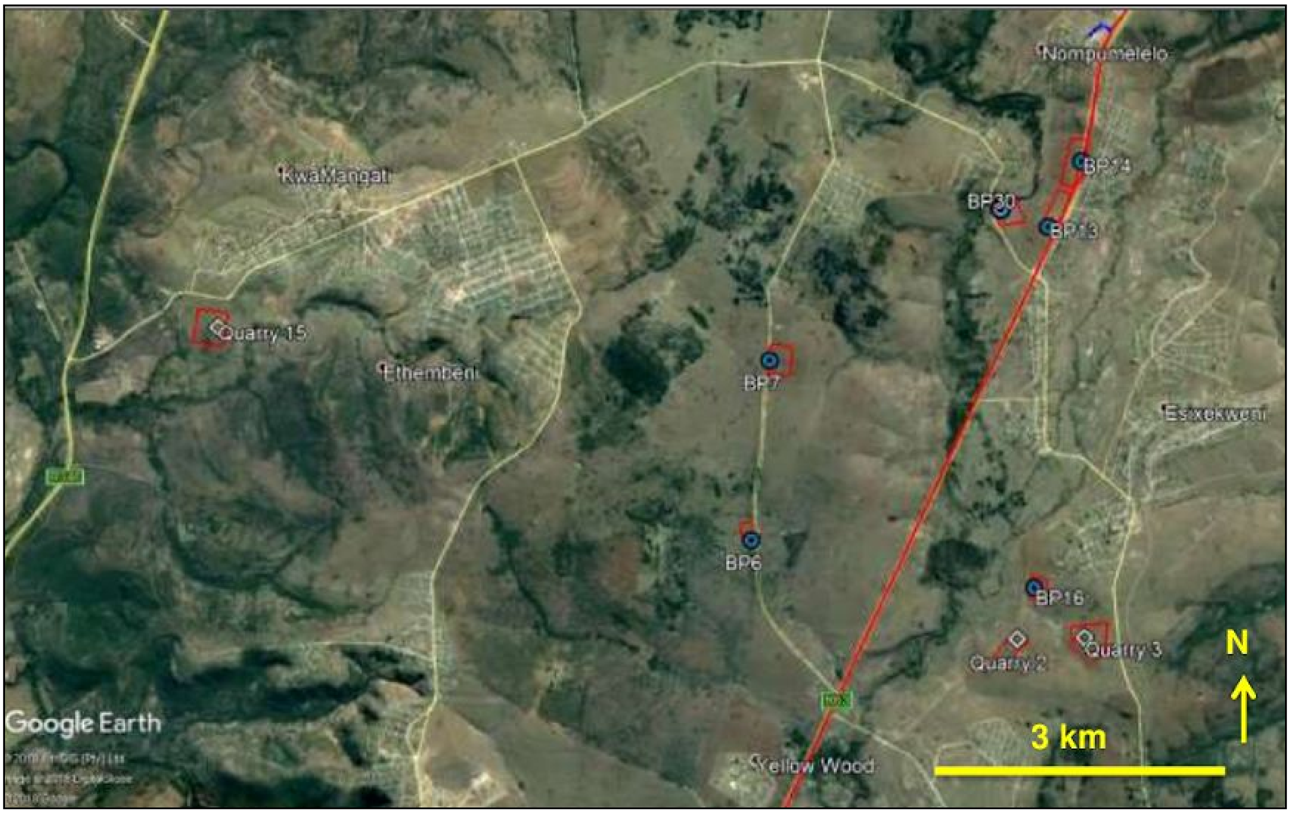

Figure 3: Google Earth© satellite image of the southern sector of the R63 study area showing the project areas for three of the four quarry sites (2,3 & 15) and all six borrow pit sites (6,7,13,14,16, 30).

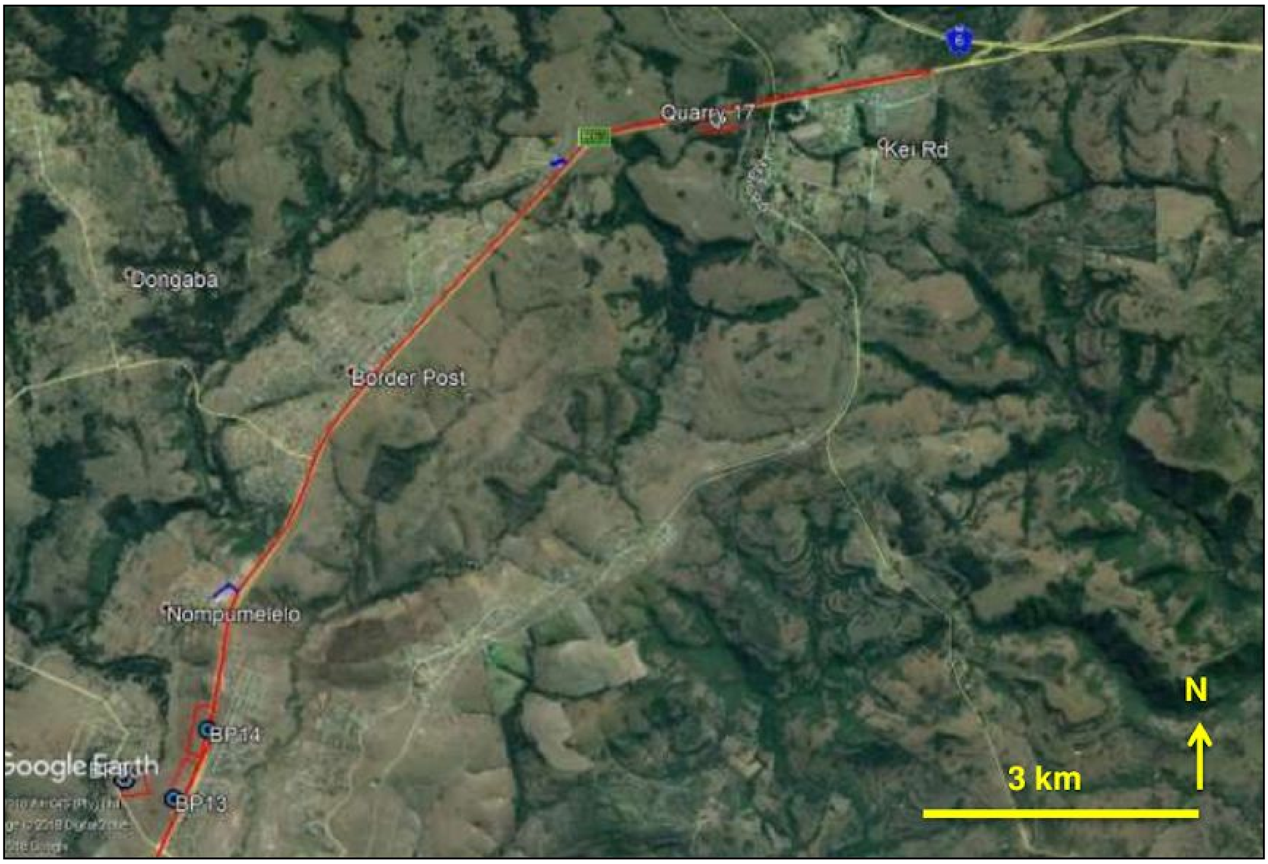

Figure 4: Google Earth© satellite image of the northern sector of the R63 study area showing the project areas for one of the four quarry sites (17) and two borrow pit sites (13,14).

2. METHODOLOGY

2.1 Purpose of Palaeontological Study

The R63 Sections 15 & 16 project area is underlain by potentially fossiliferous sediments of the Balfour Formation (Lower Beaufort Group, Karoo Supergroup). A palaeontological heritage assessment of the road project has been recommended in a recent Heritage Screener by CTS Heritage, Cape Town (CTS Heritage 2018). The purpose of this palaeontological heritage 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 palaeontological resources. It contributes to the broader environmental assessment for the road project being co-ordinated by Terreco Environmental cc, East London.

2.2 Study approach

This PIA report provides a record of the observed or inferred palaeontological heritage resources within the broader R63 road project study area. The identified resources have been assessed to evaluate their heritage significance in terms of the grading system outlined in Section 3 of the NHRA (Act 25 of 1999). Recommendations for specialist palaeontological mitigation are made where this is considered necessary. The report is based on (1) a review of the relevant scientific literature, including previous palaeontological impact assessments in the broader study region (*e.g.* Almond 2011a, 2011b, 2015a, 2015b, 2016, 2017a, 2017b, 2017c, Groenewald 2011, Durand 2014, Prevec 2014), (2) published geological maps and accompanying sheet explanations (*e.g.* Mountain 1974, Hill 1993), and (3) a palaeontological field

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study of the R63 project area between Bisho and Kei Road on 5-6 April, 2018. GPS locality data for numbered sites mentioned in the text are provided in Appendix 2.

3. GEOLOGICAL CONTEXT OF THE STUDY AREA

The R63 (Sections 15 & 16) road and quarry / borrow pit study area between Bisho and the N6 intersection near Kei Road is situated at elevations between *c.* 500 and 750 m amsl in dissected, hilly terrain located to the southeast of the main Amathole Mountain Escarpment and some 45 km inland from East London (Figs. 1 & 2). This region is characterised by relicts of the Post African 1 land surface of Early Miocene age according to Maud (2008) and is assigned to the East London Coastal Hinterland geomorphic province by Partridge *et al.* (2010). The area is drained to the south by various small tributaries of the Buffalo River such as the KwaNkwebu, Yellowwoods, iNcemertha and KwaGana Rivers. Levels of bedrock exposure in the region are generally very low, with the exception of a few road and railway cuttings, farm dams, stream and river banks, erosion gullies (*dongas*), quarries and borrow pits. The rolling uplands are grassy or transformed for agriculture while steeper slopes and valley sides are often wooded (Figs. 6 & 7).

The geology of the study area is outlined on 1: 250 000 geology sheet 3226 King William's Town (Fig. 5; Council for Geoscience, Pretoria). A very brief geological explanation for this sheet is printed on the map itself, and there is a separate report by Mountain (1974) on the geology of the East London area. The geological context for the broader study region between King William's Town and Komga has been covered in several previous palaeontological assessment reports by the author (*e.g.* Almond 2011b, 2015b, 2017a, 2017b, 2017c). The region is underlain by Late Permian continental sediments of the Balfour Formation (Lower Beaufort Group, Karoo Supergroup) that are locally intruded by major Early Jurassic dolerite sills and dykes of the Karoo Dolerite Suite. These bedrocks are mantled with a range of Late Caenozoic superficial deposits such as alluvium, colluvium (slope deposits), pedocretes and soils.

The fluvial **Balfour Formation** comprises recessive weathering, grey to greenish-grey overbank mudrocks with subordinate resistant-weathering, grey, fine-grained channel sandstones deposited by large meandering river systems in the Late Permian Period (Johnson *et al.* 2006). Thin wave-rippled sandstones were laid down in transient playa lakes on the flood plain. Reddish mudrocks are comparatively rare, but increase in abundance towards the top of the Adelaide Subgroup succession near the upper contact with the Katberg Formation. The base of the Balfour succession is defined by a sandstone-rich zone, some 50 m thick, known as the Oudeberg Member. Key recent reviews of the Balfour Formation fluvial succession have been given by Visser and Dukas (1979), Catuneanu and Elango (2001), Katemaunzanga (2009), Katemaunzanga & Gunter (2009) and Oghenekome (2012).

Exposure of the Lower Beaufort Group bedrocks – and especially the potentially fossiliferous mudrock facies - within the study area is very limited due to thick superficial sediment cover and grassy vegetation (Figs. 6 & 7). Bedrock exposure is mainly confined to the deeper parts of erosional gullies or *dongas*, river and stream banks, several borrow pits or quarries, road and railway cuttings and patchy exposures on steeper hillslopes. Balfour Formation exposures examined during the present field survey are very briefly described in the Appendix 2 with relevant GPS locality data. Road cuttings are generally strongly biased towards the resistant-weathering channel sandstone facies, with very poor representation of the more readily-weathered mudrocks that actually form the majority of the Balfour Formation succession. In general, the Balfour Formation bedrocks within the present study region are highly weathered with a thickness of several meters or more below the present land surface converted to crumbly *saprolite* (*in situ* weathered bedrock), characterised by secondarily structureless, khaki-hued overbank mudrocks and pale yellowish sandstone horizons (Figs. 10 to 16). Levels of tectonic deformation are generally low; the bedding is horizontal or gently-dipping, with only very local small-scale folding, faulting and brecciation (Fig. 17), sometimes associated with dolerite intrusion. Fresher grey-green mudrocks are usually tabular, may be thin – to thick-bedded or massive, with very occasional horizons of pebble- to cobble-sized pedogenic calcrete concretions; these last may be secondarily ferruginised and leached (Figs. 14 & 15). On closer inspection some of the grey-green "mudrock" beds are actually slurries of fine reworked angular mudrock clasts in a finer-grained matrix (Fig. 11). This "diamictite" facies may have been deposited during major flood events (with widespread reworking of consolidated mudrock banks upstream) or by gravity-driven debris flows. Sandstone units include thick, tabular-bedded channel bodies or thinner, tabular crevasse-splays (Obviously lenticular channel bodies were not seen). Channel bases are usually sharp, occasionally erosively gullied or even loaded, while sandstone bed tops often grade upwards into siltstone.

The Balfour Formation sediments between Bisho and Kei Road have been extensively intruded and baked by several major dolerite sills as well as smaller-scale dykes of the Early Jurassic (183 Ma) Karoo Dolerite Suite (Jd) (Duncan & Marsh 2006) (Fig. 5). Due to protracted tropical or subtropical weathering from Cretaceous times onwards, outcrop areas of dolerite in the study area are characterised by pervasive chemical weathering to form structureless, crumbly grey-green *sabunga*, locally traversed by veins or steep dykes of more chemically-resistant igneous lithologies (Figs. 18 to 24). Relict onionskin weathering lamination as well as corestones of fresher dolerite are common features in borrow pits and hillslopes overlying major sills (Fig. 8). The major dolerite intrusions have thermally metamorphosed (baked and recrystallised) the country rock for a considerable distance on either side of their edges, as seen with the channel sandstones thermally metamorphosed to conchoidally-fracturing pale yellow quartzite at the BP30 site, for example (Fig. 16). Good examples of *in situ* hornfels (baked mudrock) were not recorded, but bluish-green hornfels as well as quartzite stone artefacts are seen in the area (Loc. 052). Rafts or *xenoliths* of baked country rocks – such as slabs of resistant pale quartzite – embedded within weathered dolerite are also observed (Fig. 24).

Various types of **superficial deposits** of Late Caenozoic (Miocene / Pliocene to Recent) age occur widely throughout the Karoo study region (*e.g.* Holmes & Marker 1995, Cole *et al.* 2004, Partridge *et al.* 2006). They include pedocretes (*e.g.* calcretes, ferricretes), colluvial slope deposits (scree, hillwash), down-wasted surface gravels, river alluvium, wind-blown sands as well as spring and pan sediments. This mantle of superficial deposits obscures the Palaeozoic bedrock geology in most parts of the study area. Furthermore, deep chemical weathering in the Late Cretaceous to Tertiary interval has converted some of the near-surface bedrocks to *in situ* weathered saprolite. Useful geological overviews of talus deposits, alluvium and calcrete occurrences in a semi-arid Karoo region are given by Cole *et al.* (2004). Hillslopes incised by dendritic networks of erosion gullies or *dongas* usually expose thick (several meters) successions of sandy to muddy colluvial deposits of probable Pleistocene age that are provisionally assigned to the **Masotcheni Formation** (Partridge *et al.* 2006) (Fig. 25). The upper part of the colluvial succession may feature dense concentrations of irregular to rounded, pebble- to cobble-sized pale cream-coloured calcrete concretions while fine ferricrete glaebules are also a common feature (Fig. 26). Well-developed ferricrete hardpans composed of small, pea-sized glaebules are commonly developed directly overlying bedrock saprolite and may be associated with a distinct underlying pallid zone (Fig. 28). Thick, pale, subtly-bedded sandy alluvium with dispersed calcrete and ferricrete concretions is seen along the banks of the Yellowwoods River (Fig. 27). Occasional well-rounded, boulder-sized corestones of Balfour Formation sandstone (rather than the more usual dolerite) on hillcrests are relicts of protracted sphaeroidal weathering of major, well-jointed sandstone bodies in warm, humid climates (Fig. 31). Local soils vary from pale to dark brown, with locally developed orange-brown lateritic soils overlying weathered dolerite (Fig. 29). Gravelly to rubbly colluvial soils packed with angular to subrounded sandstone clasts are seen in several road cuttings (Fig. 30).

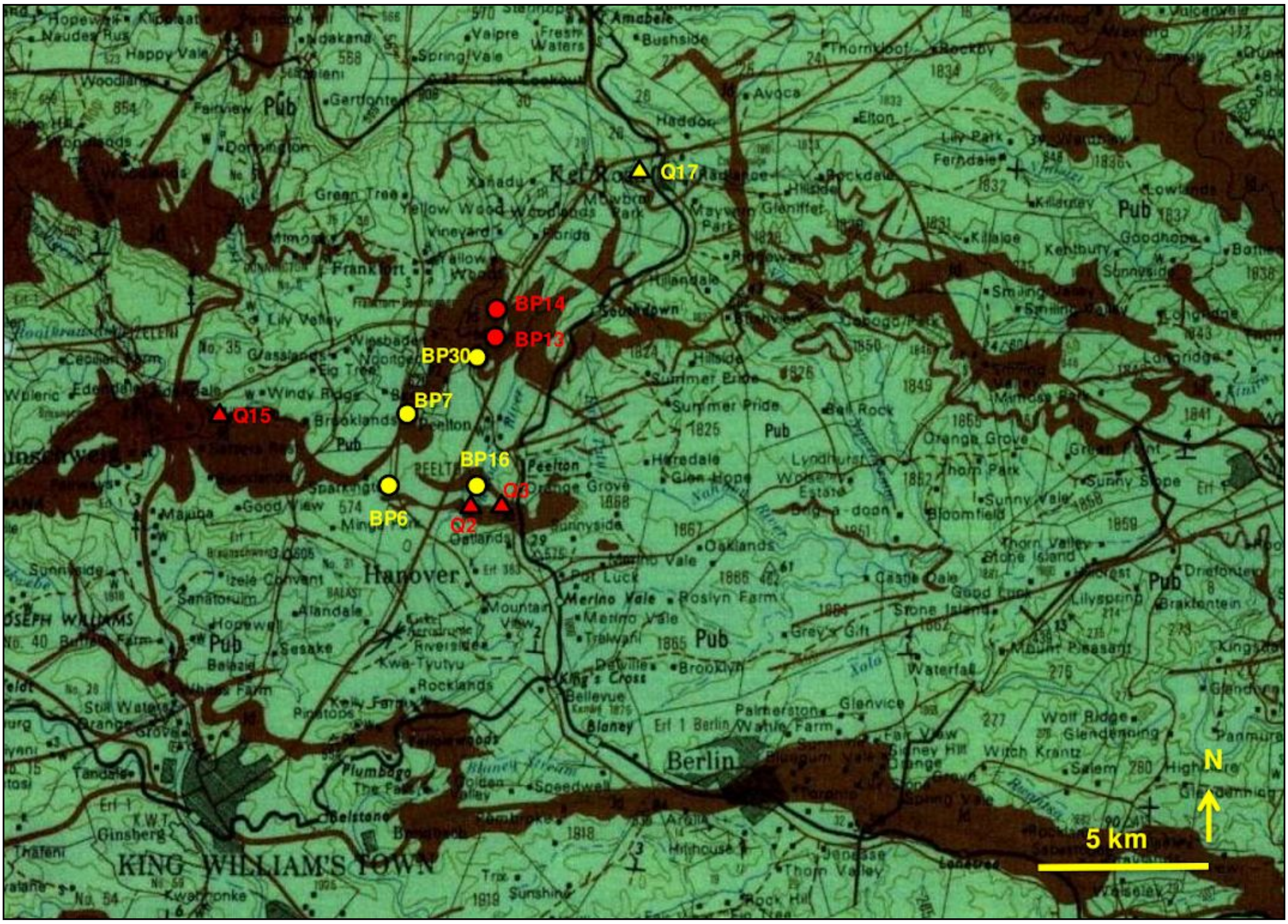

Figure 5: Extract from 1: 250 000 geological map sheet 3226 King William's Town (Council for Geoscience, Pretoria) showing the R63 road and quarry / borrow pit study areas northwest of King William's Town, between Bisho and the N6 intersection, Eastern Cape Province. The 4 quarry and 6 borrow pit study sites are *approximately* indicated by triangles and circles respectively (red = Karoo dolerite; yellow = Lower Beaufort Group sediments) (See also Table 1). KEY TO GEOLOGICAL UNITS: Dark brown (Jd) = Jurassic Karoo Dolerite Suite. Green (Pub) = Balfour Formation, Lower Beaufort Group (Adelaide Subgroup, Karoo Supergroup). Superficial deposits such as Quaternary alluvium, colluvium and soils are not mapped separately.

Figure 6: View westwards along the R63 due west of Kei Road showing the wooded KwaNkwebu River Valley in the foreground, a road cutting through Balfour Formation sandstones (Loc. 073) and the Amathole Mountains in the background.

Figure 7: View northwards along the flanks of a dolerite ridge just west of Mdange village, taken from BP14 study area. Major dolerite intrusions within the study area are far better exposed than the recessive weathering Balfour Formation country rocks.

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Figure 8: View southwards across an existing flooded dolerite quarry in the Q2 study area (Loc. 054). Note prominent-weathering, brownish-weathering dolerite corestones and bedrock exposures on the hillslopes in the background.

Figure 9: Gentle, grassy hillslopes in the Yellowwoods River Valley northeast of Bisho with extensive donga system incised into thick colluvium and soils in the foreground and Amathole Mountains on the skyline (Loc. 050).

Figure 10. Large borrow pit 600 m west of the R63 near Bisho (Loc. 042) showing thick (> 10 m) zone of khaki-hued saprolite – *i.e. in situ* weathered bedrocks (Balfour Formation sediments locally intruded by dolerite) - overlying fresher-looking, grey-green, tabular-bedded Balfour beds.

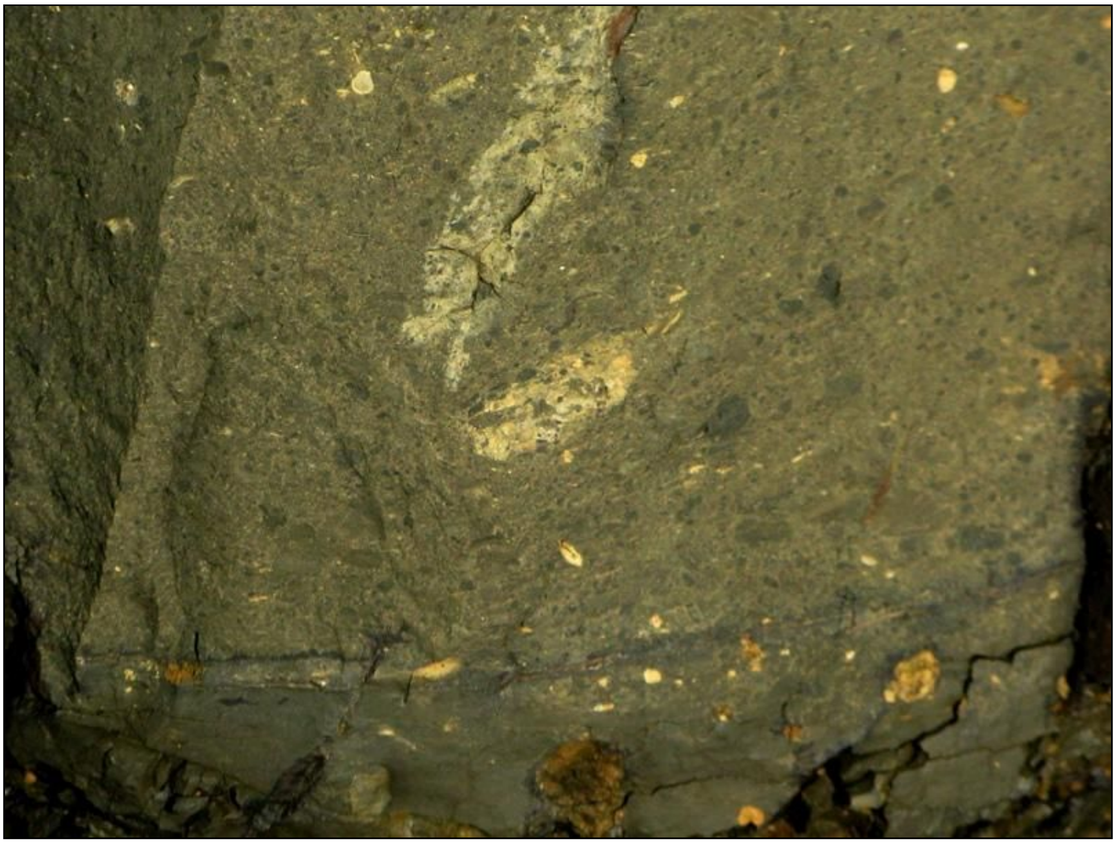

Figure 11. Close-up of dark grey-green bed (*c.* 30 cm thick) seen in foreground in preceding figure showing speckled appearance due to dispersed small (< 1 cm) angular mudflakes (slurry deposited by energetic flood or debris flow).

Figure 12. Borrow pit cut face exposing pale tabular-bedded sandstones and thinner-bedded, dark grey-green mudrocks of the Balfour Formation (BP16, Loc. 048).

Figure 13. R63 road cutting NE of Bisho exposing gently N-dipping, deeply-weathered Balfour Formation sandstones and crumbly mudrocks overlain by pale soils with large domical termitaria (Loc. 067).

Figure 14. Massive, hackly-weathering, grey-green overbank mudrocks of the Balfour Formation with sparse horizons of cobble-sized, ferruginised pedogenic calcrete concretions (arrowed) (Hammer = 30 cm) (Loc. 055).

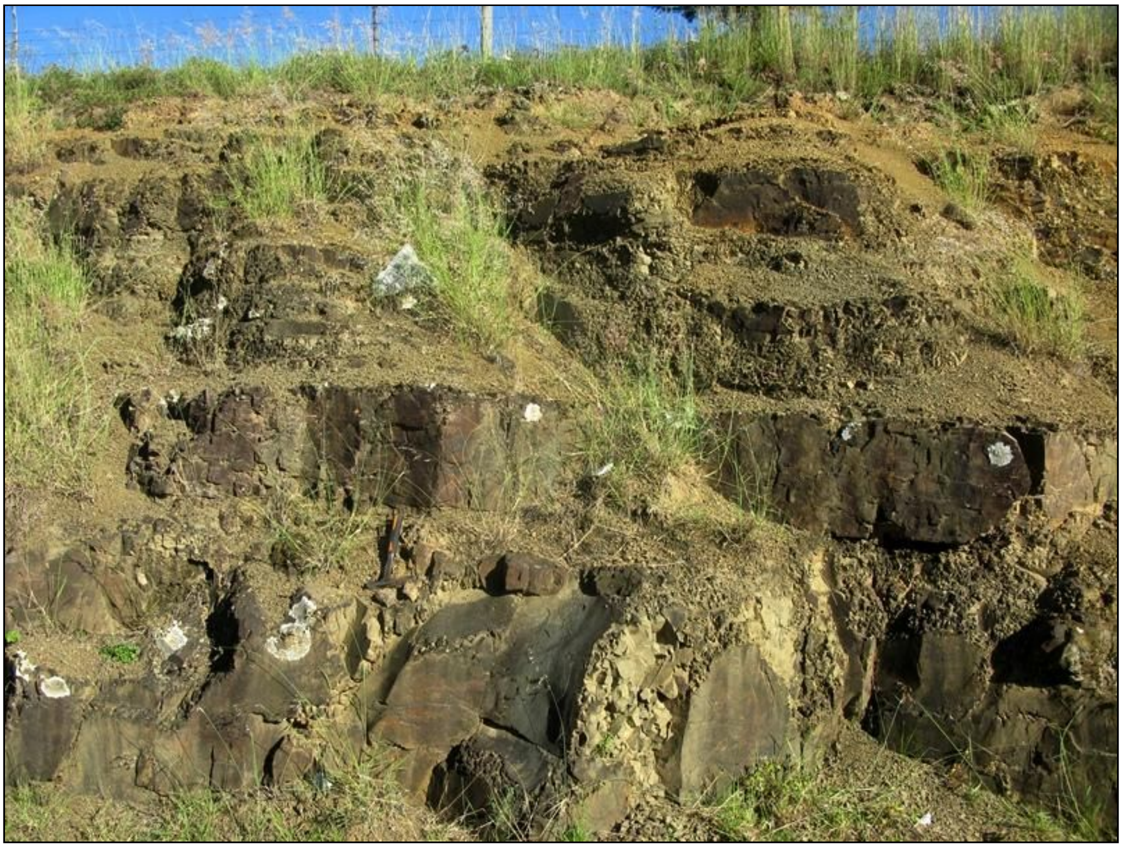

Figure 15. R63 road cutting NE of Bisho exposing upward-thinning package of dark grey, tabular Balfour Formation wackes with horizon of ferruginised pedogenic calcrete nodules (arrow) (Loc. 068) (Hammer = 30 cm).

Figure 16. Thick package of pale, well-jointed, tabular-bedded Balfour Formation channel sandstones baked to quartzites beneath a regional dolerite sill, BP30 near the iNcimerha River (Loc.064).

Figure 17. Small-scale folding, faulting and brecciation of regionally subhorizontally-bedded Balfour Formation succession, BP 16 (Loc. 049) (Hammer = 30 cm).

Figure 18. Sharp contact between baked channel sandstones of the Balfour Formation and an underlying dolerite sill. The latter is now deeply-weathered, giving a superficial massive, sandy appearance (BP7, Loc. 058).

Figure 19. Cut face along the eastern edge of Q3 quarry showing fresh greyish, jointed dolerite sharply overlain by highly-weathered, rusty-brown *sabunga* containing large rounded corestones (Loc. 053).

Figure 20. Boulder-sized rounded corestones of resistant dolerite embedded within massive grey-green *sabunga*, overlain by dark brown soils, in the Q15 study area (Loc. 060).

Figure 21. Surface expression of a major dolerite sill in the Q15 study area, viewed from the NW, with extensive, gently-rounded, brown-weathering domal surfaces and scattered corestones.

Figure 22. Thick, massive, rusty-brown weathering dolerite *sabunga* in the cut face of the BP14 site near Mdange village (Loc. 066).

Figure 23. Massive, cross-veined, sandy-hued dolerite *sabunga* with prominent-weathering, pale grey igneous vein, or perhaps a xenolith (*c.* 50 cm wide) (Loc. 052).

Figure 24. Weathered thick dolerite sill containing a paler, resistant-weathering raft of baked quartzitic country rock (arrowed) (Loc. 063).

Figure 25: Deeply-incised *donga* system near Q2 and Q3 study areas exposing thick clay-rich hillslope deposits, calcretised in the upper part (possible the Pleistocene Masotcheni Formation), overlying deeply-weathered Balfour Formation and dolerite bedrocks (Loc. 051).

Figure 26: Upper part of colluvial succession within the *donga* seen above (Loc. 051) showing dispersed, rounded pale calcrete concretions and surface wash of fine ferricrete glaebules (Hammer = 30 cm).

Figure 27: Thick, pale sandy alluvial deposits with sparse calcrete concretions and ferricrete glaebules exposed in the banks of the Yellowwoods River (Loc. 046) (Hammer = 30 cm).

Figure 28: Deeply-weathered, khaki to ochreous Balfour Formation saprolite overlain successively by a thin pallid zone, rusty-brown ferricrete hard pan and dark brown soils, borrow pit west of the R63 near Bisho (Loc. 042).

Figure 29: Orange-hued dolerite *sabunga* overlain by orange-brown lateritic soils along the margins of a borrow pit (Loc. 063).

Figure 30: R63 road cutting exposing coarse, poorly-sorted, gravelly colluvial sands and grits overlying weathered Balfour Formation saprolite (Loc. 071).

Figure 31: Isolated well-rounded corestone of Balfour Group sandstone in Q17 study area – evidence for deep subtropical weathering of the Karoo bedrocks in this region.

4. PALAEONTOLOGICAL HERITAGE RESOURCES

The overall palaeontological sensitivity of the Beaufort Group sediments within the Main Karoo Basin is rated as high (Almond *et al.* 2008, SAHRIS website) (Fig. 32). These continental sediments have yielded one of the richest fossil records of land-dwelling plants and animals of Permo-Triassic age anywhere in the world (MacRae 1999, Rubidge 2005, McCarthy & Rubidge 2005). In contrast, intrusive rocks of the Karoo Dolerite Suite do not contain fossils, while baking of adjacent country rocks during intrusion may compromise fossils originally preserved within them.

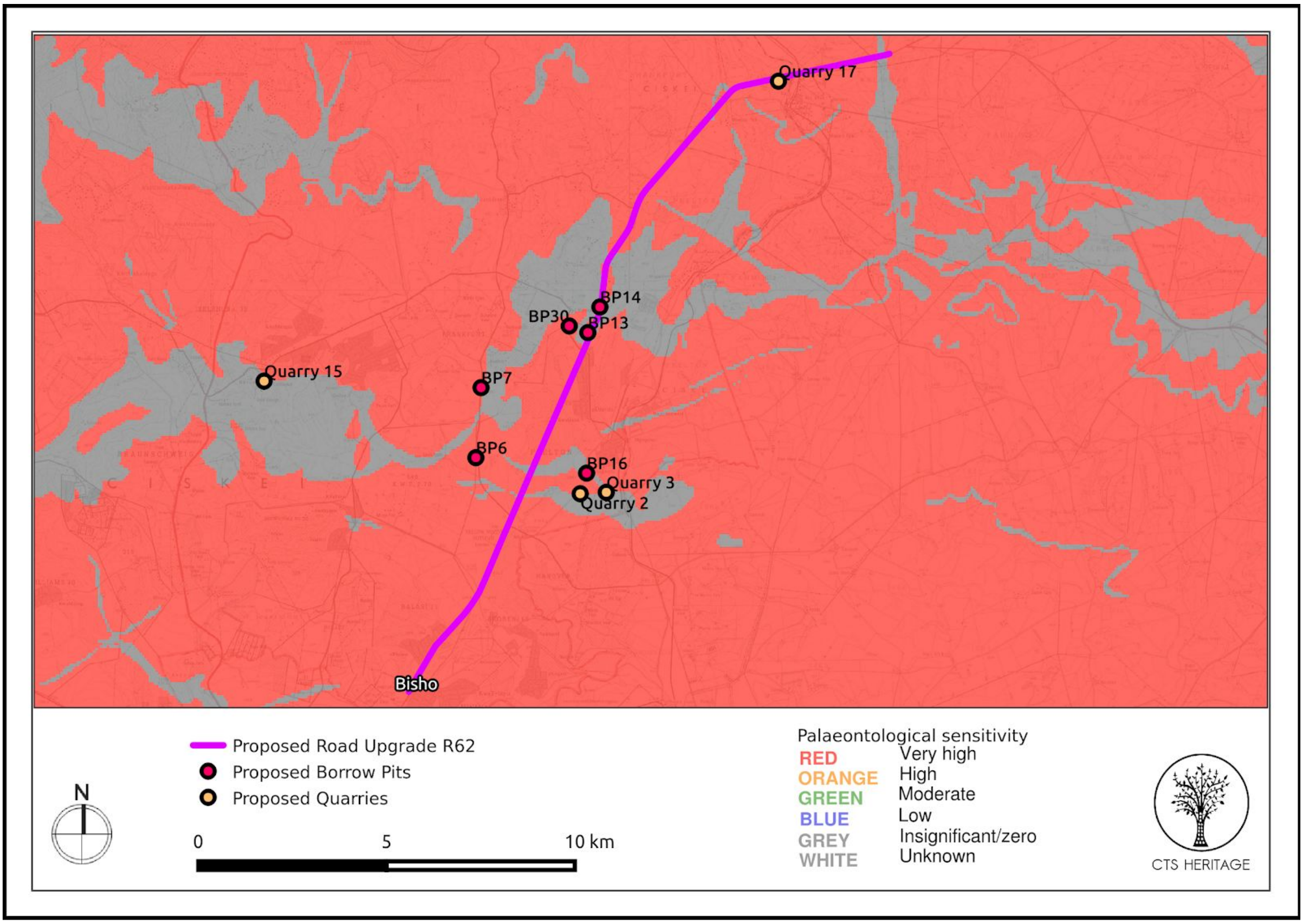

Figure 32: R63 project footprint superimposed on the SAHRIS palaeosensitivity map. Note that the majority of quarry and borrow pit sites under consideration would be excavated into unfossiliferous Karoo dolerite or baked country rocks.

4.1. Review of regional palaeontology

Palaeontological heritage reported elsewhere within the main Palaeozoic and Caenozoic sedimentary rock units that are represented in the study area along the R63 between Bisho and Kei Road as well as further afield is outlined here. This account is largely based on previous desktop and field-based studies in the region by the author and others (*e.g.* Almond 2011a, 2011b, 2014, 2015a, 2015b, 2016, 2017a, 2017b, 2017c, Gess 2011a, 2011b, 2012, Groenewald 2011, Prevec 2014, Durand 2014). Of particular relevance is the R63 road study by Almond (2107c) covering the sector between the N6 intersection and the N2 east of Komga.

A chronological series of mappable fossil biozones or assemblage zones (AZ), defined mainly on their characteristic tetrapod faunas, has been established for the Main Karoo Basin of South Africa (Rubidge 1995). Maps showing the distribution of the Beaufort assemblage zones within the Main Karoo Basin have been provided by Kitching (1977), Keyser and Smith (1979) and Rubidge (1995, 2005). An updated version based on a comprehensive GIS fossil database has been published by Van der Walt *et al.* (2010).

Most maps showing the distribution of the Beaufort Group assemblage zones within the Main Karoo Basin show that their boundaries remain uncertain in the near-coastal region of the Eastern Cape (Rubidge 1995, 2005), although some of these ambiguities have been resolved by the latest map of Van der Walt *et al.* (2010). GIS databases show that the density of fossil sites recorded within the broader East London region remain very low (Nicolas 2007, Fig. 33 herein). This is probably due to factors such as low levels of bedrock exposure, deep bedrock weathering, and extensive dolerite intrusion, although palaeoenvironmental factors as well as research neglect may also have played a significant role here. Given the current paucity of palaeontological data from the East London region, any new well-localized, identifiable fossil finds here are of considerable scientific value.

4.1.1. Balfour Formation

The majority of the Late Permian Balfour Formation succession, with the exception of the basal sandstones and the uppermost mudrocks, is assigned to the *Dicynodon* Assemblage Zone, recently renamed the ***Daptocephalus* Assemblage Zone** (Rubidge 1995, Cole *et al.*, 2004, Viglietti *et al.* 2015) (Fig. 34). This biozone has been assigned to the Changhsingian Stage (= Late Tartarian), right at the end of the Permian Period, with an approximate age range of 253.8-251.4 million years (Rubidge 1995, 2005).

Good accounts, with detailed faunal lists, of the rich Late Permian fossil biotas of the *Daptocephalus* (previously *Dicynodon*) Assemblage Zone have been given by Kitching (1995) and by Cole *et al.* (2004). There are also useful illustrated reviews by Cluver (1978), MacRae (1999), McCarthy & Rubidge (2005) and Smith *et al.* (2012). An authoritative revision has recently been published by Viglietti *et al.* (2015). In general, the following broad categories of fossils might be expected within the Balfour Formation in the Eastern Cape study area:

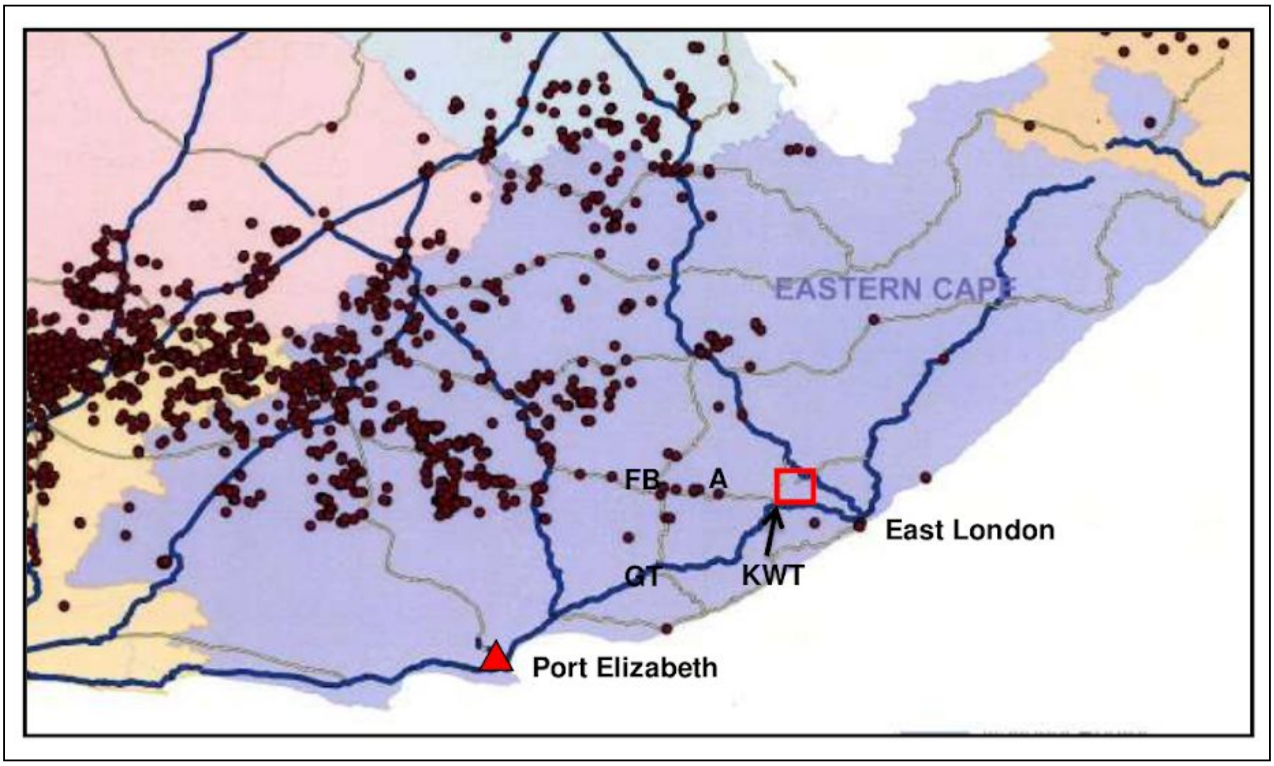

Figure 33: Distribution of vertebrate fossil sites in the Beaufort Group in the Eastern Cape (Modified from Nicolas 2007). Note the general scarcity of sites recorded in the eastern portion of the Main Karoo Basin, including the present study area near King William's Town (red rectangle). KWT = King William's Town. GT = Grahamstown. FB = Fort Beaufort. A = Alice.

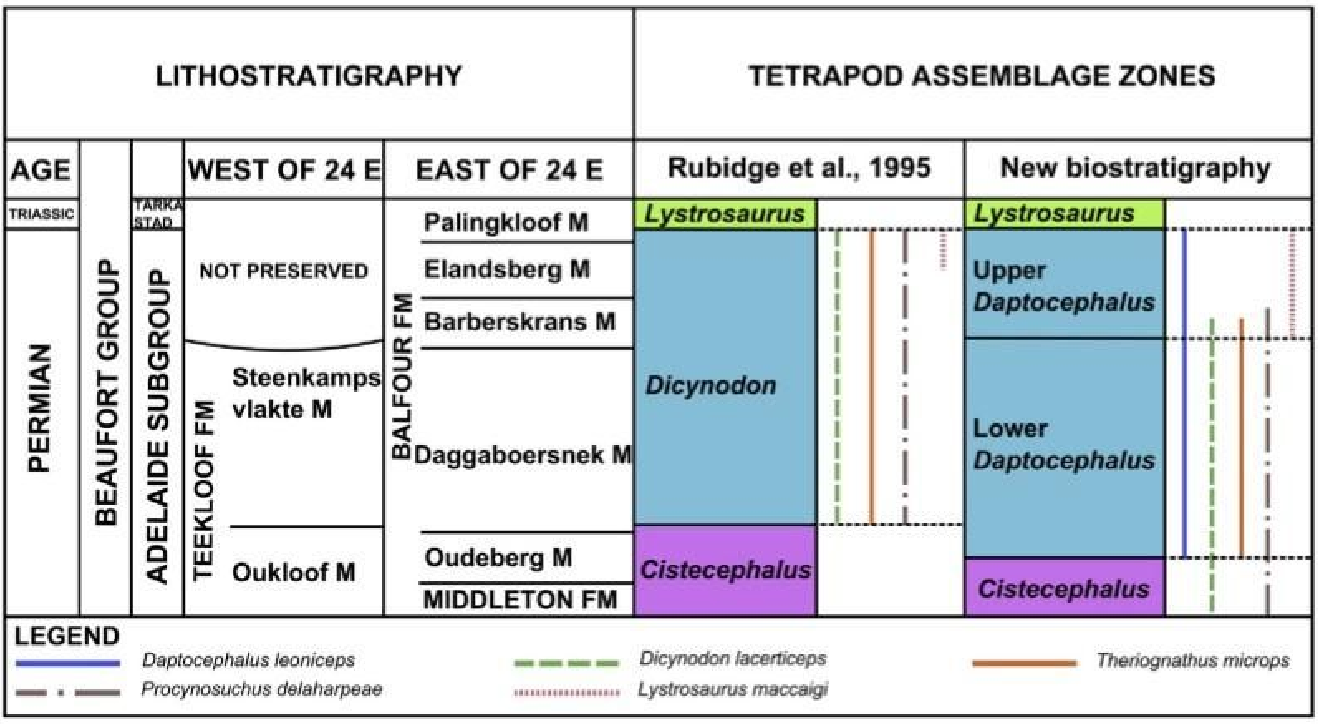

Figure 34: Revised subdivision of fossil assemblage zones (AZ) represented within the Balfour Formation (From Viglietti *et al.* 2015). The formation has not been subdivided into members in the present study area due to poor bedrock exposure levels.

- isolated petrified bones as well as articulated skeletons of terrestrial vertebrates such as true **reptiles** (notably large herbivorous pareiasaurs, small lizard-like millerettids and younginids) and **therapsids** (diverse dicynodonts such as *Daptocephalus*, *Dicynodon* and the much smaller *Diictodon*, carnivorous gorgonopsians, therocephalians such as *Theriognathus* (= *Whaitsia*), primitive cynodonts like *Procynosuchus*, and biarmosuchians) (See Fig. 35 herein);
- aquatic vertebrates such as large, crocodile-like temnospondyl **amphibians** like *Rhinesuchus* (usually disarticulated), and palaeoniscoid **bony fish** (*Atherstonia*, *Namaichthys*);
- freshwater **bivalves** (*Palaeomutela*);
- **trace fossils** such as worm, arthropod and tetrapod burrows and trackways, coprolites (fossil droppings);
- **vascular plant remains** including leaves, twigs, roots and petrified woods ("*Dadoxylon*") of the *Glossopteris* Flora (usually sparse, fragmentary), especially glossopterids and arthrophytes (horsetails).

The abundance and variety of fossils within the *Dicynodon* Assemblage Zone decreases towards the top of the succession according to Cole *et al.* (2004); however, Viglietti *et al.* (2015) argue that the Upper and Lower *Daptocephalus* AZ do not differ significantly in faunal diversity. From a palaeontological viewpoint, these diverse *Daptocephalus* AZ biotas are of extraordinary interest in that they provide some of the best available evidence for the last flowering of ecologically-complex terrestrial ecosystems immediately preceding the catastrophic end-Permian mass extinction (*e.g.* Smith & Ward, 2001, Rubidge 2005, Retallack *et al.*, 2006).

As far as the biostratigraphically important tetrapod remains are concerned, the best fossil material within this AZ is generally found within overbank mudrocks, whereas fossils preserved within channel sandstones tend to be fragmentary and water-worn (Rubidge 1995, Smith 1993). Many fossils are found in association with ancient soils (palaeosol horizons) that can usually be recognised by bedding-parallel concentrations of calcrete nodules.

Petrified (silicified) wood material showing well-developed seasonal growth rings occurs fairly frequently in the Beaufort Group in the King William's Town – East London region. It has been provisionally referred to the basket-genus *Dadoxylon* and is probably of gymnospermous affinities for the most part (*cf* Bamford 1999, 2004). Therapsid remains from the King William's Town region displayed at the Amatole Museum, King William's Town include an unidentified backbone from Sunnyvale Farm near Berlin and another from Stutterheim, some 35 km north of King William's Town (Almond 2011b).

Sparse vertebrate skeletal remains were recorded from the Balfour Formation in the Nxuba WEF study area near Bedford, some 60 m west of Fort Beaufort, by Almond (2015a). They include isolated dicynodont tusks as well as partial, semi-articulated skeletons (probably therapsid) variously embedded within mudrocks or calcrete concretions. Other fossil remains seen here include rare sandstone burrow casts as well as reworked fossil wood associated with channel sandstones. The Balfour Formation cropping out in the Nojoli WEF project area slightly further to the west has yielded abundant, well-preserved silicified wood, some material showing insect borings (Almond 2014). A sizeable chunk of a petrified log showing seasonal growth rings but without provenance is displayed in the Fort Beaufort Museum; it probably also comes from the Balfour Formation. Occasional vertebrate burrows, including a possible fossil warren, as well as possible non-marine bivalves were described from the Adelaide Subgroup along the R63 between Fort Beaufort and Alice by Almond (2016).

Recent field-based palaeontological assessments in the East London – Komga – Kei Mouth area have generally confirmed that vertebrate fossil remains are scarce within the Lower Beaufort Group bedrocks, but this may be in part attributable to low exposure levels, pervasive deep weathering as well as a historical neglect of the region by palaeontologists (Almond 2017c). Gess (2012) noted unidentified fossil bone material in a N2 road cutting just NE of East London (possibly Balfour Fm) as well as in the upper Balfour Formation in the Mbashe River Pass (Indutywa District). Invertebrate trace fossils and plant debris were recorded east of the Kei River (Gess 2011a). A palaeontological field study for the small Chaba WEF (now operational) to the southeast of Komga did not yield any notable fossil remains (Groenewald 2011). The much more extensive Great Kei WEF project area, spanning the N2 to the southeast of Komga, also yielded no vertebrate fossils but low diversity invertebrate trace fossils as well as plant remains (especially sphenophyte debris) were recorded here by Prevec (2014). Most or all of these fossil occurrences were referred to the Balfour Formation by the authors concerned. No fossil vertebrate remains were recorded from the Lower Beaufort Group in the Haga Haga WEF study area, situated *c.* 30 km to the southeast of Komga, by Almond (2017a, 2017b). While locally abundant concentrations of well-preserved Beaufort Group petrified wood blocks were noted here, these were not observed *in situ* but as reworked blocks within unconsolidated superficial sediments (*ibid.*). A recent palaeontological study of the uppermost part of the Lower Beaufort in the Mbashe River Valley by Almond (2018a, 2018 in prep.) has yielded sparse vertebrate skeletal remains, including several *Lystrosaurus* skulls, embedded within ferruginous calcrete concretions, as well as numerous vertebrate burrows. Other traces include *Katbergia* crustacean burrows, indeterminate vertical burrows and fine plant rootlets. Plant remains include occasional horizons with *Glossopteris* leaves, plant rootlets, woody stem casts and rare reworked petrified wood clasts.

No petrified wood, vertebrate remains or other fossil material was recorded during the present field assessment of the R63 (Sections 15 & 16) between Bisho and Kei Road. This is probably due largely to the deep weathering of the Beaufort Group bedrocks as well as the low bedrock exposure levels. Equivocal inclined sandstone burrow casts embedded in overbank mudrocks beneath a thin channel sandstone body were noted in the BP16 study area (Loc. 049) (Figs. 36 to 38). However, these structures show no diagnostic burrow features (*e.g.* peripheral scratches) and the base of the overlying sandstone appears to be loaded in the vicinity. It is quite likely that the features shown in Figs. 36 and 37 herein are in fact abiogenic load casts, and no special conservation or mitigation measures are therefore proposed for this site.

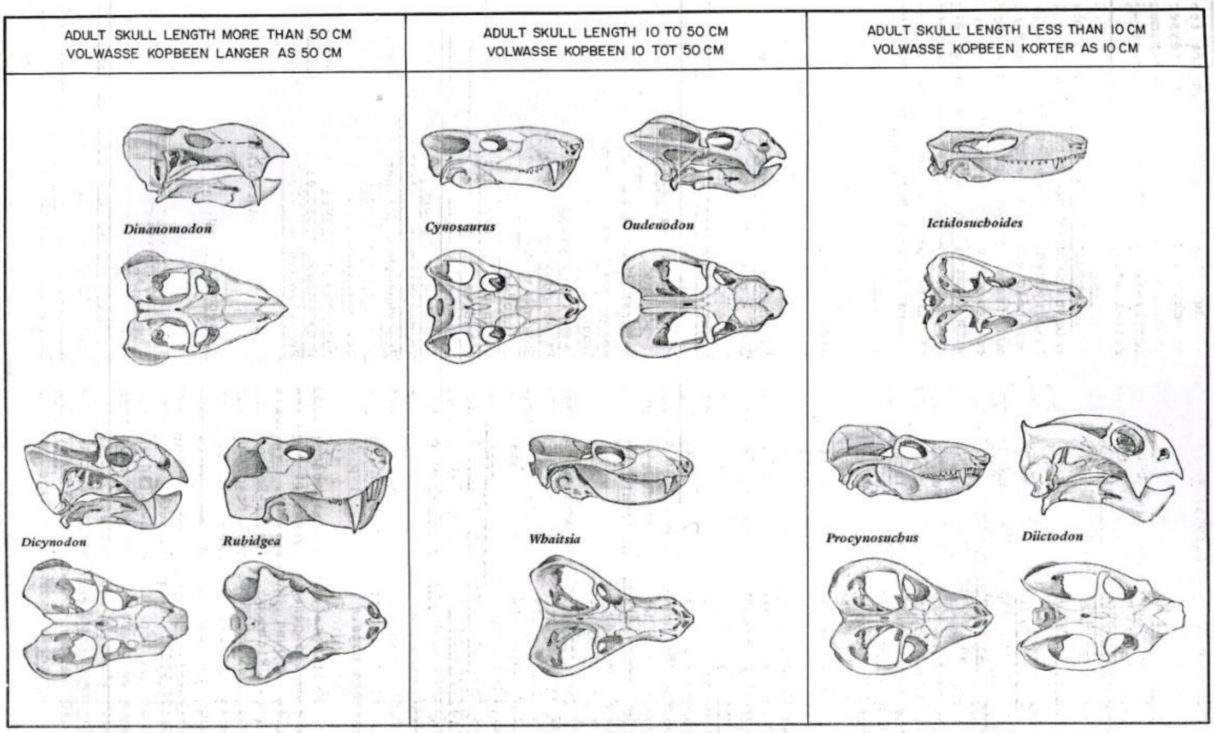

FIG. 3.6 – Characteristic fossils of the *Dicynodon lacerticeps* Assemblage Zone
Kenmerkende fossiele van die *Dicynodon lacerticeps*-versamelingsone

Figure 35: Skulls of characteristic fossil vertebrates – all therapsids - from the *Daptocephalus* (previously *Dicynodon*) Assemblage Zone (From Keyser & Smith 1977-1978). Among the dominant therapsids ("mammal-like reptiles"), *Rubidgea* and *Cynosaurus* are carnivorous gorgonopsians, *Whaitsia* (now *Theriognathus*) is a predatory therocephalian while *Ictidosuchoides* is a small insectivorous member of the same group, *Procynosuchus* is a primitive cynodont, and the remainder are large- to small-bodied dicynodont herbivores.

Figure 36: Elongate, gently-inclined sandstone structures (arrowed) embedded in dark grey mudrock beneath a tabular sandstone body (probable channel sandstone), BP16 study area (Loc. 049) (Hammer = 30 cm). See following figure for more detail.

Figure 37: Close-up of upper elongate, attached sandstone body seen in the previous figure. This *might* be a vertebrate burrow cast but shows no diagnostic features (*e.g.* peripheral scratch marks) and might rather be a sandstone load cast.

Figure 38: Googel Earth© satellite image of the BP16 study area (red polygon) showing the location of equivocal vertebrate burrow casts (quite possible abiogenic load structures) in the NE face of the existing pit (yellow marker).

4.1.2. Karoo Dolerite Suite

The dolerite outcrops in the Eastern Cape study region are in themselves of no palaeontological significance since these are high temperature igneous rocks emplaced at depth within the Earth's crust. As a consequence of their proximity to large dolerite intrusions in the East London – King Williams Town – Fort Beaufort area, the Beaufort Group sediments here often been thermally metamorphosed or "baked" (*i.e.* recrystallised, impregnated with secondary minerals). Embedded fossil material of phosphatic composition, such as bones and teeth, is frequently altered by baking - bones in the East London area are typically black, for example - and may be very difficult to extract from the hard matrix by mechanical preparation (Smith & Keyser, p. 23 *in* Rubidge 1995). Thermal metamorphism by dolerite intrusions therefore tends to reduce the palaeontological heritage potential of Beaufort Group sediments.

No fossiliferous baked country rocks were encountered at the various dolerite quarry / borrow pit study sites during the present field assessment. Occasional hollow vermiform hollows or vugs within thermally metamorphosed Karoo quartzites superficially resemble moulds of fossil bones, such as ribs, but these are in fact pseudofossils.

4.1.3. Late Caenozoic superficial deposits

The central Karoo "drift deposits" have been comparatively neglected in palaeontological terms. However, they may occasionally contain important fossil biotas, notably the bones, teeth and horn cores of mammals as well as remains of reptiles like tortoises. Good examples are the Pleistocene mammal faunas at Florisbad, Cornelia and Erfkroon in the Free State and elsewhere (Wells & Cooke 1942, Cooke 1974, Skead 1980, Klein 1984, Brink, J.S. 1987, Bousman *et al.* 1988, Bender & Brink 1992, Brink *et al.* 1995, MacRae 1999, Meadows & Watkeys 1999, Churchill *et al.* 2000 Partridge & Scott 2000). Other late Caenozoic fossil biotas from these superficial deposits include non-marine molluscs (bivalves, gastropods), ostrich egg shells, trace fossils (*e.g.* calcretised termitaria, coprolites), and plant remains such as peats or palynomorphs (pollens, spores) in organic-rich alluvial horizons (Scott 2000) and siliceous diatoms in pan sediments. In Quaternary deposits, fossil remains may be associated with human artefacts such as stone tools and are also of archaeological interest (*e.g.* Smith 1999 and refs. therein). Stone artefacts of Pleistocene and younger age may additionally prove useful in constraining the age of superficial deposits such as gravelly alluvium within which they are occasionally embedded.

Locally abundant petrified wood reworked from the Balfour Formation has been recorded from coarse alluvial gravels near Cookhouse (Almond 2014) and in the Haga Haga WEF study area *c.* 30 km southeast of Komga (Almond 2016); a similar provenance may probably be ascribed to the large chunk of petrified wood displayed in the Fort Beaufort Museum. Also displayed in the museum are several subfossil mammalian teeth, including portions of large elephant molars, found – probably at or near-surface - in the Fort Beaufort area. No new fossil material was recorded from the various Late Caenozoic superficial deposits in the present R63 study area between Bisho and Kei Road, however.

4.2. Summary of palaeontological resources identified

No indubitable body fossils (plant, animal remains) or trace fossils were recorded during the present palaeontological field study between Bisho and Kei Road (Table 1). This is probably due largely to the deep weathering of the Beaufort

Group bedrocks as well as the low bedrock exposure levels. Baking of the Balfour Formation by dolerite intrusion may also have been a factor.

Equivocal sandstone casts of vertebrate burrows (Figs. 36 & 37) were noted in the BP16 study area (Loc. 049) but their fossil status requires confirmation; they may well be abiogenic load casts.

5. ASSESSMENT OF THE IMPACT OF THE DEVELOPMENT

The R63 (Sections 15 & 16) road project is located in an area that is underlain by potentially fossiliferous sedimentary rocks of Late Palaeozoic and younger, Late Tertiary or Quaternary, age as described in Sections 3 & 4 of this report. The construction phase of the proposed road improvements and associated quarries / borrow pits will entail ground clearance as well as substantial excavations into the superficial sediment cover and locally into the underlying bedrock. All these developments may adversely affect potential fossil heritage within the project footprint by destroying, disturbing or permanently sealing-in fossils at or beneath the surface of the ground that are then no longer available for scientific research or other public good.

The inferred impact of the proposed road development and associated borrow pits / hard rock quarry on local fossil heritage resources is evaluated in Table 2 below. This assessment, which takes into account associated bridge and culvert developments, applies only to the construction phase of the project since further impacts on fossil heritage during the operational phase and rehabilitation phases of the road and quarries / borrow pits are not anticipated.

Potential impacts on fossil heritage during the construction phase are generally negative, direct and restricted to the development footprint (*site*). They are *permanent* and cannot be reversed (*irreversible*). Where rare, well-preserved fossils such as vertebrate skeletons are concerned, losses may be irreplaceable. Given (1) the highly-weathered and locally baked nature of the many of the Palaeozoic sediments in the study area, (2) the comparatively small footprint of the proposed road developments as well as (3) the absence of new fossil records made during the present field assessment of the study footprint, the severity of anticipated impacts is rated as *low (negative)* while the probability of scientifically significant impacts is low (*unlikely*). Palaeontological impacts are *partially mitigatable*, as outlined below. The overall impact significance of the R63 (Sections 15 & 16) road project, including the associated quarry / borrow pits as well as the proposed culvert and bridge improvements, is evaluated as *very low* as far as palaeontology is concerned.

Table 1: Summary of R63 road project quarries and borrow pits – geology and palaeontological heritage significance

	GPS	GEOLOGY	FOSSILS OBSERVED	COMMENTS
Q2	32°48'0.17"S 27°29'4.24"E	Major dolerite sill, weathered sabunga, corestones	NONE	No further specialist palaeontological input required
Q3	32°47'55.18"S 27°29'43.23"E	Major dolerite sill, weathered sabunga, corestones	NONE	No further specialist palaeontological input required
Q15	32°46'16.76"S 27°23'43.89"E	Major dolerite sill, weathered sabunga, corestones	NONE	No further specialist palaeontological input required
Q17	32°42'01.17"S 27°32'30.30"E	Baked Balfour Formation channel quartzites	NONE	General alert to ECO regarding potential fossil remains (See Appendix 3: Chance Fossil Finds Procedure)
BP6	32°47'23.84"S 27°27'16.97"	Highly-weathered Balfour Group mudrocks and thin sandstones	NONE	General alert to ECO regarding potential fossil remains (See Appendix 3: Chance Fossil Finds Procedure)
BP7	32°46'25.40"S 27°27'31.06"E	Weathered dolerite sill in contact with baked Balfour Formation mudrocks and sandstones.	NONE	General alert to ECO regarding potential fossil remains (See Appendix 3: Chance Fossil Finds Procedure)
BP13	32°45'26.76"S 27°29'23.35"E	Major dolerite sill, weathered sabunga, corestones	NONE	No further specialist palaeontological input required
BP14	32°45'14.61"S 27°29'27.23"E	Major dolerite sill, weathered sabunga, corestones	NONE	No further specialist palaeontological input required
BP16	32°47'37.91"S 27°29'14.71"E	Weathered Balfour Formation sandstones and mudrocks, fine diamictites.	*Equivocal sandstone cast of vertebrate burrow (requires confirmation) (Fig. 36 herein)*	General alert to ECO regarding potential fossil remains (See Appendix 3: Chance Fossil Finds Procedure)
BP30	32°45'35.42"S 27°28'57.55"E	Baked Balfour Formation channel sandstones (now quartzite)	NONE	General alert to ECO regarding potential fossil remains (See Appendix 3: Chance Fossil Finds Procedure)

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Table 2: Evaluation of impacts on fossil heritage resources due to the construction phase of the proposed upgrade of National Route R63 (Sections 15 & 16 between Bisho and N6 intersection) and associated mining applications (No further impacts are anticipated in the operational & rehabilitation phases).

POTENTIAL IMPACTS	Nature	Type	Extent	Duration	Severity	Reversibility	Irreplaceable Loss	Probability	MITIGATION POTENTIAL	IMPACT SIGNIFICANCE Without Mitigation	With Mitigation	MITIGATION MEASURES
CONSTRUCTION PHASE												
Impacts on Palaeontology: Damage, destruction of fossil remains at or beneath the ground surface within the development footprint	Negative	Direct	Site	Permanent	Low Negative	Irreversible	Resource may be partially destroyed	Unlikely that palaeontologically-important resources will be lost	Partially mitigatable	Very low (negative)	Moderate (positive – due to acquisition of new palaeontological data)	Chance finds of fossils such as vertebrate bones & teeth, petrified wood to be safeguarded by ECO & reported to ECPHRA for recording & sampling by professional palaeontologist

6. CONCLUSION AND RECOMMENDATIONS

The R63 (Sections 15 & 16) study area between Bisho and Kei Road, including the associated borrow pit and quarry sites, is underlain by Late Permian fluvial sedimentary rocks of the Balfour Formation (Lower Beaufort Group, Karoo Supergroup) which are extensively intruded by Early Jurassic dolerite bodies of the Karoo Dolerite Suite. Bedrock exposure levels are generally very poor outside road cuttings, deeper erosion gullies, borrow pits and quarries. Both the sedimentary and igneous bedrocks in the study area are deeply weathered in this part of the Eastern Cape coastal interior, with several meters of near-surface saprolite (*in situ* weathered bedrock). For this reason, comparatively few vertebrate and petrified wood fossils or trace fossil assemblages have previously been recorded here. The only potential fossil material observed during the present 2-day palaeontological field survey comprises a few *possible* inclined sandstone vertebrate burrow casts embedded in overbank mudrocks beneath a thin channel sandstone body that were noted in the BP16 study area. However, these equivocal structures show no diagnostic vertebrate burrow features (*e.g.* peripheral scratch marks) and they may well represent abiogenic load casts. No special conservation or mitigation measures are therefore proposed for this site.

The overall impact significance of the R63 (Sections 15 & 16) road project, including the associated quarry / borrow pits as well as the proposed culvert and bridge improvements, is evaluated as *very low* as far as palaeontology is concerned. Unless significant new fossil finds (*e.g.* well-preserved vertebrate remains, petrified wood) are made during the construction phase of the development, further specialist palaeontological studies or mitigation are not regarded as warranted for this project. The Environmental Control Officer (ECO) for the project should be alerted to the potential for, and scientific significance of, new fossil finds during the construction phase of the development. They should familiarise themselves with the sort of fossils concerned through museum displays (*e.g.* Amatole Museum, King William's Town, East London Museum) and accessible, well-illustrated literature (*e.g.* MacRae 1999).

Should important new fossil remains - such as vertebrate bones and teeth, petrified wood, plant-rich fossil lenses or dense fossil burrow assemblages - be exposed during construction, the responsible Environmental Control Officer should alert ECPHRA (*i.e.* The Eastern Cape Provincial Heritage Resources Authority. Contact details: Mr Sello Mokhanya, 74 Alexander Road, King Williams Town 5600; smokhanya@ecphra.org.za) as soon as possible. This is so that appropriate action can be taken in good time by a professional palaeontologist at the developer's expense. Palaeontological mitigation would normally involve the scientific recording and judicious sampling or collection of fossil material as well as of associated geological data (*e.g.* stratigraphy, sedimentology, taphonomy). The palaeontologist concerned with mitigation work will need a valid fossil collection permit from ECPHRA and any material collected would have to be curated in an approved depository (*e.g.* museum or university collection). All palaeontological specialist work should conform to international best practice for palaeontological fieldwork and the study (*e.g.* data recording fossil collection and curation, final report) should adhere as far as possible to the minimum standards for Phase 2 palaeontological studies recently developed by SAHRA (2013). These recommendations are summarized in tabular form in Appendix 3 (Chance Fossil Finds Procedure) and should be incorporated into the Environmental Management Programme (EMPr) for the R63 (Section 15 & 16) road and quarry / borrow pit development.

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APPENDICES

Appendix 1: Specialist CV

Dr John Almond has an Honours Degree in Natural Sciences (Zoology) as well as a PhD in Palaeontology from the University of Cambridge, UK. He has been awarded post-doctoral research fellowships at Cambridge University and in Germany, and has carried out palaeontological research in Europe, North America, the Middle East as well as North and South Africa. For eight years he was a scientific officer (palaeontologist) for the Geological Survey / Council for Geoscience in the RSA. His current palaeontological research focuses on fossil record of the Precambrian - Cambrian boundary and the Cape Supergroup of South Africa. He has recently written palaeontological reviews for several 1: 250 000 geological maps published by the Council for Geoscience and has contributed educational material on fossils and evolution for new school textbooks in the RSA.

Since 2002 Dr Almond has also carried out palaeontological impact assessments for developments and conservation areas in the Western, Eastern and Northern Cape, Limpopo, Northwest, KwaZulu-Natal, Mpumalanga and the Free State under the aegis of his Cape Town-based company *Natura Viva* cc. He has served as a long-standing member of the Archaeology, Palaeontology and Meteorites Committee for Heritage Western Cape (HWC) and an advisor on palaeontological conservation and management issues for the Palaeontological Society of South Africa (PSSA), HWC and SAHRA. He is currently compiling technical reports on the provincial palaeontological heritage of Western, Northern and Eastern Cape for SAHRA and HWC. Dr Almond is an accredited member of PSSA and APHP (Association of Professional Heritage Practitioners – Western Cape).

Appendix 2: GPS data

All GPS readings were taken in the field using a hand-held Garmin GPSmap 62sc instrument. The datum used is WGS 84.

LOC	GPS DATA	COMMENTS
42	32 50 21.7 S 27 26 04.1 E	Extensive borrow pitc. 600 m NW of R63 near Bisho. Excavated into weathered, flat-lying to gently-dipping Balfour Formation. Mudrocks in upper quarry face khaki, thin-bedded to laminated with sparse small concretions (1-2 cm diam., probably leached palaeocalcrete). Sandstones tabular, pale brown to yellowish, medium-bedded. Bedrocks with pale leached zone at top overlain by rusty-brown, finely nodular, semi-consolidated ferricrete horizon (c. 30 cm thick hardpan) and then dark brown soils. Local exposures of yellowish brown, sand-like material with veins is probably deeply weathered dolerite intrusion (sabunga) with lateritic soils seen at quarry margin.
43	32 50 20.3 S 27 26 03.1 E	Same pit as above, fresher lower beds towards pit floor beneath weathered zone. Grey-green tabular to lenticular, medium-bedded diamictite facies of possible debris flow or slurry origin (small chips of mudrock suspended within silty to sandy matrix) interbedded with more recessive-weathering, dark grey-green hackly mudrocks.
44	32 50 18.6 S 27 26 08.9 E	Streambank section just NE of borrow pit described above. Thick greyish-brown silty to sandy alluvium with fine gravel lenses. Capped by dark grey soils with large worm casts.
45	32 49 41.8 S 27 27 08.1 E	Shallow R63 road cutting near Bisho Hospital. Poorly exposed, weathered Balfour Fm medium-bedded channel sandstones and hackly mudrocks capped by small-glaebule ferricrete horizon and dark grey soils featuring large domical termitaria.
46	32 48 27.9 S 27 28 12.2 E	Rocky bed and alluvial banks of Yellowwoods Riverc. 450 m SE of R63. Riverbed exposure of well-jointed grey-green channel sandstone and minor overbank mudrocks, modern alluvial gravels of angular to subrounded sandstone clasts. Riverbank exposures ofc. 2m of well-bedded, pale grey sandy alluvium with sparse ferricrete glaebules towards base and scattered pale grey calcrete concretions in upper part. Alluvium grades up into darker grey sandy to silty soils.
47	32 48 01.7 S 27 29 01.2 E	Undeveloped lower grassy hillslopes within Q2 study area. Sparse dolerite corestones, becoming more abundant higher up on hill to SW, and dark grey soils.
48	32 47 39.1 S 27 29 13.3 E	BP16 existing extensive borrow pit excavated into weathered pale to dark greyish Balfour Fm hackly mudrocks and pale yellow to grey crumbly sandstones (m-scale channels, crevasse splays). Sandstones fine-upwards towards top and bases locally loaded or gullied. "Mudrocks" include speckled fine-grained diamictite facies. Locally abundant cream-coloured calcrete nodules weathering out of weathered upper part of profile (probably Quaternary) and extensive ferricrete zone at base of soils. Bedrocks overlain by thick colluvial soil profile, gravelly towards the base.
49	32 47 37.6 S 27 29 14.6 E	BP16 borrow pit area.Possiblesandstone cast of a gently-inclined vertebrate burrow (c. 10 cm deep) extending from base of massive channel sandstone. May be second castc. 2 m below.N.B.Base of sandstone here very irregular, possibly loaded. Zone of tight folding and faulting, brecciation of Balfour Formation bedrocks nearby. Large (10-20 cm diam.), rounded calcrete concerетions embedded within dark grey mudrocks (probably Pleistocene overlay).
50	32 47 48.8 S 27 29 21.2 E	Area of extensivedonga(erosion gulley) erosion between Q2, Q3 and BP16 study areas. Good exposure through thick (> 4 m) grey and brown hillslope deposits (probably attributable to Pleistocene Masotcheni Fm) overlying weathered bedrocks. Large domical termitaria.
51	32 47 50.9 S 27 29 22.8 E	Same dongasystemas above. Good sections through pale grey colluvial sands and clays, with abundant rounded cm- to dm-scale calcrete concretions within upper part as well as small ferricrete glaebules from base of soil horizon.
52	32 47 51.8 S 27 29 23.5 E	Locally common bluish-green hornfels and quartzite stone artefacts as well as dolerite upper grindstone (also used as hammer stone) associated with clay-rich upper colluvial clays. Weathered bedrocks include crumbly yellowish sandstone beds as well as sandy-yellow, massive

		doleriticsabungatraversed by dyke-like bodies of pale grey, composition-banded resistant-weathering material (probably late-stage igneous veins, or perhaps xenoliths).
53	32 47 52.4 S 27 29 33.8 E	Existing large quarry within Q3 study area exposing large dolerite sill. Fresh dolerite grey-green, colour-streaked but not obviously columnar-jointed. Undulose, brownish-weathered upper surface. Overlain by deeply-weathered rusty-brown dolerite sanbuna containing large rounded corestones. Bright orange-brown lateritic soils developed locally.
54	32 47 55.0 S 27 29 09.4 E	Shallow quarry in Q2 study area. Same features as previous locality. Large, rusty-brown weathering dolerite corestones on surrounding hillslopes.
55	32 48 13.9 S 27 27 50.5 E	Old diggings into dark grey-green, hackly-weathering Balfour Formation mudrocksc. 220 m NW of R63. Mudrocks thin-bedded to massive with occasional horizons of irregular, rounded, pebble- to cobble-sized calcrete pedocrete nodules (dark grey interior).
56	32 47 25.5 S 27 27 22.6 E	BP6 roadside borrow pit. Weathered, crumbly, grey-green to khaki mudrocks with paler thin sandstone interbeds.
57	32 46 47.3 S 27 27 24.3 E	Viewpoint towards Amathole mountains, rolling grassy foothill country with woodland in river valleys.
58	32 46 24.5 S 27 27 26.3 E	Extensive borrow pit in BP7 study area. Baked sandstone on pit floor with occasional vermiform vugs with a superficially fossil-like appearance (pseudofossils). Overlying sandy-coloured doleriticsanbungawith occasional paler, prominent-weathering dykes and veins. Pale grey to brownish, tabular Balfour sandstones with ferruginised rusty-brown mudrock interbeds above massive dolerite sill.
60	32 46 18.8 S 27 23 46.6 E	Existing quarry in Q15 study area which is underlain by major dolerite sill that dominates upper hillslopes in this region. Good examples of large rounded dolerite corestones,sabungaseen in quarry cut face, overlain by dark brown soils. Brownish-weathering, gently rounded surface exposures, domes and corestones of dolerite seen to west of quarry.
61	32 46 06.5 S 27 23 27.4 E	Roadside borrow pit showing thick development of grey-green doleritesabungacapped by dark brown soils.
62	32 45 03.7 S 27 26 17.6 E	Extensive shallow diggings into weathered, horizontally and tabular--bedded, hackly, dark grey-green Balfour Fm mudrocks. Medium- to thick-bedded. Occasional horizons of pedogenic calcrete concretions, thin crevasse-splay sandstones, mudflake breccia lenses. Cut face of quarry shows deep weathering profile extending through Balfour Fm bedrocks.
63	32 44 53.1 S 27 28 04.2 E	Borrow pit excavated into thick, massive, grey-green doleriticsanbungawith occasional rafts of bedded Balfour Formation sandstones, baked to pale yellowish quartzite. Good local development of orange-brown lateritic soils.
64	32 45 31.8 S 27 28 57.4 E	Quarry in BP30 study area, just south of iNcemerha River exposing pale yellow-brown, well-jointed, baked channel sandstone (now quartzite) of Balfour Fm regionally underlying a major dolerite sill. Fine-grained quartzites tabular, medium-bedded with flat bedding planes, conchoidal fracture.
65	32 45 45.2 S 27 29 15.6 E	Good examples of dark-patinated, well-rounded dolerite corestones adjacent to R63, ridge crest south of BP13 study area.
66	32 45 14.4 S 27 29 29.2 E	Elongate quarry into weathered dolerite sill in BP14 study area. Thick massive doleritesanbungawith large corestones, relict onionskin weathering. Major sill caps ridge to the north with good views of rounded dolerite outcrops on western slopes.
67	32 47 59.6 S 27 28 07.0 E	R63 road cutting through weathered, crumbly Balfour Fm pale yellowish sandstones and khaki mudrocks. Succession dips gently towards the north and overlain by pale brown soils with ferricretised horizon at the base.
68	32 47 12.6 S 27 28 31.1 E	Extensive R63 road cutting through weathered Balfour Formation dark grey-green, prominent-weathering sandstones and recessive weathering, crumbly khaki mudrocks. Package of upward-fining and thinning, tabular channel sandstones or wackes. Occasional horizon of

		rounded, dark brown pedogenic calcrete concretions (up to 30 cm. diam), probably secondarily ferruginised and leached.
71	32 42 38.8 S 27 31 13.4 E	R63 road cutting through Balfour Fm channel sandstone package. Lower sandstones lenticular, grey-green, fresh-looking, blocky-jointed, massive. Higher beds yellowish-brown, more weathered, thinner-bedded, interbedded with thin-bedded grey-green mudrocks. Overlying pale brown soils contain dispersed rubbly gravels of sandstone – possibly debris flow deposits reworking colluvial material. Balfour bedrocks dip northwards and truncated by major dolerite intrusion (weatheredsabunga) in northern sector of road cutting.
72	32 42 38.8 S 27 31 13.4 E	R63 road cutting through thick weathered dolerite intrusion (grey-green massivesabunga, ferruginised towards top).
73	32 42 02.4 S 27 32 09.4 E	R63 road cutting west of KwaNkwebu River showing thick package of tabular-bedded, medium-bedded, pale brown to yellowish channel sandstones of the Balfour Fm.
74	32 42 01.1 S 27 32 30.5 E	Small surface exposure of highly-weathered, pale brown Balfour Fm sandstones within Q17 study area. Occasional large boulder-sized, well-rounded corestone of sandstone at surface in region.
75	32 41 42.1 S 27 34 05.7 E	Small roadside borrow pit excavated into medium-bedded, pale brown channel sandstones of Balfour Fm.

Appendix 3

<table>
<tr><td colspan="3">CHANCE FOSSIL FINDS PROCEDURE:R63 (Sections 15 & 16) between Bisho and N6 intersection near Kei Road, Eastern Cape</td></tr>
<tr><td>Province & region:</td><td colspan="2">Eastern Cape, Amathole Municipality</td></tr>
<tr><td>Responsible Heritage Management Authority</td><td colspan="2">The Eastern Cape Provincial Heritage Resources Agency, ECPHRA (Contact details: Mr Sello Mokhanya, 74 Alexander Road, King Williams Town 5600; smokhanya@ecphra.org.za)</td></tr>
<tr><td>Rock unit(s)</td><td colspan="2">Balfour Formation (Lower Beaufort Group, Karoo Supergroup), Late Caenozoic alluvium, colluvium (including Pleistocene Masotcheni Formation)</td></tr>
<tr><td>Potential fossils</td><td colspan="2">In bedrocks: Petrified wood (e.g.logs), plant compressions, bones and teeth of mammal-like reptile and other vertebrates, trace fossils incl. vertebrate burrows. In colluvium and alluvium: teeth, bones and horncores of mammals.</td></tr>
<tr><td rowspan="5">ECO protocol</td><td colspan="2">1. Once alerted to fossil occurrence(s): alert site foreman, stop work in area immediately (N.B.safety first!), safeguard site with security tape / fence / sand bags if necessary.</td></tr>
<tr><td colspan="2">2. Record key data while fossil remains are still in situ:
● Accurate geographic location – describe and mark on site map / 1: 50 000 map / satellite image / aerial photo
● Context – describe position of fossils within stratigraphy (rock layering), depth below surface
● Photograph fossil(s) in situ with scale, from different angles, including images showing context (e.g. rock layering)</td></tr>
<tr><td>3. If feasible to leave fossils in situ:
● Alert Heritage Resources Authority and project palaeontologist (if any) who will advise on any necessary mitigation
● Ensure fossil site remains safeguarded until clearance is given by the Heritage Resources Authority for work to resume</td><td>3. If not feasible to leave fossils in situ(emergency procedure only):
● Carefully remove fossils, as far as possible still enclosed within the original sedimentary matrix (e.g. entire block of fossiliferous rock)
● Photograph fossils against a plain, level background, with scale
● Carefully wrap fossils in several layers of newspaper / tissue paper / plastic bags
● Safeguard fossils together with locality and collection data (including collector and date) in a box in a safe place for examination by a palaeontologist
● Alert Heritage Resources Authority and project palaeontologist (if any) who will advise on any necessary mitigation</td></tr>
<tr><td colspan="2">4. If required by Heritage Resources Authority, ensure that a suitably-qualified specialist palaeontologist is appointed as soon as possible by the developer.</td></tr>
<tr><td colspan="2">5. Implement any further mitigation measures proposed by the palaeontologist and Heritage Resources Authority</td></tr>
<tr><td>Specialist palaeontologist</td><td colspan="2">Record, describe and judiciously sample fossil remains together with relevant contextual data (stratigraphy / sedimentology / taphonomy). Ensure that fossils are curated in an approved repository (e.g. museum / university / Council for Geoscience collection) together with full collection data. Submit Palaeontological Mitigation report to Heritage Resources Authority. Adhere to best international practice for palaeontological fieldwork and Heritage Resources Authority minimum standards.</td></tr>
</table>