PALAEONTOLOGICAL IMPACT ASSESSMENT: DESKTOP STUDY

Upgrading and construction of water supply schemes in Cluster 2, Chris Hani District Municipality, Eastern Cape Province: Phase 1 (Schemes 27, 28 & 29)

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1. SUMMARY

The study region between Cofimvaba and Queenstown, Eastern Cape Province, is underlain by Triassic fluvial sediments of the Burgersdorp Formation (Tarkastad Subgroup, Karoo Supergroup) and by Early Jurassic Karoo dolerites . The Beaufort Group rocks are potentially fossiliferous, having yielded elsewhere a diverse biota of Early to Mid Triassic vertebrates (fish, amphibians, reptiles, therapsids), trace fossils and plants. However, in the study area these rocks are poorly exposed due to a widespread mantle of colluvium (*e.g.* doleritic scree) and alluvium. Furthermore, they have been thermally metamorphosed during dolerite intrusion, reducing their palaeontological heritage value. The igneous Karoo dolerites contain no fossils, and the palaeontological sensitivity of the superficial sediments is generally low.

The small scale excavations envisaged for the planned water scheme improvements in the Chris Hani District Municipality are unlikely to disturb large volumes of fresh, fossil-bearing rock. It is concluded that the proposed development will not have an appreciable impact on local palaeontological heritage and no further specialist mitigation is recommended for this project.

Should substantial fossil remains (notably articulated vertebrate skeletons or skulls) be exposed during construction, however, the ECO should safeguard these - *in situ*, where feasible. SAHRA and / or a professional palaeontologist should then be alerted as soon as possible so that appropriate mitigation measures can be implemented.

2. INTRODUCTION & BRIEF

The Chris Hani District Municipality are planning to upgrade the water supply to 82 villages situated *c*. 20km WNW of Cofimvaba, Eastern Cape Province. Phase 1 of the project involves the construction or upgrading of the water supply within Schemes 27, 28 and 29 whose location is shown on the topographical map Fig. 1. below. The proposed activities include the construction of several *c*. 15km long pipelines of 50-100mm diameter as well as minor earthworks such as berms and gabions.

Since these developments will involve excavation into potentially fossiliferous bedrock of the Upper Beaufort Group, a palaeontological impact assessment for the project has been commissioned by Mr Conroy van der Riet of Biotechnology & Environmental Specialist Consultancy cc, East London, in accordance with the requirements of the National Heritage Resources Act, 1999.

The various categories of heritage resources recognised as part of the National Estate in Section 3 of the Heritage Resources Act include, among others:

- geological sites of scientific or cultural importance
- palaeontological sites
- palaeontological objects and material, meteorites and rare geological specimens

Minimum standards for the palaeontological component of heritage impact assessment reports are currently being developed by SAHRA. The latest version of the SAHRA guidelines is dated May 2007.

2.1. General approach used for palaeontological impact desktop studies

In preparing a palaeontological desktop study the potentially fossiliferous rock units (groups, formations *etc*) represented within the study area are determined from geological maps. The known fossil heritage within each rock unit is inventoried from the published scientific literature, previous palaeontological impact studies in the same region, and the author's field experience (Consultation with professional colleagues as well as examination of institutional fossil collections may play a role here, or later following scoping during the compilation of the final report). This data is then used to assess the palaeontological sensitivity of each rock unit to development (Provisional tabulations of palaeontological sensitivity of all formations in the Western, Eastern and Northern Cape have already been compiled by J. Almond and colleagues; *e.g.* Almond *et al*. 2008). The likely impact of the proposed development on local fossil heritage is then determined on the basis of (1) the palaeontological sensitivity of the rock units concerned and (2) the nature of the development itself, most notably the extent of fresh bedrock excavation envisaged. When rock units of moderate to high palaeontological sensitivity are present within the development footprint, a field scoping study by a professional palaeontologist is usually warranted.

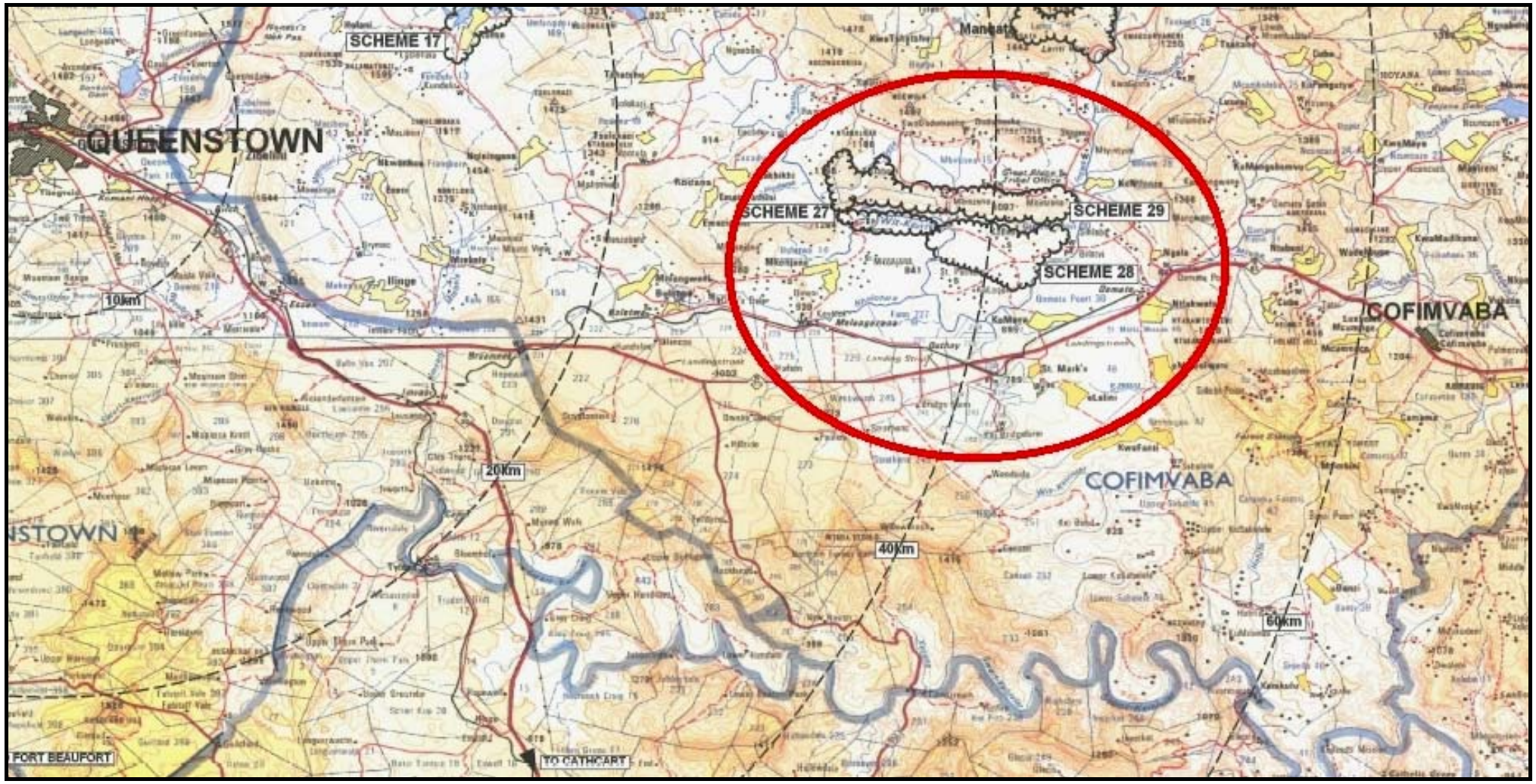

Fig. 1. Topographic map showing location (red ellipse) of the Cluster 2 water supply Schemes 27, 28 and 29 located *c*. 20km west of Cofimvaba, Chris Hani District Municipality (Extract from 1: 250 000 topographic map 3126 Queenstown, Courtesy of the Chief Directorate of Surveys and Mapping, Mowbray. Image kindly provided by Biotechnology & Environmental Specialist Consultancy cc).

3. GEOLOGICAL BACKGROUND

The geology of the study area is depicted on the 1: 250 000 geology map sheet 3126 Queenstown (Council for Geoscience, Pretoria; Johnson 1984) (Fig. 2). The area is underlain at depth by Early to Mid Triassic fluvial sediments of the **Burgersdorp Formation** (Tarkastad Subgroup, Upper Beaufort Group, Karoo Supergroup) (**TRb** in Fig. 2).

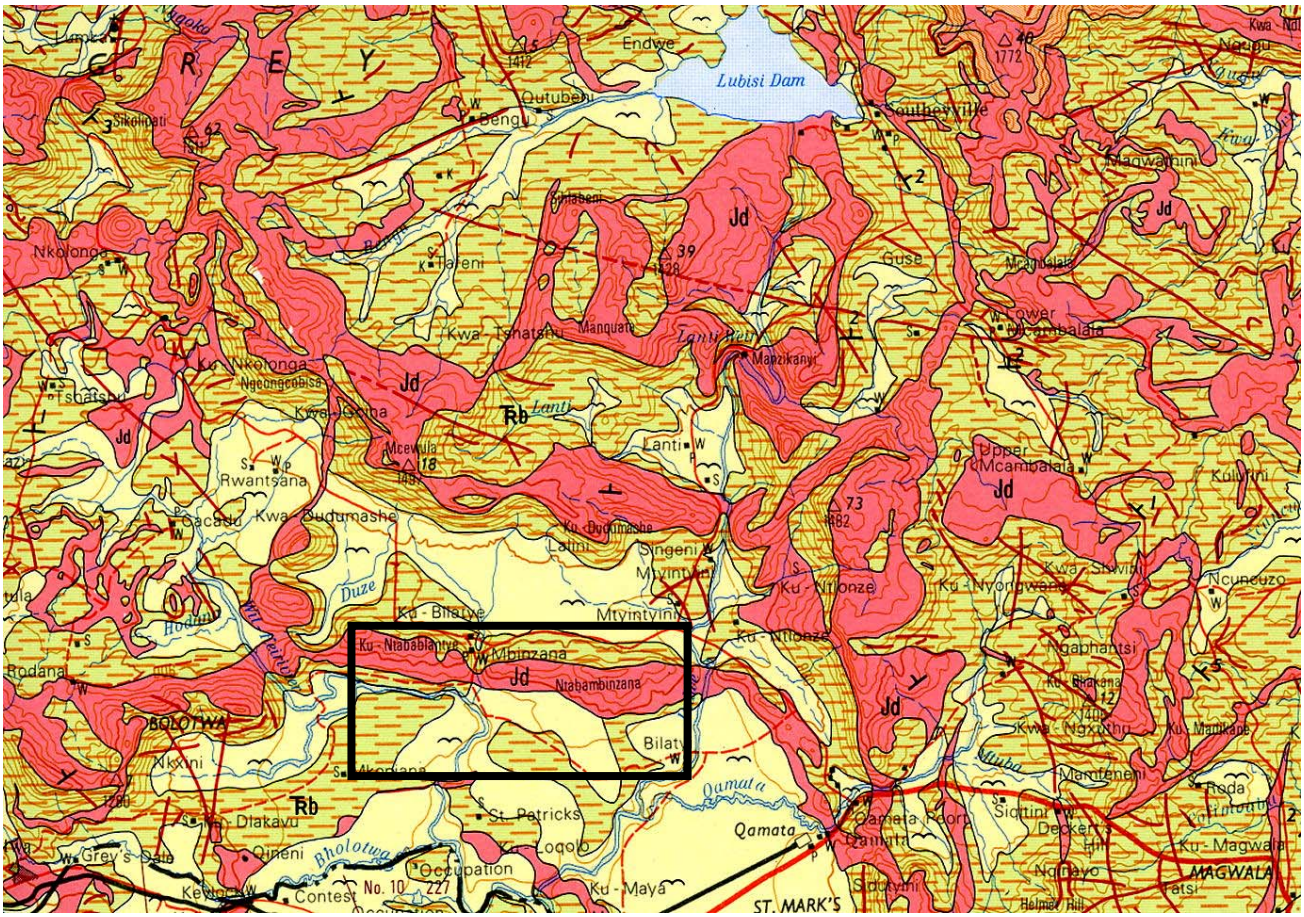

Fig. 2. Extract from 1: 250 000 geological map 3126 Queenstown (Council for Geoscience, Pretoria) showing approximate location of the study area north of the R61 (black rectangle). TRb (greenish yellow with dashes) = Early to Mid Triassic Burgersdorp Formation Jd (pink) = Early Jurassic intrusions of the Karoo Dolerite Suite Pale yellow areas = Late Caenozoic alluvium

The Burgersdorp Formation is a mudrock-rich succession of Early to Mid Triassic age with a total thickness of some 900-1000m in its southern outcrop area near Queenstown (Johnson *et al*., 2006). Brief geological descriptions of the formation are given by Johnson (1984), Johnson & Hiller (1990), Kitching (1995) and Hancox (2000; see also extensive references therein). The Burgersdorp rocks were laid down within the Main Karoo Basin by northwards-flowing meandering rivers during a warm, arid to semi-arid climatic interval. They comprise lenticular, feldspathic channel sandstones and typically greyish-red to dusky red mudrocks. Intraformational mudflake breccio-conglomerates are common at the base of the sandstone units. The mudrocks are generally massive (unbedded) but occasionally display sand-infilled mudcracks and clastic dykes. Well-laminated mudrocks with pedocrete horizons are interpreted as playa lake deposits

The Burgersdorp sediments are extensively intruded by dolerites of the Early Jurassic **Karoo Dolerite Suite** (**Jd** in Fig. 2). A major, resistant-weathering, E-W trending dolerite intrusion forms a line of hills between, and along the margins of, the three water development schemes. Much of the adjacent Burgersdorp Formation outcrop is likely to be covered with doleritic colluvium (slope

deposits), appearing rusty-brown on satellite images, and also to have been thermally metamorphosed as a result of dolerite intrusion. Furthermore, these Mesozoic bedrocks are extensively mantled by much younger alluvial sediments of the White Kei drainage system in the southern part of the study area (pale yellow in Fig. 2). Surface exposure of fresh Beaufort Group rocks within the development areas is therefore likely to be generally poor, judging from satellite images, apart from occasional stream beds, dongas and steeper hillslopes. Thicker accumulations of sandy, gravelly and bouldery alluvium of Late Caenozoic age (< 5Ma) can found in stream and river beds. These colluvial and alluvial deposits may be extensively calcretised (*i.e.* cemented with soil limestone or calcrete), especially in the neighbourhood of dolerite intrusions.

4. PALAEONTOLOGICAL HERITAGE

The Burgersdorp Formation is characterized by a diverse continental fossil biota of Early to Mid Triassic (Olenekian to Anisian) age, some 249 to 237 milllion years old (Rubidge 2005). The fauna is dominated by a wide variety of tetrapod taxa, notably a range of amphibians, reptiles and therapsids ("Mammal-like reptiles"). This distinctive biota is referred to the ***Cynognathus* Assemblage Zone** (= *Kannemeyeria – Diademodon* Assemblage Zone of earlier authors; see Kitching 1995).

Useful accounts of the palaeontological heritage of this stratigraphic unit – which has recently being recognised as one of the richest Early-Mid Triassic biotas worldwide – are given by Kitching (1977, 1995), Keyser and Smith (1977-78), MacRae (1999), Hancox (2000; see also many references therein), Cole *et al.* (2004) and Rubidge (2005). The Burgersdorp biotas include a rich freshwater vertebrate fauna, with a range of fish groups (*e.g.* sharks, lungfish, ray-finned bony fish) as well as large capitosaurid and trematosuchid amphibians; the latter are of considerable important for long-range biostratigraphic correlation. The interesting reptile fauna includes lizard-like sphenodontids, beaked rhynchosaurs, and various primitive archosaurs (distant relatives of the dinosaurs) such as the crocodile-like erythrosuchids, some of which reached body lengths of 5m. The therapsid fauna contains large herbivorous dicynodonts like *Kannemeyeria* (Fig. 3), which may have lived in herds, *plus* several small to medium-sized carnivorous or herbivorous therocephalians and cynodonts. The most famous cynodont here is probably the powerful-jawed cynodont *Cynognathus* (Fig. 3), but remains of the omnivorous genus *Diademodon* are much commoner. Tetrapods are also represented by several fossil trackways while large *Cruziana*–like burrow systems with coarsely scratched ventral walls are attributed to burrowing vertebrates (*cf* Shone 1978). Locally abundant vertebrate burrows have been attributed to small procolophonid reptiles. Contemporary invertebrate faunas are still very poorly known. Freshwater unionid molluscs are rare, while the chitinous exoskeletons of the once-abundant terrestrial arthropods do not preserve well in the highly oxidising arid-climate sediments found here; arthropod trace fossils are known but so far no fossil insects. Likewise fossil plants of the characteristic Triassic *Dicroidium* Flora are poorly represented. They include lycophytes (club mosses), ferns (including horsetails), "seed ferns" (*e.g. Dicroidium*) and several gymnospermous groups (conifers, cycads *etc*) (Anderson & Anderson, 1985). A small range of silicified gymnospermous fossil woods are also present (Bamford 1999, 2004).

According to Kitching (1995) fossil bones, including some well-articulated skeletons are associated with "thin localised lenses of silty sandstone". Pedogenic, brown-weathering calcrete concretions occasionally contain complete fossil skeletons, while transported "rolled" bone is associated with conglomeratic facies at the base of channel sandstones.

The biostratigraphy of the Early–Mid Triassic sediments of the Karoo Supergroup (Tarkastad Subgroup) has been the focus of considerable palaeontological research in recent years, and the subdivision of the *Cynognathus* Assemblage Zone into three subunits has been proposed by several authors (See Hancox *et al.*, 1995, Hancox 2000, Neveling *et al.,* 2005, Rubidge 2005 and refs therein). Recent research has also emphasized the rapidity of faunal turnover during the

transition between the sand-dominated Katberg Formation (*Lystrosaurus* Assemblage Zone) and the overlying mudrock-dominated Burgersdorp Formation (Neveling *et al.,* 2005).

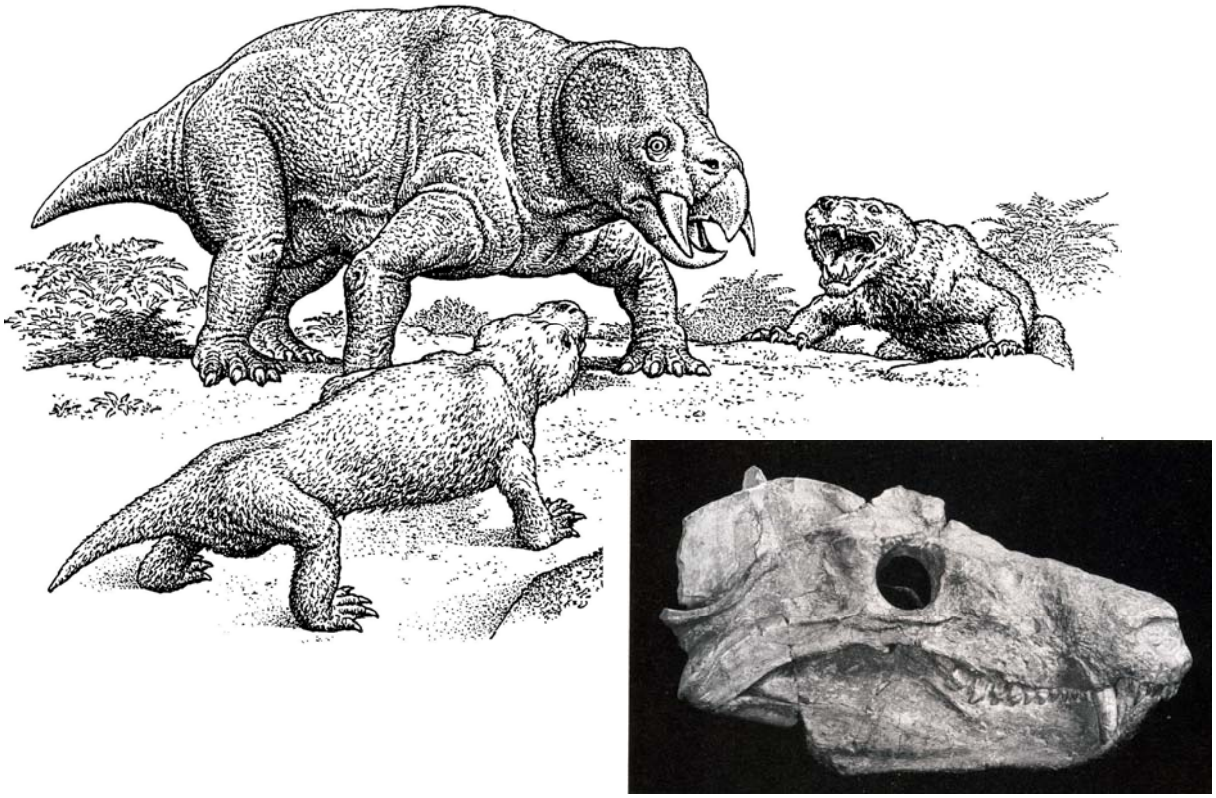

Fig. 3. Reconstruction of typical therapsids of the Early Triassic *Cynognathus* Assemblage Zone - the large tusked dicynodont *Kannemeyeria* and the predatory, bear-sized cynodont *Cynognathus*. The inset shows the heavily-built skull of *Cynognathus* (*c*. 30cm long) in lateral view.

The Karoo dolerites are igneous rocks, intruded at depth within the crust, and therefore do not contain fossils. The much younger superficial deposits (colluvium, gravels, silty alluvium *etc*) in the Karoo region as a whole have been comparatively neglected in palaeontological terms for the most part. However, they may occasionally contain important fossil biotas, notably the bones, teeth and horn cores of mammals (*e.g.* Skead 1980, Klein 1984, MacRae 1999, Partridge & Scott 2000, Partridge *et al.,* 2006). Other late Caenozoic fossil biotas from these superficial deposits include non-marine molluscs (bivalves, gastropods, rhizoliths), ostrich egg shells, trace fossils (*e.g.* calcretised termitaria, coprolites), and plant remains such as peats or palynomorphs (pollens) in organic-rich alluvial horizons.

5. CONCLUSIONS & RECOMMENDATIONS

The Burgersdorp Formation sediments underlying the study area are potentially highly fossiliferous, having yielded elsewhere a diverse biota of Early to Mid Triassic vertebrates, trace fossils and plants. However, in the Cofimvaba – Queenstown area these rocks are poorly exposed due to a mantle of colluvium (*e.g.* doleritic scree) and alluvium. Furthermore, they have been thermally metamorphosed during dolerite intrusion, reducing their palaeontological heritage value. The Karoo dolerites contain no fossils, and the palaeontological sensitivity of the superficial sediments is generally low.

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6. ACKNOWLEDGEMENTS

Mr Conroy van der Riet, Senior Environmental Consultant for Biotechnology & Environmental Specialist Consultancy cc, East London is thanked for commissioning this study and for kindly providing the necessary background information.

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QUALIFICATIONS & EXPERIENCE OF THE AUTHOR

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 under the aegis of his Cape Town-based company *Natura Viva* cc. He is 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 APHAP (Association of Professional Heritage Assessment Practitioners – Western Cape).

Declaration of Independence

I, John E. Almond, declare that I am an independent consultant and have no business, financial, personal or other interest in the proposed water development projects, application or appeal in respect of which I was appointed other than fair remuneration for work performed in connection with the activity, application or appeal. There are no circumstances that compromise the objectivity of my performing such work.

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