Palaeontological specialist assessment: desktop study

PROPOSED DEVELOPMENT OF EXISTING BOREHOLES AND CONSTRUCTION OF ASSOCIATED INFRASTRUCTURE TO AUGMENT THE POTABLE WATER SUPPLY FOR WILLISTON, NORTHERN CAPE

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EXECUTIVE SUMMARY

The Karoo-Hoogland Municipality, Northern Cape, is proposing to upgrade the potable water supply for the small Karoo town of Williston. It is proposed to equip existing boreholes with pumps and to pump the water *via* new Ø200 mm pipelines to an existing reservoir situated to the northeast of the town. The application also includes a new rising main which will pump water from the nearby Sak River to an existing dry dam in Williston. The trenches for the pipelines will be 750 mm wide and 1.5 m deep. The new pipelines will follow the routes of the existing pipelines and will be situated within 2 m of the existing pipelines.

Of the various existing and proposed borehole sites as well as proposed new pipeline sectors (See Figure 1 herein), the great majority (and perhaps all) lie within the outcrop area of unfossiliferous Karoo dolerite shown on the relevant geological map (Figure 2 herein). Satellite images suggest that the dolerite at some sites is mantled by superficial deposits (colluvium, alluvium) of low palaeontological sensitivity. Existing borehole WN7, situated about 4 km southeast of Williston, as well as its proposed new pipeline may be sited within the outcrop area of the Waterford (Koedoesberg) Formation or an associated dolerite intrusion. However, these sedimentary bedrocks are only of moderate palaeosensitivity (*e.g.* low-diversity trace fossils, petrified wood), and may well have been intensively baked by dolerite intrusion, while the combined borehole / pipeline footprint is very small. None of the existing or proposed boreholes, pipelines or associated infrastructure intersects potentially fossiliferous older (Neogene – Pleistocene) alluvial deposits that are mapped along some sectors of the Sakrivier. The proposed new pumpstation on the banks of the Sakrivier apparently overlies younger alluvial deposits - although older deposits may be present here subsurface - and also has a small footprint.

It is concluded that no significant impacts on local fossil heritage are anticipated as a result of the proposed potable water supply upgrade at Williston. It is therefore recommended that, pending the discovery of substantial new fossils remains before or during construction, exemption from further specialist palaeontological studies and mitigation be granted for the proposed development.

Should any substantial fossil remains (*e.g.* petrified wood, mammalian bones and teeth) be encountered during excavation, however, these should be safeguarded, preferably *in situ*, and reported by the ECO to SAHRA, *i.e.* The South African Heritage Resources Authority, as soon as possible (Contact details: Mrs Colette Scheermeyer, P.O. Box 4637, Cape Town 8000. Tel: 021 462 4502. Email: cscheermeyer@sahra.org.za) so that appropriate action can be taken by a professional palaeontologist, at the developer's expense. Mitigation would normally involve the scientific recording and judicious sampling or collection of fossil material as well as associated geological data (*e.g.* stratigraphy, sedimentology, taphonomy) by a professional palaeontologist. These recommendations should be included in the EMPr for the proposed development.

1. INTRODUCTION

1.1. Project outline and brief

The Karoo-Hoogland Municipality, Northern Cape, is proposing to upgrade the potable water supply for the small Karoo town of Williston that is totally dependent on groundwater supplies, mainly abstracted from production boreholes situated in and around the town. In order to increase the town water supply it is proposed to equip existing boreholes with pumps and to pump the water *via* new Ø200 mm pipelines to an existing reservoir situated to the northeast of the town. The application also includes a new rising main which will pump water from the nearby Sak River to an existing dry dam in Williston. The trenches for the pipelines will be 750 mm wide and 1.5 m deep. The new pipelines will follow the routes of the existing pipelines and will be situated within 2 m of the existing pipelines.

The following brief project description has been abstracted from the Pre-Application Information Document prepared by Sharples Environmental Services cc (March 2015) (See also Fig. 1):

> The proposal entails the development of existing boreholes and construction of associated infrastructure to augment the water supply for the town of Williston, Northern Cape. Water from the boreholes will be pumped via Ø200 mm pipelines to an existing reservoir situated northeast of the town. From here the water is fed *via* an existing pipeline to an existing reservoir. As with most of the pipelines in the area, the pipelines will cross non-perennial drainage lines. The stream / drainage line crossings will be by means of underground crossings and probably in concrete casing. The proposal also includes the construction of a new pumpstation near the Sak River south of the town which will pump water *via* a new rising main to an existing dam in Williston. There are existing pumps at the site which were used to pump water from the river to

the existing dam in the north of the town. The dam is an earthen dam so it is unclear as to how enough water will be pumped to fill it. The water will be pumped from the pump station to the earthen dam *via* an asbestos pipe. The pipeline has however been abandoned and has become damaged over the years.

The boreholes and pipelines are all situated on the Remainder of Erf 255 which is owned by the Karoo-Hoogland Municipality. The borehole coordinates are:

Borehole No.	**Latitude**	**Longitude**
WN1	31°19'41.23"S	20°56'16.62"E
WN3	31°20'00.38"S	20°55'41.20"E
WN6	31°19'32.09"S	20°53'05.32"E
WN7	31°21'54.04"S	20°57'04.75"E
WN9	31°18'49.00"S	20°57'52.27"E
WN10	31°18'47.38"S	20°57'53.24"E
WNE1	31°19'36.48"S	20°57'58.32"E
WNE2	31°19'47.82"S	20°52'41.63"E
WNE4	31°19'46.45"S	20°53'31.52"E
WNE5	31°20'30.59"S	20°52'51.74"E
Existing reservoir	31°19'55.46"S	20°55'58.27"E

The pipelines lengths are:

Pipeline section	**Length in km (approximate)**
WNE5 to connection on WNE2 line (**Section 1**)	1.33km
WN6 to connection on WNE2 line (**Section 2**)	0.45km
WNE2, WNE4 to existing reservoir (**Section 3**)	5.30km
WN3 to existing reservoir (**Section 4**)	0.50km
WN7 to existing reservoir (**Section 5**)	4.00km
WNE3 to connection on WN10, WN9 and WN1 line (**Section 6**)	1.65km
WN10, WN9 and WN1 to existing reservoir (**Section 7**)	3.99km

The proposed development area is underlain by extensive dolerite intrusions as well as potentially fossiliferous sedimentary rocks of Middle Permian and Late Caenozoic age (Sections 2 and 3). The construction phase of the development will entail excavations into the bedrocks and superficial sediment cover (*e.g.* for pipelines, new boreholes, stream crossings, pumpstation foundations). All these developments may adversely affect potential fossil heritage at or beneath the surface of the

ground within the study area by destroying, disturbing or permanently sealing-in fossils that are then no longer available for scientific research or other public good.

All palaeontological heritage resources in the Republic of South Africa are protected by the National Heritage Resources Act (Act 25 of 1999) (See Section 1.2 below). Heritage resource management in the Northern Cape is the responsibility of the South African Heritage Resources Agency, SAHRA (Contact details: Mrs Colette Scheermeyer, P.O. Box 4637, Cape Town 8000. Tel: 021 462 4502. Email: cscheermeyer@sahra.org.za). The Final Comment issued by SAHRA for the present development proposal (SAHRA Case ID: 7373) stated that:

> According to the SAHRA fossil sensitivity map the area is considered to be of moderate sensitivity, and a desktop palaeontological assessment will be required and submitted to SAHRA before construction commences.

A palaeontological heritage (desktop) assessment for the Williston water supply project study area has been commissioned by Sharples Environmental Services cc on behalf of Lyners Consulting Engineers and the applicant, the Karoo-Hoogland Municipality, as part of a Environmental Permitting Process for this development (Basic Assessment Process in terms of the National Environmental Management Act, Act No. 107 of 1998, as amended, and the Environmental Impact Assessment Regulations (2014)) (Contact details: Mr Steve Kleinhans. Sharples Environmental Services cc. Tel: 044 873 4923. Mob: 079 881 4984. Fax: 044 874 5953. E-mail: steve@sescc.net. Address: 102 Merriman Street. PO Box 9087. George 6530. Website: www.sescc.net).

1.2. Legislative context for palaeontological assessment studies

The various categories of heritage resources recognised as part of the National Estate in Section 3 of the National Heritage Resources Act (Act 25 of 1999) include, among others:

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

According to Section 35 of the National Heritage Resources Act, dealing with archaeology, palaeontology and meteorites:

(1) The protection of archaeological and palaeontological sites and material and meteorites is the responsibility of a provincial heritage resources authority.

(2) All archaeological objects, palaeontological material and meteorites are the property of the State.

(3) Any person who discovers archaeological or palaeontological objects or material or a meteorite in the course of development or agricultural activity must immediately report the find to the responsible heritage resources authority, or to the nearest local authority offices or museum, which must immediately notify such heritage resources authority.

(4) No person may, without a permit issued by the responsible heritage resources authority—
(a) destroy, damage, excavate, alter, deface or otherwise disturb any archaeological or palaeontological site or any meteorite;
(b) destroy, damage, excavate, remove from its original position, collect or own any archaeological or palaeontological material or object or any meteorite;
(c) trade in, sell for private gain, export or attempt to export from the Republic any category of archaeological or palaeontological material or object, or any meteorite; or
(d) bring onto or use at an archaeological or palaeontological site any excavation equipment or any equipment which assist in the detection or recovery of metals or archaeological and palaeontological material or objects, or use such equipment for the recovery of meteorites.
(5) When the responsible heritage resources authority has reasonable cause to believe that any activity or development which will destroy, damage or alter any archaeological or palaeontological site is under way, and where no application for a permit has been submitted and no heritage resources management procedure in terms of section 38 has been followed, it may—
(a) serve on the owner or occupier of the site or on the person undertaking such development an order for the development to cease immediately for such period as is specified in the order;
(b) carry out an investigation for the purpose of obtaining information on whether or not an archaeological or palaeontological site exists and whether mitigation is necessary;
(c) if mitigation is deemed by the heritage resources authority to be necessary, assist the person on whom the order has been served under paragraph *(a)* to apply for a permit as required in subsection (4); and
(d) recover the costs of such investigation from the owner or occupier of the land on which it is believed an archaeological or palaeontological site is located or from the person proposing to undertake the development if no application for a permit is received within two weeks of the order being served.

Minimum standards for the palaeontological component of heritage impact assessment reports (PIAs) have recently been published by SAHRA (2013).

1.3. Approach to the desktop palaeontological heritage study

The approach to this desktop palaeontological heritage study is briefly as follows. Fossil bearing rock units occurring within the broader study area are determined from geological maps and satellite images. Known fossil heritage in each rock unit is inventoried from scientific literature, previous assessments of the broader study region, and the author's field experience and palaeontological database. Based on this data as well as field examination of representative exposures of all major sedimentary rock units present, the impact significance of the proposed development is assessed with recommendations for any further studies or mitigation.

In preparing a palaeontological desktop study the potentially fossiliferous rock units (groups, formations *etc.*) represented within the study area are determined from geological maps and satellite images. 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 field assessment during the compilation of the final report). This data is then used to assess the palaeontological sensitivity of each rock unit to a development (Provisional tabulations of palaeontological sensitivity of all formations in the Northern Cape have already been compiled by J. Almond and colleagues; *e.g.* Almond & Pether 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 and scale of the development itself, most significantly the extent of fresh bedrock excavation envisaged. When rock units of moderate to high palaeontological sensitivity are present within the development footprint, a Phase 1 field assessment study by a professional palaeontologist is usually warranted to identify any palaeontological hotspots and make specific recommendations for any mitigation required before or during the construction phase of the development.

On the basis of the desktop and Phase 1 field assessment studies, the likely impact of the proposed development on local fossil heritage and any need for specialist mitigation are then determined. Adverse palaeontological impacts normally occur during the construction rather than the operational or decommissioning phase. Phase 2 mitigation by a professional palaeontologist – normally involving the recording and sampling of fossil material and associated geological information (*e.g.* sedimentological data) may be required (a) in the pre-construction phase where important fossils are already exposed at or near the land surface and / or (b) during the construction phase when fresh fossiliferous bedrock has been exposed by excavations. To carry out mitigation, the palaeontologist involved will need to apply for a palaeontological collection permit from the relevant heritage management authority (*e.g.* SAHRA for the Northern Cape). It should be emphasized that, *provided that appropriate mitigation is carried out*, the majority of developments involving bedrock excavation can make a *positive* contribution to our understanding of local palaeontological heritage.

1.4. Assumptions & limitations

The accuracy and reliability of palaeontological specialist studies as components of heritage impact assessments are generally limited by the following constraints:

1. Inadequate database for fossil heritage for much of the RSA, given the large size of the country and the small number of professional palaeontologists carrying out fieldwork here. Most development study areas have never been surveyed by a palaeontologist.

2. Variable accuracy of geological maps which underpin these desktop studies. For large areas of terrain these maps are largely based on aerial photographs alone, without ground-truthing. The maps generally depict only significant ("mappable") bedrock units as well as major areas of superficial "drift" deposits (alluvium, colluvium) but for most regions give little or no idea of the level of bedrock outcrop, depth of superficial cover (soil *etc.*), degree of bedrock weathering or levels of small-scale tectonic deformation, such as cleavage. All of these factors may have a major influence on the impact significance of a given development on fossil heritage and can only be reliably assessed in the field.

3. Inadequate sheet explanations for geological maps, with little or no attention paid to palaeontological issues in many cases, including poor locality information.

4. The extensive relevant palaeontological "grey literature" - in the form of unpublished university theses, impact studies and other reports (*e.g*. of commercial mining companies) - that is not readily available for desktop studies.

5. Absence of a comprehensive computerized database of fossil collections in major RSA institutions which can be consulted for impact studies. A Karoo fossil vertebrate database is now accessible for impact study work.

In the case of palaeontological desktop studies without supporting Phase 1 field assessments these limitations may variously lead to either:
(a) *underestimation* of the palaeontological significance of a given study area due to ignorance of significant recorded or unrecorded fossils preserved there, or
(b) *overestimation* of the palaeontological sensitivity of a study area, for example when originally rich fossil assemblages inferred from geological maps have in fact been destroyed by tectonism or weathering, or are buried beneath a thick mantle of unfossiliferous "drift" (soil, alluvium *etc.*).

Since most areas of the RSA have not been studied palaeontologically, a palaeontological desktop study usually entails *inferring* the presence of buried fossil heritage within the study area from relevant fossil data collected from similar or the same rock units elsewhere, sometimes at localities far away. Where substantial exposures of bedrocks or potentially fossiliferous superficial sediments are present in the study area, the reliability of a palaeontological impact assessment may be significantly enhanced through field assessment by a professional palaeontologist. In the present case, site visits to the various loop and borrow pit study areas in some cases considerably modified our understanding of the rock units (and hence potential fossil heritage) represented there.

In the case of the present study area near Williston the main constraint for fossil heritage studies is the limited knowledge of local fossil heritage resources based on specialist palaeontological fieldwork.

1.5. Information sources

The information used in this desktop study was based on the following:

1. A Pre-Application Information Document, accompanying maps and kmz files prepared by Sharples Environmental Services cc (March 2015)

2. A review of the relevant scientific literature, including published geological maps and accompanying sheet explanations (*e.g.* Viljoen 1989);

3. Examination of relevant topographical maps and satellite images;

4. The author's previous field experience with the formations concerned and their palaeontological heritage (See also review of Northern Cape fossil heritage by Almond & Pether 2008).

Figure 1. Outline of the proposed potable water supply infrastructure near the town of Williston, Northern Cape (Image prepared by Lyners Consulting Engineers, George). Solid red lines indicate new pipelines, the blue dotted line is the new rising main, while new and existing boreholes are marked by yellow tack symbols.

2. GEOLOGICAL OUTLINE OF THE STUDY AREA

The town of Williston lies within the north-western portion of the Main Karoo Basin of South Africa (Johnson *et al.* 2006). The geology of the Williston study area is outlined on the 1: 250 000 geology sheet 3120 Williston with a short accompanying sheet explanation by Viljoen (1989) (Fig. 2). The sedimentary bedrocks in the region belong to the upper part of the Ecca Group (Karoo Supergroup) and were originally mapped as the **Koedoesberg Formation** (Pko) which has subsequently been incorporated within the **Waterford Formation**.

The **Waterford Formation** (**Pw**) is a thick (up to *c*. 770 m), easterly-thinning wedge of fine-grained deltaic deposits of Middle Permian age that represent the last phase of infilling of the Ecca Basin before the onset of continental sedimentation of the Lower Beaufort Group. Dominant lithologies include fine greyish, massive lithofeldspathic sandstones and dark grey mudrocks (often including thin-bedded rhythmitites) that are structured into broadly coarsening-upwards, prograding cycles. Shallow water prodelta and delta platform sandstones capping the cycles typically show well-developed wave-rippled bedding planes and extensive evidence of soft-sediment deformation such as spectacular ball-and-pillow load structures. Large, ovoid ferruginous carbonate concretions of diagenetic origin are common. In the western outcrop area, the Waterford Formation has a mean thickness of *c*. 130 m and is interpreted as topset deposits of eastward-prograding fluvially-dominated deltas (Viljoen 1989, Wickens 1996, Johnson *et al.* 2006). Further eastwards along the north-western margin of the Main Karoo Basin, storm-dominated shelf deposits of the "Carnarvon facies" with a distinctly different sedimentology and ichnology predominate.

The Ecca Group sediments around Williston are very extensively intruded and thermally metamorphosed (baked) by sills and dykes of the **Karoo Dolerite Suite** (Jd) of Early Jurassic age (*c*. 183 Ma) which are unfossiliferous. These basic intrusions were emplaced during crustal doming and stretching that preceded the break-up of Gondwana (Duncan and Marsh 2006). The hot dolerite magma baked adjacent Karoo Supergroup mudrocks and sandstones to form splintery hornfels and quartzites respectively. Blocky colluvium and corestones released by weathering and erosion of the dolerites blanket many mountain slopes, obscuring the underlying fossiliferous Ecca Group sediments, as clearly seen in satellite images of the study area (rusty-brown areas). Areas of dolerite intrusion are typically associated with ferruginous lateritic soils and calcrete formation. The following description of the dolerite intrusions in the Williston area is provided in the Pre-Application Information Document for the potable water supply project prepared by Sharples Environmental Services cc (March 2015):

> In the areas north-east and south-west of Williston these intrusions occur in the form of stacked saucer type sills. The former mentioned is known as the "Williston Ring Complex" (Woodford, 2003) and dips gently to the south-east. Both ring structures form part of a larger mega ring complex and are also linked to higher elevations due to the weather-resistant character thereof.

> Numerous dykes occur throughout the area. These dykes seldom exceed 10 m in width and dips are generally sub-vertical to vertical (80º - 90º). Most commonly these dykes strike NE-SW or NW-SE. The only exception is the prominent east-west striking dyke that passes immediately north of the town. In the area immediately north-east of Williston, the Williston Ring Complex has been partially cut-off by this dyke which indicates that it has likely intruded along a fault zone.

Various types of **superficial deposits** of Late Caenozoic (Miocene / Pliocene to Recent) age occur widely throughout the Karoo region, including the study area. They include pedocretes (*e.g.*.calcretes or soil limestones), colluvial slope deposits (sandstone and dolerite scree, downwasted gravels *etc*), sheet wash, river channel alluvium and terrace gravels, soils, as well as spring and pan sediments (Cole *et al.,* 2004, Partridge *et al*. 2006). Larger tracts of Later Neogene to Quaternary alluvium overlying the Ecca Group and younger bedrocks are indicated in yellow in Figure 2. These include younger (Holocene – Recent) **alluvial deposits** as well as older (Neogene / Late Tertiary to Pleistocene) alluvial gravels ("**High Level Gravels**") associated with the ancient Sakrivier drainage system that runs to the southwest of Williston. According to the Pre-Application Information Document (Sharples Environmental Services cc, March 2015):

> The only alluvial deposits occur along the banks of the Sak River. These deposits vary from red and sandy to light grey and clayey and seldom exceed 10 m in vertical thickness. River terrace gravels are only developed along the banks of the Sak River. These deposits are generally 4 to 6 m thick and have been cemented by calcrete. The terraces are approximately 4 – 8 m above the present level of the riverbed.

Important accounts of the older, potentially-fossiliferous alluvial deposits of the Sakrivier drainage system have been given by De Wit (1993), Bamford and De Wit (1993), De Wit and Bamford (1993) and De Wit (1999), with Viljoen (1989) and Partridge *et al.* (2006) providing a more general context.

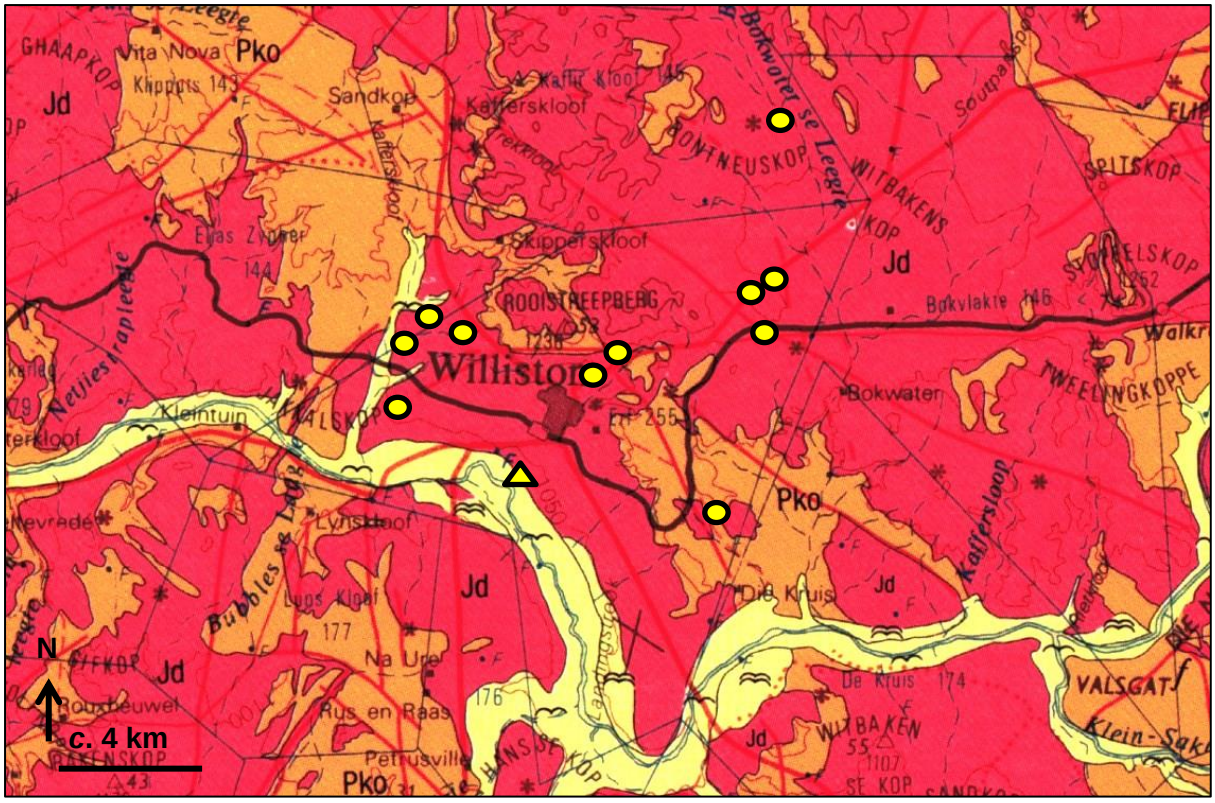

Figure 2. Extract from 1: 250 000 geology sheet 3120 Williston showing the geology of the study area for the Williston potable water supply scheme (Map published by the Council for Geoscience, Pretoria). Note that the road network shown here is now out of date. The yellow triangle shows the position of the proposed new pumpstation on the Sakrivier. Yellow circles are the *approximate* location of relevant boreholes.

The main rock units represented in the Williston study area include:

ECCA GROUP (KAROO SUPERGROUP)

Pko (pale brown) = Waterford Formation (previously Koedoesberg Fm)

KAROO DOLERITE SUITE

Jd (red) = intrusive sills and dykes.

LATE CAENOZOIC SUPERFICIAL DEPOSITS

Pale yellow = Late Caenozoic (Neogene to Recent) alluvium.

Double flying bird symbol = High Level Gravels of possible Neogene to Pleistocene age

3. PALAEONTOLOGICAL HERITAGE WITHIN THE STUDY AREA

Fossil heritage recorded within the major rock units represented in the Williston study area are outlined here, based on the palaeontological literature (*e.g.* Almond & Pether 2008, Almond 2008a, 2008b).

3.1. Fossils within the Waterford Formation

Delta platform facies of the Waterford Formation, including the "Koedoesberg facies" in the northwest, contain abundant, low diversity trace assemblages of the *Scoyenia* ichnofacies. They are dominated by the rope-like, horizontal and oblique burrows (5-6 mm wide) of the ichnogenus *Scoyenia* itself. These tubular, meniscate back-filled scratch burrows were constructed by small arthropods and characterise intermittently moist, firm substrates such as channel and pond margins on the upper delta platform (Smith & Almond 1998, Buatois & Mángano 2004, 2007). Good examples, often associated with wave-rippled surfaces, are recorded from Waterford thin-bedded sandstones and siltstones in the Roggeveld Escarpment zone by Wickens (1984, 1996) and Viljoen (1989).

Petrified wood and other plant material of the *Glossopteris* Flora (*e.g. Glossopteris. Phyllotheca*) is also common in the Waterford Formation (Anderson & Anderson 1985, Viljoen 1989, Wickens 1984, 1996, Rubidge *et al*. 2000). Leaves and stems of arthrophytes (horsetails) such as *Schizoneura* have been observed in vertical life position. Substantial fossil logs (so-called "*Dadoxylon*") showing excellent seasonal growth rings are seen in the Sutherland and Williston sheet areas as well as north of Matjiesfontein in the southern Karoo. Most are silicified, but partially or completely calcified wood is also known (Viljoen 1989). Thin section studies of petrified gymnospermous woods from the Ecca have differentiated at least two different genera, *Prototaxoxylon*, and *Australoxylon*, from the Ecca Group (Bamford 1999).

Tantalising but poorly preserved fragments of rolled tetrapod bone occur in channel lags within the uppermost Waterford Formation, as seen in the Williston sheet area (Viljoen 1989) and the southern Great Karoo. These probably belong to temnospondyl amphibians ("labyrinthodonts") but large fish and terrestrial therapsids are also possible sources. Scattered palaeoniscoid fish scales are common in the Waterford Formation, and several genera of non-marine bivalves have been described from the southern Karoo margins (Bender *et al*. 1991, Cooper & Kensley 1984).

3.2. Fossils within the Karoo Dolerite Suite

The dolerite outcrops in the study area are in themselves of no direct palaeontological significance since these are high temperature igneous rocks emplaced at depth within the Earth's crust. However, as a consequence of their proximity to large dolerite intrusions, the Ecca Group sediments nearby may well have been thermally metamorphosed or "baked" (*ie*. recrystallised, impregnated with secondary minerals). Embedded fossil material of phosphatic composition, such as bones and teeth, is frequently altered by baking – bones may become blackened, for example - and can 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 adjacent Karoo Supergroup sediments.

3.3. Fossil biotas within Late Caenozoic superficial deposits

Various types of superficial deposits ("drift") of geologically young, Late Caenozoic (Miocene / Pliocene to Recent) age occur throughout the Great Karoo region. They include pedocretes (*e.g.* calcretes), colluvial slope deposits (sandstone and dolerite scree *etc*), river alluvium, as well as spring and pan sediments (*e.g.* Partridge *et al*. 2006). These Karoo drift deposits have been comparatively neglected in palaeontological terms for the most part. However, older (Quaternary or earlier) alluvial sediments, such as seen along larger drainage systems, 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, Brink & Rossouw 2000, Churchill *et al.* 2000, Rossouw 2006). 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, *rhizoliths* or plant root casts), and plant remains such as peats or palynomorphs (pollens) in organic-rich alluvial horizons.

A range of Miocene to Pleistocene plant and vertebrate fossils has been recorded in association with ancient fluvial terrace deposits – including those of the Sakrivier - in the Brandvlei region of the Northern Cape, to the west and northwest of Williston (See Figure 3). Calcretised basal alluvial facies at Piet Louw's Vlei, relicts of the north-south trending Mid-Tertiary Geelvloer Palaeo-valley, contain bones of hippopotamus-like artiodactyls called anthracotherids indicating a Miocene age (De Wit 1993, 1999, De Wit *et al*. 2000). Anthracotherids are an extinct group of amphibious mammalian herbivores only distantly related to true hippos that were widespread in the Miocene of Africa (Schneider & Marais 2004). Early to Middle Miocene silicified woods from Piet Louw's Vlei are referable to a number of extant tree families, including the Dipterocarpaceae that mainly inhabit tropical forests in Africa and Asia today. The fossil woods and associated sediments indicate that warm, tropical to subtropical climates prevailed in the Mid Miocene and that perennial, low-sinuousity braided river systems supported lush riparian forests (De Wit & Bamford 1993, Bamford & De Wit 1993, Bamford 2000). Wet, weakly seasonal climates are suggested by the structure (indistinct growth rings) and dimensions (trunk diameters of over 50 cm) of the fossil woods (Bamford 2000).

Abraded Plio-Pleistocene fossil woods from relict alluvial terraces of the Sakrivier just north of Brandvlei include members of the Family Polygalaceae and also indicate humid growth conditions (Bamford & De Wit 1993, De Wit & Bamford 1993, De Wit 1999). These terraces were formed by meandering rivers during intermittent pluvial (*i.e.* wetter), but still semi-arid, episodes following the onset of generally arid conditions in the western portion of southern Africa towards the end of the Miocene.

Although there are no fossil records from the older, calcretised alluvial deposits of the Sakrivier near Williston, they may potentially contain important Late Tertiary to Pleistocene fossil woods and mammalian remains.

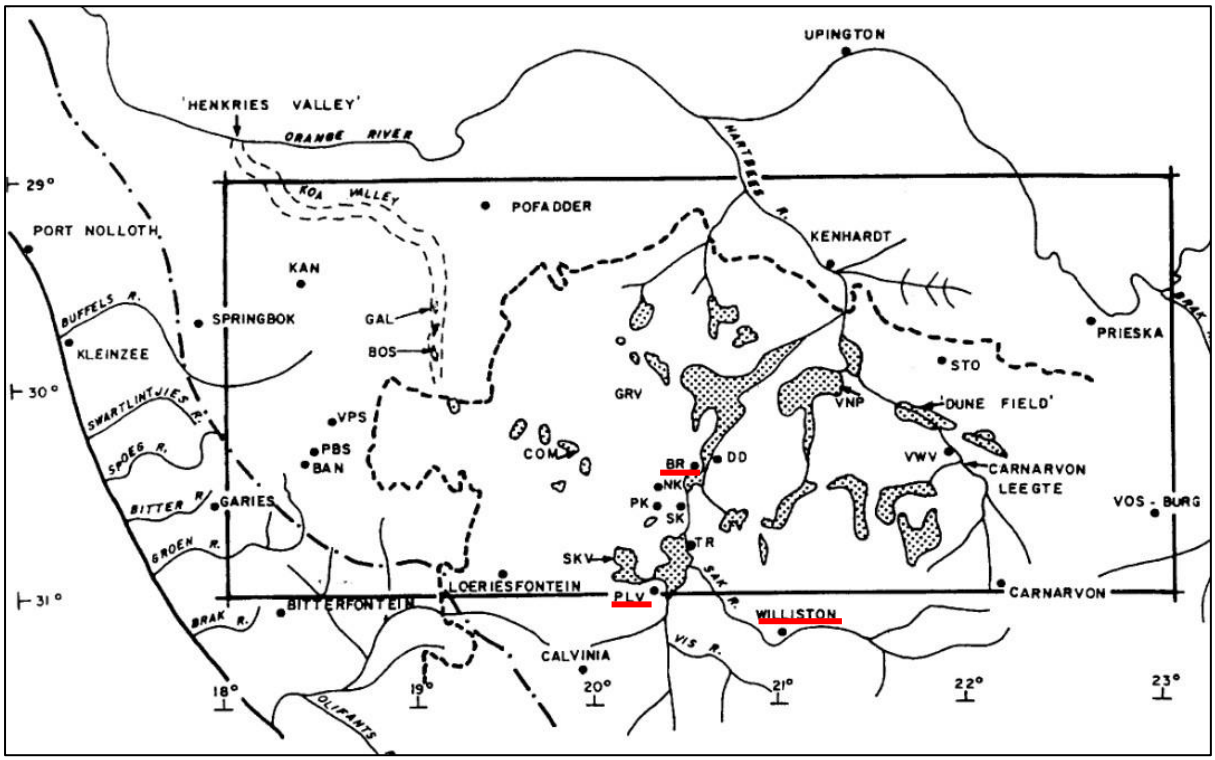

Figure 3. Map showing relict Tertiary drainage systems of the Northern Cape, including that associated with the present Sakrivier that flows south and west of Williston (From De Wit 1999). Important Late Tertiary (Neogene) and Plio-Pleistocene fossil localities associated with the broader Sakrivier drainage system occur, for example, near Brandvlei (BR) and Piet Louw's Vlei (PLV).

4. CONCLUSIONS AND RECOMMENDATIONS

Of the various existing and proposed borehole sites as well as proposed new pipeline sectors indicated in Figure 1, the great majority (and perhaps all) lie within the outcrop area of unfossiliferous Karoo dolerite shown on the geological map (Figure 2). Satellite images suggest that the dolerite at

some sites is mantled by superficial deposits (colluvium, alluvium) of low palaeontological sensitivity. Existing borehole WN7, situated about 4 km southeast of Williston, as well as its proposed new pipeline may be sited within the outcrop area of the Waterford (Koedoesberg) Formation or an associated dolerite intrusion. However, these sedimentary bedrocks are only of moderate palaeosensitivity (*e.g.* low-diversity trace fossils, petrified wood), and may well have been intensively baked by dolerite intrusion, while the combined borehole / pipeline footprint is very small. None of the existing or proposed boreholes, pipelines or associated infrastructure intersects potentially fossiliferous older (Neogene – Pleistocene) alluvial deposits that are mapped along some sectors of the Sakrivier. The proposed new pumpstation on the banks of the Sakrivier apparently overlies younger alluvial deposits - although older deposits may be present here subsurface - and also has a small footprint.

It is concluded that no significant impacts on local fossil heritage are anticipated as a result of the proposed potable water supply upgrade at Williston. It is therefore recommended that, pending the discovery of substantial new fossils remains before or during construction, exemption from further specialist palaeontological studies and mitigation be granted for the proposed development.

Mitigation measures for inclusion in the Environmental Management Programme

1. Should any substantial fossil remains (*e.g.* petrified wood, mammalian bones and teeth) be encountered during excavation, however, these should be safeguarded, preferably *in situ*, and reported by the ECO to SAHRA, *i.e.* The South African Heritage Resources Authority, as soon as possible (Contact details: Mrs Colette Scheermeyer, P.O. Box 4637, Cape Town 8000. Tel: 021 462 4502. Email: cscheermeyer@sahra.org.za) so that appropriate action can be taken by a professional palaeontologist, at the developer's expense. Mitigation would normally involve the scientific recording and judicious sampling or collection of fossil material as well as associated geological data (*e.g.* stratigraphy, sedimentology, taphonomy) by a professional palaeontologist. This must also be included as a condition of the Environmental Authorisation should the proposal be approved.

5. ACKNOWLEDGEMENTS

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7. 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 as well as Limpopo, Free State, Mpumalanga and Northwest Provinces under the aegis of his Cape Town-based company *Natura Viva* cc. He has served for several years as a 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).

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 development project, 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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- **Honours Degree in Natural Sciences (Zoology)**, University of Cambridge, UK (1980).

- **PhD in Earth Sciences (Palaeontology)**, University of Cambridge, UK (1986).

- **Post-doctoral Research Fellowships** at University of Cambridge, UK and Tübingen University, Germany (Humboldt Research Fellow).

- **Visiting Scientist** at various research institutions in Europe, North America, South Africa and fieldwork experience in all these areas, as well as in North Africa.

- **Scientific Officer, Council for Geoscience, RSA** (1990-1998) – palaeontological research and fieldwork – especially in western RSA and Namibia.

- **Managing Member, *Natura Viva* cc** – a Cape Town-based company specialising in broad-based natural history education, tourism and research – especially in the Arid West of Southern Africa (2000 onwards). *Natura Viva* cc produces **technical reports** on palaeontology, geology, botany and other aspects of natural history for public and private nature reserves.

- **Current palaeontological research** focuses on fossil record of the Precambrian / Cambrian boundary (especially trace fossils), and the Cape Supergroup of South Africa.

- **Registered Field Guide** for **South Africa** and **Namibia**

- **Member of the A-team, Botanical Society of SA** (Kirstenbosch Branch) – involved in teaching and training leaders for botanical excursions. Invited leader of annual Botanical Society excursions (Kirstenbosch Branch) to Little Karoo, Cederberg, Namaqualand and other areas since 2005.

- **Professional training of Western and Eastern Cape Field Guides** (FGASA Level 1 & 2, in conjunction with *The Gloriosa Nature Company*) and of Tourist Guides in various aspects of natural history.

- Involved in **extra-mural teaching in natural history** since the early 1980s. Extensive experience in **public lecturing**, running **intensive courses** and leading **field excursions for professional academics as well as enthusiastic amateurs** (*e.g.* Geological Society / Archaeological Society / Friends of the SA Museum / Cape Natural History Club / Mineral Club / Botanical Society of South Africa / SA Museum Summer & Winter School Programmes / UCT Summer School)

- **Development of palaeontological teaching materials** (textbooks, teachers guides, palaeontological displays) and **teacher training** for the new school science curriculum (GET, FET).

- Former long-standing member of **Archaeology, Palaeontology and Meteorites Committee for Heritage Western Cape (HWC)**. Advisor on palaeontological conservation and management issues for the Palaeontological Society of South Africa (PSSA), HWC and SAHRA (including APM Permit Committee at HWC). Compilation of **technical reports on provincial palaeontological heritage of Western, Northern and Eastern Cape** for SAHRA and HWC. Accredited member of PSSA and APHP (Association of Professional Heritage Practitioners, Western Cape).

- **Palaeontological impact assessments for developments in the Western Cape, Eastern Cape, Northern Cape, Free State, Northwest Province, Mpumulanga, Gauteng.**

- Several hundred **palaeontological heritage desktop studies and field assessments** completed over the past few years.

- **Reviews of fossil heritage** related to new 1: 250 000 geological maps published by the Council for Geoscience (Geological Survey of SA) – *e.g.* Clanwilliam, Loeriesfontein, Alexander Bay sheets.