Phase 1 Palaeontological Impact Assessment of a proposed water pipeline between Cannon Rocks and Kenton-on-Sea and between Cannon Rocks and Alexandria, EC Province.

Report prepared for Coastal Environmental Services

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Executive Summary

- A Phase 1 Palaeontological Impact Assessment was conducted between Kenton-on-Sea and Alexandria along designated routes earmarked for a pipeline to supply regional bulk water in the area.
- The proposed development will affect Palaeozoic and Late Cenozoic strata of variable palaeontological significance.
- Most of the Bokkeveld Group strata in the survey area belong to the upper, unfossilliferous Traka Subgroup.
- Conglomerates, sandstones and coquinites of the Algoa Group Alexandria Frm. are only minimally exposed and are not well represented in the survey area.
- Outcrops of Plio-Pleistocene aeolinites represented by the Nanaga Frm. (Algoa Group) are widely distributed and represent the predominant geological stratum within the footprint. Impact on potential *in situ* fossil material within the formation, as well as the overall palaeontological significance of the Nanaga Frm. is considered low.
- The intact Nahoon Frm. aeolinites recorded at Cannon Rocks have the potential to yield Quaternary vertebrate remains and trace fossils and is considered vulnerable with regard to the proposed development.
- There are no objections to the planned development on palaeontological grounds, provided that three subsections of the route, namely where the pipeline crosses the Boknes River, the section between the Bushmans River and Kenton on Sea reservoirs, and where reticulation exits into the sea at Cannon Rocks, are closely monitored during the construction phase of development when trench excavations are to be conducted.

Contents

Introduction

Amatola Water has been appointed by the Department of Water Affairs, on behalf of Ndlambe Municipality, to implement a regional bulk water supply project within the Ndlambe Municipality between Kenton-on-Sea and Alexandria in the Eastern Cape Province (**Fig. 1**). The author of this report was commissioned by Coastal Environmental Services to conduct a Phase 1 Palaeontological Impact Assessment along designated routes outlined by the proposed development. The survey is required as a prerequisite for new development in terms of the National Environmental Management Act and is also called for in terms of the National Heritage Resources Act 25 of 1999. The investigation was conducted in May 2012.

Terms of Reference

Existing, and new boreholes located predominantly on municipal land near Cannon Rocks, will be exploited in order to provide up to 7.5 Ml/day of raw water to an existing brackish reverse osmosis (BWRO) water treatment works (Fig. 2). The plant will supply up to 5.5 Ml/day of potable water and construction of bulk reticulation will provide water to Boknes and Kenton on Sea (**Fig. 2**, white line), as well as to Alexandria via an existing, refurbished pipeline which passes through the Woody Cape section of the Addo Elephant National Park (**Fig. 2**, red line). The brine generated by the BWRO plant will be reticulated to a sea outfall.

The palaeontological assessment requires:

identification and recording of potential palaeontological heritage resources in the proposed areas of impact and;

recommendation of mitigation measures if necessary to minimize potential impacts associated with the proposed development.

Description of the Affected Area

Details of area surveyed

Locality data

Map reference: 3326 DA & DC Boesmansriviermond
3326 CB & CD Alexandria

Province: Eastern Cape

Municipality: Ndlambe

Methodology

The baseline study involved a vehicle and pedestrian survey of the designated routes. Common intrusive and erosional features like testpits, excavations, outcrops and gullies were also investigated for tell-tale signs of exposed paleontological material. A Garmin Etrex Vista GPS hand model (set to the WGS 84 map datum) and a digital camera, were used to record relevant data. Relevant palaeontological information were assimilated for the report and integrated with data acquired during the on-site inspection.

Geology of the affected area

The present-day geomorphology of the landscape in the region forms part of the African Erosion Surface, and is the result of prolonged erosion and weathering that occurred throughout the subcontinent since the late Jurassic (145 Ma) until the end of the early Miocene around 15 Ma ago (Partridge and Maud, 1987). Post-Cretaceous epeirogenic events caused warping and periodic seaward tilting of the coastal belt and extensive planation from the coast inland, in time resulted in the exposure of the Cape Fold Mountains as well as the creation of the Great Escarpment and the Coastal Platform. The tectonic overprint of the Cape Folding Event and the creation of the African Land Surface in the region have in many cases been detrimental to the preservation of fossils in the underlying rocks.

The geology and palaeontology of the region has been described by Engelbrecht *et al.* (1962), Oosthuizen (1984), Partridge and Maud (1987) Illenberger (1992), Johnson and Le Roux (1994), Le Roux (1987, 1989, 1990, 1991, 1992, 2000), Maud and Botha (1999), Thamm and Johnson (2006) and Roberts *et al.* (2006). The study area is underlain by Palaeozoic and Cenozoic sediments. These are sediments of widely different geological ages (**Fig. 3**).

Bokkeveld Group

Palaeozoic Cape Supergroup strata is represented by Bokkeveld Group sediments (*Db*), which makes up the uppermost part of the Palaeozoic sequence in the study region (**Fig 4**). The Bokkeveld Group are highly folded and poorly exposed in the region as a result of the tectonic overprint of the Cape Folding Event, which makes identification of individual formations difficult. Cape Supergroup sediments have been severely deformed during the Cape Folding Event which took place about 310

million years ago. Lateral compression produced zones of intense folding. Undifferentiated strata of the Bokkeveld Group (*Db*) consist of an alternation of thick shale and thinner sandstone formations of Early to Middle Devonian age. The sandstone formations are interpreted as having been deposited along an epicontinental sea margin and the shale formations in the off-shore regions.

Algoa Group

The Bokkeveld Group strata in turn are unconformably overlain by Neogene marine deposits, aeolianites and non-calcareous coastal dunefields of the Algoa Group (Aexandria, Nanaga, Salnova Nahoon and Schelm-Hoek Formations).Sediments associated with Algoa group consist mainly of calcareous sandstone, sandy limestone, conglomerate and coquinite. The Alexandria Frm. (*Ta*) comprises a basal conglomerate of oyster shells, covered by interbedded calcareous sandstones, pebbly coquina and thin conglomerates. The Alexandria Frm. is regarded as mainly a littoral deposit and its deposition is related to a series of Middle Miocene to Pliocene marine transgression / regression cycles.

The paraconformably overlying Nanaga Frm. (*T-Q*) represents of Pliocene to Early Pleistocene aeolian sediments, occurring up to 40km inland from the coast. These aeolian deposits formed during the Neogene regressions when the Alexandria Frm. was deposited. Originally laid down as coastal dunefields, the Nanaga Formation consists of semi- to well-consolidated calcareous sandstone and sandy limestones that form smooth rounded hills with undulating ridges lying sub-parallel to the present coastline **(Fig. 4 & 5**).

Aeolian sandstones, conglomerates and unconsolidated sand dunes of the Pleistocene aged Salnova (*Qs)* and Nahoon *(Qn*) Formations occur as discontinuous outcrops along the present coastline and the lower courses of the Boesmans and Boknes Rivers (**Fig. 4**). The Salnova Frm. represents calcareous sand, coquina and shelly limestone deposits of marine or estuarine origin, accumulated at high sea level stands (< 18 m above msl) during one or more Quaternary interglacials. A small outcrop of the formation is present at Cape Padrone (**Fig 4**).

The Nahoon Formation occurs within the first few hundred meters inland from the high-water mark and was deposited during regressions associated with the last two glacial periods. It consists of calcareous sandstones with interbedded palaeosols (**Fig. 4 & 6**).

The Nanaga, Salnova and Nahoon Formations in turn are overlain by wind-blown calcareous and non-calcareous sand in the form of coastal dune fields of Holocene age. These unconsolidated coastal dune fields represent the Schelm Hoek Formation, which makes up the uppermost unit of the Algoa Group (**Fig. 4 & 7**). The formation comprises a number of active coastal dune fields occurring adjacent to the coastline, but the Alexandria and Schelm Hoek coastal dune fields at Algoa Bay constitute the type area. The dunes are often vegetated, especially along their inland margins. Intercalated shell middens (archaeological) and poorly developed soil horizons are occasionally present.

Palaeontological Background

Bokkeveld Group

Undifferentiated strata of Ceres and Traka Subgroups make up the uppermost part of the Palaeozoic sequence in the region (*Db***, Fig. 4**). Although most of the Bokkeveld strata in the study area would appear to belong to the upper, unfossilliferous Traka Subgroup, the palaeontology of the Bokkeveld Group strata is characterized by a wide variety of benthic invertebrate fossils, including brachiopods, bivalves and trilobites (**Table 1**). Cephalopods, crinoids, ophioroids, hyoliths, cricoconarids, corals and gastropods have also been recorded. Trace fossils are rare, becoming more common towards the top of the Bokkeveld succession. Fossils invariably occur as internal moulds or external impressions and are in places much distorted by tectonic deformation.

Algoa Group

Late Neogene to Recent sediments that will be affected by the development footprint include the Alexandria, Nanaga, Nahoon and Schelm Hoek Formations (**Table 1**).

The Alexandria formation (*Ta*) consists of altering layers of calcareous sandstone, conglomerate and conquinite deposits (containing marine invertebrates) which point to depositional environments ranging from foreshore to lagoonal or estuarine in nature. Numerous species of different marine invertebrate fossils have been described from the Alexandria Frm. Basal oyster-shell conglomerates are well-developed at Grassridge, Motherwell and along the lower Swartkops River, and at Spring Valley near Port Elizabeth. *Echinodiscus* fossils (“pansy shells”) occur abundantly in flat

laminated sandstone. *Ophiomorpha* burrows are abundant and shark's teeth are present in places.

The semi- to well-consolidated aeolianites and sandy limestones of the Plio-Pleistocene Nanaga Formation (*T-Q*) sporadically contain fossilized terrestrial gastropods (*Tropidophora, Achatina, Trigonephris* and *Natalina*), fragmentary marine shells and foraminifera (Le Roux 1992).

The Pleistocene Salnova Frm. (*Qs*) sandstone deposits are made up of between ten to 60 percent comminuted shell fragments. With over three hundred species of molluscs identified, fossils in this formation comprise a diverse assembly of gastropods and pelecypods, as well as broken echinoid and crustacean remains preserved in coquina and sandstone.

Minute fragments of marine shells and foraminifera occur in the Nahoon Frm. Terrestrial gastropods such as *Tropidophora, Achatina* and *Trigonephris* are present in palaeosol horizons. Fossil bone fragments have been observed in aeolinites at Black Rock between Port Alfred and Kleinemonde. Human and other animal footprints have been found in the calcareous sandstone at Nahoon Point near East London. Recent thermoluminescence and U-Th dating of shelly material in the sandstone provided an age of ˜ 200 ka BP. Last Glacial vertebrate faunal remains have been exposed at regular intervals below the unconsolidated dune fields between Oyster Bay and St. Francis Bay. The fossils derive from older deflated and wind-eroded palaeosols, which also contain fossilized hyena coprolites rich in pollen and phytoliths. These clusters of bone and hyena coprolites are interpreted as eroded hyena burrows. Vertebrate fossils formerly recovered from these deflated horizons include the remains of plains zebra, elephants, the extinct giant buffalo (*Pelorovis antiquus*) as well as a variety of other artiodactyls. Hyena burrows are intrusive features and may not be contemporaneous with their surrounding matrix. Their localized nature makes occurrences difficult to predict, but in this case highlights the potential for rich Quaternary palaeontological finds within the coastal dune fields.

Root casts and land snail shells (*Achatina*) are common in the overlying coastal dune fields of the Schelm Hoek Formation. Marine shell and skeletal algal fragments, echinoid spines and foraminifera are found in the calcareous component of the sand. Shell middens are commonly found within the dune fields which often contain fossil mammal remains.

Results

Impact on potential palaeontological resources within the footprint is summarized in **Table 2**. Results are discussed based on illustrations presented in Figs. 8 & 15. The development footprint is located within pristine as well as built environments. Superficial deposits (topsoils) are heavily disturbed where long-established farming practices, road construction and urban development took place.

Pipeline Cannon Rocks to Kenton-on Sea

Section A

The section, which includes the BWRO, is located on Nanaga Formation sediments, occasionally overlain by unconsolidated, wind-blown sands (**Fig 8, segment 1 – 2; Fig. 9**). Nanaga Frm. sediments along this section are not regarded as palaeontologically vulnerable. At Cannon Rocks, the residual water lines designated for sea outfall where reticulation exits at the car park along Dawn Street and further west along Alice Street, will impact on aeolinites of the Nahoon Frm. (**Fig. 8 segments 3 & 4; Fig. 10**). Marine shell fragments were recorded within these exposures during the survey.

Section B

The section between the Boknes and Bushmans Rivers traverses approximately 10 km of Nanaga Frm. sediments (**Fig. 8, segment 6 – 7; Fig. 11**). The reservoir at Boknes Strand is located on a thick capping of unconsolidated windblown sands underlain by Bokkeveld Group shales, while alluvium and recent aeolian deposits occur along the incised river channel where the pipeline crosses the Boknes River (**Fig. 8, segment 5 – 6; Fig. 12**). No fossil-bearing exposures were recorded along the section.

Section C

The pipeline along Section C (**Fig. 8, segment 8 – 9**) will impact on Schelm Hoek and Nanaga Frm. sediments at the Bushmans River and Kenton on Sea reservoirs (**Fig. 13 & 14**) as well as on superficial alluvial deposits accumulated along the river mouth. Terrestrial gastropods are abundant in the calcareous sands of the Schelm Hoek Frm. below the Bushmans River reservoir. Alexandria Frm. conglomerates and underlying Bokkeveld shales are exposed where channel incision is extensive along the mouth.

Pipeline Cannon Rocks to Alexandria

Section D

The section is exclusively underlain by Nanaga Frm. aeolinites (**Fig 15 & 16**). No *in situ* fossil material where recorded where exposed outcrops were noted.

Section E

The section between Cape Padrone and the northern boundary of the Woody Cape Nature Reserve will impact on Nanaga Frm. aeolinites (**Fig 17**). The section is mostly covered by pasture land and woody vegetation (**Fig 18)**. The transition between Algoa Group and Bokkeveld Group sediments occurs at Kruisfontein (**Fig. 15 no. 19**). From here the northern part of the section continues mainly over agricultural land along underlying Bokkeveld sediments up to the Alexandria reservoir (**Fig. 20)**. No fossil-bearing exposures were recorded along the section.

Impact Statement

Impact on potential palaeontological resources within the footprint is summarized in **Table 2.**

The proposed development will affect Palaeozoic and Late Cenozoic strata of variable palaeontological significance. Most of the Bokkeveld Group strata in the survey area appear to belong to the upper, unfossilliferous Traka Subgroup. Palaeontological significance of the Bokkeveld sediments in the survey area is considered medium to low. Impact on potential *in situ* fossil material within the unit is considered low.

Within the Algoa Group the conglomerates sandstones and coquinites of the Alexandria Frm. are palaeontologically significant, but outcrops are only minimally exposed as a thin veneer distributed on the underlying Bokkeveld Group strata. Even though Alexandria Frm. sediments are not well represented in the survey area, it is still regarded as palaeontologically significant enough to warrant investigation of fresh exposures. Due to the fossiliferous nature of the formation, impact on potential *in situ* fossil material within the unit is considered likely.

Outcrops of Plio-Pleistocene aeolinites represented by the Nanaga Frm. are widely distributed and represent the predominant geological stratum within the footprint. Its palaeontological footprint is mainly represented by marine invertebrates (mainly shell fragments) and occasional terrestrial gastropods. Palaeosols are scarce and vertebrate

fossils are absent. Impact on potential *in situ* fossil material within the formation, as well as the overall palaeontological significance of the Nanaga Frm. is considered low. Nevertheless, monitoring of freshly exposed deposits is still recommended.

The intact Nahoon Frm. aeolinites recorded at Cannon Rocks have the potential to yield Quaternary vertebrate remains and trace fossils and is considered vulnerable with regard to the proposed development. Impact on potential *in situ* fossil material, as well as overall palaeontological significance of the Nahoon Frm. sediments at Cannon Rocks is considered medium to high.

Recommendations

There are no objections to the planned development on palaeontological grounds. However, the best assessment of palaeontological material can in most cases be done only after the commencement of the development (i.e. excavation activities) when potentially fossil-bearing strata are freshly exposed. Excavations into sedimentary bedrock should therefore be considered on condition that access by a palaeontologist is facilitated at the appropriate stage during development and that appropriate and effective mitigation measures such as inspection of fresh excavations are undertaken by a professional palaeontologist in order to determine whether, as is probable, palaeontological remains or features are exposed *in situ.*

It is recommended that three subsections of the route, namely:

- where the pipeline crosses the Boknes River,
- the section between the Bushmans River and Kenton on Sea reservoirs,
- and where reticulation exits into the sea at Cannon Rocks,

are closely monitored during the construction phase of development when trench excavations are to be conducted **(Table 3)**.

It is also advised that newly uncovered objects of palaeontological significance, found during the course of excavation activities into intact sediments must be reported to SAHRA which may require rescue excavations at the cost of the developer.

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Tables

Table 1. Regional geology, ages and potential fossil heritage.

Group	**Formation**	**Epoch**	**Fossil footprint**
Algoa Group (Cenozoic Period)	Schelm Hoek	Holocene	Land snails, shell and skeletal algal fragments, echinoid spines, foraminifera and shell middens
	Nahoon (*Qn*)	Middle – Late Pleistocene	Land snails, vertebrate bone fragments, human and animal footprints
	Salnova (*Qs*)	Middle Pleistocene	Gastropods, pelecypods, echinoid and crustacean remains
	Nanaga (*T-Q),*	Late Pliocene – Early Pleistocene	Land snails, fragmentary marine shells and foraminifera
	Alexandria (*Ta*)	Miocene to Pliocene	Bivalves, gastropods, corals bryozoans, pelecypods, brachiopods, echinoids and shark's teeth
Bokkeveld Group (Devonian Period)			brachiopods, bivalves, trilobites, cephalopods, crinoids, ophioroids, hyoliths, cricoconarids, corals and gastropods

Table 2. Impact table summarizing impacts and palaeontological significance of the footprint.

Feature	Extent of Impact	Duration of Impact	Palaeontological significance of strata	Potential Palaeontological Impact	Mitigation
Section A	local	permanent	*T-Q* = low *Qn* = medium *Schelm Hoek* = medium to low	Medium	monitoring of fresh exposures, *Qn* & *Schelm Hoek*
Section B	local	permanent	*Db* = medium to low *Ta* = medium to low T-Q = low	Medium	monitoring of fresh exposures, *Db* & *Ta*
Section C	local	permanent	*Db* = medium to low *Ta* = medium to low *T-Q* = low *Schelm Hoek* = medium to low	Medium	monitoring of fresh exposures, *Db, Ta* & *Schelm Hoek*
Section D	local	permanent	*T-Q* = low	Low	none
Section E	local	permanent	*Db* = medium to low *Ta* = medium to low *T-Q* = low	Low	none

Table 3. Potentially sensitive transects (see geological maps in Figs. 8 & 15).

Area	Section	Locality	Coordinates			Strata
i	A	Beachfront reticulation, Cannon Rocks	33°44'39.93"S 26°33'32.20"E	to	33°44'45.12"S 26°33'32.71"E	*Qn, Schelm Hoek*
ii	B	Boknes River	33°43'39.32"S 26°34'15.99"E	to	33°43'27.46"S 26°34'28.16"E	*Db, Ta,*
iii	C	Bushmans River	33°40'50.48"S 26°39'40.79"E	to	33°40'55.40"S 26°39'4.92"E	*Db, Ta, Schelm Hoek*

Figures

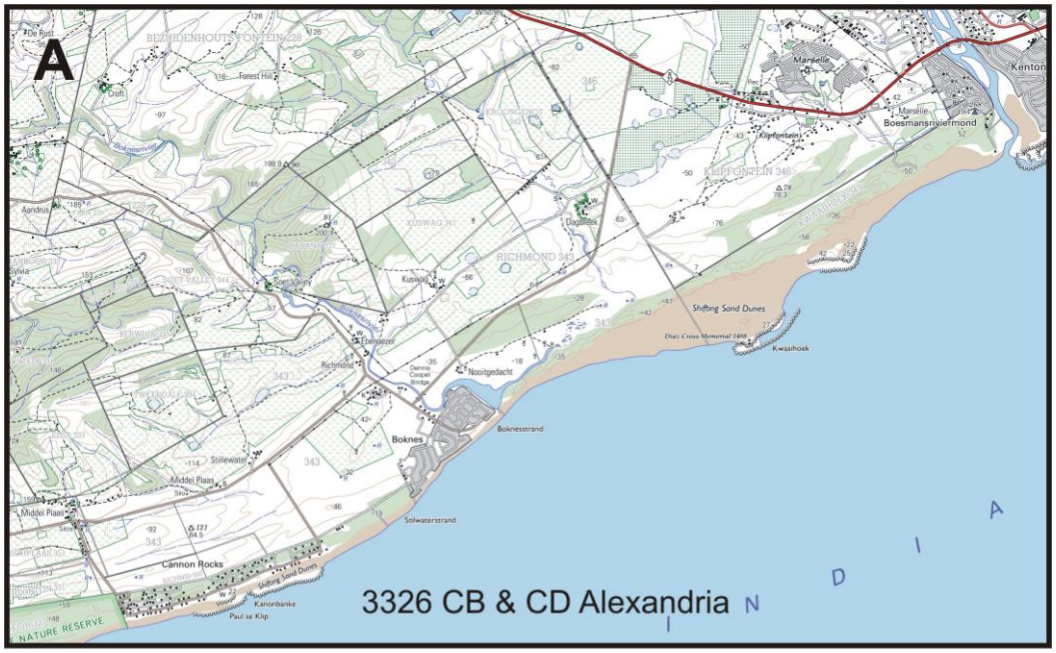

Figure 1. Portions of 1:50 000 topographic maps of the affected areas between Kenton on Sea and Cannon Rock (A) and between Cape Padrone and Alexandria (B).

Figure 2. Aerial photograph showing the layout of the proposed bulk water supply project between Kenton-on-Sea and Alexandria.

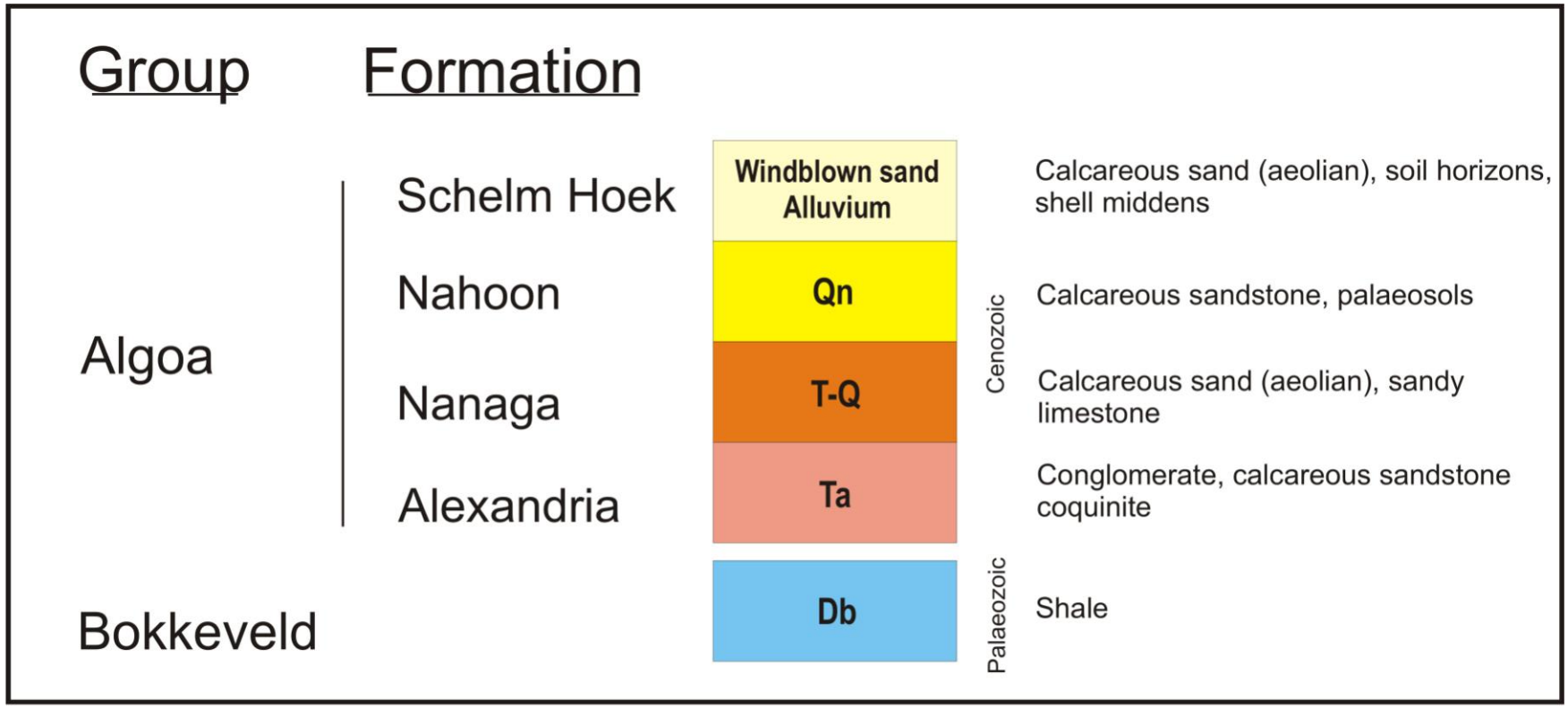

Figure 3. Schematic representation of the geology within the survey area.

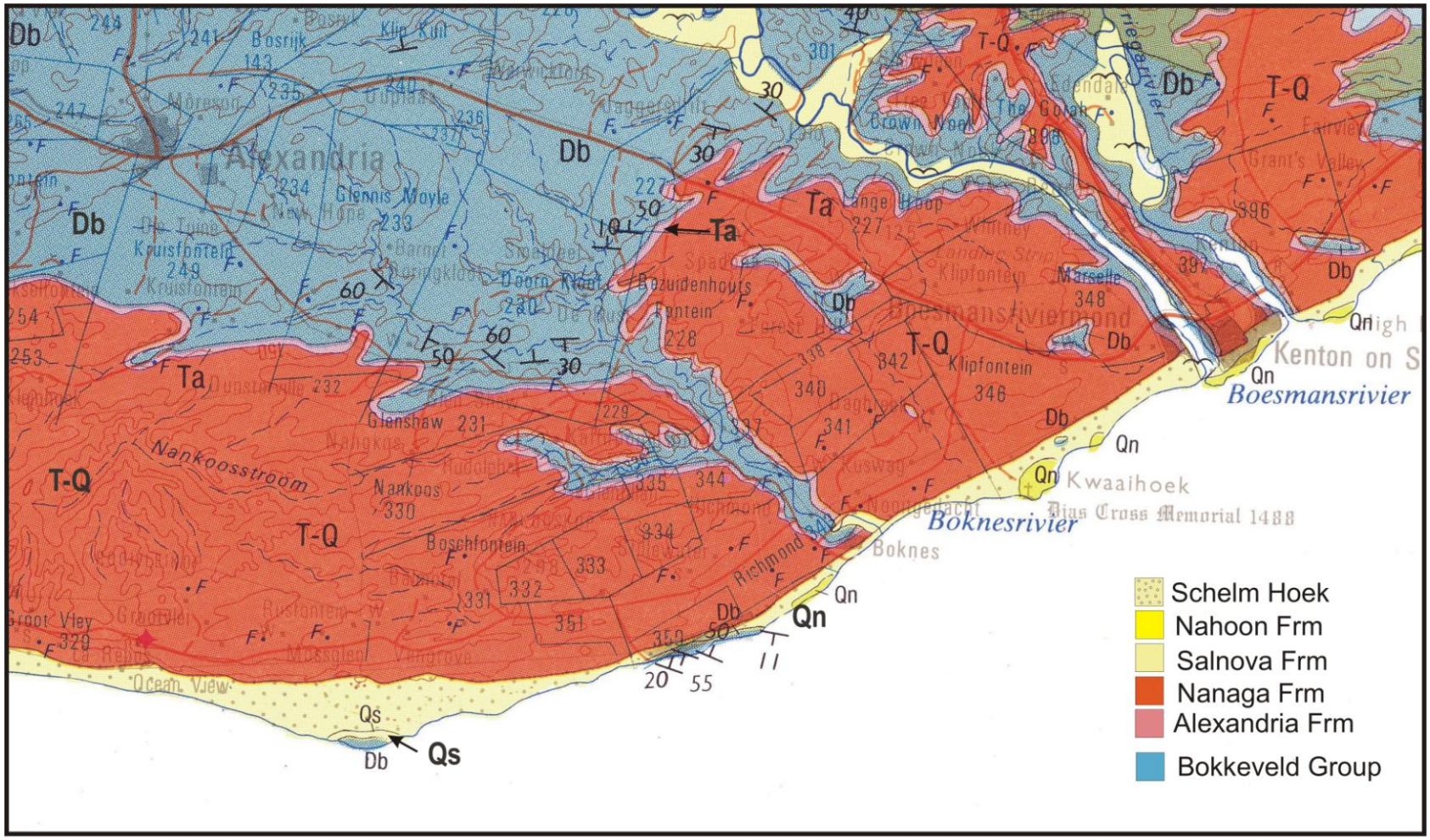

Figure 4. Portion of 1: 250 000 scale geological map 3326 Grahamstown, (Council for Geoscience, Pretoria, 1991) showing bedrock geology in the study area. From oldest to youngest, strata consist of Palaeozoic Bokkeveld Group and Cenozoic Algoa Group rocks.

Figure 5. Nanaga Formation (Algoa Group) landscape between Cannon Rocks and Boknesstrand (A) and between Boknesstrand and Kenton on Sea (B). Originally laid down as coastal dunefields, the Nanaga Formation consists of semi- to well-consolidated calcareous sandstone and sandy limestones that form smooth rounded hills with undulating ridges lying sub-parallel to the present coastline.

Figure 6. Nahoon Formation sediments The formation occurs within the first few hundred meters inland from the high-water mark. It consists of calcareous sandstones with interbedded palaeosols.

Figure 7. Unconsolidated, aeolian sand dunes of the Schelm Hoek Formation on the beach at Cannon Rocks.

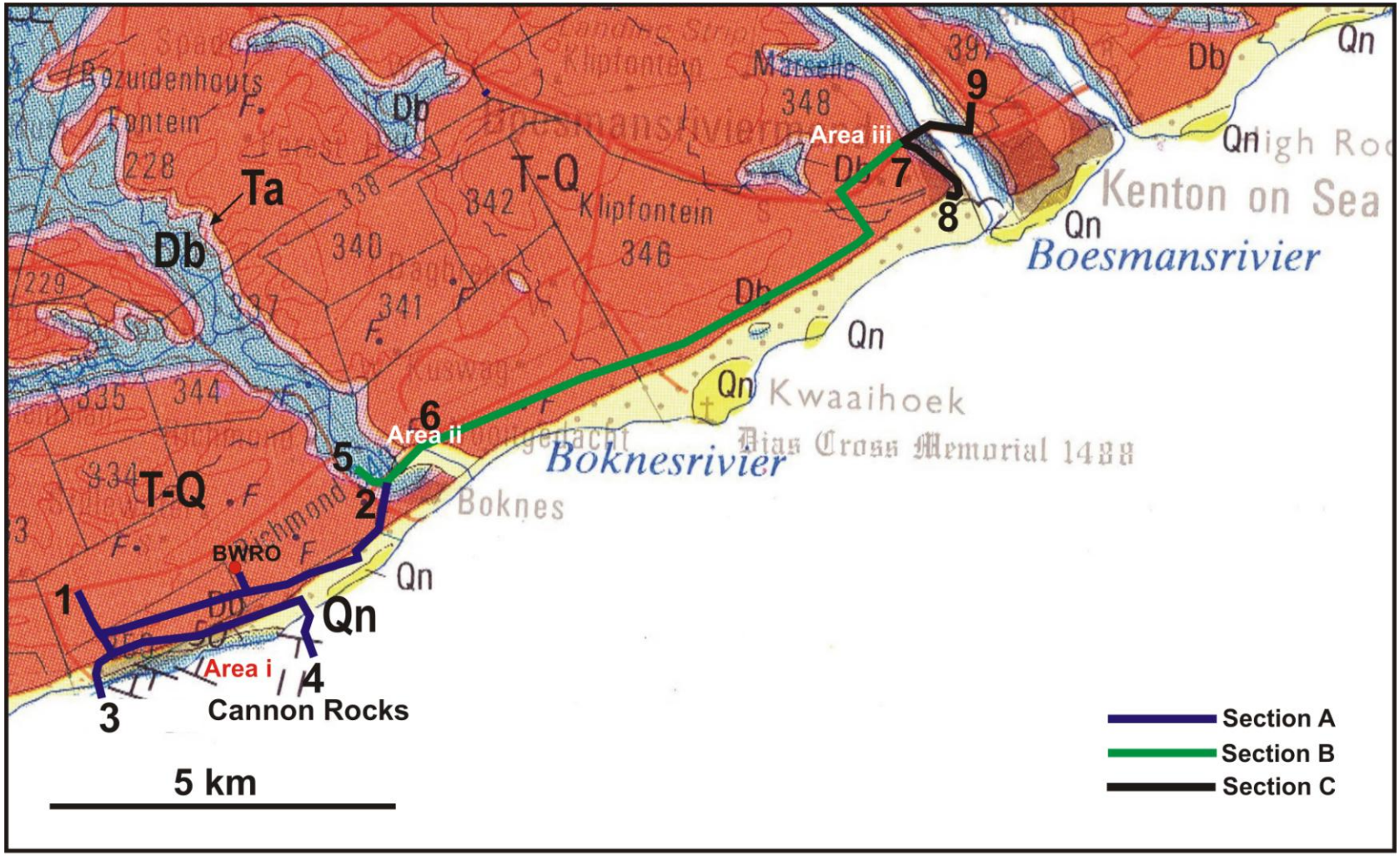

Figure 8. Portion of 1 : 250 000 geological map 3326 Grahamstown showing part of the proposed development footprint between Cannon Rocks and Kenton on Sea.

Figure 9. Pipeline section east of the BWRO, located on Nanaga Frm sediments.

Figure 10. Nahoon Frm outcrop at the Cannon Rock car park.

Figure 11. View from Boknes reservoir. Bokkeveld strata covered by geologically recent wind blown sand and vegetation.

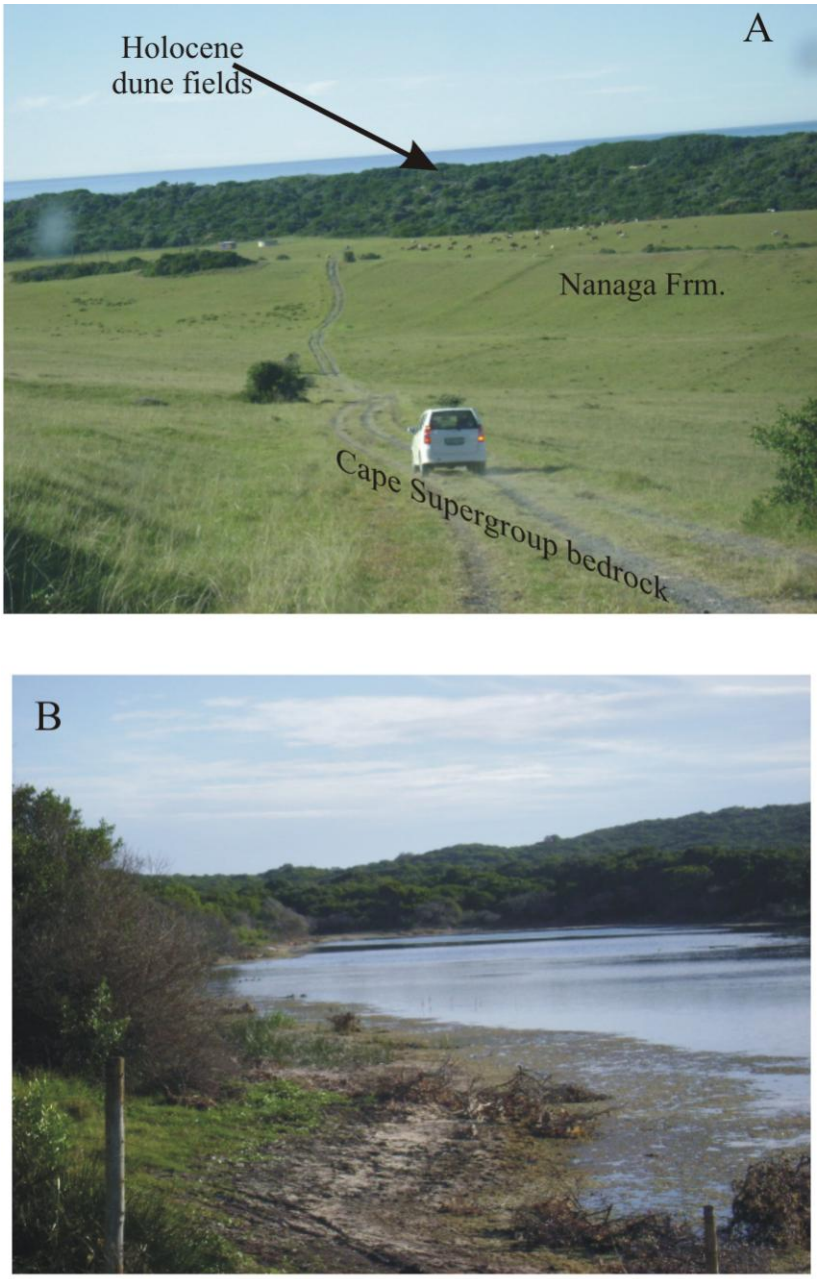

Figure 12. Nanaga Frm dune cordon (A) with wetland areas on the landward side (B) between Boknesstrand and Kenton on Sea. Schelm Hoek Frm sand dunes are visible in the background (A).

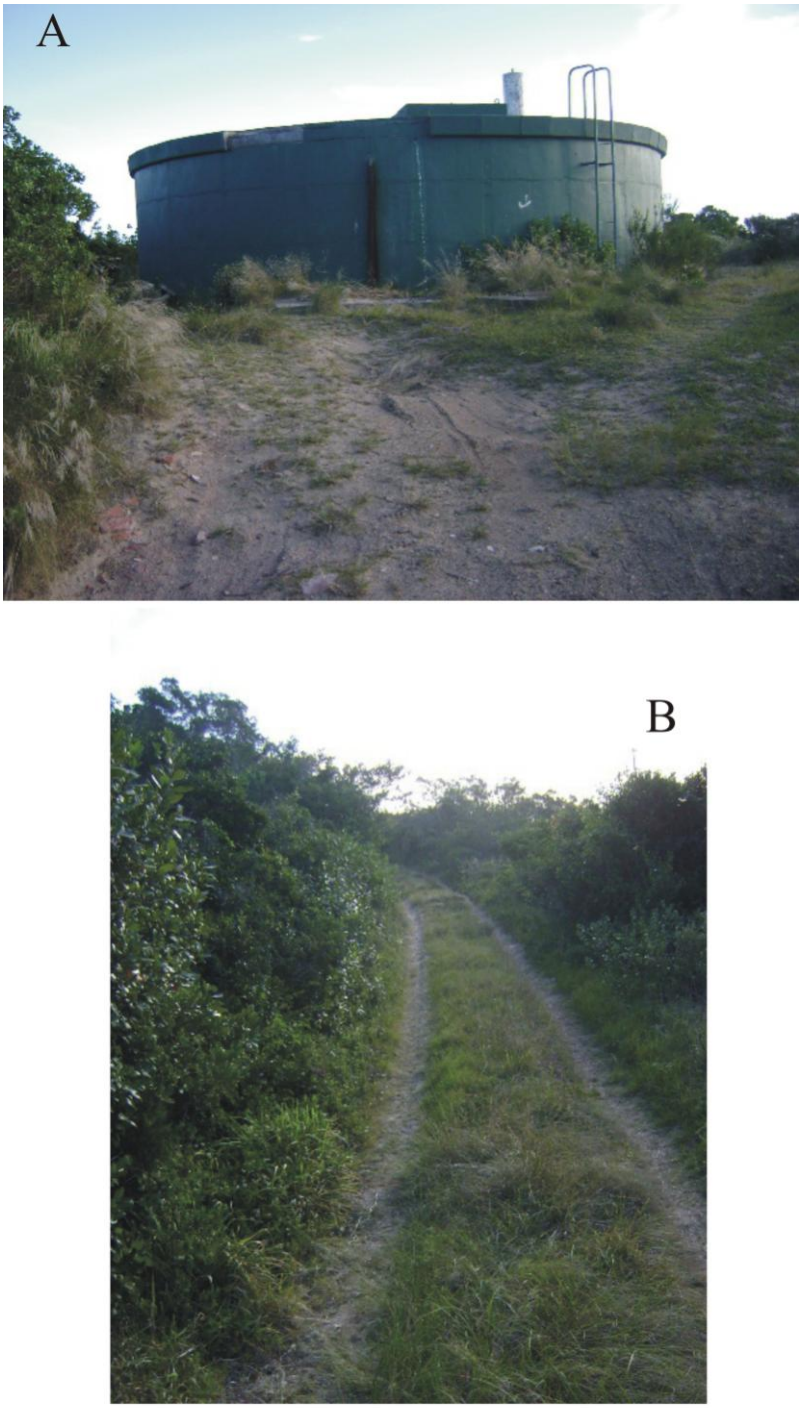

Figure 13. The Bushmans River reservoir underlain by Schelm Hoek Frm sediments (A). The track leading to the reservoir consists of calcareous sand, rich in shelly material and land snails (B).

Figure 14. View of Bushmans River mouth from the Kenton on Sea reservoir (A). The underlying rock is made up of semi-consolidated, calcareous Nanaga Frm sandstone (B).

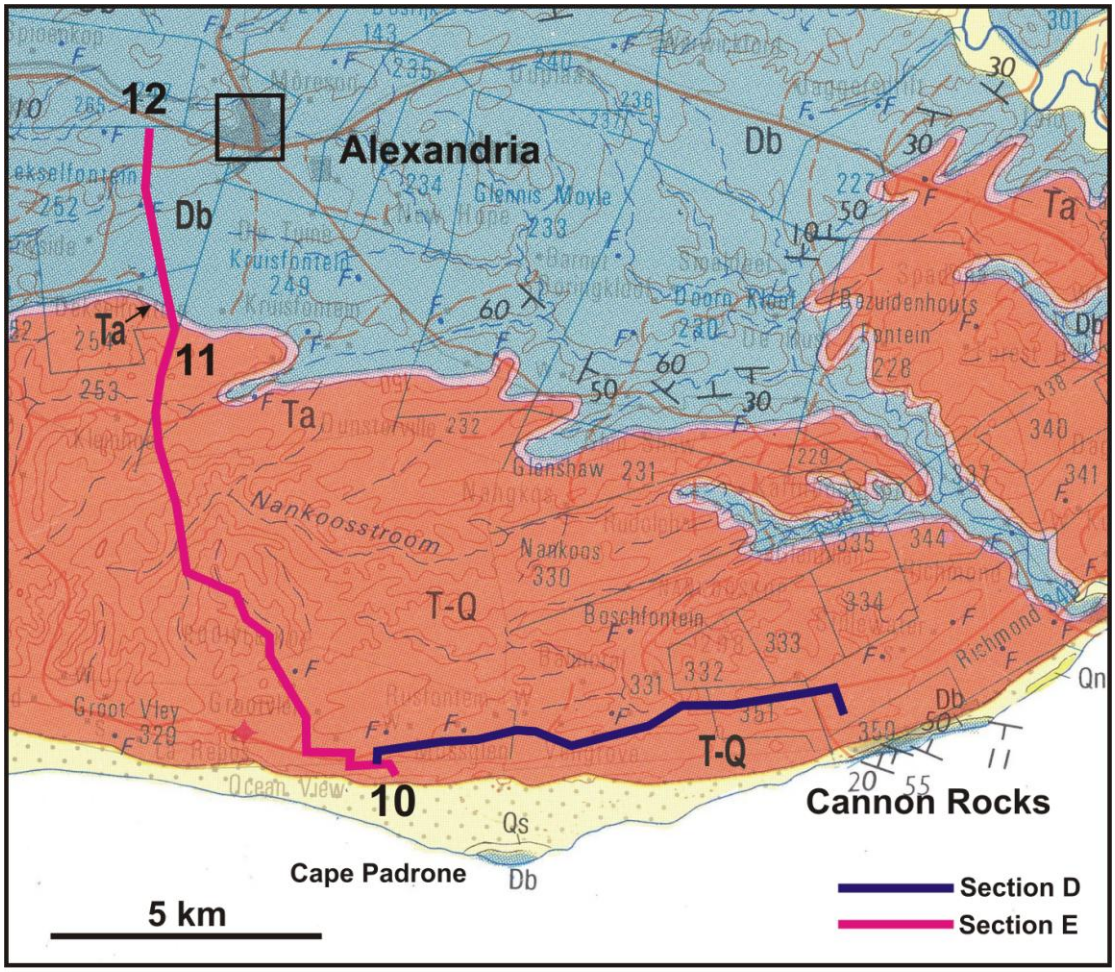

Figure 15. Portion of 1 : 250 000 geological map 3326 Grahamstown showing part of the proposed development footprint between Cannon Rocks and Alexandria.

Figure 16. Section between Cannon Rocks and Cape Padrone showing undulating topography of the landscape (Nanaga Frm).

Figure 17. Outcrop of well-consolidated calcareous sandstone and sandy limestones (Nanaga Frm).

Fig 18. The section between Cape Padrone and the Woody Cape Nature Reserve. Nanaga Frm. aeolinites are covered by pasture land (A) and forest vegetation (B).

Figure 19. Pasture land at Kruisfontein undelain by Nanaga Frm aeolinites and Bokkeveld Group sediments.

Figure 20. Looking south from the reservoir at Alexandria (Bokkeveld Group) towards smooth, rounded hills (Nanaga Frm) in the background.