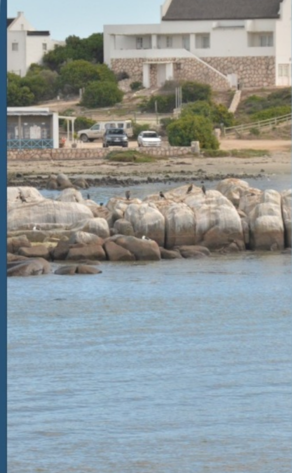
Environmental Impact Assessment (EIA) for the proposed construction, operation and decommissioning of the Saldanha Regional Marine Outfall Project of Frontier Saldanha Utilities (Pty) Ltd. at Danger Bay in the Saldanha Bay region

FINAL EIA REPORT

CHAPTER 3:

DESCRIPTION OF THE AFFECTED ENVIRONMENT



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3 DESCRIPTION OF THE AFFECTED ENVIRONMENT

3.1 BACKGROUND

The Saldanha Bay area is located about 150 km from Cape Town and has strong road and rail links with the City of Cape Town. The largest towns are Saldanha and Vredenburg. There are some human settlements — which include fishing villages and rural farming towns — in the region of the pipeline and electrical corridor route (e.g. Jacobsbaai, Diazville). From an economic perspective, there is a strong industrial focus in the Saldanha Bay region. The port serves as the main export facility for iron ore. There are several heavy and light industries located in the area; and an IDZ at Saldanha Bay— which will focus on manufacturing and marine services — is also being proposed. The IDZ was officially launched on 31 October 2013 by President Jacob Zuma. The new IDZ is expected to give a major boost to the country's industrialisation and labour creation drives, while attracting both local and foreign direct investment into the country.

The Vredenburg Peninsula is known for its natural beauty and tremendous biodiversity value — in particular the Langebaan Lagoon, the Berg River Estuary and the coastline from the West Coast National Park north to St Helena Bay. The area is also rich in history with a range of significant cultural, historical, archaeological and paleontological resources.

As such, the pipeline and electrical corridor selected for the proposed SRMO Project follows the majority of its extent along the exact corridor selected for the WCDM desalination plant EIA (Environmental Authorisation for the project was granted by the Western Cape DEA&DP on 13 August 2013), which was subjected to a rigorous screening exercise during the EIA process that considered all biodiversity, heritage and technical considerations in traversing the region of high ecological sensitivity located north-east of Danger Bay comprising intact Strandveld fragments.

Two alternative pipeline routings were assessed in this EIA as explained in Chapter 1 and 2 of this FEIAR. This includes the 'Jacobsbaai Eastern Corridor 'which will follow old agricultural land and road alignments from the proposed SSP of Frontier Saldanha Separation (Pty) (Ltd), along the Jacobsbaai Road and south along a degraded (deep sandy soils) agricultural trench to a marine outfall in Danger Bay. The other alternative routing that was assessed in this EIA is referred to as the 'Jacobsbaai Western Corridor'. It is located within the Jacobsbaai road reserve. Due to landowner constraints as explained in Chapters 1 and 2, the Jacobsbaai Eastern Corridor has proved unfeasible during negotiations with certain landowners along the Jacobsbaai Eastern Corridor. The botanical specialist has assessed the Jacobsbaai Western Corridor (see Ecology study in Appendix B of Volume II of the FEIAR). The Jacobsbaai Western Corridor has been identified as the only feasible alternative and is therefore the preferred pipeline routing for the SRMO Project. The Jacobsbaai Western Corridor was included and assessed and was also put forward as the preferred alternative in WCDM EIA Amendment Application to DEA&DP for the proposed desalination plant. Frontier Utilities and the WCDM wish to have their pipelines within the same corridor for environmental and technical reasons.

3.2 CLIMATE

The climate of the Saldanha Bay area is mild to cool and is strongly influenced by the cold Benguela Current that moves up the west coast of southern Africa. Temperatures in the area are mostly less than 20°C and rarely exceed 30°C. The area has a semi-arid Mediterranean climate with an average annual rainfall of approximately 300-330 mm. Most of the rainfall occurs in winter, with summers generally being dry.

Coastal fogs caused by the interaction between cold marine air (the result of the Benguela Current) and the warmer land mass are common, particularly in autumn. There is a strong seasonality in the winds over Saldanha Bay, reflecting the changes in the synoptic weather patterns prevailing at different times during the year (See Figure 3.1). Southerly winds pre-dominate in this region for most of the year, modulated by short periods of calm conditions or north-westerly winds which are associated with the propagation of coastal lows southwards along the west coast of southern Africa and weather fronts passing south of the sub-continent. Only in the mid-winter months do north to north-westerly winds predominate (CSIR, 1996).

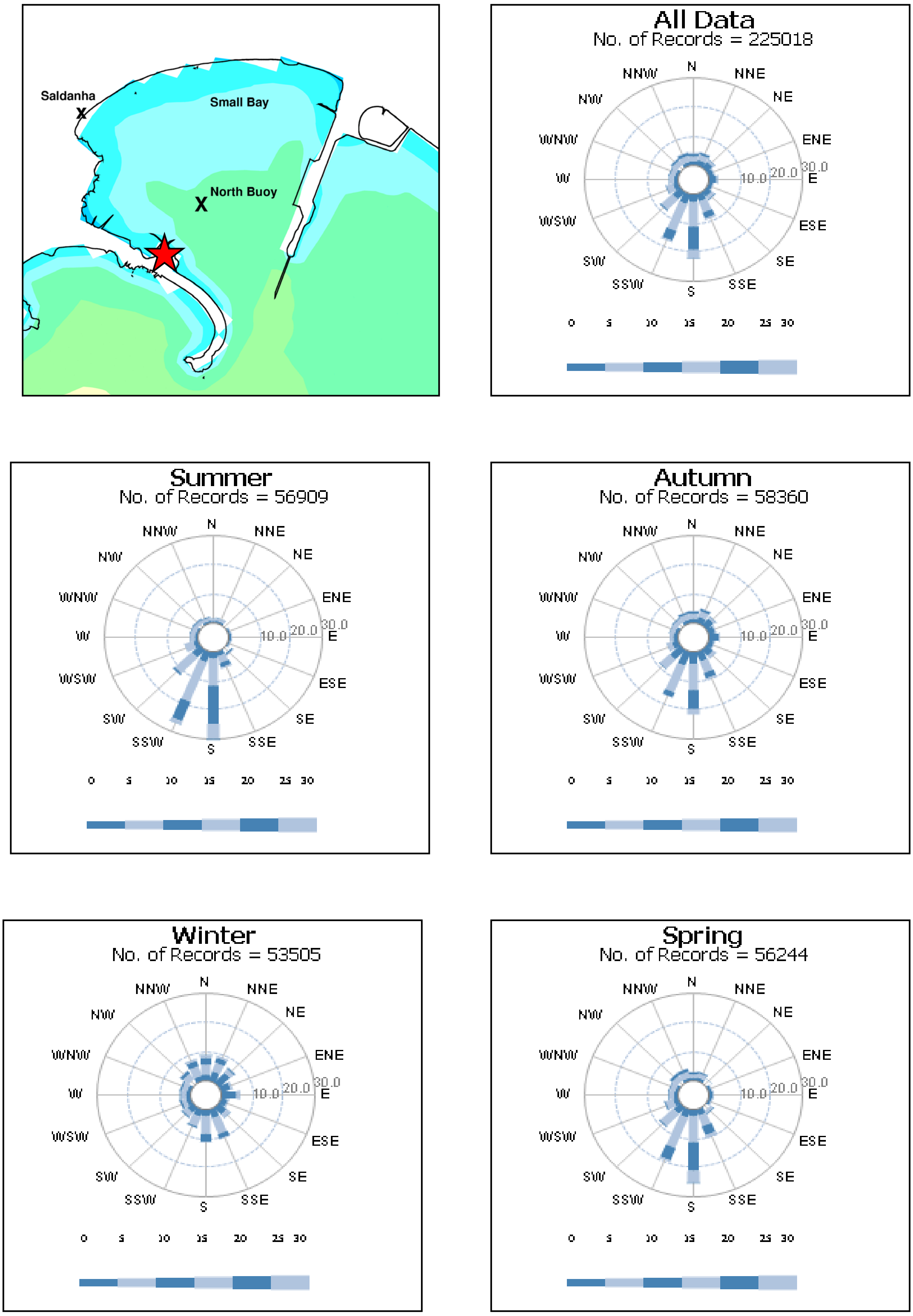


Figure 3.1 Wind roses measured at Port Control in Saldanha Bay

3.3 TOPOGRAPHY AND GEOLOGY

As reported by the visual specialist, Mr Henry Holland, the landscape along the pipeline and electrical corridor is flat to openly undulating coastal plains. Steep granite hills protrude from this landscape throughout the region and provide potential scenic viewpoints. The landscape character has a complex mixture of industrial, urban, agricultural and holiday resort elements (see Figure 3.2 and Figure 3.3). Having said that, areas around Danger Bay — although not pristine — are mostly free of industrial type developments and very few buildings exist there (in the absence of the proposed WCDM desalination plant).

The surface sedimentary geology of the low-lying areas consists mainly of calcretised and unconsolidated coastal and marine deposits; these are underlain by granite bedrock. Along the pipeline and electrical corridor, the soil is of low - medium agricultural potential according to the national Agricultural Geographic Information Systems database and the soils are greyish and sandy soils with minimal development potential, usually shallow, on hard or weathering rock, with or without intermittent diverse soils. Soils have good water holding potential but may be prone to erosion without appropriate mitigation. Lime will be present along most of the proposed pipeline corridor.

Figures 3.2 and 3.3/...

Figure 3.2 The coastal plain to open rolling hills with mining activity visible from Jacobsbaai Road

Figure 3.3 Industrial structures visible from Jacobsbaai Road

No geotechnical investigation was completed for the SRMO pipeline; however, a Geotechnical Investigation was completed by Inroads Consulting in December 2012 entitled Report on Geotechnical Investigation for the SSP – Western Cape. Following is an extract of the report related to the geotechnical conditions for the separation plant:

"According to the 1:250 000 geological series map of Cape Town referenced 3318, the site is underlain by Quaternary deposits in the form of windblown (aeolian) sands. Calcrete bands underlie these sands and are interlayered with calcareous sands which can extend to depths of up to 10 m. This sequence is evident in the road cutting to the Saldanha Bay Harbour. Marine sediments in the form of sands and gravels underlie the aforementioned windblown and calcareous sands to depths of some 20 m. These are in turn underlain by sand and gravel layers interbedded with clay and peat to depths of up to 30 m from where weathered granite rock is encountered. The site is blanketed by very loose and loose aeolian sand to depths ranging from 0.1 to 2.3 m below the present ground surface and averaging 0.8 m. It is generally thicker along the north western boundary of the site and north eastern perimeter of the footprint to the two Plant sites (SSP and CAPF). Fill in the form of very loose sand was encountered in test pits and extends to an average depth of 0.7 m below the ground surface. Calcrete gravels, cobbles and boulders underlie the aeolian sand in about half of the test pits excavated, and occur fairly randomly. Where encountered this boulder calcrete horizon extends to an average depth of 1 m and is between 0.1 and 0.8 m thick. It comprises gravels, cobbles and boulders of soft or medium hard rock calcrete in a matrix of calcified sand, and generally has an overall consistency of dense. The backacter "refused" on calcrete of soft rock consistency in all of the test pits. No groundwater or water seepage was encountered within any of the test pits excavated over the site during the course of this investigation, which was carried out at the start of the winter rain season. The presence of the regional water table was also not determined in this investigation. It must be noted that most of the test pits were only 0.5 m to 1.0 m deep due to the presence soft rock calcrete."

3.4 VEGETATION OVERVIEW

The terrestrial botanical impact assessment was conducted by Mr Nick Helme of *Nick Helme Botanical Surveys*. It was commissioned in order to help inform the planning and environmental authorisation process for a proposed marine outfall pipeline in the Saldanha Bay region of the Western Cape. Two alternative routes were proposed for assessment, although for about 70% of their length they either share the same alignment or are on opposite sides of the same road.

The study area is part of the greater West coast region, and lies within what may be termed the Saldanha Peninsula bioregion. This bioregion has a fairly distinct flora, and a particularly high number of locally and regionally endemic plant species, as well as plant Species of Conservation Concern (SCC) (Helme & Koopman 2007).

The study area lies within the Fynbos biome and the Core Cape Floristic Region (CFR). The latest data from the Red Data Book listing process undertaken for South Africa is that 67% of the rare or threatened plant species in the country occur only in the southwestern Cape, and these total over 1 800 species (Raimondo *et al.* – 2009). It should thus be clear that the southwestern Cape is a major national and global conservation priority, and is quite unlike anywhere else in the country in terms of the number of threatened plant species.

The study area is within the planning domain of the Saldanha Fine Scale Conservation Plan (Pence 2008), which has identified and mapped Critical Biodiversity Areas (CBAs) throughout the region. Critical Biodiversity Areas are regarded as essential areas for the achievement of regional conservation targets, and are designed to ensure minimum land take for maximum result (Maree & Vromans 2010). The Fine Scale Plan indicates that both pipeline route alternatives cross significant CBAs. As many as 25 different plant SCC are potentially found within 200 m of both proposed routes, usually where these cross CBAs. If any of these SCC are within the study area they are likely to be within the mapped areas of Very High Sensitivity, and are not likely to be found in significant numbers outside the Very High Sensitivity areas.

Approximately 8 500 m of the blue pipeline alternative (Jacobsbaai Western Corridor) is within mapped CBAs, whereas this figure is about 9 615 m for the purple alternative (Jacobsbaai Eastern Corridor (Figure 3.4)). The latter thus crosses about 11% more CBA than the former.

Figure 3.4 Extract of the Saldanha Municipality Fine Scale Conservation Plan (Pence 2008), showing the two alternative pipeline routes (blue and purple lines) in relation to the mapped terrestrial Critical Biodiversity Areas (in green). The two red arrows mark additional, subsequently identified areas of botanical importance that were not selected as Critical Biodiversity Areas due to a lack of data at the time (2008).

The SA vegetation map (Mucina & Rutherford 2006) and the more accurate Saldanha Fine Scale Vegetation Map (Helme & Koopman 2007; Figure 3.5) indicate that the proposed route crosses four main terrestrial vegetation types. It should be noted that Figure 3.5 shows what would originally (prior to disturbance) have been the extent of the vegetation types, and that in fact less than 20% of the original natural vegetation is left along the route, with most having been lost to agriculture, and increasingly, to urban and industrial development. Most of what remains is thus a CBA, and if not a CBA, can anyway be considered sensitive, especially if it is in good condition and has not been previously heavily disturbed.

Saldanha Flats Strandveld is regarded as Endangered on a national basis (Rouget *et al.* 2004; DEA 2011).

Saldanha Granite Strandveld is listed as an Endangered vegetation type (DEA 2011), and the coastal form in the area between Jacobsbaai and Danger Bay supports an unusual assemblage of species that does not occur elsewhere (pers. obs).

Saldanha Limestone Strandveld was previously listed as an Endangered vegetation type (Rouget *et al.* 2004), and then was unfortunately downgraded to Least Threatened (DEA 2011), due to an oversight by the South African Biodiversity Institute (SANBI), and this error will apparently only be remedied in about 2015. The unit has the highest number of threatened and localised plant species of all vegetation types in the Saldanha region, and the Jacobsbaai area is one of two primary hotspots for highly localised species (Helme & Koopman 2007). The unit is also poorly conserved (represented) in the West Coast National Park.

Langebaan Dune Strandveld was regarded as Vulnerable in terms of the NSBA (Rouget *et al.* 2004), but the unit is now not listed as a Threatened Ecosystem on the National List (DEA 2011), mainly because large areas are well protected within the West Coast National Park.

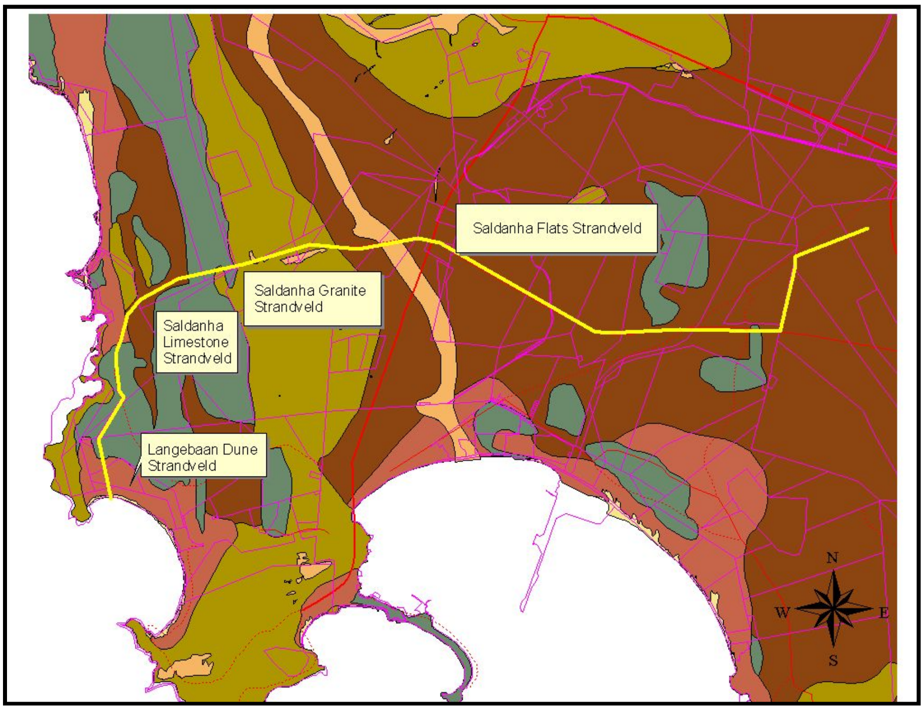


Figure 3.5 Extract of the CapeNature Fine Scale Vegetation Map (Helme & Koopman 2007) for the area, showing the four main vegetation types crossed by the route (yellow line).

The dunes in the vicinity of the discharge area in fact have many elements of another vegetation type - ***Cape Seashore Vegetation***, which is typically associated with coastal dune systems in the southwestern Cape. This is also a Least Threatened vegetation type (Rouget *et al.* 2004; DEA 2011).

3.4.1 Plant Species of Conservation Concern

At least twenty five plant SCC (Raimondo *et al.* 2009) have been recorded from the vicinity of the project area (defined as being within 200 m of the proposed route). Many of these are endemic to the Saldanha region*, i.e.* they occur nowhere else, and many occur in very small, isolated populations which are easily destroyed or damaged by development.

The known or likely SCC within or close to the study area include *Daubenya zeyheri* (Vulnerable), *Cephalophyllum rostellum* (Endangered), *Limonium acuminatum* (Vulnerable), *Limonium capense* (Near Threatened), *Passerina ericoides* (Vulnerable), *Lampranthus vernalis* (Near Threatened), *Ruschia langebaanensis* (Threatened), *Ruschia cupulata* (Vulnerable), *Drosanthemum marinum* (Near Threatened), *Agathosma thymifolia* (Vulnerable), *Otholobium bolusii* (Vulnerable), *Passerina filiformis* ssp. *glutinosa* (Near Threatened), *Arctopus dregei* (Near Threatened), *Aloe distans* (endemic, should be regarded as a subspecies of *A. perfoliata*), *Felicia elongata* (Vulnerable), *Romulea elliptica* (Endangered), *Romulea barkerae* (Endangered), *Moraea calcicola* (Endangered), *Cheiridopsis rostrata* (Vulnerable), *Anessorhiza calcicola* (Vulnerable), *Osteospermum calcicola* (Vulnerable)*, Bulbinella calcicola* (Critically Endangered)*, Sparaxis calcicola* (not yet assessed)*, Moraea hainebachiana* (Vulnerable), *Zaluzianskya parviflora* (Near Threatened) and *Wiborgiella dahlgrenii* (Endangered).

If any of these SCC are within the study area they are likely to be within the Very High Sensitivity areas shown in Figure 3.6 and Figure 3.7, and are not likely to be found in significant numbers outside the Very High Sensitivity areas. It should however be noted that the Very High Sensitivity areas shown are only shown within 200 m of the proposed routes, and even though they may extend more than 200 m away they are not shown in those areas.

The sensitive area shown in Figure 3.7 is driven mainly by the known occurrence of *Romulea elliptica*, an Endangered bulb species known from only four small patches. It would appear that the proposed pipeline will be located just to the north of the position of the *Romulea elliptica*, and it should thus impact on the species here.

The pipeline through Jacobsbaai has the potential to cause significant damage to sensitive habitat and SCC, **but if located west of the main road this damage is likely to be significantly less than if located east of the road**, as most of the SCC are located east of the road. The only four SCC known from within 12 m of the west side of the road are *Zaluzianskya parviflora* (Near Threatened), *Limonium capense* (Near Threatened), *Felicia elongata* (Vulnerable) and *Ruschia langebaanensis* (Threatened).

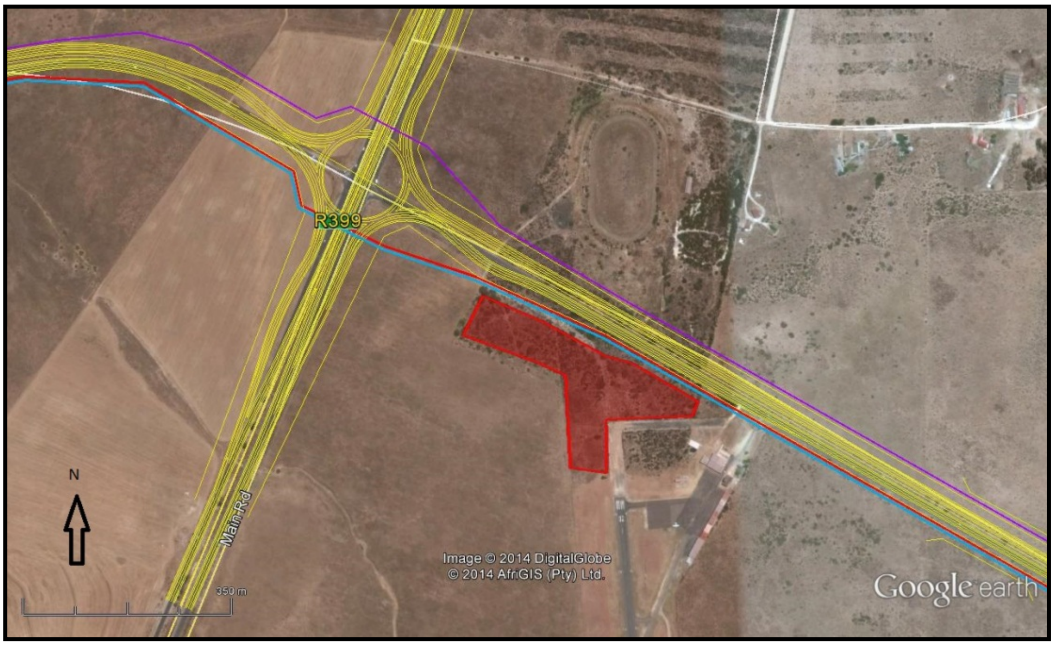


Figure 3.6 Map showing the Very High Sensitivity botanical area (red shading and outline) between the proposed pipeline and the airfield, just east of the Vredenburg – Saldanha road.

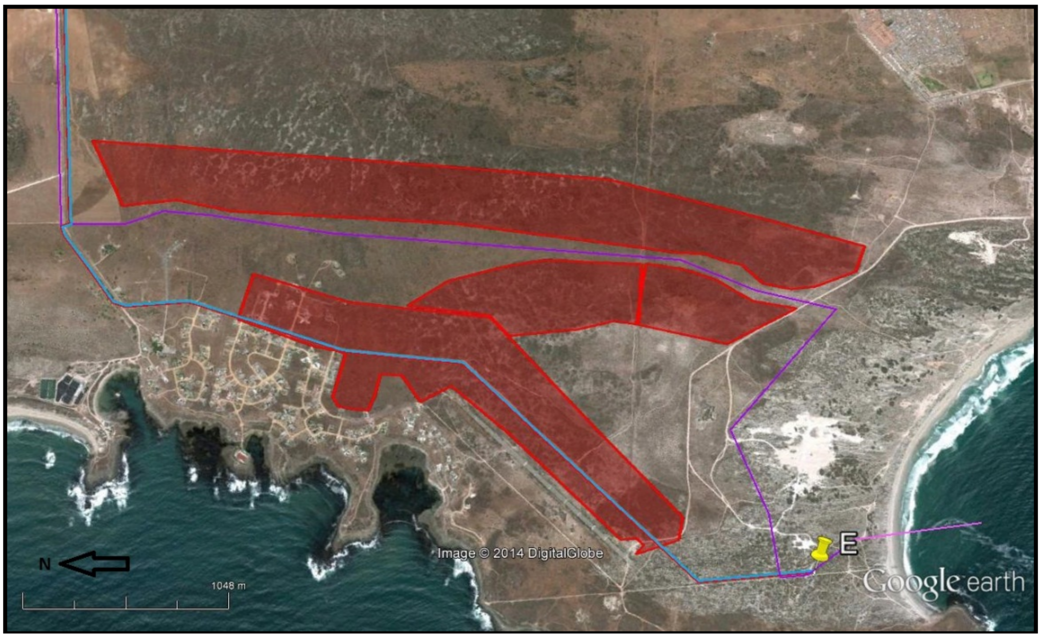


Figure 3.7 Map showing the Very High Sensitivity botanical areas (red shading and outline) within 200 m of the routes through the Jacobsbaai area. Unshaded areas within 200 m of the routes are of Low or Medium botanical sensitivity.

Figure 3.8 The blue shaded area is a sensitive wetland and botanical area just south of the Jacobsbaai road. This area would be negatively impacted by the blue route alternative.

3.5 THREATENED FAUNAL SPECIES

The terrestrial faunal impact assessment was conducted by Mr Nick Helme of *Nick Helme Botanical Surveys.* Likely impacts on the terrestrial fauna are to a large extent expected to mirror the botanical impacts, mainly because the faunal species of concern are largely dependent on areas of remaining natural habitat. Two faunal SCC have been recorded from the study area (Rose's Rainfrog (*Breviceps rosei),* – SW coastal endemic, and Black Girdled Lizard (*Cordylus niger)* – Near Threatened), and a further six reptile SCC may occur (probably in low numbers) within the study area.

Highly mobile vertebrates like birds and most surface dwelling (non-fossorial) mammals are not likely to be significantly or permanently impacted by pipeline construction, and are thus not further discussed. However, tortoises, frogs and snakes are a particular concern when trenches are dug, as they are liable to fall in and become trapped. There is a high density of tortoises in the area (pers. obs.), and the only species in the area is the widespread Angulate Tortoise (*Chersina angulata*).

Burrowing mammals like golden moles could theoretically be impacted by construction, and two species of concern could occur in the general study area - Grant's Golden Mole *Eremitalpa granti* (Vulnerable; EWT 2004) and Cape Golden Mole *Chrysochloris asiatica* (Data Deficient; EWT 2004). Their presence or abundance in the area is entirely unknown.

Most of the potential faunal SCC in the area are reptiles, with one frog. There are confirmed records of Rose's Rainfrog from the study area, and of the Black Girdled Lizard, but all the other six threatened reptiles are only potential occurrences, and probably occur at low densities.

Rose's Rainfrog is a declining Western Cape endemic species with a restricted coastal distribution, and has been heard by the author within the study area. It is not Red Listed as threatened. The area from Paternoster to Postberg is also home to a disjunct population of the Black Girdled Lizard, a species otherwise found only in montane regions on the Cape Peninsula, and is able to survive here due to the cooler conditions caused by the prevailing southern, summer winds which cross cold water. This species is Red Listed as Near Threatened (Bates *et al.* 2014), and it is fairly common on most rocky outcrops in the Jacobsbaai area, especially within 400 m of the sea.

The following faunal Species of Conservation Concern could potentially occur on site: Cape Sand Snake *Psammophis leightoni* (Vulnerable; Bates *et al.* 2014); Kasner's Dwarf Burrowing Skink *Scelotes kasneri* (west-coast endemic; Near Threatened; Bates *et al.* 2014); Gronovi's Dwarf Burrowing Skink *Scelotes gronovii* (west-coast endemic; Near Threatened; Bates *et al.* 2014); Blouberg Dwarf Burrowing Skink *Scelotes montispectus* (west-coast endemic; Near Threatened; Bates *et al.* 2014); and Southern Adder *Bitis armata* (Vulnerable; Bates *et al.* 2014).

No threatened butterfly species are known from any of the vegetation types occurring in the study area (Mecenero *et al.* 2013).

Mortality impacts on powerline infrastructure will particularly affect large terrestrial birds (e.g. Blue Crane, Ludwig's Bustard), commuting wetland birds (*e.g.* flamingo spp., waterfowl, shorebirds), and birds of prey (e.g. Martial Eagle *Polemaetus bellicosus*, Verreaux's Eagle *Aquila verreauxii*, Jackal Buzzard *Buteo rufofuscus*, Black Harrier, African Marsh Harrier *Circus ranivorus*, Peregrine Falcon *Falco peregrinus*, Lanner Falcon *Falco biarmicus* and Cape Eagle-Owl *Bubo capensis*), and will involve collision of flying birds with the overhead lines, and electrocution of birds perching on power poles and substations.

3.6 HERITAGE RESOURCES

ASHA Consulting (Dr Jayson Orton) was requested to produce an integrated Heritage Impact Assessment (HIA) that addresses archaeology, palaeontology, built environment, graves, cultural landscapes and scenic routes. The palaeontological specialist study was undertaken by John Pether and was integrated into the HIA.

3.6.1 Palaeontology

The bedrock formations in the area, Malmesbury Group shales and the Cape Granites, are of no palaeontological interest. However, a number of younger deposits occur above the bedrock and these have yielded important fossil finds in a number of localities. The Langebaan, Springfontyn, Prospect Hill, Witzand and Velddrif Formations are important in this regard (Pether 2014; Appendix E of Volume II of this FEIAR). Aeolian deposits are expected to contain isolated fossil snails, tortoises, ostrich bones and eggshell fragments and other sparsely scattered bones. Bone concentrations are usually associated with calcrete which has formed a 'roof' beneath which hyenas can burrow. They are known to accumulate bones in their dens. Dune slacks with accumulated water may have attracted animals in the past and can produce rich fossil assemblages. Thick beds of calcrete that have built up in phases can also harbour fossils but these can be difficult to find. The fossil potential in the study area is presented in Table 3.1 (Pether 2014; Appendix E of Volume II of this report).

Known highly significant palaeontological resources in the area are remarkably rich including such sites as the famous Langebaanweg Fossil Park which lies some 3.5 km east of the study area (Halkett & Hart 1999; Hendey 1969; Singer 1961) and Elandsfontein further to the south (Klein 1988; Klein *et al*. 2007; Singer 1954; Singer & Wymer 1968). Spreeuwalle, which has yielded far fewer fossils (unpublished data referenced in Klein *et al.* 2007), and the 117 000 year old human and animal tracks (trace fossils) preserved in aeolianite (Roberts & Berger 1997) both along the shores of the Langebaan Lagoon. Further detailed review of the palaeontological context is contained in the appended specialist report by Pether (2014) (Appendix E).

Table 3.1 Surface formations of the Sandveld Group in the study area (Source: Pether 2014; Appendix 2).

FORMATION	AGE AND DESCRIPTION	SENSITIVITY
WITZAND - Q5	Holocene and recently active dune fields and cordons <~12 ka.	Mainly archaeological sites.
SPRINGFONTYN - Q1 & Q2	Quaternary to Holocene, mainly quartzose dune and sandsheet deposits, interbedded palaeosols, basal fluvial deposits <~2 Ma.	Fossil bones very sparse, local to high signif. Basal fluvial deposits locally – high signif.
VELDDRIF - VD	Quaternary raised beaches & estuarine deposits, <~1.2 Ma. Sea-levels below ~15 m asl.	Shell fossils common, local signif. Fossil bones very sparse, high signif.
LANGEBAAN - LB	Late Pliocene to Late Quaternary aeolianites <~3 Ma to ~60 ka.	Fossil bones mod. common, local to high signif.
PROSPECT HILL - PH	Late Miocene aeolianite 12-9 Ma?	Fossils very sparse – high signif.

3.6.1.1 The Bedrock

The older bedrock of the region consists of **Malmesbury Group** shales. Their origin dates from over 560 Ma (Ma: million years ago, Mega-annum), when mainly muddy sediments were deposited on the margins of an ancient ocean. The ocean basin subsequently was compressed by tectonic forces and the Malmesbury sediments were transformed into shales and were then intruded by molten magma that cooled to form the crystalline "**Cape Granites**". These bedrock formations are not of palaeontological interest.

3.6.1.2 The Older Sandveld Group

During the early history of the coastal plain it was deeply eroded by courses of the ancestral Berg River and the soft Malmesbury shales along the coast have mostly been eroded away to below sea level, while the hard granites form the hills. The deposits that overlie this erosion surface are much younger than the bedrock, being of Cenozoic age. These various formations are grouped together as the **Sandveld Group**.

During the early Miocene about 20 Ma, rising sea level caused the rivers in the valleys to "back up", filling the valleys with river (fluvial) sediments and peat beds with plant fossils. This fluvial valley fill is the **Elandsfontyn Formation**, the oldest formation of the Sandveld Group of coastal deposits. It is not exposed, being deeply covered by marine deposits and ancient dunes.

Eventually, by ~16 Ma during the Mid-Miocene Climatic Optimum, enough of the Antarctic ice cap had melted to raise sea level to the extent that the coastal plain was submerged as a shallow sea and the granite hills were islands upon which seabirds roosted, their guano leaching into and phosphatizing the granites. This ancient shoreline is now uplifted to ~100 m asl. and in places along the West Coast is marked by marine gravels occurring seaward of a prominent slope "nick" or even vertical "fossil" sea cliffs. However, to the writer's knowledge, *in situ* mid-Miocene marine deposits at high elevations have not been exposed or recognized in the Saldanha area. Notwithstanding, phosphatic, ostensibly marine deposits are recognized in boreholes and just to the north of Elandsfontein extend to 90 m asl. (borehole S22, Rogers, 1980). Should the age of these deposits indeed prove to mid-Miocene, precedence dictates that it is named the **Saldanha Formation.**

At lower elevations marine deposits of Pliocene age drape the bedrock and older sediments on the coastal plain. These include two formations, *viz*. the early Pliocene **Varswater Formation** and the mid-Pliocene "**Uyekraal Formation**". The type area of the former is the exposures at the West Coast Fossil Park (Langebaanweg) where the fossils from the upper part show that the age of the deposits is about 5 Ma and that the origin of the deposits is related to rising sea level during the warming of the early Pliocene Warm Period. The peak palaeoshoreline of this sea level high is now uplifted to 50-60 m asl. The equivalent deposits on the Namaqualand Coast comprise the "50 m Package" or Avontuur Formation.

Sea level rose again during the Mid Pliocene Warm Period (~3.0 Ma) up to a level now at ~30-35 m asl. The associated deposits on the Namaqualand Coast comprise the "30 m Package" or Hondeklip Bay Formation (informal). Equivalent marine deposits underlie the flat plain extending west from the West Coast Fossil Park and were named the Uyekraal Shelly Sand Member of the "Bredasdorp Formation" by Rogers (1983) (the latter now superseded by the Sandveld Group). The unit has a capping hardpan calcrete, beneath which is green-hued shelly, gravelly sand with phosphatic casts (steinkerns) of molluscs and shark teeth (Rogers, 1982, 1983). The evidence from wider afield proves that this marine formation is a discrete stratigraphic unit that underlies the outer part of the coastal plains below ~30 m below sea level. It is thus deserving of separate recognition as the Uyekraal Formation, in the Sandveld Group.

The aforementioned fossiliferous marine deposits are generally too deeply buried beneath old dune deposits (aeolianites) to be intersected in shallow excavations.

3.6.1.3 The Younger Sandveld Group

Aeolianites or "dune rocks/fossil dunes" overlie the marine deposits of the coastal plain, *i.e.* the "Saldanha", upper Varswater and Uyekraal formations. They rest on wind-deflation erosion surfaces formed on the marine deposits and are comprised of calcareous sand reworked from the marine deposits by wind and also blown off the beaches of the receding sea levels. The calcareous aeolianites are evident in the coastal landscape as the ridges, low hills and mounds beneath a capping calcrete crust.

Much of the aeolianite sand is tiny fragments of shell. The cementing of this "calcarenite" is generally quite weak, but much denser cementing has taken place in the uppermost part of the fossil dunes in the form of a "carapace" or capping of calcrete. The calcrete is a type of cemented soil called a pedocrete, formed in the near-surface by evapo-transpiration after the dunes became inactive and were vegetated.

The aeolianites contain further calcretes and leached terra rosa soils at depth, attesting to a number of periods of reduced rates of sand accumulation, surface stability and soil formation. There are more marked breaks between periods of sand accumulation, shown by erosion surfaces or very thick calcretes formed over a long time.

The dune plumes accumulated episodically, under the influence of climate (windiness, rainfall) and available sand source areas (sea-level position, sediment supply), with erosion and re-deposition of previous dunes also taking place in some areas, separated by periods of stability and soil formation.

3.6.1.4 The Prospect Hill Formation - aeolianite

The inner aeolianite ridge stretching north from Saldanha Bay up the coast to near Paternoster has been found to have fossil eggshell fragments of extinct ostriches (*Diamantornis wardi*) and extinct land snail forms (Roberts & Brink, 2002). *Diamantornis wardi* is dated as Miocene 10-12 Ma in the Namib Desert (Senut & Pickford, 1995) and, based on dated occurrences in East Africa and Arabia, an age of 12-9 Ma is indicated. These aeolianites, previously belonging to the Langebaan Formation, are now called the Prospect Hill Formation (Figure 3.9), due to the significantly older age indicated by the fossils (Roberts & Brink, 2002; Roberts *et al.*, 2006). Separation of this aeolianite as a distinct formation is also justified by it being lithologically distinct from the younger aeolianites that abuts it.

Table 3.2 lists the age of geological formation in the Saldanha Bay region from youngest to oldest.

Table 3.2 Age of geological formation in the Saldanha Bay region from youngest to oldest.

Q5: Recent windblown sands and dunes along the beach are mapped as unit Q5. Prominent dune plumes extend north from sandy beaches. Called the **Witzand Formation**.
Q1: Another surface unit is the recent soil-unit Q1, white to slightly-reddish sandy soil, which is mainly a stabilized sand sheet blanketing the underlying geology.
Q2: An older surface unit Q2, shallow sandy soil with heuweltjies (heuweltjiesveld), occurs inland the coast. Incipient calcretes occur in Q2.
QC: The **Langebaan "Limestone" Formation**, aeolianite Unit QC, is underlain mainly by marine deposits of Pliocene age (**Varswater** & **Uyekraal** fms).
The **Prospect Hill Formation.** Part of the Langebaan Fm between Saldanha Bay and Paternoster has now been separated as this new formation, due to fossil finds indicating that it is significantly older than the other aeolianites included in the Langebaan Formation.
G1, G2, G3, G4 and **G5** are outcrops of various bedrock granites of the Cape Granite Suite.

3.6.1.5 The Langebaan Formation - aeolianites

Most of the calcareous aeolianites of the southern portion of the west coast are included in the Langebaan Formation or "Langebaan Limestones" (Figure 3.9) deep yellow, QC). The Langebaan Fm. thus includes various aeolianites of different ages, as an "amalgam" of the dune plumes that formed on the coastal plain, at differing places and times. This is reflected in the different ages indicated from fossils found at various places.

Of course, the aeolianites must be younger than the underlying "foundation" of marine deposits. Potentially the oldest Miocene aeolianites would overlie mid-Miocene Saldanha Fm., mid-Pliocene and younger aeolianites would overlie the Varswater Fm and early Quaternary and younger aeolianites would overlie the Uyekraal Fm. The youngest Langebaan Fm. aeolianites postdate the Velddrif Formation (Figure 3.9) and are as young as ~60 ka. In the case of the younger Quaternary dunes, the most favourable sand supply conditions seem to have prevailed at sea levels below present, in the range of 10-40 m bsl.

3.6.1.6 The Springfontyn Formation

The Springfontyn Formation is an informal category that accommodates the mainly non-calcareous, windblown sand sheets and dunes that have covered parts of the landscape during the Quaternary. Its spatial extent is depicted on the geological map in pale yellow hues wherein Visser & Schoch (1972, 1973) differentiate the coversands by their surface appearance into 2 surficial units, **Q2** (older cover) and **Q1** (younger cover). The Springfontyn Fm. consists of the sequences beneath these "coversands", *i.e*. SubQ2 and SubQ1.

Unit Q2 is characterized by its surface manifestation as the distinct "heuweltjiesveld", the densely dot-patterned landscape of low hillocks that are termitaria made by *Microhodotermes viator*. Its true spatial extent is not immediately appreciated as it laps onto bedrock and onto the Langebaan Fm., but for the purposes of geological mapping these overlap areas are not shown. It is also apparent that Q2 underlies large areas now covered by Q1.

The dot-patterned "heuweltjiesveld" is merely the surface-soil characteristic of Unit Q2. Not much detail is known about Unit Q2 at depth (Sub-Q2). Pedogenic layers of ferruginous concretions, clayey beds and minor calcretes occur among sandy-soil beds. Clearly Q2 will differ from place to place according to the local setting. In this area, in addition to mainly windblown sands from the south, Sub-Q2 will likely comprise the local colluvial/hillwash/sheetwash deposits, small slope-stream deposits, alluvium in the lower valleys and vlei and pan deposits.

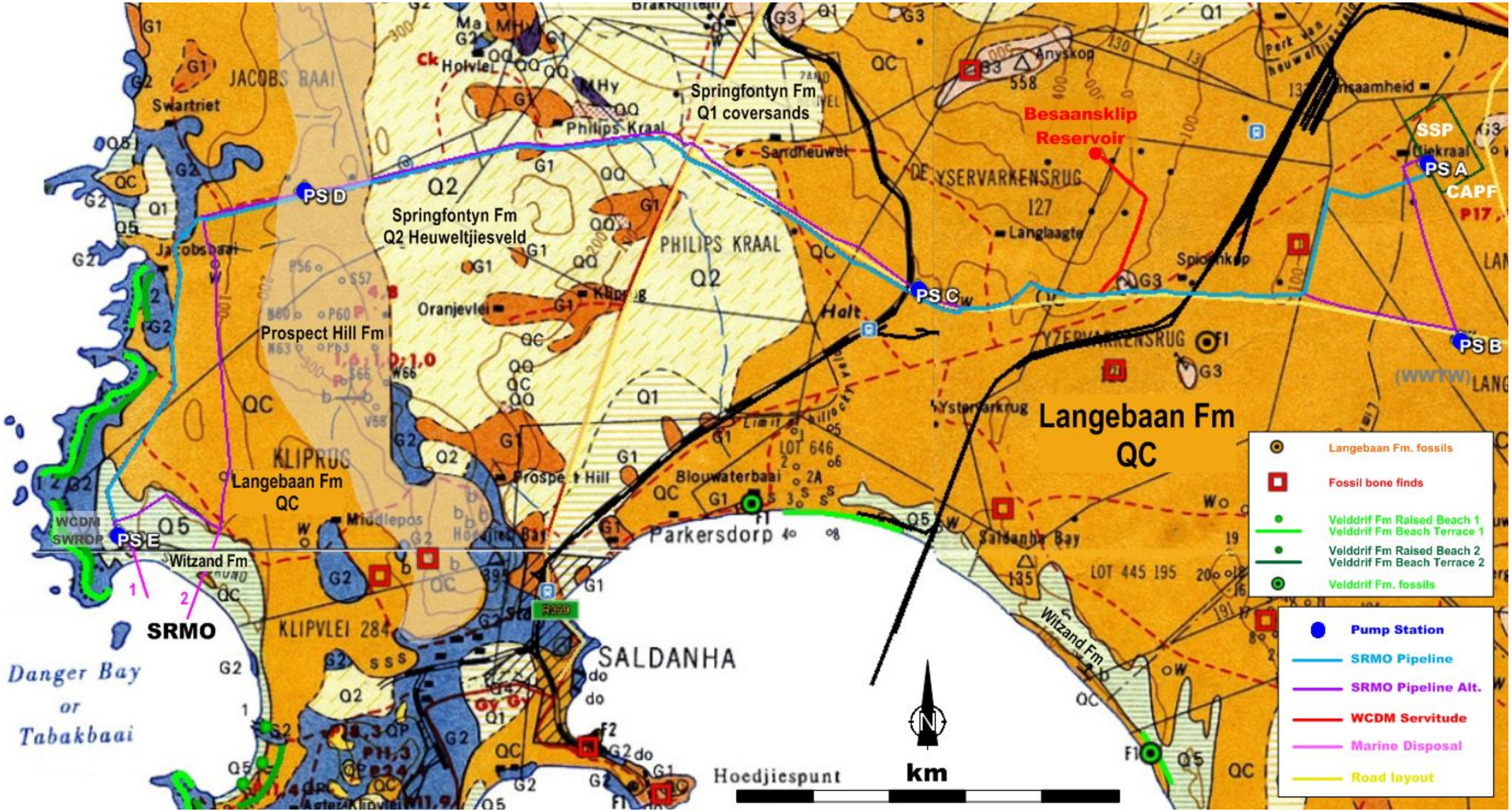


Figure 3.9 Surface geology of the study area. Annotated extract from Visser & Schoch (1972), 1:125000 Map Sheet 255: 3217D & 3218C (St Helenabaai), 3317B & 3318A (Saldanhabaai). Legend in order of youngest to oldest formations.

Surface Unit Q1 is a younger "coversand" geological unit and is "white to slightly-reddish sandy soil" (Visser & Toerien, 1971; Visser & Schoch, 1973). These are patches of pale sand deposited in geologically-recent times. In places these sands are undergoing semi-active transport and locally have been remobilized into active sandsheets and dunes.

Chase & Thomas (2007) have cored Q1 coversands in a regional survey of various settings along the West Coast and applied optically stimulated luminescence (OSL) dating techniques to establish the timing of sand accumulation. Their results indicate several periods of deposition of Q1 during the last 100 ka, with activity/deposition at 63–73, 43–49, 30–33, 16–24 and 4–5 ka. Notably, underlying sands produced dates from ~150 to ~600 ka, reflecting the accumulation of Unit Q2 in the middle Quaternary.

The Springfontyn Formation aeolianites date from at least ~600 ka, if not older and, in parts, may be of similar ages as parts of the Langebaan Fm. (Figure 3.9), but derived from less calcareous sources and/or deposited in settings more prone to subsequent groundwater leaching in water tables. The reworking of older coastal-plain deposits was likely the major sediment source. It is also possible that decalcified marine sands have not been recognized as marine in origin, especially if only encountered in boreholes, and been included in the Springfontyn Fm.

3.6.1.7 The Witzand Formation - aeolian

The latest addition of dunes to the coastal plain is shown in Figure 3.9 as **Unit Q5**, called "Holocene dunes" and otherwise known as the Witzand Formation (Rogers, 1980), for obvious reason. These are sands blown from the beach in the last few thousand years and added to the fossil dune cordon or "sand wall" parallel to the coast, or have blown further as dune plumes transgressing a few to several kilometres inland.

3.6.1.8 The Velddrif Formation – marine and estuarine

After ~2.6 Ma the Earth went into "Ice House" mode (the Quaternary Period) and major ice caps formed in the polar regions, subtracting water from the oceans. During Ice Ages sea levels fluctuated at positions mainly below present (Figure 3.9) and coastal rivers eroded their valleys to deeper levels. These now-submerged shorelines were also the source of the sand for further additions to the Langebaan Formation in the form of dune plumes blown far inland.

During the Quaternary period there were brief intervals of global warming (interglacials), of which the present time is an example, when sea levels were similar to the present level or several metres above or below present level. The higher sea levels are the Quaternary "raised beaches" found at low elevations (<15 m asl.) around the coast, where they are exposed in cliffs beneath dune rocks, on top of low marine platforms fringing the coast and within the lower reaches of valleys, *e.g.* the Berg River. They comprise the Velddrif Formation (Figure 3.9).

Most of the Velddrif Formation deposits that are exposed date to the Last Interglacial (LIG) about 125 ka (ka: thousand years ago) and are found up to ~8 m asl. due to storm deposition, but the mean sea level was about 5-6 m asl. The LIG is also known as Marine

Isotope Stage 5e (MIS 5e). In Figure 3.9 the LIG deposits are shown as the lower "Raised Beach 1" and "Beach Terrace 1".

Farther inland are higher-lying marine terrace deposits up to 12-15 m asl. This older raised beach is very poorly known and it is possible that beach deposits of differing ages are preserved from place to place. It is probable that most of such occurrences relate to an older interglacial high sea level around 400 ka (MIS 11). In Figure 3.9 these older deposits are shown as the upper "Raised Beach 2" and "Beach Terrace 2".

Deposits relating to the MIS 7 interglacial about 200 ka are often found interbedded in the bases of the Langebaan Formation aeolianite seacliffs and exposed in the intertidal zone and below sea level. These include estuarine/lagoonal and coastal vlei deposits, the latter reflecting high water tables associated with the nearby high sea level (Figure 3.10). The vlei deposits include organic-rich and peaty beds with terrestrial fossil bones.

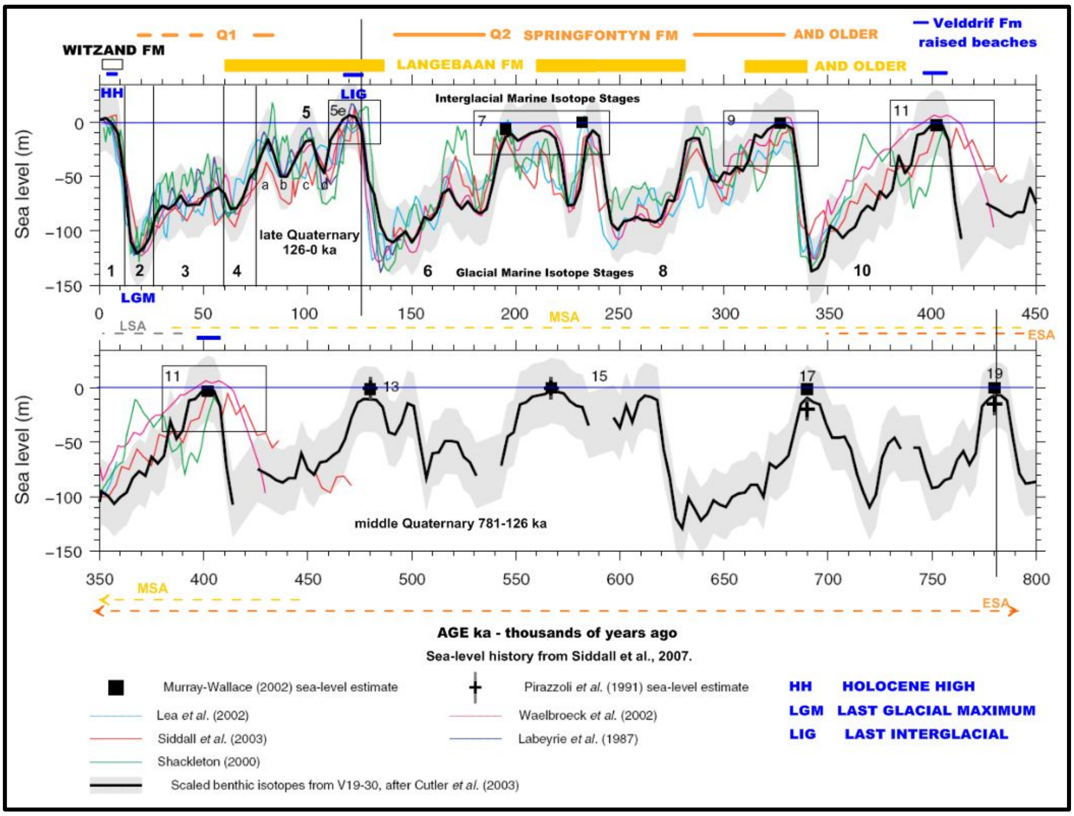


Figure 3.10 Sea level history for the middle and late Quaternary, showing glacial/interglacial Marine Isotope Stages. (From Siddall *et al.*, 2007)

3.6.2 Archaeology

Several Middle Stone Age (MSA) shell middens occur in this part of South Africa (Avery *et al.* 2008; Berger & Parkington 1995; Stynder *et al.* 2001); these are of international significance. Bifacial points commonly associated with the MSA period known as "Still Bay" have also been found on the Vredenburg Peninsula (Bateman 1946; Smith 2006).

Later Stone Age (LSA) material is more common, however, and sites of this age are widely distributed in the landscape. The Kasteelberg hill, located 10 km northwest of Vredenburg is particulary important as it attracted much settlement (Sadr *et al.* 2003; Smith 2006; Smith *et al.* 1991). The agricultural lands around the hill contain rare isolated artefacts and very few concentrations of artefacts large enough to be referred to as sites (Webley *et al.* 2010). One site of significance that has been documented in the open lands around Kasteelberg is KFS5 where it was suggested that a Khoekhoe kraal may have once been present (Fauvelle-Aymar *et al.* 2006). Various studies on the plains in the eastern part of the study area have shown that archaeological material in that area is virtually entirely absent away from the immediate coastline (Hart 2003; Hart & Pether 2008; Orton 2011; Smith 2011). Within the grounds of the Langebaanweg Fossil Park is a large deflation hollow on a low hill called Anyskop. In addition to occasional ESA and MSA artefacts, numerous LSA artefacts and burnt stones indicative of hearths have been found there (Dietl *et al.* 2005; Kandel & Conard n.d.).

Later Stone Age shell middens occur behind the rocky outcrops in the vicinity of Club Mykonos (Hart 2001; Hart and Gribble 1998; Hart & Jerardino 1998), while another very large midden (now completely destroyed) was located in the town of Saldanha Bay (Orton 2009). The south-western and western coastline of the Vredenburg Peninsula has also been found to have many shell middens and scatters of varying density (Buchanan *et al.* 1978; Glenny 2003; Hart 2010; Hine 2004; Kaplan 2011; Robertshaw 1977, 1979; Sadr 2009; Sadr & Gribble 2010; K. Sadr, pers. comm. 2011); the desalination plant survey showed a number to be present in the white aeolian dunes around the shores of Danger Bay (Orton 2012).

LSA burials are relatively uncommon from this area (Morris 1992), although as many as six burials were found buried in Diaz Street Midden (Dewar 2010).

Two sites of special archaeological concern (JB001 and DB022) have been identified (Figure 3.11). These sites contain shell scatters and should ideally be avoided or would require full mitigation.

Figure 3.11 A shell midden draped over a deflating dune at DB022. Source: Orton (2012).

3.6.2.1 Historical aspects

Throughout the early history of the occupation of the Cape, the Dutch used Saldanha Bay extensively. Gribble (2009:81) notes that 'Saldanha Bay had been seen as a fine anchorage, a safe haven for vessels in need, and had proven itself to be a pantry for the settlement, a rich source of fish, seal and penguin meat and oil, birds' eggs and salt, and a source of stock bartered from the indigenous Khoi Khoi population".

Archaeological sites relating to the colonial period are generally rare with the most significant one from this region being Oudepost, a Dutch East India Company outpost on the Churchaven Peninsula (Schrire *et al.* 1990). Historical records suggest that European settlers were living in the area from quite early on, but no other known historical archaeological sites are on record. A survey close to Saldanha Bay did find a scatter of late 19^{th} or early 20^{th} century glass and ceramics but these artefacts were not associated with any particular find (Orton 2007).

3.6.2.2 Built environment

Farm houses and outbuildings dating to the 19^{th} and 20^{th} centuries are common on the Vredenburg Peninsula, but Fransen (2004) documents relatively few as significant heritage resources. Saldanha Bay was still a very small village in the early 20^{th} century (Figure 3.12) and was centred strongly on the north-westernmost corner of the bay. By 1938 it had not expanded much at all (Figure 3.13). Most development is thus fairly recent. A pipeline was constructed during World War II to bring water from the Berg River to the town (Visser & Monama 2008). This laid the platform for development of the town. Just north of Jacobsbaai, Hart (2010) recorded a typical vernacular fisherman's cottage built of local calcrete and still in reasonable condition. Such structures are now rare.

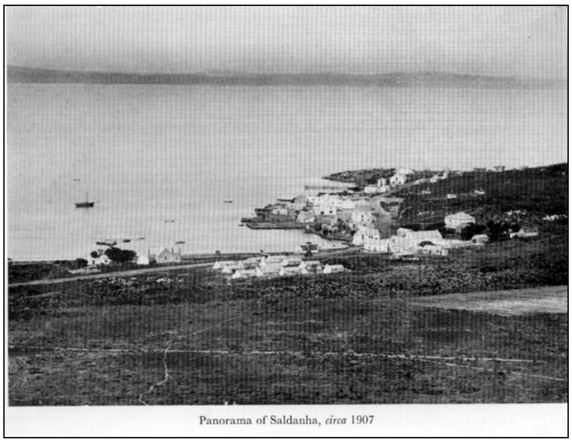


Figure 3.12 Early 20th century view of Saldanha Bay looking towards the southwest (Wide Blue,n.d.).

Figure 3.13 1938 Aerial photograph of Saldanha Bay.

The well-known Hoedjieskop is visible at bottom centre.

3.6.2.3 Maritime archaeology

Historical shipwrecks are known to occur throughout the area. The South African Heritage Resources Agency Maritime Archaeology Unit has documented these and compiled a database of known wrecks. A number do occur around the Vredenburg Peninsula and in Saldanha Bay (Gribble 2009; Truter, n.d.; J. Boschoff, pers. comm. 2012). None are known to occur in Danger Bay.

3.6.2.4 Military history

World War II structures are known to occur to the north of Danger Bay and the present naval facilities are situated at SAS Saldanha to the south of Danger Bay.

3.7 FRESHWATER RESOURCES

The west coast is generally a semi-arid region with low rainfall and associated watercourses and wetlands.

3.7.1 Ecoregion context

An ecoregional classification produced by Kleynhans *et al*. (2005) divided the country's rivers into 31 distinct ecoregions, or groups of rivers which share similar physiography, climate, geology, soils and potential natural vegetation. The present site lies in the South Western Coastal Belt Ecoregion. This ecoregion is characterised by the following broad attributes:

- Comprises mainly plains with a moderate to low relief;
- Dominant vegetation type is West Coast Renosterveld although significant areas of Fynbos, Succulent Karoo and Thicket occur;
- Mean annual precipitation is Moderate in a limited area in the south, decreasing to low in the north;
- Drainage density is low;
- Stream frequency is low/medium; and
- Mean annual temperatures are moderate/high.

3.7.2 Catchment context

The proposed SRMO pipeline routing options lie within DWA quarternary catchment G10M, in the Berg River Water Management Area. One of the wetlands assessed in this study (Wetland 1; Figure 3.14) lies within minor catchments, which either dissipates or drains directly into the sea to the west. The other assessed area (Wetland 2) is situated in the catchment of the Bok River (Figure 3.15), which flows south into Saldanha Bay.

3.7.3 Wetlands

Wetland 1 is classified as a Strandveld Depression (Job *et al*. 2008). Strandveld Depressions Strandveld depression wetlands such as this occur primarily on the Saldanha Peninsula and just north of the lower Berg River, and are described as being primarily reliant on precipitation rather than groundwater or surface flow, and usually brackish to saline. In the present case, the wetland appeared to function as a perched system, and did not connect to any channelled outflow. During periods of particularly high surface runoff, it is likely that the wetland expands its extent of inundation into the surrounding farmland, rarely overtopping to the extent that it drains into the adjacent watersheds.

Wetland 2 is classified as a Strandveld Valley Bottom Wetland which are located almost exclusively on the Saldanha Peninsula, and comprising seasonal wetlands, associated with lower foothill and lowland rivers. They are generally fed by hillslope seeps lying on higher ground and are not particularly groundwater-dependent. Most of the valley bottoms have a well-defined channel, but it is likely that historically they lacked a channel and water flowed as diffuse flow through marshy areas. Strandveld valley bottoms tend to be saline, and occur on neutral to alkaline sands or granite-derived soils.

Data from the National Freshwater Ecosystem Priority Area (NFEPA) and the wetland impact assessment study undertaken by Dr Liz Day as part of the WCDM desalination EIA indicated that there are 2 areas where watercourses or wetlands may be traversed by the pipeline and electrical corridor (Wetland 1 and Wetland 2); these are shown in Figure 3.14 and Figure 3.15 below.

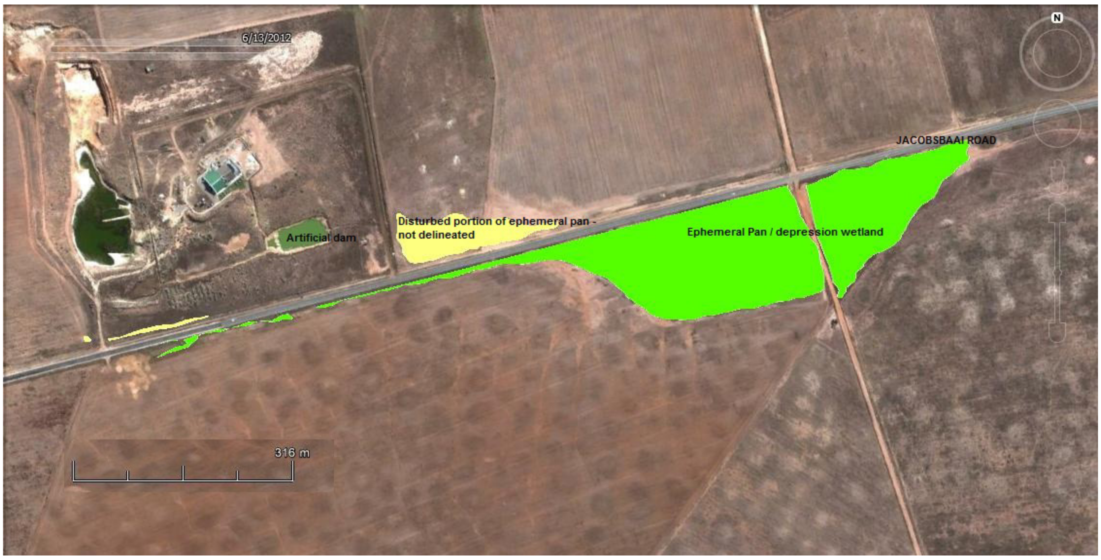


Figure 3.14 Wetland 1 off the Jacobsbaai Road (green polygon), disturbed portion of ephemeral pan (beige polygon)

Figure 3.15 Wetland 2 off the Jacobsbaai Road (green polygon)

Routing the pipeline corridor along the Jacobsbaai Road would potentially affect wetlands in the area of Wetlands 1 and 2. Excavation of a pipeline trench, stockpiling of excavated soil and compaction over the pipelines would have adverse implications for wetlands.

These impacts would be considered highly undesirable in the case of the delineated Wetland 1 on the southern side of the Jacobsbaai Road. The impacts are likely to be permanent and of medium intensity, and although taking place within only a small portion of the wetland, would be considered as taking place at a regional scale, given the conservation importance of Wetland 1. It is for these reasons (amongst others) that the proposed Frontier SRMO Project and electrical corridor will be routed along the northern section of the Jacobsbaai Road through the disturbed portion of ephemeral pan (beige polygon).

In the case of Wetland 2, comprising the Bok River valley bottom wetland, installation of the pipelines would be likely to trigger most of the above impacts, over a highly localised area, but nevertheless an area with implications for flow along the channel. As the proposed corridor development will occur within 500 m of these wetlands, a Water Use Licence Application (WULA) will be submitted to the Department of Water Affairs (DWA) with the Final EIR (this approach was confirmed by Mr Warren Dreyer of DWA).

Groundwater regionally flows in a south-westerly direction across the site towards the coast. As groundwater regionally flows south-westwards, it flows away from both the Langebaan Road and Elandsfontein Aquifer Systems, as well as away from existing groundwater users in the area east of the Salkor Yard. According to the 1:250 000 Hydrogeological map of Cape Town the Electrical Conductivity of groundwater found in the region are between 150 – 300 mS/m.

According to the DWAF (1998), *Quality Guidelines for Domestic Water Supplies*, this range is classified as unacceptable for drinking purposes and represents saline conditions. The quality of the natural groundwater is a direct result of the closeness of these aquifers to the ocean. Ambient groundwater tends towards a Na-Cl character, which is common for groundwater along the coast (Aurecon, 2013).

3.8 MARINE ENVIRONMENT

The semi-arid Mediterranean climate of the Cape West Coast is influenced by the cold northward-flowing Benguela Current. There is a strong seasonality in the winds over the region, reflecting the changes in the synoptic weather patterns prevailing at different times during the year. In summer the winds are predominantly southerly with significant south westerly and to a lesser extent south easterly wind components. The regular passage of cold fronts in winter results in predominantly north westerly winds with the occurrence of south westerly and south easterly wind components. The winds along the west coast have a significant diurnal component as well as inter-annual variability. There exists a wealth of information regarding the metocean characteristics of the Saldanha Bay but less so on Danger Bay.

3.8.1 Physical environment

3.8.1.1 Bathymetry

Danger Bay is a relatively enclosed bay with rocky points to both the north and south extremities of the bay. The slope of the bottom is relatively shallow. The -10 m Mean Sea-level (MSL) contour is approximately 500 to 700 m offshore, while the -20m MSL depth contour typically lies more than 1 km offshore (see Figure 3.16 and Figure 3.17). The -10 m and -20 m MSL water depth contour in the vicinity of the northern point are located closer inshore, lying approximately 450 m and 700 m offshore respectively. To the south of Danger Bay, the -20 m MSL isobath lies < 400 m from the shoreline. The bathymetric chart for Danger Bay area is depicted in Figure 3.17).

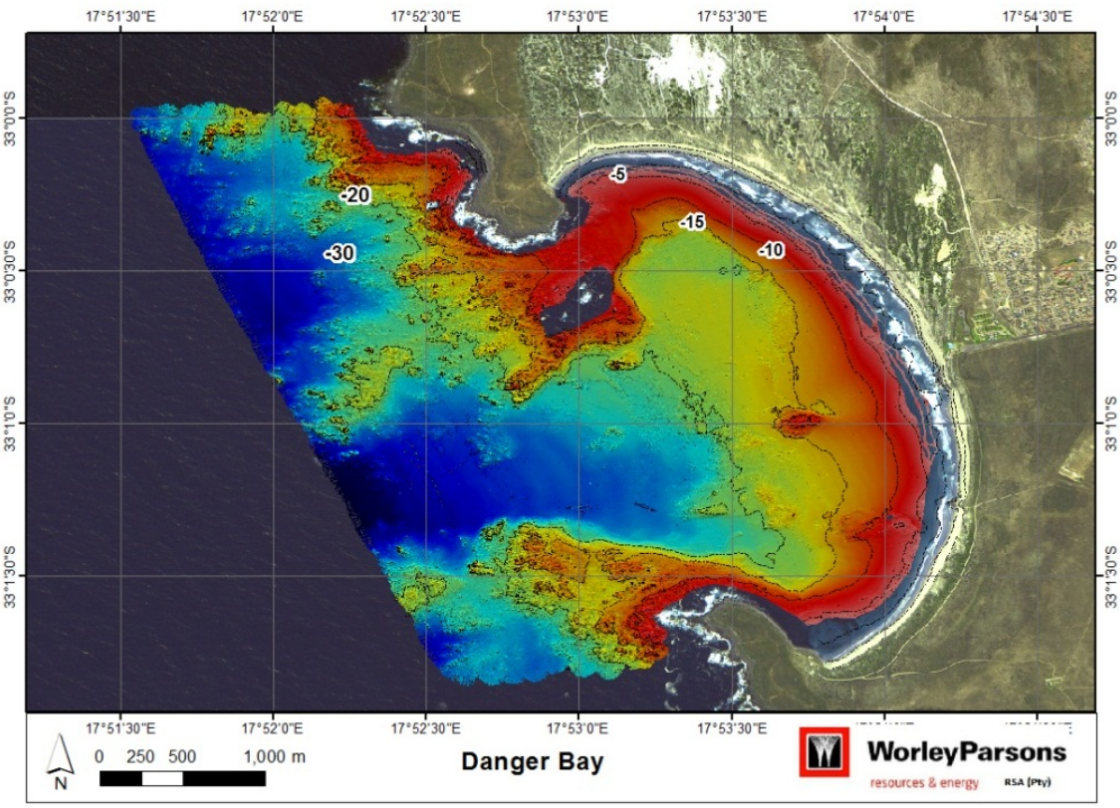


Figure 3.16 Bathymetry at Danger Bay– July 2012 (from CSIR, 2013)

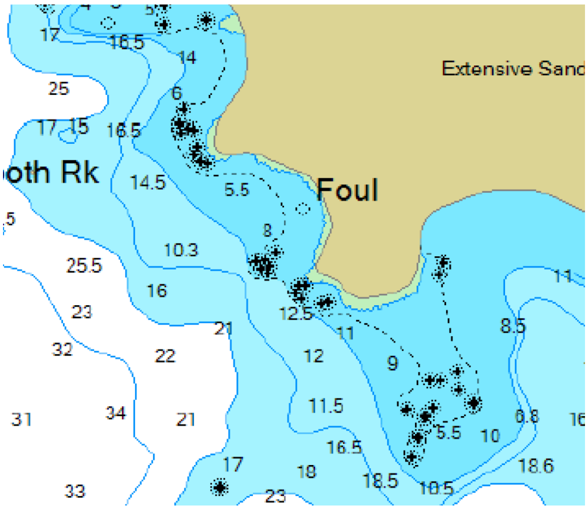


Figure 3.17 Danger Bay bathymetry chart (from WorleyParsons RSA, 2012)

3.8.1.2 Waves and tides

Most of the west coast of southern Africa is classified as exposed, experiencing strong wave action, rating between 13 - 17 on the 20 point exposure scale (McLachlan 1980). Danger Bay is relatively exposed to the open-coast swell conditions, with waves approaching from the southwest to west throughout the year. The heavy south-westerly swells are generated in the roaring forties, but significant sea waves are also generated locally by the prevailing moderate to strong southerly winds characteristic of the region.

Winter swells are strongly dominated by those from the southwest to south-southwest (see Figure 3.18 and Figure 3.19), which occur almost 80% of the time, and typically exceeding 2 m in height, averaging about 3 m, and often attaining over 5 m. With wind speeds capable of reaching 100 km/h (during heavy winter south-westerly storms, winter swell heights can exceed 10 m). Summer swells tend to be smaller on average, typically around 2 m with a more pronounced southerly swell component. These southerly swells tend to be wind-induced, with shorter wave periods (~8 seconds), and are generally steeper than swell waves. The wind-induced southerly waves are relatively local and work together with the strong summer southerly winds to cause the northward-flowing nearshore surface currents, which results in substantial nearshore sediment mobilisation and northwards transport.

Wave run-up is site specific and depends on the beach profile characteristics and local wave climate. Assessments undertaken as part of the WCDM desalination EIA at Danger Bay indicate that wave run-up levels reach the bottom of the dunes where the average elevation is +3.0 m MSL.

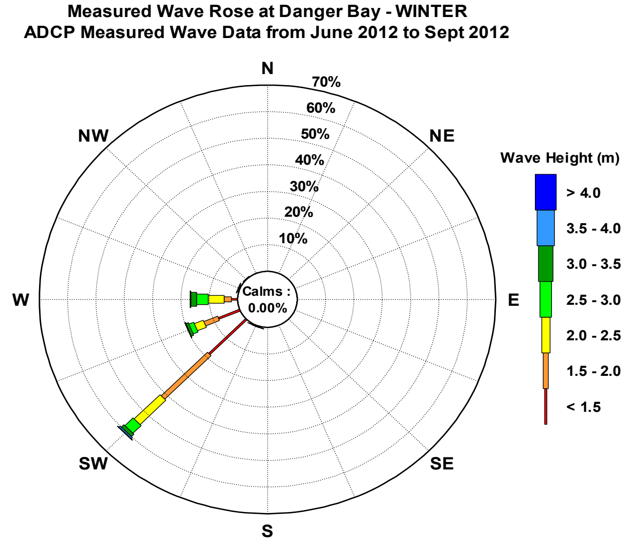


Figure 3.18 Wave rose at proposed marine outfall in Danger Bay at ADCP location (33.01336° S; 17.88990° E) - Winter

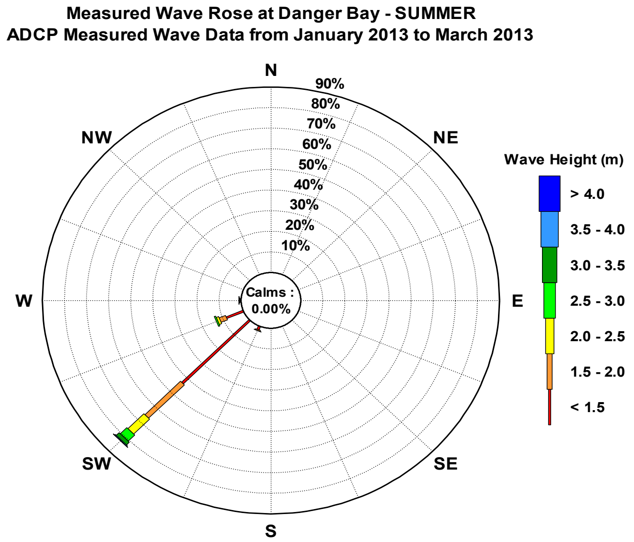


Figure 3.19 Wave rose at proposed marine outfall in Danger Bay at ADCP location (33.01336° S; 17.88990° E) - Summer

The tides along the west coast are semi-diurnal, with an approximate 2 m tidal range during spring tides.

3.8.1.3 Wind, currents and circulation patterns

In the Saldanha Bay region, there is a strong seasonality in the winds, reflecting the changes in the synoptic weather patterns prevailing at different times during the year. In summer the winds are predominantly southerly with significant southwesterly and to a lesser extent southeasterly wind components. The regular passage of cold fronts in winter results in predominantly northwesterly winds with the occurrence of southwesterly and southeasterly wind components. The winds along the West Coast have a significant diurnal component as well as inter-annual variability.

Winds are the main physical driver of the Benguela nearshore region, and physical processes are characterised by the average seasonal wind patterns. Consequently, the Benguela region is primarily characterised by variable, northward flowing, longshore surface currents, generated by the consistent south and southwest winds and swells (Shillington *et al*. 1990, Shannon & Nelson 1996). These nearshore surface currents remain closely aligned with the coastline and the winds, generally flowing in a northerly direction. Currents tend to follow major topographic features, with typical current speeds in the region ranging from 10 - 50 cm/s. Over the southern Benguela region there is a southward flow of cold water close inshore near the surface, which occurs during periods of barotropic reversals, and during the winter non-upwelling period (Nelson & Hutchings 1983). There is also a significant southerly poleward flow of sub-thermocline water on the continental shelf and at the shelf break, forming a poleward undercurrent, which becomes more consistent to the south (Nelson 1989, Boyd & Oberholster 1994, Shannon & Nelson 1996).

The currents within Danger Bay are predominantly forced by waves and wind, with tides playing less of a role. The relative influence of the processes changes with depth and location in the bay. In general, wind is the dominant physical forcing mechanism determining the surface layer current speed and direction. Wave-driven currents are likely to dominate in the surf-zone. Current flow was predominantly from the NE to ENE near the surface, variable in the mid water column, and becoming polarised between SSW and the NE directions near the seabed. Mean current speeds range between 9.9 cm/s and 3.8 cm/s from surface to seabed, with maximum speeds of 38 cm/s measured near the surface and a maximum speed of 13.5 cm/s recorded at the seabed at 13 m depth (WorleyParsons 2014).

Current roses from numerical model results undertaken for the WCDM desalination EIA (WP/CSIR, 2012) for Danger Bay show that current magnitude with depth-average current speeds are approximately 0.18 m/s on average and peaking at 0.79 m/s (see Figure 3.20). Note that the currents include tidal, wind and wave-driven components.

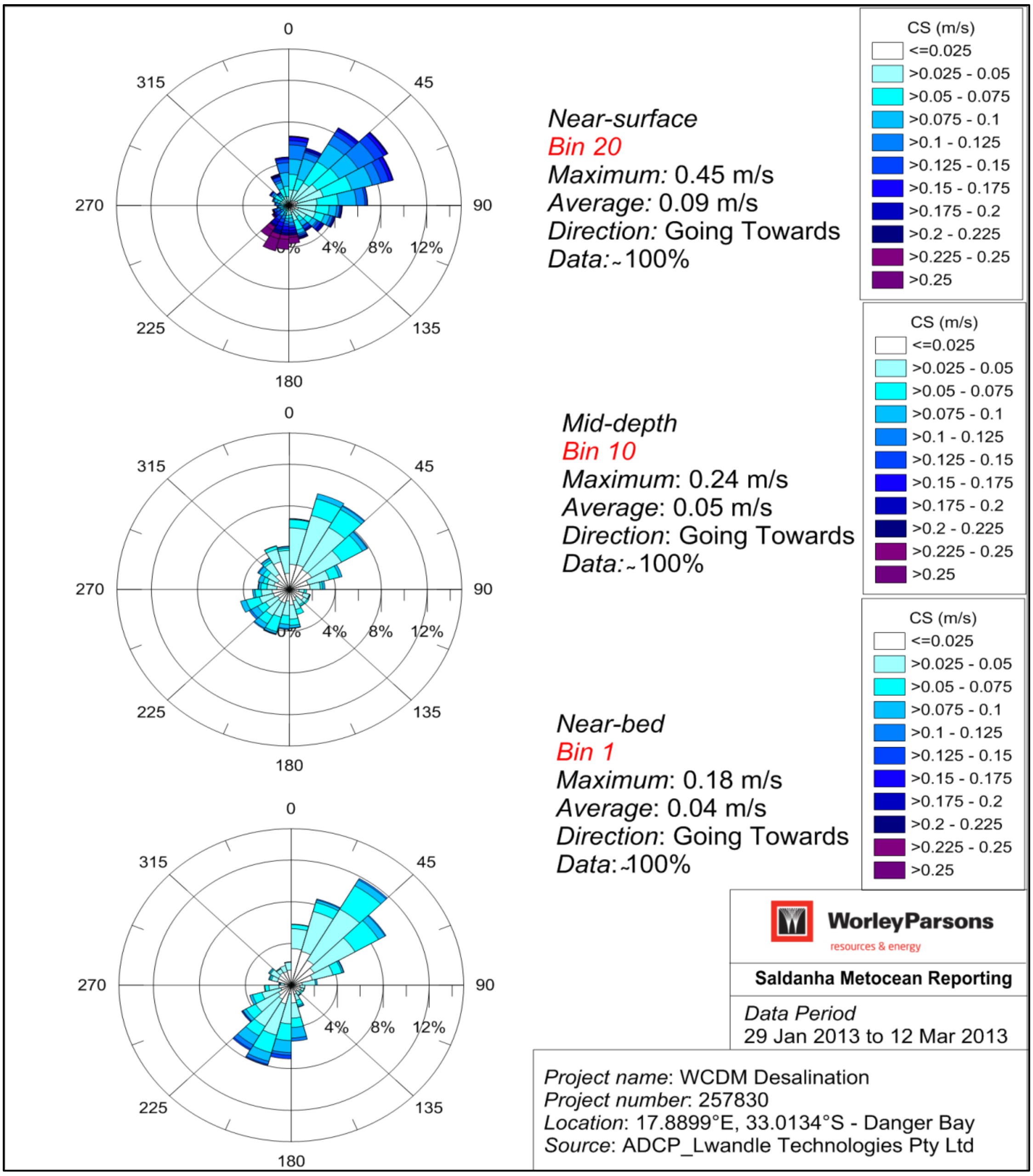


Figure 3.20 Current rose at Danger Bay intake

The water column structure in Danger Bay is seasonal, varying from being strongly thermally stratified for most of the year (August to May) to well-mixed conditions during the mid-winter months (June to July). Inshore waters are relatively well-mixed, but water column stratification does occur in the deeper portions of the bay. Strong stratification is maintained by atmospheric heat fluxes into the surface waters and the inflow of cold bottom waters from upwelling on the adjacent continental shelf. Local winds mix the water column vertically and break down the thermocline. Winter temperatures varied between 10.8°C and 15.2°C, whereas during summer temperatures varied between 9.4°C and 13.1°C at 17 m depth and between 9.4°C and 16.4°C in shallower areas. Salinity within the bay varied between 32.8 and 35.4 psu and pH varied between 7.7 and 8.9.

3.8.1.4 Upwelling and Plankton Production

Coastal, wind-induced upwelling is the principal physical process that shapes the marine ecology of the Benguela region. The prevailing longshore, equatorward winds move nearshore surface water northwards and offshore. To balance the displaced water, cold, deeper water wells up inshore. Although the rate and intensity of upwelling fluctuates with seasonal variations in wind patterns, the most intense upwelling tends to occur where the shelf is narrowest and the wind strongest. The largest and most intense upwelling cell on the southern African west coast is in the vicinity of Lüderitz in Namibia, and upwelling can occur there throughout the year (Shannon & O'Toole 1998, Shillington 2003). Several secondary upwelling cells occur. Danger Bay falls into the influence of the Cape Columbine cell (33°S) (Figure 3.21) and is thus likely to be periodically influenced by upwelling-related processes. The Namaqua (30°S) and Cape Point (34°S) upwelling cells are located to the north and south of the project area, respectively. Upwelling in these secondary cells is seasonal, with maximum upwelling occurring between September and March. During the winter months westerly winds result in relaxation of upwelling and often warmer surface water temperatures (Lutjeharms & Meeuwis 1987).

During upwelling the comparatively nutrient-poor surface waters are displaced by deep water rich in inorganic nutrients, thereby supporting substantial seasonal primary phytoplankton production (Chapman & Shannon 1985). High phytoplankton productivity in the upper layers again depletes the nutrients in these surface waters, resulting in a wind-related cycle of plankton production, mortality, sinking of plankton detritus and eventual nutrient re-enrichment occurring below the thermocline as the phytoplankton decays.

Biological decay of plankton blooms can, however, lead to "black tide" events, as the available dissolved oxygen is stripped from the water during the decomposition process. Subsequent anoxic decomposition by sulphur reducing bacteria can result in the formation and release of hydrogen sulphide (Pitcher & Calder 2000). Sulphur eruptions are, however, uncommon along the South African coastline, primarily occurring north of Lüderitz, in Namibia.

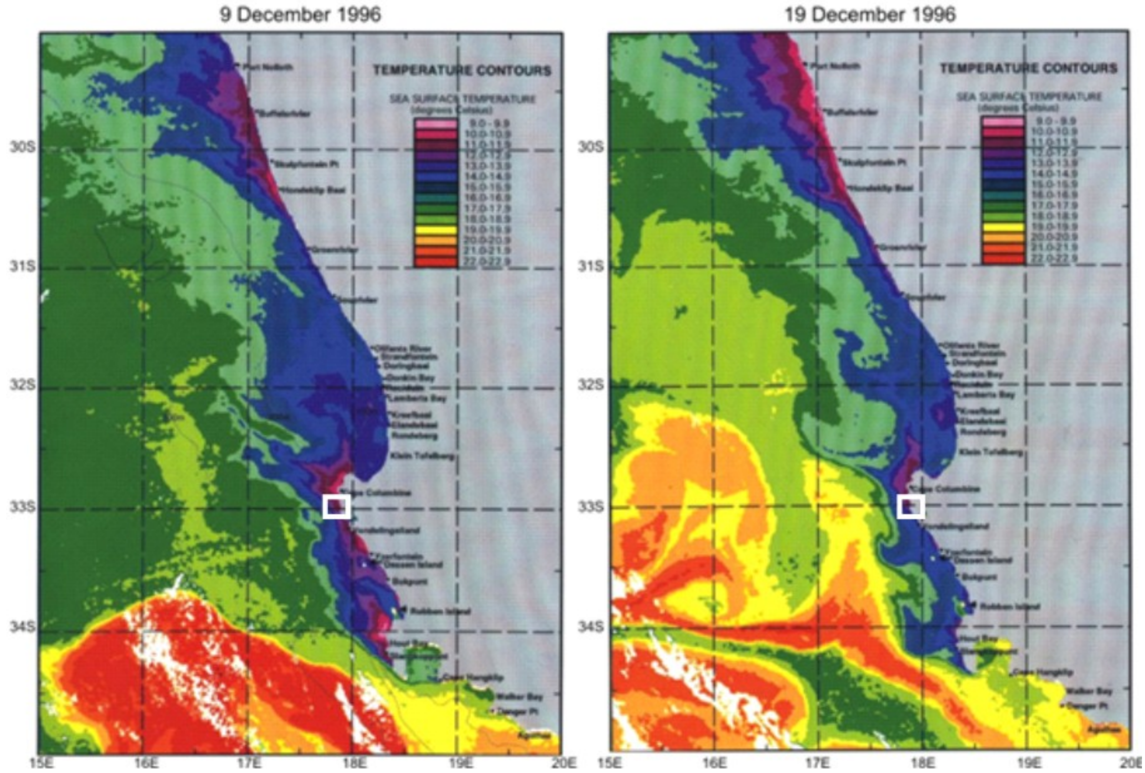


Figure 3.21 Satellite sea-surface temperature images showing upwelling intensity along the South African west coast and the influence of the Agulhas current on temperatures on the southwest coast (from Lane & Carter 1999). The white block denotes the project area.

3.8.1.5 Organic Inputs

The Benguela upwelling region is an area of particularly high natural productivity, with extremely high seasonal production of phytoplankton and zooplankton. These plankton blooms in turn serve as the basis for a rich food chain up through pelagic baitfish (anchovy, pilchard, round-herring and others), to predatory fish (snoek), mammals (primarily seals and dolphins) and seabirds (African penguins, cormorants, pelicans, terns and others). All of these species are subject to natural mortality, and a proportion of the annual production of all these trophic levels, particularly the plankton communities, die naturally and sink to the seabed.

Balanced multispecies ecosystem models have estimated that during the 1990s the Benguela region supported biomasses of 76.9 tons/km^2 of phytoplankton and 31.5 tons/km^2 of zooplankton alone (Shannon *et al.* 2003). Thirty six percent of the phytoplankton and 5% of the zooplankton are estimated to be lost to the seabed annually. This natural annual input of millions of tons of organic material onto the seabed off the southern African West Coast has a substantial effect on the ecosystems of the Benguela region. It provides most of the food requirements of the particulate and filter-feeding benthic communities that inhabit the offshore sandy-muds, and results in the high organic content of the muds in the region. As most of the organic detritus is not directly consumed, it enters the seabed decomposition cycle, resulting in subsequent depletion of oxygen in deeper waters.

3.8.1.6 Low Oxygen Events

The continental shelf waters of the Benguela system are characterised by low oxygen concentrations with <40% saturation occurring frequently (e.g. Visser 1969; Bailey *et al.* 1985). The low oxygen concentrations are attributed to nutrient remineralisation in the bottom waters of the system, the absolute rate of which is dependent upon the net organic material build-up in the sediments, with the carbon rich mud deposits playing an important role. (Chapman & Shannon 1985). As the mud on the shelf is distributed in discrete patches, there are corresponding preferential areas for the formation of oxygen-poor water. The two main areas of low-oxygen water formation in the southern Benguela region are in the Orange River Bight and St Helena Bay (Chapman & Shannon 1985; Bailey 1991; Shannon & O'Toole 1998; Bailey 1999; Fossing *et al.* 2000). The spatial distribution of oxygen-poor water in each of the areas is subject to short- and medium-term variability in the volume of hypoxic water that develops. De Decker (1970) showed that the occurrence of low oxygen water off Lambert's Bay is seasonal, with highest development in summer/autumn. Bailey & Chapman (1991), on the other hand, demonstrated that in the St Helena Bay area daily variability exists as a result of downward flux of oxygen through thermoclines and short-term variations in upwelling intensity. Subsequent upwelling processes can move this low-oxygen water up onto the inner shelf, and into nearshore waters, often with devastating effects on marine communities.

Periodic low oxygen events in the nearshore region can have catastrophic effects on the marine communities leading to large-scale stranding of rock lobsters, and mass mortalities of marine biota and fish (Newman & Pollock 1974; Matthews & Pitcher 1996; Pitcher & Calder 2000; Cockcroft *et al.* 2000) (Figure 3.22). The development of anoxic conditions as a result of the decomposition of huge amounts of organic matter generated by algal blooms is the main cause for these mortalities and walkouts. The blooms develop over a period of unusually calm wind conditions when sea surface temperatures were high. Algal blooms usually occur during summer-autumn (February to April) but can also develop in winter during the 'berg' wind periods, when similar warm windless conditions occur for extended periods. Low-oxygen events have, however, not been reported from the region south of St Helena Bay in which the project area is located.

Figure 3.22 Mass stranding, or 'walk-out' of rock lobsters that occurred at Elands Bay on the South African west coast in February 2002 (Photo from http://www.waterencyclopedia.com).

3.8.1.7 Turbidity

Turbidity is a measure of the degree to which the water loses its transparency due to the presence of suspended particulate matter. Total Suspended Particulate Matter (TSPM) can be divided into Particulate Organic Matter (POM) and Particulate Inorganic Matter (PIM), the ratios between them varying considerably. The POM usually consists of detritus, bacteria, phytoplankton and zooplankton, and serves as a source of food for filter-feeders. Seasonal microphyte production associated with upwelling events will play an important role in determining the concentrations of POM in coastal waters. PIM, on the other hand, is primarily of geological origin consisting of fine sands, silts and clays.

Concentrations of suspended particulate matter in shallow coastal waters can vary both spatially and temporally, typically ranging from a few mg/ℓ to several tens of mg/ℓ (Bricelj & Malouf 1984; Berg & Newell 1986; Fegley *et al.* 1992). Field measurements of TSPM and PIM concentrations in the Benguela current system have indicated that outside of major flood events, background concentrations of coastal and continental shelf suspended sediments are generally <12 mg/ℓ, showing significant long-shore variation (Zoutendyk 1995). Considerably higher concentrations of PIM have, however, been reported from southern African West Coast waters under stronger wave conditions associated with high tides and storms, or under flood conditions. During storm events, concentrations near the seabed may even reach up to 10 000 mg/ℓ (Miller & Sternberg 1988).

The major source of turbidity in the swell-influenced nearshore areas off the West Coast is the redistribution of fine inner shelf sediments by long-period Southern Ocean swells. The current velocities typical of the Benguela (10-30 cm/s) are capable of resuspending and transporting considerable quantities of sediment equatorwards. Under relatively calm wind conditions, however, much of the suspended fraction (silt and clay) that remains in suspension for longer periods becomes entrained in the slow poleward undercurrent (Shillington *et al.* 1990; Rogers & Bremner 1991).

Superimposed on the suspended fine fraction, is the northward littoral drift of coarser bedload sediments, parallel to the coastline. Longshore sediment transport varies considerably in the shore-perpendicular dimension, being substantially higher in the surf-zone than at depth, due to high turbulence and convective flows associated with breaking waves, which suspend and mobilise sediment (Smith & Mocke 2002).

3.8.1.8 Water quality

There is no information regarding the water quality of Danger Bay and it is the intention of WorleyParsons to obtain this data utilising water quality sampling analyses currently underway as part of the WCDM pilot plant trials for the design component of the actual 25,5 Ml desalination facility. Frontier Saldanha Utilities is a member of the Saldanha Bay Water Quality (SBWQ) Forum and the Forum has agreed to extend their monitoring campaign to include the Danger Bay area.

3.8.1.9 Beach profile

A topographical survey of the beach was undertaken at Danger Bay for the WCDM desalination EIA. The lower part of the beach profile has an average slope of 1:28. In seasonal trends it is generally found that profiles are more eroded in the stormy winter months and slow signs of accretion in the milder summer period. Successive profiles over several seasons would need to be collected so as to quantify the envelope of profile change.

3.8.1.10 Sediments

Sediment data was collected at Danger Bay along the intertidal zone for the WCDM desalination EIA. The data shows varying median grain size along the bay. As expected, coarser median grain size was found at the centre (more exposed) area of the bay. The median grain size reduces toward the ends of the embayment as depicted in Figure 3.23.

Figure 3.23 Median grain size at Danger Bay

3.8.1.11 Geophysics

A geophysical survey was conducted at Danger Bay for the WCDM desalination EIA. The survey results indicate that the bottom composition comprises rocky reefs and sand as depicted in Figure 3.24. Water jet probing using a 4 m pvc pipe was also undertaken at Danger bay to provide an indication of the sand layer thickness at the nearshore. The results are depicted in Figure 3.25 below.

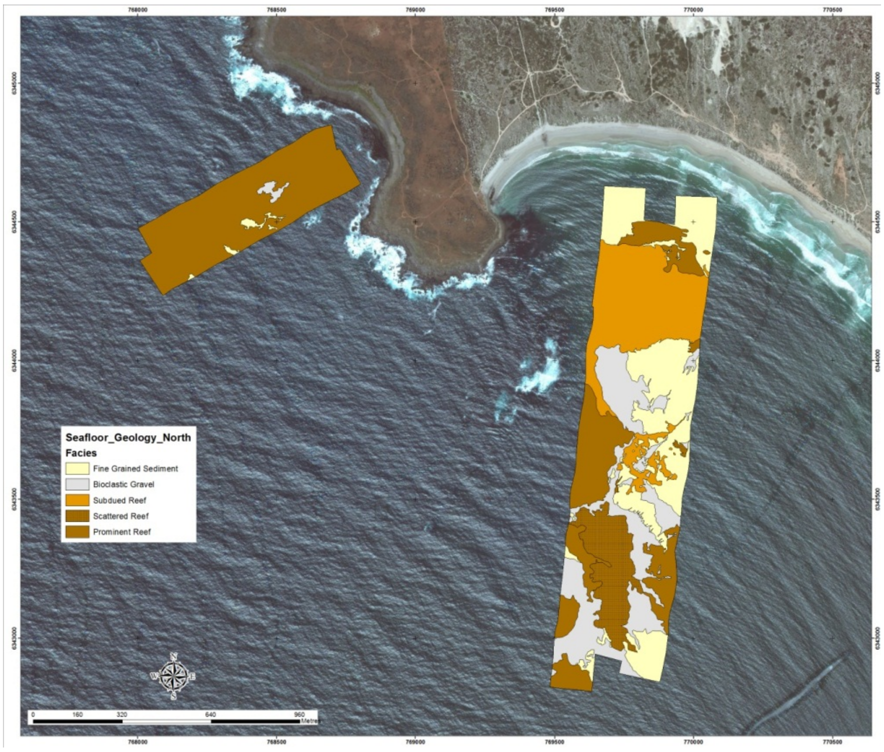


Figure 3.24 Danger bay seafloor geology

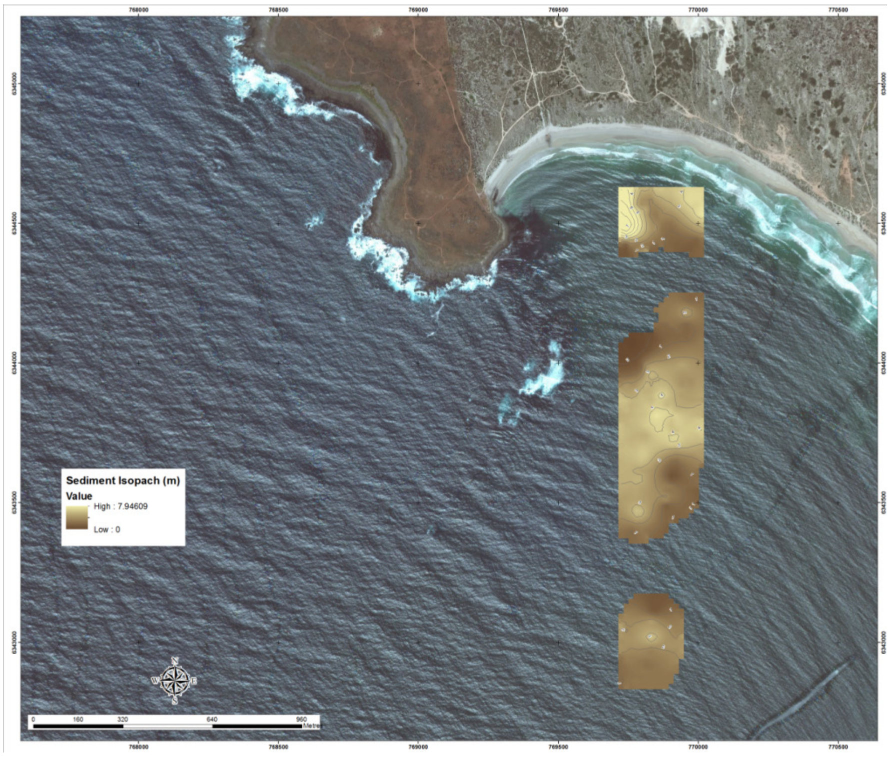


Figure 3.25 Sand layer thickness at Danger Bay

Biogeographically, Danger Bay and the surrounding coastline fall within the cool temperate Namaqua province, which extends from Cape Point to Lüderitz, and is primarily driven by the coastal upwelling characteristic of the region (Emanuel *et al*. 1992; Lombard *et al*. 2004). The biota of nearshore marine habitats on the West Coast is relatively robust, being naturally adapted to an extremely dynamic environment where biophysical disturbances are commonplace. The benthic communities are generally ubiquitous throughout the southern African West Coast region, being particular only to substratum type (i.e. hard vs. soft bottom), wave exposure and/or depth zone. They consist of many hundreds of species, often displaying considerable temporal and spatial variability (even at small scales).

Habitats in Danger Bay primarily include:

- Sandy intertidal and subtidal substrates,
- Intertidal rocky shores and subtidal reefs, and
- The water body.

Although none of these habitats has been specifically sampled in Danger Bay and the immediate surrounds, it can be assumed that their associated biological communities are representative of the 'typical' intertidal and shallow subtidal habitats in the Namaqua biogeographic province. The biological communities in each of these habitats are described briefly below, focussing both on dominant, commercially important and conspicuous species, as well as potentially threatened or sensitive species, which may be affected by the proposed project.

3.8.2 Biological environment

3.8.2.1 Sandy substrate habitats and biota

The benthic biota of soft bottom substrates constitutes invertebrates that live on, or burrow within, the sediments, and are generally divided into megafauna (>10 cm), macrofauna (animals >1 mm) and meiofauna (<1 mm).

3.8.2.1.1 Intertidal Sandy Beaches

Eventhough the coastline outside of Danger Bay is highly dominated by rocky shores, the Bay itself comprises a beach. Sandy beaches are one of the most dynamic coastal environments. The composition of their faunal communities is largely dependent on the interaction of wave energy, beach slope and sand particle size, which is termed beach morphodynamics. Three morphodynamic beach types are described: dissipative, reflective and intermediate beaches (McLachlan *et al.* 1993). Generally, dissipative beaches are relatively wide and flat with fine sands and high wave energy. Waves start to break far from the shore in a series of spilling breakers that 'dissipate' their energy along a broad surf zone. This generates slow swashes with long periods, resulting in less turbulent conditions on the gently sloping beach face. These beaches usually harbour the richest intertidal faunal communities. Reflective beaches have low wave energy, and are coarse grained (>500 µm sand) with narrow and steep intertidal beach faces. The relative absence of a surf-zone causes the waves to break directly on the shore causing a high turnover of sand.

The result is depauperate faunal communities. Intermediate beach conditions exist between these extremes and have a very variable species composition (McLachlan *et al.* 1993, Jaramillo *et al.* 1995, Soares 2003). This variability is mainly attributable to the amount and quality of food available. Beaches with a high input of e.g. kelp wrack have a rich and diverse drift-line fauna, which is sparse or absent on beaches lacking a drift-line (Branch & Griffiths 1988). As a result of the combination of typical beach characteristics, and the special adaptations of beach fauna to these, beaches act as filters and energy recyclers in the nearshore environment (Brown & McLachlan 1990).

Numerous methods of classifying beach zonation have been proposed, based either on physical or biological criteria. The general scheme proposed by Branch & Griffiths (1988) is used below (Figure 3.26), supplemented by data from various publications on West Coast sandy beach biota (e.g. Bally 1987, Brown *et al.* 1989, Soares *et al.* 1996, 1997, Nel 2001, Nel *et al.* 2003, Soares 2003, Branch *et al.* 2010, Harris 2012).

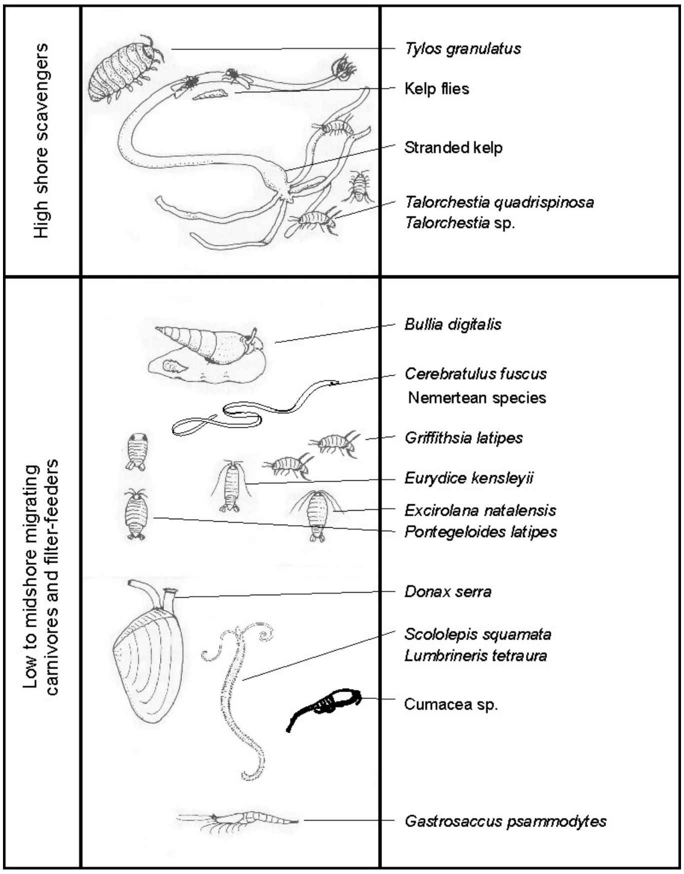


Figure 3.26 Schematic representation of the West Coast intertidal beach zonation (adapted from Branch & Branch 1981). Species commonly occurring on the Namaqualand beaches are listed.

The macrofaunal communities of sandy beaches are generally ubiquitous throughout the southern African West Coast region, being particular only to substratum type, wave exposure and/or depth zone. Due to the exposed nature of the coastline in the study area, most beaches are of the intermediate to reflective type. The supralittoral zone is situated above the high water spring (HWS) tide level, and receives water input only from large waves at spring high tides or through sea spray. This zone is characterised by a mixture of air breathing terrestrial and semi-terrestrial fauna, often associated with and feeding on kelp deposited near or on the driftline. Terrestrial species include a diverse array of beetles and arachnids and some oligochaetes, while semi-terrestrial fauna include the oniscid isopod *Tylos granulatus*, and amphipods of the genus *Talorchestia*. The intertidal zone or mid-littoral zone, has a vertical range of about 2 m. This mid-shore region is characterised by the cirolanid isopods *Pontogeloides latipes*, *Eurydice* (*longicornis*) *kensleyi*, and *Excirolana natalensis*, the polychaetes *Scolelepis squamata*, *Orbinia angrapequensis*, *Nepthys hombergii* and *Lumbrineris tetraura*, and amphipods of the families Haustoridae and Phoxocephalidae (Figure 3.27). In some areas, juvenile and adult sand mussels *Donax serra* may also be present in considerable numbers.

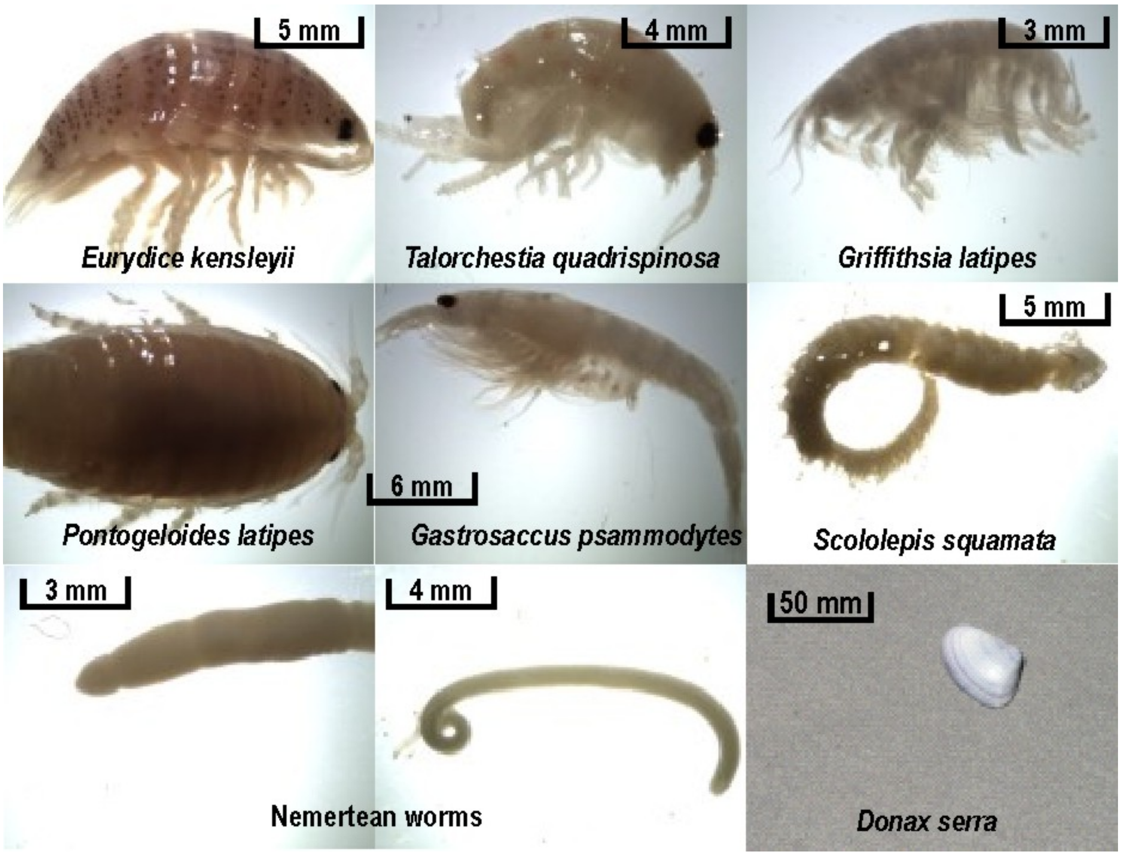


Figure 3.27 Common beach macrofaunal species occurring on exposed West Coast beaches.

3.8.2.2 Rocky substrate habitats and biota

The following general description of the intertidal and subtidal habitats for the West Coast is based on Field *et al.* (1980), Branch & Branch (1981), Branch & Griffiths (1988) and Field & Griffiths (1991). The biological communities of rocky intertidal and subtidal reefs are generally ubiquitous throughout the southern African West Coast region, being particular only to wave exposure, turbulence and/or depth zone.

3.8.2.2.1 Intertidal Rocky Shores

Several studies on the west coast of southern Africa have documented the important effects of wave action on the intertidal rocky-shore community. Specifically, wave action enhances filter-feeders by increasing the concentration and turnover of particulate food, leading to an elevation of overall biomass despite low species diversity (McQuaid & Branch 1985, Bustamante & Branch 1995a, 1996a). Conversely, sheltered shores are diverse with a relatively low biomass, and only in relatively sheltered embayments does drift kelp accumulate and provide a vital support for very high densities of kelp trapping limpets, such as *Cymbula granatina* that occur exclusively there (Bustamante *et al.* 1995a, 1995b). In the subtidal, these differences diminish as wave exposure is moderated with depth.

West Coast rocky intertidal shores can be divided into five zones on the basis of their characteristic biological communities: The Littorina, Upper Balanoid, Lower Balanoid, Cochlear/Argenvillei and the Infratidal Zones. These biological zones correspond roughly to zones based on tidal heights (Figure 3.28 and Figure 3.29). Tolerance to the physical stresses associated with life on the intertidal, as well as biological interactions such as herbivory, competition and predation interact to produce these five zones.

Supralittoral fringe or Littorina zone - The uppermost part of the shore is the supralittoral fringe, which is the part of the shore that is most exposed to air, perhaps having more in common with the terrestrial environment. The supralittoral is characterised by low species diversity, with the tiny periwinkle *Afrolittorina knysnaensis*, and the red alga *Porphyra capensis* constituting the most common macroscopic life.

Upper Mid-littoral or Upper Balanoid zone - The upper mid-littoral is characterised by the limpet *Scutellastra granularis*, which is present on all shores. The gastropods *Oxystele variegata*, *Nucella dubia*, and *Helcion pectunculus* are variably present, as are low densities of the barnacles *Tetraclita serrata*, *Octomeris angulosa* and *Chthalamus dentatus*. Flora is best represented by the green algae *Ulva* spp.

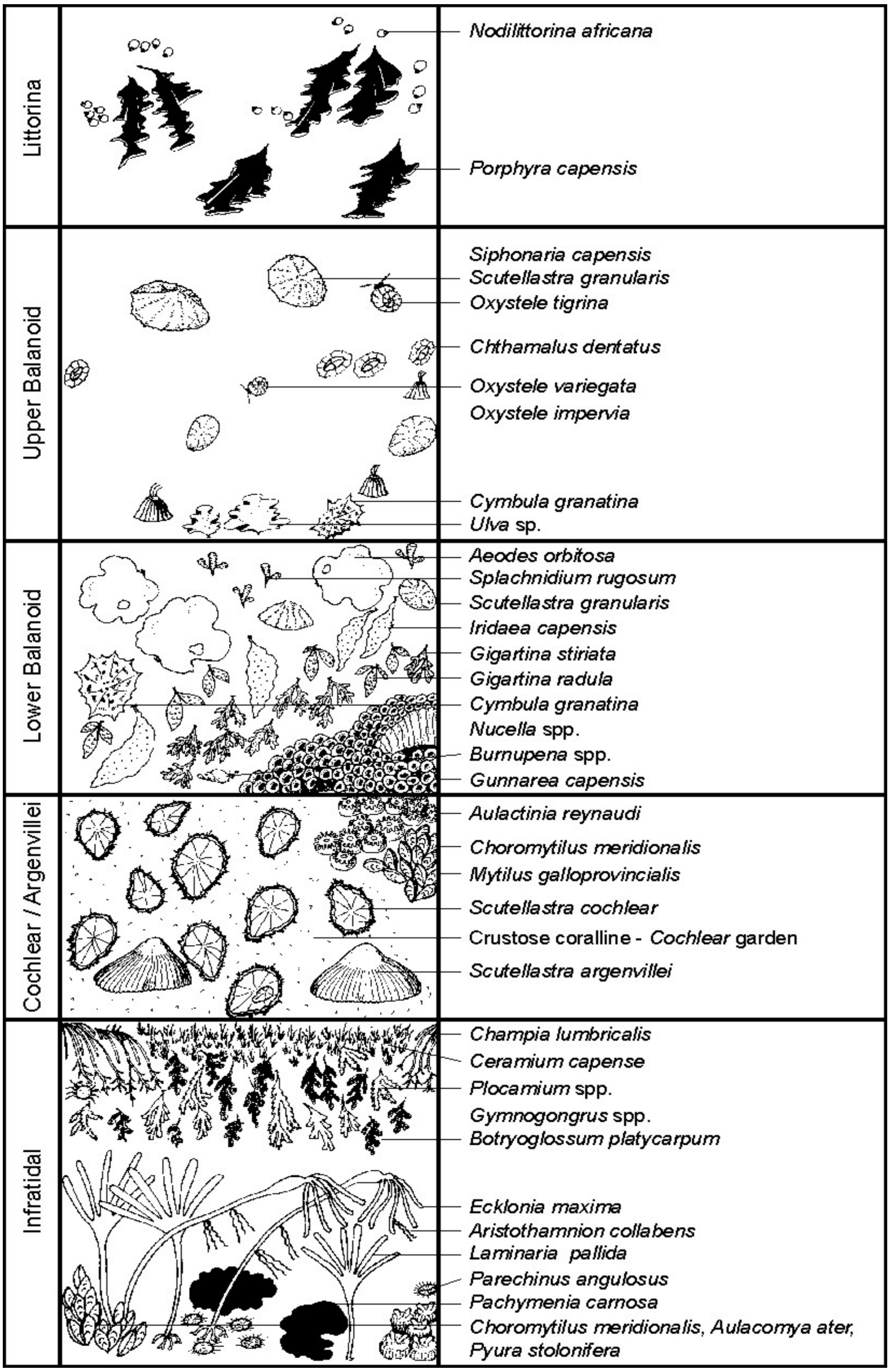


Figure 3.28 Schematic representation of the West Coast intertidal zonation. Species commonly occurring north of the Olifants River mouth are listed (adapted from Branch & Branch 1981).

Figure 3.29 Typical rocky intertidal zonation on the southern African west coast.

Lower Mid-littoral or Lower Balanoid zone - Toward the lower shore, biological communities are determined by exposure to wave action. On sheltered and moderately exposed shores, a diversity of algae abounds with a variable representation of: green algae – *Ulva* spp, *Codium* spp.; brown algae – *Splachnidium rugosum*; and red algae – *Aeodes orbitosa*, *Mazzaella (=Iridaea) capensis*, *Gigartina polycarpa* (=*radula*), *Sarcothalia* (=*Gigartina*) *stiriata*, and with increasing wave exposure *Plocamium rigidum* and *P. cornutum*, and *Champia lumbricalis*. The gastropods *Cymbula granatina* and *Burnupena* spp. are also common, as is the reef building polychaete *Gunnarea capensis*, and the small cushion starfish *Patiriella exigua*. On more exposed shores, almost all of the primary space can be occupied by the dominant alien invasive mussel *Mytilus galloprovincialis*. First recorded in 1979 (although it is likely to have arrived in the late 1960's), it is now the most abundant and widespread invasive marine species spreading along the entire West Coast and parts of the South Coast (Robinson *et al.* 2005). *M. galloprovincialis* has partially displaced the local mussels *Choromytilus meridionalis* and *Aulacomya ater* (Hockey & Van Erkom Schurink 1992), and competes with several indigenous limpet species (Griffiths *et al.* 1992, Steffani & Branch 2003a, b). Recently, another alien invasive has been recorded, the acorn barnacle *Balanus glandula*, which is native to the west coast of North America where it is the most common intertidal barnacle. The presence of *B. glandula* in South Africa was only noticed a few years ago as it had always been confused with the native barnacle *Cthamalus dentatus* (Simon-Blecher *et al.* 2008). There is, however, evidence that it has been in South Africa since at least 1992 (Laird & Griffith 2008). At the time of its discovery, the barnacle was recorded from 400 km of coastline from Elands Bay to Misty Cliffs near Cape Point (Laird & Griffith 2008). As it has been reported on rocky shores south of Lüderitz in Namibia

(Pulfrich 2013), it is likely that it occurs in the study area. When present, the barnacle is typically abundant at the mid zones of semi-exposed shores.

Sublittoral fringe or Argenvillei zone - Along the sublittoral fringe, the large kelp-trapping limpet *Scutellastra argenvillei* dominates forming dense, almost monospecific stands achieving densities of up to 200/m^2 (Bustamante *et al.* 1995). Similarly, *C. granatina* is the dominant grazer on more sheltered shores, also reaching extremely high densities (Bustamante *et al.* 1995). On more exposed shores *M. galloprovincialis* dominates. There is evidence that the arrival of the alien *M. palloprovincialis* has led to strong competitive interaction with *S. argenvillei* (Steffani & Branch 2003a, b, 2005). The abundance of the mussel changes with wave exposure, and at wave-exposed locations, the mussel can cover almost the entire primary substratum, whereas in semi-exposed situations it is never abundant. As the cover of *M. galloprovincialis* increases, the abundance and size of *S. argenvillei* on rock declines and it becomes confined to patches within a matrix of mussel bed. As a result exposed sites, once dominated by dense populations of the limpet, are now largely covered by the alien mussel. Semi-exposed shores do, however, offer a refuge preventing global extinction of the limpet. In addition to the mussel and limpets, there is variable representation of the flora and fauna described for the lower mid-littoral above, as well as the anemone *Aulactinia reynaudi*, numerous whelk species and the sea urchin *Parechinus angulosus*. Some of these species extend into the subtidal below.

On more exposed shores *M. galloprovincialis* dominates. There is evidence that the arrival of the alien *M. palloprovincialis* has led to strong competitive interaction with *S. argenvillei* (Steffani & Branch 2003a, b, 2005). The abundance of the mussel changes with wave exposure, and at wave-exposed locations, the mussel can cover almost the entire primary substratum, whereas in semi-exposed situations it is never abundant. As the cover of *M. galloprovincialis* increases, the abundance and size of *S. argenvillei* on rock declines and it becomes confined to patches within a matrix of mussel bed. As a result exposed sites, once dominated by dense populations of the limpet, are now largely covered by the alien mussel. Semi-exposed shores do, however, offer a refuge preventing global extinction of the limpet. In addition to the mussel and limpets, there is variable representation of the flora and fauna described for the lower mid-littoral above, as well as the anemone *Aulactinia reynaudi*, numerous whelk species and the sea urchin *Parechinus angulosus*. Some of these species extend into the subtidal below.

Very recently, the invasion of west coast rocky shores by another mytilid, the small *Semimytilus algosus*, was noted (de Greef *et al.* 2013). It is hypothesized that this species has established itself fairly recently, probably only in the last ten years. Its current range extends from the Groen River mouth in the north to Bloubergstrand in the south. Where present, it occupies the lower intertidal zone, where it completely dominates primary rock space, while *M. galloprovincialis* dominates higher up the shore. Many shores on the West Coast have thus now been effectively partitioned by the three introduced species, with *B. glandula* colonizing the upper intertidal, *M. galloprovincialis* dominating the mid-shore, and now *S. algosus* smothering the low-shore (de Greef *et al.* 2013).

3.8.2.2.2 Rocky Subtidal Habitat and Kelp Beds

Biological communities of the rocky sublittoral can be broadly grouped into an inshore zone from the sublittoral fringe to a depth of about 10 m dominated by flora, and an offshore zone below 10 m depth dominated by fauna. This shift in communities is not knife-edge, and rather represents a continuum of species distributions, merely with changing abundances.

From the sublittoral fringe to a depth of between 5 and 10 m, the benthos is largely dominated by algae, in particular two species of kelp. The canopy forming kelp *Ecklonia maxima* extends seawards to a depth of about 10 m. The smaller *Laminaria pallida* forms a sub-canopy to a height of about 2 m underneath *Ecklonia*, but continues its seaward extent to about 30 m depth, although further north up the west coast increasing turbidity limits growth to shallower waters (10-20 m) (Velimirov *et al.* 1977; Jarman & Carter 1981; Branch 2008). *Ecklonia maxima* is the dominant species in the south forming extensive beds from west of Cape Agulhas to north of Cape Columbine, but decreasing in abundance northwards. *Laminaria* becomes the dominant kelp north of Cape Columbine, extending from Danger Point east of Cape Agulhas to Rocky Point in northern Namibia (Stegenga *et al.* 1997, Rand 2006).

Kelp beds absorb and dissipate much of the typically high wave energy reaching the shore, thereby providing important partially-sheltered habitats for a high diversity of marine flora and fauna, resulting in diverse and typical kelp-forest communities being established (Figure 3.30). Through a combination of shelter and provision of food, kelp beds support recruitment and complex trophic food webs of numerous species, including commercially important rock lobster stocks (Branch 2008).

Growing beneath the kelp canopy, and epiphytically on the kelps themselves, are a diversity of understorey algae, which provide both food and shelter for predators, grazers and filter-feeders associated with the kelp bed ecosystem. Representative under-storey algae include *Botryocarpa prolifera*, *Neuroglossum binderianum*, *Botryoglossum platycarpum*, *Hymenena venosa* and *Rhodymenia* (=*Epymenia*) *obtusa*, various coralline algae, as well as subtidal extensions of some algae occurring primarily in the intertidal zones (Bolton 1986). Epiphytic species include *Polysiphonia virgata*, *Gelidium vittatum (=Suhria vittata)* and *Carpoblepharis flaccida*. In particular, encrusting coralline algae are important in the under-storey flora as they are known as settlement attractors for a diversity of invertebrate species. The presence of coralline crusts is thought to be a key factor in supporting a rich shallow-water community by providing substrate, refuge, and food to a wide variety of infaunal and epifaunal invertebrates (Chenelot *et al.* 2008).

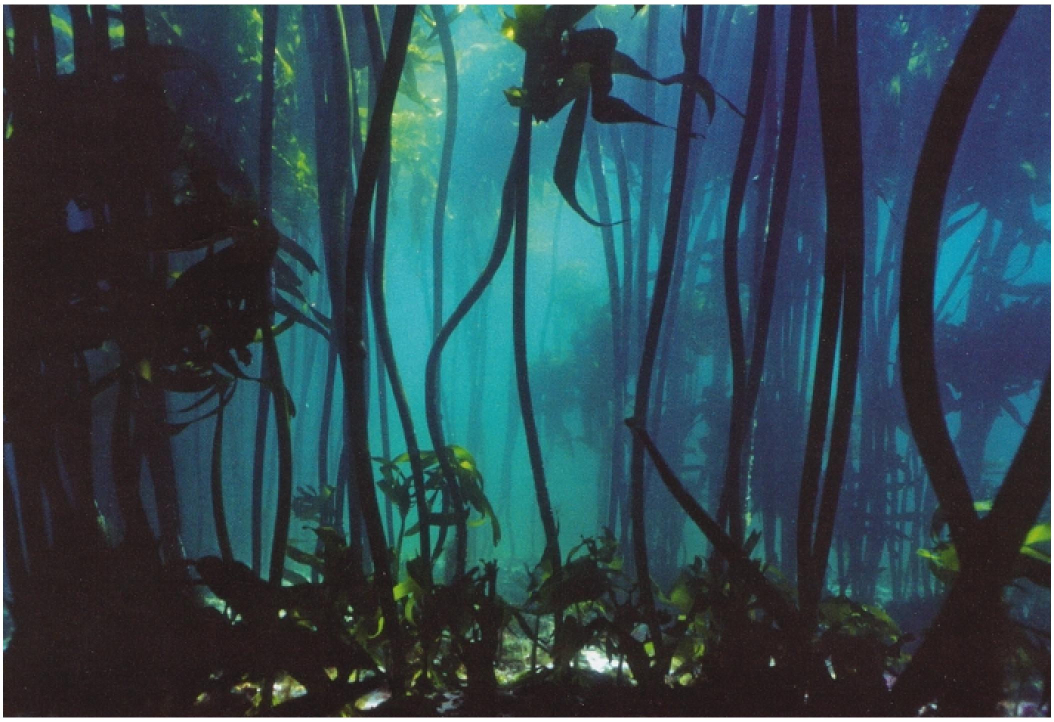


Figure 3.30 The canopy-forming kelp *Ecklonia maxima* provides an important habitat for a diversity of marine biota (Photo: Geoff Spiby).

The sublittoral invertebrate fauna is dominated by suspension and filter-feeders, such as the mussels *Aulacomya ater* and *Choromytilus meriodonalis*, and the Cape reef worm *Gunnarea capensis*, and a variety of sponges and sea cucumbers. Grazers are less common, with most herbivory being restricted to grazing of juvenile algae or debris-feeding on detached macrophytes. The dominant herbivore is the sea urchin *Parechinus angulosus*, with lesser grazing pressure from limpets, the isopod *Paridotea reticulata* and the amphipod *Ampithoe humeralis*. The abalone *Haliotis midae*, an important commercial species present in kelp beds south of Cape Columbine is naturally absent north of Cape Columbine (but see section 1.3.7). Key predators in the sub-littoral include the commercially important West Coast rock lobster *Jasus lalandii* and the octopus *Octopus vulgaris*. The rock lobster acts as a keystone species as it influences community structure *via* predation on a wide range of benthic organisms (Mayfield *et al.* 2000). Relatively abundant rock lobsters can lead to a reduction in density, or even elimination, of black mussel *Choromytilus meriodonalis*, the preferred prey of the species, and alter the size structure of populations of ribbed mussels *Aulacomya ater*, reducing the proportion of selected size-classes (Griffiths & Seiderer 1980). Their role as predator can thus reshape benthic communities, resulting in large reductions in taxa such as black mussels, urchins, whelks and barnacles, and in the dominance of algae (Barkai & Branch 1988, Mayfield 1998).

Of lesser importance as predators, although numerically significant, are various starfish, feather and brittle stars, and gastropods, including the whelks *Nucella* spp. and *Burnupena* spp. Fish species commonly found in kelp beds off the West Coast include hottentot

Pachymetopon blochii, two tone finger fin *Chirodactylus brachydactylus*, red fingers *Cheilodactylus fasciatus*, galjoen *Dichistius capensis*, rock suckers *Chorisochismus dentex* and the catshark *Haploblepharus pictus* (Branch *et al.* 2010).

There is substantial spatial and temporal variability in the density and biomass of kelp beds, as storms can remove large numbers of plants and recruitment appears to be stochastic and unpredictable (Levitt *et al.* 2002, Rothman *et al.* 2006). Some kelp beds are dense, whilst others are less so due to differences in seabed topography, and the presence or absence of sand and grazers.

Due to their importance as recruitment, nursery, and feeding grounds for numerous species, including the commercially important rock lobster *J. lalandii*, kelp beds are considered a medium sensitivity habitat.

3.8.2.3 Pelagic communities

The study area is located in the southern Benguela ecosystem and, as there are few barriers to water exchange, pelagic communities are typical of those of the region. The pelagic communities are typically divided into plankton, fish, and marine mammals (seals, dolphins and whales).

3.8.2.3.1 Plankton

Plankton range from single-celled bacteria to jellyfish, and include bacterio-plankton, phytoplankton, zooplankton, and ichthyoplankton (Figure 3.31).

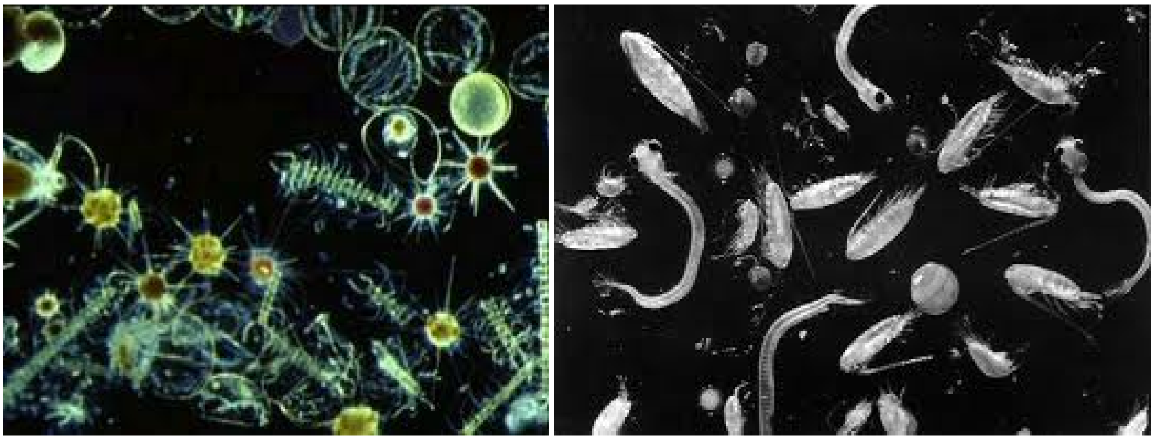


Figure 3.31 Phytoplankton (left, photo: hymagazine.com) and zooplankton (right, photo: mysciencebox.org) is associated with upwelling cells.

The phytoplankton includes diatoms, dinoflagellates, coccolithophorids and microflagellates. Phytoplankton biomass in the southern Benguela is generally high in summer during the upwelling season, but also quite extensive in the autumn and spring, with diatoms generally dominating inshore and small flagellates offshore (Barlow *et al.* 2005). Maximum diatom concentrations are found in the upper 10 m and thereafter decrease with an increase in depth. Common and widely distributed diatom species include *Asterionella glacialis*, *Leptocylindrus danicus*, *Minidiscus trioculatus*, *Skeletonema costatum*, *Thalassionema nitzschioides* and a number of *Navicula*, *Nitzschia* and *Thalassiosira* species. The most common member of the microflagelattes is a species of *Pyramimonas*. Dinoflagellates are represented by several members of the genus *Gyrodinium*, *Ceratium*, *Protoperidilium* amongst others. Also present in the area are toxic dinoflagellate species such as *Alexandrium catenella* and various members of the genus *Dinophysis*, which can cause mass mortalities of fish, shellfish, marine mammals, seabirds and other animals (Pitcher & Calder 2000).

Zooplankton is characterised by pelagic crustaceans (e.g. copepods, cumaceans, hyperiid amphipods, chaetognaths, mysids, euphausiids), invertebrate larvae (e.g. bivalve, polychaete, *etc*.), pelagic cnidarians, and ichthyoplankton. Crustacean zooplankters often contribute greatest to the total zooplankton with copepods (e.g. *Calanus* spp., *Centropages* spp., *Metridia* spp.) being the most common organisms in the zooplankton (Verheye & Richardson 1998, Hutchings *et al.* 2006). Ichthyoplankton constitutes the eggs and larvae of fish. Long-term changes in the southern Benguela include a significant increase in zooplankton over the past five decades, with a decline since 1995 linked to a concomitant increase in pelagic fish biomass as the main predators on zooplankton (Hutchings *et al.* 2006).

3.8.2.3.2 Fish

Small pelagic species that occur in the area include the sardine (*Sardinops sagax*), anchovy (*Engraulis encrasicolus*), juvenile Cape horse mackerel (*Trachurus trachurus capensis*), and round herring (*Etrumeus whiteheadi*). Although these species generally occur within the 200 m contour, they may often be found very close inshore (Pecquerie *et al.* 2004). Demersal fish include deep water (*Merluccius paradoxus*) andshallow water hake (*M. capensis*), kingklip (*Genypterus capensis*), and St Joseph shark (*Callorhinchus capensis*) in shallow inshore waters. Linefish species include (juvenile) snoek (*Thyrsites atun*), silver kob (*Argyrosomus inodorus*), white steenbras (*Lithognathus lithognathus*), blacktail (*Diplodus sargus*), white stumpnose (*Rhabdosargus globiceps*), Hottentot (*Pachymetopon blochii*), geelbek (*Atractoscion aequidens*) and galjoen (*Dichistius capensis*).

The surf-zone and outer turbulent zone habitats of sandy beaches are considered to be important nursery habitats for marine fishes (Modde 1980, Lasiak 1981, Kinoshita & Fujita 1988, Clark *et al.* 1994). However, the composition and abundance of the individual assemblages seems to be heavily dependent on wave exposure (Blaber & Blaber 1980, Potter *et al.* 1990, Clark 1997a, b). Surf-zone fish communities off the South African West Coast have relatively high biomass, but low species diversity. Typical surf-zone fish include harders (*Liza richardsonii*), white stumpnose (*Rhabdosargus globiceps*) (Figure 3.32), Cape sole (*Heteromycteris capensis*), Cape gurnard (*Chelidonichthys capensis*), False Bay klipfish (*Clinus latipennis*), sandsharks (*Rhinobatos annulatus*), eagle ray (*Myliobatis aquila*), and smooth-hound (*Mustelus mustelus*) (Clark 1997b).


Figure 3.32 Common surf-zone fish include the harder (left, photo: aquariophil.org) and the white stumpnose (right, photo: easterncapescubadiving.co.za).

Fish species commonly found in kelp beds off the West Coast include hottentot *Pachymetopon blochii*, twotone fingerfin *Chirodactylus brachydactylus*, red fingers *Cheilodactylus fasciatus*, galjoen *Dichistius capensis*, rock suckers *Chorisochismus dentex,* maned blennies *Scartella emarginata* and the catshark *Haploblepharus pictus* (Sauer *et al.* 1997; Brouwer *et al.* 1997; Branch *et al.* 2010). Several additional species of fish are also commonly caught in gill-nets set over rocky reef areas between the Orange River and Cape Columbine. Species of importance include harder *Liza richardsonii*, pilchard *Sardinops sagax*, strepie *Sarpa salpa*, houndsharks *Mustelus mustelus* and cowsharks *Notorynchus cepedianus* (K. Hutchings, UCT, pers. comm.).

3.8.2.3.3 Marine Mammals

The marine mammal fauna of the West Coast comprises between 28 and 31 species of cetaceans (whales and dolphins) and four species of seals of which the Cape fur seal *Arctocephalus pusillus* is the most common.

The Cape fur seal (Figure 3.33, left) is the only species of seal resident along the west coast of Africa, occurring at numerous breeding and non-breeding sites on the mainland and on nearshore islands and reefs (refer to Figure 3.36). Vagrant records from four other species of seal more usually associated with the subantarctic environment have also been recorded: southern elephant seal (*Mirounga leoninas),* subantarctic fur seal (*Arctocephalus tropicalis),* crabeater *(Lobodon carcinophagus)* and leopard seals (*Hydrurga leptonyx)* (David 1989). There are a number of Cape fur seal colonies within the broader study area: Paternoster Rocks and Jacobs Reef at Cape Columbine, and Robbesteen near Koeberg. Non-breeding colonies occur at Paternoster Point at Cape Columbine and Duikerklip in Hout Bay. Seals are highly mobile animals with a general foraging area covering the continental shelf up to 120 nautical miles offshore (Shaughnessy 1979), with bulls ranging further out to sea than females. The timing of the annual breeding cycle is very regular, occurring between November and January. Breeding success is highly dependent on the local abundance of food, territorial bulls and lactating females being most vulnerable to local fluctuations as they feed in the vicinity of the colonies prior to and after the pupping season (Oosthuizen 1991).

Dusky dolphin (*Lagenorhynchus obscurus*) and Heaviside's (Benguela) dolphin (*Cephalorhynchus heavisidii*) (Figure 3.33, right) are resident year round throughout the Benguela ecosystem coastal waters (Findlay *et al.* 1992, Elwen 2008, Elwen *et al.* 2010). Whale species that may be sighted in the area include southern Right whale (*Balaena glacialis*), Humpback whale (*Megaptera novaeangliae*), and Killer whale (*Orcinus orca*), along with Antarctic Minke (*Balaenoptera acutorostrata*) and Bryde's (*B. brydei*) whales (Best 2007). Whales occurring in the nearshore regions of the project area will largely be transitory.

Figure 3.33 Colony of Cape fur seals *Arctocephalus pusillus pusillus* (Photo: Dirk Heinrich)(left) and the endemic Heaviside's (Benguela) Dolphin *Cephalorhynchus heavisidii* (right) (Photo: De Beers Marine Namibia).

3.8.2.4 Birds

Large numbers of pelagic seabirds exploit the pelagic fish stocks of the Benguela system. Of the 49 species of seabirds that occur in the Benguela region, 14 are defined as resident, 10 are visitors from the northern hemisphere and 25 are migrants from the southern Ocean. The area between Cape Point and the Orange River supports 38% and 33% of the overall population of pelagic seabirds in winter and summer, respectively. 14 species of seabirds breed in southern Africa; Cape Gannet, African Penguin, four species of Cormorant, White Pelican, three Gull and four Tern species. The breeding areas are distributed around the coast with islands being especially important. Breeding islands within the project area are Bird Island at Lambert's Bay, the Saldanha Bay islands, Dassen Island off Yzerfontein and Robben Island in Table Bay. The number of successfully breeding birds at the particular breeding sites varies with food abundance.

Birds endemic to the region and liable to occur most frequently in the project area include Cape Gannets, Kelp Gulls, African Penguins, African Black Oystercatcher (Figure 3.34, left), Bank, Cape and Crowned Cormorants (Figure 3.34, right), and Hartlaub's Gull. Of these the Black oystercatcher and Bank cormorant are rare. The breeding success of African Black oystercatcher is particularly susceptible to disturbance from off-road vehicles as they nest and breed on beaches between the Eastern Cape and southern Namibia. Caspian and Damara terns are likewise rare and breed in the study area, especially in the wetland and saltpan areas associated with the Olifants River estuary.

Most of the breeding seabird species forage at sea with most birds being found relatively close inshore (10 - 30 km), although African Penguins and Cape Gannets are known to forage up to 60 km and 140 km offshore, respectively.

Figure 3.34 The African Black Oystercatcher (Left, photo: patrickspilsbury.blogspot.com) and Crowned

Cormorant (right, photo: savoels.za.net) occur in the Island Point area.

3.8.3 Beneficial uses

3.8.3.1 Conservation Areas

Numerous conservation areas and a marine protected area (MPA) exist along the coastline of the Western Cape, although none fall within the project area in Danger Bay (Figure 3.35) For the sake of completeness, they are briefly summarised below. The Rocher Pan MPA, which stretches 500 m offshore of the high water mark of the adjacent Rocher Pan Nature Reserve, was declared in 1966. The MPA primarily protects a stretch of beach important as a breeding area to numerous waders.

The West Coast National Park, which was established in 1985 incorporates the Langebaan Lagoon and Sixteen Mile Beach MPAs, as well the islands Schaapen (29 ha), Marcus (17 ha), Malgas (18 ha) and Jutten (43 ha). Langebaan Lagoon was designated as a Ramsar site in April 1988 under the Convention on Wetlands of International Importance especially as Waterfowl Habitat. The lagoon is divided into three different utilization zones namely: wilderness, limited recreational and multi-purpose recreational areas. The wilderness zone has restricted access and includes the southern end of the lagoon and the inshore islands, which are the key refuge sites of the waders and breeding seabird populations respectively. The limited recreation zone includes the middle reaches of the lagoon, where activities such as sailing and canoeing are permitted. The mouth region is a multi-purpose recreation zone for power boats, yachts, water-skiers and fishermen. However, no collecting or removal of abalone and rock lobster is allowed. The length of the combined shorelines of Langebaan Lagoon MPA and Sixteen Mile Beach is 66 km. The uniqueness of Langebaan lies in its being a warm oligotrophic lagoon, along the cold, nutrient-rich and wave exposed West Coast.

No rock lobster may be caught in Saldanha Bay eastwards of a line between North Head and South Head. There is also a Rock Lobster Sanctuary in St Helena Bay. Further marine conservation areas in the Saldanha/Cape Columbine region include:

- Paternoster Rocks – Egg and Seal Island reserves for seabirds and seals
- Jacob's Reef - Island reserve for seabirds and seals
- An area within the military base, SAS Saldanha
- Vondeling Island

Further south on the Cape Peninsula, the Table Mountain National Park (TMNP) MPA was declared in 2004, and includes 996 km^2 of the sea area and 137 km of coastline around the Cape Peninsula from Moullie Point in the North to Muizenberg in the south. Although fishing is allowed in the majority of the MPA (subject to Department of Agriculture, Forestry and Fisheries (DAFF) permits, regulations and seasons), the MPA includes six 'no-take' zones where no fishing or extractive activities are allowed. These 'no-take' zones are important breeding and nursery areas for a wide variety of marine species thereby providing threatened species with a chance to recover form over-exploitation.

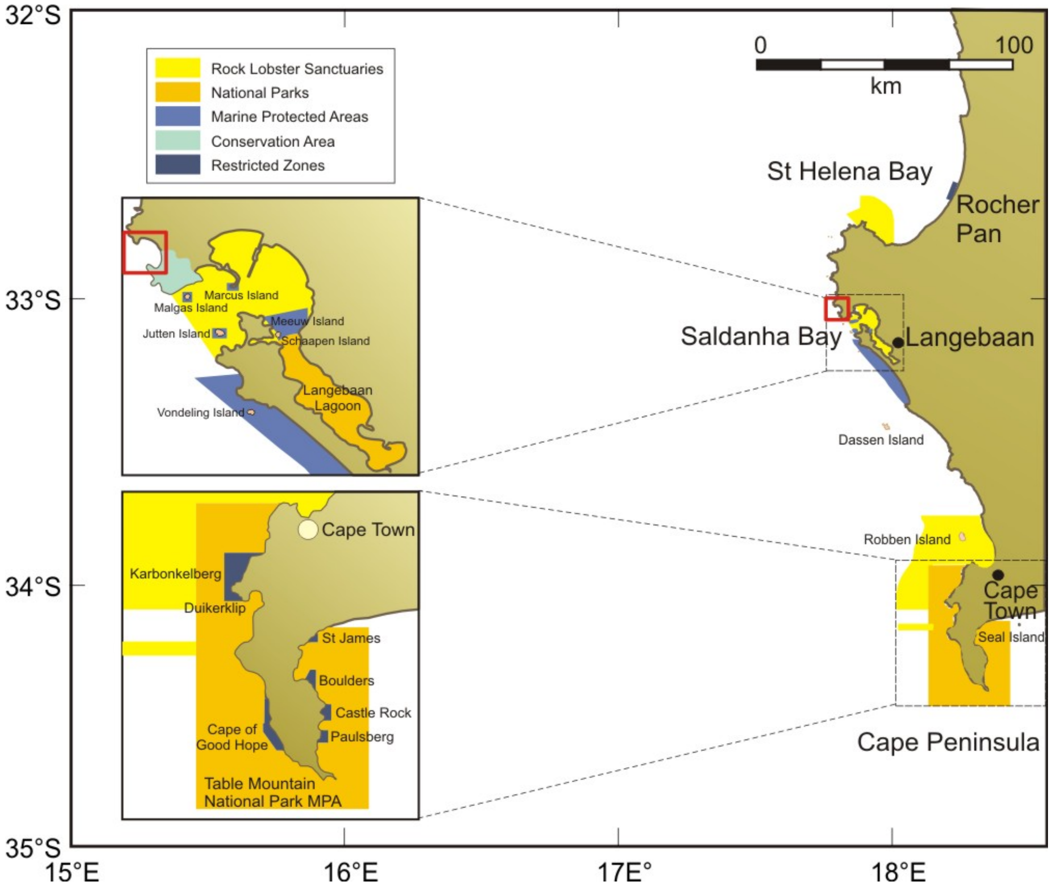


Figure 3.35 The project area (red square) in relation to conservation areas and Marine Protected Areas on the West Coast.

Using biodiversity data mapped for the 2004 and 2011 National Biodiversity Assessments a systematic biodiversity plan has been developed for the West Coast with the objective of identifying coastal and offshore priority focus areas for MPA expansion (Sink *et al.* 2011; Majiedt *et al.* 2013). The biodiversity data were used to identify nine focus areas for protection on the West Coast between Cape Agulhas and the South African – Namibian border-those within the broad project area shown in Figure 3.36. Danger Bay falls within the West Coast Consolidation, which spans two ecoregions and includes coastal, inshore and offshore habitat types, including the Cape Canyon and five existing MPAs within the West Coast National Park. This is the only focus area where targets for the Namaqua Boulder Shore (Critically Endangered) and Southern Benguela Canyon (Critically Endangered) can be met (Majiedt *et al.* 2013).

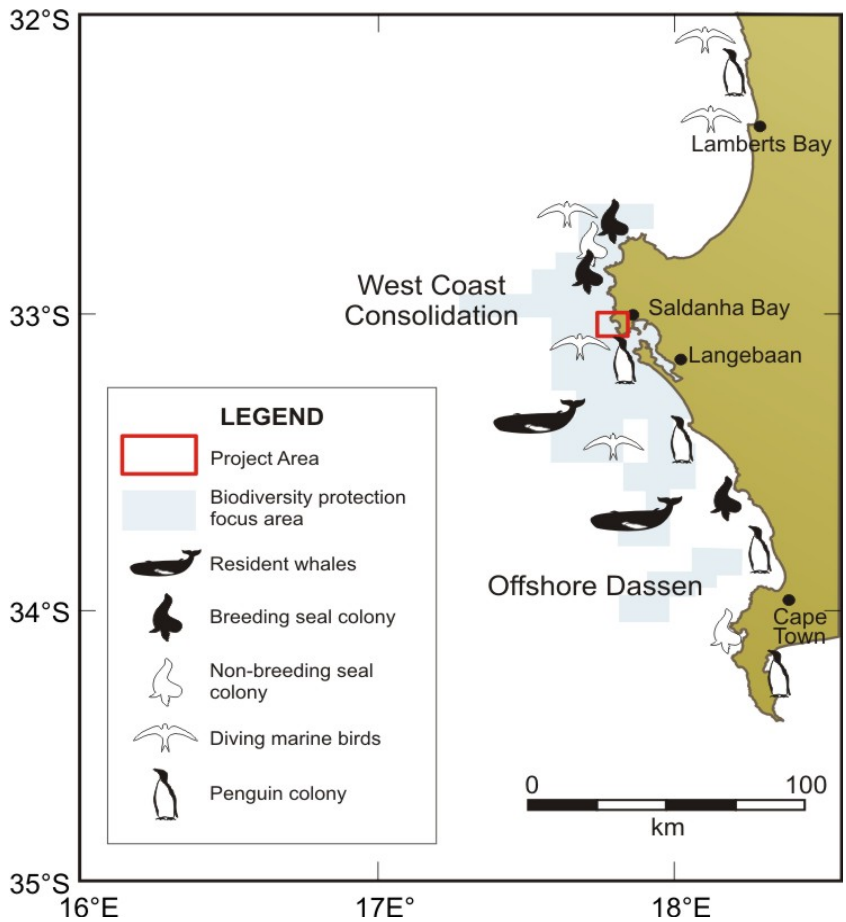


Figure 3.36 Project - environment interaction points on the West Coast, illustrating the location of Danger Bay in relation to seabird and seal colonies and resident whale populations. Areas identified by Majiedt *et al.* (2013) as priority areas for the protection of benthic and pelagic habitats are shaded light blue.

Using the SANBI benthic and coastal habitat type GIS database (Figure 3.37), the threat status of the benthic habitats potentially affected by the proposed marine outfall pipeline and its alternative shore crossings were identified (Table 3.3).

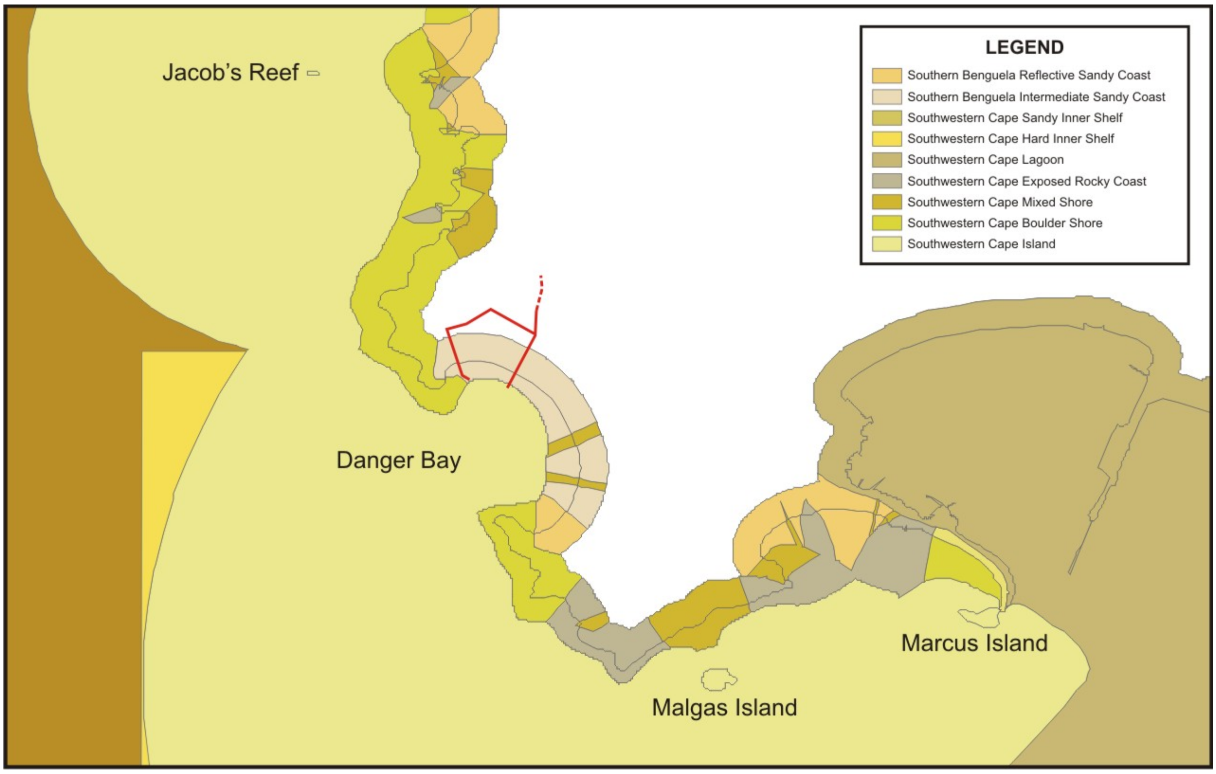


Figure 3.37 The proposed discharge pipeline routings (red line) in relation to offshore benthic and coastal habitat types in the Danger Bay area. The threat status of the habitats is provided in Table 3.4.

Table 3.3 Ecosystem threat status for marine and coastal habitat types in the general project area (adapted from Sink *et al.* 2011). Those habitats affected by the proposed pipeline are shaded.

Habitat Type	Threat Status
Southern Benguela Intermediate Sandy Coast	Least Threatened
Southern Benguela Reflective Sandy Coast	Least Threatened
Southwestern Cape Boulder Shore	Critically Endangered
Southwestern Cape Exposed Rocky Coast	Endangered
Southwestern Cape Hard Inner Shelf	Endangered
Southwestern Cape Island	Endangered
Southwestern Cape Lagoon	Vulnerable
Southwestern Cape Mixed Shore	Vulnerable
Southwestern Cape Sandy Inner Shelf	Least Threatened

3.8.3.2 Mariculture Areas

No mariculture activities exist within Danger Bay. Within Saldanha Bay, the Transnet National Ports Authority (TNPA) has set aside a total of 395 ha of sea area for mariculture activities. Marine aquaculture operations currently undertaken within these areas are:

- Mussel farming comprising rope culture of the alien Mediterranean mussel *Mytilus galloprovincialis* and the indigenous black mussels *Choromytilus meridionalis*.
- Farming of the Pacific oyster *Crassostrea gigas; and*
- Commercial harvesting of the agarophyte *Gracilaria gracilis*.

3.8.3.3 Commercial and Recreational Fisheries

The commercial fishery in the Saldanha Bay region consists mainly of line fishing from small boats and gill netting. Linefishing is conducted both within the bay and along the open coast to the north of Saldanha Bay, whereas gill-netting is confined to within the bay. Species such as white stumpnose, white steenbras, kob, elf, steentjie, yellowtail, snoek, hottentot and smoothhound shark support the commercial line fisheries, and also a large shore angling and recreational boat fishery, which contributes significantly to the tourism appeal and regional economy of Saldanha Bay and Langebaan (Atkinson *et al.* 2006).

The landings and effort in the linefishery show distinct seasonality, influenced to a large extent by the availability of the target species. Of the species targeted by the linefishery, the hottentot is available to the fishermen throughout the year. The occurrence of snoek is more seasonal with the fish being more abundant during late summer and autumn. Yellowtail show a similar seasonality with catches peaking in March/April. Catches of galjoen are limited to the winter months, there being a closed season from 15 October to the end of February.

Recreational line-fishing is confined largely to rock and surf angling within Saldanha Bay and the more accessible coastal stretches in the regions along the Cape Columbine coast. Target species consist mostly of hottentot, white stumpnose, kob, steenbras and galjoen, with catches being used for domestic consumption, or sold.

The West Coast rock lobster *Jasus lalandii* is a valuable resource of the South African West Coast and consequently an important income source for West Coast fishermen. Following the collapse of the rock-lobster resource in the 1970s, fishing has been controlled by a Total Allowable Catch (TAC), a minimum size, restricted gear, a closed season and closed areas (Crawford *et al.* 1987, Melville-Smith & Van Sittert 2005). The West Coast rock lobster fishery is seasonally restricted to the period 15 November to the last day in May. Management of the resource is geographically specific, with the TAC annually allocated by Area. Although no rock lobster may be caught in the entire Saldanha Bay area between North Head and South Head, recreational and commercial rock-lobster fishing takes place northwards along the coast to as far as the St Helena Bay Rock Lobster Sanctuary. Actual rock-lobster fishing, however, takes place only at discrete suitable reef areas along the shore within this broad depth zone. Lobster fishing is conducted from a fleet of small dinghies/bakkies. The majority of these work directly from the shore within a few nautical miles of the harbours, with only 30% of the total numbers of bakkies participating in the fishery being deployed from larger deck boats. As a result, lobster fishing tends to be concentrated close to the shore.

Recreational rock lobster catches are made primarily by diving or shore-based fishing using baitbags (Cockcroft & McKenzie 1997). The majority of the recreational take of rock lobster is made by locals resident in areas close to the resource.

3.9 SOCIO-ECONOMIC BASELINE DESCRIPTION

The significance of impacts is often highly dependent on the economic environment or context within which they occur. For example, job creation in a small local community with a stagnating economy will be far more significant than it would be in a larger community with a healthy economy than that of the Saldanha Bay region. With this in mind, this section describes the economic environment focusing on the local area and region where the majority of impacts of the proposed pipeline development are likely to be felt. The main information sources used were Census 2001 data, 2007 Community Survey data, Integrated Development Plans (IDPs), Spatial Development Frameworks (SDFs) and Demarcation Board data. While the survey component of Census 2011 has been completed unfortunately no data is yet available.

The economic context includes information on the Western Cape, the West Coast District and the Saldanha Bay Municipal area as well as the key individual towns or settlements within it with most potential for impacts, namely: Saldanha Bay, Vredenburg and Jacobsbaai.

3.9.1 Surrounding land uses

The eastern portion of the pipeline will be roughly adjacent to the existing ArcelorMittal Smelter in the Saldanha industrial zone (approximately 1 km north-east). The eastern portion of the pipeline is therefore in the immediate area of heavy industrial land uses which are integrated with significant infrastructure — primarily in the form of the nearby iron ore terminal, road networks and high capacity power provision installations.

The western portion of the The Jacobsbaai Eastern Corridor pipeline will run parallel to the Jacobsbaai Road through degraded farmlands. When the corridor turns to the south before the town of Jacobsbaai, the route will traverse areas characterised by coastal vegetation disturbed in places by activities such as sand mining and previous farming developments. The Jacobsbaai Western Corridor will be located within the road reserve and will transverse a sensitive limestone area. A gravel road links Jacobsbaai and Diazville and there are a number of 4X4 tracks in the area leading to the coast used primarily by fishermen and other recreational users. The character of the area is primarily that of a rugged and largely undeveloped coastline — but with human settlements and activities relatively nearby.

3.9.2 Demographics

According to the 2011 Census, the total population in the SBM was 99,170 (see Table 3.4). This is up from roughly 70,261 in 2001 and represents a relatively high annual growth rate of 3.45% over the period. The 2011 population of Saldanha Bay was 28,135 and approximately 16,983 for Diazville. Jacobsbaai had a population of 415 in keeping with its smaller size.

Table 3.4 Population in the study area (2011)

Population group	Western Cape	West Coast District	Saldanha Bay Municipality	Saldanha	Vredenburg	Jacobs Bay	Diazville
Black African	1,912,470	64,101	24,292	8,404	11,026	2	5,839
Coloured	2,840,214	260,826	55,333	15,279	21,397	14	10,766
Indian or Asian	60,760	2,181	772	391	248	4	203
White	914,918	61,506	17,850	3,811	5,302	395	13
Other	93,964	3,098	923	250	408	0	162
Total	**5,822,326**	**391,712**	**99,170**	**28,135**	**38,381**	**415**	**16,983**

Source: Census 2011

3.9.3 Employment

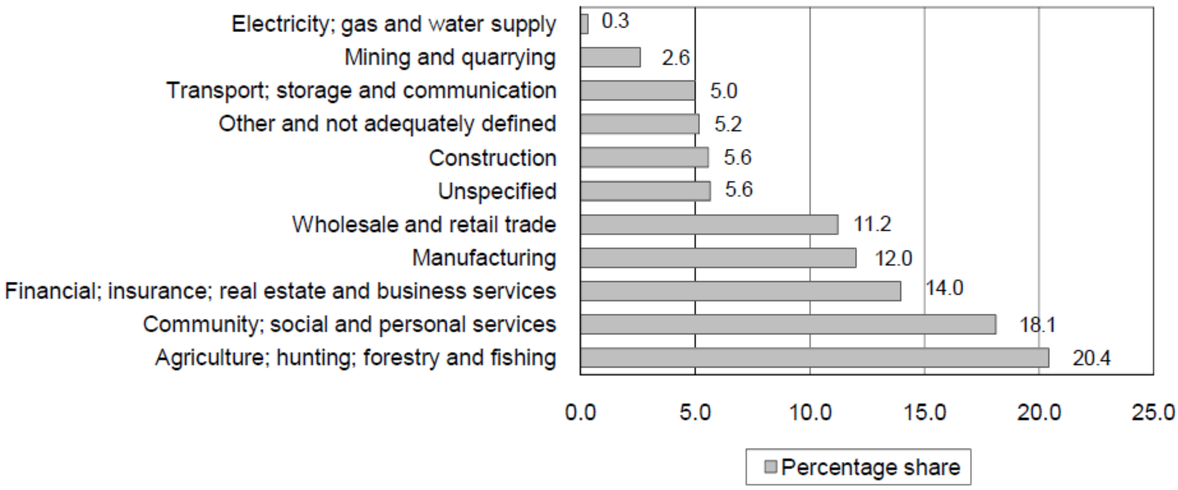
As with the rest of the country, unemployment is a major challenge in the area. This situation continues to be exacerbated by the current difficult economic climate characterised by relatively low levels of economic growth. Based on Census 2011, the SBM had an increased unemployment rate of approximately 23.4% compared to 21.5% in 2001 (Table 3.5). This was higher than the rate for the West Coast District (14.6% unemployment) and somewhat lower compared to Saldanha Bay and Vredenburg (approximately 26% unemployment for both) as well as for Diazville (33% unemployment).

Table 3.5 Unemployment by area and population group (2011)

Employment status	Western Cape	West Coast District	Saldanha Bay Municipality	Saldanha	Vredenburg	Jacobs Bay	Diazville
Employed	2,010,533	141,097	34,351	8,938	13,303	225	5,033
Unemployed	552,711	24,204	10,470	3,072	4,665	13	2,474
% unemployed	21.6%	14.6%	23.4%	25.6%	26.0%	5.5%	33.0%

Source: Census 2011

The Community Survey 2007 results indicate that the sectoral composition of employment has largely remained the same since 2001 albeit with greater emphasis on services and a decrease in manufacturing (see Figure 3.38). Within the manufacturing sector, the food and beverage (46.6%) and the metals (32.5%) sub-sectors contributed the most to employment (Demacon, 2009). This primarily reflects the presence of large companies such as Sea Harvest, AcelorMittal and Dufreco.



Source: Stats SA, Community Survey 2007

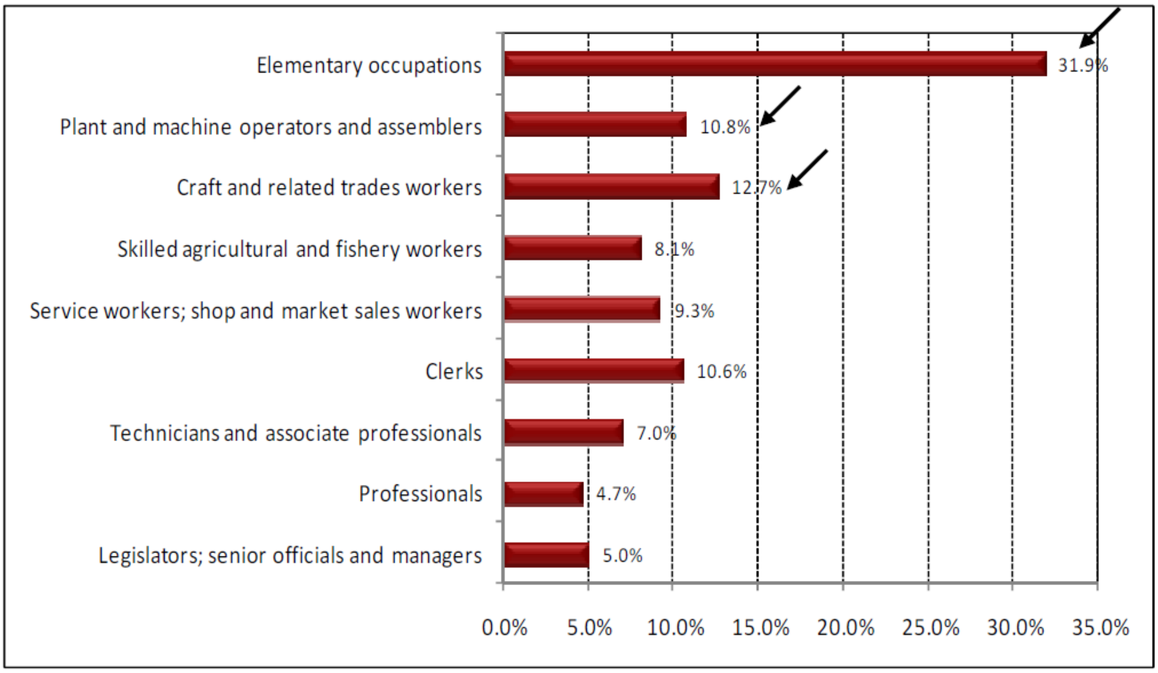
Figure 3.38 Jobs per sector for Saldanha Bay Municipality in 2007

Unfortunately it is not possible to get an accurate estimate of current jobs in the tourism sector on the basis of Census statistics as they do not have a separate category for tourism. Tourism is however recognised as a key sector in the local area and region, contributing significantly to employment. As a general rule, the tourism sector is reflected primarily in the transport, retail trade, personal services and business services sectors. These sectors have shown robust growth which is probably at least partially attributable to growth in the tourism sector.

Figure 3.39 illustrates the dominant occupation groups in the Saldanha Bay municipal area:

- Elementary occupations (31.9%),
- Craft and related trades workers (12.7%),
- Plant and machine operators and assemblers (10.8%), Clerks (10.6%) and
- Service workers; shop and market sales workers (9.3%).

This profile reflects a predominant blue collar occupation profile with a high proportion of middle to low income level workers (Demacon, 2009).



Source: Demacon, 2009

Figure 3.39 Jobs per occupation group for Saldanha Bay Municipality in 2007

3.9.4 Household incomes

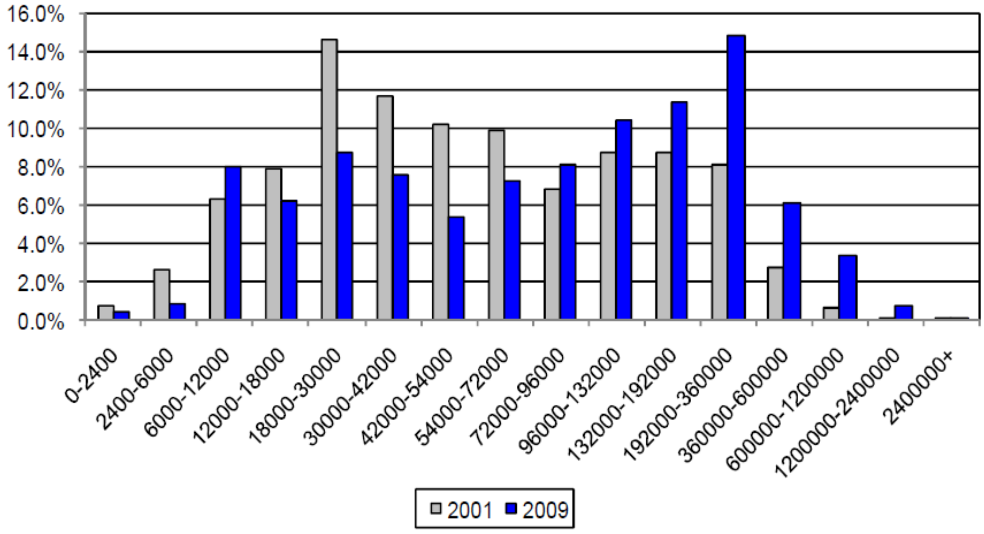
Table 3.6 reports on household income levels in the study area for 2011. Approximately 30% of households in the West Coast District and 33% of households in Saldanha Bay had incomes below R19,600 per year. Household incomes in Vredenburg were substantially higher with only 9% of households in this income category whilst incomes in Diazville were lower with 39% of households earning below R19,600.

Table 3.6 Household income by area and population group (2011)

Annual household income level	Western Cape	West Coast District	Saldanha Bay Municipality	Saldanha	Vredenburg	Jacobs Bay	Diazville
No income	13%	11%	14%	15%	8%	13%	16%
R 1 - R 4800	3%	2%	2%	3%	1%	2%	3%
R 4801 - R 9600	4%	3%	4%	5%	0%	4%	5%
R 9601 - R 19 600	12%	14%	11%	10%	0%	11%	15%
R 19 601 - R 38 200	18%	22%	17%	19%	6%	18%	23%
R 38 201 - R 76 400	16%	19%	17%	17%	10%	17%	19%
R 76 401 - R 153 800	13%	13%	15%	14%	13%	15%	13%
R 153 801 - R 307 600	11%	9%	11%	10%	26%	11%	4%
R 307 601 - R 614 400	7%	5%	6%	5%	23%	6%	1%
R 614 001 - R 1 228 800	3%	1%	2%	1%	11%	1%	0%
R 1 228 801 - R 2 457 600	1%	0%	0%	0%	1%	0%	0%
R 2 457 601 or more	0%	0%	0%	0%	3%	0%	0%
Total	100%	100%	100%	100%	100%	100%	100%

Source: Census 2011

Figure 3.40 compares annual household income levels within Saldanha Bay Municipality for 2001 and 2009. In 2001, 43.8% of all households had annual incomes of between R0 to R42 000 whilst in 2009, 32% fell into this category. In 2001, households with an annual income of R18 000 - R30 000 accounted for the largest concentration (14.6%) of households within an income category. In 2009, households with an annual income of R192 000 - R360 000 accounted for the largest concentration (14.8%) of households within an income category (PGWC, 2010).



Source: Global Insight

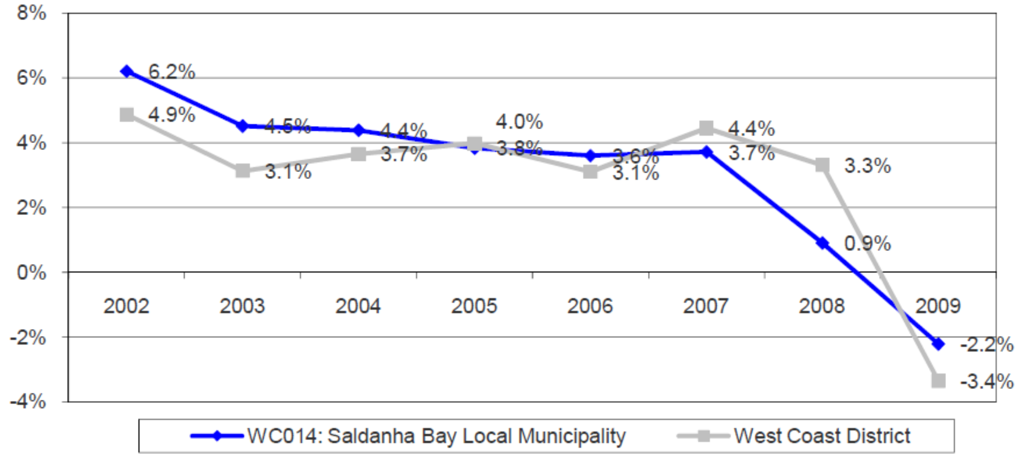
Figure 3.40 Household income for Saldanha Bay Municipality (2001 and 2009)

3.9.5 Economic output, growth and development trends

The Saldanha Bay Municipality's regional gross value added figure (GVA)[1] amounted to R3.326 billion in 2009 accounting for 35.1% of the total value added of the West Coast District of R9.480 billion.

Figure 3.41 presents the economic growth rate of the Saldanha Bay municipal area in comparison to the West Coast District's growth rate for the period 2001 to 2009. It shows that Saldanha Bay's economy grew at an annual average rate of 3.1% over the period 2001 to 2009 compared to the District's annual average growth rate of 2.9%. Growth in individual years was also higher for Saldanha Bay with the exception of 2007 and 2008. In 2008, Saldanha Bay was particularly severely impacted on by the global recession and economic growth lowered to 0.9% (PGWC, 2010).

[1] GVA and GDP are very similarly related concepts. GVA excludes taxation and subsidies, but GDP includes it.



Source: Western Cape Provincial Treasury calculations based on Global Insight

Figure 3.41 Economic growth in the local area and district between 2001 and 2009

Table 3.7 from PGWC (2010) shows the sectoral contribution to Saldanha Bay's GVA-R in 2001 and 2009 of nine key sectors in the SBM. The construction sector experienced the highest average annual growth rate over the 2001 to 2009 period at 9.5%. This was followed by finance & business services, catering & accommodation at 7.8% and electricity services at 4.4%. In their pre-feasibility study for the Saldanha Bay Industrial Development Zone (SBIDZ), Demacon (2009) notes that the regional economy and specific local economies have become increasingly diversified over the past two decades. The implication is that consumer demand and favourable local market conditions have created numerous investment opportunities for services sector based activities.

Table 3.7 Saldanha Bay Municipality Gross Value Added (GVA) trends from 2001 to 2009

Sector	2001 GVA-R Constant 2005 prices (R million)	2009 GVA-R Constant 2005 prices (R million)	2001-2009 Annual Average Growth Rate
1 Agriculture	248,329	295,271	2.2%
2 Mining	22,510	9,901	-9.8%
3 Manufacturing	832,445	886,895	0.8%
4 Electricity	13,776	19,369	4.4%
5 Construction	113,133	234,178	9.5%
6 Trade	202,832	221,732	1.1%
7 Transport	406,125	462,690	1.6%
8 Finance	353,315	645,886	7.8%
9 Community services	416,009	551,060	3.6%

Source: Western Cape Provincial Treasury calculations based on Global Insight

3.1.6 Economic Development Potential

The Saldanha Bay area has long been recognised as an area of significant economic opportunity. The Provincial Growth and Development Strategy of 2006 identified the Saldanha- and Mossel Bay areas as the two 'regional motors' in the province (PGWC, 2006). Van der Merwe *et al*. (2005) found Saldanha Bay and Vredenburg to have a very high growth potential in their survey of the growth potential of towns in the Western Cape. This study is in the process of being updated and the draft version also classifies Saldanha Bay as an area with high growth potential (see Figure 3.42). The growth potential of the Saldanha Bay municipal area with its proximity to Cape Town and natural deep water harbour have also resulted in it being recognised as a Presidential Development Growth Node.

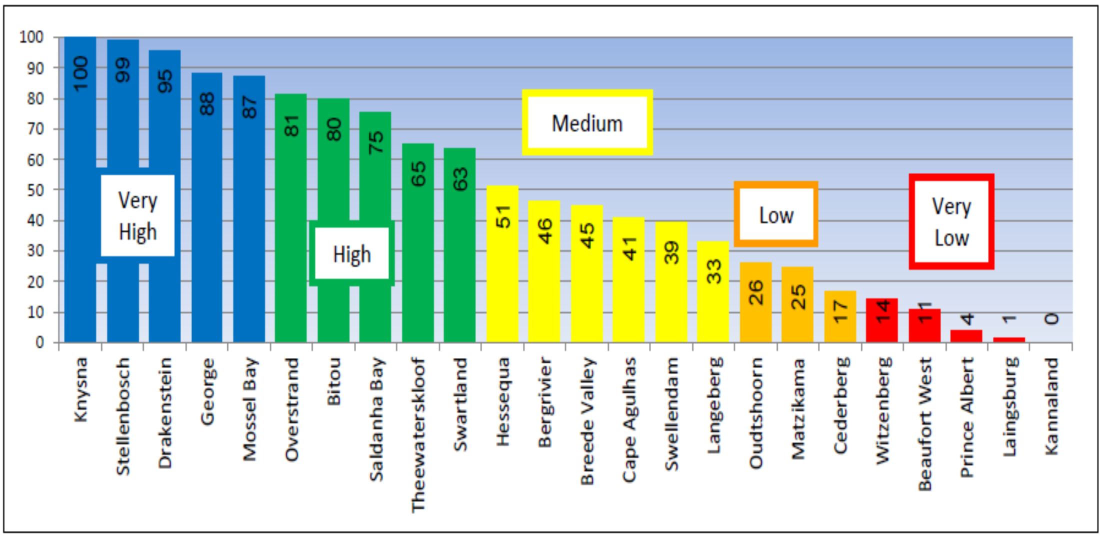


Figure 3.42 Growth potential of municipal areas in the Western Cape. Source: DEA&DP, 2013.