ENVIRONMENTAL IMPACT ASSESSMENT FOR THE PROPOSED NUCLEAR POWER STATION ('NUCLEAR 1') AND ASSOCIATED INFRASTRUCTURE

Dune Geomorphology Impact Assessment

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Prepared by: Illenberger & Associates

Prepared for: Arcus GIBB Pty Ltd

On behalf of: Eskom Holdings Ltd

Tel 083 626 1917
fax 0866 733 831

e-mail: werner@illenberger.biz

Illenberger & Associates
55 Emerald St
Mount Pleasant
6070
Port Elizabeth
South Africa

13 October 2010

DECLARATION OF INDEPENDENCE

I, Werner Kurt Illenberger as principal of Illenberger & Associates, hereby confirm my independence as a specialist and declare that I do not have any interest, be it business, financial, personal or other, in any proposed activity, application or appeal in respect of which Arcus GIBB was appointed as environmental assessment practitioner in terms of the National Environmental Management Act, 1998 (Act No. 107 of 1998), other than fair remuneration for worked performed, specifically in connection with the Environmental Impact Assessment for the proposed conventional nuclear power station ('Nuclear 1'). I further declare that I am confident in the results of the studies undertaken and conclusions drawn as a result of it – as is described in my attached report.

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Full Name: Werner Kurt Illenberger
Illenberger & Associates
werner@illenberger.biz

Title / Position: Dr
Qualification(s): BSc, BSc Hons, MSc, PhD
Experience : 26 years
Registration(s):Geol Soc SA, Pr Sci Nat

EXECUTIVE SUMMARY

This specialist study investigates environmental impacts related to dune dynamics for the nuclear power station ('Nuclear-1') that Eskom proposes to build. There are three sites under consideration: Duynefontein, Bantamsklip and Thyspunt. Aerial photographs from 1942 to 2007 were analysed to assess the dune morphology and dynamics of the mobile dunefields and vegetated dunefields at the three sites. Available literature on the subject was perused, including diverse reports prepared for Eskom, and various environmental specialists were consulted. Site visits were made, including visits with the wetlands and botany specialists.

Duynefontein

The dunes at Duynefontein form part of the Atlantis corridor dunefield. The dune varieties found are mobile transverse dunes, transverse dunes artificially stabilised with alien vegetation such as Rooikrans, and naturally vegetated parabolic dunes. Groundwater only "daylights" at Duynefontein in one or two small ephemeral interdune hollows, so there are no significant impacts related to the interaction between groundwater and dune dynamics at this site.

Access roads and transmission lines can be built across the mobile dunes with operational impacts ranging from medium to low. Access roads and transmission lines can be built across the vegetated dunefields with operational impacts ranging from low to insignificant.

Topsoil and spoils stockpiles located on the mobile dunes will have medium operational impacts. Topsoil and spoils stockpiles located on the vegetated dunefields will have low operational impacts.

At Duynefontein, 25% of the specific variety of mobile dunes will be lost if the proposed NPS site is used, and although it would be preferable not to lose these mobile dunes, this is not a fatal flaw in terms of their geomorphologic conservation value. The artificially vegetated dunes have no conservation value. A small proportion of the Late Holocene parabolic dunes will be lost; this is of low conservation significance.

Bantamsklip

Transgressive dunefields occur along the coast in the Bantamsklip area. They consist mainly of transverse dunes, which are mostly artificially stabilised with alien vegetation such as Rooikrans and some indigenous species. There are no currently mobile dunes on the site itself. There are some much older naturally vegetated fossil parabolic dunes formed during the previous interglacial (~ 120 000 years ago). Groundwater does not "daylight" at the site and so there are no impacts related to the interaction between groundwater and dune dynamics at the site.

Access roads and transmission lines can be built across the artificially vegetated dunefields with low operational impacts. Access roads and transmission lines can be built across the older naturally vegetated parabolic dunes with low operational impacts after careful rehabilitation.

Topsoil and spoils stockpiles located on the artificially vegetated dunefields or on the older naturally vegetated parabolic dunes will have low operational impacts.

The geomorphologic conservation value of the dunefields at the Bantamsklip site is low, considering that other examples of dunefields of their type are hardly impacted

Thyspunt

The dune varieties found at Thyspunt are mobile dunefields of the headland-bypass dunefield variety (the Oyster Bay dunefield), and vegetated parabolic dunes and hairpin parabolic dunes. In addition, sidewalls of previously mobile dunefields form long, vegetated dune ridges. Parts of the mobile dunefields have been artificially stabilised with alien vegetation such as Rooikrans. The mobile dunefields are very dynamic.

At Thyspunt groundwater "daylights" in many interdune areas within the Oyster Bay dunefield to form ponds in the interdune areas (also known as dune slacks), where wetlands are often found. The behaviour and flow characteristics of groundwater and surface water were investigated to help determine the viability, in respect of dune dynamics, of building transmission lines and an access road to Thyspunt from the north, across the Oyster Bay dunefield.

Mobile dune dynamics at Thyspunt were investigated in detail. An access road, transmission lines and a temporary conveyor belt or haul road could potentially be built across the mobile dunes of the Oyster Bay dunefield at Thyspunt. ***Further groundwater monitoring work on surface water and shallow groundwater flow as required was in progress at the time of writing this report.***

The access road can be built either using an aerodynamically smooth road slightly raised above the interdune surface with frequent culverts, or with an aerodynamically shaped bridge that crosses the mobile dunes and interdune wetlands to allow sand to be transported below the road without causing sand build-up. The aerodynamically shaped bridge design would have a lower operational impact.

Transmission lines can be built across the mobile Oyster Bay dunefield. The operational impacts of towers spaced at 300 - 400 m intervals would range from medium in the case of access roads being used for construction, to low in the case of helicopters being used for construction. Using towers spaced at 800 m intervals, the whole mobile dunefield could be crossed with no activities or structures being located within the mobile dunes, and thus without any impacts whatsoever.

A temporary conveyor belt or haul road can be built across the mobile Oyster Bay dunefield to carry spoils to the "panhandle" in the north of the site. The environmental impact would be low after the conveyor belt or haul road is removed and rehabilitation is completed. ***However, rehabilitation would be slow.***

Access roads, transmission lines and a temporary conveyor belt or haul road could be built across the vegetated dunefield with low operational impacts. Installing the conveyor belt foundations using low-diameter piles instead of concrete foundations will reduce impacts further. Terraforce or similar blocks must be used to stabilise the sides of the cut and fill, as rehabilitation by vegetating the slopes will be difficult and slow.

Topsoil and spoils stockpiles cannot be located on the mobile Oyster Bay dunefield at Thyspunt. Topsoil and spoils stockpiles can be located on the vegetated dunefield at Thyspunt with medium operational impacts.

The geomorphologic conservation value of the headland-bypass dunefields at Thyspunt is high, as they are the only remaining large dunefields of this type that are still active in South Africa. The headland-bypass dunefields at Cape St. Francis are unique on a local, regional and probably global scale. The vegetated dunefield is a classic, almost pristine example of a suite of Holocene and Pleistocene dune ridges with a variety of origins: parabolic dunes, hairpin parabolic dunes, and sidewalls of previously mobile headland-bypass dunefields, including fairly unique examples of such sidewalls. Overall, the dunefields at Thyspunt has high interpretive value for elucidating coastal dune dynamics.

Climate change

The possible effects of climate change on dune dynamics are:

Retreat of the coastline in response to higher sea level may shift or create new sandy beaches that supply wind-blown sand to dunes. Mobile dunes and dunefields may thus be created in areas that are currently vegetated.

Rainfall decrease and temperature increase at Duynefontein and Bantamsklip will stress vegetated dunes, so it will be easier for blowouts to form. At Thyspunt, rainfall is not expected to change, but temperature will increase, so it will be somewhat easier for blowouts to form, but not as much as at the other sites.

Wind speed increase is not expected to have any significant environmental impact.

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Dune geomorphology Impact Assessment

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ABBREVIATIONS

DEA	Department of Environmental Affairs (previously the Department of Environmental Affairs and Tourism)
ECO	Environmental Control Officer
EIA	Environmental Impact Assessment
SSR	Site Safety Report
NPS	Nuclear Power Station
HV yard	high-voltage transformer yard
amsl	above mean sea level
IPCC	Inter-Governmental Panel for Climate Change

GLOSSARY

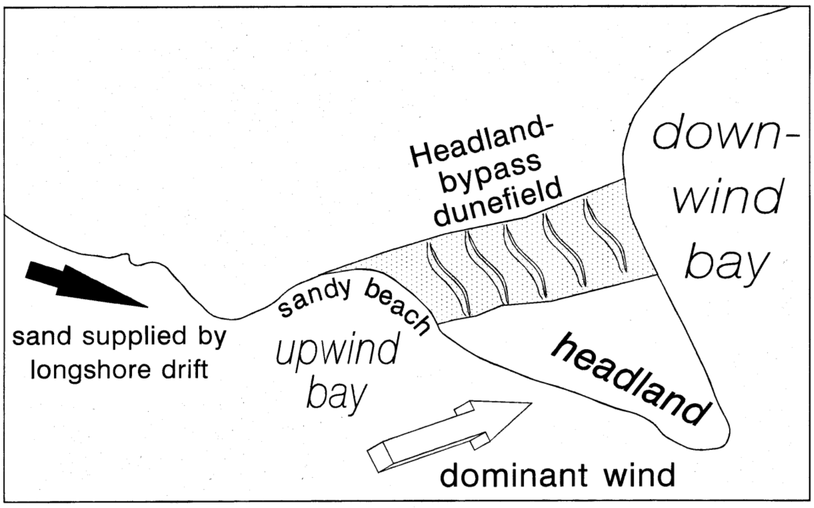
Aquifer: A geological formation, which has structures or textures that hold water or permit appreciable water movement through them.

Aquitard: A geological formation, which has a low permeability that retards and restricts the vertical and / or horizontal movement of groundwater, but does not stop the movement of groundwater.

Aquiclude: A geological formation, which is impermeable so that there is no movement of groundwater through it.

Corridor dunefield: A coastal dunefield that develops where dune mobility is high, often due to strong onshore winds. Insignificant accretion occurs, as the sand is blown along too vigorously for plants to take hold. These dunefields typically take the form of linear corridors of well spaced transverse dunes that extend inland from sandy beaches. Corridor dunefields are oriented parallel to the prevailing wind.

Headland-bypass dunefield: A type of corridor dunefield in which sand is blown from an upwind beach and transported across a low-relief headland to the downwind bay, bypassing the transport of sand by longshore drift around the headlands, as shown in the conceptual diagram on the right.



These dunefields were recognised and defined by Ken Tinley in his seminal work on South African coastal dunes (Tinley, 1985, page 29). They are a feature of the south Cape coast of South Africa, which is characterised by a series of log spiral bays and associated headlands of the resistant quartzites of the Table Mountain Group. The coastline configuration, together with the eastward transport of sand due to the prevailing west-south-westerly wave and wind regime, result in the formation of headland bypass dunefields whenever sandy beaches occur along the upwind shores of headlands. Longshore drift replenishes the sand that the wind blows off the upwind beach.

Examples of headland bypass dunefields are found at Cape Agulhas, Waenhuiskrans, Buffelsbaai, Cape St. Francis and Cape Recife (Port Elizabeth). The artificial stabilisation of most these dunefields over the past 50 years, without due cognisance of the role that the dunefields play in the coastal sediment transport system, has resulted in beach erosion in down-wind bays (e.g. McLachlan *et al.,* 1994).

"Daylight" or "daylights" with reference to groundwater: The groundwater table reaches the local land surface, creating a pond or a spring typically surrounded by mobile dunes.

Dune slack: Alternate term for interdune area. It is a fairly permanent surface over which dunes move. It represents the erosional base level below which wind cannot erode, either because the ground is wet due to groundwater "daylighting", or because a pebbly or hard rock surface is exposed.

Holocene: Geologic time scale for the last 10 000 years, which is the duration of the current interglacial period. The last glacial episode ended at the begin of this period, and the sea returned to the present level from its lowpoint of 130 m below present at the peak of the last glacial. The sea reached the present level 6500 years ago. **Holocene dunefields** have been formed since the sea reached its present level (e.g. Illenberger, 1998; Illenberger & Burkinshaw, 2008).

Parabolic dunes: A parabolic dune is a U-shaped tongue of mobile sand with two trailing arms, or sidewalls, that are anchored by vegetation. The leading nose of sand is the mobile component of the dune. The nose moves downwind and has a terminal slip face. The vegetated sidewalls form the fixed component of the dune, with an orientation parallel to the prevailing wind. The form and size of parabolic dunes depend on the strength and directional variability of the wind, the source and amount of sand available, and the type of vegetated terrain over which the dunes move (Tinley, 1985; Illenberger & Burkinshaw, 2008).

On a larger scale, parabolic dunes may become very elongated when they develop in regions of strong unidirectional winds. Such dunes are known as hairpin parabolic dunes (Tinley, 1985), because of the long, paired parallel ridges which trail the dune. When the nose of a parabolic dune is breached, the remaining parallel ridges are called wind-rift ridges.

Parabolic dunes may develop from a point source of sand, such as a small sandy beach. They may also develop from blowouts where vegetation is destroyed, by natural or artificial means. The destruction of vegetation on foredunes, or on larger permanent vegetated ridges that form as foredunes grow, may be caused naturally when winds are accelerated over the ridge crest. This will initiate blowouts.

Pleistocene: Geologic time scale for the period 10 000 to 2 million years. During this period there were numerous glacial - interglacial episodes. The last interglacial was from 110 000 to 125 000 years ago. The second-last interglacial was about 250 000 years ago. The period from 250 000 to 10 000 years ago is loosely referred to as Late Pleistocene.

Transgressive dunefield: A mobile coastal dunefield that moves inland and incorporates mobile unvegetated dunes that transgress landward. Some accretion of sand takes place, i.e. the dunefield gets thicker with time. Parabolic dunes and transverse dunes are found in transgressive dunefields.

Transverse dune: Unvegetated mobile dune with crest line at right angles to the prevailing wind. These dunes have an asymmetric shape; wind blows sand up the gently sloping windward side to the dune crest, whence it avalanches down the steep slipface. The windward side slopes at angles of 10–15°, whereas the slip face slopes at angles of up to 34°. Transverse dunes commonly move at rates of 10 m/yr and are unvegetated, because plants cannot survive in such a mobile and unstable environment. In areas where a secondary wind blows in the opposite direction to the prevailing wind, some temporary reversal of dune movement occurs.

ACKNOWLEDGEMENTS

I have had fruitful discussions with (in alphabetic order) Bill Branch, Jenny Burkinshaw, Lucian Burger, Karen Burgers, Debbie Claasen, Richard Cowling, Liz Day, Johann du Plooy Fred Ellery, Lauren Ellington, Caryl Logie, Barrie Low, Marc Goedhart, Pete Illgner, Norbert Klages, Gillian McGregor, Koos Reddering, Chris Roberts, Geoff Roberts, Izak Rust, Frank Silberbauer and Aubrey Withers.

1 INTRODUCTION

1.1 Background

Eskom Holdings (Ltd) has proposed the construction of a Nuclear Power Station (NPS) on one of five alternative sites, located in the Northern, Eastern and Western Cape Provinces of South Africa. ARCUS GIBB (Pty) Ltd (GIBB) was appointed by Eskom Holdings (Pty) Ltd (referred to hereafter as Eskom) to undertake the Environmental Impact Assessment (EIA) for the proposed NPS and its associated infrastructure at each site.

Five possible sites were initially identified. Two sites, were excluded after the scoping process: Brazil (Northern Cape located in Kleinsee/Port Nolloth area) and Schulpfontein (Northern Cape located in Hondeklipbaai/Kleinsee area), and are not considered in this study.

The three remaining sites included in the detailed EIA assessment are Duynefontein (Western Cape), Bantamsklip (Western Cape) and Thyspunt (Eastern Cape) (Figure 1.1). Since these sites include or are associated with dunefields and dune systems, Illenberger & Associates was appointed by GIBB to provide specialist input into the EIA process.

The present document is written in support of the Environmental Impact Assessment Report. The potential impact on dunefields was only identified as requiring a specialist study after the Scoping Phase.

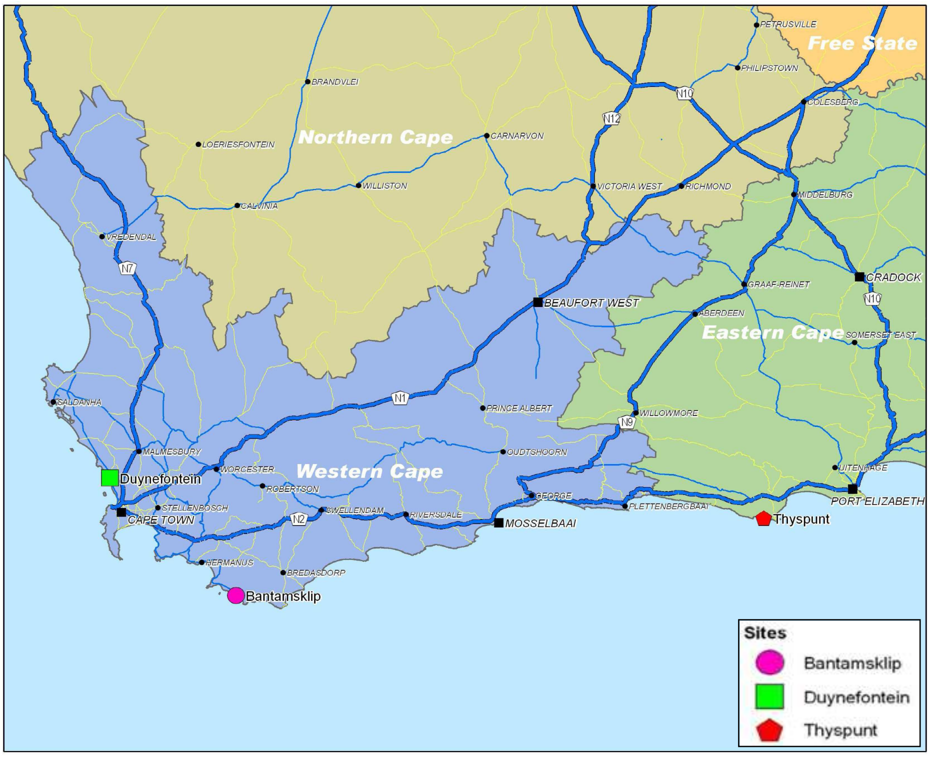


Fig 1.1. Overall locality of the three sites under consideration for development of a nuclear power station. Modified from wetlands report (Day, 2008).

1.2 Terms of Reference

The dune specialist will be required to undertake the following assessments with respect to dune dynamics at the three proposed sites:

1.2.1 Duynefontein

1. Assessment of aspects of groundwater and surface water as far as they have impact on the dunes and proposed activities within the dune areas.
2. Assessment of dune dynamics of the mobile dunes, with specific investigation into the viability of constructing infrastructure and access roads.
3. Assessment of dune dynamics and stability of the artificially vegetated (fixed) dunes, with specific investigation into the viability of constructing infrastructure and access roads.
4. Assessment of the potential impact of the disposal of soil and sediments excavated from the power station construction site on the above mentioned dune systems.
5. Assessment of the potential impacts of climate change on the dunes.

1.2.2 **Bantamsklip**

6. Assessment of aspects of groundwater and surface water as far as they have impact on the dunefields and proposed activities within the dunefields.
7. Assessment of dune dynamics and stability of dunefields on the site, with specific investigation into the viability of constructing infrastructure and access roads.
8. Assessment of the potential impact of the disposal of soil and sediments excavated from the power station construction site on the dunefields.
9. Assessment of the potential impacts of climate change on the dunes.

1.2.3 Thyspunt

10. Assessment of aspects of groundwater and surface water as far as they have impact on the dunes and proposed activities within the dune areas.
11. Assessment of dune, wetland and groundwater dynamics in the St. Francis Bay headland-bypass dunefield with specific investigation into whether or not the northern and/ or western access road can be built across the mobile, unvegetated dunes and interdune wetlands.
12. Assessment of stability of the fixed, vegetated dunes, with specific investigation into whether or not access roads can be built across the fixed, vegetated dunes.
13. Assessment of whether or not transmission and distribution lines from the plant to the High-Voltage Yard (HV yard) and ancillary service roads and construction roads can be built across the mobile, unvegetated dunes and interdune wetlands.
14. Assessment of stability of the fixed, vegetated dunes, with specific investigation into the viability of access roads, transmission lines from the plant to the HV yard and ancillary service roads and construction roads being built across the fixed, vegetated dunes.
15. Assessment of the potential impact of the disposal of soil and sediments excavated from the power station construction site on the above mentioned dunes.
16. Assessment of the potential impacts of climate change on the dunes.

The investigation at Thyspunt includes addressing a known information gap regarding interdune wetland and surface and groundwater dynamics in the area, and this knowledge is critically needed to address other tasks relating to the remainder of the Thyspunt Terms of Reference.

Dune dynamics at Bantamsklip and Duynefontein sites are much simpler than at the Thyspunt site. Also, these two sites are not pristine as they have been artificially vegetated in places. Investigations at these sites are thus much simpler.

1.3 Climate change scenario used for this EIA

The scenario used here is based on the 4th Assessment report of the Inter-Governmental Panel for Climate Change (IPCC) as reported in Burger (2009), with some further input by Prof Hannes Rautenbach of Pretoria University (Lucian Burger, pers. comm., November 2009).

- Sea level is expected to rise by a maximum of 2 m by 2100.
- Temperatures are expected to increase by up to 3º C by 2100.
- Storms frequency is expected to increase. The amount of increase was not specified.
- Wind speed is expected to increase by about 10%.
- The two western sites (Duynefontein and Bantamsklip) might experience increased dry conditions in future. At Thyspunt large changes in annual and mid-summer rainfall totals are unlikely to occur.
- Winds at Thyspunt are expected to have a larger proportion of easterly winds.

1.4 No-Go alternative: option of not proceeding with building the NPS

In the event of the No-Go alternative being selected, Eskom will put the properties in question up for sale. No impact is expected on dune dynamics.

1.5 Decommissioning phase

All permanent structures within the dunes must be removed using the rehabilitation techniques as described below for removing temporary structures like conveyor belts. This issue will require no other actions and will not be discussed further in this report.

1.6 Legislative framework

The legislative framework for this report is summarised in the below table (modified from Low, 2009).

Table 1.1. Laws, policies & plans relating to the natural environment	
Constitution of the Republic of South Africa (Act No. 108 of 1996), article 24 (b) – (c)	*“everyone has the right to have the environment protected, for the benefit of present and future generations, through reasonable legislative and other measures that prevent pollution and ecological degradation; promote conservation; and secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development”.*
National Environmental Management Act, 1998 (NEMA) (Act No. 107 of 1998)	The National Environmental Management Act (Act 107, 1998) states in s2(4)(k) that “The environment is held in public trust for the people, the beneficial use of resources must serve the public interest and the environment must be protected as the people’s common heritage”. Section 2(4)(a) specifies that sustainable development requires the consideration of all relevant factors including the following: ▪ that the disturbance of ecosystems and loss of biological diversity are avoided, or, where they cannot be altogether avoided, are minimised and remedied; ▪ that the development, use and exploitation of renewable resources and the ecosystems of which they are part do not exceed the level beyond which their integrity is jeopardised; ▪ that a risk-averse and cautious approach is applied, which takes into account the limits of current knowledge about the consequences of decisions and actions; ▪ that negative impacts on the environment and on people’s environmental rights be anticipated and prevented, and where they cannot be altogether prevented, are minimised and remedied; ▪ that equitable access to environmental resources, benefits and services be pursued to meet basic human needs and ensure well-being. Special measures may be taken to ensure access by categories of persons disadvantaged by unfair discrimination. Section 28 imposes a “duty of care” obligation for the environment on every person with regard to taking reasonable measures to prevent pollution or degradation of the environment or, where unavoidable, to minimize and rectify such pollution or degradation.

National Environmental Management Act, 1998 (NEMA) (Act No. 107 of 1998): listed activities in terms of Sections 24 and 24D; Environmental Impact Assessment Regulations, made under section 24(5) of the Act and published in Government Notice No. R. 385 of 2006	The construction of roads within dunes is a listed activity because: • the roads are situated wholly or partly within 100 metres of the seashore (Schedule 2); • building the roads involves placing synthetic material on dunes and exposed sand surfaces within 100 metres of the seashore (Schedule 3); • building the roads involves the removal or damaging of indigenous vegetation of more than 10 square metres within 100 metres of the seashore (Schedule 5); and • building the roads involves the excavation, moving, depositing or compacting of sand covering an area exceeding more than 10 square metres within 100 metres of the seashore (Schedule 6).
National Environmental Management: Protected Areas Act, 2003 (Act No. 57 of 2003)	The objectives of this Act, within the framework of the National Environmental Management Act, include the protection and conservation of ecologically viable areas representative of South Africa's biological diversity and its natural landscapes and seascapes in order to: • Protect areas with significant natural features or biodiversity • Protect areas in need of long-term protection for the provision of environmental goods and services • Provide for sustainable flow of natural products and services to meet the needs of a local community; involvement of private landowners. The Act provides for the involvement of parties other than organs of State in the declaration and management of protected areas.
National Environmental Management: Integrated Coastal Management Act (Act 24 of 2008), implemented 1st December 2009	The Act's intention, through integrated coastal and estuarine management, is to ensure that development and the use of natural resources within the coastal zone is socially and economically justifiable and ecologically sustainable, amongst others, through appropriate regulation, management, protection, conservation and rehabilitation measures. The Act focuses on regulating (by restricting or controlling) human activities within, or that affect the 'coastal zone'. The 'coastal zone' is defined as the area comprising coastal public properly, the coastal protection zone, coastal access land and coastal protected areas, the seashore, coastal waters and the exclusive economic zone and includes any aspect of the environment on, in, under and above such area. The coastal protection zone includes any land situated wholly or partially within 1 km of the HWM which, when this Act came into force, (i) was zoned for agricultural or undetermined use; or (ii) was not zoned and was not part of a lawfully established human settlement, and any

	land within 100m of the HWM. This coastal protection zone, through regulation, management and/or restrictions, aims (s17) to protect its ecological integrity, natural character and socioeconomic/ aesthetic values, avoid increasing the severity or effect of natural hazards in this zone, protect people, property and economic activities from dynamic coastal processes (including sea level rise), maintain the natural functioning of the littoral active zone, maintain the productive capacity, and make land available to the state or authorized persons for specified purposes. The MEC must establish coastal set-back lines to prohibit or restrict the building, erection, alteration or extension of structures sea-ward of these lines; the lines may be wholly or partially outside the coastal zone. The Act makes the preparation of a provincial and municipal coastal management plans compulsory within a specified time period, and prescribes its contents. It also provides for coastal planning schemes to facilitate its objectives. The Act also regulates the discharge of effluent into coastal waters, incineration or dumping of waste at sea, Development in the coastal zone must take into account both the impacts of the activity on the coastal environment (including cumulative impacts), and the impacts of coastal environmental processes on that activity. Any activity within the coastal protection zone should be consistent with its purpose (s17).

1.7 Study Approach

Available literature on the subject was perused. These are listed in the References Section, and are referred to in the text of Section 2 where relevant.

Various specialists familiar with the sites were consulted. These specialists include:

Specialists on the EIA team:

- Liz Day (The Freshwater Consulting Group): wetlands study;
- Barrie Low (Coastec): botanical study;
- James Harrison (JAH Consulting): fauna study;
- Lucian Burger (Airshed Planning Professionals): air quality study;
- Marc Goedhart, Koos Reddering, Debbie Claasen (Council for Geoscience): geology and seismic hazard; and
- Karen Burgers, Johann du Plooy (SRK): geohydrology.

Acknowledged academic specialists:

- Izak Rust, Jenny Burkinshaw, Aubrey Withers, Fred Ellery, Gillian McGregor and Lauren Ellington: physical coastal environment;

- Richard Cowling, Norbert Klages, Pete Illgner and Bill Branch: biological coastal environment;

Existing reports for the Eskom EIA and Site Safety Report (SSR) relevant to this investigation were perused. These reports are:

- wetlands;
- botanical resources;
- air quality;
- geohydrology;
- groundwater modelling – part of geohydrology;
- hydrology; and
- geology.

The reports are listed in the References Section.

The following aerial photographs were used:

Table 1.2. Aerial photographs used for Duynefontein

Date	job	scale	strip numbers	comments
1989-01-26	919	1:50 000	15	
2005-01-15				GoogleEarth
2007-09-07		~ 1:1 000		supplied by Eskom

Table 1.3. Aerial photographs used for Bantamsklip

Date	job	scale	strip numbers	comments
1989-12-08	931	1:50 000	C4	
2004-12-05				GoogleEarth
2007-09-04		~ 1:1 000		supplied by Eskom

Table 1.4. Aerial photographs used for Thyspunt

Date	job	scale	strip numbers	state of dunefield	comments
1942	2/42	1:30 000	7, 8	wet	
1961		1:36 000	18, C1	moderately dry	
1969	622	1:36 000	12	dry	
1971	622	1:36 000	C3	wet	after 1971 floods
1975	498/71	1:30 000	6	dry	

1985-09-17		1:30 000	15, 16	wet	
2003-06-27				wet	GoogleEarth
2006-03-06				dry	GoogleEarth
2007-09-01		~ 1:1 000		wet	supplied by Eskom

1.7.1 Timing of site assessments

Field visits were conducted on the following dates:

- Duynefontein
  - 28 April 2009
- Bantamsklip
  - 29 April 2009
- Thyspunt
  - 12 September 2008;
  - 7 October 2008;
  - 27-29 March 2009; and
  - 8-9 September 2009.

1.8 Limitations of specialist investigation

Information required for this report is sufficiently complete at Duynefontein and Bantamsklip.

The following limitations are relevant to the Thyspunt site:

- the geohydrological investigation undertaken for the EIA was focused on the NPS site itself, with only two boreholes drilled within the mobile Oyster Bay dunefield; and

- the hydrological investigation undertaken for the EIA focused on the NPS site itself, with no investigation of the mobile Oyster Bay dunefield.

These limitations have not seriously compromised this investigation, as field observations and aerial photo interpretation has provided sufficient information to achieve a moderate to high degree of confidence in the results of the investigation and deductions made.

If construction of roads or other structures through the mobile Oyster Bay dunefield does go ahead, detailed investigation of surface water and shallow groundwater flow within the dunefield is needed, particularly in relation to wetland functioning. In addition, geotechnical test holes should be drilled through the interdune sediments, and these must be perused by a suitably qualified specialist to confirm that the assumptions made in this report are valid.

1.8.1 Academic investigations currently underway

A study investigating the structure and functioning of the Oyster Bay Dunefield system is being undertaken by a group led by Fred Ellery and involving Gillian McGregor and Lauren Elkington, all from the Department of Environmental Science, Rhodes University; Richard Cowling from the Nelson Mandela Metropolitan University. An MSc thesis entitled "Morphology, patterns and processes in the Oyster Bay Dune field system" by Ms Lauren Elkington is at an advanced stage of preparation. This is a work in progress, and the data collected cannot be presented or discussed here until the MSc is completed. However, if the thesis is completed before the final Environmental Impact Assessment Report is completed, the results of the thesis will be incorporated. This course of action was agreed upon after discussion with Fred Ellery and his group in February 2010.

At the public participation meeting of 25 May 2010 held at St Francis Bay, Prof Ellery agreed that he would release information and data for inclusion in the Dune Geomorphology Report. However, Ms Lauren Elkington is currently out of the country and apparently not contactable, so Prof Ellery is not able to access her data. Prof Ellery supplied a paper on wetlands in preparation (i.e. unpublished). This paper did not investigate any wetlands in the greater Cape St. Francis – Oyster Bay area, and did not include any data relevant to this Report. (It does not mention debris flows). As such no data from Fred Ellery's group can be incorporated in this Report at this stage.

2 DESCRIPTION OF AFFECTED ENVIRONMENT

2.1 Duynefontein

The Duynefontein site is adjacent to, and north of, the present Koeberg Nuclear Power Station, and lies some 8km north of Melkbosstrand, on the sandy coastal plain of the West Coast (Figure 1.1).

Fig 2.1. The Atlantis corridor dunefield. Duynefontein lies at the southern end of this dunefield. The dunefield is mostly naturally vegetated, consisting of parabolic dunes. The patches of mobile transverse dunes in the centre and in the southern end of the dunefield are naturally unvegetated. Details of the Duynefontein portion of the dunefield are illustrated in Fig 2.2.

The dunefield at Duynefontein forms part of the Atlantis corridor dunefield (Figure 2.1) (Tinley, 1985; Illenberger, 1998; Illenberger & Burkinshaw, 2008). The Atlantis corridor dunefield formed during the Holocene (the last 6500 years). The dunefield is mostly naturally vegetated, consisting of parabolic dunes. The patches of mobile transverse dunes are naturally unvegetated. The transverse dunes move northward, driven by the dominant southerly wind. This is probably the southeast wind of the Cape Town area, which swings to a direction varying from south to southeast up the west coast. The alternation of vegetated and unvegetated dunes is due to sand being supplied to the dunefield in pulses. The patches of mobile transverse dunes have been artificially vegetated in places, mostly in the southern end.

Duynefontein lies at the southern end of this dunefield. The dunefield at Duynefontein consists of four dune varieties (Figure 2.2):

1. Currently active transverse dunes (Figure 2.3).

2. Artificially stabilised transverse dunes (Figure 2.4).

3. Mid Holocene parabolic dunes.

4. Late Holocene parabolic dunes (Figure 2.5).

An explanation of the dune types is given in the Glossary.

The Mid and Late Holocene dates are not accurate. They are based on their geomorphologic character, and are sufficiently accurate to illustrate dune processes. At the northern end of the Atlantis corridor dunefield there are Early Holocene parabolic dunes.

The currently active or mobile transverse dunes are on average about 8 m high, with the highest dunes reaching 12 m. The parabolic dunes are on average about 5 m high. Movement rates have not been calculated in this area, but are estimated to be about 5 to 8 m/yr. The average rate of sand movement is estimated to be about 20 m^3/m width/year.

2.1.1 Interdune ponds, wetlands and groundwater at Duynefontein

Groundwater only “daylights” in one or two small ephemeral interdune hollows at Duynefontein (Day, 2009). The dune dynamics are thus very unlikely to have any significant interaction with wetlands or groundwater. so there are no significant impacts related to the interaction between groundwater and dune dynamics at this site.

2.1.2 Sensitivity

The sensitivities of the dunefield types are:

1. Currently active transverse dunes are resilient because the wind will re-create their natural shape if they are disturbed artificially (Rust & Illenberger, 1996). This type of dune is thus classified as having a low sensitivity.

2. Artificially vegetated transgressive dunefields have a low sensitivity as soil is very poorly developed on these dunefields, with very few nutrient-rich fines. Any winnowing out of fines if the dune sand is de-vegetated during construction will thus have a very low impact as very few nutrients will be lost. Further, any disturbed or damaged vegetation can be rehabilitated by re-planting the dune sand with suitable pioneer species of indigenous vegetation to re-stabilise the dune sand.

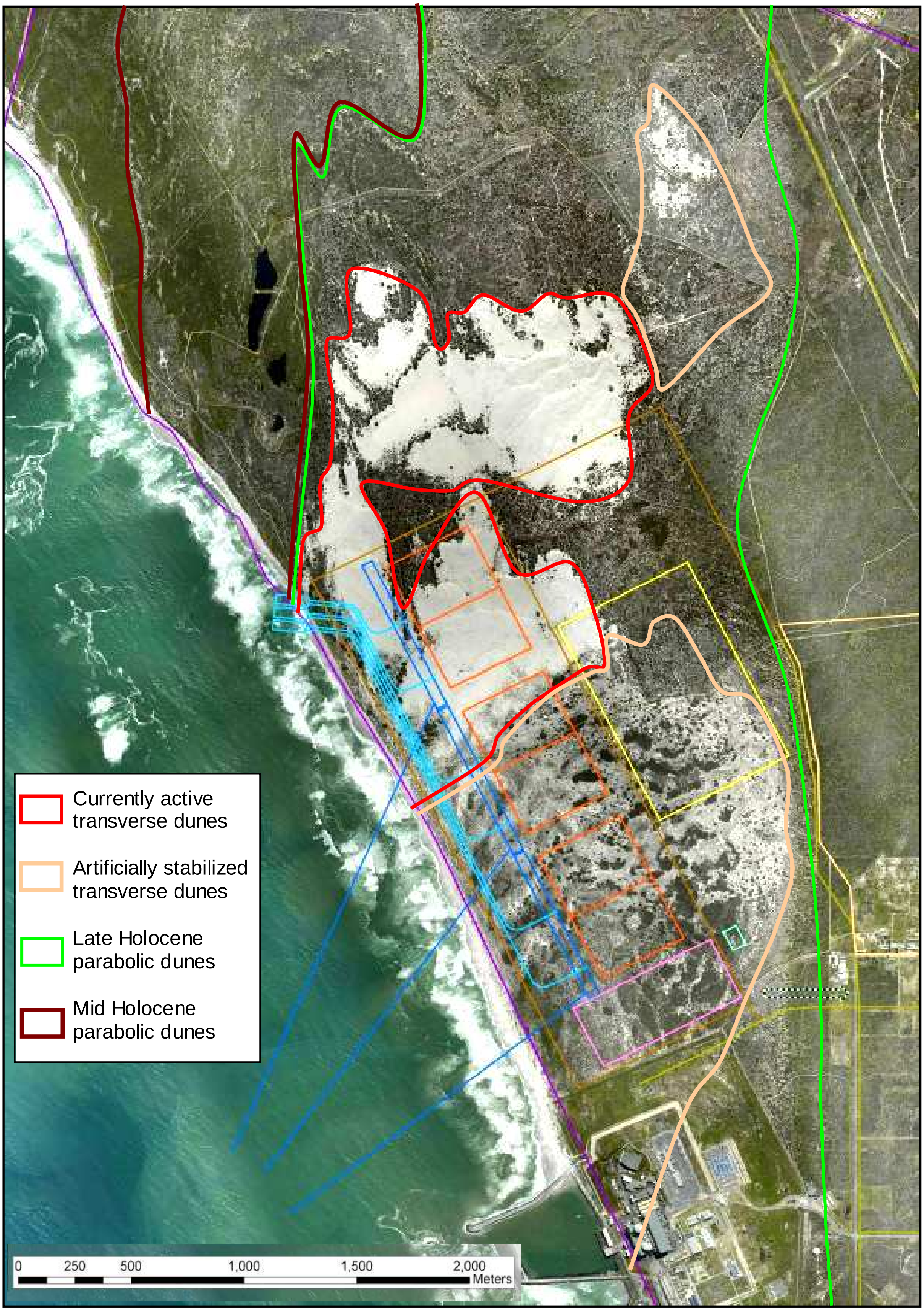


Fig 2.2. Dunefield varieties at Duynefontein and surroundings. The dunefield forms part of the Atlantis corridor dunefield. In order to make the map more legible, the zones are not shaded. The area inside each demarcation line is the corresponding zone.

Figure 2.3. Transverse dune advancing into a vegetated area.

Figure 2.4. Artificially vegetated transverse dune.

Figure 2.5. Naturally vegetated parabolic dunes.

3. Mid and Late Holocene parabolic dunes that are naturally vegetated have a low sensitivity as soil is very poorly developed on Holocene dunefields, with few nutrient-rich fines. Any winnowing out of fines if the dune sand is de-vegetated during construction will thus have a low impact as few nutrients will be lost. Further, any disturbance or damage to the vegetation can be rehabilitated by re-planting the dune sand with suitable pioneer species of indigenous vegetation to re-stabilise the dune sand.

2.2 Bantamsklip

The Bantamsklip site lies on the western side of the Agulhas Plain, which extends from the Klein River mouth to the Breede River (Figure 1.1).

There are two types of dunefield found in the Bantamsklip area (Figure 2.6) (Tinley, 1985; Illenberger, 1998; Illenberger & Burkinshaw, 2008):

1. **Transgressive dunefields** consisting mainly of transverse dunes that are Holocene in age, i.e. these dunefields have been formed since the start of the present interglacial, when the sea reached its present level, about 6500 years ago (e.g. Illenberger, 1998; Illenberger & Burkinshaw, 2008). These dunefields originate from sandy beaches that provide a source of mobile sand that moves too fast for plants to cope with sand inundation. The transverse dunes move

south-eastward, driven by the north-westerly wind that is dominant in this part of the coast. These dunefields have mostly been artificially vegetated, largely with the invasive alien Rooikrans (*Acacia cyclops*) (Figure 2.7). In some areas re-activation of the fossil dunes has taken place. These have been artificially re-vegetated by CapeNature to keep the dunes stable.

2. **Fossil dunefields** with subdued hilly dune topography (Figure 2.8). Remnant subdued fossil parabolic dune shapes can be discerned on aerial photographs, e.g. Figure 2.6. These dunefields are Pleistocene in age, i.e. much older than the transgressive dunefields that are Holocene in age. They were probably formed during the last interglacial (about 120 000 years ago), at which time the sea was about 3 m higher than the present level. They have a moderately developed soil, medium grey in colour (Figure 2.9), which sustains a fair variety of plant species: about 3 times as many (73 species) as the much less developed younger soil of the artificially vegetated transgressive dunefields (23 species) (Low, 2008).

2.2.1 Interdune ponds, wetlands and groundwater at Bantamsklip

There are no interdune wetlands in the dunefield at Bantamsklip, as was observed during the site visit, from inspection of aerial photographs, and as reported in the wetlands specialist report (Day, 2009). Groundwater does not “daylight” within the dunefield. The dunefield thus does not interact with and is not affected by wetlands or groundwater.

2.2.2 Sensitivity

The artificially vegetated transgressive dunefields have a low sensitivity regarding disturbance or damage to the vegetation as any impacts can be rehabilitated by re-planting the dune sand with suitable pioneer species of indigenous vegetation to re-stabilise the dune sand.

The fossil dunefields have a moderate sensitivity as:

- Soil is better-developed, so soil exposed during construction and in soil stockpiles will be liable to wind erosion that winnows the nutrient-rich fines out of the soil, causing a loss of soil nutrients; and

- Rehabilitation of vegetation to its natural state will require some effort in order to reach the original species diversity.

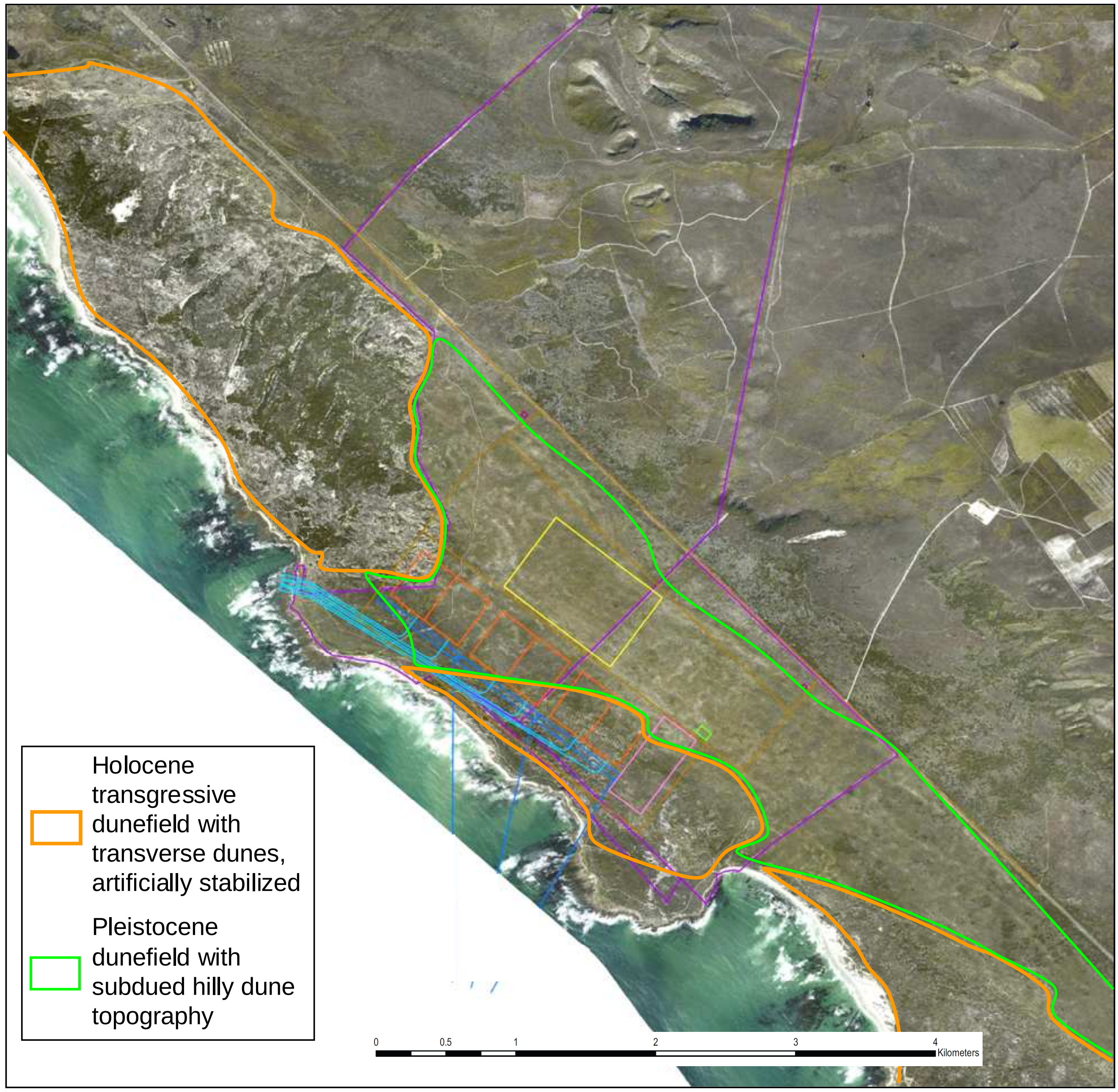


Fig 2.6. Dunefield varieties at Bantamsklip and surroundings. The NPS layout shown is not the final layout.

Figure 2.7. Artificially vegetated transverse dunes at Bantamsklip.

Figure 2.8. Naturally vegetated fossil parabolic dunes of Pleistocene age with a fair variety of plant species.

Figure 2.9. Moderately developed soil, medium grey in colour, developed on fossil parabolic dunes of Pleistocene age.

2.3 Thyspunt

The Thyspunt site lies in the Eastern Cape, on the Cape St. Francis headland (Figure 1.1). The topography of the site consists of a mix of unvegetated mobile dunefields of the headland-bypass dunefield variety, and vegetated stable dune ridges (Figure 2.10).

In terms of dune morphology, dune dynamics, groundwater interactions and dune varieties the Thyspunt site is by far the most complex of the three sites under consideration. Some of the dunes are very mobile, and can move at 10's of metres per year.

Most of the information in this section is from the PhD thesis of Jenny Burkinshaw (Burkinshaw, 1998), and McLachlan et al (1994), partly as presented in Illenberger & Burkinshaw (2007).

Regarding the names used to describe the various areas of mobile dunefield, various names have been used for the different dunefields in the specialist reports. It seems sensible to name the dunefields following the terminology used by Burkinshaw (1998) in her PhD thesis on the dunefields, as shown in Figures 2.11 and 2.12.

The low-relief Cape St. Francis headland hosts the most spectacular and last two remaining active examples of large-scale mobile headland-bypass dunefields on the south coast of South Africa (Tinley, 1985; Burkinshaw, 1998; Illenberger & Burkinshaw, 2008). ***Headland-bypass dunefields and the part they play in the movement of coastal sediments are described in the Glossary.*** The corridors of transverse dunes run parallel to the dominant westerly to south-westerly wind. The mobile dunefields are very dynamic. A feature of the Cape St. Francis dunefields is the formation of pans, often 1-2 m deep, in the interdune areas during high rainfall events. Annual rainfall varies from 700 mm/yr to 900 mm/yr. High rainfall events (typically 50 – 100 mm) are common in winter, but do occur through the year, as rainfall can be very variable and major floods can occur at any time of the year.

The eastern third quarter of the dunefield is drained by the Sand River, which flows episodically during periods of high rainfall; floods transport appreciable volumes of sand to the Kromme estuary.

The larger Oyster Bay dunefield (also locally referred to as the Sand River dunefield) originates from the beach at Slangbaai (also known as Oyster Bay), and spans the Cape St. Francis headland over a maximum distance of 18 km when fully active. Perusal of the aerial photographs shows that the leading nose (eastern end) of the dunefield was about to reach the shore of St. Francis Bay in 1961. The Oyster Bay dunefield is currently active over a length of about 14 km as both ends of the dunefield have been artificially stabilised. Dunefield width varies from about 500 m to 1200 m. Transverse dune height varies from 40 m in the western end of the dunefield to 5 m at the eastern end (Figures 2.15). The smaller Thysbaai dunefield, south of the Oyster Bay dunefield, originates from the Thysbaai beach. It has a maximum length of about 6 km and a maximum width of 1000 m. Average transverse dune height within this dunefield is about 11 m.

Since 1942 the dunefield has become progressively more vegetated, both within the dunefield and along the northern margin (Figures 2.12, 2.13, 2.14). This is caused mostly by various invasive alien *Acacia* species, predominantly Rooikrans.

In line with their policy at the time to stabilise and reclaim areas of drifting sands, the Department of Forestry attempted to cut off the sand supply from the Slangbaai beach to the Oyster Bay dunefield between 1917 and 1924 (Keet, 1936). This project was considered only partially successful, but study of the 1942 aerial photographs shows that the Oyster Bay dunefield had effectively been cut off from its source supply by then, particularly the northern section of the dunefield.

There were a few holiday cottages at St. Francis Bay before 1960. Major growth of the village started with the development of the marina in the early 1960’s. The foredunes behind the beach of St Francis Bay and the downwind nose of the Oyster Bay dunefield were stabilised by 1964. A third dunefield, the Santareme dunefield, which occurred along the eastern seaboard of the headland, was completely stabilised during the 1970's and 80's to enable the development of the southern part of St. Francis Bay village and Santareme. This has led to considerable beach erosion along the St. Francis Bay beach. A small headland-bypass system, about 200 m wide and 700 – 800 m long, still crosses the eastern-most cape (Cape St. Francis).

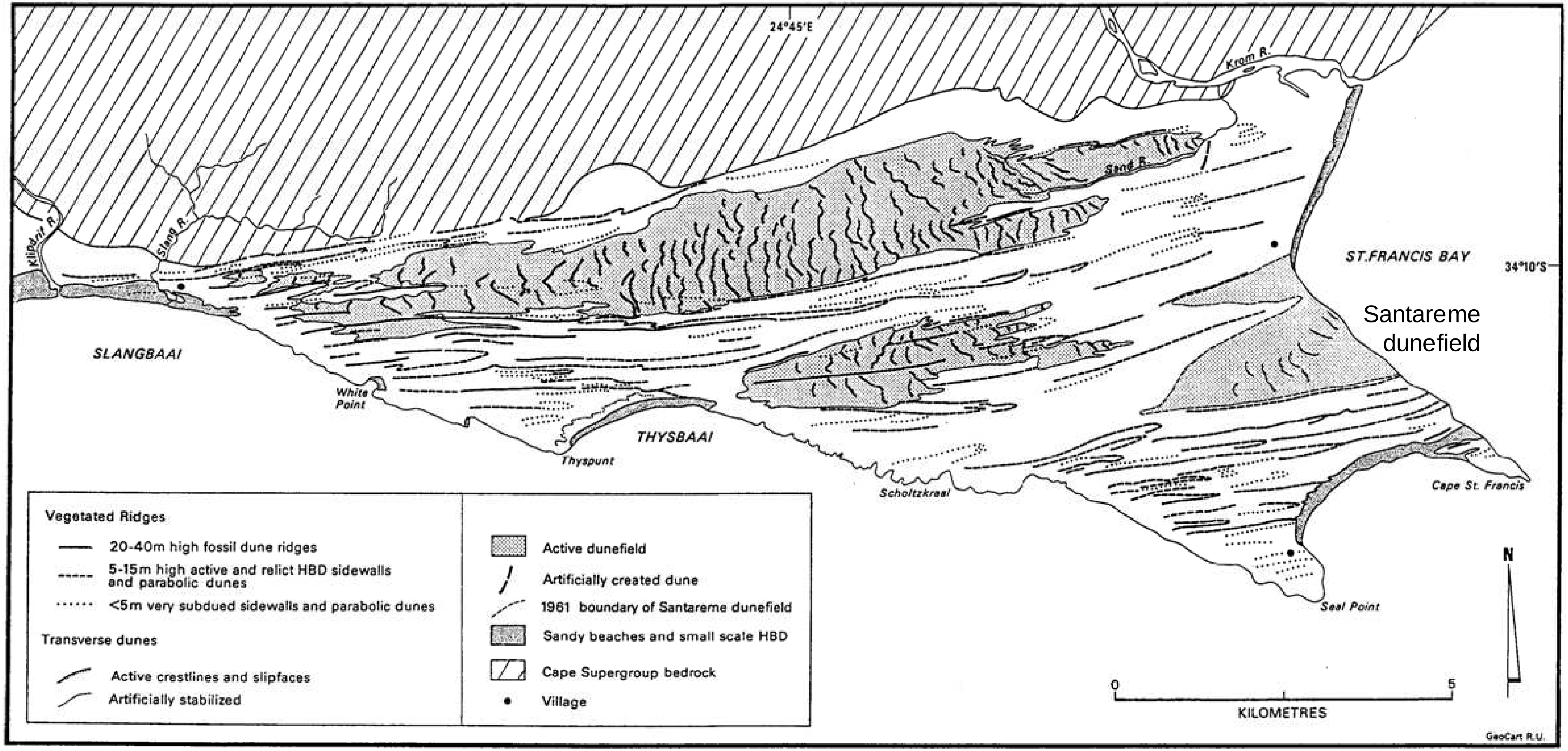


Figure 2.10. Geomorphologic map of dunefields on the Cape St Francis headland, based on the1985 aerial photographs. The Santareme dunefield is mapped as it was in 1961. The northern margin of the dune sands is from geological maps (Council for Geoscience, 2008). From Burkinshaw (1998).

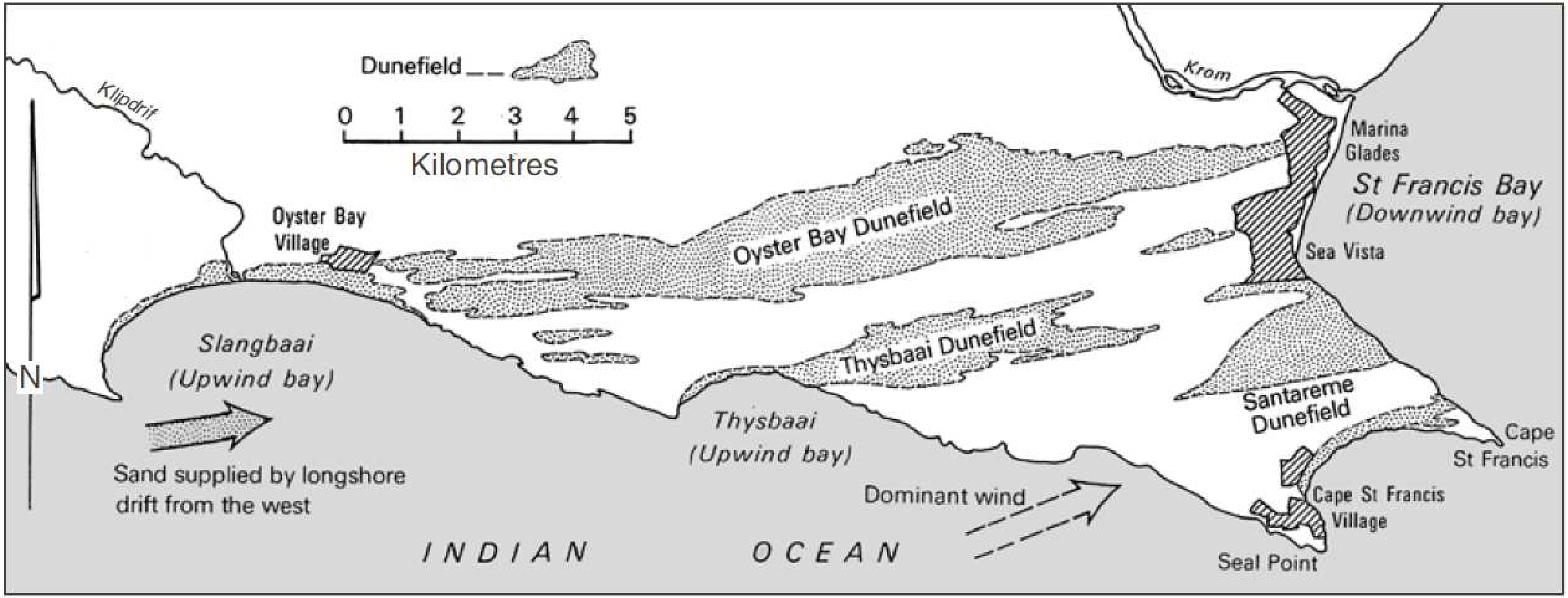


Figure 2.11. Headland-bypass dunefields in the Cape St Francis area, mapped from 1961 aerial photographs Note the direction of longshore drift and of the dominant wind. Sand moves from west to east through the dunefields. From Illenberger & Burkinshaw (2008). Dunefield names as used by Burkinshaw (1998).

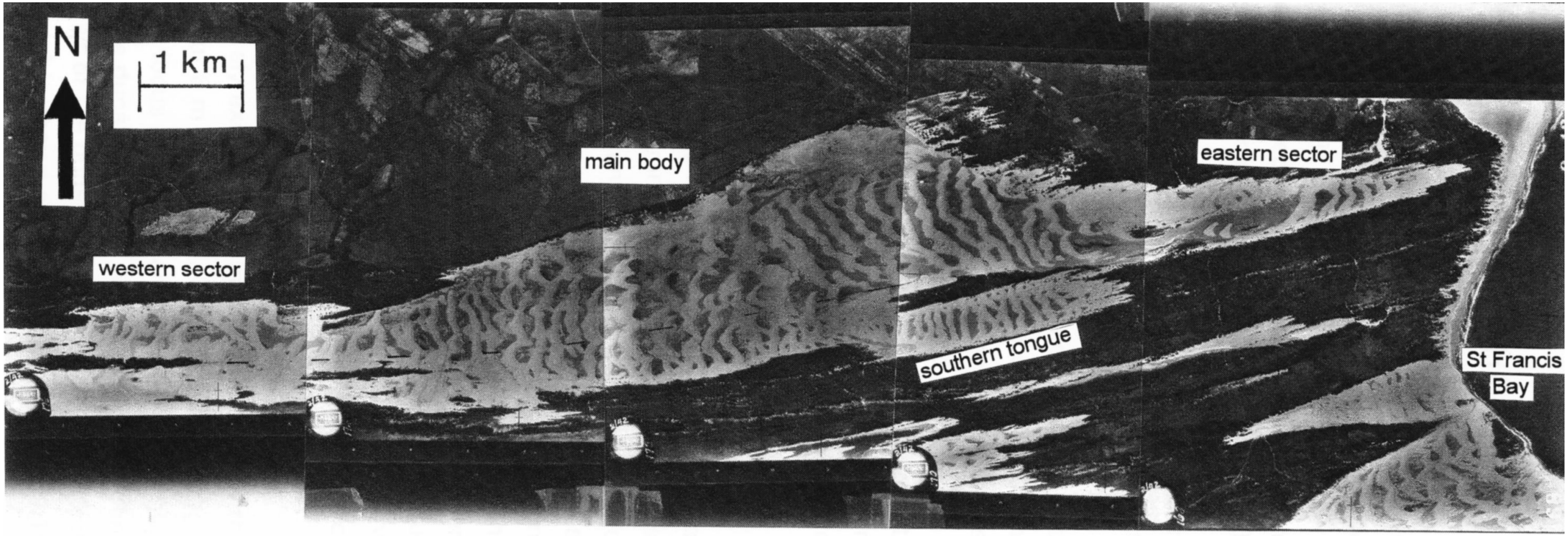


Figure 2.12. Detailed terminology for the Oyster Bay dunefield, mapped from 1942 aerial photographs, using terminology from Burkinshaw (1998). The extent of unvegetated dunes, before artificial vegetating with Rooikrans, can be seen by comparison with the 1985 aerial photographs (Figure 2.14).

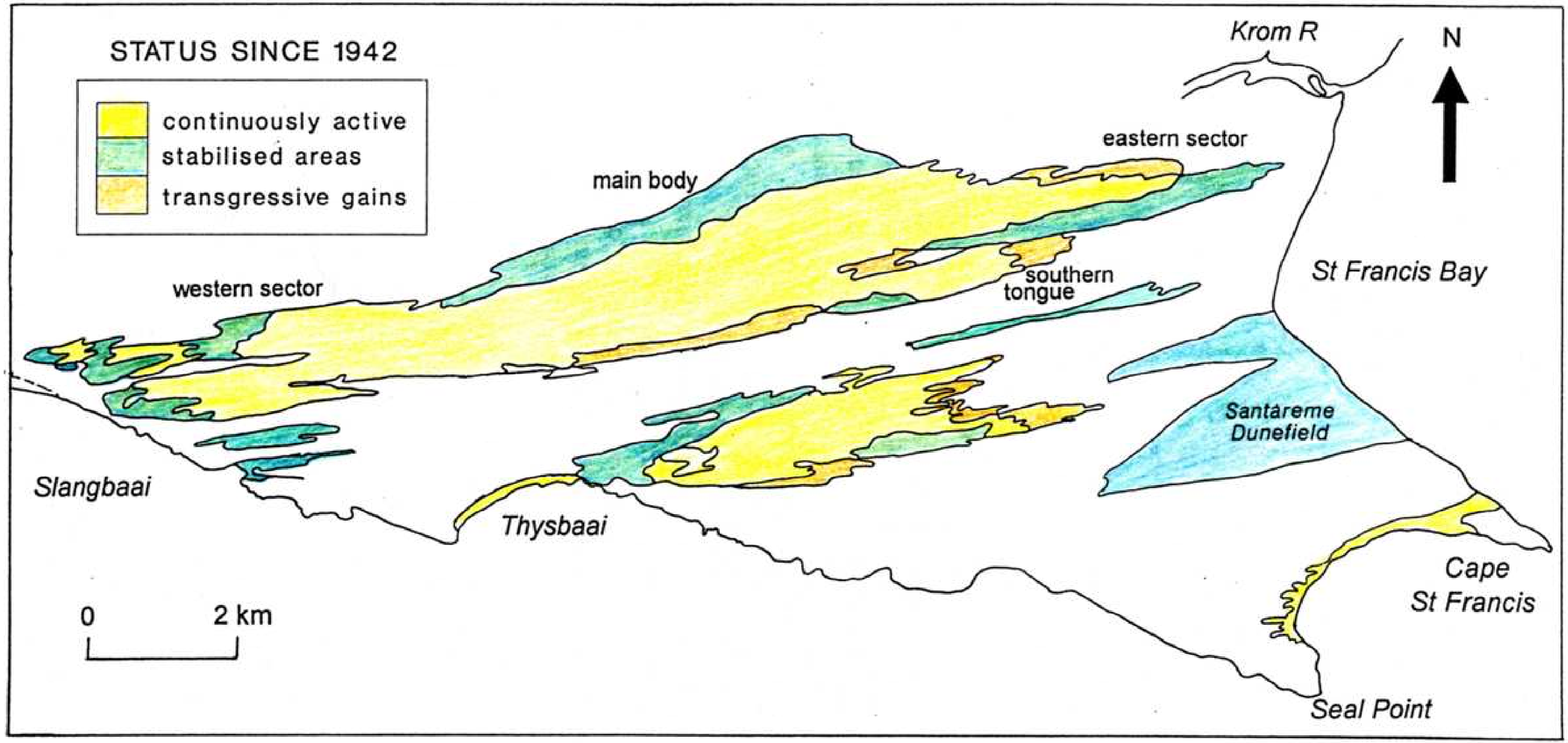


Figure 2.13. Headland-bypass dunefields in the Cape St Francis area, showing the change in the margins of the dunefields between 1942 and 1985 (see Figures 2.12 & 2.14). Since 1942 the dunefield has become progressively more vegetated, both within the dunefield in the pan areas, and along the northern margin mostly by various invasive alien Acacia species, dominantly Rooikrans. Note the areas where the dunefields have transgressed over previously vegetated areas due to the natural advance of the dunefields. The belt of dunes along the western Thysbaai beach is a primary dune ridge, mostly vegetated, with some small parabolic dunes. Most of the area south of the Oyster Bay dunefield is covered in vegetated parabolic dunes and hairpin parabolic dunes, with some long ridges that are sidewalls of previously mobile dunefields. From Burkinshaw (1998).

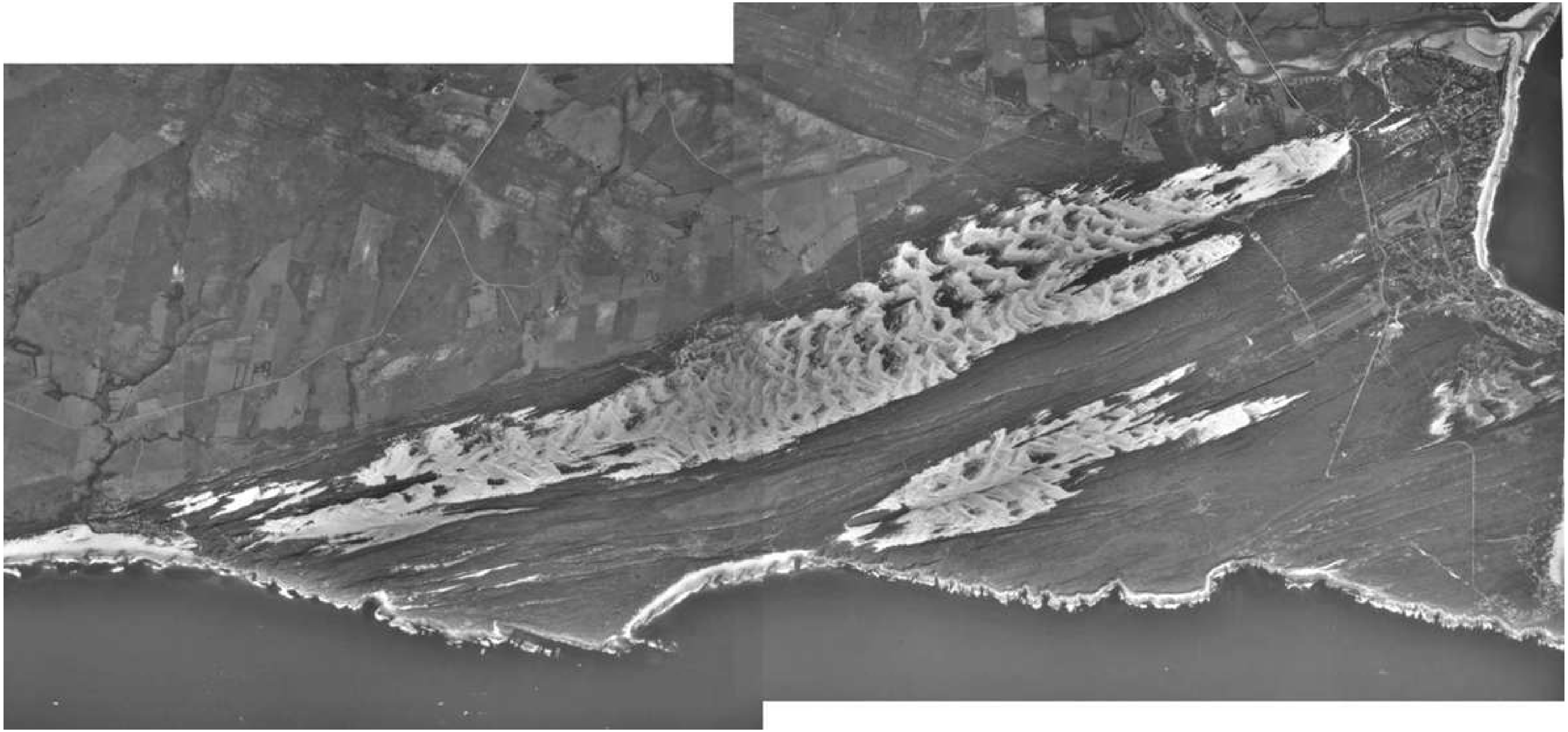


Figure 2.14. Overall view of headland-bypass dunefields at Cape St Francis in 1985. Comparison with Figure 2.12 shows the changes in the margins of the dunefields between 1942 and 1985. Figure 2.13 depicts these changes. Since 1942 the dunefield has become progressively more vegetated, both within the dunefield in the pan areas, and along the northern margin mostly by various invasive alien Acacia species, dominantly Rooikrans. Note the areas where the dunefields have transgressed over previously vegetated areas due to the natural advance of the dunefields. From Burkinshaw (1998).

Figure 2.15. Transverse dune within the main body of the Oyster Bay dunefield

Humans have directly impacted on the natural functioning of the dunefield in the past century. Both dunefields have been cut off from their respective source beaches, and will slowly be stabilised by natural re-vegetation processes over the next 1000 years or so (Burkinshaw, 1998).

2.3.1 Nature and rate of dune movement in the mobile Oyster Bay dunefield

Dune height varies along the length of the dunefield. Dunes are on average 20 m high in the west, and gradually become smaller towards the east, where the average height is 5 m. ***Because the volume of sand moving is approximately constant, a larger dune moves slower, and conversely a smaller dune moves faster.***

According to aerial photos of the past 50 years, dunes and the leading tongues of dunefields move eastwards at rates of 10 to 30 m/yr (Burkinshaw, 1998). Thus it would take 1000-1300 years for a dune to cross the headland.

The average volume or rate of sand movement is 30 m^3/m width/year (Burkinshaw, 1998). This rate is not constant: when there is no dune passing a particular point, the rate of sand movement is zero, and when a dune is passing a particular point, the rate will increase to typically 4-5 times the average rate.

2.3.2 Vegetated dunefield between the Oyster Bay dunefield and the sea

This dunefield consists mostly of parabolic dunes and hairpin parabolic dunes up to 25 m high. Sidewalls of previously mobile dunefields form long ridges in some areas, up to 15 m high. Similarly, the arms of the parabolic dunes and sidewalls of the previously mobile dunefields form steep ridges (Figures 2.16, 2.17, 2.18). The ridges are all oriented parallel to the dominant wind, roughly east-west. Older dune ridges may become lightly cemented to form “dune rock”. The dunefield is well-vegetated with South Coast Dune Fynbos and Dune Forest (Low, 2008). Some of the parabolic dunes were active in 1942 (Figure 2.12), but these are now mostly vegetated by Rooikrans.

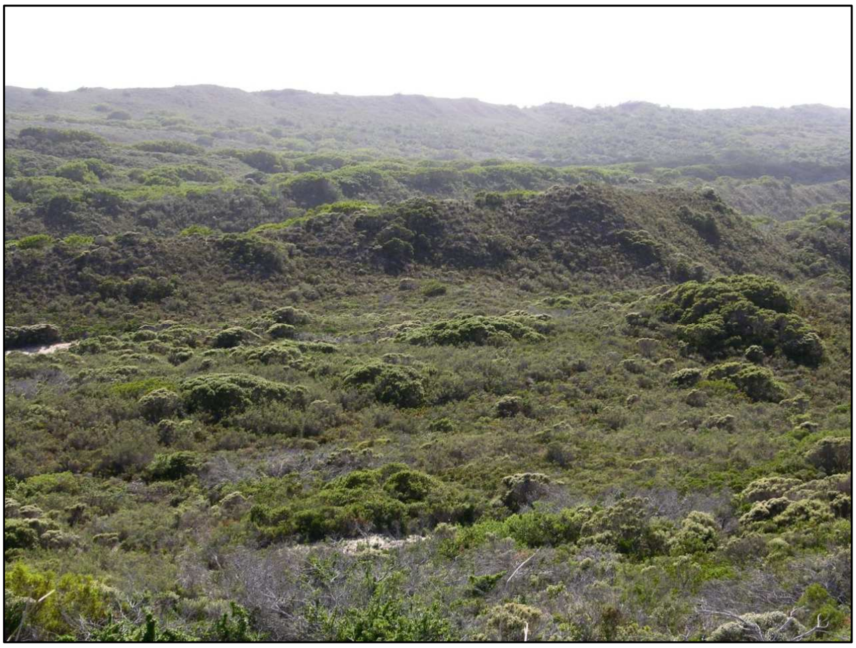


Figure 2.16. Steep ridges formed by arms of parabolic dunes (middle foreground) and sidewalls of previously mobile dunefields (skyline ridge).

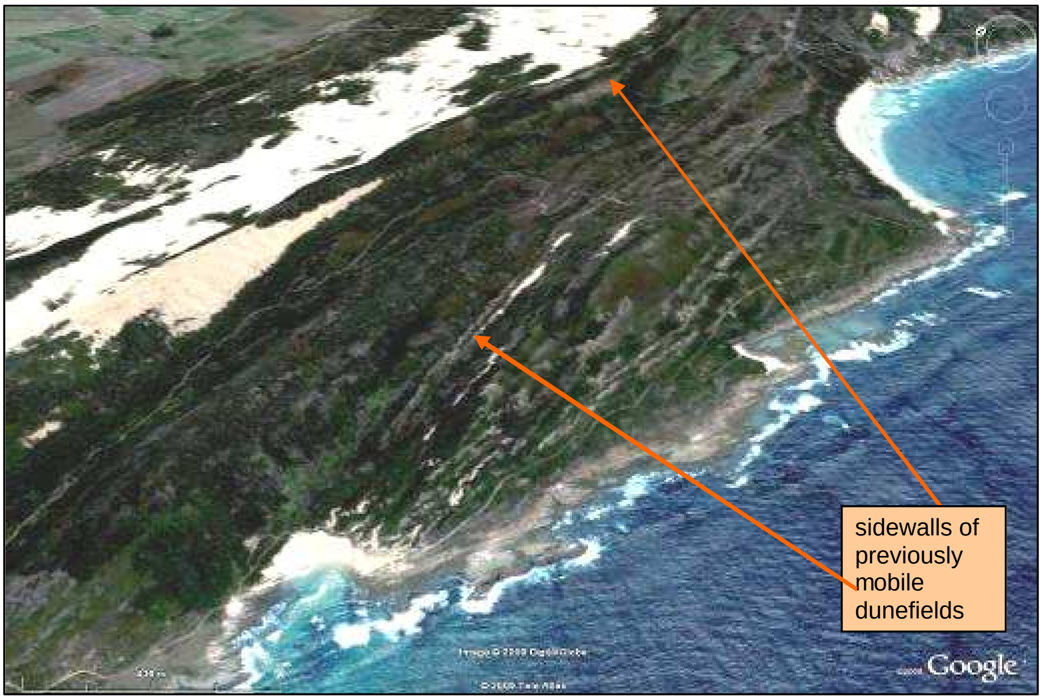


Figure 2.17. Steep ridges formed by arms of parabolic dunes and sidewalls of previously mobile dunefields. Oblique view looking north-east. Image from GoogleEarth.

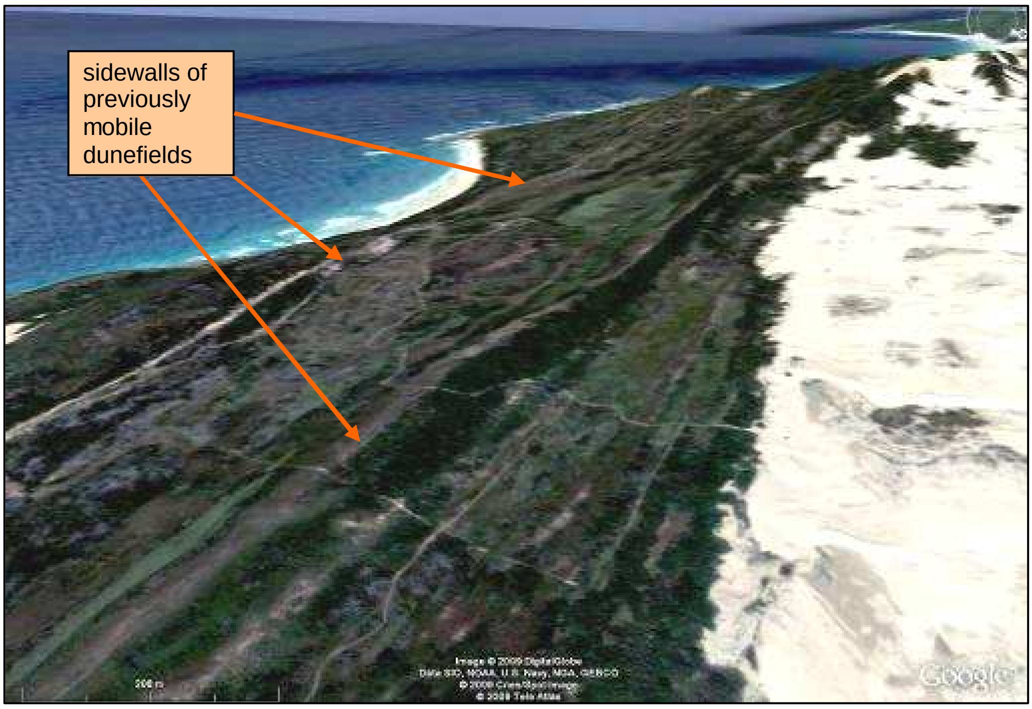


Figure 2.18. Steep ridges formed by arms of parabolic dunes and sidewalls of previously mobile dunefields (e.g. large ridge running through centre of image). Oblique view looking south-west. Image from GoogleEarth.

In some places, where previously mobile dunefields have been vegetated naturally, dune sand of these dunefields has been completely blown out to expose the erosional base level over which the dunefields move. The erosional base level usually is a smooth surface, by which it is identified on topographic maps. The surface represents the hard-rock erosional base level, with a thin veneer of fossil soils and calcrete in places. The surface is smooth because it was formed by wave erosion over millions of years, (e.g. Illenberger, 1994; Council for Geoscience, 2008). Wetlands and small fountains such as Langefonteinvlei are probably situated on or close to this surface, because the substrate is an aquitard, and the overlying dune sand is an aquifer that is mostly saturated in this area.

Earlier (pre-Holocene) dunefield activity at Cape St. Francis is manifested by sets of east-west trending hairpin parabolic dunes and remnant lateral margins of previous corridor dunefields 10-15 m high; in addition, 20 - 40 m high fossil dune ridges are associated with the sand-supply ends of both the Thysbaai and Oyster Bay dunefields.

Luminescence dating of sand samples from the Oyster Bay dune ridges confirm dune activity associated with the Late Pleistocene interglacials, 105 000 and 225 000 years ago. Sands cemented by iron oxides that are found on the flanks of the fossil ridges were dated to 225 000 years ago (Oyster Bay dunefield) and 490 000 years ago (Thysbaai dunefield) (Illenberger, Burkinshaw, Rust & Vogel, 1997; Woodborne & Collett, 1999). The headland dune system hosts Late Stone Age middens and Middle Stone Age artefacts that date to 20 000-125 000 years ago (Binneman, 1999). Early Stone Age artefacts that date to 125 000 – 2 000 000 years ago have been found on the high central fossil dune ridge in the Thysbaai dunefield (Binneman, 1999). These archaeological ages support the luminescence dates.

2.3.3 Surface drainage of the Oyster Bay dunefield

Within the main body of the Oyster Bay dunefield, the interdune surface slopes westward at 1:135 in the western sector, and slopes eastward at 1:85 in the eastern sector. The level central portion extends for about 1 km (Figure 2.19). In addition, the interdune surface usually has a slight southward slope. As discussed above, the interdune surface usually is smooth because it mimics the hard-rock erosional base level, formed by wave erosion over millions of years.

One third of the Oyster Bay dunefield (the eastern sector) is drained by the fairly permanent Sand River (Figure 2.20). The headwaters of the river are in farmland to the north of the dunefield. The steeper slope of the eastern sector helps the Sand River keep its channel open because river flow is fast, and hence has strong erosional power. The smaller dunes in the eastern sector will also make it easy for the river to keep its channel open, as less dune sand needs to be eroded and carried downstream by the river. The river eventually discharges into the Kromme Estuary. Surface flow only occurs after high rainfall events; the river responds rapidly to such rainfall events. The river may continue to flow for some months during rainy periods. The dynamics of the dunefield are thus somewhat different in the eastern sector of the dunefield, as compared with the western sector (see below).

No surface flow takes place in the central portion of the dunefield (Figure 2.20); discrete interdune ponds are found here during rainy periods.

Figure 2.19. Slopes of the interdune surfaces in the Oyster Bay dunefield. The slope is steeper in the eastern sector of the dunefield. Base photo is the Google image of 2004.

There is only one fairly permanent river channel in the westward sloping portion of the dunefield (Figure 2.20). This is a short channel of the Penny Sands River (name introduced in this report; Figure 2.20), which soaks away in the high dunes in this area (Figure 2.21). In wetland terminology this is a "channelled valley bottom wetland" (Day, 2009). The other short channels shown in the westward sloping portion of the dunefield (Figure 2.20) only exist for short periods of time when there have been high rainfall events. The dynamics of the dunefield are thus somewhat different in the eastern sector of the dunefield, as compared with the western sector (see below).

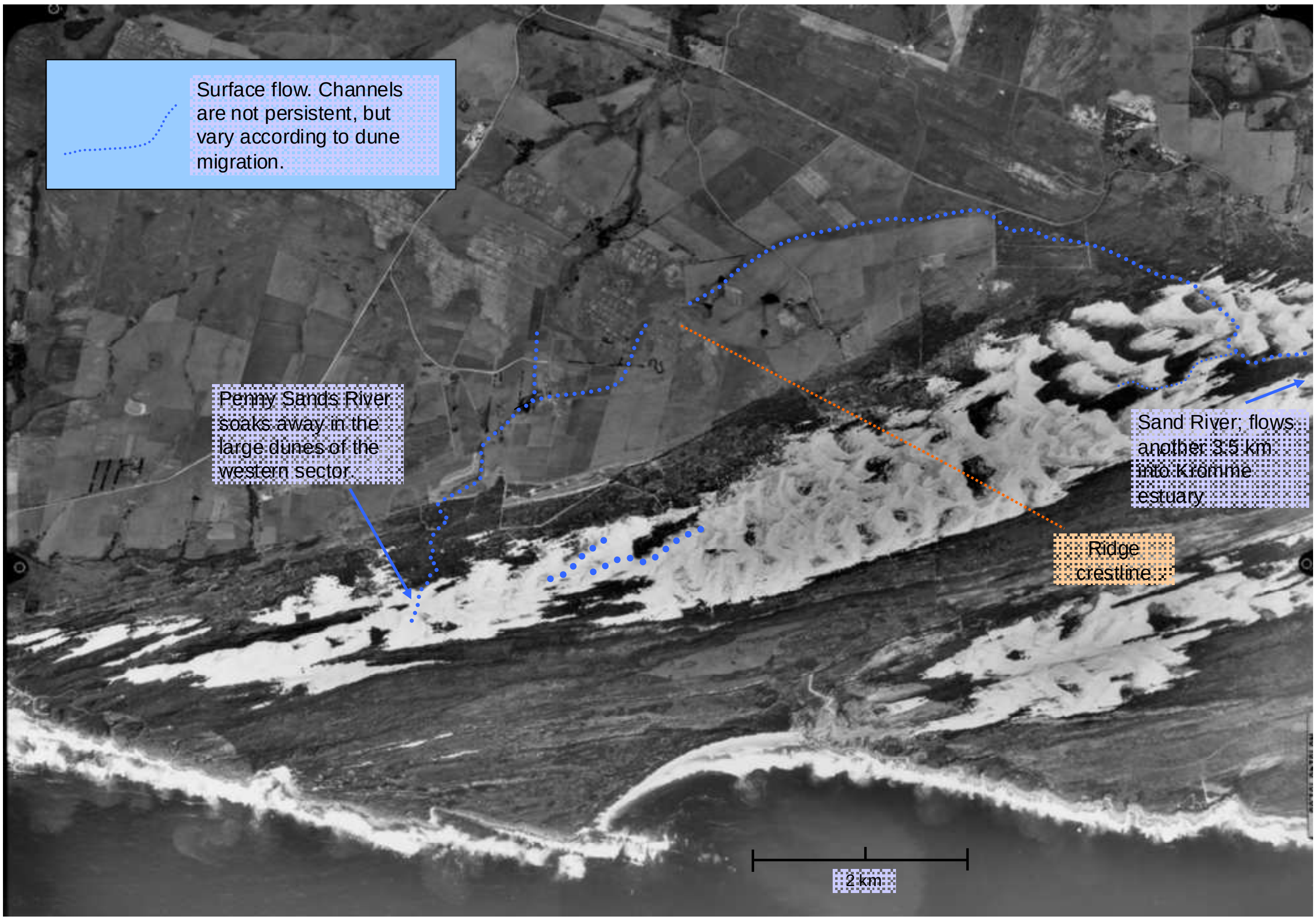


Figure 2.20. Surface flow in the Oyster Bay dunefield. Only the main drainage channels of the Sand River and Penny Sands River are shown in the farmlands. Base photo 5 Sept 2000.

2.3.4 Groundwater at the Thyspunt site

An understanding of aspects of interdune ponds, groundwater movement and behaviour within mobile dunes and in the vegetated dunes is required to assess dune dynamics as well as possible impacts of constructing access roads and transmission line pylons.

Figure 2.21. Short channel of the Penny Sands River that soaks away in high dunes of the western sector of the Oyster Bay dunefield. In wetland terminology, this is a "channelled valley bottom wetland" but in its lower reaches it is associated with broad wetland flats and wetland depressions, which are fed by a combination of surface overflow and groundwater (Day, 2008).

The summary of groundwater characteristics at the Thyspunt site from SRK (2009: 90-91) is quoted verbatim:

"*The superficial deposits of the Algoa Group*[1] *are classified as a primary or intergranular aquifer. Groundwater flow and storage takes place within the original pore spaces between constituent grains. The upper boundary of the aquifer is the water table and this aquifer is therefore unconfined. For the purpose of this study the primary aquifer is called the Algoa Aquifer.*

The following regional information pertains to the intergranular aquifer within the Nanaga and Alexandria Formations (Algoa Group):

- *Groundwater mainly occurs in the basal Alexandria conglomerate which shows variable thickness and is discontinuous; The Nanaga aeolianite dominates the Algoa sediments in the Thyspunt area but the Alexandria conglomerate has been identified as underlying the aeolianite across the eastern and southern parts of the Site;*
- *Water seeps rapidly through the highly porous, fine sandy and calcareous material to the base of the intergranular aquifer, where rapid flow occurs in the basal conglomerate and along the contact with the underlying TMG*[2] *rocks. The groundwater flows out as seeps or commonly occurring springs at sea-level and from within the dune fields;*
- *Build-up of groundwater seldom occurs because of the high hydraulic conductivity of these formations;*
- *Groundwater flow direction is to the south / east with discharge along the beaches and rocky outcrop into the ocean, and to the south-east into the*

[1] The Algoa Group includes the dune sand of the Oyster Bay dunefield and the vegetated dune ridges between the Oyster Bay dunefield and the sea.
[2] Quartzites of the Table Mountain Group.

Sand River aquifer. Local groundwater flow also occurs in westerly and eastern directions, possibly along channels between the dunes and then enters streams or rivers with subsequent southerly flow towards the ocean;

- *Borehole yields from the Algoa Group are typically <0.5 L/s and groundwater levels at 10 - 20 mamsl. However, yields from the basal conglomerate can be in the order of 10 - 15 L/s;*
- *A high yielding significant intergranular aquifer occurs to the east of Thyspunt at Mostert's Hoek and St Francis Bay where a spring occur with an artesian yield of 8 L/s.*

Due to the rapid flow of groundwater through the Algoa Group sediments, the proximity to the coast and relative impermeability of the fractured rock aquifer, limited interconnection between the intergranular aquifer and fractured rock aquifer is envisioned in the Thyspunt area.

The following regional information pertains to the fractured rock aquifer, mainly within the TMG rocks (Meyer et al., 1998 and Vegter, 1995). The Bokkeveld rocks can be classed as an aquiclude in the general site area:

- *A network of joints and fractures control the infiltration, recharge, storage and movement of groundwater in the competent but often brittle TMG, with deep fracture extensions providing deep groundwater circulation (Vegter, 1995);*
- *A network of joints and fractures control the infiltration, recharge, storage and movement of groundwater in the competent but often brittle TMG, with deep fracture extensions providing deep groundwater circulation;*
- *The average depth to groundwater within the fractured rock aquifer is ~30 - 50 m below ground surface;*
- *Average sustainable borehole yields range from 0.5 to 2 L/s, but yields of >5 L/s have been obtained from discrete fractures;*
- *Springs are common in the TMG and are fault or lithologically controlled by impeding layers such as the Cedarberg Formation shale;*
- *Recharge to the fractured rock aquifer occurs in relatively high rainfall areas located at high elevations and an average of ~15 % infiltration of precipitation occurs, but higher recharge rates are possible;*
- *The fractured rock aquifers are classified as minor aquifers of moderate vulnerability;*
- *Groundwater flow directions are predominantly to the south and east with flow from higher elevation discharging into the ocean; and*
- *Groundwater flow from higher elevations around the Krom River occurs towards the river, then south-east towards the ocean*."

Figure 2.22 shows groundwater flow directions at the Thyspunt site; the directions in the northern part of the map are not accurate and will be revised (SRK, 2009).

2.3.5 Interdune ponds and groundwater of the Oyster Bay dunefield

Various specialist reports have covered groundwater from different perspectives (SRK, 2009; Day, 2009). Additional investigations as needed to cover specific issues relating to dunefields are presented here.

The interdune ponds are referred to as wetland variety "Wetland depressions within the mobile dunefields – these wetlands are also referred to as duneslack wetlands" in Day (2009).

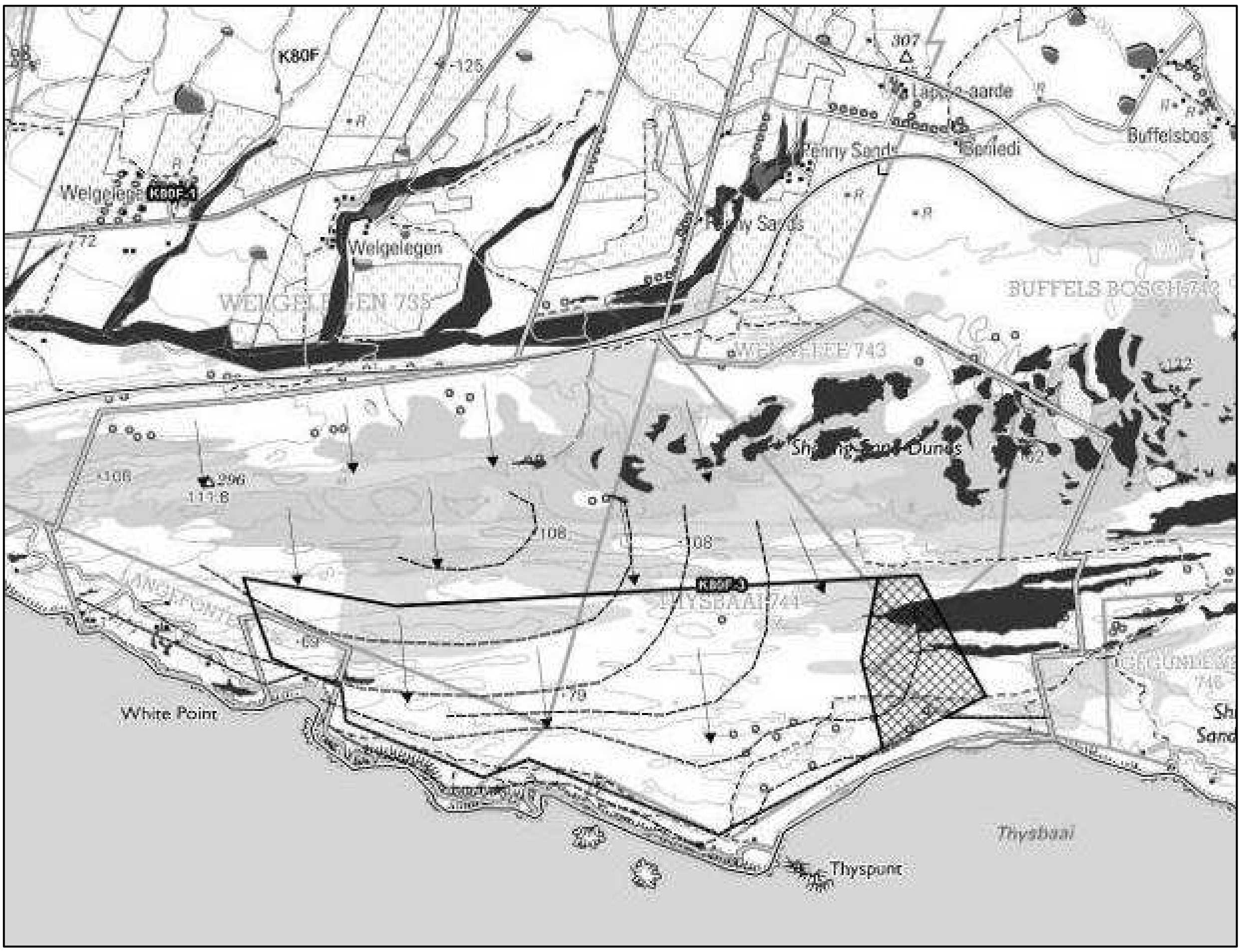


Figure 2.22. Groundwater flow directions at the Thyspunt site; from SRK (2009). The flow directions in the northern part of the map are not accurate. (SRK, 2009).

Muddy material is on occasion carried by surface flow, presumably during very wet periods, and deposited on the shoreline and floor of interdune ponds (Figure 2.23). The muddy material is mostly derived from fossil soil horizons in the substrate beneath the dunes and dried out algae in the floors of the ponds.

The interdune ponds (Figure 2.24) in the westward and eastward sloping portions of the Oyster Bay dunefield are mostly not vegetated, and migrate with the moving dunes. These interdune ponds dry out quickly during periods of low rainfall. In wetland terminology, these are “hydroperiod duneslack depressions”.

Some of the interdune ponds, in particular in the central, level portion of the Oyster Bay dunefield, do not move with the dunes, but instead are fixed. The dunes move through the ponds, so the ponds are periodically filled with dune sand. This was ascertained from inspection of aerial photos of different dates. It is surmised that these ponds are located in shallow hollows in the bedrock of the interdune surface. Wetland plants such as bullrushes, reeds and other wetland biota are abundant in these ponds. They are labelled “duneslack wetland depressions” in wetland terminology.

Figure 2.23. Mud layer that was deposited in an interdune pond, now being eroded by wind.

Figure 2.24. Interdune pond in eastern sector of Oyster Bay dunefield. Photographed 16 days after the August 2006 flood. The mud deposit along the far shore shows the maximum water level during the flood.

These interdune ponds regularly dry out during periods of low rainfall. One of these interdune ponds, about 500 m west of the interdune pond labelled DS3A in the wetlands specialist report (Day, 2009, Figures 4 & 5), shows water depth variation from 0 m (dry) to 2 m, from observations between December 2007 to May 2009 (Figure 2.25). Burkinshaw (1998) observed similar degrees of variation.

Figure 2.25. Interdune pond in March 2008 (left) when water depth was about 1 m, and May 2009 (right; photograph by R H Gathercole) when the pond was dry. Water depth of up to 2 m has been observed in this pond (R H Gathercole, pers. comm.).This interdune pond is a “duneslack wetland depression” in wetland terminology. It is about 500 m west of the interdune pond labelled DS3A in Day (2009).

The water in interdune ponds mostly has a blue-greenish colour (e.g. Figures 2.24 & 2.26). This colour is probably due to suspended clays in the water.

In a few interdune ponds the water is brown. This is mostly due to organic-rich wetlands to the north of the Oyster Bay dunefield (called “valley bottom wetlands in agricultural areas north of the Sand River dunes” in Day, 2009, page 50) that discharges into the dunefield during wet periods. Burkinshaw (1998, Figure 3.5a) shows this occurring at Penny Sands River. It also was observed in ponds in this area in September 2007, as can be seen on aerial photographs (Figure 2.27).

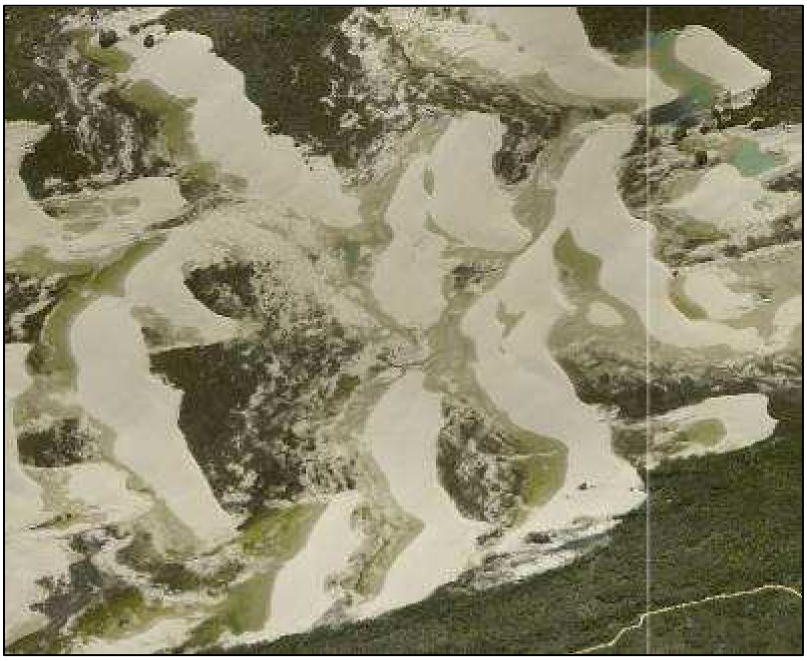


Figure 2.26. Blue-green to green water in interdune ponds in the main body of the Oyster Bay dunefield. Photographed on 1 September 2007. Source: Aerial photographs supplied by ESKOM.

Figure 2.27. Brown water in interdune ponds (lower left) near Penny Sands River (that flows approximately from top right to lower left). Photographed on 1 September 2007. Source: Aerial photographs supplied by ESKOM.

The interdune ponds are mostly filled with groundwater from the primary aquifer. Flow of groundwater in the primary aquifer within the Oyster Bay dunefield will be slow in most areas as the primary aquifer within the Oyster Bay dunefield consists of fine sands that have medium to low permeability. The flow will be downslope along the contact with the Table Mountain Group quartzites, i.e. eastward in the eastern portion with a northward component, and westward in the western portion with a southward component. The southward component exits the Oyster Bay dunefield along the contact with the Table Mountain Group quartzites, and continues downslope along the base of the vegetated dunefield south of the Oyster Bay dunefield, eventually reaching the sea.

There has been speculation that groundwater from the secondary aquifer (the Table Mountain Group quartzites) flows upwards during wet periods to augment the groundwater in the primary aquifer (the dune sands) and contribute to surface flow in the Sand River. Considering the rapid response of interdune ponds and surface flow in the Sand River to rainfall events, any contribution from groundwater in the secondary aquifer is probably small. Modelling of groundwater flow predicts slight upward and downward flow between the primary and secondary aquifers (SRK, 2009).

2.3.6 Groundwater in the vegetated dunefield between the Oyster Bay dunefield and the sea

In areas where the dune sand is thick, such as in the vegetated dunefield between the Oyster Bay dunefield and the sea, groundwater does not reach the surface (SRK, 2009). The dune sand and lightly cemented dune rock is porous. It thus allows free passage of groundwater, both downward to the contact between the dunefield and the Table Mountain Group, and along the contact in a down-slope direction, i.e. southward (SRK, 2009).

The groundwater flow reaches the surface ("daylights") to form wetlands in areas where the dune sand has been completely blown out to expose the erosional base level over which the dunefields have moved. The erosional base level is possibly the bedrock surface of the Table Mountain Group. Langefonteinvlei is an example of such a wetland. Surface flow is directed southwestward, until it reaches the east-west trending dune ridges, where water flow goes underground. Langefonteinvlei is a "hillslope seep wetland" (Day, 2009). Fines accumulating against the east-west trending dune ridges may create a perched groundwater table along this southern margin.

3 DESCRIPTION OF KEY ACTIVITIES ASSOCIATED WITH THE PROPOSED DEVELOPMENT

This EIA report considers the implications for the mobile and vegetated dunefields of the development of a NPS (capable of generating up to 4000MW) and auxiliary buildings, along with some of the site-specific developments that would be associated with its construction or operational phases, such as access roads, HV yard and disposal of spoils from excavation.

The construction of the 4000MW NPS is considered Phase 1 of Eskom's overall nuclear programme. Up to three phases of NPS development have been proposed to date, so the figures presented in this report show the layout of the proposed NPS sites indicating all three phases. This assessment considers the maximum carrying capacity of the proposed site as depicted in the layouts provided, as well as the impact of constructing the proposed 4000MW plant of Phase 1 on each of the sites.

3.1 Layout of NPS sites

Figures 3.1-3.3 show the proposed layout for the development of all three phases of the NPS sites. Aspects of the development relevant to dunefields are:

- Overall layout of the NPS and auxiliary buildings; and
- HV yard.

These layouts are from the diagrams supplied by Eskom on 27 May 2009.

3.2 Layout of transmission lines, access roads, topsoil stockpiles and spoils stockpiles

Figures 3.4-3.6 show the proposed layout of access roads and transmission lines. These layouts are from the diagrams supplied by Eskom on 27 May 2009.

Two types of transmission line are being considered:

- Conventional 400 kV transmission lines. The maximum span is limited to 400 m.
- Dual circuit 400 kV transmission lines. The maximum span is limited to 300 m.

The figures also show the expected volumes and footprints for topsoil and spoils (sand and rock) stockpiles from the data supplied by Eskom 19 May 2009. The stockpiles can be located anywhere within the property owned by Eskom. Offshore disposal of spoils is also an option that will however not be discussed in this study as it falls within the ambit of the marine specialist and is not relevant to dunefields.

The expected volumes and heights of topsoil stockpiles and spoils stockpiles are in the table below. All the topsoil stockpiles are temporary and 1 m high. The length of time for the stockpile again is not known and will depend on the final construction methodology, however assume that it will exist for an extended period of time during construction. Construction will be approximately 6 years.

Table 3.1. Volumes and heights of topsoil and spoils stockpiles			
Site	Topsoil stockpile volume (m^3); all are 1 m high	Spoils stockpile volume (m^3)	Maximum height of the spoils stockpile (m)
Duynefontein	184 000	8 630 000	30
Bantamsklip	198 000	11 768 000	35
Thyspunt	229 200	7 661 000	25

3.3 Site-specific construction activities at Thyspunt

The type, extent, pristine nature and size of the dunefields at Thyspunt, which include a mobile dunefield, and the abundance of subsurface water, have led to the formulation by the Eskom engineers of a modified approach to construction of the NPS at this site, as outlined below. The site is also environmentally more complex than the other sites.

3.3.1 Access roads

Three access roads to the Thyspunt site have been proposed for assessment. The initially proposed access road from the east was developed during an iterative process with the botanical, heritage and wetland specialists. This road would be used for heavy vehicles. Subsequently a northern as well as a western light-vehicle access roads have been proposed, as two access roads are required for safety purposes. Figure 3.6 shows the layouts. According to Eskom document 'Main road access to sites' Civil 0001 revision A-2008-05-09,' the road reserve is 30 m, made up as two lanes of 3.7m and shoulders of 2.5 m; the balance is 8.8 m reserve on each side. The total hard surface width will thus be 12.4 m.

3.3.2 Linkage of transmission lines from the NPS to the proposed HV yard – Thyspunt Site

The proposed location of the Thyspunt HV yard is approximately 3 km north of the NPS site, and separated from the NPS site by the vegetated dunefield and the mobile headland-bypass dunefield. The mobile dunefield is about 800 m wide here. The following approaches to crossing the mobile headland-bypass dunefield have been proposed:

- Crossing of the dunefield using conventional 400 kV transmission lines. The maximum span is limited to 400 m. This implies that only one row of towers needs be located in the mobile dunefield. The towers are typically 40 m high. Four lines would be needed.

- Crossing of the dunefield using dual circuit 400 kV transmission lines. The maximum span is limited to 300 m. This implies that two rows of towers will need to be located in the mobile dunefield. These towers are typically 50 m high. Two lines would be needed.

- The use of specially designed transmission tower structures to span the 800 m width of the mobile dunefield. This option is probably not viable because winds are too strong at Thyspunt.

A single 132kV distribution line is required to supply power for construction and for back-up purposes. 132kV distribution lines have towers typically 40 m high. The span is limited to 400 m.

The total corridor width is 225 m if conventional transmission lines are used: 50 m for the 132kV distribution line and 175 m for the four 400kV transmission lines. These two lines will run in parallel.

The total corridor width is 145 m if dual circuit transmission lines are used: 50 m for the 132kV distribution line and 95 m for the two 400kV transmission lines. These two lines will run in parallel.

The bases of the towers are 24 x 24 m, and foundations at each corner will probably be 3 x 3 m concrete blocks.

Access roads can run under the transmission lines.

3.3.3 Spoils disposal

It is expected that about 7 500 000 m^3 of material will need to be disposed, according to data supplied by Eskom on 19 May 2009. Proposed options are:

- Disposal offshore. Offshore disposal of spoils is an option that will however not be discussed in this assessment as it falls within the ambit of the marine specialist report and is not relevant to dunefields.

- Disposal on Eskom property on:
  - the mobile dunefield;
  - the vegetated dunefield; and
  - the “Panhandle” i.e. the agricultural land on the northern side of the dunefields. This option entails transporting spoils across the vegetated & mobile dunefields.

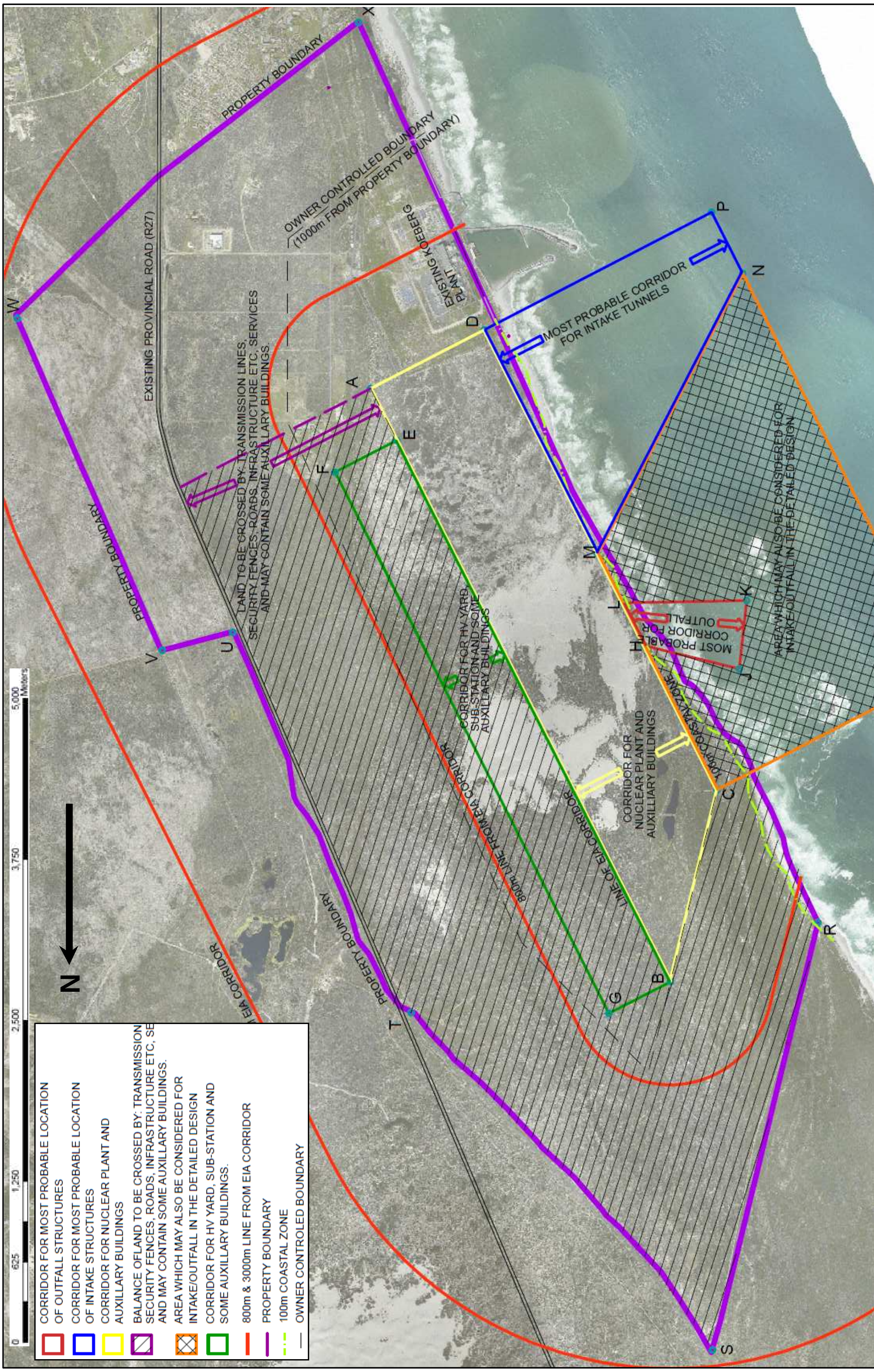


Fig 3.1. Proposed NPS layout at Duynefontein. Source of base map: 96_20007_rev04E_Duynefontein_Extent of Plant_EIA Corridor wi.pdf received 27 May 2009.

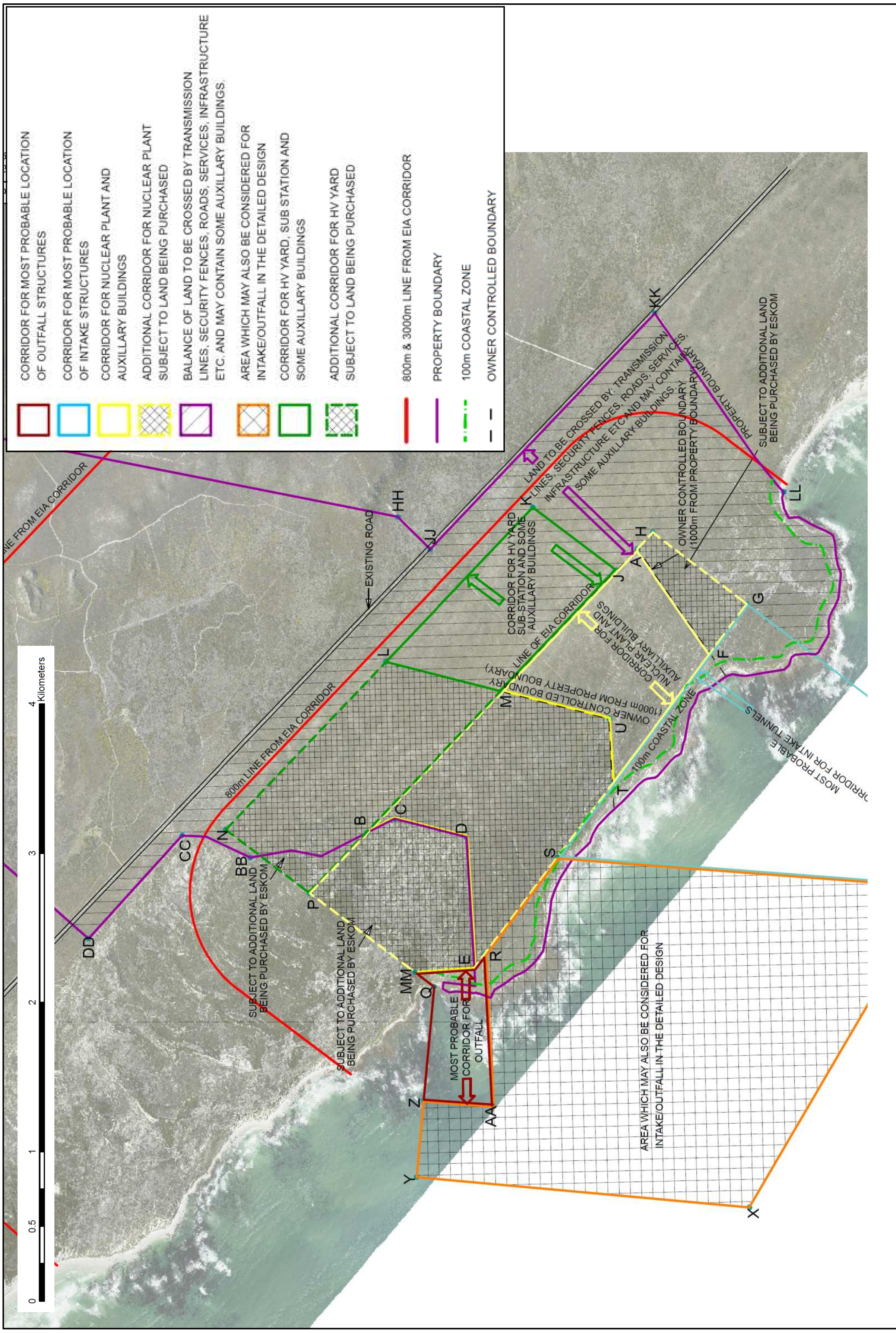
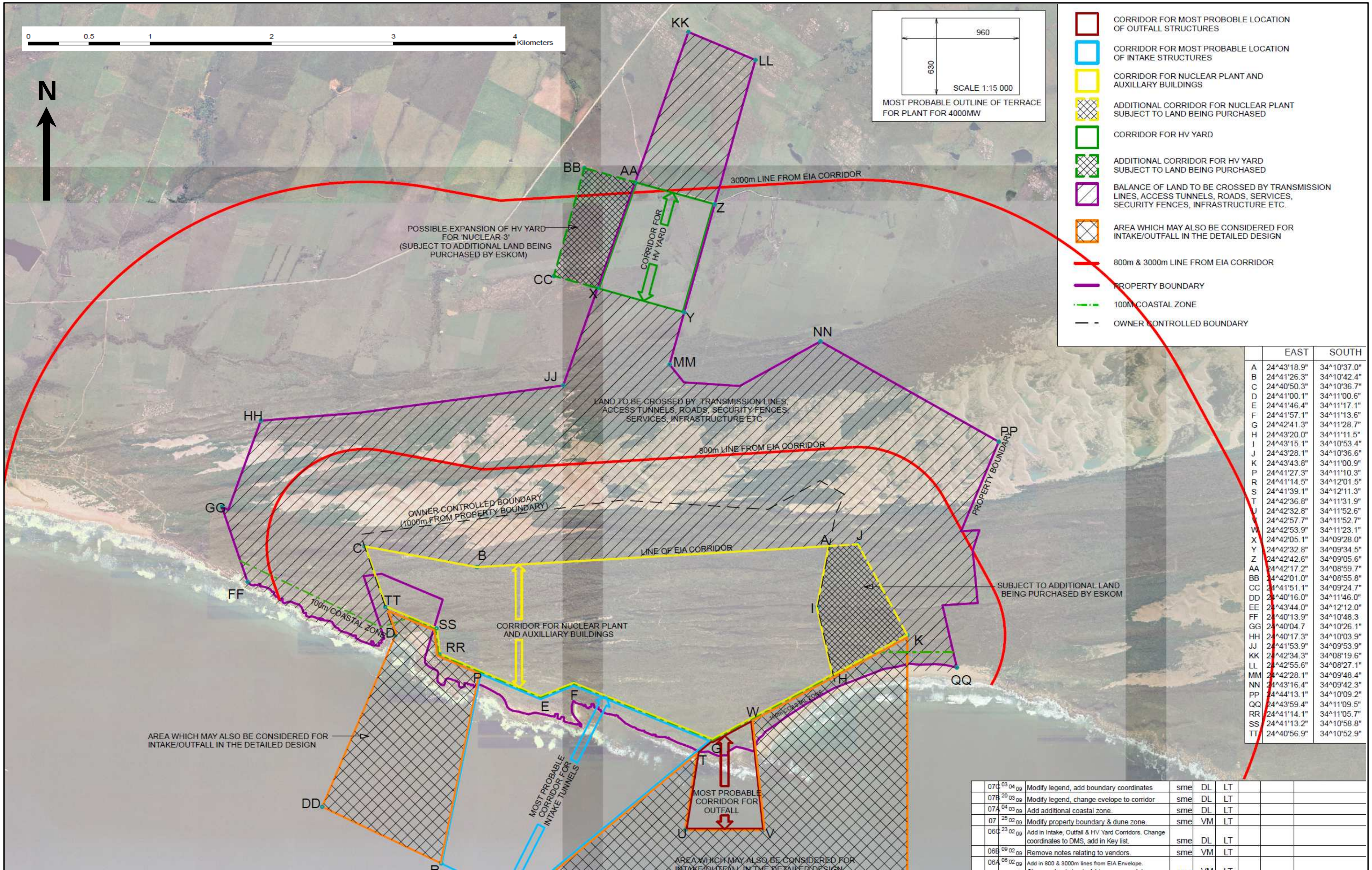


Fig 3.2. Proposed NPS layout at Bantamsklip. Source of base map: 96_10009_rev07F_Bantamsklip_Extent of Plant_EIA Corridor wit.pdf received 27 May 2009



	EAST	SOUTH
A	24^43'18.9"	34^10'37.0"
B	24^41'26.3"	34^10'42.4"
C	24^40'50.3"	34^10'36.7"
D	24^41'00.1"	34^11'00.6"
E	24^41'46.4"	34^11'17.1"
F	24^41'57.1"	34^11'13.6"
G	24^42'41.3"	34^11'28.7"
H	24^43'20.0"	34^11'11.5"
I	24^43'15.1"	34^10'53.4"
J	24^43'28.1"	34^10'36.6"
K	24^43'43.8"	34^11'00.9"
P	24^41'27.3"	34^11'10.3"
R	24^41'14.5"	34^12'01.5"
S	24^41'39.1"	34^12'11.3"
T	24^42'36.8"	34^11'31.9"
U	24^42'32.8"	34^11'52.6"
V	24^42'57.7"	34^11'52.7"
W	24^42'53.9"	34^11'23.1"
X	24^42'05.1"	34^09'28.0"
Y	24^42'32.8"	34^09'34.5"
Z	24^42'42.6"	34^09'05.6"
AA	24^42'17.2"	34^08'59.7"
BB	24^42'01.0"	34^08'55.8"
CC	24^41'51.1"	34^09'24.7"
DD	24^40'16.0"	34^11'46.0"
EE	24^43'44.0"	34^12'12.0"
FF	24^40'13.9"	34^10'48.3
GG	24^40'04.7	34^10'26.1"
HH	24^40'17.3"	34^10'03.9"
JJ	24^41'53.9"	34^09'53.9"
KK	24^42'34.3"	34^08'19.6"
LL	24^42'55.6"	34^08'27.1"
MM	24^42'28.1"	34^09'48.4"
NN	24^43'16.4"	34^09'42.3"
PP	24^44'13.1"	34^10'09.2"
QQ	24^43'59.4"	34^11'09.5"
RR	24^41'14.1"	34^11'05.7"
SS	24^41'13.2"	34^10'58.8"
TT	24^40'56.9"	34^10'52.9"

Fig 3.3. Proposed NPS layout at Thyspunt. Source of base map: 96_00049_rev07C_Thyspunt Site_EIA Corridor with Aerial Photo.pdf received 27 May 2009.

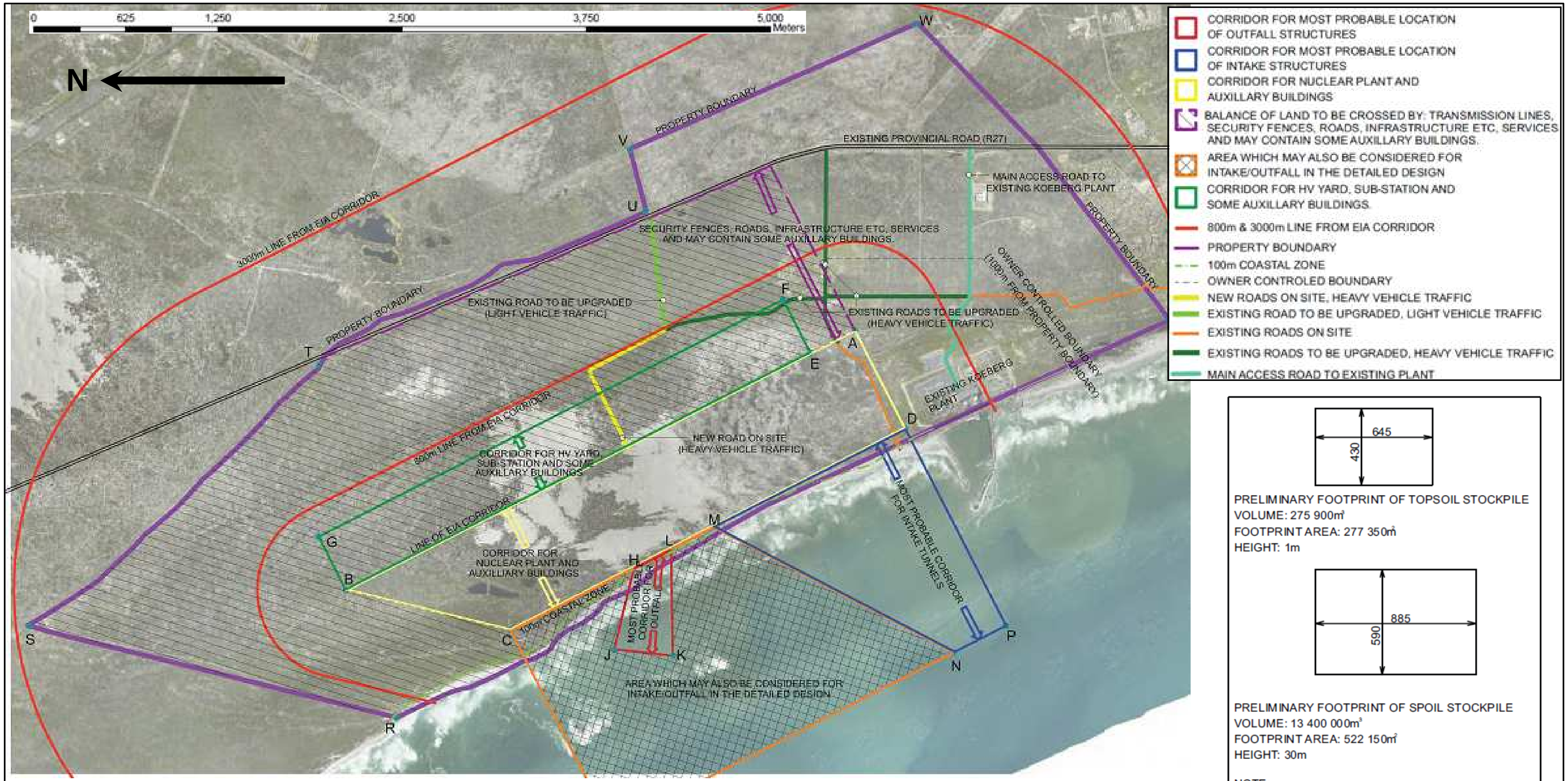


Fig 3.4. Proposed layout of roads and stockpiles at Duynefontein. Source of base map: 96_20023_rev00A_Duynefontein_Extent of Plant_EIA Corridor wi.pdf received 27 May 2009.

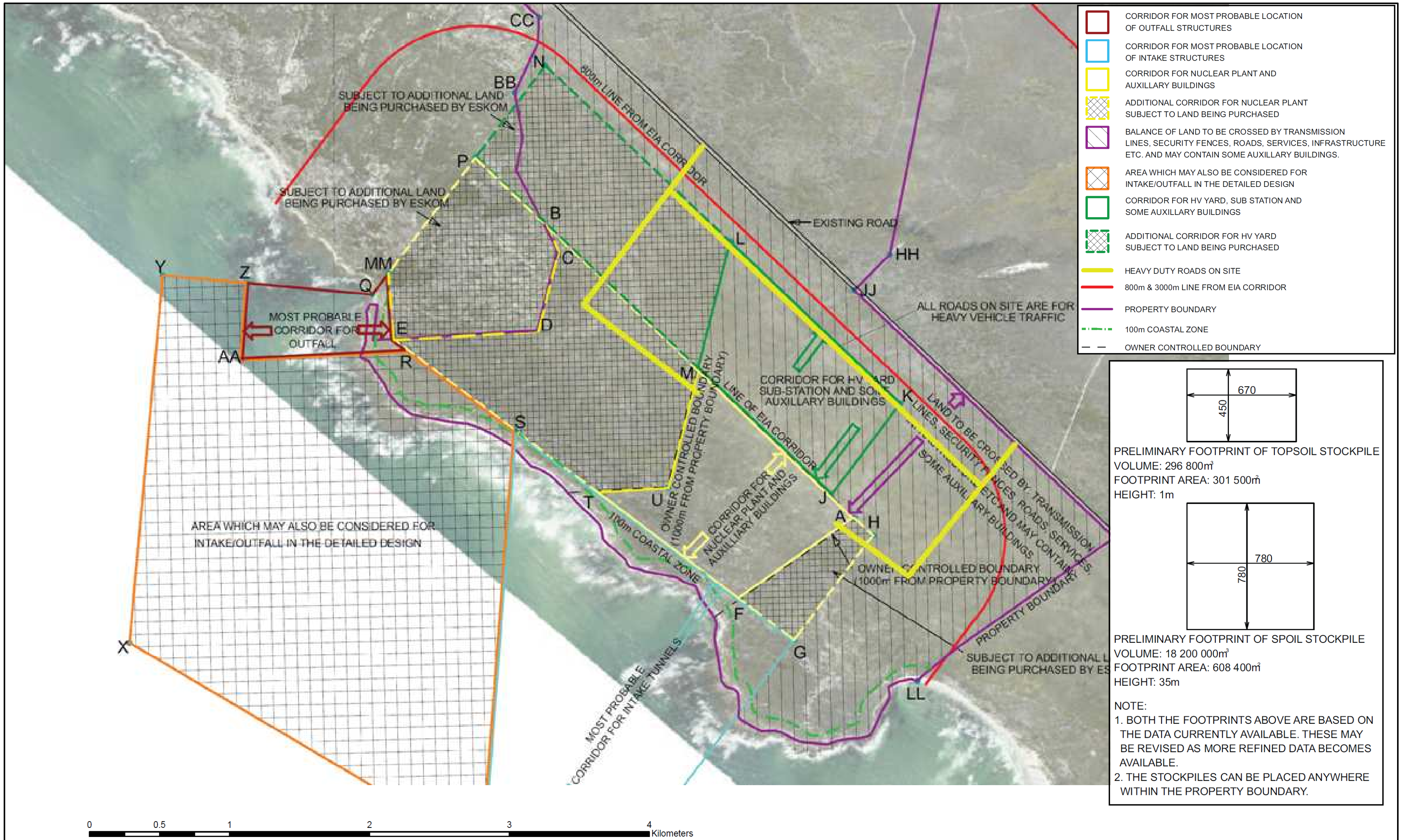


Fig 3.5. Proposed layout of roads and stockpiles at Bantamsklip. Source of base map: 96_10014_rev00B_EIA Corridor with Stockpile and Roads on Pho.pdf received 27 May 2009.

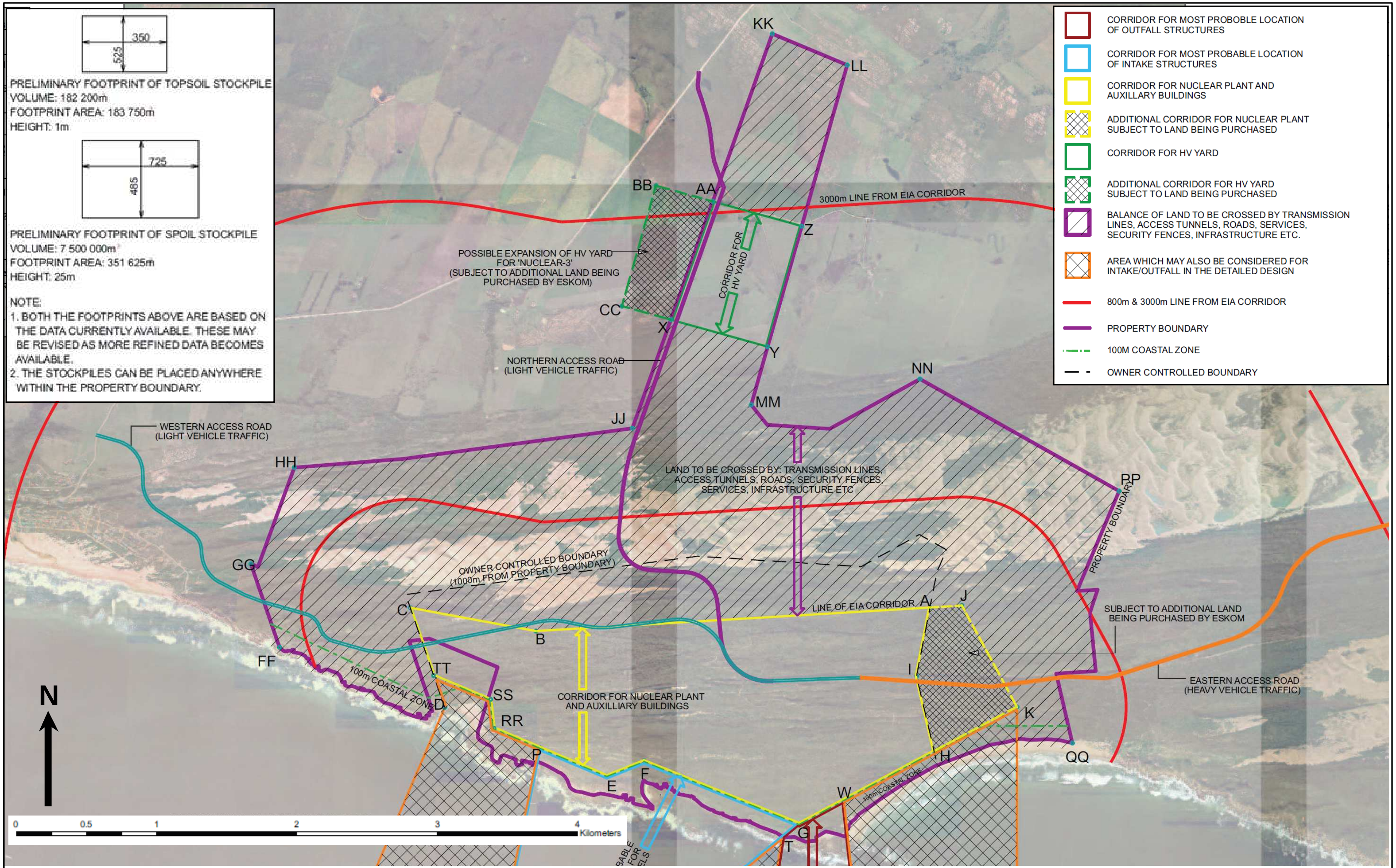


Fig 3.6. Proposed layout of roads and stockpiles at Thyspunt. Source of base map: 96_00120_rev00B_Thyspunt Site_EIA Corridor with Stockpile an.pdf received 27 May 2009.

4 METHODS FOR CROSSING MOBILE DUNES AT THYSPUNT

Because of the dynamic nature of the mobile dunes at Thyspunt, as well as the complex wetlands, surface water and groundwater hydraulics, special designs are proposed in this report in order to construct roads across the mobile dunes. They are described in this chapter.

4.1 The nature of wind-blown sand movement

Wind-blown sand moves in a series of hops, when grains are picked up by sufficiently strong winds. The process is called saltation, and was first described in detail in the classic study by Bagnold (1941) entitled “The physics of blown sand and desert dunes”. On sandy surfaces, the energy of a hopping grain is dissipated as it lands, because it dislodges grains lying on the surface. Sand grains bounce on smooth hard surfaces, and thus move faster than sand moving over sandy surfaces. The wind-blown sand transport rate on smooth hard surfaces would thus be higher than sand movement over sandy surfaces.

Sediment particles smaller than sand (silt & clay, conveniently referred to as dust) are winnowed out of dunes, because these fine particles stay suspended if they are picked up by wind. Thus there is virtually no dust in a sand dune, and a moving dune does not generate dust.

4.2 Smooth road slightly raised above the interdune surface

This would entail an aerodynamically smooth hard-surfaced road raised a maximum of 1 m above the interdune surface, with gently sloping smooth hard-surfaced verges (Figure 4.1). The purpose of the hard, smooth surfaces is to accelerate wind-blown sand movement so that dune sand does not accumulate on the road, and dunes will not form on the road. Front-end loaders could be used to move dunes across the road if necessary when a particularly large dune moves onto the road, “helping” natural wind-blown sand movement. As explained in Section 4.1, no dust will be generated.

The road will cause disturbance to interdune wetlands, surface water and groundwater flow. The surface water flow and shallow groundwater flow associated with the interdune wetlands must not be impeded. This can be achieved by placing culverts under the road to allow surface water and groundwater flow. The culverts must be closely spaced and must extend downward through the whole thickness of the primary aquifer. The culverts must be back-filled with sand to allow groundwater movement.

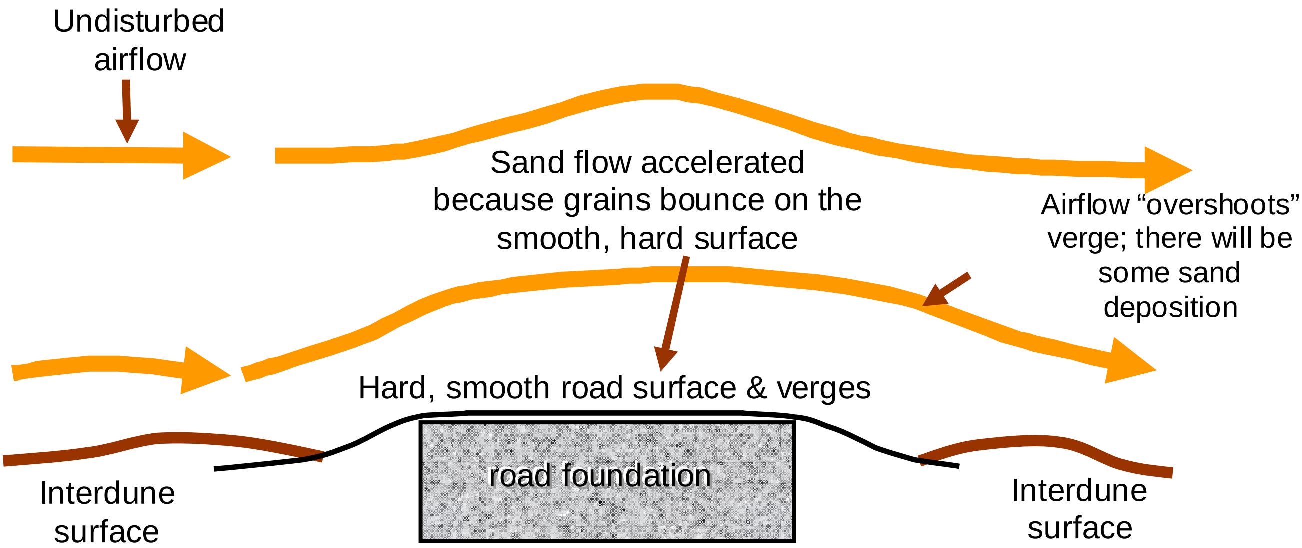


Figure 4.1. Design of an aerodynamically smooth road over the active, mobile dunefield. (Not to scale). The purpose of the hard, smooth surfaces is to accelerate wind-blown sand movement so that dune sand does not accumulate on the road, and dunes will not form on the road.

4.3 Aerodynamically shaped bridge that crosses the mobile dunes and wetlands

An aerodynamically shaped bridge (Figure 4.2), designed to speed up airflow and hence the wind-blown sand movement rate under the bridge, can be built across the mobile dunefield so that no accumulation or build-up of sand takes place around the bridge. Instead sand is blown under the bridge as dunes migrate. There will be no accumulation of sand under the bridge. Static dunes will be created on both sides of the bridge. The downwind dune will be bigger than the upwind dune. Figure 4.3 shows a structure that behaves like such a bridge. A static interdune wetland will thus be formed under the bridge. This would be a “duneslack wetland depression” in wetland terminology. Surface and groundwater flow would not be impeded. An unusual characteristic of this wetland is that it would not be subject to periodic “sand inundation” by moving dunes. Only the water level in the wetland pond would change depending on whether periods of low rainfall or high rainfall are being experienced.

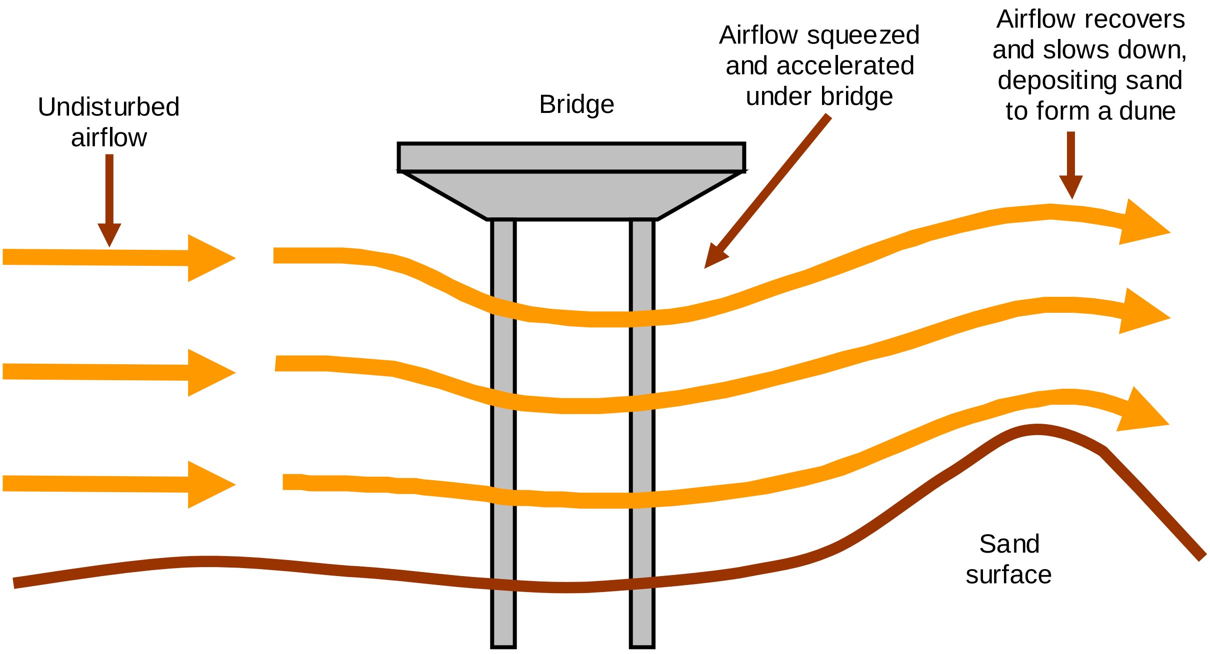


Figure 4.2. Design of aerodynamic bridge shaped to speed up airflow and hence the wind-blown sand movement rate under the bridge so that dunes do not accumulate and build up against the bridge. (Not to scale). Instead sand is blown under the bridge as dunes approach the bridge so sand does not accumulate under the bridge. A small dune may form upwind of the bridge, and a large dune forms downwind of the bridge. There is no build-up of sand beneath the bridge; an interdune wetland would form here.

Figure 4.3. An example of a "bridge" shaped so that airflow under the bridge is accelerated, so there is no build-up of sand under the bridge. The dominant wind blows from left to right. A small dune forms at times upwind of the bridge (left), and a large dune forms downwind of the bridge (right).

5 ENVIRONMENTAL ASSESSMENT & MITIGATION

The assessments in this specialist report only consider dune dynamics. Thus “it is viable to do *xxxx*” means that, ***in terms of dune dynamics***, *xxxx* can be undertaken.

5.1 Duynefontein

This assessment concerns the mobile dunes on the northern portion of the proposed site, the artificially vegetated dunes on the southern portion of the site, and Late Holocene parabolic dunes on the eastern portion of the site.

5.1.1 Impacts related to groundwater and surface water as far as they affect dunes

Groundwater and surface water have no impact on the mobile or artificially vegetated dunes.

5.1.2 Dynamics of mobile dunes (with specific investigation into the viability of constructing infrastructure, transmission lines and access roads)

Mobile dunes upwind of infrastructure, transmission lines and access roads will be blown onto same. This will have a high impact.

Mitigation: stabilise the mobile dunes with drift fences, brushwood and with pioneer indigenous dune vegetation. This will reduce the impact to low.

Mobile dunes downwind of infrastructure and access roads will be starved of sand supply. Mobile dunes will cease to exist when the ground level drops to the interdune level, and the area will become naturally vegetated. This environmental impact will be low, as natural processes will be mimicked, albeit at an accelerated rate.

Mitigation: None.

5.1.3 Dynamics and stability of the artificially vegetated (fixed) dunes (with relation to the construction of infrastructure, transmission lines and access roads)

Major disturbance or damage to the vegetation on the artificially vegetated dunes will re-mobilise the dunes. This will be a high impact.

Mitigation: stabilise the re-mobilised dunes with drift fences, brushwood and with pioneer indigenous dune vegetation, using brushwood and drift fences where necessary to re-stabilise the dune sand prior to planting. This will reduce the impact to low.

5.1.4 Dynamics and stability of the naturally vegetated Late Holocene parabolic dunes (with relation to the construction of infrastructure, transmission lines and access roads)

Major disturbance or damage to vegetation of the naturally vegetated Late Holocene parabolic dunes will re-mobilise the dunes. This will be a high impact.

Mitigation: stabilise the re-mobilised dunes with drift fences, brushwood and with pioneer indigenous dune vegetation, using brushwood and drift fences where necessary to re-stabilise the dune sand prior to planting. This will reduce the impact to low.

5.1.5 Potential impact of topsoil stockpile

Mobile dunes

Mobile dunes upwind of the topsoil stockpile will be blown onto the topsoil stockpile. This option is not viable for technical/management reasons, unless the mobile dunes are stabilised with drift fences, brushwood and with pioneer indigenous dune vegetation. Stabilising the mobile dunes will be a high impact, but localised over a small area.

Mitigation: stabilise the mobile dunes with drift fences, brushwood and with pioneer indigenous dune vegetation. This will reduce the impact to low.

Mobile dunes downwind of the topsoil stockpile will be starved of sand supply. Mobile dunes will cease to exist when the ground level drops to the interdune level, and the area will become naturally vegetated. The environmental impact will be low to insignificant, as natural processes will be mimicked, albeit at an accelerated rate.

Mitigation: None.

Artificially vegetated dunes

There will be no environmental impact on the artificially vegetated dunes.

Mitigation: None.

Late Holocene parabolic dunes

Any disturbance or damage to vegetation of the naturally vegetated Late Holocene parabolic dunes can be rehabilitated by re-planting the dune sand with suitable pioneer species of indigenous vegetation to re-stabilise the dune sand and using brushwood and drift fences where necessary. The environmental impact will be low.

Mitigation: None.

5.1.6 Potential impact of spoils stockpile

The spoils will be excavated from the power station construction site and will consist of about 80% sand and 20% rock.

Mobile dunes

Mobile dunes upwind of the spoils stockpile will be blown onto the spoils stockpile. This option is not viable for technical/management reasons, unless the mobile dunes are stabilised with drift fences, brushwood and with pioneer indigenous dune vegetation. Stabilising the mobile dunes will be a high impact, but localised over a small area.

Mitigation: None.

Mobile dunes downwind of the spoils stockpile will be starved of sand supply. Mobile dunes will cease to exist when the ground level drops to the interdune level, and the area will become naturally vegetated. This environmental impact will be low to insignificant, as natural processes will be mimicked, albeit at an accelerated rate.

Mitigation: None.

Artificially vegetated dunes

There will be no environmental impact on the artificially vegetated dunes.

Mitigation: None.

Late Holocene parabolic dunes

Any disturbance or damage to vegetation of the naturally vegetated Late Holocene parabolic dunes can be rehabilitated by re-planting the dune sand with suitable pioneer species of indigenous vegetation to re-stabilise the dune sand and using brushwood and drift fences where necessary. The environmental impact will be low.

Mitigation: None.

5.1.7 Impacts due to climate change

Retreat of the coastline in response to higher sea level may shift or create new sandy beaches that supply wind-blown sand to dunes. Mobile dunes and dunefields may thus be created in areas that are currently vegetated. This would require monitoring and suitable management in the distant future.

Wind speed is expected to increase by 10%, and storminess is expected to increase. Because wind-blown sand transport rate is roughly proportional to the cube of wind speed, sand transport rate and correspondingly dune movement rates of mobile dunes would increase by about 30%. This will not have any environmental impact.

Rainfall decrease and temperature increase will have no effect on mobile dunes. Plants on vegetated dunes will be stressed by rainfall decrease and temperature increase, so blowouts will form more easily.

Mitigation: Monitor vegetated dunes and repair blowouts by placing brushwood or using drift fences on the bare sand surfaces, and then re-vegetating the bare sand with suitable pioneer species.

5.1.8 Geomorphologic conservation value

Mobile dunes

In terms of geomorphology, this specific variety of mobile dunes still occurs in four patches, two in the Yzerfontein corridor dunefield, and two in the Atlantis corridor dunefield (Figure 5.1),while similar corridor dunefields occur further northward along the west coast: the Bitter-Spoeg, Kleinsee-Port Nolloth and Koingnaas corridor dunefields (Tinley, 1985; Illenberger, 1998).

Roughly 10% of the general dunefield variety and 25% of the specific variety will be lost if the proposed NPS site is used, and although is would be preferable not to lose these mobile dunes, this is not a fatal flaw in terms of their geomorphologic conservation value. Additionally, the landward (northern) portion of the Yzerfontein dunefield falls within the West Coast National Park, which affords it protection.

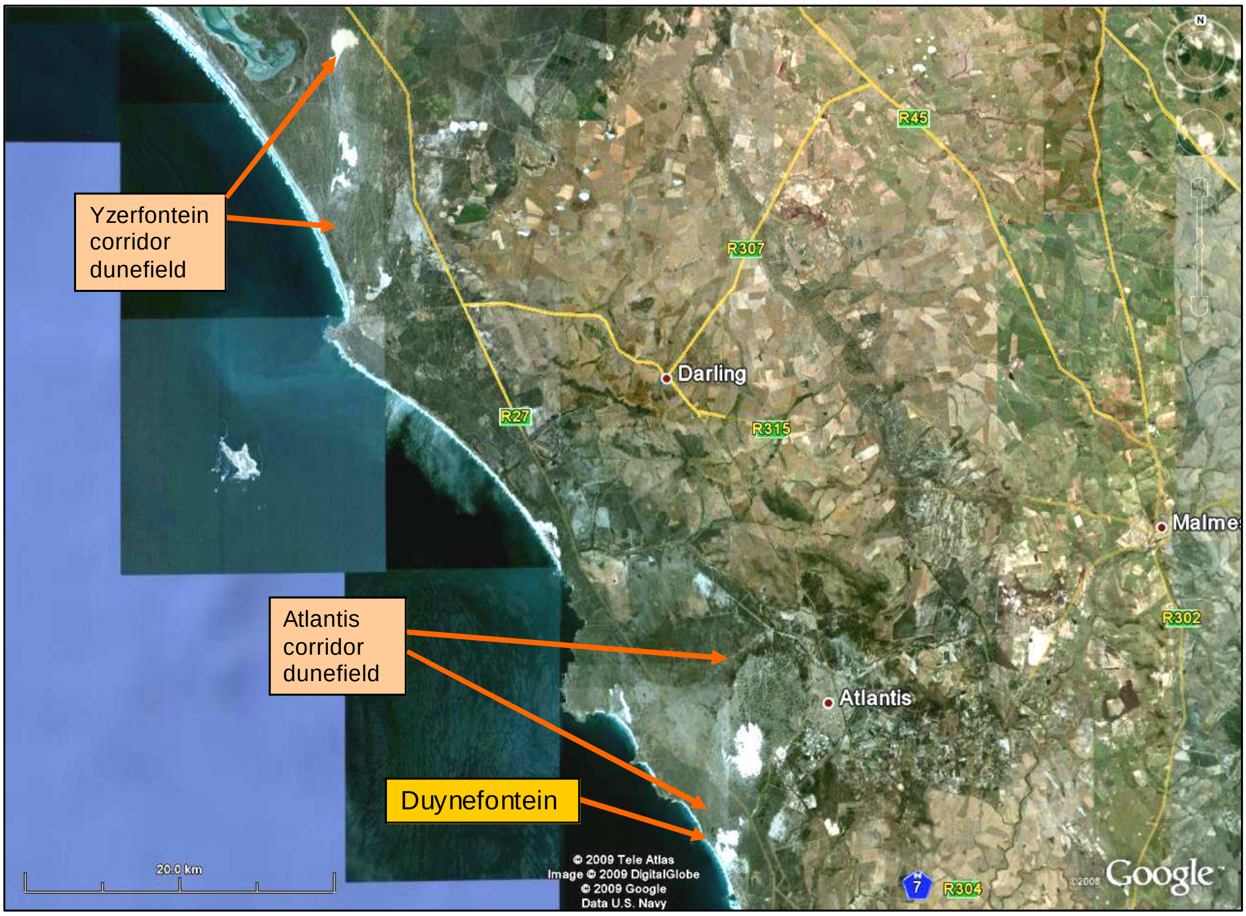


Figure 5.1. Conservation value of the dunefields at the Duynefontein site. Their conservation value is low, considering that other examples of dunefields of their type are much less impacted (Tinley, 1985; Illenberger, 1998).

Artificially vegetated dunes

The artificially vegetated dunes have no conservation value.

Late Holocene parabolic dunes

The Late Holocene parabolic dunes cover a vast area in the Atlantis and Duynefontein corridor dunefields. The small proportion that will be lost is of low conservation significance.

5.2 Bantamsklip

5.2.1 Aspects of groundwater and surface water as far as they have impact on the dunefields

Groundwater and surface water have no impact on the mobile or artificially vegetated dunes.

5.2.2 Dune dynamics and stability of the artificially vegetated mobile dunes on the site, with specific investigation into the viability of constructing infrastructure, transmission lines and access roads

Any disturbance or damage to vegetation of the artificially vegetated mobile dunes can be rehabilitated by re-planting the dune sand with suitable pioneer species of indigenous vegetation to re-stabilise the dune sand and using brushwood and drift fences where necessary. The environmental impact will be low.

Mitigation: None.

5.2.3 Dune dynamics and stability of the naturally vegetated Late Pleistocene parabolic dunes, with specific investigation into the viability of constructing infrastructure, transmission lines and access roads

The Late Pleistocene parabolic dunes have a moderately developed soil with nutrient-rich fines so soil exposed during construction and in soil stockpiles will be liable to wind erosion that winnows these fines out of the soil. The environmental impact will be moderate.

Mitigation: minimise area being cleared for construction at any one time, wet down these areas. Wet down soil stockpiles, cover stockpiles with brushwood. This will reduce the temporary environmental impact to low.

Any disturbance or damage to vegetation can be rehabilitated by re-planting the dune with suitable pioneer species of indigenous vegetation to re-stabilise the dune sand using brushwood and drift fences where necessary. However, rehabilitation of vegetated dunes to their natural state will be difficult, as climax vegetation will have to be re-introduced once the pioneers are established. The environmental impact will be low to moderate.

Mitigation: appoint a suitably qualified environmental officer to supervise the rehabilitation of vegetation on the Late Pleistocene parabolic dunes. This will reduce the environmental impact to low.

5.2.4 Impact of the disposal of topsoil and spoils excavated from the power station construction site on the above mentioned dune systems

There will be no environmental impact on the artificially vegetated dunes or the naturally vegetated Late Pleistocene parabolic dunes.

Mitigation: None.

5.2.5 Impacts due to climate change

Retreat of the coastline in response to higher sea level may shift or create new sandy beaches that supply wind-blown sand to dunes. Mobile dunes and dunefields may thus be created in areas that are currently vegetated. This would require monitoring and suitable management in the distant future.

Wind speed is expected to increase by 10%, and storminess is expected to increase. Because wind-blown sand transport rate is roughly proportional to the cube of wind speed, sand transport rate and correspondingly dune movement rates of mobile dunes (that currently are only found off the site, towards Pearly Beach) would increase by about 30%. This will not have any environmental impact.

Rainfall decrease and temperature increase will have no effect on mobile dunes. Plants on vegetated dunes will be stressed by rainfall decrease and temperature increase, so blowouts will form more easily.

Mitigation: Monitor vegetated dunes and repair blowouts by placing brushwood or using drift fences on the bare sand surfaces, and then re-vegetating the bare sand with suitable pioneer species.

5.2.6 Geomorphologic conservation value

The conservation value of the dunefields at the Bantamsklip site is low, considering that other examples of dunefields of their type are hardly impacted (Figure 5.2; Tinley, 1985; Illenberger, 1998).

Figure 5.2. Conservation value of the dunefields at the Bantamsklip site. Their conservation value is moderate to low, considering that similar dunefields between Hermanus and Cape Agulhas are hardly impacted (Tinley, 1985; Illenberger, 1998).

5.3 Thyspunt

5.3.1 Access road across the mobile Oyster Bay dunefield

When this option was first mooted, it was for a route along the eastern side of the "panhandle", where dunes are lower: maximum height about 10 metres. The route currently under consideration (the "Northern Access Road in the revised Draft EIR) runs along the western side of the “panhandle”, where transverse dunes are about 30 m high; dune height increases westward. There is a maximum dune height that this option could handle, probably about 10 m. This option is thus not viable for the route along the western side of the “panhandle”. In addition, large cut and fill will be required as two large vegetated dune ridges would have to be crossed, which again makes this route unviable.

Mitigation: Move the road eastward to where maximum dune height is below 10 metres. The zone in which this road could be located is shown in Figure 5.3.

The easternmost part of the zone shown is preferred because the road would cross the narrowest part of the mobile dunefield, and inspection of aerial photographs reveals that the patches of vegetated dunes on either side of the narrowest part of the mobile dunes are vegetated parabolic dunes without any surface water flow, which would minimize the environmental impact of this route. Subsurface flow probably occurs in these areas, so culverts would be needed. The southern portion of this route that crosses large vegetated linear dune ridges has been laid out to cross the ridges at low points, minimizing cut and fill.

The route (if selected) must be laid out in close collaboration with dune and wetland specialists.

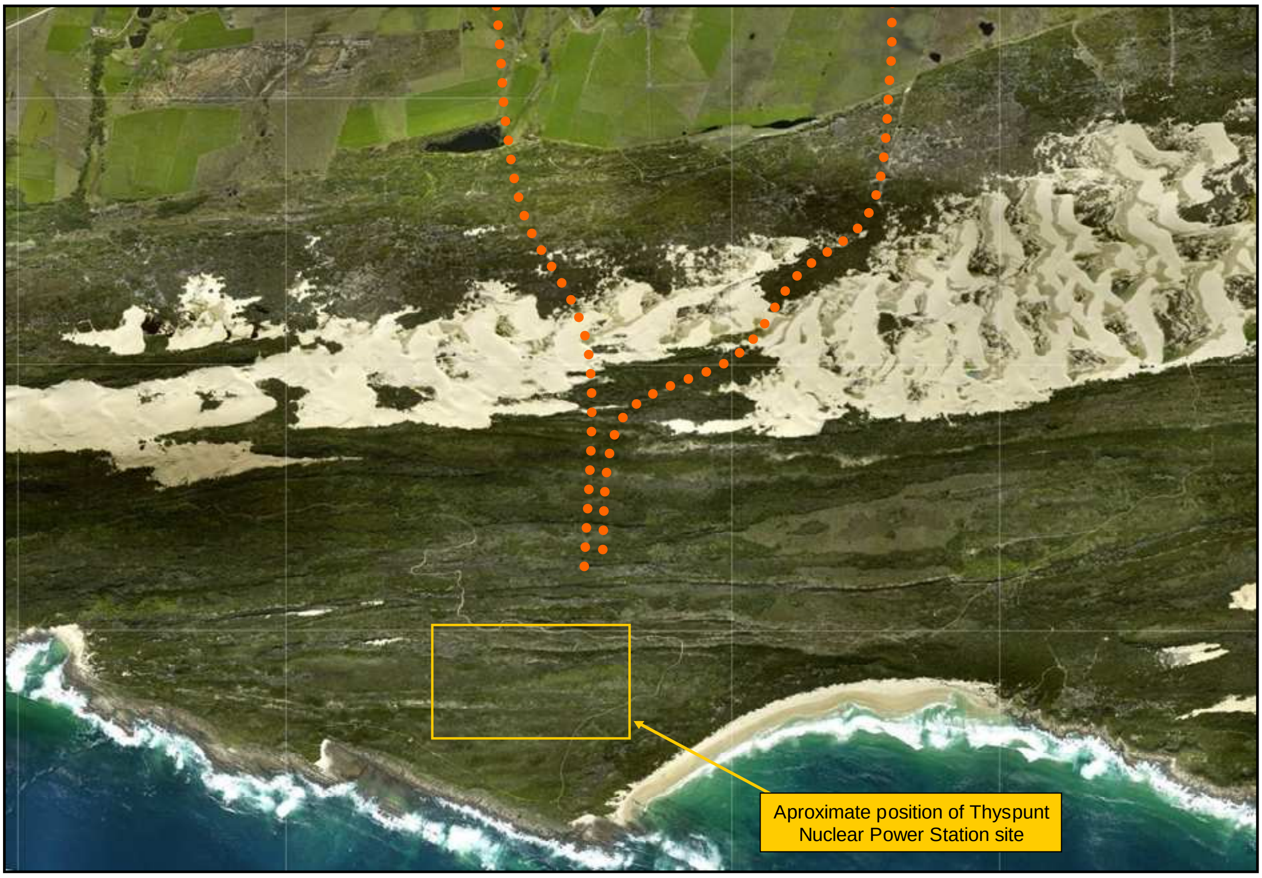


Figure 5.3. The area between the dotted lines show the preferred locality of roads or conveyor belts that have to cross the mobile Oyster Bay dunefield and vegetated dune ridges to the south of the dunefield.

Potential environmental impacts on dune dynamics involve the natural wind-driven movement of the mobile dunes, movement of surface water, movement of groundwater, and interdune wetland areas. Two options are under consideration:

(a) Smooth road slightly raised above the interdune surface

This would entail a smooth hard-surfaced road raised a maximum of 1 m above the interdune surface, with gently sloping smooth hard-surfaced verges as described in Section 4.2.

The raised road will cause disturbance to interdune wetlands, surface water and groundwater flow. Surface water flow and shallow groundwater flow associated with the interdune wetlands must not be impeded. This can be achieved by placing culverts under the road to allow surface water and groundwater flow. The culverts must be closely spaced and must extend downward through the whole thickness of the primary aquifer. The culverts must be back-filled with sand to allow groundwater movement. There will be a high construction phase impact, in particular along the northern part of the dunefield where there are large areas of continuous wetlands that may have to be crossed. Construction and rehabilitation must be undertaken carefully and thoroughly and continuously monitored by a suitably qualified ECO. Final recovery of the natural surface water and groundwater dynamics will probably take decades. Environmental impact after the construction phase would be reduced to medium to low.

Mitigation/special measures:

- *Avoid wetland areas wherever possible.*
- *Because of issues such as wetland fragmentation in such areas (Day, 2009), culverts must be so closely spaced that they virtually form a bridge over wetlands that have to be crossed, to allow groundwater flow and wetland functioning.*
- *The road reserve and width disturbed during construction must be kept as narrow as possible, not more than 20 m.*
- *Monitoring and repair of possible uncontrolled blowouts or water erosion that may occur as a result of windy or rainy periods during rehabilitation and recovery phases must be undertaken.*
- *Special rehabilitation techniques may have to be developed to ensure that the wetlands, surface water and groundwater dynamics recover fully.*
- *A suitably qualified ECO is needed to supervise the construction phase and rehabilitation of the construction road.*

(b) Aerodynamically shaped bridge that crosses the mobile dunes and wetlands

An aerodynamically shaped bridge as described in Section 4.3, designed to speed up airflow and hence the wind-blown sand movement rate under the bridge, can be built across the mobile dunefield so that no accumulation or build-up of sand takes place around the bridge. Instead sand is blown under the bridge as dunes migrate. There will be no accumulation of sand under the bridge. Static dunes will be created on both sides of the bridge. The downwind dune will be bigger than the upwind dune.

Environmental impact after construction would be low, and would be restricted to areas disturbed by the foundations of the bridge pillars.

Mitigation: Increase the span between the bridge pillars to minimise the footprint of the bridge foundations. This will reduce the extent of the impact.

A temporary construction road would be required along the bridge during the construction phase. The environmental impact of this temporary road would be high, as groundwater flow would be impeded, which could have impacts on wetlands in the area. However, it would be a medium-term impact as the road would be removed after construction of the bridge. Final recovery of the natural surface water and groundwater dynamics will probably take decades. It must be emphasized that rehabilitation must be undertaken carefully and thoroughly. Environmental impact after the construction phase would be reduced to low.

Mitigation/special measures:

- *Monitoring of possible uncontrolled blowouts or water erosion, that may occur as a result of windy or rainy periods during rehabilitation and recovery phases, must be undertaken.*

- *Rehabilitation of this construction road would entail removing the base and sub-base, and then back-filling to mimic the characteristics of the sediment that was excavated.*

- *Special rehabilitation techniques must be developed to ensure that the wetlands, surface water and groundwater dynamics recover fully.*

- *A suitably qualified ECO is needed to supervise the construction phase and rehabilitation of the construction road.*

5.3.2 Access roads across the fixed, vegetated dunes: Eastern and Western Access Roads, and part of Northern Access Road

This entails crossing the vegetated dunes with a road that would need cut and fill to create a road with a smooth gradient. Terraforce or similar blocks must be used to stabilise the sides of the cut and fill, as rehabilitation by vegetating the slopes will be difficult and slow. There will thus be little effect on the stability of the dunes, apart from the risk of slumping during the construction phase. The environmental impact will be low.

Mitigation: None.

Blowouts may form during construction when bare sand is exposed. The environmental impact will be moderate.

Mitigation:

- *Blowouts can be repaired by placing brushwood or using drift fences on the bare sand surfaces, and then re-vegetating the bare sand with suitable pioneer species.*
- *Terraforce or similar blocks must be used to stabilise the sides of the cut and fill as quickly as possible.*

This will reduce the impact to low.

5.3.3 Construction of transmission lines across the mobile, unvegetated dunes

This entails building transmission lines directly across the mobile dunefield from the power station in the south to the High Voltage Yard in the north (in the "panhandle" section of the site). The dunefield is about 800 m wide in the area where the crossing is proposed. In this area, transverse dunes in the mobile dunefield move eastward at rates of 15 to 20 m/yr, with interdune wetland areas. The dunes are about 10 - 20 m high in this area. It is assumed that access roads needed to build the towers will be permanent.

Conventional transmission towers with a maximum span of 400 m

For towers located within the mobile dune area, access roads would be periodically covered in sand and would cause disturbance to surface water and groundwater flow. With suitable layout, only one set of towers will be needed within the mobile dunefield, as it is about 800 m wide in the area where the crossing is proposed. The environmental impacts and construction techniques are the same as for the smooth hard-surfaced road described in Section 5.3.1. The environmental impacts, impacts during construction phase and mitigation measures will be the same.

Mitigation:

- *Use helicopters to transport materials to build the towers within the mobile dunefield, so that access roads are not required.*
- *Use an all-terrain vehicle or light 4 wheel drive vehicle to service the transmission lines* ***(i.e. no permanent access roads are built).***
- *Position the towers so that only one set must be built within the mobile dunefield.*
- *Use a suitably qualified ECO to supervise positioning and emplacement of the towers.*

This will reduce the impact to low.

A note for the engineers designing the transmission line that crosses the mobile dunefield: The dunes are 10-20 m high in this part of the mobile dunefield. The relative tower height would thus be reduced by 10-20 m as a dune passes under a transmission line. It may be necessary to build higher towers in this area. A dune specialist must be consulted during the design phase.

Dual circuit transmission towers with a maximum span of 300 m

The impacts will be the same as for the conventional transmission towers, except that two sets of towers will be needed within the mobile dunefield, as it is about 800 m wide in the area where the crossing is proposed. Conventional transmission towers are thus preferred.

Special transmission structures that span 800 m

This span would allow a single span to cross the whole mobile dunefield with no towers within the dunefield. Access roads across the mobile dunefield could also be avoided, as access to the northern and southern towers would be possible from the north and south respectively. There would be no impact on the mobile dunefield. ***However, the visual impacts would be higher than for the other options.***

5.3.4 Construction of transmission lines across the fixed, vegetated dunes

This entails crossing the vegetated dunefield that consists of ridges running east – west. Construction roads and future access roads are assumed to be required, firstly a road running north – south, secondly roads running east – west along each row of towers. These roads would presumably be retained after construction for servicing the transmission lines.

Conventional transmission towers with a maximum span of 400 m

1. If towers are located on a narrow steep-sided ridge, the ridge may be destabilised by the width required to build a tower foundation and an access road that must pass alongside the foundation to the position of the next tower foundation. The environmental impact will be moderate.

Mitigation:

- *Locate the towers on a relatively broad, low ridge. Some flattening of the ridge may be needed. The substrate would be stable, as the sides of the ridges would slope at a sufficiently low angle.*

- *Use Terraforce or similar blocks if necessary to stabilise the sides of the ridges.*

This will reduce the impact to low.

2. If towers are located in an inter-ridge valley there may not be enough space for the tower footprint and access road, which would necessitate cutting into the adjacent ridges, which would destabilise the ridges. The environmental impact will be moderate.

Mitigation: Use Terraforce or similar blocks to stabilise the sides of the ridges. A better mitigation is to locate the towers in a sufficiently wide inter-ridge valley so that no cutting into the adjacent ridges is required. This will reduce the impact to low.

3. If towers are located in an inter-ridge valley, taller towers with a larger foundation may be required as the ridge that is the southern sidewall of the Oyster Bay dunefield is about 35 m above the level of the valley floor to the south of the ridge. There may not enough space for the tower footprint and access road,

which would necessitate cutting into the adjacent ridges. The environmental impact will be moderate.

Mitigation: increase the footprint of the towers minimally. Use Terraforce or similar blocks if necessary to stabilise the sides of the ridges. This will reduce the impact to low.

The use of helicopters to transport materials to build the towers will reduce the impact to virtually insignificant.

Dual circuit transmission towers with a maximum span of 300 m

The impacts will be the same as for conventional transmission towers.

5.3.5 Impact of the disposal of topsoil and spoils excavated from the NPS construction site

There are three possible options that impact on the dunefields.

1 Disposal in mobile dunefield

For this option, the spoil is removed to the mobile dunefield where it is dumped in areas of mobile dunes where no vegetation is growing. The spoil would be left to the elements of nature. The overall impact of this is very high, as the nature and dynamics of dunes that would eventually form would be different from the existing dunes, interdune wetlands would be destroyed, and any material finer than about 60 microns would be carried away as dust, with a high impact on down-wind areas where the dust will eventually settle. This option is fatally flawed, as all the impacts listed above are unacceptably high, and cannot be mitigated significantly.

[Temporary access roads would be needed across the unvegetated dunefield and within the mobile dunefield to move the spoils.]

2 Disposal in vegetated dunefield

For this option, the spoil is disposed of within the vegetated dunefield. The stockpile will have a surface area of about 350 000 m², roughly 5% of the total surface area of the vegetated dunefield on the Eskom property. The stockpile will be 25 m high, higher than many of the dune ridges. The dunes and the vegetation on the vegetated dunefield will be destroyed, and the very distinctive natural dune ridge topography will be completely altered. Airflow will be modified significantly, leading to localised speed-up of winds that may result in blowouts and re-mobilizing of dunes. This will be a high impact.

Mitigation:

- *Blowouts can be repaired by placing brushwood or using drift fences on the bare sand surfaces, and then re-vegetating the bare sand with suitable pioneer species.*
- *Re-create the original dunefield topography (elongate east-west ridges) and vegetation as far as is possible. The re-created surface will be unnaturally higher that the surrounding dunes, and so this mitigation will reduce the impact to moderate.*

3 Disposal in panhandle north of the Oyster Bay dunefield

This option involves moving the spoil from the excavation over the sand dune to the 'panhandle' (Figure 3.6). For this option, the spoil will need to be transported across the vegetated & mobile dunefields by means of:

- a temporary conveyor belt with supports at a close spacing and an associated construction road; or

- a temporary haul road.

Use of the eastern or western roads as haul roads will obviously negate all impacts on the mobile dunefield.

(a) Conveyor belt & associated temporary construction road

Within the mobile (unvegetated) dunefield, there would be no damage to mobile dunes, but it will probably be best to route the conveyor to avoid mobile dunes because of the difficulty of construction and high operational maintenance in mobile dunes. As the structures would be temporary, drift-fences installed by hand can be used to temporarily stop wind-blown movement of dunes in places where it is difficult to avoid mobile dunes. When the structures are removed, the drift-fences would be removed by hand. Use of temporary drift-fences will be a low to insignificant impact, as natural wind-blown dune movement will only be interrupted for a short while.

The environmental impacts and construction techniques are the same as for the smooth hard-surfaced road described in Section 5.3.1. The environmental impacts, impacts during construction phase and mitigation measures will be the same.

Rehabilitation of the foundations of the conveyor belt supports and the temporary construction road will have the same impacts and rehabilitation methods as for the temporary road needed to construct the aerodynamic bridge option discussed above in Section 5.3.1.

Mitigation: See aerodynamic bridge option discussed above.

In the vegetated dunefield supports for the conveyor belt at a close spacing and the temporary construction road will entail crossing the vegetated dune ridges with a road that would need cut and fill to create a road with a smooth gradient. Terraforce or similar blocks must be used to stabilise the sides of the cut and fill, as stabilising by vegetating the slopes will be difficult and slow. There will thus be little effect on the stability of the dunes, apart from the risk of slumping during the construction phase. The environmental impact will be low.

Blowouts may form during construction when bare sand is exposed. The environmental impact will be moderate.

Mitigation:

- *Blowouts can be repaired by placing brushwood or using drift fences on the bare sand surfaces, and then re-vegetating the bare sand with suitable pioneer species.*

- *Terraforce or similar blocks must be used to stabilise the sides of the cut and fill as quickly as possible.*

This will reduce the impact to low.

In the vegetated dunefield rehabilitation of the foundations of the conveyor belt supports and the temporary construction road would entail removing the foundations of the conveyor belt supports, and the base and sub-base of the construction road, and then re-creating the original dunefield topography and vegetation as far as is possible. Recovery of the vegetation will be slow but it will recover completely after some decades. The environmental impact would be low.

Mitigation: Use a suitably qualified specialist to guide rehabilitation. Install the conveyor belt foundations using low-diameter piles instead of concrete foundations. The only impact on the substrate will thus be the holes left when the piles are pulled out. This will reduce the impact caused by the foundations, but the overall impact is still rated as low.

(b) Haul road

The same environmental impacts and mitigation measures for a temporary construction road as described in Section 5.3.1 would apply to a temporary haul road.

5.3.6 Impacts due to climate change

Retreat of the coastline in response to higher sea level may shift or create new sandy beaches that supply wind-blown sand to dunes. Mobile dunes and dunefields may thus be created in areas that are currently vegetated. This would require monitoring and suitable management in the distant future.

Wind speed is expected to increase by 10%, and storminess is expected to increase. Because wind-blown sand transport rate is roughly proportional to the cube of wind speed, sand transport rate and correspondingly dune movement rates of mobile dunes would increase by about 30%. This will not have any environmental impact.

Winds at Thyspunt will have a larger proportion of easterly winds, so the seasonal reversal of mobile dune movement will be higher, and overall sand transport rate and correspondingly dune movement rates will decrease. As the proportion has not been quantified, the amount of decrease cannot be estimated.

Temperature increase will have no effect on mobile dunes. Plants on vegetated dunes will be stressed by temperature increase, so blowouts will form more easily.

Mitigation: Monitor vegetated dunes and repair blowouts by placing brushwood or using drift fences on the bare sand surfaces, and then re-vegetating the bare sand with suitable pioneer species

5.3.7 Geomorphologic conservation value

The conservation value of the headland-bypass dunefields is high, as they are the only remaining large dunefields of this type that are still active in South Africa, ***even though not fully active, as their feeder areas have been artificially stabilized*** (Figure 5.3; Tinley, 1985; Illenberger, 1998). The headland-bypass dunefields at Cape St. Francis are unique on a local, regional and probably global scale (Illenberger, 1998).

The vegetated dunefield is a classic, almost pristine example of a suite of Holocene and Pleistocene dune ridges with a variety of origins: parabolic dunes, hairpin parabolic dunes, and sidewalls of previously mobile headland-bypass dunefields, including fairly unique examples of such sidewalls. The dunefield has high interpretive value for elucidating coastal dune dynamics.

Figure 5.4. Conservation value of the dunefields at Thyspunt. The conservation value of the headland-bypass dunefields is high, as they are the only remaining large dunefields of this type that are still active. The conservation value of the vegetated dunefield is high as it constitutes a classic example of a suite of Holocene and Pleistocene dune ridges with a variety of origins: parabolic dunes, hairpin parabolic dunes, and sidewalls of previously mobile headland-bypass dunefields. The dunefields has high interpretive value for elucidating coastal dune dynamics.

5.4 No-Go alternative: option of not proceeding with building the NPS

In the event of the No-Go alternative being selected, Eskom will put the properties in question up for sale. There will be no impact on dune dynamics or other items specified in the Terms of Reference.

6 SUMMARY TABLES — ENVIRONMENTAL ASSESSMENT AND MITIGATION MEASURES

6.1 Environmental assessment and mitigation measures

Summary tables of environmental assessment and mitigation measures for the three sites are presented below in Tables 6.1, 6.2 and 6.3.

6.2 Recommended monitoring and evaluation programme

The dynamics of mobile and vegetated dunes are well-understood at all three sites, and no periodic monitoring or measurements of dunes are required to gather further background information. Wetland and vegetation monitoring that are necessary are specified in the respective specialist reports.

Mobile dunes in the vicinity of any construction activities must be monitored by a suitably qualified ECO, particularly within the Oyster Bay dunefield. Monthly visits are required. Any ad-hoc issues that crop up such as obstruction of moving dunes must be addressed.

After construction of either of the aerodynamically smooth hard-surfaced road, or the aerodynamically shaped bridge across the mobile dunes at Thyspunt, dune movement up to 300 m from the road or bridge must be monitored at 3-monthly intervals by a suitably qualified ECO to ensure that natural dune movement is unimpeded, and that the wetlands, surface and groundwater flow are functioning naturally. Additional wetland and vegetation monitoring that are necessary are specified in the respective specialist reports.

The monitoring frequency can be reduced to six-monthly after 3 years, and annually after 6 years.

Vegetated dunes in the vicinity of any construction activities must be monitored on a monthly basis by a suitably qualified ECO to address any ad-hoc issues that crop up. Rehabilitation of vegetation will require monitoring as specified in the botany specialist report.

The vegetated dunes in the vicinity of the completed structure must be monitored at 3-monthly intervals by a suitably qualified dune specialist to check that there is no de-stabilization. The monitoring frequency can be reduced to six-monthly after 3 years, and annually after 6 years.

Environmental audits must be undertaken by a specialist auditor.

Table 6.1: Eskom Nuclear 1: Assessment of impacts at Duynefontein

Impact	*Nature*	*Intensity*	*Extent*	*Duration*	*Consequence*	*Impact on irreplaceable resources*	*Probability*	*Significance*
Dune dynamics of the mobile dunes - constructing infrastructure, transmission lines and access roads								
Mobile dunes upwind of infrastructure	*Negative*	*High*	*Low*	*High*	*Low*	*Medium*	*Low*	*Medium*
Mitigation: stabilise with drift fences, brushwood and with pioneer indigenous dune vegetation	*None*							
Mobile dunes downwind of infrastructure	*Negative*	*Medium*	*Low*	*High*	*Low*	*Medium*	*Low*	*Low - Medium*
Mitigation: none possible	*none*							
Stability of the artificially vegetated dunes - constructing infrastructure, transmission lines and access roads								
Constructing infrastructure and access roads	*Negative*	*High*	*Low*	*High*	*Low*	*Medium*	*High*	*Medium*
mitigation: stabilise with drift fences, brushwood and with pioneer indigenous dune vegetation	*None*							
Stability of the naturally vegetated late Holocene parabolic dunes - constructing infrastructure, transmission lines and access roads								
Constructing infrastructure and access roads	*Negative*	*High*	*Low*	*High*	*Low*	*Medium*	*High*	*Medium*
Mitigation: stabilise with drift fences, brushwood and with pioneer indigenous dune vegetation	*None*							
Topsoil stockpile on mobile dunes								
Mobile dunes blowing onto stockpile	*Negative*	*High*	*Low*	*Low*	*Low*	*Medium*	*High*	*Medium*
Mitigation: stabilise with drift fences, brushwood and with pioneer indigenous dune vegetation	*None*							
Topsoil stockpile on artificially vegetated dunes								
Impact on the artificially vegetated dunes	*Negative*	*Low*	*Low*	*Low*	*Low*	*Low*	*High*	*Low - Medium*
Mitigation: stabilise with drift fences, brushwood and with pioneer indigenous dune vegetation	*none*							
Topsoil stockpile on the naturally vegetated Late Holocene dunes								
Impact on Holocene parabolic dunes	*Negative*	*Low*	*Low*	*Low*	*Low*	*Low*	*High*	*Low - Medium*
Mitigation: stabilise with drift fences, brushwood and with pioneer indigenous dune vegetation	*None*							
Spoils stockpile on the mobile dunes								

Impact	*Nature*	*Intensity*	*Extent*	*Duration*	*Consequence*	*Impact on irreplaceable resources*	*Probability*	*Significance*
Mobile dunes blowing onto stockpile	*Negative*	*High*	*Low*	*Low*	*Low*	*Medium*	*High*	*Low - Medium*
Mitigation: stabilise with drift fences, brushwood and with pioneer indigenous dune vegetation	*None*							
Spoils stockpile on the artificially vegetated dunes								
Impact on the artificially vegetated dunes	*Negative*	*Low*	*Low*	*Low*	*Low*	*Low*	*High*	*Low - Medium*
Mitigation: stabilise with drift fences, brushwood and with pioneer indigenous dune vegetation	*None*							
Spoils stockpile on the naturally vegetated Late Holocene dunes								
Impact on Holocene parabolic dunes	*Negative*	*Low*	*Low*	*High*	*Low*	*Low*	*High*	*Low - Medium*
Mitigation: stabilise with drift fences, brushwood and with pioneer indigenous dune vegetation	*None*							

Table 6.2. Eskom Nuclear 1: Assessment of impacts at Bantamsklip

Impact	*Nature*	*Intensity*	*Extent*	*Duration*	*Consequence*	*Impact on irreplaceable resources*	*Probability*	*Significance*
Stability of the artificially vegetated dunes - constructing infrastructure, transmission lines and access roads								
Constructing infrastructure and access roads	*Negative*	*High*	*Low*	*High*	*Low*	*Medium*	*High*	*Medium*
Mitigation: stabilise with drift fences, brushwood and with pioneer indigenous dune vegetation	*None*							
Stability of the naturally vegetated late Pleistocene parabolic dunes - constructing infrastructure, transmission lines and access roads								
Exposure of soil to wind erosion	*Negative*	*Medium*	*Low*	*High*	*Low*	*Medium*	*High*	*Medium*
Mitigation: reduce wind erosion	*Negative*	*Low*	*Low*	*Low*	*Low*	*Low*	*High*	*Low - Medium*
Damage of vegetation	*Negative*	*Medium*	*Low*	*Low*	*Low*	*Medium*	*High*	*Medium*
Mitigation: careful rehabilitation	*None*							
Topsoil stockpile on artificially vegetated dunes								
Impact on artificially vegetated dunes	*Negative*	*Low*	*Low*	*Low*	*Low*	*Low*	*High*	*Low - Medium*
Mitigation: stabilise with drift fences, brushwood and with pioneer indigenous dune vegetation	*None*							
Topsoil stockpile on the naturally vegetated late Pleistocene parabolic dunes								
Exposure of soil to wind erosion	*Negative*	*Medium*	*Low*	*Low*	*Low*	*Medium*	*High*	*Medium*
Mitigation: reduce wind erosion	*Negative*	*Low*	*Low*	*Low*	*Low*	*Low*	*High*	*Low - Medium*
Damage of vegetation	*Negative*	*Medium*	*Low*	*Low*	*Low*	*Medium*	*High*	*Medium*
Mitigation: careful rehabilitation	*None*							
Topsoil stockpile on artificially vegetated dunes								
Impact on the artificially vegetated dunes	*Negative*	*Low*	*Low*	*Low*	*Low*	*Low*	*High*	*Low - Medium*
Mitigation: stabilise with drift fences, brushwood and with pioneer indigenous dune vegetation	*None*							
Spoils stockpile on the naturally vegetated late Pleistocene parabolic dunes								
Exposure of soil to wind erosion	*Negative*	*Medium*	*Low*	*Low*	*Low*	*Medium*	*High*	*Medium*
Mitigation: reduce wind erosion	*Negative*	*Low*	*Low*	*Low*	*Low*	*Low*	*High*	*Low - Medium*
Damage of vegetation	*Negative*	*Medium*	*Low*	*Low*	*Low*	*Medium*	*High*	*Medium*
Mitigation: careful rehabilitation	*None*							

Table 6.3. Eskom Nuclear 1: Assessment of impacts at Thyspunt

Impact	Nature	Intensity	Extent	Duration	Consequence	Impact on irreplaceable resources	Probability	Significance
Northern Access Road and conveyor belt or temporary haul road across mobile dunes and interdune wetlands of the Oyster Bay Mobile Dune Field								
Destruction and alteration of dune topography and interruption of natural sand movement (power station construction phase)	*Negative*	*High*	*Low*	*High*	*High*	*High*	*High*	*High*
Impact on dune, groundwater - wetland dynamics (operational phase)	*Negative*	*Medium*	*Low*	*Medium*	*High*	*Medium*	*High*	*Medium*
Mitigation: move the road eastward and avoid wetlands	*Negative*	*Low*	*Low*	*High*	*High*	*Medium*	*High*	*Medium*
Formation of blowouts	*Negative*	*Medium*	*Low*	*Low*	*Low*	*Medium*	*High*	*Medium*
Formation of blowouts (mitigated): stabilise and rehabilitate, install conveyor belt foundations using low diameter piles	*Negative*	*Low*	*Low*	*Low*	*Low*	*Low*	*High*	*Low - Medium*
Removal of conveyor belt or temporary haul road across mobile dunes and interdune wetlands of the Oyster Bay Mobile Dune Field (end of construction phase)								
Destruction and alteration of dune topography and interruption of natural sand movement (construction and operation)	*Negative*	*High*	*Low*	*Medium*	*High*	*High*	*High*	*High*
Mitigation: Careful rehabilitation with ECO	*Negative*	*Low*	*Low*	*Medium*	*High*	*Medium*	*High*	*Medium*
Northern Access Road: smooth access road across mobile dunes and interdune wetlands of the Oyster Bay mobile dune field - construction phase								
Constructing infrastructure and access roads	*Negative*	*High*	*Low*	*Low*	*High*	*High*	*High*	*High*
Mitigation: avoid wetlands, where possible, keep road narrow	*Negative*	*Low*	*Low*	*Low*	*High*	*Low*	*High*	*Low - Medium*
Mitigation: space culverts closely so that wetland functioning not impaired	*Negative*	*Low*	*Low*	*Low*	*High*	*Low*	*High*	*Low - Medium*
Mitigation: repair of blowouts and water erosion	*Negative*	*Low*	*Low*	*Low*	*Low*	*Low*	*High*	*Low - Medium*
Mitigation: ECO and special rehabilitation techniques	*Negative*	*Low*	*Low*	*Low*	*High*	*Low*	*High*	*Low - Medium*
Northern Access Road: smooth access road across mobile dunes and interdune wetlands of the Oyster Bay mobile dune field - operational phase								
Impact on dune - groundwater - wetland dynamics	*Negative*	*Low*	*Low*	*High*	*High*	*Medium*	*High*	*Medium*
Mitigation: none	*Negative*	*Low*	*Low*	*High*	*High*	*Medium*	*High*	*Medium*
Northern Access Road: aerodynamic bridge across mobile dunes and interdune wetlands of the Oyster Bay mobile dune field - construction phase								
Impact on dune - groundwater - wetland dynamics	*Negative*	*Medium*	*Low*	*Low*	*High*	*Medium*	*High*	*Medium*
Temporary construction road	*Negative*	*High*	*Low*	*Low*	*High*	*Medium*	*High*	*Medium - High*
Mitigation: ECO and special rehabilitation techniques	*Negative*	*Low*	*Low*	*Low*	*High*	*Medium*	*High*	*Low - Medium*
Northern Access Road: aerodynamic bridge across mobile dunes and interdune wetlands of the Oyster Bay mobile dune field - construction phase								

Impact	Nature	Intensity	Extent	Duration	Consequence	Impact on irreplaceable resources	Probability	Significance
Impact on dune - groundwater - wetland dynamics	Negative	High	Low	Low	High	Medium	High	Medium - High
Temporary construction road	Negative	Medium	Low	Low	High	Medium	High	Medium
Mitigation: ECO and special rehabilitation techniques	Negative	Low	Low	Low	High	Low	High	Low - Medium
Northern Access Road: aerodynamic bridge across mobile dunes and interdune wetlands of the Oyster Bay mobile dune field - operational phase								
Impact on dune - groundwater - wetland dynamics	Negative	Low	Low	Low	High	High	High	High
Continue careful rehabilitation of dune-groundwater - wetland	Negative	Medium	Low	Medium	High	Medium	High	Medium
Eastern and Western Access Roads across vegetated dunefield - construction phase								
Formation of blowouts	Negative	Medium	Low	Low	Low	Medium	High	Medium
Mitigation: stabilise, rehabilitate	Negative	Low	Low	Medium	Low	Low	High	Low - Medium
Eastern and Western Access Roads across vegetated dunefield - operational phase								
Usage of access roads	Negative	Low	Low	High	Low	Low	High	Low - Medium
Mitigation: None	Negative	Low	Low	High	Low	Low	High	Low - Medium
Transmission lines with 300-400m span across mobile dunes and interdune wetlands of the Oyster Bay mobile dune field - construction phase								
Constructing infrastructure and access roads	Negative	High	Low	High	High	High	High	High
Mitigation: Careful positioning of towers with ECO	Negative	Medium	Low	High	Low	Medium	High	Medium
Mitigation: Use helicopters for construction	Negative	Low	Low	Low	High	Medium	High	Low - Medium
Transmission lines with 300-400m span across mobile dunes and interdune wetlands of the Oyster Bay mobile dune field - operational phase								
Infrastructure and access roads	Negative	Low	Low	High	High	Medium	High	Medium
Mitigation: Use light vehicles for maintenance	none							
Transmission lines with 300-400m span across vegetated dune field - construction phase								
Constructing infrastructure and access roads	Negative	High	Low	Low	High	High	High	High
Mitigation: Locate towers on broad ridges and wide interridge valleys	Negative	Medium	Low	Low	Medium	Medium	High	Medium
Mitigation: Use helicopters for construction	Negative	Low	Low	Low	Medium	Low	High	Low - Medium
Transmission lines with 300-400m span across vegetated dune fields - operational phase								
Infrastructure and access roads	Negative	Medium	Low	High	Medium	Low	High	Medium
Mitigation: Use light vehicles for maintenance	Negative	Low	Low	High	Medium	Low	High	Low - Medium
Topsoil and spoils stockpiles on mobile dunes of the Oyster Bay dune field & Temporary conveyor belt or temporary haul road to carry topsoil and spoil across mobile dunes and interdune wetlands of the Oyster Bay mobile dunefield								
Impact on mobile dune field	Negative	High	High	High	High	High	High	High
Topsoil and spoils stockpile on naturally vegetated dune field								
Destruction of dune vegetation & topography	Negative	High	Low	Medium	Medium	Medium	High	Medium
Mitigation: Re-create original topography	Negative	Medium	Low	Medium	Medium	Medium	High	Medium

Table 6.4. Eskom Nuclear 1: Impacts on dune geomorphology at all three sites

Impact	*Nature*	*Intensity*	*Extent*	*Duration*	*Consequence*	*Impact on irreplaceable resources*	*Probability*	*Significance*
Potential impacts of climate change								
Creation of new active mobile dunefields due to sea-level rise	*Negative*	*High*	*Low*	*High*	*Low*	*Medium*	*Medium*	*Medium*
Mitigation: none	*Negative*	*High*	*Low*	*High*	*Low*	*Medium*	*Medium*	*Medium*
Blowout increase due to rainfall decrease and temperature increase	*Negative*	*Low*	*Low*	*Low*	*Low*	*Low*	*High*	*Low - Medium*
Mitigation: stabilise with drift fences, brushwood and with pioneer indigenous dune vegetation	*Negative*	*Low*	*Low*	*High*	*Low*	*Low*	*High*	*Low - Medium*

7 CONCLUSIONS AND RECOMMENDATIONS

7.1 Duynefontein

Groundwater does not “daylight” at Duynefontein and thus there are no impacts related to the interaction between groundwater and dune dynamics at this site.

Access roads and transmission lines can be built across the mobile dunes with operational impacts ranging from medium to low. Mobile dunes in the vicinity of infrastructure would need to be artificially stabilised. Access roads and transmission lines can be built across the artificially vegetated dunefield with insignificant operational impacts. Access roads and transmission lines can be built across the naturally vegetated parabolic dunefield with low operational impacts.

Topsoil and spoils stockpiles located on the mobile dunes will have medium operational impacts. Topsoil and spoils stockpiles located on the artificially vegetated dunefields or the naturally vegetated parabolic dunefield will have low operational impacts.

7.2 Bantamsklip

Groundwater does not “daylight” at Bantamsklip and so there are no impacts related to the interaction between groundwater and dune dynamics at this site.

Access roads and transmission lines can be built across the artificially vegetated dunefields with low operational impacts. Access roads and transmission lines can be built across the older naturally vegetated parabolic dunes with low operational impacts after careful rehabilitation.

Topsoil and spoils stockpiles located on the artificially vegetated dunefields or on the older naturally vegetated parabolic dunes will have low operational impacts.

7.3 Thyspunt

At Thyspunt groundwater “daylights” in many interdune areas within the Oyster Bay dunefield to form ponds in the interdune areas where wetlands are often found. The dune dynamics interacts with wetland, groundwater and surface water.

7.3.1 Access road, transmission lines, temporary conveyor belt or temporary haul road across the mobile, unvegetated dunes and interdune wetlands: Northern Access Road

An access road could be built across the mobile dunes of the Oyster Bay dunefield, using an aerodynamically smooth hard-surfaced road slightly raised above the interdune surface with frequent culverts, or with an aerodynamically shaped bridge that crosses the mobile dunes and interdune wetlands. Both structures would allow sand to be transported across the road without causing sand build-up and with little effect on surface water and groundwater flow. Further work on surface water and shallow groundwater flow is required to confirm this. The smooth hard-surfaced road and the aerodynamically shaped bridge would both have high impacts during the construction phase. The smooth hard-surfaced road would have a low operational impact. The aerodynamically shaped bridge would have a somewhat lower operational impact. The route must be laid out in close collaboration with dune and wetland specialists.

There would obviously be no impacts in the case of not building the Northern Access Road at all (as was the decision at the November 2009 integration meeting and as recommended in the Draft EIR).

Transmission lines can be built across the mobile Oyster Bay dunefield to the proposed HV yard in the "panhandle". The operational impacts of towers spaced at 300 - 400 m intervals would range from medium in the case of access roads being used for construction, to low in the case of helicopters being used for construction ***(the latter option was recommended in the Revised Draft EIR).*** Using towers spaced at 800 m intervals, the whole mobile dunefield could be crossed with no activities or structures being located within the mobile dunes and thus without any impacts whatsoever.

A temporary conveyor belt or haul road can be built across the mobile Oyster Bay dunefield to carry spoils to the "panhandle". The environmental impact would be low after the conveyor belt or haul road is removed and rehabilitation is completed. ***However, rehabilitation would be slow.***

7.3.2 Access roads across the fixed, vegetated dunes: Northern Access Road and Western Access Road

Access roads, transmission lines and a temporary conveyor belt or haul road could be built across the vegetated dunefield with low operational impacts. Installing the conveyor belt foundations using low-diameter piles instead of concrete foundations will reduce impacts further. Terraforce or similar blocks must be used to stabilise the sides of the cut and fill, as rehabilitation by vegetating the slopes will be difficult and slow.

7.3.3 Topsoil and spoils stockpiles

Topsoil and spoils stockpiles cannot be located on the mobile Oyster Bay dunefield. Topsoil and spoils stockpiles can be located on the vegetated dunefield, but the operational impact will be medium.

7.4 Climate change

The possible effects of climate change on dune dynamics are:

- Retreat of the coastline in response to higher sea level may shift or create new sandy beaches that supply wind-blown sand to dunes. Mobile dunes and dunefields may thus be created in areas that are currently vegetated.

- Rainfall decrease and temperature increase at Duynefontein and Bantamsklip will stress vegetated dunes, so it will be easier for blowouts to form. At Thyspunt, rainfall is not expected to change, but temperature will increase, so it will be somewhat easier for blowouts to form, but not as much as at the other sites.

- Wind speed increase is not expected to have any significant environmental impact.

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Company name	Illenberger & Associates
Specialist signature	
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