PROPOSED ESKOM KUDU 400Kv TRANSMISSION POWER-LINE FROM ORANJEMOND SUBSTATION TO JUNO SUBSTATION

AGRICULTURAL IMPACT ASSESSMENT

Prepared by:

JJN Lambrechts
F Ellis
A Kunneke

Department of AgriSciences
University Stellenbosch
Private Bag X1
Matieland
Stellenbosch
7602

Prepared for:

STRATEGIC ENVIRONMENTAL FOCUS
P.O. Box 74785
Lynnwood Ridge
0040

EXECUTIVE SUMMARY

1. Present land use

Five broad farming regions are recognized in the study area, viz. Coastal Region, Central Mountains and Broken Veld, Hardeveld, Knersvlakte and Olifants River Irrigation Region. The Coastal Region is primarily used for grazing. It is considered as the best grazing area in the Northwest Agricultural Sub-region because of the moderate summers and regular fog in the afternoons. The sandy nature of the soils acts as a sponge and prevents runoff and the marine clays in the subsoil act as a barrier that prevents deep drainage of water and it is retained in the soil for plant use. Because of the sandy nature of the soils, wind erosion is a severe risk in the event of over-grazing or other disturbances. The Olifants River Irrigation Region is a high-intensity irrigated farming area with irrigation water from the Clanwilliam and Bulshoek Dams. It is used for the production of a variety of high-income crops. The Hardeveld is the hilly area to the west of Nuwerus. Although the rainfall is generally higher than that of the Coastal Region, the hilly terrain and less sandy and predominantly shallow soils lead to a drier soil moisture regime. The two most important farming activities in this region are small livestock and small-grain production. The Central Mountains and Broken Veld Region is in many ways comparable to the Hardeveld. This region is characterized by a large variation is rainfall that range from as low as 100 mm to more than 300 mm per annum in the higher lying areas. Except for a small quantity of small-grain that is produced in the Swartdoring River area and Kamies Mountains, it is mainly used for small livestock. Late frost, however, causes problems in the production of small-grain because the heaviest frost normally occurs during the flowering stage of wheat. Sheep farmers in the Knersvlakte Region experience problems because of the low grazing potential of the natural veld. Natural veld recovery is very slow following disturbance events due to the low rainfall. Because of the low and unreliable nature of the rainfall in this semi-arid area, small-grain production is not an economically viable agricultural practice in the study area.

2. Comparative description of environment along the alternative corridors

Land type information (Land Type Survey Staff, 1972 - 2001) on which the assessment of the effect of the construction of transmission power-lines along the proposed alternative corridors might have on agriculture was checked against the soil-terrain information of Ellis (1988) and aerial photographs supplied by Mr. MV Richter and the site plan of the location of the photos.

A large number of land types occur along alternative transmission power-line corridors C and E. To compare the alternative corridors in terms of general agricultural soil suitability (definition of land type), soil properties (effective soil depth; topsoil clay content) and terrain characteristics (percentage level land; local relief) these properties were qualified according to a set of predetermined guidelines. Based on the distance that the transmission power-line cuts across a land type in an alternative route and the total distance of that particular route, a weighted average was calculated for each parameter.

Alternative C has the lowest average weighted suitability for general agriculture because of long distances of shallow red apedal soils (land type Ag) and shallow Mispah and Glenrosa form soils (land type Fb and Fc).

The soils are shallow (average effective depth is slightly more than 300 mm) with an average weighted clay content of more than 6 %. The terrain is predominantly uneven (hilly and mountainous) with less than 50 % level land and local relief of more than 300 m. The average annual rainfall is 157 mm.

Alternative E has a higher average weighted suitability for general agriculture compared to C. Relatively deep red apedal (land type Ae) and yellow and red, eutrophic, apedal soils (land type Ah) are common compared to shallow red apedal soils (land type Ag). The weighted average effective depth is more than 600 mm. The soils are sandy with a weighted average topsoil clay content of 6 %. The terrain is relatively even (less hilly) with more than 50 % level land and a local relief of around 150 m. The average annual rainfall is 110 mm.

Existing ESKOM servitude has the highest average weighted suitability due to the long distances of highly rated deep soils associated with land types Ae, Ah and Ai. The average soil depth is >900 mm and the topsoils are very sandy with less than 6 % clay. The terrain is predominantly level with average local relief of less than 150 m. No arable agriculture is practised because of the extremely low average annual rainfall of only 57 mm.

3. Relative wind and water erosion susceptibility

The two most important soil-related negative impacts during the construction and operational phases associated with the proposed transmission power-line from Oranjemond to Juno are accelerated wind and water erosion. Disturbance and even destruction of the natural vegetation in uncultivated areas with a natural veld cover as a result of heavy vehicle traffic will expose the soil surface to the direct mechanical transport effect of wind and surface flowing water. In cultivated lands heavy vehicle traffic could destruct existing soil aggregation making the soil more susceptible to wind erosion or it will, through compaction, create linear depression lines, along which accelerated water flow will take place that will increase water erosion.

The susceptibility of a land type to increased amounts of either wind or water is a function of the nature of the soils (soil form and topsoil texture), terrain type (percentage level land and local relief) and climate (average annual rainfall). To compare the alternative routes in terms of susceptibility to accelerated wind and water erosion as a result of disturbance, each land type (soil-terrain-climate combination) was characterised by a qualitative wind and water erosion rating based on a set of predetermined guidelines.

Due to the hilly and mountainous nature of the terrain along alternative C, many land types are susceptible to water erosion. Expressed as a percentage of the total distance of alternative C, land types with a moderate or severe water erosion hazard occupy 16 % and 62 % of the distance respectively. None of the land types are wind erosion sensitive.

The northern section of alternative E on the coastal plain, commonly with deep sandy soils, is sensitive to wind erosion. Land types with a moderate (25 km) or high (11 km) wind erosion hazard occupies approximately 13 % of the route. The southern section cuts across the hilly Hardeveld with shallower soils on rock. In this section land types with a moderate or high water hazard covers about 28 km (10 %) and 72 km (26 %) respectively of the route.

The water erosion hazard along the existing ESKOM servitude is very low. Due to the dry, windy climate and the sandy nature of the soils, the wind erosion hazard is predominantly moderate (93 km; 71 %) to severe (21 km; 16 %).

4. Impact assessment

Heavy vehicle traffic during the construction phase and traffic along the service road along the transmission power-line during the operational phase will lead to accelerated wind and water erosion along certain land types with a moderate to severe wind and water hazard. These two negative impacts as well as the effect on grazing and dry land small-grain production and on the Olifants River Farming Region will be discussed.

4.1 Wind erosion

The soil surface will be exposed due to clearance and destruction of the natural vegetation for roads used by heavy construction vehicles, at pylon construction sites and during the construction of the service road that will be used during the operational phase. Land types with a moderate to severe wind erosion hazard will experience accelerated wind erosion during dry, windy periods, especially in the low rainfall northern section of the transmission power-line corridors, along the cleared roads and pylon construction sites. Sand/soil will be blown out and away from the cleared roads and deposited in a downwind direction onto the existing vegetation. Unstable, young dunes may develop if the erosion action is severe. If the impact is severe, these blown-out sections will lose all fertile topsoil and the natural seed bank destroyed. Recovery of these areas will be very slow and may even remain bare for an extended period of time. The young, unstable dunes that might develop will be susceptible to further wind erosion and will remain bare for a long period. Without mitigation the impact of wind erosion will be of low to medium significance along the northern section of alternative E and of medium significance along the exiting ESKOM servitude. Wind erosion will be of no significance along alternative C.

4.2 Water erosion

Clearance and destruction of the natural vegetation for dirt roads used by heavy construction vehicles will expose the soil surface. Wheels of construction vehicles will compact the soil to form linear depressions. The same will happen during the construction of the service road that will be used during the operational phase. Land types with a moderate to severe water erosion hazard will experience accelerated water erosion along the cleared roads during rain events, especially when precipitation rate is high. At pylon construction sites this hazard will be low because of the localized clearing of vegetation. Soil will be eroded along the cleared and compacted roads and will be deposited on lower, down-slope positions with a slope gradient small enough that the flow rate is slowed down to a level where the transported soil material will deposit and accumulate. The above-mentioned eroded areas will loose fertile topsoil and even relatively infertile subsoil. Under severe erosion all the soil will be removed and the underlying weathering base rock will be exposed.

Together with the fertile topsoil the natural seedbed will also be lost throughout the eroded area. The vertical and linear extent of the erosion will depend on the rainfall intensity, the number of rainfall events, slope gradient and slope length. It is further affected by the high levels of extractable magnesium plus sodium in subsoils developed from *in situ* weathered undifferentiated granites and gneisses of the Namaqualand Metamorphic Complex. On long, steep slopes the potential water erosion will be significantly greater, especially along the lower section of the slope, than on short, less steep slopes. Under less severe conditions only part of the topsoil will be removed and the erosion scar can be covered by shallow plough or disc cultivation laterally across the eroded area. Under severe conditions the water will remove the topsoil and cut into the underlying subsoil to form gullies with vertical edges. Depending on the amount of rain and rate and volume of runoff water as well as the nature of the soil, two narrow gullies will form along the compacted wheel track alignments or, under extreme conditions, virtually all the soil along the road can be removed to form fairly wide, deep gullies. Deep, wide gullies are difficult to rehabilitate. The down-slope accumulated soil material must mechanically be brought back to fill the gully. Along alternative C from Schaaprivier east of Springbok to as far south as Nuwerus, and along the central section of alternative E the nature of the terrain and chemical composition of the subsoil are of such a nature that the impact of water erosion will be at least of medium significance. The significance of the impact of water erosion will be higher during both the construction and operational phases for those sections of the route that crosses lands cleared for small-grain production compared to natural veld.

4.3 Impact on grazing and dry land small-grain production

Clearing and destruction of the natural vegetation will lower the grazing potential until that time that the cleared areas have become revegetated, while soil compaction in lands cleared for small-grain production will lower the yield potential. During the construction phase the cleared construction road and pylon sites will have a small impact over a short time span on total area available for grazing. After rehabilitation of the veld along the construction road and at pylons, only the service road will continue to have a low grazing potential. The total area occupied by the service road, however, will be very small compared to the total area grazed and will have a negligible impact on the grazing potential. South of Namaqua National Park along alternative E and along alternative C from Kamieskroon to Nuwerus there are fairly extensive areas cleared for small grain production. During the construction phase, construction roads and pylon construction sites will have a negative impact on crop production practices if it coincides with the period from land preparation for sowing of small-grain to harvest. During non-growing periods, on fallow lands and during the operational phase after rehabilitation it will have no impact on small-grain production. During the operational phase the service road will have a small negative or positive impact on small-grain production. The positive impact is when the farmer uses the service road as an additional access road to camps or plowed fields. The impact is negative when the service road has no advantage as an access road and cannot be used for planting of small-grain crops. The area occupied by the service road, however, is small compared the total area of cultivated lands. Because of the low small-grain yield potential in the study area as a result of the low and unreliable rainfall during the growing season, the net production loss associated with the service road is therefore low and the significance low.

4.4 Impact on the Olifants River Irrigation Farming Region

From north of Koekenaap to Juno the route of alternative E follows and cuts across the irrigated, high value land of the Olifants River Irrigation Farming Region. Due the high impact during the construction phase of the transmission power-line as well as during the operational phase on all agricultural activities and loss of valuable land and crops, this section of alternative E cannot be considered as a viable option.

5. Conclusion and recommendations

The main agricultural impacts associated with the construction of the transmission power-line and the service road are accelerated wind and water erosion that will affect grazing potential and suitability of the soils for small-grain production. Along alternative C wind erosion is of no significance, but water erosion is significant along 270 km the route. Along alternative E water and wind erosion is significant along 100 km and 36 km respectively of the route. Along the existing ESKOM servitude the equivalent distances are 4 km and 113 km. A range of mitigation measures can be implemented to eliminate or minimise these impacts. Most important is to keep the cleared and disturbed area as small as possible; i.e. minimum lateral disturbance. The alignment of the transmission power-line could be changed to bypass very erodible land types. In wind erosion sensitive land types construction should be done in winter when the soils are moist/wet and in water erosion sensitive land types during the non-rainy months of the year. During construction signs of accelerated wind or water erosion must continuously be monitored and recommended mitigation measures implemented; e.g. mulching or artificial windbreaks for wind erosion or construction of water diversion ridges for water erosion.

It is concluded that, although there are significant impacts in terms of accelerated wind and water erosion and potential loss of grazing potential during the construction phase, these impacts are of short duration provided that the recommended mitigation measures are followed. Along the transmission power-line service road these impacts will exist as long as the transmission power-line is operational. The degree of the impact on the production potential of small-grain during the construction phase will depend on the period of the year that construction takes place compared to the planting and growing period of small-grain. The service road, however, will have a long-term effect if it cuts across cleared lands. To improve the yield potential for small-grain the soil along compacted construction roads and at pylon sites must be loosened with a tine implement during summer or spring when the soil is dry.

Although the agricultural potential of the soils along alternative E is on average higher than that of the soils along alternative C, E is the preferred alternative from an agricultural perspective. Along this alternative the rehabilitation of disturbed areas, especially wind disturbed, will be faster due to the more level terrain and the prevailing fog that supplements the water requirement of young seedlings. To rehabilitate disturbed, especially water eroded, areas with steep slopes as along alternative C, require considerably more inputs.

It is recommended that a competent individual or organisation is appointed that will monitor the effect of the actions during the construction phase on accelerated wind and/or water erosion and control the implementation of the required mitigation measures. The impact of the service road should be monitored in a similar way over the long-term.

TABLE OF CONTENTS Page

EXECUTIVE SUMMARY

REPORT

TABLES Page

FIGURES Page

APPENDIX TABLES Page

APPENDIX FIGURE Page

1. INTRODUCTION

This is a specialist report that will assess the impact of the Kudu Integration project for transmission power-lines and substations on the surrounding environment with specific reference to agriculture.

2. BACKGROUND AND BRIEF

The purpose of this study was to assess the environmental impact on agriculture of the ESKOM Kudu Integration project. This entailed the following:

1. Provide a short comparative assessment of the alternative alignments identified during the scoping phase.
2. Establish the baseline condition of potentially affected agricultural areas found within the area of influence of the proposed transmission power-line(s).
3. Identify what possible (positive and/or negative) impacts of the proposed transmission power-line(s) and all associated infrastructure (e.g. expansion of the substations) could have on existing agricultural activities, including dry land agriculture, irrigated agriculture and grazing during the construction and operational phases of the development.
4. Recommend mitigation measures to reduce or eliminate negative impacts and enhance any possible positive impacts on agricultural activities.
5. Compile a report on the above aspects.

3. STUDY APPROACH

3.1 Information base (source)

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

1. A literature review: The following documents were found to be applicable to the study:
   a. Scotney *et al*. (1987);
   b. Land Type Survey Staff (1972 - 2001);
   c. Ellis, F (1988);
   d. Department of Agriculture and Water Supply (1989);
   e. Elsenburg Agricultural Development Institute (1991); and
   f. Provincial Government Western Cape (2003).

2. A site visit during 3-6 May 2005 that included flying sections of alternative route A between Juno and Gromis substations as proposed by ESKOM and the existing servitude between Gromis and Oranjemond, and ground inspection of the area around the existing substations. Ground truthing study of the southern section of the route from Koekenaap to Juno was

conducted during the Olifants/Doring River irrigation study (Provincial Government Western Cape, 2003).

3. Additional information that was used includes a series of oblique aerial photographs taken during the flight excursion by Mr. MV Richter of Moore Spence & Jones (Pty) Ltd, Consulting Geotechnical, Civil & Environmental Engineers, Westville, 3630. These photographs cover alternative route A from Juno to Namagua National Park and from Gromis to Oranjemond.

4. Professional judgement based on experience gained with similar projects.

3.2 Assumptions

Due to the extent of the proposed alternative corridors C and E, and the inaccessible nature of large sections of the corridors, it was impossible to do a proper ground study of the soil types and distribution patterns along the corridors. The only database that fully covers the soil, terrain and climate variation along the corridors is the land type maps and soil, terrain and climate inventories of the study area (Land Type Survey Staff, 1972 – 2001). Because the assessment of the impact of the ESKOM Kudu Integration Project on agriculture in the affected areas is largely based on the land type information, it was assumed that the land type information is essentially correct in terms of delineation the land type polygons and soil-terrain-climate characterisation of the polygons.

3.3 Limitations

Factors that could limit the accuracy of the information on variation in soils, terrain and climate along the proposed transmission power-line corridors and the implications of these limitations for the findings of the EIA process include the following:

1. The scale of the project and length of time available for site visits was insufficient for proper ground truthing.

2. The proposed alignments cross mostly private and mining property onto which access in most instances is difficult or impossible.

3. The proposed alignments mostly crossed inaccessible areas; i.e. dune fields, hilly and mountainous areas and through agricultural fields.

Because the agricultural impact assessment is essentially based on land type information, these limitations should not limit the level and reliability of the information acquired.

3.4 Glossary of terms

Aeolian: Pertaining to wind; especially soils and deposits whose constituents were transported and laid down by atmospheric currents.

Study area: Refers to the entire study area, encompassing alternative alignments C, E and the existing ESKOM servitude as indicated on the study area map.

Corridor: Refers to a specific alignment as numbered on the study area map.

Alternative alignment: Refers to a specific alignment with one of the variations.

Proposed servitude: Refers to the proposed final alignment that the transmission power-line should follow.

Transmission power-line: Pylons that support the 400 kV transmission power-lines consist of two steel support structures, supported by guy wires. Transmission power-lines are suspended between the supports.

Sub-station: A distribution point within the local and national network from which electrical current is rerouted along different transmission power-lines as well as distributed to local and municipal networks.

3.5 List of abbreviations

ARC	Agricultural Research Council
ca	An accumulation of carbonates of alkali earth metals, usually calcium
cs	An accumulation of gypsum
Cv	Clovelly soil form: Orthic A - Yellow-brown apedal B - Unspecified material
db	Dorbank; reddish brown silica cemented hardpan
Du	Dundee soil form: Orthic A - Stratified alluvium
EIR	Environmental Impact Report
Es	Estcourt soil form: Orthic A - E horizon - Prismacutanic B
Fw	Fernwood soil form: Orthic A - Regic sand
gc	Gleyed clay, usually with a firm consistence
Gs	Glenrosa soil form: Orthic A - Lithocutanic B
ha	Hectare
hp	A hardened material cemented by iron oxides that cannot be cut, even in a wet condition, with a spade (hardpan ferricrete)
Hu	Hutton soil form: Orthic A - Red apedal B - Unspecified material
ISCW	Institute for Soil, Climate and Water
Ka	Katspruit soil form: Orthic A - G horizon
ka	A hardened material cemented by calcium carbonate (calcrete)
Kd	Kroonstad soil form: Orthic A - E horizon - Gleycutanic B
km	Kilometre
km h^{-1}	Kilometre per hour
m	Metre

mm	Millimetre
Ms	Mispah soil form: Orthic A - Hard rock; hardpan calcrete or dorbank
ne	Unconsolidated material with weak signs of soil development
Oa	Oakleaf soil form: Orthic A - Neocutanic B - Unspecified material
Pn	Pinedene soil form: Orthic A - Yellow-brown apedal B - Gleycutanic B
pr	A material, that is not a gleyed (wet) clay, with a strongly developed prismatic or columnar structure
R	Hard rock
so	Weathering rock that, although unconsolidated, still has easily recognisable geogenic properties (saprolite)
Ss	Sterkspruit soil form: Orthic A - Prismacutanic B
Sw	Swartland soil form: Orthic A - Pedocutanic B - Saprolite
U	Unconsolidated material without saprolitic properties
Va	Valsrivier soil form: Orthic A - Pedocutanic B - Unconsolidated material
Vf	Vilafontes soil form: Orthic A - E horizon - Neocutanic B
vp	Soil material that is not gleyed and the colour not dominantly red, with structure that is at least moderate blocks in the moist state

3.6 Methodology

3.6.1 Literature survey

In **3.1 Information Base** the publications that cover the soils, terrain, climate as well as agricultural activities along the proposed alternative transmission power-line corridors are listed. It was therefore considered unnecessary to do a detailed literature search for additional information that would only cover specific facets in localised areas.

3.6.2 Verifying land type information

The land type information (Land Type Survey Staff, 1972 - 2001) on which the assessment of the effect of the transmission power-lines along the proposed corridors might have on agriculture was checked against the soil-terrain information of Ellis (1988). The aerial photographs supplied by Mr. MV Richter and the site plan on which the position of the different photos relative to the alternative corridor A and the existing ESKOM servitude are indicated, were also used to confirm the nature of the different land type polygons and general land use.

No additional ground truthing was done.

3.6.3 Land type data extraction

The delineation of the alternative transmission power-line corridors C and E, and the existing ESKOM servitude, was added as a separate layer on the digitised land type map database as supplied by the Institute of Soil, Climate and Water, Agricultural Research Council (ARC), Pretoria, to the Department of GIS and Earth Observation, Faculty of AgriSciences, University Stellenbosch (**Appendix Figure 1**). From the combined land type maps and corridor delineations the land types that are traversed by the alternative transmission power-line routes were extracted from the database and sequentially numbered from north to south. The distance that the transmission power-lines cut across each land type was determined. For each alternative corridor a list of land types, sequentially arranged from north to south, including the distance that the line crossed the land type, was compiled (**Appendix Table 1**).

From the land type inventories (Land Type Survey Staff, 1972 - 2001) the land type symbol, terrain type symbol, climate zone and soil forms and series were extracted. Soil forms are the higher level in the Binomial Soil Classification System for South Africa and are defined in terms of a specific vertical sequence of diagnostic horizons (MacVicar *et al*., 1977). Soil forms are subdivided into soil series, the second level in the system, using soil additional soil properties that are not used in the definition of diagnostic horizons. For each soil series, or group of soil series in a land type the effective depth (in mm), percent of land type, range of clay content in the topsoil and subsoil limitations were tabulated. The mean annual rainfall for each land types was obtained from the definition of the climate zone of the specific land type.

To compile a chemical profile of the different soil series/types in the affected area, analytical data of modal profiles was extracted from the soil inventories.

This information was used to qualify land types in terms:

1 effective depth;
2 profile water retention;
3 susceptibility to water erosion;
4 susceptibility to wind erosion;
5 risk of flooding; and
6 wetness.

4. DESCRIPTION OF THE AFFECTED ENVIRONMENT

4.1 General overview of affected environment

4.1.1 Geomorphology

The study area can be subdivided into three broad geomorphological units.

The western unit is a broad coastal plain with an inland elevation of approximately 200 m above sea level and gradual slope towards the coast. The monotonous landscape is broken by a number of low hills that may reach an elevation of 300 m and more and river valleys such as the Holgat and Buffels Rivers. The coastal plain is covered by a variety of Tertiary marine sediments with a blanket of relatively old (red sands) to recent unstable (dunes) aeolian deposits of varying thickness. Common pedological materials throughout the plain are subsoil hardpans cemented by sepiolite (sepiocrete), silica (reddish coloured dorbank) and lime (calcrete). In many deep exposures more than one hardpan may be found in a vertical profile. Old termite mounds (heuweltjies) are another common soil feature on the coastal plain. On the higher lying inland part of the plain the density of heuweltjies is very high and decreases towards the coast. Soils associated with the heuweltjies usually contain free lime and/or silica; either as soft calcareous material or cemented as a hardpan.

To the east the coastal plain changes fairly abruptly into a rolling, hilly landscape, with crest heights from as low as 300 m at Perdekop to as high as 400 m at Swartrug in the so-called Hardeveld. The hilly landscape is broken by low-lying plains, approximately 200 m above sea level, associated with west-flowing rivers such as the Groen River. The hilly landscape is usually characterised by fairly shallow soils on poorly weathered undifferentiated granites and gneisses of the Namaqualand Metamorphic Complex. The hilly landscape is characterized by a very high density of heuweltjies (**Figure 1**). The heuweltjies are always calcareous. The hardpan calcrete in the heuweltjies changes to red silica cemented dorbank in the surrounding soils provided that the soil is sufficiently stable and deep enough for dorbank development.

Figure 1: Landscape along the southern section of alternative E with abundant calcareous heuweltjies.

East of the rolling landscape along the northern and central sections of alternative C the landscape changes to low to moderately high mountains with a maximum elevation that range from 800 m to about 1 200 m above sea level. The base rock is undifferentiated granites and gneisses of the Namaqualand Metamorphic

Complex and the soils are usually shallow and poorly weathered. Heuweltjies are very common in localized areas.

4.1.2 Farming activity

Elsenburg Agricultural Development Institute (1991) subdivided the study area into the following broad farming regions: Coastal Region, Central Mountains and Broken Veld, Hardeveld, Knersvlakte and Olifants River Irrigation Region.

The Coastal Region is equivalent to the coastal plain described above and is primarily used for grazing. It can be considered the best grazing area in the Northwest Agricultural Sub-region mainly because of the moderate summers and regular fog in the afternoons. The sandy nature of the soils acts as a sponge and prevents runoff of water. The marine clays in the subsoil act as a barrier that prevents deep drainage of water and it is retained in the soil for plant use. Because of the sandy nature of the soils, wind erosion is a severe risk in the event of over-grazing or other disturbances. Plants in this region, however, have the ability to recover fairly quickly after disturbance events, especially in the southern part of the coastal plain where the rainfall is fairly high. In the north where rainfall is very low (≈50 mm per annum) the recovery is very slow. In the past certain areas were cleared to make lands for small-grain production. This practice, however, has stopped due to the sensitivity of the sandy soils for wind erosion. This region is the only one in the Northwest Agricultural Sub-region where such lands have become rehabilitated with natural plants.

The Olifants River Irrigation Region is a high-intensity irrigated farming area with irrigation water from the Clanwilliam and Bulshoek Dams. It is used for the production of a variety of high-income crops. In the Lutzville-Koekenaap area the main crops are wine grapes, tomatoes, onions, beans etc.

The Hardeveld is the hilly area to the west of Nuwerus. The rainfall is generally higher than that of the Coastal region, but the hilly terrain and less sandy and predominantly shallow soils results in a drier soil moisture regime. The two most important farming activities in this region are small livestock and small-grain production. These two activities are highly integrated in the sense that farmers produce their own fodder in the form of oats, wheat and hay, and stubble lands are used in summer for grazing. Up to 18 % of the better natural veld grazing has been cleared for small-grain production. The long-term small-grain production potential, even on the better soils, is low due to the unreliability of the rainfall during the growing season. Although reasonable yields are obtained during good rainfall years, crop failures are commonplace. Another problem associated with small-grain production is water erosion. Due to the high cost, most lands are not protected by contour-banks and water-eroded lands are common in the Hardeveld.

The Central Mountains and Broken Veld Region is in many ways comparable to the Hardeveld. This region is characterized by a large variation is rainfall that range from as low as 100 mm to more than 300 mm per annum in the higher lying areas. Except for a small quantity of small-grain that is produced in the Swartdoring River area and Kamies Mountains, it is mainly used for small livestock. Nearly 70 % of the farmers are dependent on veld grazing. The subdivision of old family farms resulted in many farms that are smaller than the average farm size in this region, and many are uneconomical units. Most of these uneconomical units occur in that part of the region where small-grain can relatively successfully be produced and contribute to the carrying capacity of the farms. Late frost, however, causes problems in the production of small-grain because the heaviest frost normally occurs during the flowering stage of wheat. The problem is further exacerbated by different planting dates that can range from early (April-May) to late (June) depending on rainfall. Although there is no alternative farming practices that can be recommended for this region, certain lupine cultivars and *Medicago's* could replace small-grain in the higher rainfall areas.

Sheep farmers in the Knersvlakte Region experience problems due the low grazing potential of the natural veld. Natural veld deterioration has taken place over large parts of the Knersvlakte as a result of overgrazing. Due to the low rainfall, natural veld recovery is very slow following disturbance events. In the past, areas with deep sandy soils northeast of Vredendal were cleared for wheat production. The practice has stopped due to the severe wind erosion of these exposed sandy soils.

From the aerial photographs taken during the flight from Juno along alternative route A to south of the Namaqua National Park, it is evident that large parts of the less steep mid- and lower slopes have been cleared for small-grain production (**Figure 2**). In certain areas these cleared lands are the dominant landscape feature. To put the small-grain production potential in that region in perspective, the crop water requirement during the growing season has to be compared to the average annual rainfall during that period.

Figure 2: Cleared lands for small-grain production south of Namaqua National Park along alternative E. Observe the impact of wind erosion along the central low-lying area.

Based on evaporation data the amount of rain required from May (sowing date) to September (harvest) to produce an annual grain crop such as wheat or oats can be estimated using crop conversion factors to convert class A-pan evaporation data to crop water requirement. The accepted conversion factors are 0.3 for May and June, 0.6 for July and August and 0.3 for September. Based on the climate statistics of climate zone 187W (Land Type Survey Staff, 1972 - 2001) the estimated crop water requirement is approximately 300 mm. The total average rainfall during the months May – September for this climate zone is only 90 mm. This value is comparable to the total average rainfall for the same months according to Department of Agriculture and Water Supply (1989) for the different farming regions, viz: Coastal Region 88 mm; Central Mountains and Broken Veld 111 mm; Hardeveld 96 mm; Knersvlakte 106 mm; Olifants River Irrigation Region 124 mm.

It is evident that the crop water requirement of small-grain is approximately three times higher than the average rainfall during the growing season. This together with the unreliable nature of the rainfall in this semi-arid area leads to the conclusion that small-grain production is not an economically viable agricultural practice in the study area.

4.1.3 Description of routes

The existing ESKOM servitude from Gromis to Oranjemond is on the coastal plain.

East of Gromis (elevation approximately 150 m) alternative C is on the coastal plain to as far as Buffelsbank at an elevation of 200 m. From Buffelsbank alternative C essentially follows the Buffels River valley to Schaaprivier. From Schaaprivier the route extends into the mountains and reaches an elevation of approximately 1 200 m at Springbok. From Springbok south to as far as Kamieskroon the route is in the moderately high mountains with an elevation around 1 000 m. From Kamieskroon to Rooiberg south of Nuwerus the route is in the low mountains and high hills at an elevation between 300 m and 400 m. From Rooiberg to Juno substation alternative C cuts across the Knersvlakte at an elevation of less than 250 m.

The northern section of alternative E also follows the coastal plain. From Gromis south to as far as Hondeklipbaai the elevation changes from approximately 150 m at Gromis, through a high of 240 m at Sonnekwa to 50 m at Hondeklipbaai. From Hondklipbaai east the elevation gradually increases to about 400 m near the farm Kameelboom. From Kameelboom south alternative E cuts through the rolling, hilly landscape. The elevation ranges from about 250 m to a maximum of approximately 400 m at Swartrug in the Hardeveld. From north of Koekenaap the elevation along alternative E drops to approximately 120 m and essentially follows the old, high-lying Olifants River erosion terrace at an elevation of less than 100 m to Juno.

In **Appendix Table 1** the different land types along the existing ESKOM servitude from Oranjemond to Gromis and alternative routes C and E from Gromis to Juno are listed with a specification of terrain type, mean annual rainfall, soil forms and subsoil limitations.

4.2 Comparative description of environment affected by alternatives

4.2.1 General

From **Appendix Table 1** it is evident that a large number of different land types occur along the alternative transmission power-line corridors. To compare the alternative corridors in terms of general agricultural soil suitability (as implied by land type), soil properties (e.g. effective soil depth and topsoil clay content) and terrain characteristics (percentage level land and local relief) it is impossible to use individual land types. For this reason these properties were qualified following the guidelines as set out in **Appendix Table 2** and **3**. For each property the lowest value (1) was given to the agriculturally most unsuitable class and the highest value to the most suitable class. For example an effective soil depth of 0-300 mm was rated 1 and >1 200 mm as 5, with three 300 mm intervals between classes 1 and 5.

Based on the distance that the transmission power-line cuts across a land type in an alternative route and the total distance of that particular route, a weighted average was calculated for each parameter listed above (see **Table 1**).

Table 1: Weighted average qualitative ratings for important soil and terrain characteristics and rainfall along the alternative transmission power-line corridors.

Alternative	Weighted average qualitative ratings					Weighted average annual rainfall (mm)
	Land type	Effective depth	Topsoil clay content	Percentage level land	Local relief	
Alternative C	4.5	2.0	1.2	2.4	2.2	157
Alternative E	5.9	3.0	1.1	3.1	2.9	110
Existing ESKOM servitude	6.1	4.0	1.0	3.9	2.7	57

Although the existing ESKOM servitude is fixed it is included for comparative purposes.

Alternative C

Based on land type symbols the soils have the lowest average weighted suitability for general agriculture in comparison to alternative E and the existing ESKOM servitude. This is the result of long distances of shallow red apedal soils (land type Ag) and shallow Mispah and Glenrosa form soils (land type Fb and Fc) relative to the distance of deeper red and other soils. This is reflected in the lowest effective depth rating of 2.0 that implies that the average effective depth is between 300 - 600 mm. The average weighted rating for topsoil clay content of 1.2 is higher than that of alternative E. The average weighed clay content is therefore more than 6 %. Although the average topsoil clay content of most of the land types north of Nuwerus is less than 6 %, land types from Nuwerus to Juno contain more than 6 % clay up to a maximum of 18.7 % in land type Fb571. The weighted average percentage level land rating of 2.4 and local relief rating of 2.2 is the lowest for the alternatives. This implies that the terrain is predominantly uneven (hilly and mountainous) with less than

50 % level land and a local relief of close to 300 m. The weighted average annual rainfall along this route is 157 mm. The reason for this high value is the high rainfall (up to 360 mm) in land types in high lying areas.

Alternative E

Based on land type symbols the soils have a average weighted suitability of 5.9 for general agriculture. This value higher compared to that of alternative C. Fairly long distances of red apedal (land type Ae) and yellow and red, eutrophic, apedal soils (land type Ah) that are deeper than 300 mm occur along this alternative. Shallow red apedal soils (land type Ag) with a lower suitability rating are found along the southern part of the route. The dominance of deeper soils compared to shallow soils along this alternative is reflected in a larger weighted average effective depth of 3.0 that implies that the average effective depth is more than 600 mm. Although a short distance of soils with more than 6 % clay occurs in the south along this alternative, the weighted average topsoil clay rating is 1.1. This implies that the average clay content is marginally more than 6 %. The weighted average percentage level land rating of 3.1 and local relief rating of 2.9 are both larger than that of alternative C. This implies that the terrain is more even (less hilly) with more than 50 % level land and a local relief of around 150 m. South of Namaqua National Park this route is characterised by fairly large areas of cultivated wheat lands. The weighted average annual rainfall along this route is 110 mm.

Existing ESKOM servitude

In comparison to the alternatives C and E, the average weighted land type rating of 6.1 is the highest. This is due to the large distances of highly rated deep soils associated with land types Ae, Ah and Ai. Only a small distance of shallow land type Ag soils occur along the route. The soils are deep (average depth >900 mm) and the topsoils are very sandy with less than 6 % clay. The average percentage level land is close to 80 % the average local relief is less than 150 m. No cultivated lands are found along this route. No arable agriculture is practised because of the extremely low average annual rainfall of only 57 mm.

4.2.2 Relative wind and water erosion susceptibility

The two most important soil-related negative impacts during the construction and operational phases associated with the proposed transmission power-line from Oranjemond to Juno are accelerated wind and water erosion (**Figure 3, 4** and **5**). Disturbance and even destruction of the natural vegetation in uncultivated areas with a natural veld cover as a result of heavy vehicle traffic will expose the soil surface to the direct mechanical transport effect of wind and surface flowing water. In cultivated lands heavy vehicle traffic could destruct existing soil aggregation making the soil more susceptible to wind erosion or it will, through compaction, create linear depressions lines along which accelerated water flow will take place and accelerate increase water erosion.

Figure 3: Pronounced wind erosion along the existing ESKOM servitude due to disturbance in a land type with pale coloured sandy soils.

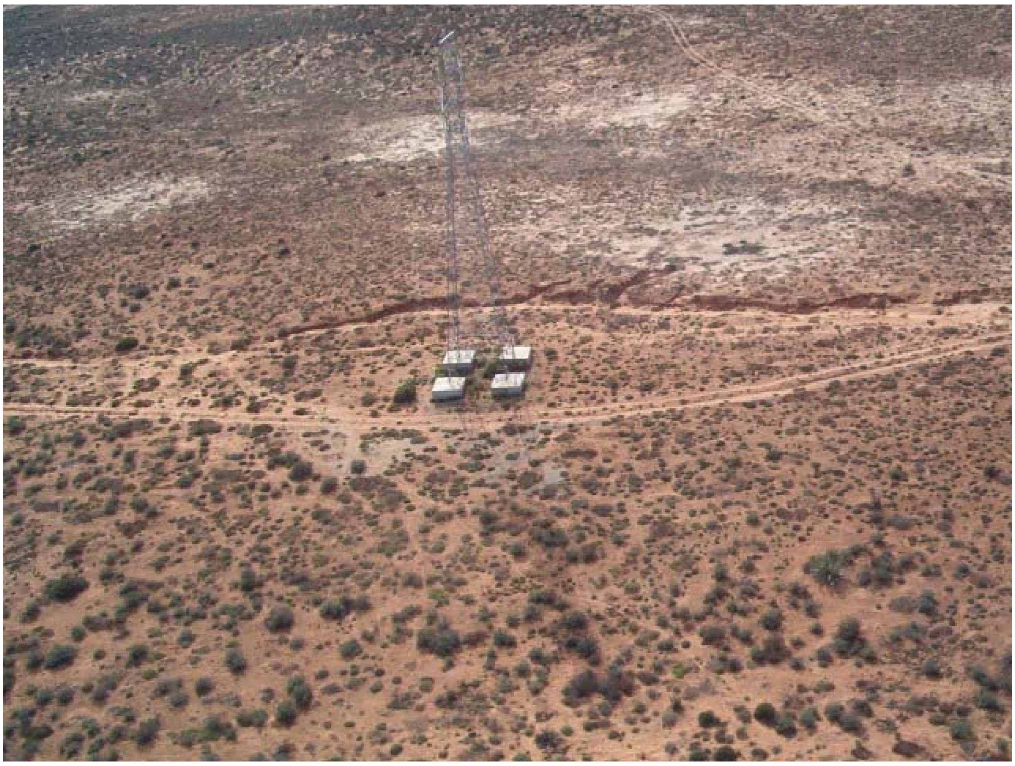

Figure 4: Pronounced water erosion along the existing ESKOM servitude as a result of preferential water flow in an old service road.

Figure 5: Pronounced water erosion in the Hardeveld due to overgrazing.

The natural variation in soils and terrain along the alternative transmission power-line corridors is very complex. Certain soil-terrain combinations are susceptible to accelerated wind erosion due to disturbance while other combinations are more susceptible to accelerated water erosion. To compare the alternative routes in terms of susceptibility to accelerated wind and water erosion as a result of disturbance, each soil-terrain combination was characterised by a qualitative wind and water erosion rating.

Evaluation of the wind erosion hazard is primarily based on the nature of soils. The following classes are used: Severe (1) = Dunes dominant; Moderate (2) = Dunes subdominant plus Fernwood soil form dominant; Low-Moderate (3) = Dunes rare and Clovelly soil form dominant; Low (4) = Deep sandy Hutton soil form dominant; None (5) = Other soils. The actual rating given to a specific land type was slightly modified according to the average annual rainfall. A specific land type along the existing ESKOM servitude with an extremely low rainfall was rated more susceptible to wind erosion than a similar land type in the southern section of the study area with a higher rainfall. Land types on the coastal platform with more regular wind with higher wind speed compared to similar inland land types were also given a higher wind erosion hazard rating.

According to Scotney *et al*. (1987) wind erosion can lead to very high soil losses and the hazard is probably greater than normally realized. In general, wind speeds of less than 20 km h^{-1} are not considered to be erosive. Wind erosion losses are significantly affected as the mass of 0.1 – 0.5 mm diameter particles in the topsoil increases. The mass of soil clods > 0.84 mm in the top 2.5 cm of the soil profile also affects erosion losses, where increased amounts decrease the erosion hazard. Wind erosion hazard is largely determined by texture. Scotney *et al*. (1987) classed a topsoil clay content of 0 - 6 % as a high wind erosion hazard and 6 - 10 % as a moderate to high risk.

Water erosion hazard ratings are based on the terrain type symbol. The percentage level land and relief classes were given ratings according to **Appendix Table 3**. The lower the percentage level land and greater the local relief the lower the rating. As a first approximation the two values for a specific terrain type were multiplied in the following manner:

(5 – Percentage level land rating) x (6 – Local relief rating)

An increase in the combined rating implies a decrease in the percentage level land and/or increase in local relief. Potential runoff and water erosion will therefore increase with an increase in the combined rating. These values were used to qualify the potential water erosion hazard of the terrain types along the transmission power-line routes (**Table 2**).

Table 2: Water erosion hazard of terrain types along the transmission power-line corridors [In brackets are the first approximation hazard values based on class ratings calculated as follow: (5 – Percentage level land rating) x (6 – Local relief rating)].

Local relief	**Percentage level land class symbol**			
	A	B	C	D
	Class description			
	>80 % of land has slope <8 %	50-80 % of land has slope <8 %	20-50 % of land has slope <8 %	<20 % of land has slope <8 %
	Water erosion hazard			
0-30 m	None (1)			
30-90 m	None (2)	Low (4)		
90-150 m	Low (3)	Low-Mod(erate) (6)	Mod(derate) (9)	
150-300 m	Low (4)	Mod(erate) (8)	Sev(ere) (12)	
300-900 m		Sev(ere) (10)	Sev(ere) (15)	Sev(ere) (20)

In **Appendix Table 4** the water and wind erosion hazard of the different land type based on terrain characteristics along alternative routes C and E and the existing ESKOM servitude are listed. In **Table 3** the information in **Appendix Table 4** is summarised. The total distance of the water and wind hazard classes are given for each alternative corridor. It is also expressed as a percentage of total distance.

Table 3: Distance of water and wind erosion hazard classes along alternative power-line corridors C and E and the existing ESKOM servitude and expressed as a percentage of the total distance.

Alternative (Total distance of corridor)	Water erosion				Wind erosion			
	Erosion class	Class symbol	Distance (km)	Percent of route	Erosion class	Class symbol	Distance (km)	Percent of route
Alternative C (345.3 km)	None	1	9.3	2.7	None	1	327.8	94.9
	Low	2	65.9	19.1	Low	2	15.7	4.5
	Low-Mod	3	0.0	0.0	Low-Mod	3	1.8	0.5
	Moderate	4	55.1	16.0	Moderate	4	0.0	0.0
	Severe	5	215.0	62.3	Severe	5	0.0	0.0
Alternative E (276 km)	None	1	29.3	10.6	None	1	82.3	29.8
	Low	2	125.8	45.6	Low	2	123.4	44.7
	Low-Mod	3	21.4	7.8	Low-Mod	3	34.7	12.6
	Moderate	4	27.5	10.0	Moderate	4	24.8	9.0
	Severe	5	72.1	26.1	Severe	5	10.9	3.9
Existing ESKOM servitude (130 km)	None	1	42.9	32.9	None	1	0.0	0.0
	Low	2	79.9	61.4	Low	2	11.8	9.1
	Low-Mod	3	3.5	2.7	Low-Mod	3	5.1	3.9
	Moderate	4	0.0	0.0	Moderate	4	92.7	71.2
	Severe	5	3.9	3.0	Severe	5	20.7	15.9

Along alternative C the majority of the land types have a moderate to severe water erosion hazard (55 km and 215 km respectively) and respectively covers about 16 % and 62 % of the total distance. Land types with no or low water erosion hazard occurs along 9 km (3 %) and 66 km (19 %) respectively of the route. The wind erosion hazard of 100 % of the land types was qualified as none or low. The high water erosion hazard is mainly due to the hilly to mountainous nature of the terrain, with an average weighted percentage level land in the order of 50 % and local relief close to 300 m.

The northern section of alternative route E is on the coastal plain with common deep sandy soils while the southern section cuts across the hilly Hardeveld with shallower soils on rock and onto the flat, old alluvial terraces of the Olifants River with heavier textured soils. For these reasons different land types are prone to either water or wind erosion. Land types with a moderate or high water hazard covers about 28 km (10 %) and 72 km (26 %) respectively of the route. Only 21 km (8 %) has a low-moderate hazard while land types along the rest of the route has no or a low water erosion hazard (155 km; 56 %). The wind erosion hazard is predominantly lower than moderate (240 km; 87 %). Land types with a moderate (25 km) or high (11 km) wind erosion hazard makes up less than 13 % of the route.

It is evident that the water erosion hazard along the existing ESKOM servitude is very low. However, due to the dry, windy climate and the sandy nature of the soils the wind erosion hazard is predominantly moderate (93 km; 71 %) to severe (21 km; 16 %).

5. IMPACT ASSESSMENT

Heavy vehicle traffic during the construction phase and traffic along the service road along the transmission power-line during the operational phase will lead to accelerated wind and water erosion along certain land types with a moderate to severe wind and water hazard. These two negative impacts as well as the effect on grazing and dry land small-grain production and on the Olifants River Farming Region will be assessed separately.

5.2 Wind erosion

The potential impact of accelerated wind erosion along certain sections of the alternative routes are summarised in **Table 4**.

- *Source of the impact:*

  Clearance and destruction of the natural vegetation for dirt roads used by heavy construction vehicles and at pylon construction sites that support the transmission power-line, will expose the soil surface. The same will happen during the construction of the service road that will be used during the operational phase.

- *Description of the impact:*

  Land types with a moderate to severe wind erosion hazard will experience accelerated wind erosion along the cleared roads and pylon construction sites during dry, windy periods, especially in the low rainfall northern section of the transmission power-line corridors. Sand/soil will be blown out and away from the cleared roads and deposited in a down-wind direction onto the existing vegetation. Unstable, young dunes may develop if the wind erosion is severe.

  If the impact is severe, these blown-out sections will lose all fertile topsoil and the natural seed bank is destroyed. Recovery of these areas will be very slow and may even remain bare for an extended period of time. The young, unstable dunes that might develop will be susceptible to further wind erosion and will also remain bare for a long period.

  The location of sections of the route with a moderate or severe wind erosion hazard is high lighted in **Appendix Figure 1**.

Table 4: Impacts of wind erosion

Nature	Loss of grazing capacity and potential arable land and formation of new unstable dunes	Status	-
Impact source(s)	Clearance of land for roads for construction vehicles, pylon sites and service road		
Affected stakeholders	Individuals or organisations with properties along the route; those concerned with conservation and tourism		
Alternative C			
Magnitude	*Extent*	No wind erosion expected	
	Intensity		
	Duration		
	Reversibility		
	Probability	Improbable	
Significance	*Without mitigation*	No significance	N
	With mitigation	No significance	N
Confidence	High		
Alternative E			
Magnitude	*Extent*	Local (36 km is moderately or severely affected along route)	
	Intensity	Low to medium	
	Duration	Short term	
	Reversibility	Reversible	
	Probability	Probable	
Significance	*Without mitigation*	Low-Medium	L-M
	With mitigation	No significance-Low	N-L
Confidence	High		
Existing ESKOM servitude			
Magnitude	*Extent*	Off-site (113 km is moderately or severely affected along route)	
	Intensity	Medium to high	
	Duration	Medium to long term	
	Reversibility	Reversible	
	Probability	Highly probable	
Significance	*Without mitigation*	Medium	M
	With mitigation	Low-Medium	L-M
Confidence	High		

The extent of accelerated wind erosion will be local along the construction vehicle roads in the central and southern sections of alternative E with a higher rainfall. In the northern section of alternative E and along the existing ESKOM servitude with a low rainfall and very low density of plant cover the impact of wind erosion will extend off-site in a down-wind direction. At pylon construction sites and along the service road the extent of the wind erosion impact will be similar to that of the construction vehicle roads. According to **Table 3** the distances along the service road over which wind erosion will have an impact on land types with a moderate or severe wind erosion hazard along the alternative corridors are:

- alternative C = 0 km;
- alternative E = 36 km; and
- existing ESKOM servitude = 113 km.

The distances along the construction roads in the different alternatives will be greater than that along the service road. Although the area affected by the footprint of the proposed crossrope suspension pylons that will be used is very small, the disturbance during construction activities could be considerably wider (**Figure 6**).

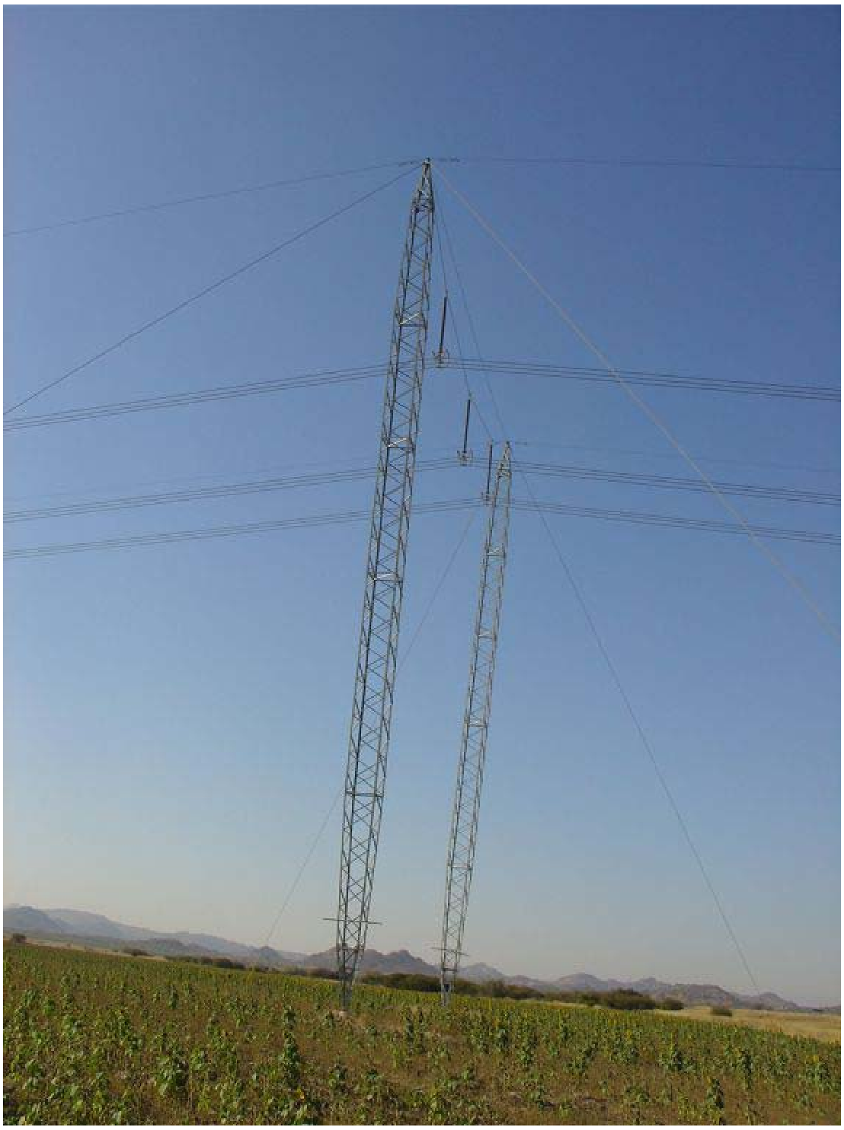

Figure 6: Example of a crossrope suspension pylon with a very small footprint near Pilansberg in the Northwest.

The intensity of the wind erosion impact in the southern higher rainfall sections of alternative E will be low. In the dry, low rainfall north (existing ESKOM servitude) and the northern section of alternative E the impact will range from medium to high along construction roads, service road and pylon construction sites. This difference in the intensity of the impact from north to south is due to the lower density of plants in the dry north compared to a denser vegetation cover in the south.

The wind erosion impact along construction roads and at the pylon sites will be of short-term duration along the central and southern sections of alternative E. In the dry north the duration of the impact will be medium to long term. The reason for the difference in the duration of the impact between north and south is the effect of the higher rainfall in the south on the recovery rate of the natural vegetation. As soon as the exposed soil surface is covered with plants, wind will have virtually no effect on sand mobilization and transport. Along the service road, however, the duration of the wind erosion impact will be long term because the soil surface and new plant growth are regularly disturbed.

It is highly probable that wind erosion will take place along the existing ESKOM servitude along construction roads, disturbed pylon sites and along the service road due to the dry, windy conditions and unstable nature of land types Af (include dunes) and Hb with very sandy soils. In the denser vegetated central and southern sections of alternative E wind erosion along construction roads and during construction of the pylons is probable. The probability that wind erosion will occur, however, will largely depend on the climatic conditions during construction. If construction takes place during a very dry season with strong winds, wind erosion is highly probable while it is improbable that wind erosion will take place during a period when the rainfall is sufficient to wet the soils to a depth of at least 300 mm. Along the service road wind erosion is highly probable because the soil surface is regularly disturbed and vegetation destroyed.

- *Significance:*

Only along the existing ESKOM servitude the significance of wind erosion as an impact is medium to high without mitigation and medium with mitigation. This is due to the dry, windy climatic conditions as well and the very sandy nature of soils in certain land types (some with dunes as an integral component of the land type). Rehabilitation of affected areas will also be very slow and, though reversible, it will take a long time.

Along alternative E the significance of the impact is considered none to low because of the fewer land types with wind erosion sensitive soils, higher average annual rainfall, denser vegetation and lower wind speeds compared the existing ESKOM servitude. The combination of factors will restrict the spatial effect of wind erosion as an impact to small wind sensitive disturbed areas that, however, will recover relatively fast and become revegetated under the higher rainfall conditions.

- *Mitigation:*

Mitigation measures that can minimize or even prevent the effect of wind erosion in disturbed areas include the following:

- Clearance of vegetation for construction roads in wind sensitive land types should be avoided. Non-sensitive land types should be selected wherever possible. If possible the transmission power-line route should be shifted laterally from wind sensitive land types to adjacent less wind sensitive land types.

- Construction on wind sensitive land types should preferably be done during the rainy season and not during dry, windy months of the year.
- The width of the strip cleared of vegetation for construction roads should be reduced and kept as narrow as possible. The lateral extent cleared at construction sites for pylons should be kept as small as possible.
- During the construction phase sections of construction roads and pylon sites that experience accelerated wind erosion should be protected by windbreaks (e.g. nets) or covered with organic (e.g. straw) or synthetic mulches.
- After construction, wind eroded areas that do not recover and become revegetated after good rains and continue to be affected by wind erosion (e.g. along the existing ESKOM servitude) should be kept covered with an organic or synthetic mulch or windbreaks (e.g. nets) could be erected. Reseeding of affected areas combined with mulching should be considered.
- Mitigation of wind erosion sensitive and affected areas along the service road is virtually impossible because of the continuous disturbance of the soil surface and destruction of new plant growth. Mulching and windbreaks might be considered, although the latter option could have a negative visual impact on the environment.

5.2 Water erosion

The potential impact of accelerated wind erosion along certain sections of the alternative routes are summarised in **Table 5**.

- *Source of the impact:*

  Clearance and destruction of the natural vegetation for dirt roads used by heavy construction vehicles will expose the soil surface. Wheels of construction vehicles will also compact the soil to form linear depressions. The same will happen during the construction of the service road that will be used during the operational phase.

- *Description of the impact:*

  Land types with a moderate to severe water erosion hazard will experience accelerated water erosion during rain events, especially when the precipitation rate is high, along the cleared roads. At pylon construction sites this hazard should be low because of the localized clearing of vegetation. Soil will be eroded along the cleared and compacted roads and will be deposited on lower, down-slope positions with a slope gradient small enough that the flow rate is slowed down to a level where the transported soil material will deposit and accumulate.

Table 5: Impacts of water erosion

Nature	Loss of grazing capacity and potential arable land due to surface water erosion and formation of erosion gullies	Status	-
Impact source(s)	Clearance of land for roads for construction vehicles, pylon sites and service road		
Affected stakeholders	Indivi duals or organisations with properties along the route; those concerned with conservation and tourism		
Alternative C			
Magnitude	*Extent*	Local (270 km is moderately and severely affected along route)	
	Intensity	Medium to high	
	Duration	Medium to long term	
	Reversibility	Reversible	
	Probability	Highly probable	
Significance	*Without mitigation*	Medium	M
	With mitigation	Low	L
Confidence	High		
Alternative E			
Magnitude	*Extent*	Local (100 km is moderately and severely affected along the route)	
	Intensity	Medium	
	Duration	Medium	
	Reversibility	Reversible	
	Probability	Highly probable	
Significance	*Without mitigation*	Low to medium	L-M
	With mitigation	Low	L
Confidence	High		
Existing ESKOM servitude			
Magnitude	*Extent*	Local (4 km is severely affected along route)	
	Intensity	Medium	
	Duration	Medium	
	Reversibility	Reversible	
	Probability	Probable	
Significance	*Without mitigation*	Low	L
	With mitigation	Low	L
Confidence	High		

The above-mentioned eroded areas will lose fertile topsoil and even relatively infertile subsoil. Under severe erosion all the soil will be removed and the underlying weathering base rock will be exposed. Together with the fertile topsoil the natural seedbed will also be lost throughout the eroded areas.

The vertical and linear extent of the erosion will depend on the rainfall intensity, the number of rainfall events, slope gradient and slope length. On long, steep slopes the potential water erosion will be significantly greater, especially along the lower section of the slope, than on short, less steep slopes. Under less severe conditions only part of the topsoil will be removed. The extent of the erosion will be such that the erosion scar can be covered by shallow plough or disc cultivation laterally across the eroded area. Under severe conditions the water will remove the topsoil and cut into the underlying subsoil to form gullies with vertical edges. Depending on the amount of rain, rate and volume of runoff water as well as the nature of the soil, two narrow gullies will form along the compacted wheel track alignments or, under extreme conditions, virtually all the soil along the road can be removed to form fairly wide, deep gullies. Deep, wide gullies are difficult to rehabilitate. The down-slope accumulated soil material must mechanically be brought back to refill the gully.

Another factor that influences the water erodibility of the soils, especially the subsoil, is the relative concentration of extractable ions. In soils with a low erosion hazard, extractable calcium usually dominates the exchange complex with low concentrations of magnesium and sodium. Most soils in the study area that developed from *in situ* weathered undifferentiated granites and gneisses of the Namaqualand Metamorphic Complex, however, contain more extractable magnesium plus sodium than calcium in the subsoil. Sodium - magnesium rich soil material is physically unstable. This chemical condition will accelerate the mechanical removal of soil material by flowing water through clay dispersion.

The land types that are moderately or severely susceptible to water erosion are highlighted in **Appendix Figure 1**. These are mostly land types with a low percentage level land and great local relief; i.e. hilly, mountainous terrain. Terrain forms with a moderate water erosion hazard include B4 and C3, while B5, C4, C5 and C5 have a severe hazard.

According to **Table 3** the distances along the service road over which water erosion will have an impact on land types with a moderate or severe water erosion hazard along the alternative corridors are:

- alternative C = 270 km;
- alternative E 100 = km; and
- existing ESKOM servitude = 4 km.

- *Significance:*

Along alternative C from Schaaprivier east of Springbok to as far south as Nuwerus, and along the central section of alternative E the terrain and chemical composition of the subsoil are of such a nature that water erosion will have a moderate to severe impact. Depending on the slope gradient and length over which runoff is canalised along cleared construction and service roads the extent of the impact may range from site to off-site. The significance of water erosion as an impact should generally be medium without mitigation and low with mitigation. Under exceptional conditions (e.g. more than one event with a high rainfall intensity within a few days) the impact without mitigation could, however, be high. Once a deep gully has scarred the landscape it will be difficult to ameliorate and even with mitigation will have a medium to high impact

Along the construction roads the intensity will vary from low to medium depending on the duration of use and whether the roads are used during summer or the rainy season. With a low intensity the duration of the impact will be short term and the impact will be reversible because of the relatively high rainfall along alternatives C and E, provided that the road is in natural veld that will act as a natural seed bank

Along the service road that will be used on a regular basis, the impact intensity of water erosion will at least be medium because of the regular compaction and disturbance of new plant growth. The impact will be long term and will be irreversible. In natural veld with a low runoff intensity the impact will be lower than in cleared fields with high runoff intensities on steep and long slopes.

The impact assessment criteria will have a higher or more severe rating for water erosion during both the construction and operational phases for those sections of the route that crosses cleared lands compared to natural veld. Along the southern sections of alternatives C and E fairly extensive areas have been cleared for small-grain production and will therefore be more impacted by water erosion than the northern sections, and water erosion impacts on these lands will be more difficult to rehabilitate.

- *Mitigation:*

Mitigation measures that can minimize the effect of water erosion in disturbed areas or even prevent water erosion to take place include the following:

- Clearance of vegetation for construction roads along very steep areas that are sensitive to water erosion should be avoided. Less steep areas (land types with a higher percentage level land and relatively small local relief) with a lower water erosion hazard should be selected wherever possible. If possible the transmission power-line route should be shifted away from water erosion sensitive land types to adjacent less sensitive land types.
- Construction on water erosion sensitive land types should preferably be done during the dry season.
- The width of the strip cleared for construction roads should be kept as narrow as possible.
- During construction of the transmission power-line, runoff along sections of construction roads that are steep over long distances and therefore sensitive to water erosion, should be minimized by constructing ridges in the road to divert runoff water into the adjacent natural veld.
- After construction, the compacted soil material along construction routes and at pylon sites should be loosened with a tine implement to improve water infiltration. Revegetation will also be faster on the loosened soil compared to compacted soil material.
- Water eroded areas that do not recover and become revegetated after good rains and continue to be affected by water erosion should be kept covered with an organic mulch. Reseeding of affected areas combined with mulching should be considered.
- Mitigation of water erosion along long and steep sections of the service road is difficult because of the continuous disturbance of the soil surface and destruction of new plant growth. Water diversion ridges must be constructed at regular intervals on steep sections of the service road to shorten the runoff distance and lower the water erosion hazard.
- At the first signs of water erosion (rill or gully formation) along the service road, the eroded

sections must be refilled with soil material and additional diversion ridges constructed.

- To improve the rate of water infiltration on soils that tends to form a surface crust, surface application of gypsum combined with mulching should be considered.

5.3 Impact on grazing and dry land small-grain production

The main farming activities in the study area are small livestock production with natural veld grazing and small-grain production. The impact of the construction of the power-line, pylon sites and the use of the service road are summarized in **Table 6**.

- *Source of the impact:*

  Clearing of natural vegetation along construction roads, at pylon sites and the service road, combined with soil compaction by the construction vehicles and along the service road.

- *Description of the impact:*

  Clearing and destruction of the natural vegetation will lower the grazing potential until that time that the cleared areas have become revegetated, while soil compaction in cleared lands used for small-grain production will lower the yield potential of the land.

- *Significance:*

  During the construction phase the cleared construction roads and pylon sites will have a small impact over a short time span on total area available for grazing. After rehabilitation of the veld along the construction roads and at the pylons, only the service road will continue to have a low grazing potential. The total area occupied by the service road, however, will be very small compared to the total area grazed and will have a negligible impact on the grazing potential.

  South of Namaqua National Park along alternative E and along alternative C from Kamieskroon to Nuwerus there are fairly extensive areas cleared for small-grain production. During the construction phase construction roads and the pylon construction sites will have a negative impact on crop production practices if it coincides with the period from land preparation for sowing to harvest. During non-growing periods, on fallow lands and during the operational phase after rehabilitation it will have no impact on small-grain production. During the operational phase the service road will have a small negative or positive impact on small-grain production. The positive impact is when the farmer uses the service road as an additional access road to camps or plowed fields. The impact is negative when the service road has no advantage as an access road and cannot be used for planting of small-grain. The area occupied by the service road, however, is small compared the total area of cultivated lands. Because of the low small-grain yield potential in the study area as a result of the low and unreliable rainfall during the growing season, the net production loss associated with the service road is therefore low and the impact low.

Table 6: Impacts on grazing capacity and small-grain production

Nature	Loss of grazing capacity and potential arable land	Status	-
Impact source(s)	Clearance of land for roads for construction vehicles, pylon sites and service road		
Affected stakeholders	Small livestock farmers and small-grain producers		
Alternative C			
Magnitude	*Extent*	Local	
	Intensity	Low	
	Duration	Short to medium	
	Reversibility	Reversible	
	Probability	Probable	
Significance	*Without mitigation*	Low to medium	L-M
	With mitigation	No significance	N
Confidence	High		
Alternative E			
Magnitude	*Extent*	Local	
	Intensity	Low	
	Duration	Short to medium	
	Reversibility	Reversible	
	Probability	Probable	
Significance	*Without mitigation*	Low to medium	L-M
	With mitigation	No significance	N
Confidence	High		
Existing ESKOM servitude			
Magnitude	*Extent*	Local	
	Intensity	Low	
	Duration	Short to medium	
	Reversibility	Reversible	
	Probability	Probable	
Significance	*Without mitigation*	Low	L
	With mitigation	No significance	N
Confidence	High		

- *Mitigation:*

The same measures required for mitigation of the negative impacts of wind and water erosion and to ensure that cleared areas are revegetated can be implemented to improve the grazing capacity following clearing and disturbance.

Compaction by wheels of heavy construction vehicles that lowers the yield potential of small-grain can be mitigated through deep tillage with a tine implement. This is an action that should be undertaken when the soils are dry too ensure proper loosening of the compacted soil. This action should never be done when the soils are moist or wet.

5.4 Impact on the Olifants River Irrigation Farming Region

From north of Koekenaap to Juno the route of alternative E follows and cuts across the irrigated, high value land of the Olifants River Irrigation Farming Region. Due the high impact during the construction phase of the transmission power-line as well as during the operational phase on all agricultural activities and loss of valuable land and crops, this section of alternative E cannot be considered as a viable option.

The initial irrigated land development was below the irrigation canal; especially on the low-lying, nearly flat alluvial plain. During the last few decades more new irrigated lands were developed above the canal on the higher lying old erosion terraces. This is mainly due to soil types that react better on physical amelioration measures (e.g. deep subsoil tillage) than the alluvial soils, and have more favourable chemical (e.g. low salinity) and physical (e.g. porosity) properties for deep-rooted crops such as wine grapes. The climate is also more favourable for the production of quality wines than on the low-lying alluvial soils. During the Western Cape Olifants/Doring River Irrigation Study (Provincial Government Western Cape. 2003) it was determined that vast areas of soils suitable for irrigated wine grape development occur above the irrigation canal from Koekenaap south to as far as Klawer. With additional irrigation water through raising of the Clanwilliam Dam wall and/or collecting and storing water from the Doring River, at least another 5 000 ha might become available for irrigated crop production in the Olifants River Irrigation Farming Region. It is highly probable that this additional irrigation water will be used for development above the existing canal. This will imply that new irrigation developments will expand laterally.

Not to limit future lateral expansion of irrigated crop production from Koekenaap to Juno the transmission line should be placed as far away as possible from the existing irrigation canal.

6. MITIGATION

From an agricultural perspective there are no generic mitigation measures that are regarded as environmental good practice that do not relate specifically to any of the impacts mentioned above.

7. ALTERNATIVES

Alternative C

Compared to alternative E this is the longest (345 km) alternative. Although wind erosion has no impact, alternative C cuts across the greatest number (and longest distance) of land types with a moderate to severe water erosion hazard. Soils in water erosion sensitive land types are predominantly shallow and the terrain is hilly to mountainous with a low percentage level land and high local relief. To mitigate the negative impact, especially along the service road, will be difficult due to the steep slopes and high runoff rates especially in land types with a class B5, C4, C5 and D5 terrain type. From Springbok to as far south as Nuwerus lands cleared for small-grain production is common in localized areas where the terrain is more level with a higher percentage of deeper soils suitable for arable crop production. The impact of the pylon footprints on loss of arable land and production of small-grain will, however, be small. It is only the service road that will have a slight impact on the total small-grain yield.

Alternative E

Compared to alternative C this is the shortest alternative (276 km). In the north the land is used mainly for grazing while lands cleared for small-grain production is common in the south (south of Namaqua National Park). Wind erosion will have the greatest impact in the north where land types sensitive to wind occur. However, recovery of the natural vegetation in disturbed and wind-impacted areas will be fairly rapid due to the fairly high rainfall and surrounding natural vegetation that acts as seed bank. The soils are predominantly deep red sands and the terrain is flat and the local relief is low. Land types that are sensitive to water erosion are common in the central and southern section of the route. It will impact on a great number of properties with lands cleared for small-grain production along the southern section of the route. To mitigate the negative impact of water erosion is in many cases more difficult than that of wind erosion in areas with undisturbed natural vegetation. The soils that are sensitive to water erosion are predominantly shallow and the terrain is hilly with a low percentage level land and high local relief. Although this is the shortest route with the least disturbance due to a shorter footprint, less pylons and shorter construction time, it is probably a no-go alternative as a result of the Namaqua National Park that it crosses.

Another negative aspect of this alternative is the alignment of the route from Koekenaap to Juno where it follows the irrigated crop production area along the Olifants River. If alternative E is changed so that it follows alternative A from the farm Kameelboom near Ouplaas straight to Juno and does not swing back to alternative B, it is probably the most viable alternative from an agricultural point.

Existing ESKOM servitude

This is the only alternative for the transmission line route between Oranjemond and Gromis sub-station.

8. CONCLUSION

The study area is dry with an average annual rainfall at Oranjemond in the north as low as 45 mm. However, to the south it increases gradually to a maximum of around 134 mm in the Hardeveld but decreases again to about 100 mm at Juno. Along alternative C the rainfall increases from 65 at Gromis to more than 200 mm in the mountains from Springbok to Kamieskroon. From Kamieskroon south the rainfall gradually decreases to about 134 mm north of the Knersvlakte to a low of approximately 100 mm at Juno.

According to the Land Type Survey Staff (1972 - 2001) alternative routes C and E and the existing ESKOM servitude are characterised by a large range of land types. A land type denotes an area that can be shown at 1 : 250 000 scale and that displays a marked degree of uniformity with respect to terrain form, soil pattern and climate. The terrain along the existing ESKOM servitude and the northern and southern sections of alternative E is fairly flat with a high percentage level land and low local relief. The central section is hilly with a lower percentage level land and greater local relief. Except the north-western and southern sections of alternative C with a high percentage level land and low local relief, it is mainly hilly to mountainous with a low percentage level land and great local relief.

Land types with a level terrain (e.g. along the existing ESKOM servitude and the northern section of alternative E on the coastal plain) are usually characterised by moderately deep to deep red and/or yellow, sandy soils with a low clay content. With an decrease in percentage level land and increase in local relief the soil depth generally decreases to less than 400 mm. In hilly and mountainous areas the soils are very shallow and rock outcrops are common and may even be the dominant feature in the landscape.

The dominant land-use in the study area is small livestock production with natural veld grazing. The natural veld is in a fairly good condition and well preserved in certain areas with a higher rainfall along alternative C and E. However, due to overgrazing natural veld deterioration has taken place in water erodible, hilly and mountainous areas and on the Knersvlakte with a low rainfall. Between Springbok and Nuwerus along alternative C and south of the Namaqua National Park along alternative E, fairly extensive areas have been cleared for small-grain production. Yields, however, are fairly low due to the low and generally unreliable nature of the rainfall. Small livestock and small-grain production are highly integrated in the sense that farmers produce their own fodder in the form of oats, wheat and hay, and stubble lands are used in summer for grazing.

The main agricultural impacts associated with the construction of the transmission power-line and the service road is accelerated wind and water erosion that will affect grazing potential and suitability of soils for small-grain production. The evaluation of wind erosion hazard of land types was based on the nature of the dominant soils while terrain type (in terms of percentage level land and local relief) was used to evaluate the water erosion hazard. Based on these evaluations the distance of land types along a route with a moderate or severe wind and water erosion hazard was determined. Along alternative C wind erosion is not an impact, but nearly 270 km of the route cuts across land types with a moderate or severe water erosion hazard. Along alternative E the respective distances with a moderate or severe water and wind erosion hazard are 100 km and 36 km. Along the existing ESKOM servitude the equivalent distances are 4 km and 113 km.

A range of mitigation measures can be implemented to eliminate or minimise the impacts of wind and water erosion on grazing and arable crop production. One of the most important measures is to keep the area that are cleared for construction and service roads and pylon sites as small as possible; i.e. minimum lateral disturbance. If possible the actual alignment of the transmission power-line along the alternative routes could be slightly changed to bypass very erodible land types to a joining less sensitive land types. In wind erosion sensitive land types construction should preferable be done in winter when the soils are moist/wet and in water erosion sensitive land types during the non-rainy months of the year when the risk of high rainfall events are small. During construction signs of accelerated wind or water erosion must continuously be monitored and recommended mitigation measures implemented; e.g. mulching or artificial windbreaks for wind erosion or construction of water diversion ridges for water erosion.

The duration of the impacts on the grazing potential and dry land small-grain production during the construction phase will be short to medium term, but after mitigation it will be of no or very low significance. The loss of arable land will be small because of the small footprint of the pylons. It is only the service road that will have a long-term impact on small-grain production from Springbok to Nuwerus along alternative C and south of Namaqua National Park along alternative E. The effect on total production will, however, be minimal because of the small surface area occupied by the service road compared to the size of the small-grain lands.

From north of Koekenaap to Juno the route of alternative E follows and cuts across the irrigated, high value land of the Olifants River Irrigation Farming Region. Due the high impact during the construction phase of the transmission power-line as well as during the operational phase on all agricultural activities and loss of valuable land and crops, this section of alternative E cannot be considered as a viable option. It is recommended that the southern section of alternative E should follow the alignment of alternative A to Juno.

9. RECOMMENDATIONS

It is concluded that, although there are significant impacts in terms of accelerated wind and water erosion and potential loss of grazing potential during the construction phase, these impacts are of short duration provided that the recommended mitigation measures are followed. Along the transmission power-line service road these impacts will exist as long as the transmission power-line is operational. The degree of the impact on the production potential of small-grain during the construction phase will depend on the period of the year that construction takes place compared to the planting date and growing period of small-grain. The service road, however, will have long-term effect if it cuts across cleared lands.

The more important mitigation measures recommended for accelerated wind erosion include the following:

- Clearance of vegetation for construction roads in wind sensitive land types should be avoided and non-sensitive land types should be selected wherever possible.
- Construction on wind sensitive land types should preferably be done during the rainy season.
- The width of strip cleared of vegetation for construction roads should kept as narrow as possible.
- Sections of construction roads and at pylon construction sites that experience accelerated wind erosion should be protected by windbreaks or covered with organic or synthetic mulches.
- After construction, wind eroded areas that do not recover should be kept covered with an organic or synthetic mulch or even windbreaks (e.g. nets). Reseeding of affected areas combined with mulching could be considered.
- Mitigation of wind erosion sensitive and affected areas along the service road is virtually impossible because of the continuous disturbance of the soil surface and destruction of new plant growth. Mulching and windbreaks might be considered, although the latter option could have a negative visual impact on the environment.

The more important mitigation measures that can minimize the effect of water erosion in disturbed areas or even prevent water erosion to take place include the following:

- Clearance of vegetation for construction roads along very steep slopes that are sensitive to water erosion should be avoided.
- Construction on water erosion sensitive land types should preferably be done during the dry season.
- The width of the strip cleared for construction roads should be kept as narrow as possible.
- To decrease runoff along long and steep construction roads diversion ridges should be constructed in the road to divert runoff water into the natural veld.
- After construction, the compacted soil material along construction routes and at pylon sites should be loosened with a tine implement. Revegetation will be faster on the loosened soil.
- Water eroded areas that do not recover after good rains should be kept covered with an organic mulch and reseeding should be considered.
- At the first signs of water erosion along the service road, the eroded sections must be refilled with soil material and additional diversion ridges constructed.
- To improve the rate of water infiltration on soils that tends to form a surface crust, surface application of gypsum combined with mulching should be considered.

To improve the yield potential for small-grain the soil along compacted construction roads and at pylon sites must be loosened with a tine implement during summer or spring when the soil is dry.

Although the agricultural potential of the soils along alternative E is on average higher than that of the soils along alternative C, E is the preferred alternative. Along this alternative the rehabilitation of disturbed areas, especially wind disturbed, will be faster due to the more level terrain and the prevailing fog that supplements the water requirement of young seedlings. To rehabilitate disturbed, especially water eroded, areas with steep slopes as along alternative C, require considerably more inputs.

Based on GoogleEarth satellite images cleared areas for small-grain production along alternative E are significantly less than along alternative C. For this reason the impact of the service road along the transmission power-line on total small-grain production will be lower along E than C.

It is further recommended that the southern section of alternative E should follow the alignment of alternative A to Juno, and not along the irrigated, high value land of the Olifants River Irrigation Farming Region.

It is recommended that a competent individual or organisation is appointed that will monitor the effect of the actions during the construction phase on accelerated wind and/or water erosion and control the implementation of the required mitigation measures. The impact of the service road should be monitored in a similar way over the long-term. This monitoring should concentrate on the visible removal and displacement of soil material along construction and service roads and at pylon construction sites as a result of wind or water action. Affected sites should be identified as soon as possible and the most applicable mitigation measure(s) to lower or control the degree of the negative impact during the construction phase should be identified and implemented. Immediately after the construction phase mitigation measures should be implemented to rehabilitate the affected areas/sites to its natural state within the shortest possible time.

10. REFERENCES

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Appendix Table 1: Different land types along existing ESKOM servitude from Oranjemond to Gromis and alternative routes C and E from Gromis to Juno with a specification of terrain type, mean annual rainfall, soil forms and subsoil limitations.

ALTERNATIVE C

Landtype symbol	Rainfall zone	North-south index	Mean annual rainfall (mm)	Length (km)	Terrain type	Soil forms			Limitations		
						Dominant ≥50 %	Subdominant 10-50 %	Rare ≤10%	Dominant	Sub-dominant	Rare
Af 17	154W	1	65	1.8	A2	Hu		Cv, Vf, Ms			ka, ne
Ag 54	158W	2	105	11.3	C4	Hu	Ms	R, Ms, Oa, Du	R, db	R	R, db
Fb157	173W	3	260	5.7	C5		Ms, Gs, Sw, R	Hu, Ss, Oa, Du		R, so, vp	R, pr
Fc133	169W	4	186	18.6	C5	R	Hu	Ms, Gs, Sw, Va, Oa	R	R, db, ka	R, pr, vp, so
Ah 38	155W	5	76	15.4	A3		Hu, Cv, Vf, Pn	Du		ca, ka, db, ne, gc	
Ae 77	158W	6	105	7.2	A2	Hu		Ms, Oa, Du	db, R, ka		db, R
Ag 55	164W	7	115	10.0	A3	Hu		R, Ms, Du, Sw, Oa	R, db		U, db, vp
Fb154	159W	8	119	0.9	D5		R, Ms, Gs, Hu	Sw, Du		R, so	vp, R
Ib124	165W	9	220	5.5	C5	R	Hu	Ms, Gs, Sw, Ss, Oa, Du	R	R	so, vp, pr, R
Fc133	169W	10	186	13.0	C5	R	Hu	Ms, Gs, Sw, Va, Oa	R	R, db, ka	R, pr, vp, so
Ib127	170W	11	75	5.1	D5	R	Hu	Gs, Ms, Va, Du	R	R, db, ka	so, vp, R
Ae 80	169W	12	186	10.0	A3		Hu, R, Gs	Sw, Oa, Va, Ss, Du		R, db, ka	R, vp, pr
Ib124	165W	13	220	11.5	C5	R	Hu	Ms, Gs, Sw, Ss, Oa, Du	R	R	so, vp, pr, R
Ae 81	171W	14	200	6.5	B4		R, Gs, Hu, Sw	Oa, Kd, Du		R, so, vp	R, gc
Ib235	173W	15	260	3.9	D5	R	Hu	Ms, Gs, Sw, Oa, Du	R	R, db	so, vp, R
Ic 64	188W	16	366	4.6	C5	R		Gs, Ms, Hu, Cv, Oa	R		so, R, U
Ag 94	189W	17	222	20.9	C4	Hu	R	Gs, Cv, Oa, Sw	so, db	R	so, vp
Ai 17	190W	18	251	5.4	C4		R, Cv	Ms, Oa, Hu		R, so	U, R, so
Ib273	191W	19	200	8.2	C5	R	Gs	Ms, Cv, Oa, Hu	R	so, R	R, so, db
Ai 18	190W	20	251	4.0	C4		Cv, R	Hu, Kd, Pn, Ms		R, so	R, so, gc
Ah 40	192W	21	230	12.6	C3		Cv, R, Hu	Pn, Gs, Ms, Oa, Es, Kd		R, so	gc, so, R, U
Ag 99	187W	22	134	10.3	C3	Hu	R	Oa, Du, Vf	db, R	R	R
Ae163	187W	23	134	5.7	C4	Hu		R, Oa, Cv, Pn, Du	R, db		R, so, gc
Ag 87	187W	24	134	82.5	C4	Hu	R, Ms	Gs, Oa	R, so, db, ca	R	R, so
Ag100	187W	25	134	8.2	C4	Hu	R	Cv, Oa, Ms, Du, Other	R	R	R, U
Ag205	2759W	26	105	3.1	B4		Hu, Oa, Ms	Gs, Du, R, Stream		R, db	R
Fb571	2759W	27	105	16.8	C3		Ms, Gs, R	Hu, Oa, Stream		so, R	R
Ah120	2759W	29	105	14.9	A3		Hu, Cv, Oa, Ms, Gs	Du, Other, Streams		db, ka, so, R	R
Fb571	2759W	30	105	5.8	C3		Ms, Gs, R	Hu, Oa, Stream		so, R	R
Ia195	2758W	31	148	0.4	A2	Oa	Du	Ms, Va, Gs	R	R	R
Ae372	2758W	32	148	15.7	A3	Hu	Oa	Ms, Other	db, ka	db	R, db
Total				345.3							

Alternative E

Landtype symbol	Rainfall zone	North-south index	Mean annual rainfall (mm)	Length (km)	Terrain type	Soil forms			Limitations		
						Dominant ≥50 %	Subdominant 10-50 %	Rare ≤10%	Dominant	Sub-dominant	Rare
Ah 38	155W	1	76	30.0	A3		Hu, Cv, Vf, Pn	Du		ca, ka, db, ne, gc	
Ai 13	154W	2	65	19.7	A3	Cv	Pn, Vf	Ms, Hu, Oa, Du		gc, ne	ka, ca, ne
Hb 80	155W	3	76	11.1	A1		Fw, Ms, Pn	Cv, Kd, Vf, Pans		hp, ka, gc	ka, pr, ne
Ai 19	155W	4	76	10.8	A3	Dunes		Cv, Hu, Other			ne, db, pr
Ah 48	155W	5	76	7.8	A2	Hu	Dunes	Other, R	ne, pr		R
Ai 21	155W	6	76	17.0	A3		Cv, Dunes	Hu, Fw, R, Other		ne, pr	ne, pr, R
Af 18	155W	7	76	4.3	B2	Hu	Oa	Cv, R	R, db		R
Ae161	187W	8	134	9.9	C4	Hu		R, Oa, Cv	R, so, db		U, so
Ae167	187W	9	134	5.2	B3	Hu	Oa	R	R, db		R
Ag 98	155W	10	76	9.9	C3	Hu	Oa	R	R, db	R, db	R, db
Hb 63	155W	11	76	0.1	A1	Dunes		Hu, Ms, R, Other			ne, pr, ka
Ae165	155W	12	76	11.8	B3	Hu	Oa	R, Cv, Du	R, db		R, db
Ae163	187W	13	134	6.8	C4	Hu		Oa, Cv, R, Du, Pn	R, db		R, so, gc
Ag105	187W	14	134	4.4	B3		Hu, R, Oa			R, db, U	
Ag 87	187W	15	134	33.4	C4	Hu	R, Ms	Gs, Oa	R, so, db, ca	R	R, so
Ag 95	187W	16	134	12.4	C3	Hu	R	Oa	R, so, db	so, db	U
Ia 36	187W	17	134	1.0	A1		Oa, Du, Cv	R, Hu			R
Ae168	187W	18	134	11.1	B2	Hu		Oa, R	R, so, db		R
Ag100	187W	19	134	22.0	C4	Hu	R	Cv, Oa, Ms, Du, Other	R	R	R, U
Ae374	2761W	20	157	19.9	A4	Hu	Oa	Cv, R, Stream, Other	db, R	db, R	db, R, so
Ae372	2758W	21	148	8.2	A3	Hu	Oa	Ms, Other	db, ka	db	R, db
Ai 66	2762W	22	125	2.9	A3	Cv		Pn, Kd, Other			gc, sp
Ag203	2758W	23	148	5.2	C3	Hu	R	Ms, Oa, Other	db, ka	db, ka	R, db
Ae373	195W	24	110	1.9	A3	Hu	Oa	Ms, Other	db, ka	db	R, db
Ia193	195W	25	110	1.1	A1		Oa, Pans, Stream	Du, Vf, Kd, Ka, Hu, Pn		Cl	gc, db
Ia192	2758W	26	148	8.2	A1		Oa, Kd	Hu, Du, Fw, Stream		Cl, gc	db, R, so
Total				276.1							

Existing ESKOM servitude

Landtype symbol	Rainfall zone	North-south index	Mean annual rainfall (mm)	Length (km)	Terrain type	Soil forms			Limitations		
						Dominant ≥50 %	Subdominant 10-50 %	Rare ≤10%	Dominant	Sub-dominant	Rare
Existing ESKOM servitude											
Fc339	124W	1	45	3.5	B3	Ms	R, Cv	Hu, Fw	R, ka, cs	R, ca	R, ca
Ai 10	124W	2	45	12.9	A2		Cv, Ms	Fw, Hu, R, Pans		R, ca, cs	R, ka, cs
Ah 36	137W	3	50	24.6	A4	Hu	Cv	Oa	ca	ca	ca, ka, cs
Ah 35	138W	4	45	2.1	A3	Cv	Hu	Oa, Fw, Pans			ka, cs, ca
Ha 32	123W	5	50	7.7	A4	Fw	Cv	Ms, Pans			ka, cs
Ah 33	140W	6	55	37.6	A4	Hu		Cv, Oa			ca
Ae 71	154W	7	65	7.9	A3	Hu		Ms, Oa, Du	db, ka		R, ka
Ai 12	154W	8	65	1.6	A2	Cv	Vf	Hu, Fw, Ms		ne	ka
Af 17	154W	9	65	28.4	A2	Hu		Cv, Vf, Ms			ka, ne
Ag 52	157W	10	100	3.9	B5		Hu, Ms, R, Gs	Oa, Du		R, db, so	so
Total				130.2							

Refer to Appendix A Table 2 and 3 for a definition of the land types and terrain symbols.

Appendix Table 2: Brief description of land types and general agricultural suitability rating from best (8) to worst (1) based on the general nature of the dominant soils (see Appendix Table 1).

Land type symbol	Description	Suitability rating
Red and yellow, apedal to weakly structured, freely drained soils This class refers to yellow and red soils with the absence of water tables and belonging to one or of the following soil forms: Hutton, Clovelly, red Oakleaf series and where one of these soils occupy at least 40 % of the area		
Ae	Deeper than 300 mm, red, eutrophic, apedal soils (yellow soils comprise <10%); without dunes	8
Af	Deeper than 300 mm, red, eutrophic, apedal soils (yellow soils comprise <10%); with dunes	5
Ag	Shallow (<300 mm deep), red, eutrophic, apedal soils (yellow soils comprise <10%)	4
Ah	Red and yellow, eutrophic, apedal soils with <15% clay (red and yellow soils each comprise >10%)	7
Ai	Yellow, eutrophic, apedal soils with <15% clay (red soils comprise <10%)	6
Shallow soils of pedologically young landscapes This class refers to land of pedologically young landscapes that is nor predominantly rock or alluvial or aeolian. Mispah and Glenrosa soil form dominate.		
Fb	Lime rare/absent upland soils but present in low-lying soils	3
Fc	Usually lime throughout much of landscape	3
Grey regic sands This class indicates areas where deep grey sands of the Fernwood form are dominant		
Ha	Deep grey sands dominant (comprise >80% of land type)	3
Hb	Deep grey sands sub dominant (comprise >20% of land type)	4
Deep (> 1 000 mm) unconsolidated deposits This class indicates areas of which at least 60 % comprises pedologically young, deep, unconsolidated deposits, excluding regic sands. They are usually associated with recent deposits on alluvial river terraces. Common soil forms are Dundee and Oakleaf.		
Ia	Deep alluvial soils comprise >60% of land type	6
Other soils This class is usually associated mountainous areas where a variety occur without any one dominant		
Ib	Rock outcrops comprise 60 – 80 % of the land type	2
Ic	Rock outcrops comprise > 80 % of the land type	1

Appendix Table 3: Rating of soil properties and terrain type for the qualitative evaluation of soil suitability and wind and water erosion hazard.

3.1 Soil depth

Depth	Class rating
>1 200 mm	5
900 – 1 200 mm	4
600 – 900 mm	3
300 – 600 mm	2
<300 mm	1

3.2 Topsoil clay content

Clay content	Class rating
>15 %m	3
6.1 – 15 %	2
<6 %	1

3.3 Percentage level land

Class symbol	Class description	Class rating
A	>80% of the area has slopes less than 8%	4
B	50-80% of the area has slopes less than 8%	3
C	20-50% of the area has slopes less than 8%	2
D	<20% of the area has slopes less than 8%	1

3.4 Local relief

Relief class	Relief description	Class rating
1	0-30 m	5
2	30-90 m	4
3	90-150 m	3
4	150-300 m	2
5	300-900 m	1

Appendix Table 4: Water and wind erosion hazard of land types along the alternative transmission power-line corridors and the parameters on which the hazard was base.

ALTERNATIVE C

Land type symbol	Terrain type	North-south index number	Length (km)	Average depth (mm)	Average clay (%)	Water erosion hazard	Wind erosion hazard
Af 17	A2	1	1.8	1271	4.0	None	Low-Mod
Ag 54	C4	2	11.3	249	3.5	Severe	None
Fb157	C5	3	5.7	218	6.4	Severe	None
Fc133	C5	4	18.6	228	4.6	Severe	None
Ah 38	A3	5	15.4	904	1.3	Low	None
Ae 77	A2	6	7.2	634	3.0	None	None
Ag 55	A3	7	10.0	395	3.2	Low	None
Fb154	D5	8	0.9	225	1.7	Severe	None
Ib124	C5	9	5.5	266	5.0	Severe	None
Fc133	C5	10	13.0	228	4.6	Severe	None
Ib127	D5	11	5.1	198	3.3	Severe	None
Ae 80	A3	12	10.0	617	3.7	Low	None
Ib124	C5	13	11.5	266	5.0	Severe	None
Ae 81	B4	14	6.5	433	4.0	Moderate	None
Ib235	D5	15	3.9	205	1.6	Severe	None
Ic 64	C5	16	4.6	254	3.5	Severe	None
Ag 94	C4	17	20.9	397	5.6	Severe	None
Ai 17	C4	18	5.4	463	2.5	Severe	None
Ib273	C5	19	8.2	490	4.8	Severe	None
Ai 18	C4	20	4.0	353	2.8	Severe	None
Ah 40	C3	21	12.6	629	3.1	Moderate	None
Ag 99	C3	22	10.3	484	3.9	Moderate	None
Ae163	C4	23	5.7	381	3.6	Severe	None
Ag 87	C4	24	82.5	316	4.6	Severe	None
Ag100	C4	25	8.2	416	3.8	Severe	None
Ag205	B4	26	3.1	363	16.5	Moderate	None
Fb571	C3	27	16.8	234	18.7	Moderate	None
Ah120	A3	28	14.9	528	7.7	Low	None
Fb571	C3	29	5.8	234	18.7	Moderate	None
Ia195	A2	30	0.4	747	11.8	None	None
Ae372	A3	31	15.7	612	2.7	Low	Low
			345.3 km				

Alternative E

Land type symbol	Terrain type	North-south index number	Length (km)	Average depth (mm)	Average clay (%)	Water erosion hazard	Wind erosion hazard
Ah 38	A3	1	30.0	904	1.3	Low	Low
Ai 13	A3	2	19.7	955	3.0	Low	Low-Mod
Hb 80	A1	3	11.1	862	2.1	None	Low-Mod
Ai 19	A3	4	10.8	1239	3.0	Low	Severe
Ah 48	A2	5	7.8	1016	3.0	None	Moderate
Ai 21	A3	6	17.0	972	1.2	Low	Moderate
Af 18	B2	7	4.3	718	4.8	Low	Low
Ae161	C4	8	9.9	702	4.2	Severe	Low
Ae167	B3	9	5.2	611	3.3	Low-Mod	Low
Ag 98	C3	10	9.9	486	4.9	Moderate	Low
Hb 63	A1	11	0.1	1140	2.4	None	Severe
Ae165	B3	12	11.8	700	4.4	Low-Mod	Low
Ae163	C4	13	6.8	381	3.6	Severe	Low
Ag105	B3	14	4.4	514	3.8	Low-Mod	Low
Ag 87	C4	15	33.4	316	4.6	Severe	None
Ag 95	C3	16	12.4	427	4.0	Moderate	None
Ia 36	A1	17	1.0	1298	2.8	None	Low-Mod
Ae168	B2	18	11.1	777	4.0	Low	Low
Ag100	C4	19	22.0	416	3.8	Severe	None
Ae374	A4	20	19.9	516	2.9	Low	Low
Ae372	A3	21	8.2	612	2.7	Low	Low
Ai 66	A3	22	2.9	895	2.5	Low	Low-Mod
Ag203	C3	23	5.2	335	8.6	Moderate	None
Ae373	A3	24	1.9	612	2.1	Low	Low
Ia193	A1	25	1.1	1036	6.3	None	None
Ia192	A1	26	8.2	952	9.2	None	None
			276.1 km				

Existing ESKOM servitude

Land type symbol	Terrain type	North-south index number	Length (km)	Average depth (mm)	Average clay (%)	Water erosion hazard	Wind erosion hazard
Fc339	B3	1	3.5	216	2.7	Low-Mod	Low-Mod
Ai 10	A2	2	12.9	206	2.5	None	Severe
Ah 36	A4	3	24.6	1092	5.8	Low	Moderate
Ah 35	A3	4	2.1	1137	5.1	Low	Moderate
Ha 32	A4	5	7.7	1244	2.3	Low	Severe
Ah 33	A4	6	37.6	1207	4.9	Low	Moderate
Ae 71	A3	7	7.9	734	3.9	Low	Low
Ai 12	A2	8	1.6	1217	2.6	None	Low-Mod
Af 17	A2	9	28.4	1271	4.0	None	Moderate
Ag 52	B5	10	3.9	215	3.2	Severe	Low
			130.2 km				