Report to Strategic Environmental Focus on a Preliminary Geotechnical Appraisal for the Proposed New Eskom Kudu Overhead Powerline: Alexander Bay to Vredendal

Reference : 05-096R03

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1. INTRODUCTION AND TERMS OF REFERENCE

Moore Spence Jones (Pty) Ltd were requested by Strategic Environmental Focus (SEF) to submit a proposal to carry out a preliminary geotechnical appraisal for the proposed new Eskom Kudu overhead power transmission line between Alexander Bay and Vredendal, Northwest Cape Province. SEF appointed MSJ to proceed with this work in May 2005.

It was understood from the specialist's meeting held at the offices in SEF on 5 May 2006 in the offices of SEF in Cape Town that Moore Spence Jones' brief incorporates the preparation of 2 separate reports for this project. These are:

1) Report discussing geotechnical issues pertaining to the various alternative routes for the proposed powerline with recommendations for selection of a preferred route, as required for the Scoping Phase of the project, and
2) Report on the Preliminary Geotechnical Appraisal for the preferred route(s) as required for the Environmental Impact Report (EIR).

This report consists of the final version of the second report mentioned above, i.e. the Report on the Preliminary Geotechnical Appraisal for the preferred route(s) as required for the Environmental Impact Report (EIR).

The Scoping Report, which integrated the results and recommendations from the specialist reports, was submitted in June 2006 by SEF to Eskom. In this report it was indicated that, given all factors presented by the specialists, the preferred routes for the proposed Eskom Kudu line area are Routes C and E. These routes were chosen on the basis of their value to the tourism industry and to minimise the debilitating environmental impacts on the Knersvlakte and other sensitive areas along the routes, and not necessarily on other factors such as the cost of construction.

Subsequently, a second specialists meeting was held in the offices of SEF on 2 October 2006 in Pretoria. After the presentation of the various specialist's reports to ESKOM's representative, Mr J Gearingh, it was requested that an additional two routes, designated Routes F and G, be evaluated as preferred routes along with Routes C and E.

The four preferred routes are shown in Figure 1.

This report reviews the geological and related geotechnical conditions along the preferred routes and provides, where possible, a comparative evaluation of the geotechnical and civil engineering impacts on the costs of construction of the powerline. The EIR work is to focus on a 3km wide servitude area within which the preferred alignment is to be located.

The following characteristics will affect the costs of construction of the line:

- Topography
- Proximity of the steel towers to the corrosive environment of the coastline,
- Location and design of service roads in relation to the powerline with access roads off provincial and national routes,
- Straightness of route i.e. minimisation of bends, or changes in direction, in the route which are relatively uneconomic
- Impact of geotechnical issues on costs of construction with respect to :

- Earthworks associated with tower construction
- Materials usage for foundations and road construction
- Tower foundations
- Tensioned ground anchors

The route will supply electricity generated from a proposed power station to be located at the Oranjemond Sub-Station area on the southern bank of the Orange River some 15 km from Alexander Bay. This proposed new power station will generate some 800 MW using gas obtained from the Namibian gas fields. Nampower requires about 200MW to augment the Namibian domestic supply and the balance will be offered to ESKOM for integration into the RSA national grid. Therefore two 400 kV lines will be extended to Oranjemond, with one of these extending to Juno and the other connected at Oranjemond and operated at 220kV, with the option of upgrading this second line to 400 kV to accommodate future expanded capacity of the power station.

2. INFORMATION SUPPLIED

The following information was provided for use in the investigation:-

i) Locality plan to a scale of 1:50000 and a proposed layout of the development.
ii) A scanned aerial photograph to a scale of 1:3000 showing the extent and proposed divisions of the site.
iii) Copy of orthophoto drawing to scale of 1:5000 showing the proposed layout of the platform for the proposed community health centre, with cross-sections through the platform
iv) Copy of a CD providing information relating to slope analysis,
v) Copy of PDF file supplied by SEF indicating the proposed alternatives of the route.
vi) Copy of power point presentation illustrating the tower design and construction method, and
vii) Copy of report prepared by SEF for Eskom, titled *“Final Scoping Report for Kudu Integration Project for Transmission Power-lines and Substations”*, dated 23 May 2006.
viii) Copy of digital shape files showing preferred routes C, E, F and G.

3. NATURE OF INVESTIGATION

The preliminary geotechnical assessment for the proposed new Oranjemond- Juno power transmission line comprised the following:

- Desktop Study, and
- Preliminary Field assessment

3.1 Desktop Study

A desktop study which included the scrutiny of relevant topocadastral plans and geological maps, and the investigation of geological references of the area was carried out. In particular the following geological maps were used for the desk study:

- Figure 2 : 1:250 000 Topocadastral Series No’s: 2816, 2916, 3017, 3118 and 3018
- Figure 3 : 1:1000 000 Geological Map of South Africa (1997), Council of Geoscience.

3.2 Preliminary Field Assessment

The fieldwork for the preliminary geotechnical assessment was carried out during April 2005 and comprised the following:

i. Drive over assessment of parts of the line accessible by road and visits to the Oranjemond, Gromis and Juno Substations,
ii. Visual appraisal of the route from air by helicopter, carried out largely along the existing Gromis-Oranjemond 1 line, and a direct route between Juno and Gromis Substations

iii. Selective inspections on the ground in the vicinity of Juno, Gromis and Oranjemond Substations to visually asses the soils and geological conditions for confirmation with the desktop study evaluation

4. GENERAL DESCRIPTION OF THE ALTERNATIVE POWERLINE ROUTES

Apart from the common section of line between Alexander Bay and Gromis, i.e. the Gromis-Oranjemond 1 line, Routes C and F follow very different alignments to Routes E and G, which are fairly similar.

In summary these routes can be described as follows:

Route C:

i. First leg : Gromis-Oranjemond 1 line
ii. Second leg : Gromis-Nama 1
iii. Third leg : Nama to Vredendal along N7
iv. Fourth leg : Helios-Juno 1 line

The approximate length of Route C is 372km.

Route E:

i. First leg : Gromis-Oranjemond 1 line
ii. Second leg : Gromis to Hondeklipbaai
iii. Third leg : Hondeklipbaai to Spoegrivier,
iv. Fourth leg : Spoegrivier – Landplaas along ESKOM A Route
v. Fifth leg : (Landplaas) – Juno Substation

The approximate length of Route E is 276km.

Route F:

i. First leg : Gromis-Oranjemond 1 line
ii. Second leg : Gromis-Nama 1 to Spektakelpas
iii. Third leg : Spektakelpas to Kotzesrus
iv. Fourth leg : Kotzesrus to Juno Substation

The approximate length of Route F is 319km.

Route G:

i. First leg : Gromis-Oranjemond 1 line
ii. Second leg : Route A (ESKOM)
iii. Third leg : Deviation through Namaqua National Park
vi. Fourth leg : Route A (ESKOM) to Landplaas
vii. Fifth leg : (Landplaas) – Juno Substation

The approximate length of Route G is 269km.

With reference to Figure 2, the topographical features along the routes are described in more detail below.

4.1 Topography along Route C : Oranjemond-Gromis-Nama-Juno

First Leg : Gromis-Oranjemond 1 line

The first section of the Eskom Kudu line will follow the existing Gromis-Oranjemond 1 line between Oranjemond Substation near Alexander Bay at the mouth of the Orange River and Gromis Substation near the town of Kleinsee.

From Oranjemond Sub-Station (Plates 1 to 4; Plates 14 and 15) the existing line traverses mainly scattered yellow dune sands (Plate 16) forming caps which overlie the more reddish brown dune sands (Plates 17 to 19). The topography is characterised by rolling hilltops and valleys which have slight to moderate and occasionally steep slopes. Localised rock outcrops occur and form the relatively uncommon topographical highs evident from the air. Large exposed areas of rock outcrop and scoured and eroded landscapes are evident along this section, as seen in the Holgat River (Plates 20 and 21). Southeast of the Holgat River the line crosses similar topography but somewhat steeper valley and higher ground with steeper valleys and hills become evident in the vicinity of the town of Lekkersing. From here to Gromis Substation the topography is dominated more by rocky hills and mountains and generally more rugged terrain.

Second Leg : Gromis-Nama

From Gromis (Plates 10 to 12; Plate 24) the existing line turns inland towards the Nama Substation at Springbok, i.e. the Gromis-Nama 1 line and runs due southeast roughly parallel to the Buffels River drainage line, utilising the flatter gradients until the Spektakelpas is encountered (Plates 26 to 28) at which a magnificent escarpment leading up to the generally mountainous area (Plates 29 to 31) within which the town of Springbok is located. The line will run to Nama Substation located on the outskirts of Springbok. The line will in all likelihood run parallel, and close to the existing line which runs within about 2 or 3 km of the existing gravel road itself.

Third Leg : Nama to Vredendal along N7

This leg, starting at Nama Substation, will follow the N7 National Route from Springbok to the point where it intercepts the Helios-Juno 1 line. The route will generally be located on the western side of the N7 and will follow the road within a reasonable distance. Where possible it would be necessary to straighten out the route relative to the N7 to eliminate unnecessary bends and deviations in the line. This is the longest section of Route C and extends from relatively mountainous area of Springbok through to Garies. From Garies to the vicinity of Van Rhynsdorp the line crosses more rolling topography which is not as rugged as the previous section.

Fourth Leg : Helios-Juno 1

The fourth leg will follow the Helois-Juno 1 line which cuts from inland near Ratelkop and then to Juno on the northern outskirts of Vredendal. The topography in this area is similar to southern part of the previous section, comprising gently undulating hills. The Hol Rivier, which flows into the Olifants Rivier near Juno is crossed by the existing line.

4.2 Topography along Route E : Oranjemond-Gromis-Hondeklipbaai-Juno

First Leg : Gromis-Oranjemond 1 line

Common section.

Second Leg : Gromis to Hondeklipbaai

This leg of the route deviates from Gromis, gradually approaching the Atlantic Ocean coastline at Hondeklipbaai, where it follows an existing powerline and road servitudes associated with the diamond mining activities in this area. The topography is characterised by much flatter gradients and rolling, semi-permanent dune topography.

Third Leg : Hondeklipbaai to Spoegrivier,

From Hondeklipbaai the route once again edges inland, i.e. to the southeast very gradually and for the most part is characterised by dunes and gently rolling landscape topography (Plates 32 and 33). The route will approach and run parallel to the Spoegrivier until it connects with ESKOM : Route A to the south of the town of Spoegrivier.

Fourth Leg : Spoegrivier-Landplaas

This leg, running on the alignment of the ESKOM : Route A, is characterised by rolling, gentle topography, ranging from dunes through to rounded rocky hills. Flatter, more rolling topography becomes the norm from about 30km north of Juno Substation in the vicinity of Landplaas (Plates 34 and 35).

Fifth Leg : Landplaas to Juno Substation

The leg between Landplaas and Juno follows the last section of the Cape Nature: Route B alignment, and follows the road connecting Landplaas, Koekenaap, Lutzville and Juno. The area near Vredendal (Plates 40 to 46) is more frequently characterised by cultivated lands on a rolling landscape with occasional mountains rising from the plains.

4.3 Topography along Route F : Oranjemond-Gromis-Juno

First Leg : Gromis-Oranjemond 1 line

Common section.

Second Leg : Gromis – Nama1 to Spektakelpas

This leg follows Route C until Spektakelpas before deviating to the southeast along existing district and farm roads.

Third Leg : Spektakelpas to Kotzesrus

Route F crosses the N7 National Road some 25km, and again at 75km, from Springbok and then runs due south before turning to the southwest near Leliefontein. The topography in this area is fairly rugged, characterised by fairly steep gradients and rocky mountains, such as seen along the N7 passing through this general area.

It then runs on to join with Route B : Cape Nature in the vicinity if the Brakrivier near Kotzesrus.

Fourth Leg Kotzesrus to Juno Substation

From about Kotzesrus, Route F now runs along Route B due south towards Juno. From Kotzesrus the line deviates towards the west around Lepelfontein before turning towards the east near Landplaas and running due south parallel to the existing road connecting Koekenaap, Lutzville and Juno Substation. The topography in this area becomes typical of the coastal belt area, being characterised by aeolian deposited dune sands which are gently undulating. However, in the area near Vredendal cultivated lands on a rolling landscape with occasional mountains rising from the plains become the norm.

4.4 Topography along Route G : Oranjemond-Gromis-Juno

First Leg : Gromis-Oranjemond 1 line

Common section.

Second Leg : Route A (ESKOM) to NNP

Route G follows, by and large, the initial ESKOM preferred route (Route A) which adopts a straight line between Gromis and Juno.

Third Leg : Deviation through NNP

Route G deviates just before the northern border of the Namaqualand National Park, taking a large bow shaped turn to the east through the eastern highland area of the Park in the vicinity of Soebatsfontein, before connecting with the ESKOM Route A again.

Fourth Leg :NNP to Landplaas

On existing from the NNP, the route once again follows the ESKOM: Route A line to Landplaas. The topography is fairly flat and typified by gently rolling topography, with occasional rocky hills where the underlying gneiss and granite rocks form outcrops.

Fifth Leg : Landplaas to Juno Substation

The leg between Landplaas and Juno follows the last section of the Cape Nature: Route B line which runs along the road connecting Landplaas, Koekenaap, Lutzville and Juno. The area near Vredendal (Plates 40 to 46) is more frequently characterised by cultivated lands on a rolling landscape with occasional mountains rising from the plains.

5. ROUTE GEOLOGY

5.1 General Geological Conditions along the Routes

The general geology of the area between Oranjemond and Juno is fairly complex, with a number of metamorphic and granitic suites evident. This complex geology is part of the Namaqua-Natal Metamorphic and Igneous Province. The area around Springbok and Okiep is well known for base metal reserves and copper, zinc and iron mines have occurred here both in current and historic times. The older metamorphic rocks are overlain by younger, but metamorphosed sedimentary rocks on the north near the Lekkersing area and carbonaceous rocks near Vredendal. The geology beneath the routes is evaluated from the geological map given in Figure 3, but discussed in detail below.

5.2 Geology – Route C

In summary, the section of the route common to both Route C and E is underlain in the immediate area of Oranjemond by metamorphosed sedimentary rocks comprising schists and chert formations of the Grootderm Formation, Gariep Supergroup. Within a few kilometres south of Oranjemond the Gariep Supergroup is covered with a mantle of recent dune sands. As one proceeds towards the south very occasional rock outcrops in the form of the quartzites of the Stinkfontein Formation of the Gariep Supergroup, become evident. Such sandstones are also encountered near Gromis.

From Gromis Route C runs next to the Gromis-Nama 1 line until it reaches Nama Substation in Springbok. This line crosses the granitic and gneissic rocks of the various formations: Rietsberg Granite, Concordia Granite, Nababeep Gneiss and Buffels River Granite representing granitic plutons intruded into the older Bushmanland Complex. These rocks from prominent outcrops and contribute to the very rugged topography along this part of the route. Soil cover over these rocks is very limited and good outcrop is evident both along the road to Springbok and from the air.

From Nama along the N7 until the Helios-Juno 1 line is intercepted, similar geology prevails: Buffels River Granite, Bitterfontein Formation (Bushmanland Complex), Kamieskroon Gneiss, Bieisiesfontein Granite, Stalhoek Complex Nababeep Gneiss and quartzites of the Flaminkberg Formation, Vanrhynsdorp Group.

Route C then follows the Helios-Juno 1 line which crosses over mainly recent alluvial and dune soils (Plates 44 and 45) until Juno is reached.

5.3 Geology – Route E

From Gromis Route E edges gradually towards Hondeklipbaai on the Atlantic Ocean. This area is dominated by rolling dunes and the associated diamond mining activity.

From Hondklipbaai Route E passes through Wallekraal until it runs parallel to the Spoegrivier where outcrops associated with the leucocratic gneiss of the Concordia Granite and biotite granite of the Nababeep Granite become evident. It then follows the Spoerivier until it turns east. At this point the route follows the straight bearing between Gromis and Juno (ESKOM: Route A). This section of the line crosses over dune sands interspersed with outcrop of the Kamieskroon and Kliphoek granite becoming more common to the south.

The section of the line following the Cape Nature : Route B between Landplaas and Juno crosses similar geology characterised by rolling dunes interspersed with the gneisses, quartzites, and schists of the Bitterfontein Formation, Bushmanland Complex.

5.4 Geology – Route F

The geology from Gromisto Spetakelpas is common to both Routes C and F, and described under Route C above.

From Spektakelpas to the Groenrivier Route F is underlain by similar geological conditions that are described under that of Route C, i.e. granites of the Buffels River Granite, gneisses, quartzites and schists of the Bitterfontein Formation (Bushmanland Complex), gneisses of the Kamieskroon Gneiss, granites and gneisses of the Bieisiesfontein Granite, schists and gneisses of the Stalhoek Complex, gneiss of the Nababeep Gneiss and quartzites of the Flaminkberg Formation, Vanrhynsdorp Group.

From Groenrivier the line crosses over dune sands interspersed with outcrop of the Kamieskroon and Kliphoek granite becoming more common to the south.

The section of the line following the NNP reserve corridor from about Kotzesrus is underlain by similar geology characterised by rolling dunes interspersed with the leucocratic gneiss of the Kamieskroon gneiss near the Brakrivier, granitic rocks of the Kliphoek Granite near the Soutrivier, and the quartzites, schists and gneisses of the Bitterfontein Formation of the Bushmanland Complex as the line approaches Juno Substation near Vredendal.

5.5 Geology – Route G

From Gromis, Route G crosses through an area underlain Aeolian deposited dune sands until the point where Route G deviates into the northern part of the Namaqualand National Park. From here the line is generally underlain by scattered outcrops of leucocratic gneisses of the Kamieskroon Gneiss. Where Route G joins again with ESKOM:Route A at the southern boundary of the Park, the line is more consistently underlain by the leucocrtatic gneisses with occasional interspersed dune deposits to Landplaas, with occasional outcrops of leucogranites and hornblende granites of the Biesiesfontein Granite occur in the vicinity of Rietpoort.

The section of the line following the Cape Nature : Route B between Landplaas and Juno crosses similar geology characterised by rolling dunes interspersed with the gneisses, quartzites, and schists of the Bitterfontein Formation, Bushmanland Complex.

6. GEOTECHNICAL ASSESSMENT OF PREFERRED ROUTES

A geotechnical assessment has been conducted over the power line corridor using the topographical, geomorphological and geological mapping information gathered from both the desk study and the preliminary field visit. This assessment evaluates the impact of geotechnical issues on costs of construction with respect to :

- Earthworks associated with tower construction
- Materials usage for foundations and road construction
- Tower foundations
- Design and construction of maintenance roads along the transmission line route, and
- Access routes to the line from the district and national road network into the area

6.1 Common Route : Oranjemond Substation - Gromis Substation

A very good indication of the requirements for earthworks was obtained from the aerial inspection conducted of the Gromis-Oranjemond 1 line. The towers constructed along this section can be seen in numerous photographs (Plates 3 to 11). This area is mainly dominated by the reddish brown sand dunes which are generally known to be stable. However, caps of whiter, migrating dunes are interspersed throughout this region and these tend to be problematic since their migration is rapid and seasonal. Significantly high sand dune drifts can cause a significant horizontal loading on the towers for which they have not been designed.

In general earthworks in this general area are likely to be Soft Excavation (SABS 1200:1988) and easily carried out by hand or light earthmoving plant.

Occasional rock outcrops will be encountered on which isolated towers will be positioned. The earthworks for these towers will require Hard Excavation. However significant cost savings can be achieved at these tower positions as a result of higher achievable bearing pressures, i.e. necessitating smaller foundations, and the judicious use of rock anchors.

An advantage of the mast construction in this general area, consisting of the stable dune sands, is the adoption of a more or less standard design for the tower, which may prove to be the most economic section of the corridor. A probable, but relatively insignificant, disadvantage is the need to make rather large bases for the following reasons:

- Passive or deadweight design of the footings (to resist uplift forces), and
- Relatively low allowable bearing pressures of insitu soils for lateral and vertical loads.

This part of the corridor is also very accessible from the main gravel road network in the area and the construction of roads through the dune sands a simple process. However, apart from the migrating dunes a significant problem relating to this general area is the high erodibility of the sands and the formation of erosion gulleys or dongas either by wind or sheetwash erosion along preferential paths such as un-hardened service roads running adjacent to the line.

6.2 Route C

6.2.1 Route C : Gromis to Nama

The section of corridor between the Gromis and the Spektakelpas (Plate 13; Plates 24 to 31) is generally relatively gentle in nature with relatively thin soil cover. Shallow foundations are likely to be the normal founding method but shallow rock may well pose excavation problems, with Intermediate Hard Excavation (SABS 1200:DM) being required for foundation excavations. Judicious use of ground/rock anchors will also limit costs significantly where required to counter uplift forces.

From the Spektakel Pas to Nama the topography is characterised by very mountainous and rugged terrain. The towers supporting the transmission line will therefore need to be very carefully located. The rugged terrain, characterised by rugged peaks and valleys may require longer spans between elevated locations and resultant changes to the standard tower design to accommodate the longer cable spans.

The earthworks for these towers will generally require Hard Excavation. However significant cost savings can be achieved at these tower positions as a result of higher achievable bearing pressures, i.e. necessitating smaller foundations, and the judicious use of rock anchors to counter uplift. In this case rock anchors would consist of simple high tensile steel reinforcing dowels grouted into bedrock beneath foundations.

6.2.2 Route C : N7 route : Nama to Helios-Juno 1 line and Juno

This section of the line will run parallel; to the N7 National Route. No existing line runs long this route and the required servitude for this new line would need to be created. The area is characterised by a fairly shallow mantle and shallow pad foundations are likely to be the normal founding method. Shallow rock may well pose excavation problems in foundation excavations. Judicious use of ground/rock anchors will also limit costs significantly where required to counter uplift

Earthworks are likely to be kept to a minimum. An advantage of this route is that due to its proximity to the N7 access will be relatively easily managed with short access roads from the N7 to the service road.

The section of Route C running parallel to the existing Helios-Juno 1 line should find similar founding conditions although deeper soil cover may be anticipated in isolated areas.

6.3 Route E

6.3.1 Route E : Gromis – Hondeklipbaai - Spoegrivier

The section of line from Gromis to Hondeklipbaai (Plates 7 to 9) is underlain by dune sands which are similar to those encountered near Alexander Bay. In general earthworks in this general area are likely to be Soft Excavation and easily carried out by hand or light earthmoving plant.

An advantage of the mast construction in this general area, consisting of the stable dune sands, is the adoption of a more or less standard design for the tower, which may prove to be the most economic section of the corridor. A disadvantage is probably the need to make rather large bases for the following reasons:

- Passive or deadweight design of the footings, and
- Relatively low bearing pressures of insitu soils for lateral and vertical loads

Alternatively, piled foundations may be required for the towers but the need for piled foundations would be determined by detailed geotechnical investigations at tower positions.

This part of the corridor is also very accessible from the main gravel road network in the area and the construction of roads through the dune sands a simple process. However, apart from the migrating dunes other significant problems relating to this general area are the following:

- High erodibility of the dune sands and the formation of erosion gulleys or dongas either by wind or sheetwash erosion along preferential paths such as un-hardened service roads running adjacent to the line, and
- High corrosion potential of steel masts due to the proximity to the ocean

6.3.2 Route E : Spoegrivier- Cape Nature Corridor- Juno

The section of line from Spoegrivier through the National Parks corridor to Juno is similar to the previous section in that earthworks in this general area are likely to be Soft Excavation and easily carried out by hand or conventional light earthmoving plant. However the route now runs between 20 and 30km from the ocean and will not be affected by the high corrosion potential of the fog from the ocean.

Occasional areas with shallow bedrock, particularly between the Brakrivier and the Soutrivier, may require hard excavation. Once again significant cost savings can be achieved at these tower positions as a result of higher achievable bearing pressures, i.e. necessitating smaller foundations, and the judicious use of rock anchors.

6.4 Route F

6.4.1 Route F : Gromis to Groenrivier

Route F between Gromis and Spektakelpas is generally relatively gentle in nature with relatively thin soil cover. Shallow foundations are likely to be the normal founding method but shallow rock may well pose excavation problems, with Hard Excavation being required for foundation excavations. Judicious use of ground/rock anchors will also limit costs significantly where required to counter uplift.

From Spektakelpas to the Groenrivier, the geotechnical assessment is very similar in nature to the area along the N7, where no existing line runs along the route and the required servitude for this new line would need to be created. The area is characterised by a fairly shallow mantle and shallow pad foundations are likely to be the normal founding method. Shallow rock may well pose excavation problems in foundation excavations. Judicious use of ground/rock anchors will also limit costs significantly where required to counter uplift

Earthworks are likely to be kept to a minimum. Access to this part of the line from main routes like the N7 is limited, however, a network of gravel rural or farm roads occur in some areas that will allow access to the line.

6.4.2 Route F : Groenrivier to Juno

This section of Route F is underlain by mainly dune sands with occasional interspersed granite and gneiss outcrops. In general earthworks in this general area are likely to be Soft Excavation and easily carried out by hand or light earthmoving plant.

An advantage of the mast construction in this general area, consisting of the stable dune sands, is the adoption of a more or less standard design for the tower, which may prove to be the most economic section of the corridor. A disadvantage is probably the need to make rather large bases for the following reasons:

- Passive or deadweight design of the footings, and
- Relatively low bearing pressures of insitu soils for lateral and vertical loads

Alternatively, piled foundations may be required for the towers but the need for piled foundations would be determined by detailed geotechnical investigations at tower positions.

This part of the corridor is also very accessible from the main gravel road network in the area and the construction of roads through the dune sands a simple process. However, apart from the migrating dunes other significant problems relating to this general area are the following:

- High erodibility of the dune sands and the formation of erosion gulleys or dongas either by wind or sheetwash erosion along preferential paths such as un-hardened service roads running adjacent to the line, and
- High corrosion potential of steel masts due to the proximity to the ocean, particularly where the line bends to within 10 km of the ocean in the vicinity of the Soutrivier.

6.5 Route G

6.5.1 Route G: Gromis to NNP

From Gromis, Route G (and Route B) crosses through an area underlain Aeolian deposited dune sands. In general earthworks in this general area are likely to be Soft Excavation and easily carried out by hand or light earthmoving plant. It is likely that large foundation bases will be required to cater for the following:

- Passive or deadweight design of the footings, and
- Relatively low bearing pressures of insitu soils for lateral and vertical loads

Piled foundations may be required for the towers but the need for piled foundations would be determined by detailed geotechnical investigations at tower positions.

6.5.2 Route G: NNP to Juno

From the NNP the line is generally underlain relatively solid geology comprising granite and gneisses, as well as occasional areas of interspersed dune cover and more scattered outcrops of rock.

The area is characterised by a fairly shallow mantle and shallow pad foundations are likely to be the normal founding method. Shallow rock may well pose excavation problems in foundation excavations. Judicious use of ground/rock anchors will also limit costs significantly where required to counter uplift. In the vicinity of Koekenaap the line crosses over transported soils once again where foundations will need to be taken deeper, and in some cases, piles will need to be considered.

7. GEOTECHNICAL AND CIVIL ENGINEERING FACTORS AFFECTING THE CONSTRUCTION COSTS OF PROPOSED POWERLINE

Factors affecting the costs of construction of the power line, from geotechnical and civil engineering perspectives are the following:

- Topography,
- Susceptibility of erosion,
- Proximity of the steel towers to the corrosive environment of the coastline,
- Location and design of service roads in relation to the powerline with access roads off provincial and national routes,
- Straightness of route i.e. degree of minimisation of bends, or changes in direction, in the route. Bends and crossovers are costly and add to the cost of the line,
- Impact of geotechnical issues on costs of construction with respect to :
    - Earthworks associated with tower construction
    - Materials usage for foundations and road construction
    - Tower foundations
    - Tensioned ground anchors

It was indicated by Mr Gearingh that the line will have a design life of 30 years.

7.1 Proposed Tower Design

The proposed tower design is known as the compact cross-rope type. The design incorporates two diagonal tower arms joined by a horizontal straining cable which supports the powerline. The entire arrangement is stabilised on either side by vertical tension cables anchored to the ground. The design is preferable to the traditional cross beam tower arrangement from a faunal impact aspect. However, other aspects such as foundations and the use of the lateral stabilising cables secured by ground anchors requires more competent geological conditions. Uplift forces between successive towers are significant factor that must be accommodated in the design of foundations.

The average distance between towers is 450 metres.

Generally the tower foundation design is facilitated by construction in areas underlain by shallow soil cover overlying bedrock. In these areas foundations will comprise simple pad footings taken into bedrock while the anchors will be simple steel dowels drilled and grouted into the weathered bedrock.

In areas underlain by deep soil cover the use of relatively large foundation bases, mainly to counter uplift forces. Piled foundations may be required in selected areas requiring deep installation which will increase construction costs significantly.

7.2 Straightness of Proposed Line on Construction Costs

The straightness of the various proposed powerlines is a critical factor affecting costs of construction of the line. The need to construct bends as a result of deviations in the chosen route will add up to R1.5 million to the cost of an affected tower. Furthermore, similar cost penalties will occur in cases where the new line may be required to cross over the existing one. Final design considerations would govern the number of bends and deviations in the routes. As determined from Figure 2, the number of anticipated deviations or bends along each of the routes between Gromis and Juno, is as follows:

Route C : 470
Route E : 52
Route F : 61
Route G : 65

7.3 Topography

Topography may also have a profound effect on the cost of line construction. Generally, where the line traverses steep areas of rugged topography the following could become necessary:

- Shortening/lengthening of span
- Deviations to avoid extremely rugged areas
- Additional stabilisation measures to support towers at steep cliff areas
- Adhoc alterations to tower design to accommodate specific conditions
- Difficulty of construction associated with difficult and very steep terrain, relating to access to tower locations.

7.4 Corrosion

Corrosion of the steel components of towers will be affected by their proximity to the ocean. The corrosive effect of the fog from the Atlantic Ocean is most pronounced within 10 km from the coastline. For this reason powerlines are best located beyond about 20 km from the ocean to minimise corrosion. Costs associated with the corrosion of the towers are related to the following:

- Increased maintenance of towers, cables and resistors
- Mitigating measures to limit corrosion, such as galvanic treatment to steel components and use of alternative materials for mast components which may be relatively expensive.

8. QUALITATIVE COMPARISON OF CONSTRUCTION COSTS FOR ROUTES C AND E

In order to carry out a comparative assessment of Routes C, E, F and G in terms of suitability for development from geotechnical and civil engineering perspectives, a system of rating various aspects discussed in this report has been adopted.

In that all routes will follow the existing ESKOM servitude from Oranjemond to Gromis, it is therefore only necessary to compare the routes from Gromis to Juno for Routes C, E, F and G. The various attributes of the two routes are rated numerically from 1 to 10, with 1 representing the least favourable and 10 representing the most favourable site for each of the geotechnical/ civil engineering attributes considered.

The following geotechnical aspects are considered for comparison purposes:-

- Topography,
- Proximity of the steel towers to the corrosive environment of the coastline,
- Location and design of service roads in relation to the powerline with access roads off provincial and national routes,
- Straightness of route i.e. minimisation of bends, or changes in direction, in the route which are relatively uneconomic,
- Actual length of route,
- Impact of geotechnical issues on costs of construction with respect to :
  - Earthworks associated with tower construction
  - Materials usage for road construction
  - Tower foundations
  - Tensioned ground anchors.

The comparison of the sites on the basis of the attributes described above is given in Table 1 below.

Table 1 : Rating of Attributes of Alternative Powerline Routes

Geotechnical and Civil Engineering Attribute	Alternative Route:-			
	C	E	F	G
A. Topography	3	8	4	7
B. Corrosive Environment	8	3	7	8
C: Access Road to Construction	8	5	6	4
D: Straightness of Route	5.5	10	8.52	8
E: Length of Finished Route	7.23	9.74	8.44	10
F: Geotechnical/ Geological				
F1: Earthworks	3	7	4	7
F2: Materials for Road Construction	5	5	5	5
F3: Foundations/ Ground Anchors	7	4	6	5
TOTAL ATTRIBUTE SCORE	**46.73**	**51.74**	**48.96**	**54.0**

9. CONCLUSIONS

Based on the preliminary geotechnical assessment given in this report, the comparison of Routes C, E, F and G given in Section 8 above indicates that Route G is geotechnically the most suitable for the proposed new Oranjemond-Juno power line. This does obviously not take into account other planning and design issues, which must also be considered in selecting a site. Route E, which is very similar in terms of attribute scoring, may also be considered. This route may in fact become most suitable in view of the fact that it does not cross through the Namaqua National Park. However, this presents an environmentally determined outcome not covered by the scope of this report.

Finally, the discussions in this report are based on the information obtained from a desktop study and driveover and flyover of the sites only. Geological conditions and the effect on development are inferred from the information available, and could thus vary significantly from that anticipated, particularly in view of the highly variable characteristics of the prevailing regional geological conditions. It is thus extremely important that a detailed geotechnical investigation be carried out along the preferred or chosen route so that construction costs can be fixed or reliably estimated. Indeed, the final design of either of the routes, and therefore construction cost, would depend heavily on such detailed geotechnical findings.

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PLATES

PROPOSED NEW ESKOM KUDU OVERHEAD POWERLINE : ALEXANDER BAY TO VREDENDAL

DRIVEOVER ASSESSMENT : ORANJEMOND-GROMIS

Plate 1

Plate 2

Plate 3

Plate 4

PLATES 1 to 4 : ORANJEMOND SUBSTATION, ORANGE RIVER

PROPOSED NEW ESKOM KUDU OVERHEAD POWERLINE : ALEXANDER BAY TO VREDENDAL

DRIVEOVER ASSESSMENT : ORANJEMOND-GROMIS

Plate 5

Plate 6

Plate 7

PLATES 5 to 7 : ROAD BETWEEN ORANJEMOND AND PORT NOLLOTH : NOTE WHITE UNDULATING DUNE SANDS

PROPOSED NEW ESKOM KUDU OVERHEAD POWERLINE : ALEXANDER BAY TO VREDENDAL

DRIVEOVER ASSESSMENT : ORANJEMOND-GROMIS

Plate 8

Plate 9

PLATES 8 & 9 : PORT NOLLOTH TO KEINSEE : NOTE DIAMOND MINING ACTIVITIES

Plate 10

Plate 11

DRIVEOVER ASSESSMENT : ORANJEMOND-GROMIS


Plate 12


Plate 13

PLATES 10 to 12 : GROMIS SUBSTATION AND SURROUNDING AREAS

PLATE 13 : GROMIS TO SPEKTAKELPAS

PROPOSED NEW ESKOM KUDU OVERHEAD POWERLINE : ALEXANDER BAY TO VREDENDAL

FLYOVER ASSESSMENT (APPROXIMATE POSITION OF AIR-PHOTO SHOWN ON FIGURE 2)

1. ORANJEMOND TO GROMIS

Plate 14

Plate 15

PLATES 14 & 15 : ORANJEMOND SUBSTATION

Plate 16

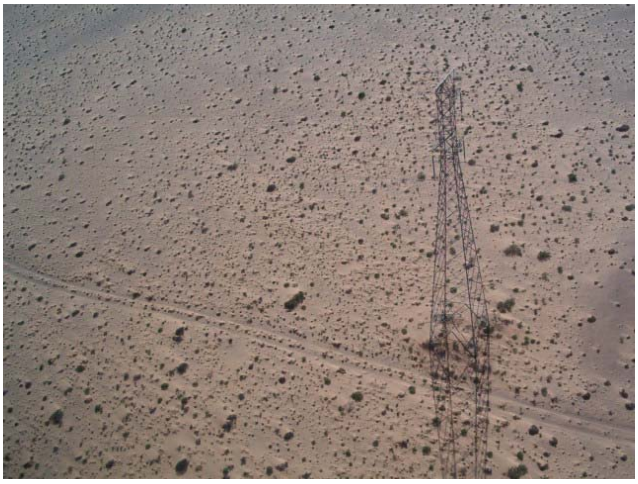

Plate 17

PLATES 16 & 17 : UNVEGETATED WHITE DUNE SANDS – ORANJEMOND AREA

FLYOVER ASSESSMENT (APPROXIMATE POSITION OF AIR-PHOTO SHOWN ON FIGURE 2)

Plate 18

Plate 19

PLATES 18 & 19 : RED DUNE SANDS, GENTLE TOPOGRAPHY

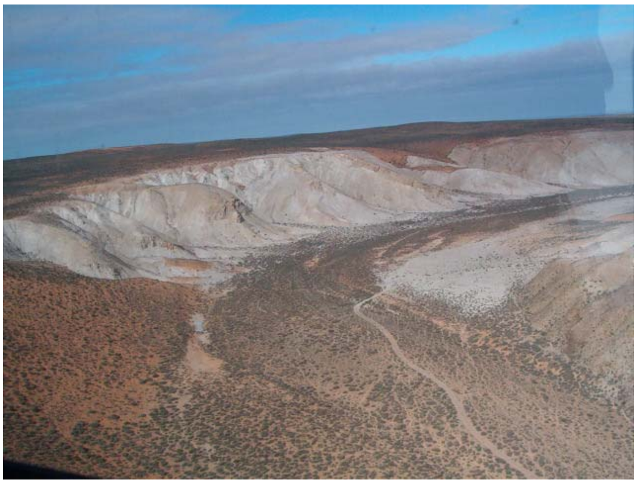

Plate 20

Plate 21

PLATES 20 & 21 : HOLGAT RIVER

FLYOVER ASSESSMENT (APPROXIMATE POSITION OF AIR-PHOTO SHOWN ON FIGURE 2)

Plate 22

Plate 23

PLATES 22 & 23 : RED DUNE SANDS, GENTLE TOPOGRAPHY

Plate 24

Plate 25

PLATES 24 & 25 : GROMIS SUBSTATION

FLYOVER ASSESSMENT (APPROXIMATE POSITION OF AIR PHOTO SHOWN ON FIGURE 2)

2. GROMIS TO NAMA

Plate 26

Plate 27

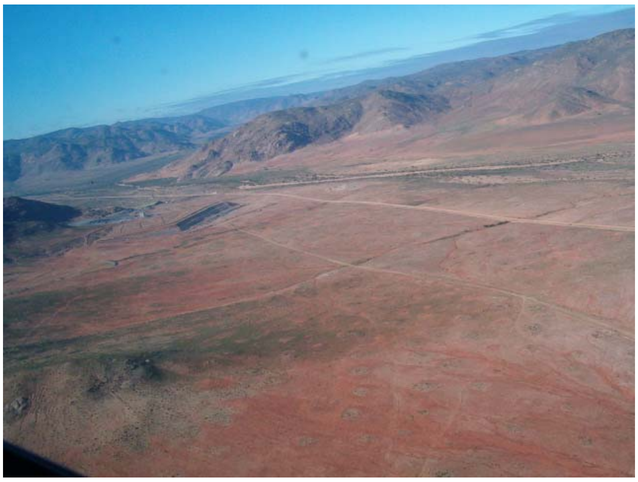

Plate 28

PLATES 26 TO 28 : APPROACH TO SPEKTAKELPAS : NOTE MORE RUGGED TERRAIN

PROPOSED NEW ESKOM KUDU OVERHEAD POWERLINE : ALEXANDER BAY TO VREDENDAL

FLYOVER ASSESSMENT (APPROXIMATE POSITION OF AIR PHOTO SHOWN ON FIGURE 2)

2. GROMIS TO NAMA

Plate 29

Plate 30

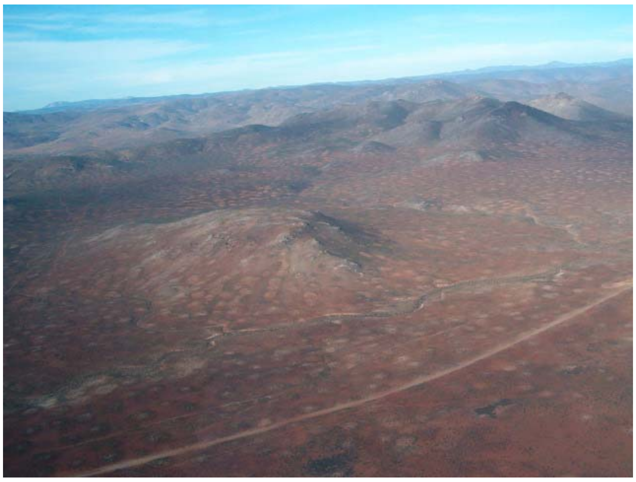

Plate 31

PLATES 29 to 31 : INCREASINGLY MOUNTAINOUS AND RUGGED NEAR SPRINGBOK

FLYOVER ASSESSMENT (APPROXIMATE POSITION OF AIR PHOTO SHOWN ON FIGURE 2)

3. GROMIS TO JUNO

Plate 32

Plate 33

PLATES 32 & 33 : UNDULATING TOPOGRAPHY MIDWAY BETWEEN GROMIS AND JUNO

Plate 34

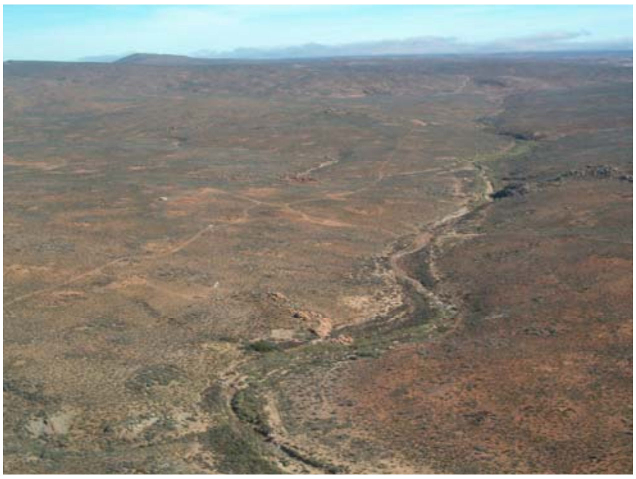

Plate 35

PLATES 34 & 35 : AREA IN VICINITY OF GROEN RIVIER

FLYOVER ASSESSMENT (APPROXIMATE POSITION OF AIR PHOTO SHOWN ON FIGURE 2)

3. GROMIS TO JUNO

Plate 36

Plate 37

PLATES 36 & 37 : MODERATE TOPOGRAPHY BETWEEN GROEN RIVIER AND SOUT RIVIER

Plate 38

Plate 39

PLATES 38 & 39 : UNDULATING TOPOGRAPHY APPROACHING VREDENDAL

FLYOVER ASSESSMENT (APPROXIMATE POSITION OF AIR PHOTO SHOWN ON FIGURE 2)

3. GROMIS TO JUNO

Plate 40

Plate 41

PLATE 40 : OLIFANTS RIVIER

Plate 42

Plate 43

PLATES 41 & 42 : RED DUNE SOILS BETWEEN OLIFANTS RIVIER AND VREDENDAL

PLATE 43 : TRIBUTARY OF OLIFANTS RIVIER

FLYOVER ASSESSMENT (APPROXIMATE POSITION OF AIR PHOTO SHOWN ON FIGURE 2)

3. GROMIS TO JUNO

Plate 44

Plate 45

Plate 46

PLATES 44 to 46 : JUNO SUBSTATION AND SURROUNDING AREAS

FIGURES