ROUTE EVALUATION AND ENVIRONMENTAL IMPACT ASSESSMENT
PROPOSED 132 kV POWER LINE FROM AUS SUB-STATION TO REHOBOTH SUB-STATION
AND
PROPOSED 220 kV POWER LINE FROM AUS SUB-STATION TO THE KHOMAS SUB-STATION

Environmental Impact Assessment on the vegetation

Report prepared by

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for

Enviro Dynamics (Pty) Ltd and NamPower

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1. Introduction

With the ever-increasing demand for electricity in both Windhoek and Rehoboth municipal areas, a need exists to upgrade the distribution network from the Auas Station east of Windhoek both to Rehoboth as well as to western Windhoek. An environmental impact assessment of the proposed routes has been duly commissioned. For the impact on the vegetation the following Terms of Reference apply:

Terms of Reference

The Consultant shall perform the botanical specialist contribution to the Route Evaluation and Environmental Impact Assessment of the of the proposed 132 kV power line from the Aus sub-station east of Windhoek to the Rehoboth sub-station near Rehoboth and for the proposed 220 kV power line from the Aus sub-station to the Khomas sub-station to the west of Windhoek.

The main tasks of this specialist study shall be:

a. Review the existing information on the general area traversed by the alignment.

b. Devise an appropriate sampling strategy that would focus on the most sensitive components.

c. Attendance of meetings with team members to discuss route evaluation and mitigation

d. Zoning of areas according to sensitivity, and possible mitigation measures. Scenes can be provided on hard copy maps, to be included in the GIS database.

f. Reporting.

The report shall detail the following:

- Methodology followed
- Assumptions and limitations of the study
- A general description of the botanical components, focusing on sensitive areas along the route
- Appropriate rating of areas from highly sensitive to least sensitive, on a scale as may be appropriate.
- More detailed description of important sites found at sensitive areas
- Examples of typically important sites, with photographs included.

- Recommendations for deviations/alternatives routes to avoid sensitive vegetation, if needed.
- For the route selected, a description of potential impacts (providing the extent, duration, significance, mitigation confidence, and/or other parameters as may be deemed suitable)
- Proposed mitigation strategy
- References

2. Methods

As a first step, the proposed routes have been studied on the supplied copies of the 1:50 000 maps as well as well as on hard copies of aerial photographs of the study area. Known literature on the vegetation along the route was consulted to determine preliminary types.

This was followed by a field visit to get an on-the-ground idea of the dominant vegetation types and possible environmental issues likely to be encountered en route. For the woodlands, an estimate was made of the density of trees using the Nearest-Neighbour approach (Cottam & Curtis 1956; Mueller-Dombois & Ellenberg 1974).

Broad vegetation maps for the area were drawn, using existing studies as guidelines (Volk & Leipert 1971; Kellner 1986; Strohbach 1997; Strohbach 2002; Irish 2002; Strohbach 2003; Burke & Wittneben 2004) and the supplied topographic maps as base.

A rating was assigned to each broad landscape type regarding its biodiversity as well as its general sensitivity to disturbances.

3. Assumptions and limitations of this study

This project was hampered by the following problems:

Only low-resolution hard copies of the aerial photographs were supplied (again excluding the far southern part of the study area), thus making interpretation of the ground features difficult.

A helicopter survey (even if only a video tape of the proposed route would have been supplied) would have helped immensely in gathering a first impression of the route and identifying the difficulties / problem areas along the route.

Technical information on the construction process is lacking. Although the servitude width has been stated in the scoping documents (40 m or 55 m), nowhere is stated how wide the actual clearance has to be. A (simplified) technical briefing (even as document) would assist in understanding the potential impacts on soil and vegetation.

4. Vegetation types encountered

The entire route falls within the southern part of the Highland savanna *sensu* Giess (1998). Other than the western Highland savanna, the topography is more gentle, being formed on granites of the Hohewarte complex (Geological Survey 1980). These gently rolling plains are interspersed by a number of inselbergs of various geological origin. Also typical for the Highland savanna are scattered rocky outcrops, which, in some cases, can have a considerable magnitude. Less typical are the fast expanses of Camelthorn woodlands, which occur along the western and south-western valleys filled with alluvial deposits (Figure 1).

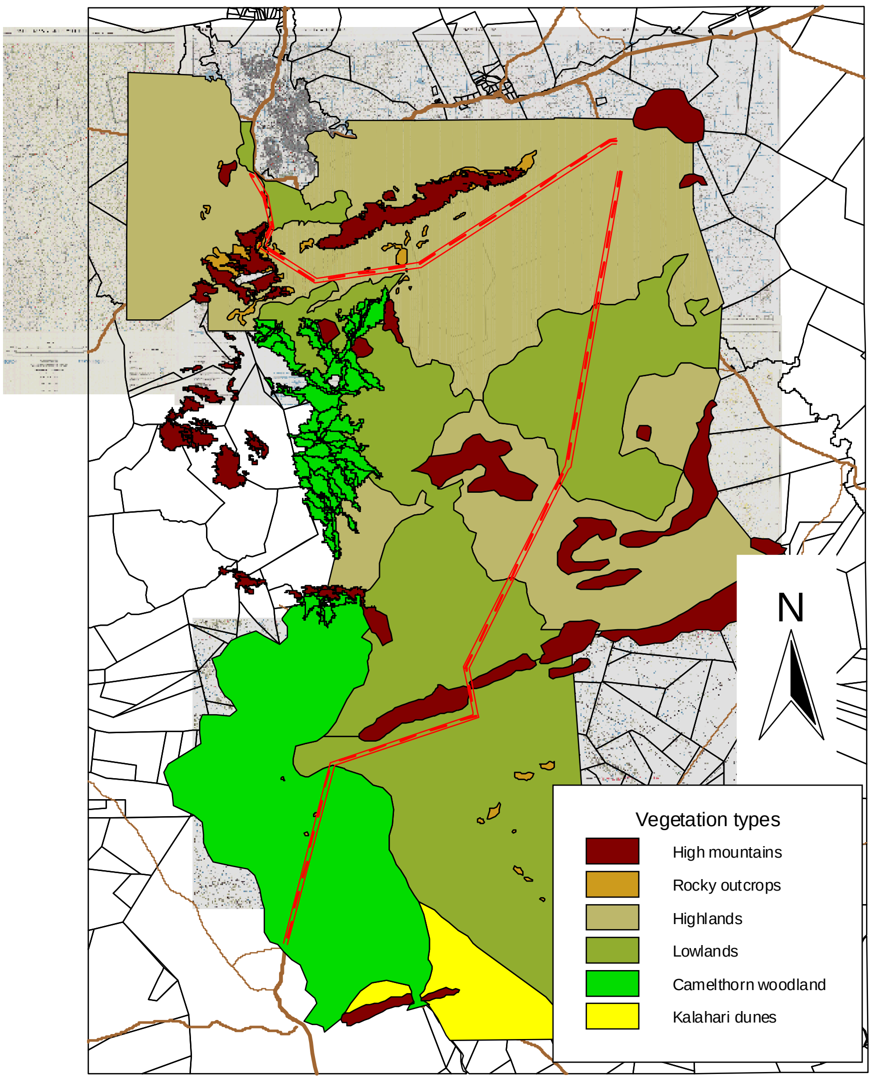

Figure 1: Broad vegetation types encountered along the power line routes.

4.1. High mountains

The high mountains form part of three complexes sensu Irish (2002): The Khomas Hochland complex, as well as the northern and southern Auas Mountain complexes. The northern Auas Mountain range (Lichtenstein, Regenstein, Auas Mountains and Bismarkberge) are closely related to the Khomas Hochland from their geological origin as well as the fact that they are interlinked. Burke & Wittneben (2004) state that these mountains have a distinct floristic composition due to their high altitude. Also Craven (2001) recognises here a centre of high diversity. Because of this, the Auas mountain complex has been identified as an Important Plant Area, worthy of further conservation (Hofmeyer 2004).

The southern Auas Mountain complex (Oamites, Nauaspoort, Grimmrücken, Bahnhofberg, and related ranges) are of varied geological origin, and first indications are that they also support a different, highly specific vegetation (Volk & Leipert 1971; Strohbach 2002). These ranges are very understudied, but as they are not directly affected by the proposed power lines, not further studied for the purpose of this evaluation.

Figure 2: Typical high mountains: Regenstein south of Windhoek.

4.2. The Rocky Outcrops

The topography of the Highland savanna is formed by shallow rocks of mostly the Kuiseb formation (Geological Survey 1980). A feature of this topography is a high number of outcrops of these underlying rocks – from small outcrops (Figure 3) to large cliff faces (Figure 4). These are generally scattered through the landscape, but particularly prominent along escarpments and bigger mountains. Volk & Leipert (1971) as well as Kellner (1986) recognised the rocky outcrops as an own unique vegetation type. Data from a recent survey of the Auas-Oanob conservancy to the immediate west of the present study area suggests that these rocky outcrops are not only a unique habitat with a unique vegetation type – the vegetation is also highly diverse with a high number of niche species restricted to theses outcrops. This particular factor makes the rocky outcrops highly sensitive to disturbances.

Of particular note is a string of rocky outcrops south of the Auas mountains, approximately along the border between Waldeck and Aris (Figure 5), as well as numerous outcrops south of the Nauaspoort mountains (Figure 6). Both these are of granitic origin, and have a different vegetation than those of the outcrops on schist of the Khomas Hochland. Again, virtually no information is available, except that these outcrops are likely to have a high diversity and are thus to be regarded as sensitive. One such outcrop next to the Windhoek – Rehoboth road south of the Nauaspoort mountains is directly in the path of the proposed power line.

Figure 3: Rocky outcrops can be small or large, but support a substantial part of the high species diversity of the Highland savanna.

Figure 4: Steep cliff faces are generally associated with the Auas mountains, e.g. at the break along the Windhoek – Rehoboth road (eastern face of the Regenstein). The route of the proposed Auas-Khomas line is to run along these cliff faces.

Figure 5: Part of the ridge of rocky outcrops east of Aris. These granitic outcrops form a steep escarpment between the Aris valley and the eastern highlands.

Figure 6: A small granitic outcrop east of the Rehoboth station. Note the dense stand of *Aloe littoralis*.

4.3. The Highlands

Typical for the Khomas Hochland is what Volk & Leipert (1971) termed the *Acacia hereroensis* – *Tarchonanthus camphorathus* association. According to these authors, the shrub layer is relatively open and species poor, a view not shared today. This is due to the wide-spread phenomenon of bush encroachment (de Klerk 2004). These highlands have been found to be relatively species rich, but because of their extensiveness, less endangered by disturbances.

The soils are shallow to moderately deep, with a high sceletal component (i.e. stones). The Highland savannas are known for their erodible soils (due to their slopes and high fine sand and loam content). This holds true for both the soils derived from mica schists (Kuiseb formation) to the west and south-west of Windhoek as well as soils derived from granitic origin, as found in the study area south-east of Windhoek. This is due to the nature of the soil, consisting of fine sands and loams, but little clay, and is aggravated by the generally rolling to moderately steep slopes of the landscape. This is by far the biggest threat to this landscape.

Figure 7: Typical shrubland vegetation of the Khomas Hochland. Note the steep slopes, as well as the fact that the soils are often exposed under the open to semi-open grass layer.

4.4. The Lowlands

The foot slopes to the Khomas Hochland as well the high mountain ranges are similarly stony in nature as the upper slopes, have however a more gentler slope. Volk & Leipert (1971) described the vegetation as very similar to those of the upper slopes, but also recognize here already the formation of dense stands of *Acacia mellifera* subsp. *detinens*. These lower hills and rises have a lower species diversity than the highlands, and are generally prone to bush encroachment.

Figure 8: Bush encroached foot slopes to the Khomas Hochland are a well-known sight around Windhoek.

Figure 9: Footslopes SW of the Nauaspoort mountains. Note that the vegetation here is far sparser than further north, because of a more arid environment.

Within the Windhoek Townlands, these lower footslopes have been extensively been degraded to mine gravel for road construction purposes (Strohbach & Seely 2003). Here these lowlands can be regarded as extremely disturbed and many additional disturbances as non-consequential. The danger of erosion remains high, however, primarily due to the denuded nature of these landscapes.

Closely associated with these lowlands are often omirimbi (relatively flat, wide water courses with very little gradients and no visible flow channel) (Figure 10). These omirimbi are highly important for the soil moisture regulation of the entire landscape surrounding them (Pringle & Tinley 2003). Being formed by alluvial deposited soils, these omirimbi are highly susceptible to erosion. Volk & Leipert (1971) describe the vegetation as a *Themeda triandra* association having a dense grass cover. Recent experience with similar vegetation types SW of Windhoek show that many are already eroded, and that the once dense perennial grass sward has been replaced by an open to moderately closed annual grass sward with a high herb component (Strohbach 2002).

Figure 10: Typical grassy omuramba SW of Windhoek. Note the low herbaceous cover, which Volk & Leipert (1971) originally described as a dense, ca 140 cm high grass sward.

4.5. The Camelthorn woodlands

The best known vegetation feature of the Rehoboth district is the Camelthorn woodlands on the alluvial plains north and south of the town. Here a high density of well-grown *Acacia erioloba* trees occurs, many of a size to suggest an age of many hundreds of years. At a sample point between Rehoboth Station and the Town, ca 524 trees / ha were found, standing on average 11.42 m apart. South of Windhoek these woodlands have been found to have a relatively low diversity of species (Strohbach 2002), however, a common problem with the data is that geophytes are normally not sampled due to their difficult identification (Strohbach 2001). Evidence has been found during the field work phase of this project that these woodlands harbour a high number of geophytic species, which are generally little known in Namibia.

Conservation of these woodlands is of concern to the Directorate of Forestry as well as the Rehoboth community (Strohbach 1997), meaning that a route needs to be chosen through these woodlands in such a way that the least damage is caused to the trees.

Figure 11: Open Camelthorn woodland on an alluvial plain.

Figure 12: Note the large density of geophytes under this *Acacia erioloba* tree (above). On the right is the common *Pseudogaltonia clavata* (or Suidwes Slangkop), at the time of the field survey starting to flower. Also seen in the vicinity were *Crinum* spp., *Nerine* spp as well as other geophytes, possibly of the lesser known genera *Scilla* and *Ledebouria*.

Two large rivers cross (or are nearby) the route: the Schaap river as well as the Usib river. All have splendid riverine woodlands along their banks. The power line should cross these riverine woodlands at the thinnest possible part, in such a way that the least of the riverine woodlands are destroyed. These woodlands protect the embankments from erosion. By protecting the riverine woodlands, infrastructure build nearby rivers (pumps, homesteads as well as power lines) can be effectively protected from flash flood damage. Care should be taken that the power line does not follow rivers and thus damaging large stretches of woodland.

Figure 13: The Usib river near the Rehoboth Station. In the foreground is a sandbank covered with *Stipagrostis namaquanum*, in the background the riverine woodland dominated by *Acacia karroo* can be seen.

4.6. Protected species likely to be encountered

Aloe littoralis (Windhoek Aloe)[NC]
Aloe viridiflora (green Aloe)[NC]
Aloe hereroensis (Sand aloe)[NC]
Acacia erioloba (camelthorn)[F]
Albizia anthelmintica (worm cure Albizia)[F]
Boscia albitrunca (shepherd's tree)[F]
Maerua schinzii (ringwood tree)[F]

[NC] Protected by the Nature Conservation Ordinance (Ordinance 4 of 1975)
[F] Protected by the Forestry Act (Act 12 of 2001)
This list is not exhaustive. Other protected species might also occur!

5. Recommendations for deviations

5.1. Proposed Auas – Rehoboth power line

The proposed route crosses two sensitive areas: the Highlands of the Khomas Hochland (sensitive due to the danger of erosion) as well as the Camelthorn woodlands (sensitive vegetation) (Figure 14). No alternative route can be proposed for crossing the Highlands of the Khomas Hochland, as this route will follow existing power lines closely and will thus not cause new paths through “virgin” land. The last leg through the Camelthorn woodlands is however unnecessary long (17.6 km). Although the servitude width is 40 m, it seems that a clearing of ca 6 m width is sufficient for this power line (photographic material provided by NamPower). Thus about 10.56 ha of this vegetation, or approximately 5 500 trees, will be destroyed. On this last leg, the power line also crosses (or near-misses) some highly-sensitive rocky outcrops.

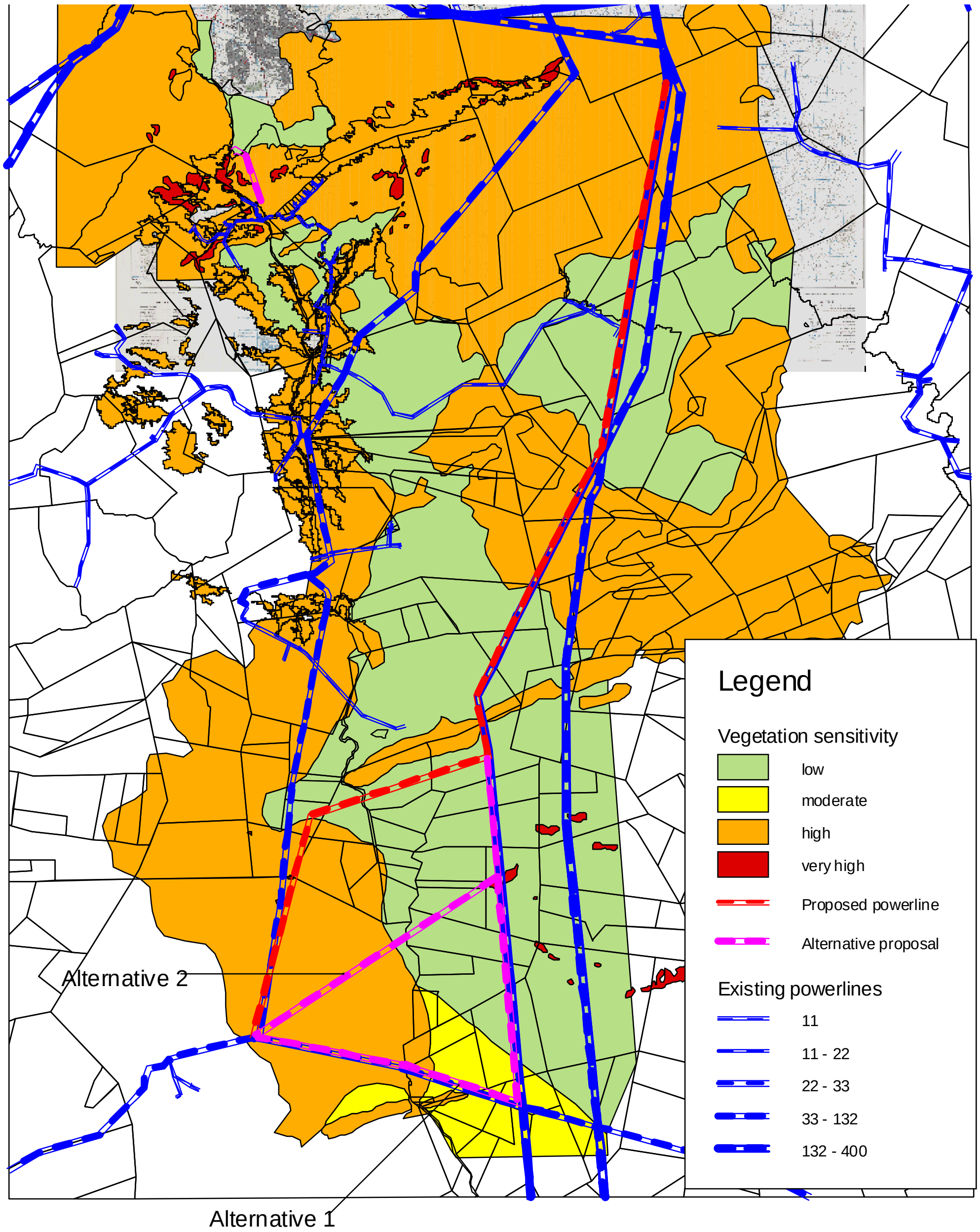

Figure 14: Sensitivity of the vegetation types crossed by the proposed Auas – Rehoboth line. An alternative route proposal for the last 31 km of the proposed power line is shown in purple. This will lead to less damage to the Camelthorn woodlands.

Two alternative routes are proposed:

Alternative 1 (preferred): This route will follow the existing 400 kV transmission line until it crosses the smaller 66 kV distribution line leading up to the Rehoboth substation. This option will lengthen the proposed route by ca 16 km, but will have the least impact on the sensitive Camelthorn woodlands, as a) an existing route is followed (the servitude is basically widened, whilst the service road can be shared for both power lines) (Figure 15), and b) the power line crosses online 13.3 km of the Camelthorn woodland (translating to 8 ha or ca 4 200 trees which might be endangered, if a new clearing needs to be constructed).

Alternative 2 would follow the existing 400 kV transmission line further south, and cut across to the Rehoboth substation at a point at which the Camelthorn savanna is at its narrowest. In this way the power line will cross only 10.6 km of the Camelthorn woodlands, with the clearing destroying 6.36 ha or approximately 3 300 trees. The overall length of the power line will not be affected. The disadvantage of this second option is that the new power line will cross to date unspoilt Camelthorn woodlands.

Figure 15: The servitude along the existing 66 kV distribution line to the east could be widened to accommodate the new power line. A service road already exists here.

5.2. Proposed Auas – Khomas power line

This proposed power line follows the southern edge of the Auas Mountain range. Due to its sheer size, it requires a 55 m wide servitude. It crosses mainly sensitive Khomas Hochland Highlands, but also crossing some extremely sensitive rocky outcrops, especially in the narrow break between Grossherzog Friedrich / Regenstein mountains to the west and the Auas range to the east (along the main route Windhoek - Rehoboth). Here an alternative route is proposed, to cross the lower, less steep part of the Auas mountain range to the east of the Heroes Acre, and crossing to the west just north of Luiperd's Valley Military base. In this way the least of the steep, sensitive rocky outcrops will be endangered (Figure 16). A slight alteration of the route to the south at the eastern part of the farm Aris might also be advisable, in order to cross a less steep (and thus less rocky) part of the escarpment between the Aris Valley and the Highlands of the farm Waldeck.

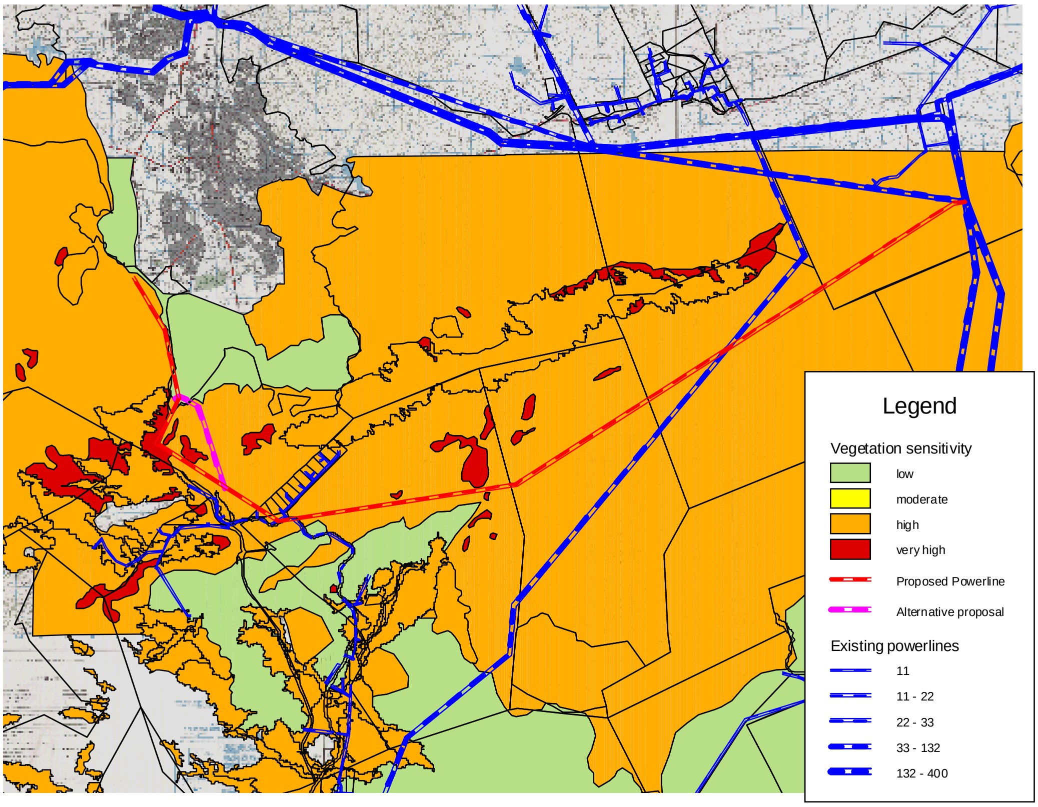

Figure 15: Sensitivity of the vegetation types crossed by the proposed Auas – Khomas line. An alternative route is proposed for crossing the gap between the Regenstein and the Auas mountain ranges, shown in purple. This will protect the highly sensitive rocky outcrops at the eastern base of the Regenstein mountain.

6. Proposed mitigating actions

6.1. Proposed Auas – Rehoboth power line

The proposed power line will affect the vegetation in two ways: during construction, vegetation is destroyed for clearing the power line route, whilst after completion, a service road is kept open along / below the power line.

As large parts of the route will pass through soils sensitive to erosion (both due to physical and chemical soil properties as well as due to the topography of the landscape, care should be taken to destruct as little as possible of the vegetation and not to scrape off any topsoil during the clearing operation.

The service road needs to be constructed in such a way that runoff will not cause any unnecessary erosion. For this purpose at least humps need to be installed at regular intervals along any slopes. The steeper the slopes, the more frequent humps need to be installed.

Should any erosion start on the service roads in future, this need to be controlled properly.

A permit is needed from the Directorate of Forestry to remove any protected trees during power line construction. Likewise, a permit is needed from the Ministry of Environment and Tourism to remove any other protected plants. It is also recommended, what staff of the National Botanic Garden / National Botanical Research Institute be tasked to do rescue missions of any *Aloe* populations and/or other succulents encountered en route whilst doing the final (on the ground) planning of the route. It is also recommended that bulbs (geophytes) be removed from the route (especially through any omiribi or through the Camelthorn woodlands before clearing commences. These can be transplanted next to the clearing in a relocation effort, or cultivated at the National Botanical Gardens.

During the final design process of the route, care should be taken to avoid special large or well-developed trees, if in any way possible.

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