APPENDIX D

Vegetation study
(Ekotrust)
Vegetation of the Inca, Tubas and Shiyela sites of Reptile Uranium Namibia (RUN)

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September 2010
EXECUTIVE SUMMARY

Ekotrust CC was appointed by Softchem CC as an independent botanical consultant to survey the vegetation and flora of the proposed Reptile Uranium Namibia (RUN) mining sites near Swakopmund in Namibia.

The Central Namib along the west coast of Namibia is contained in the Desert Biome and geographically covers the area between the Kuiseb River in the south and the Huab River in the north. The RUN mining sites are about 40 km east of Swakopmund and fall within the Namib-Naukluft National Park. The area is still in a relatively natural state except for the presence of some roads, power lines, some previous mining activity and the current exploration activities. Off-road tracks are visible in several places, especially in the Inca site.

The approach that was followed included a survey of the vegetation of the INCA, TUBAS and SHIYELA sites of RUN as part of the scoping and environmental assessment of the area. The main objective was firstly, to distinguish the different plant communities of the area, secondly to search the area for rare and/or threatened plant species, and thirdly to determine the impacts that the proposed mining venture will have on the vegetation and flora of the area.

In preparation for the field surveys, the area was stratified into relatively homogeneous units on aerial images. The stratification was based on the physiography, e.g. geology and terrain form, as well as the differences in vegetation structure and composition. A total of 88 sample plots were spread in a stratified random manner over the property, using standard plant sociological methodology for the classification and description of vegetation types. All identifiable plant species were recorded per sample plot and an indication of cover-abundance was given per species.

The surveys were done during June 2010 and coincided with the dry season. The field survey was preceded by severe and hot bergwind (east-wind) conditions. The plant species checklist should therefore be seen as preliminary because of the absence of many ephemeral and geophytic plant species. It is recommended that follow-up flora surveys in the growing season be done.

The vegetation survey consisted of a systematic recording of all identifiable woody species, grasses, forbs and alien (exotic) plants within each of the stratified units on site, as well as physical habitat features, e.g. geology, topography and rock cover. The different plant communities have been described and mapped. The area was surveyed for rare plant
species and a preliminary checklist of the plant species of the area was compiled.

Ten plant communities have been described and mapped for the three RUN sites. A number of rare, protected and endemic plant species have been identified at the mining site, such as *Welwitschia mirabilis*, *Hoodia cf currorii*, *Acacia erioloba*, *Acanthosicyos horridus*, *Aloe asperifolia*, *Arthraerua leubnitziae*, *Capparis hereroensis*, *Commiphora saxicola* and *Euphorbia lignosa*.

No Red Data plant species were recorded on site. However, six species are protected according to the Namibia Forest Act, three species under the Namibia Nature Conservation Ordinance and six species are listed under CITES. Two restricted endemic, seven endemic and 12 near-endemic plant species were recorded on site.

The vegetation types were evaluated in terms of sensitivity and sensitivity maps were compiled based on the sensitivity analysis of the area (Figures 20, 21 & 22). The parameters that were used to delineate the different categories of sensitivity (low, low–medium, medium, medium-high and high) include the threatened status of the ecosystem (% area intact, or degree of transformation); presence of rare and protected plant species; protected trees; presence of endemic plant species; terrain type (topography); plant community species richness; constraints to ecological processes; degree of connectivity and/or fragmentation of the ecosystem; and the presence of biodiversity offset areas.

The rating is interpreted as follows:

‘Low and low-medium sensitivity’ means that the sensitivity is not significant enough to influence the decision about the project. Nevertheless, no protected trees or other scheduled rare species may be removed/destroyed without a permit. ‘Medium’ sensitivity indicates a sensitivity rating that is tangible and sufficiently important to require management, such as management or protection of the rare/threatened fauna and flora or protection of the sensitive habitats. Rare species may not be removed/destroyed without a permit. ‘Medium-high’ refers to a sensitivity rating, which could warrant that specific habitats should be excluded from any development. ‘High sensitivity’ means a sensitivity rating that should influence the decision whether or not to proceed with the project.

The potential impact of mine activities on the vegetation on the three RUN sites was evaluated. The sensitivity of the 10 plant communities is as follows (Figures 1 - 3):
Community 1 - medium-high
Community 2 - medium-high
Community 3 - medium
Community 4 - medium-high
Community 5.1 - low
Community 5.2 - low
Community 5.3 - low-medium
Community 6 - medium
Community 7 - low
Community 8 - low
Community 9 - medium
Community 10 - low

The significance of the impacts on a number of issues is as follows (indicated for three phases, i.e. construction, operational and decommissioning/rehabilitation):

Indigenous vegetation/plant communities - medium, high, low
Impact of vegetation removal on fauna - medium, medium, medium
Ephemeral drainage lines/water courses - low, medium, low
Vehicles, off-road travel, trampling and compaction - medium, medium, low
Alien plants - low, low, low
Loss of topsoil - medium, medium, medium
Dust levels - low, low, low

*Welwitschia mirabilis*

The seeds germinate only if fairly heavy rain occurs over a number of days. These conditions rarely occur in the desert and therefore recruitment is episodic with some colonies being of the same age. Seedlings are dependent on fog to survive the dry times. However, the plants are dependent on rainfall also. This plant is able to absorb fog water, which condenses on the leaf surface and is channeled to the base of the stem. The primary root is strong and wedge-shaped and up to 3 m long. Most thin secondary roots are found just below the surface where they collect dew in the early mornings. Driving close to plants may therefore damage these roots and compromise the survival of the plant. The plant is fairly easy to cultivate by simulating its native environment, although regular watering and fungal control is a prerequisite. It was found that transplanting of seedlings under cultivation can be done without much mortality.
The presence of the protected species *Welwitschia mirabilis*, especially in the Inca site, and the probable impact on the species, is cause for concern. The current exploration drilling occurs in that community and special measures should already be taken to conserve this species, especially because transplanting of mature specimens of this species has apparently met with little success in the past.
SCOPE OF THE REPORT

Ekotrust CC was appointed Softchem CC to conduct a vegetation and flora survey as one of the specialist studies required for inclusion in the Environmental Impact Assessment and Environmental Management Plan of Reptile Uranium Namibia (RUN). The vegetation and flora study included the following:

1. A desktop vegetation study, which included:
   • a literature review on the vegetation of the region, incorporating published literature, reports of similar mining ventures in the region, and legislation regarding Namibian flora;
   • classify the vegetation into different communities
   • descriptions of the floristic region, biome and regional vegetation types;
   • compiling of lists of the dominant flora and vegetation types of the region;
   • brief description of the basic geological substrates of the region; and
   • listing of Red Data and endemic plant species of the region.

2. Conduct phytosociological field surveys based on stratified aerial images of the sites in order to:
   • determine the species composition of the different communities;
   • classify the vegetation into different communities;
   • survey the area for the presence of rare/threatened, endemic and alien invasive plant species.

3. Describe and map the different vegetation units/plant communities of the area and relate them to the vegetation studies previously done in the general area.

4. Compile a preliminary checklist of plant species of the area, including an analysis of the rare, threatened and endemic species recorded in the area.

5. Determine the possible impacts of the proposed development on the biotic environment and propose preliminary mitigation measures.

6. Conduct a sensitivity analysis of the different plant communities

7. Compile a report for the environmental assessment of the area.
ABBREVIATIONS:

CITES - Convention on International Trade in Endangered Species
DEA - Directorate of Environmental Affairs
EIA - Environmental Impact Assessment
EMP - Environmental Management Plan
EPL - Exclusive Prospecting Licence
MET - Ministry of Environment and Tourism
MME - Ministry of Mines and Energy
MRC - Mineral Rights Commission
NNBRI - Namibian National Botanical Research Institute
NNBI - Namibian National Biodiversity Institute
IUCN - International Union for Conservation of Nature
NFA - Namibia Forest Act (No 12 of 2001)
NCO - Nature Conservation Act (Act No. 4 of 1975)
RUN - Reptile Uranium Namibia
SANBI - South African National Biodiversity Institute
1. **INTRODUCTION**

Ekotrust CC was appointed by Softchem CC as an independent botanical consultant to survey the vegetation and flora of the proposed Reptile Uranium Namibia (RUN) mining sites near Swakopmund in Namibia. This report focuses on the vegetation and flora of the study area and includes a vegetation classification and vegetation map of the three RUN sites. The Inca, Tubas and Shiyela sites cover 2 575 ha, 10 511 ha and 5 400 ha respectively. The RUN sites are situated in the Namib-Naukluft National Park, managed by the Ministry of Environment and Tourism, Namibia. Three major groups of landowners exist in Namibia: central government owning 56% of the land, private individuals or companies owning 43%, and local authorities owning 1% of the land. While the state holds all mineral rights in Namibia, exploration and mining on privately held land requires permission of access from the owner (Mansfeld 2006). Before an Exclusive Prospecting Licence (EPL) is granted by the Ministry of Mines and Energy, the prospector must apply for environmental clearance (Mansfeld 2006). According to Mansfeld (2006), a full EIA and EMP are required when a prospector intends operating in a protected area.


Development in the study area is currently limited, and is restricted to a few roads, exploration sites, power lines and the remains of old mines and borrow pits.

The current survey was done in June 2010 following a relatively dry season and a short time after an exceptionally dry and hot bergwind (east-wind) period, where strong hot winds and sand-blasting occurred. Most of the annual flora component of the gravel plains was therefore absent during the survey. The geophytes are also not visible above-ground during the late winter dry period. The absence of the annual and geophytic components of the vegetation during the survey period justifies further studies in this regard. This situation was also reported by Strohbach (2009) when doing surveys in the Langer Heinrich area. The annuals and geophytes are very dependent on the irregular rainshowers occurring in the Namib Desert and may not appear at all during droughts. During the current survey the plant communities were therefore mostly identified by the perennial component of the vegetation. From a biodiversity point of view it is therefore recommended that follow-up surveys should be done in the study area in a more suitable season.
2. LOCALITY AND BRIEF ENVIRONMENTAL DESCRIPTION

The mining sites fall within the Erongo region of Namibia and are situated in the Namib-Naukluft National Park. The first 15 km from Swakopmund falls under the West Coast Recreation Area that has a lower status of protection than the Namib-Naukluft National Park.

The sites under study include the plains on both sides of the gravel road between Swakopmund and Windhoek, approximately 40 kilometers from Swakopmund. They fall in grid 2215 CC. The Inca, Tubas and Shiyela sites cover 2 575 ha, 10 511 ha and 5 400 ha respectively.

Geographically the sites fall in the Central Namib geographic region, which covers the area between the Kuiseb River in the south and the Huab River in the north (Giess 1968, 1971). It is confined by the Atlantic Ocean in the west and the escarpment in the east (Burke 2003a). The Central Namib is divided into three zones, namely the coastal strip of about 35 to 40 km wide where fog is frequent, an arid zone further east of about 50 km wide, and a semi-arid eastern zone where the desert merges into the arid savanna and the escarpment, also called the pro-Namib (Robertson 1976). The RUN sites are situated predominantly in the coastal strip.

Topography, geology and soils

The topography of the study area comprises gravel plains, undulating terrain and gentle low hills, small rocky outcrops and some high ridges, inselbergs and ephemeral rivers, washes and sheetwashes. Topographically the gravel plains are quite homogenous. They consist of broad peneplains with low relief, interrupted by shallow sheetwashes and washes, ridges and inselbergs (Robinson 1976). In general, the watercourses are important for the development of perennial vegetation on the gravel plains.

Superficial sandy deposits dominate the landscape Geological Survey (1995). Ridges and outcrops consisting of undifferentiated marble and minor calc-silicate rock are found in the Inca site and the southern parts of the Tubas site. Low ridges of pink feldspathic quartzite and meta-arkose occur in the west and east of the Inca site as well as forming north-south ridges in the Shiyela site. Locally in the Inca and Shiyela sites, greyish-green, calc-silicate rock, minor metaconglomerate, mica schist and amphibolite are found. Red granites are found locally in the Inca and the southern parts of the Tubas site.

The soils are generally very poorly developed owing to the arid environment, lack of biomass
and regular scouring of wind (Mansfeld 2006). Better soils with higher silt contents occur along the drainage lines.

Surface run-off of water is high on the plains and is partially attributed to the occurrence of so-called foam soils at or near the soil surface (Robinson 1976). These soils develop where bubbles of air are trapped in the fine-grained surface soils when it is wetted, and when the soils dry out these bubbles are cemented.

Gypsum crusts in the fog-belt of the gravel plains are related to sulphur releases during upwelling events in the ocean. Sulphur reacts with oxygen to form sulphate, which is carried inland by spray and coastal fog. The sulphate precipitates onto the soils, which contain lime and together with calcium and water, produce gypsum (Grünert 2003). The extent of the gypsum is therefore restricted to the coastal fog zone.

Floristic differences in the region are influenced by edaphic features such as silcretes, calcretes, gypsum crusts and salt crusts (Jürgens et al. 1997). A distinctive flora occurs on soil types such as quartz pebble ridges and gypsum crusts. Gypsum crusts are best developed in the low-lying areas in the coastal fog zone. The soils of the drainage lines and gravel plains vary from fine to medium feldspar and quartz gravel.

**Climate**

Plants in hot deserts face severe physiological stress from drought and heat. The availability of moisture is unpredictable in timing, amount and space and therefore vegetation is sparse and often patchy. Nevertheless, deserts still provide ecosystem services such as ecotourism, recreation, aesthetic values and genetic diversity.

The mean annual rainfall along the Swakop River ranges from 0 mm at the coast to 100 mm at approximately 100 km inland (to the east) (Jacobson et al. 1996; Burke 2003a). Jürgens *et al.* (1997) report that the mean annual rainfall ranges from 8 mm at Swakopmund to 25 mm at Gobabeb, falling mainly from January to March. The rainfall is spatially and temporarily highly variable. Along the coast, where rainfall rarely occurs, fog is the most important source of moisture for plants and animals. The fog precipitation at the coast may be as high as 50 mm per year. The fog belt extends approximately 30 km to 40 km inland and affects the kind of vegetation that is found near the coast. Between Cape Cross north of Swakopmund and Walvisbay in the south more than 100 fog days were recorded during 1984. Further inland the incidence of fog decreases to less than 50 days per year (Robinson 1976).
The mean annual temperature at Gobabeb is about 21°C with extreme maximum and minimum temperatures of 42.3°C and 2.1°C respectively (Robinson 1976). The extreme temperatures measured at the coast at Walvis Bay are 40.0°C and -3.9°C respectively. Frost is not prevalent in the Central Namib although Robertson (1976) reported extreme temperatures below freezing point for Walvisbaai.

Two main types of wind occur in the region, the sea-breeze carrying fog inland and the land-breeze (east winds or bergwinds) blowing from the plateau towards the sea. The usually strong bergwinds are most prevalent during the winter months from May to August and are accompanied by dry weather and hot conditions, which influences evaporation, fog incidence and consequently the vegetation (Robinson 1976). Dusty conditions and sand-blasting occur during these conditions which have a pronounced influence on the vegetation of the gravel plains. Wind-blown detritus that collects under vegetation and vegetation hummocks provide shelter and food for insects and other small fauna.

The vegetation on the gravel plains is subjected to extremes in temperature, strong winds and encroaching sands. Plants have therefore developed adaptations involving the acquisition, retention and storage of water (Mansfeld 2006).
3. METHODS

Desktop studies


Field surveys

The study sites (Inca, Tubas and Shiyela) were stratified on aerial images into relatively homogeneous units based on physiography and vegetation cover. A stratified-random approach was followed in selecting sample sites and it was strived to include all terrain, substrate and vegetation types within the area. The size of sample plots varied between the habitat types but were in general 100 m x 50 m in size. GPS readings were taken at the different survey sites. A total of 88 sites were surveyed over the study area.

The area experienced some strong and hot bergwind (east wind) conditions prior to the field visit in June 2010, which had a significant impact on the grass, ephemeral forb and geophyte composition. The vegetation survey consisted of visiting as many units as possible and systematically recording all identifiable woody species, grasses, forbs and alien (exotic) plants within each of the stratified units on site, and estimating their cover-abundance. Physical habitat features, e.g. geology, topography, and rock cover, were noted. The area was also surveyed for rare and/or threatened and endemic plant species and a checklist of the plant species of the area was compiled. During the site visit, digital photographs of the sample plots and some individual plant species were taken and representative photos of the different plant communities are included in the report. With the assistance of Me. M. Strohbach, some of the plant species were identified from digital photographs.

Data analysis

A classification of the vegetation data was done with the TURBOVEG and MEGATAB computer programmes (Hennekens & Schaminee 2001), which includes the TWINSPLAN
divisive clustering technique (see Table 1). A differential table was compiled (Table 1) and the different plant communities have been described and mapped.

The Red Data status, conservation and protected status of plant species were determined from the Red Data lists of Loots (2005), Nature Conservation Ordinance (No. 4 of 1975), the Namibian Forest Act, (Act No. 12 of 2001), CITES website, NBRI database and SANBI database.

A sensitivity assessment of each plant community was done and a rating awarded. A sensitivity map of the area was compiled. The possible impacts of the mining operation on the vegetation of the area are discussed and mitigation measures recommended.
4. **VEGETATION TYPES ON SITE**

**Introduction**

Phytogeographically, three floristic regions are contained in Namibia: the Zambian region, the Kalahari-Highveld transition zone and the Karoo-Namib region (White 1983). The area under consideration falls within the Karoo-Namib region which incorporates the Kaokoveld and Succulent Karoo centres of plant diversity (Maggs 1998). Irish (1994) distinguished five biomes for Namibia, i.e. the Savanna Biome, Nama-Karoo Biome, Edaphic Nama-Karoo of the Etosha Basin, Desert Biome and the Succulent Karoo Biome. The RUN sites fall in the Desert Biome.

In the vegetation map of Namibia (Giess 1971; Craven & Loots 2002; Loots 2005), fifteen broad vegetation types are distinguished. The desert vegetation types are subdivided into the Northern Namib, Central Namib, Southern Namib, Desert and Succulent Steppe (winter rainfall area), and the Saline Desert with dwarf shrub savanna fringe in the Etosha area. The RUN sites fall in the Central Namib region of the Desert Biome.

The western part of the Central Namib in the coastal fog zone (Robertson 1976), which stretches from the coast to about 40 – 60 km inland, is dominated by two halophytic dwarf shrubs, namely *Arthraerua leubnitziae* and *Zygophyllum stapffii* (Jürgens et al. 1997). Both species occur on the plains and in drainage lines, with *Zygophyllum stapffii* also present on rocky outcrops. *Salsola tuberculata* is another species that is prominent in more saline areas. Phreatophytes such as *Welwitschia mirabilis* are present on the gravel plains and sheetwashes at about 40 – 60 km inland.

According to Mendelsohn *et al.* (2002), the species richness of the Namib gravel plains is estimated to be less than 50 species, with only about 5 species endemic to the area. During the present survey at the RUN sites, 72 plant species were identified of which 7 species were endemic. This list should not be considered as complete because the survey was done during the dry season (June 2010). Consequently, very few geophytes and ephemerals (annuals) were encountered in the current survey.

Plant diversity in the Namibian Desert Biome is comparable to other desert regions of the world, but the levels of endemism are remarkably high (Irish 1994). More than 30% of the plant species in the Namibian section of the southern African Desert Biome are believed to be restricted to this area. Just over 400 plant species, about 10% of the flora of Namibia, occur in the Central Namib (Burke 2003a). In general, annual plant species constitute a large percentage of the flora of hot deserts and this fraction tends to increase with
environmental variability (Fox 1992).

The most detailed vegetation study of the Central Namib was done by Robinson (1976). Hachfeld did an extensive survey of the vegetation of the Central Namib in 2000 (in Strohbach 2009). The communities of the ‘Namib fog desert’ and inland plains described by Robinson (1976) are as follows:

1. *Salsola nollothensis* community

This community is found on hummocks in the sandy areas close to the coast and is dominated by *Salsola nollothensis*.

2. *Salsola tuberculata* community

This community is differentiated by *Salsola tuberculata* and four subcommunities are recognised:

2.1 Typical subcommunity characterised by *Salsola tuberculata*.

2.2 *Zygophyllum stapfii* subcommunity with *Zygophyllum stapfii*, *Aloe asperifolia* and *Dyerophytm africanum* the differential species. Other dwarf shrubs common in this community include *Arthraerua leubnitziae*, *Kleinia longiflora*, *Calicorema capitata*, *Euphorbia lignose* and *Orthanthera albida*. This community was found on sloping sites and rocky outcrops.

2.3 *Arthraerua leubnitziae* subcommunity with *Arthraerua leubnitziae* the differential species. This community was found on gently undulating plains and granite outcrops with *Hermbstaedtia sparthulifolia*, *Kleinia longiflora*, *Zygophyllum stapfii* and *Stipagrostis ciliata* the accompanying species.

2.4 *Stipagrostis obtusa* subcommunity with *Stipagrostis obtusa*, *Enneapogon desvauxii*, *Stipagrostis uniplumis* and *Trianthema triquetra* some of the differential species.

Some of the vegetation types distinguished by Strohbach (2009) west of the Langer Heinrich Uranium mine, that show relationships with the plant communities of the RUN sites include:

5.1 *Aizoanthemum rehmannii-Monechma desertorum* sparse grasslands (Strohbach 2009)
This sparse grassland is most prominent on the low undulating plains and schist outcrops. The soils are calcareous and contain some schist or granite gravel. The sandy soils are generally deeper than those found in the RUN sites.

5.2 *Salsola tuberculata*-*Jamesbrittenia barbata* sparse grasslands (Strohbach 2009)

This community occurs on light-coloured, somewhat rounded quartz pebbles on top of a layer of fine sand.

These two communities may be compared with communities 9 & 10 of the RUN sites.

**Vegetation of the RUN sites (Inca, Tubas and Shiyela)**(Table 1, Figures 1 – 19)

Four major physiographic/vegetation zones were distinguished in the area:

1. The northern gravel plains and sheetwashes of the Inca site and the northwestern portion of the Tubas site, where *Arthraerua leubnitziae, Zygophyllum stapfii* and *Welwitschia mirabilis* are present and *Salsola tuberculata* is absent.

2. The southern and eastern plains of the Tubas and Shiyela sites, with *Salsola tuberculata, Arthraerua leubnitziae* and *Zygophyllum stapfii* the dominant species, with *Welwitschia mirabilis* mostly absent.

3. The rocky inselbergs, ridges and other outcrops, which cover a relatively small part of the three sites, have their own diagnostic species, e.g. *Aloe asperifolia, Hoodia cf currorii* and *Commiphora saxicola*.

4. The ephemeral rivers, washes and sheetwashes, with *Salsola tuberculata, Arthraerua leubnitziae, Pechuel-Loeschia leubnitziae* and *Citrullus ecirrhosus* the dominant species.

According to Robinson (1976), most of the variability of the vegetation in the Central Namib can be explained in terms of gradients from dry to moist, shallow to deep substrates, and fresh to saline groundwater. Water supply is influenced by the type of substrate, its depth, presence of impervious layers and the quantity of run-off water that is collected.

A plant community is defined as a vegetation unit described by a specific plant species composition, having a uniform physiognomy and being restricted to a specific habitat (Mueller-Dombois & Ellenberg 2004). The plant communities (or associations) described do not exist as completely separated, clearly defined units in the area. Because of the relatively
homogenous character of the habitat, these communities are in many instances related and form a continuum from one community to the next community within the larger ecosystem.

Figure 1 Vegetation map of the INCA site (legend on following page).
1. *Searsia marlothii-Sarcostemma viminalis* sparse shrubveld

2. *Aloe asperifolia-Hoodia cf currorii* sparse shrubveld

3. *Zygophyllum stapffii-Brownanthus sp.* sparse shrubveld

4. *Acanthosicyos horridus-Pechuel-Loeschia leubnitziae* shrubveld

5.1. *Arthraerua leubnitziae-Salsola tuberculata-Gomphocarpus filiformis* dwarf shrubveld

5.2. *Arthraerua leubnitziae-Salsola tuberculata-Stipagrostis obtusa* sparse shrubveld

5.3. *Arthraerua leubnitziae-Citrullus ecirrhosus* sparse shrubveld

6. *Arthraerua leubnitziae-Welwitchia mirabilis* sparse shrubveld

7. *Zygophyllum stapffii-Arthraerua leubnitziae* sparse shrubveld

8. *Salsola tuberculata* shrubveld

9. *Arthraerua leubnitziae* rocky ridges

10. Barren gravel plains

Main road

Secondary roads

Power line

Ekotrust CC
Figure 2 Vegetation map of the TUBAS site (see Figure 1 for legend).
Figure 3 Vegetation map of the SHIYELA site (see Figure 1 for legend).
The following plant communities were distinguished on the three sites (Figures 1, 2 & 3, Table 1):

1. *Searsia marlothii*-Sarcostemma viminale sparse shrubveld of granite inselbergs
2. *Aloe asperifolia*-Hoodia cf currorii sparse shrubveld of rocky outcrops and schist ridges
3. *Zygophyllum stapffii*-Brownanthus sp. sparse shrubveld of rocky ridges and ‘hardeveld’ along drainage lines
4. *Acanthosicyos horridus*-Pechuel-Loeschia leubnitziae riverbeds and washes
5. *Arthraerua leubnitziae*-Zygophyllum stapffii dwarf shrubland of the gravel plains and washes
   5.1 *Arthraerua leubnitziae*-Salsola tuberculata-Gomphocarpus filiformis dwarf shrubland of the gravel plains and sheetwashes
   5.2 *Arthraerua leubnitziae*-Salsola tuberculata-Stipagrostis obtusa sparse shrubveld of the gravel plains
   5.3 *Arthraerua leubnitziae*-Citrullus ecirrhosus sparse shrubland of gravel plains and sheetwashes
6. *Arthraerua leubnitziae*-Welwitschia mirabilis sparse dwarf shrubland of the northern gravel plains and sheetwashes
7. *Zygophyllum stapffii*-Arthraerua leubnitziae dwarf shrubland of the gravel plains
8. *Salsola tuberculata* shrubland of river terraces and undulating plains and footslopes
9. *Arthraerua leubnitziae* rocky ridges and dolerite dykes
10. Barren gravel plains

Description of the plant communities (Table 1, Figures 1 - 19)

1. *Searsia marlothii*-Sarcostemma viminale sparse shrubveld of the granite inselberg

This community is found on the granite inselberg (or granite pluton) in the western part of the Tubas site (Figures 2, 4 & 5). Geologically, this outcrop consists of pink to grey foliated porphyritic to non-porphyritic coarse-grained monzogranite and granodiorite. These granite inselbergs have a steeply rounded appearance, and dykes of different hardness traverse the granite, and thus the inselbergs are often dissected by numerous small gullies, providing sites for plants to establish (Robinson 1976). The plant species found at the foot of this outcrop on the Tubas site and in the sheltered gullies are distinct from the other habitats on site (Table 1).
The diagnostic species of this community include *Searsia marlothii*, *Sarcostemma viminalae*, *Cotyledon orbiculata*, *Lycium cf oxycarpum* and *Euclea pseudebenus* (species group 1, Table 1). Most of the diagnostic plant species found in this community were not recorded elsewhere on the three RUN sites. Besides the diagnostic species, other species of note include *Aloe asperifolia*, *Commiphora saxicola*, *Asparagus pearsonii*, *Euphorbia cf. chersina*, *Jamesbrittenia maxii*, *Tetragonia reduplicata*, *Orthanthera albida* and *Zygophyllum stapffii*. Twenty-seven species were recorded in this community.

The communities of the rocky outcrops and the watercourses are the most species rich communities on site. Communities 1, 2 & 4 have 27, 30 and 25 species recorded per community, while less than 14 species per community were recorded in communities 5.2, 6, 7, 8, 9 & 10, with community 10 consisting of only three species. The vegetation of inselbergs in deserts is often more diverse than the surrounding plains and comprises taxa that usually occur in areas of higher rainfall, e.g. *Commiphora* spp. (Jürgens et al. 1997).

Figure 4 Community 1 Granite inselberg surrounded by sparsely vegetated plains.
Rare and protected species in this community:

IUCN Red Data list: None
NFA: *Euclea pseudebenus*
NCO: *Aloe asperifolia, Welwitschia mirabilis*
CITES: *Aloe asperifolia, Euphorbia cf. chersina, Welwitschia mirabilis*
Endemic species: *Aloe asperifolia, Commiphora saxicola, Zygophyllum stapfii*

2. *Aloe asperifolia-Hoodia cf. currorii* sparse shrubveld of rocky ridges, outcrops and inselbergs

This community is found on the prominent ridges of undifferentiated marble and minor calc-silicate in the southeastern parts of the Tubas site (Figures 2, 6 & 7).

The diagnostic species of this community include *Hoodia cf. currorii, Monechma clemoides, Forsskaolea candida* and *Kleinia longiflora* (species group 2, Table 1).

The vegetation cover is sparse and the most prominent species in this community are *Zygophyllum stapfii, Arthraerua leubnitzae, Tetragonia reduplicata, Aloe asperifolia* and
Commiphora saxicola. Characteristic species of the southeastern ridges include Cadaba aphylla, Euphorbia lignosa, Hypertelis salsoloides and Sarcocaulon cf. marlothii. Thirty species were recorded in this community.

Figure 6 Community 2: Rocky outcrop with species such as Hoodia cf. currorii and Aloe asperifolia.

Rare and protected species in this community:
IUCN Red Data list: None
NFA: None
NCO: Aloe asperifolia, Hoodia cf. currorii
CITES: Aloe asperifolia, Euphorbia cf. chersina, Euphorbia lignosa, Euphorbia phylloclada, Hoodia cf. currorii
Endemic species: Arthraerua leubnitziae, Aloe asperifolia, Commiphora saxicola, Petalidium canescens, Psilocaulon cf. salicornioides, Zygophyllum stapfii
3. *Zygophyllum stapfii-Brownanthus* sp. sparse shrubveld of rocky ridges and river terraces

This community is found on the prominent ridge in the west of the Tubas and Shiyela sites, as well as on the reddish coloured hard and gravelly riverbanks/terraces in the Tubas and Shiyela sites (Figures 2, 3 & 8). The geology consists mainly of pink feldspathic quartzite and meta-arkose. The vegetation of the rocks as well as the gullies/washes at the footslopes is included in this community.

The diagnostic species include *Brownanthus* sp., *Hexacyrtis dickiana* and *Aizoanthemum rehmannii* (species group 4, Table 1). The vegetation cover is very sparse and is characterized by *Zygophyllum stapfii*, *Brownanthus* sp., *Sesuvium sesuvioides*, *Orthanthera albida*, *Tetragonia reduplicata* and *Galenia papulosa*. In the small washes running from the ridge in the west, species such as *Welwitschia mirabilis*, *Hexacyrtis dickiana*, *Citrullus ecirrhosus*, *Stipagrostis ciliata* and *Salsola tuberculata* are prominent. Nineteen species were recorded in this community.

Rare and protected species in this community:

IUCN Red Data list: None
NFA: *Welwitschia mirabilis*
NCO: *Welwitschia mirabilis*
CITES: *Welwitschia mirabilis*
Endemic species: *Aizoanthemum rehmannii, Arthraerua leubnitziae, Euphorbia phylloclada, Zygophyllum stapfii*

Figure 8 Community 3: Bare rocky ridges with species such as *Orthanthera albida* and *Hexacyrtis dickiana* in the gullies.

4. *Acanthosicyos horridus-Pechuel-Loeschea leubnitziae* open to dense shrubveld of riverbeds and washes

This community is found mainly in the lower reaches of the Tumas River (Tubas site), and in some sheetwashes of the Shiyela site (Figures 2, 3 & 9). The substrate consists of superficial deposits of coarse sandy soils and locally fine-grained alluvial soils.

The diagnostic species of the main riverbeds include sparsely distributed *Acacia erioloba* trees, as well as *Acanthosicyos horridus, Capparis hereroensis, Tamarix usneoides* and *Radyera urens* (species group 6, Table 1). Dense clumps of *Salsola tuberculata, Pechuel-Loeschea leubnitziae, Arthraerua leubnitziae* and *Galenia papulosa* occur locally in this community. Other prominent species include *Gomphocarpus filiformis, Citrullus ecirrhosus, Hermbstaedtia spathulifolia, Sesuvium sesuvioides, Zygophyllum stapfii*, and the grasses
Stipagrostis ciliata and Stipagrostis obtusa. Twenty-five species were recorded in this community.

Ephemeral rivers in the central Namib such as the Kuiseb and Swakop support woodlands dominated by Acacia erioloba, Faidherbia albida, Euclea pseudebenus and Tamarix usneoides (Jacobsen et al. 1995). A few of these species were encountered either on site or in close proximity of the sites. All are NFA protected tree species.

Figure 9 Community 4: Open to dense vegetation in the Tumas riverbed characterized by Gomphocarpus filiformis, Salsola tuberculata and scattered individuals of Acacia erioloba, Tamarix usneoides, Acanthosicyos horridus and Capparis hereroensis.

Rare and protected species in this community:

IUCN Red Data list: None
NFA: Acacia erioloba, Acanthocicyos horridus, Faidherbia albida, Tamarix usneoides, Welwitschia mirabilis
NCO: Welwitschia mirabilis
CITES: Welwitschia mirabilis
Endemic species: Arthraerua leubnitziae, Capparis hereroensis, Hermbstaedtia spathulifolia, Zygophyllum stapffii
5. *Arthraerua leubnitziae-Zygophyllum stapffii* dwarf shrubveld of the gravel plains and washes

This community is divided into three sub-communities based on the presence or absence of species such as *Salsola tuberculata, Pechuel-Loeschia leubnitziae, Gomphocarpus filiformis* and *Citrullus ecirrhosus*.

Robinson (1976) described the communities of the Namib fog desert and inland plains and distinguished three communities and four sub-communities for the area. The most prominent plant species include *Salsola nollothensis* at the coast, as well as *Salsola tuberculata, Zygophyllum stapffii, Arthraerua leubnitziae, Stipagrostis ciliata* and *Stipagrostis obtusa*. *Arthraerua leubnitziae* is the most prominent species of the gypsum plains.

![Figure 10 Community 5.1 in wash in foreground with community 3 on terraces in the background.](image)

5.1. *Arthraerua leubnitziae-Salsola tuberculata-Gomphocarpus filiformis* dwarf shrubveld of the gravel plains and sheetwashes

This sub-community covers most of the plains and sheetwashes of the Tubas and Shiyela sites. The poorly defined upstream sections of the sheetwashes were not mapped separately in Figures 1, 2, 3 & 10, and thus form part of the gravel plains. The substrate
consists of superficial deposits of coarse sandy soils and locally fine-grained alluvial soils. The soils are generally shallow and less than 300 mm deep.

The community is not differentiated by a diagnostic species group, but the presence of the species listed in species groups 7, 9 - 12 differentiates this sub-community from sub-communities 5.2 and 5.3 (Table 1).

The most prominent species are *Arthraerua leubnitziae* and *Salsola tuberculata*. Other conspicuous species include *Zygophyllum stapffii*, *Pechuel-Loeschia leubnitziae*, *Gomphocarpus filiformis*, *Citrullus ecirhosus*, *Galenia papulosa*, *Sesuvium sesuvioides*, and the grasses *Stipagrostis ciliata* and *Stipagrostis obtusa*. Seventeen species were recorded in this subcommunity.

Figure 11a Community 5.2: Sparsely vegetated plains with *Arthraerua leubnitziae* and *Salsola tuberculata* the dominant species.

Rare and protected species in this subcommunity:

IUCN Red Data list: None
NFA: None
NCO: None
Figure 11b Community 5.2: Denser vegetation in the east of the Tubas site with *Arthraerua leubnitziae* and *Salsola tuberculata* the dominant species.

5.2 *Arthraerua leubnitziae*-Salsola tuberculata-Stipagrostis obtusa sparse shrubveld of the gravel plains

This sub-community covers the southern plains of the Tubas and Shiyela sites (Figures 2, 3, 11a & 11b). The substrate consists of superficial deposits of coarse sandy soils.

The sub-community is differentiated from sub-communities 5.1 and 5.3 by the absence of *Pechuel-Loeschia leubnitziae*, *Gomphocarpus filiformis* and *Citrullus ecirrhosus* and the presence of *Salsola tuberculata* (see species groups 8-12, Table 1). The most prominent species include *Arthraerua leubnitziae*, *Salsola tuberculata*, *Zygophyllum stapffii*, *Hermbstaedtia spathulifolia*, *Sesuvium sesuvioides* and *Stipagrostis ciliata*. Only nine species were recorded in this subcommunity.

Rare and protected species in this subcommunity:
5.3 *Arthraerua leubnitziae-Citrullus ecirrhosus* sparse shrubland of gravel plains and sheetwashes

This sub-community occurs in the sheetwashes of the Inca site as well as the northwestern parts of the Tubas site (Figures 1, 2 & 12). The substrate consists of superficial deposits of coarse sandy soils and locally fine-grained alluvial soils. Many wash communities colonize areas with slight slopes in lower-lying areas of the plains and thus collect run-off water that improves the survival of vegetation of the plains.

Community 5.3 is separated from sub-community 5.1 because of the absence of *Salsola tuberculata*, and is differentiated from sub-community 5.2 by the absence of *Pechuel-Loeschia leubnitziae, Gomphocarpus filiformis* and *Citrullus ecirrhosus* in sub-community 5.2 (see species groups 6, 8 - 11, Table 1). *Salsola tuberculata* is basically absent in the Inca site but most prominent in the Tubas site.

The most prominent species include *Pechuel-Loeschia leubnitziae, Gomphocarpus filiformis, Citrullus ecirrhosus, Salsola tuberculata, Zygophyllum stapffii, Galenia papulosa, Hermbstaedtia spathulifolia, Sesuvium sesuvioides*, and the grasses *Stipagrostis ciliata* and *Stipagrostis obtusa*. Eighteen species were recorded in this community.

Rare and protected species in this community:

IUCN Red Data list: None
NFA: *Welwitschia mirabilis*
NCO: *Welwitschia mirabilis*
CITES: *Welwitschia mirabilis*
Endemic species: *Arthraerua leubnitziae, Hermbstaedtia spathulifolia, Zygophyllum stapffii*
6. *Arthraerua leubnitziae-Welwitschia mirabilis* sparse shrubland of the northern plains and sheetwashes

This community occurs predominantly in the Inca site and in a small area in the west of the Tubas site (Figures 1, 2 & 13). The substrate consists of superficial deposits of coarse sandy soils.

The diagnostic species group that differentiates this community (species group 8, Table 1) includes *Welwitschia mirabilis* and *Zygophyllum simplex*. Of note is the absence of *Salsola tuberculata*.

The southern limit of *Welwitschia mirabilis* in Namibia is close to the Kuiseb River near Natab. *Welwitschia mirabilis* occurs on the plains and shallow drainage lines in a zone 34 km to 45 km from the coast along the Swakopmund to Windhoek road.

The most prominent species are *Arthraerua leubnitziae*, *Welwitschia mirabilis*, *Zygophyllum stapfii*, *Zygophyllum simplex*, *Hermbstaedtia spathulifolia*, *Galenia papulosa*, *Sesuvium sesuvioides* and the grasses *Stipagrostis ciliata* and *Stipagrostis obtusa*. Thirteen species were identified in this community.
Rare and protected species in this community:

IUCN Red Data list: None
NFA: *Welwitschia mirabilis*
NCO: *Welwitschia mirabilis*
CITES: *Euphorbia phylloclada, Welwitschia mirabilis*
Endemic species: *Arthraerua leubnitziae, Hermbstaedtia spathulifolia, Zygophyllum stapfii*

Figure 13 Community 6: *Welwitschia mirabilis* plains.

7. *Zygophyllum stapfii-Arthraerua leubnitziae* sparse shrubland of gravel plains

This community occurs mainly in the southeastern parts of the Inca site, but is also found locally in the Tubas and Shiyela sites (Figures 1, 2, 3 & 14). The geology consists mainly of pink feldspathic quartzite and meta-arkose, although superficial sandy deposits and some calc-silicate rock also occur widespread.

There is no diagnostic species group that differentiates this community but the presence of species of species group 10, and the absence of species from species groups 1 – 9
characterise this community (Table 1). The species richness is very low with only eight species recorded in this community.

The most prominent species include *Zygophyllum stapffii* and *Arthraerua leubnitziae*, while *Sesuvium sesuvioides* occurs scattered throughout the area. *Stipagrostis ciliata* is the dominant grass species.

Rare and protected species in this community:

<table>
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<th>IUCN Red Data list:</th>
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<tbody>
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</tr>
<tr>
<td>CITES:</td>
<td><em>Euphorbia phylloclada</em></td>
</tr>
<tr>
<td>Endemic species:</td>
<td><em>Arthraerua leubnitziae, Zygophyllum stapffii</em></td>
</tr>
</tbody>
</table>

Figure 14 Community 7: Undulating terrain with scattered individuals of *Arthraerua leubnitziae*. 
8. *Salsola tuberculata* shrubland of river terraces and undulating plains and footslopes

This community occurs on the plains, undulating terrain and slopes near the main watercourses of the Tubas site (Figures 2 & 15). The substrate consists of superficial deposits of coarse sandy soils and the soil depth ranges from shallow (less than 100 mm) to deeper than 700 mm. The soils in this community are probably alkaline (calcareous) and the community is characterised by halophytic species that usually occur on calcareous (brackish soils) and gypsum soils. In some places the shrubs of *Salsola tuberculata* form sand hummocks by trapping wind-blown sand.

There is no diagnostic species group that differentiates this community (see species group 10, Table 1) but the community is dominated by *Salsola tuberculata*. *Arthraerua leubnitziae* occurs scattered between the *Salsola tuberculata* shrubs. Only six species were identified in this community.

Rare and protected species in this community:

- **IUCN Red Data list:** None
- **NFA:** None
- **NCO:** None
- **CITES:** None
- **Endemic species:** *Arthraerua leubnitziae, Hermannia spathulifolia*
Figure 15 Community 8: Stands of *Salsola tuberculata* on river terraces.

Figure 16 Community 9: Flat rocky ridges almost devoid of any plants.
9. *Arthraerua leubnitziae* rocky ridges and dykes

This rocky habitat is basically devoid of any vegetation cover and occurs locally in all three RUN sites (Figures 1, 2, 3, 16 & 17). This community occurs on a variety of rocky outcrops ranging from amphibolite, marble, calc-silicate rock, metaconglomerate, mica schist and quartzite. The only species that are found in small numbers are *Arthraerua leubnitziae*, *Salsola tuberculata* and *Zygophyllum stapfii* (species group 12, Table 1). Only eight species were recorded on these ridges.

Rare and protected species in this community:

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<tr>
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<tr>
<td>Endemic species:</td>
<td><em>Arthraerua leubnitziae</em>, <em>Zygophyllum stapfii</em></td>
</tr>
</tbody>
</table>

Figure 17 Community 9: Small rocky outcrops on the Inca site.
Barren gravel plains

This community is related to community 9, but is characterised by gravel plains covered by a layer of fine quartz pebbles and is mostly devoid of any vegetation (Table 1, Figures 1, 2, 3 & 19). The surface is covered by superficial sandy deposits with a substrate consisting of marble, calc-silicate rock and feldspathic quartzite. These plains are exposed to high winds speeds. Although fog occurs, moisture infiltration may be inhibited by the ‘foam soils’ and/or gypsum crusts on the soil surface. A few small individuals of *Arthraerua leubnitziae* and *Salsola tuberculata* occur scattered through the area (Table 1).

It is interesting to note that small local habitats such as quartzite and pegmatite pebble ridges and outcrops were not encountered on the three RUN sites. However, to the west and east of the RUN sites, this habitat is present (Van Rooyen 2004a, 2004b). It is the most important community in the region in terms of the occurrence of rare succulent plant species such as *Lithops* spp., *Larryleachia* spp. and *Avonia albissima*.

Rare and protected species in this community:
- **IUCN Red Data list:** None
- **NFA:** None
- **NCO:** None
CITES: None
Endemic species: *Arthraerua leubnitziae, Zygophyllum stapfii*

Figure 19 Community 10: Barren plains with ‘foam or spongy’ soils covered with small quartz pebbles.

The density of the most prominent shrub species in the RUN sites was determined by Cunningham (2010). A mean density of 537 shrubs per ha was recorded for the most densely populated areas (drainage lines).
5. RARE, THREATENED AND ENDEMIC PLANT SPECIES

Introduction

The vegetation of the Namib Desert developed under harsh conditions, and although plant species are well-adapted, the vegetation remains vulnerable to operational disturbance (Mansfeld 2006). Vegetation patches provide food and shelter as well as migration corridors for small mammals, reptiles and insects.

The conservation status of plant species serves as a guideline to determine which taxa need to be conserved to prevent the possibility of extinction. Conservation priorities and monitoring strategies can be implemented to ensure that those taxa with a threatened status are protected in their natural habitat (Loots 2005). Besides rarity, aspects such as economic value, genetic distinction and endemism are added criteria to determine the status of species. Red Data, protected and endemic species are usually first indicators of the changes taking place in an ecosystem.

Public awareness and education are important to increase awareness for the conservation of plant biodiversity because most rare plant species that should be conserved do not necessarily occur in formally protected areas.

A total of 72 plant species was identified during the surveys conducted in June 2010, of which 17 were tree and shrub species, eight dwarf shrub species, 14 succulent species, 23 forbs species, one geophyte and nine grass species (Appendix A). Two restricted endemics, eight endemic and 12 near-endemic species were identified on site. A total of 11 species have some form of protection (Table 2).

Threats

The main threats to the survival of rare plant species include mining related activities, agriculture, illegal collecting, especially of succulent plants, habitat fragmentation and habitat destruction. Another threat to biodiversity is the possible effects of global warming. Some of the consequences of global climate change to plants include shifting of suitable climate zones, loss of pollinators and dispersers, threats of an increase in exotic plant species, and an increase in more extreme climatic events (Loots 2005).

Plant species in Namibia are protected by several regulations. On a national level, the Nature Conservation Ordinance (No. 4 of 1975) and the Namibia Forest Act (No 12 of 2001) provide protection to certain species on the basis of their rarity and perceived threats to their
survival (Burke 2003a). Protection is also provided to certain keystone species, such as the camel thorn (*Acacia erioloba*). Under this legislation the removal or destruction of these plants can be prosecuted. International CITES regulations govern the trade of certain species, such as *Welwitschia mirabilis*. Red Data lists usually list species on the basis of their rarity or due to imminent threats.

**Red Data Lists**

A total of 3 961 higher plant taxa (Spermatophytes) are found in Namibia. The Red list status of Namibian plants is summarised by Craven & Loots (2002) of the National Botanical Research Institute of Namibia as well in the more recent Red Data Book of Namibian Plants (Loots 2005). According to Craven & Loots (2002), a total of 1 152 species are on the Red Data list of Namibia. Loots (2005) listed 1 212 Red Data taxa out of 1 272 taxa evaluated against IUCN criteria. The number of taxa on the Red Data list includes 23 Threatened taxa, 38 Near Threatened taxa, 96 Rare taxa, 301 Data Deficient taxa and 754 taxa of Least Concern. Of the threatened taxa, two are Critically Endangered, two are Endangered and 19 are Vulnerable, representing less than 1% of the total number of higher plant taxa in Namibia. These taxa are facing a high risk of extinction and require urgent conservation measures.

The Red Data plant species, Protected Plants (NCO), NFA species, CITES listed plant species and endemic and near-endemic plant species of the RUN sites are listed in Table 2. No Red Data plant species were recorded on site. However, six species are protected under the NFA, three species under the NCO and six species are listed under CITES Appendix II. Two restricted endemic plant species, eight endemic and 12 near-endemic plant species were recorded on site.

**RED Data list of Namibia** (Craven & Loots (2002)):

This list was based on the previous IUCN categories and was followed up by the Red Data list of Namibia of Loots (2005), following the current IUCN categories for Red Data species. The following plant species found on the RUN sites are listed as Lower Risk – least concern by Craven & Loots (2002):
Table 2 Rare, protected and endemic plant species recorded in the RUN sites

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<th>Species</th>
<th>Restricted endemic</th>
<th>Endemic</th>
<th>NCO*</th>
<th>NFA*</th>
<th>Red Data</th>
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*NCO – Nature Conservation Ordinance (No 4 of 1975)
*NFA – Namibia Forest Act (No 12 of 2001)

Extinct and threatened taxa: none recorded

Lower Risk – least concern:

Aizoanthemum rehmannii
Aloe asperifolia
Arthraerua leubnitziae
Blepharis obmitrata
Cadaba aphylla
Capparis hereroensis
Citrullus ecirrhosus
Commiphora saxicola
Euphorbia cf. chersina
Euphorbia lignosa
Euphorbia phylloclada
Faidherbia albida
Forsskaolea candida
Galenia papulosa
Gomphocarpus filiformis
Hermbstaedtia spathulifolia
Hexacyrtis dickiana
Hoodia cf. currorii subsp. currorii
Petalidium canescens
Monechma cleomoides
Monechma genistifolium subsp. genistifolium
Orthanthera albida
Petalidium canescens
Psilocaulon cf. salicornioides
Senecio cf. sarcoides
Stipagrostis hochstetteriana
Welwitschia mirabilis
Zygophyllum simplex
Zygophyllum stapfii

Red Data list of Namibia (Loots 2005):

According to the Red Data lists provided by Loots (2005), no taxa found on site qualifies under the IUCN categories of Critically Endangered, Endangered, Vulnerable, Near Threatened, Least Concern or Rare.

Namibia Forest Act (No. 12 of 2001) (NFA)

According to the Forest Act, no person may cut, destroy or remove any tree, bush or shrub that occurs in or within 100 m of a river, stream or watercourse without authorisation. The following tree and shrub species that occur in the study area are therefore protected according to the Forest Act (No 12 of 2001) (Burke 2003a, 2003b).

Acacia erioloba
Acanthosicyos horridus  
Euclea pseudebenus  
Faidherbia albida  
Tamarix usneoides  
Welwitschia mirabilis

**Nature Conservation Ordinance, (No. 4 of 1975) (NCO)**

The following protected plant species, listed in the Ordinance, occur on the RUN site:

*Aloe asperifolia*  
*Hoodia cf. currorii* subsp. *currorii*  
*Welwitschia mirabilis*

All Aloe species are protected in Namibia (Rothmann 2004).

**CITES**

Appendix II lists species that are not necessarily now threatened with extinction but that may become so unless trade is closely controlled (Website: [www.cites.org](http://www.cites.org)).

*Aloe asperifolia*  
*Hoodia cf. currorii* subsp. *currorii*  
*Euphorbia phylloclada*  
*Euphorbia lignosa*  
*Euphorbia cf. chersina*  
*Welwitschia mirabilis*

The monotypic family Welwitschiaceae, represented by *Welwitschia mirabilis*, is the only gymnosperm in Namibia and is listed as a CITES: Appendix II species.

**Endemic taxa**

A first estimation of endemic plant taxa in Namibia resulted in 579 Spermatophyte (dicots) taxa (Maggs 1998). It was estimated that about 17% of Namibian vascular flora is endemic to Namibia. According to Craven & Loots (2002), a total of 602 taxa are endemic to Namibia.

Endemic taxa restricted to the Central Namib:
Restricted endemics: these are endemic species restricted to the Central Namib

*Aizoanthemum rehmannii*
*Petalidium canescens*

Namibian endemic taxa: refers to taxa occurring in Namibia and nowhere else.

*Aloe asperifolia*
*Arthraerua leubnitziae*
*Capparis hereroensis*
*Commiphora saxicola*
*Hermbstaedtia spathulifolia*
*Psilocaulon cf. salicornioides*
*Zygophyllum stapfii*

Near-endemic taxa: these taxa may also occur outside of Namibia.

*Acanthosicyos horridus*
*Citrullus ecirrhosus*
*Enneapogon scaber*
*Euphorbia cf. chersina*
*Hoodia cf. currorii subsp. currorii*
*Hexacyrtis dickiana*
*Monechma cleomoides*
*Monechma genistifolium subsp. genistifolium*
*Orthanthera albida*
*Stipagrostis hochstetteriana*
*Welwitschia mirabilis*
*Zygophyllum simplex*

The Namibia Red Data plant species (Loots 2005) that occur in the 2215 grid wherein the RUN sites are located, are listed in Table 3. None of the Red Data list plant species (Loots 2005) were recorded on the RUN sites.

Comments:

- The threats to the succulent species in particular are collection and habitat degradation.
• Species endemic to Namibia should be afforded the maximum protection, as they occur nowhere else in the world.
• It is imperative that all populations of rare plant species are protected as conservation of only one population essentially ignores genetic diversity.
• *In situ* conservation is preferable to *ex situ* conservation.
• Translocation of a rare plant population is an unacceptable conservation measure since the translocated species may have undesirable ecological effects on new habitats, translocation may result in rapid changes in the species itself and translocations are expensive and rarely successful.
• Suitable habitat adjacent to known rare plant populations has a high probability of being colonized.

**Table 3 Namibian Red Data species that occur in the 2215 grid**

<table>
<thead>
<tr>
<th>Name</th>
<th>Family</th>
<th>Status</th>
<th>Endemic</th>
<th>Habitat</th>
<th>Threats</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aloe namibensis</td>
<td>Asphodelaceae</td>
<td>Least concern</td>
<td>x</td>
<td>Granite and marble ridges</td>
<td>Habitat destruction and collecting</td>
</tr>
<tr>
<td>Lithops gracilidelineata subsp. gracilidelineata</td>
<td>Mesembryanthemaceae (Aizoaceae)</td>
<td>Least concern</td>
<td>x</td>
<td>Quartz and pegmatite pebbles/gravel</td>
<td>Collecting</td>
</tr>
<tr>
<td>Lithops ruschiorum</td>
<td>Mesembryanthemaceae (Aizoaceae)</td>
<td>Least concern</td>
<td>x</td>
<td>Quartz and pegmatite pebbles/gravel, calcrete, chert, gneiss</td>
<td>Collecting, mining</td>
</tr>
<tr>
<td>Adenia pechuelii</td>
<td>Passifloraceae</td>
<td>Near threatened</td>
<td>x</td>
<td>Hills, mountain slopes, conglomerate, granite, mica schist</td>
<td>Collecting</td>
</tr>
<tr>
<td>Chamaegigas intrepidus</td>
<td>Schrophulariaceae</td>
<td>Least concern</td>
<td>x</td>
<td>Shallow pools, granite</td>
<td>Overuse of pool water</td>
</tr>
<tr>
<td>Cyphostemma bainesii</td>
<td>Vitaceae</td>
<td>Least concern</td>
<td>x</td>
<td>Tree and shrub savanna</td>
<td>Collecting</td>
</tr>
</tbody>
</table>

**Species richness (number of species per community) of the plant communities and subcommunities described during the current survey:**

- Community 1: 27
- Community 2: 30
- Community 3: 19
- Community 4: 25
In comparison, the number of species per community or subcommunities described by Robinson (1976) for the ‘Namib fog desert’ during a relatively moist season range from one species to 40 species, with a mean of 21 species per community. The number of species described by Strohbach (2009) for the plains habitats near Langer Heinrich to the east range from 40 to 59 species, with a mean of 50 species.

**Exotic and invasive species**

The impact of mining on the distribution or introduction of alien invasive species should be included in the environmental management plan. Only a few individuals of the tree *Prosopis glandulosa* were found in the central gravel plains and sheetwashes in the Tubas site. *Prosopis glandulosa* is one of the most important terrestrial alien invasive species in southern Africa because of the wide ecological tolerance of the species high local densities and its impact on biodiversity and ecosystem functioning. This species is adapted to warm and dry regions and has the potential to colonize disturbed areas on the mining sites. The plants on site should be eradicated to prevent further spread, especially along the ephemeral rivers in the area.

**Lichens**

Cunningham (2010) identified seven species of lichen in the RUN sites. Lichen fields form a characteristic component of the Namib vegetation near the coast but extensive lichen fields do not occur on site. Lichens occur throughout Namibia, with more than 100 species identified so far (Mansfeld 2006). Lichens are considered the first colonists of bare habitats in the desert and therefore stabilize the soil and form a groundcover that prevents wind and
water erosion by holding the soil together (Craven & Marais 1986, Lange et al. 1989). The gypsum crust in the fog zone support some of the most diverse lichen fields in the world.

Vehicles damage the soil crust when traveling over the gravel plains and the tracts remain visible for decades. Off-road and other heavy vehicles easily destroy the delicate lichen cover and promote soil movement (Wessels & Van Vuuren 1986). Damage to the soil crust takes decades to recover, if it recovers at all. It is strongly advised that only a few dedicated and demarcated roads be used and vehicles should not venture off-road at all.

**Welwitschia mirabilis**

This plant species occurs in significant numbers in especially the Inca site of RUN. Some background is given regarding the life history, ecology and cultivation of the species.

The species was discovered by the Austrian botanist and medical doctor Friedrich Welwitsch in 1859 in southern Angola. It occurs from southwestern Angola at Mocamedes southwards to the Kuiseb River south of Walvis Bay and its distribution coincides with the coastal fog belt. *Welwitschia mirabilis* is neither endangered nor rare, nevertheless it is protected by law. Removal of plants by plant collectors is one of the main threats to the survival of the species.

*Welwitschia mirabilis* is described as a terminally truncated caudiciform, although initially it is a semi-succulent, woody xerophyte. The plant has a lifespan of between 500-600 years on average, although some plants may be as old as 1500 – 1 500 years. The plant consists of two strap-shaped leaves, an unbranched stem base and roots. Mature plants reach a height of 1.8 m and leaves may be up to 10 m long. The leaves are the original leaves from when the plant was a seedling that continue growing. The stem is low, woody, obconical in shape. Seeds germinate in wet years, the cotyledons photosynthesizing for 1.5 years. In nature the average leaf growth is 120-150 mm annually but almost twice the length in cultivation.

The root is strong and wedge-shaped and up to 3 m long. Most thin secondary roots are found just below the surface where they collect dew in the early mornings. The leaves are broad and drooping and collect water by condensation for its own roots.

A relationship exists between fog incidence and the presence of certain plant species. In the *Welwitschia mirabilis* zone in the desert biome of Angola and Namibia, the bulk of moisture required for current growth is derived from sea fogs. Radiation and advection fog at Swakopmund occurs on 121 days per year with up to 130 mm per annum of intercepted moisture, about 7 times the mean annual rainfall.
The sexes of *Welwitschia mirabilis* are separate (dioecious) and growth and flowering takes place in summer. The cones are not wind-pollinated as it produces small amounts of pollen, with nectar to attract insects. Ripe seeds are spread by wind in spring, about 9 months after fertilization. Seeds remain viable for a number of years but a fungal infection, insects and small animals may account for up to 80% mortality. The seeds germinate only if fairly heavy rain occurs over a number of days. These conditions rarely occur in the desert and therefore recruitment is episodic with some colonies being of the same age. Seedlings are dependent on fog to survive the dry times. However, the plants are dependent on rainfall also.

*Welwitschia mirabilis* is not a primitive CAM plant as was previously assumed but possesses an ordinary C3 pathway (Eller *et al.* 1983). It is able to absorb fog water, which condenses on the leaf surface and is channeled to the base of the stem (Jurgens *et al.* 1997). Stomata occur on both leaf surfaces and its ability to take up water through stomata is not confirmed as yet (Jurgens *et al.* 1997).

Usually plants are propagated in long tubes to provide space for the long taproot. However, the best way to propagate the plants is from seeds in ordinary pots. Germination percentages of more than 70% have been achieved. It was found that transplanting of seedlings under cultivation can be done without much mortality.

The plant is fairly easy to cultivate by simulating its native environment, although regular watering and fungal control is a prerequisite. It requires well-drained sterilized sandy soils with a low organic content and regular watering. The soil in pots should not dry out. Germination of seeds occurs from 7 days to a few months after sowing. Seedlings with leaves of 30 – 40 mm long have fine multi-branched roots of up to 400 mm long. In Kirstenbosch, young plants flowered two and a half years after grown from seed. The most crucial stage is during its first eight months after germination when it is prone to fungal attack. The taproot grows fast in the initial stages and care must be taken not to damage the root tip when transplanting seedlings. The cotyledons may last for up to two years in cultivation.

The presence of the protected species *Welwitschia mirabilis*, especially in the Inca site, and the probable impact on the species, is cause for concern. Driving close to plants may therefore damage these roots and compromise the survival of the plant. The current exploration drilling occurs in that community and special measures should already be taken to conserve this species, especially because transplanting of mature specimens of this species has apparently met with little success in the past.
6. SENSITIVITY ANALYSIS

The vegetation types on site were evaluated in terms of sensitivity and sensitivity maps were compiled (Figures 20, 21 & 22). The parameters that are used to delineate the different categories of sensitivity (low, low–medium, medium, medium-high and high) are the following (Driver et al. 2004; Mucina & Rutherford 2006; De Witt et al. 2006):

1. Threatened status of the ecosystem (% area intact, or degree of transformation)

   The ecosystems are classified into the following categories:

   Low sensitivity: If “Least Threatened”, the vegetation type has most of its habitat intact, i.e. more than 80%; or the vegetation type is adequately statutory or formally conserved in parks and reserves.

   Medium sensitivity: If “Vulnerable”, the vegetation type has from 60% to 80% of the ecosystem intact. For example, the vegetation type is rich in plant species but is not a pristine example of a vegetation type, therefore some transformation or disturbance occurred, such as human structures, degraded veld due to overgrazing and/or bush encroachment.

   Medium-high sensitivity: If “Endangered”, the vegetation type has from 40% to 60% of the ecosystem intact; or 40% to 60% transformed due to disturbance, cultivation or alien species; or the ecosystem is statutory poorly conserved e.g. less than about 3% conserved.

   High to very high sensitivity: If “Critically Endangered”, the vegetation type has only 16% to 36% of the ecosystem intact. The richer the ecosystem is in terms of species, the higher the percentage threshold.

2. Rare/protected plant species

   The sensitivity scale ranges from low to high and the rating depends on the presence of rare fauna and flora in a vegetation type, or the presence of suitable habitat for specific Red Data species.
3. Protected trees

The presence of protected tree species (NFA) in a vegetation type should be considered as of medium or higher conservation value depending on the availability of habitat in the broader region and the protection and management guidelines for these species.

4. Endemic plant species

The presence of endemic species should be considered as of low-medium to high conservation value depending on the availability of habitat in the broader region, number of endemic species and the protection and management guidelines for these species.

5. Terrain type (topography)

All specialized habitats, e.g. ridges and especially quartzite outcrops, as well as wetlands and dunes should be considered to have a medium to high conservation value. However, this should be seen in the context of the presence of representative habitat in the broader region or in conservation areas.

6. Plant community species richness

The species-richness (or number of species per plot or vegetation type) will depend on the region, climate, topography, ecosystem and degree of transformation. The assessment consists of determining the number of species per vegetation type of a specific habitat, e.g. ridge, and compared to the number of species found in a relative unspoilt (pristine) vegetation type of the same habitat type. The sensitivity scale ranges from low to high.

7. Nature of ecological processes. Constraints on the ecological processes, especially hydrological, (e.g. water courses, wetlands), presence of migration routes; or ridges would result in a high sensitivity.

8. Degree of connectivity and/or fragmentation of the ecosystem
Connectivity with surrounding or adjacent natural areas and/or fragmentation of plant communities, e.g. high connectivity with surrounding similar habitat, or low fragmentation of habitat is considered as having a low sensitivity.

9. Presence of biodiversity offset areas

Biodiversity offsets are conservation actions intended to compensate for the residual, unavoidable harm to biodiversity caused by development projects or other harmful activities, so as to ensure no net loss of biodiversity (De Witt et al. 2006).

The need to consider a biodiversity offset is only triggered when residual biodiversity impacts of medium-high to higher significance are evident. In other words, biodiversity offsets are a last resort measure to consider once all the options and alternatives to prevent, minimize and mitigate impacts have been explored and evaluated during the EIA process and the residual biodiversity impacts have been found to be of medium or higher significance. For example, “very high” impacts represent a total flaw for the development in that the biological impacts will be irreversible, compromise ecological integrity and therefore be undesirable. “Low” impacts of low significance will not require the developer to offset impacts.

Sensitivity rating

‘Low and low-medium sensitivity’ means that the sensitivity is not significant enough to influence the decision about the project. Nevertheless, no protected trees or other scheduled rare species may be removed/destroyed without a permit. ‘Medium’ sensitivity indicates a sensitivity rating that is tangible and sufficiently important to require management, such as management or protection of the rare/threatened fauna and flora or protection of the sensitive habitats. Rare species may not be removed/destroyed without a permit. ‘Medium-high’ refers to a sensitivity rating, which could warrant that specific habitats should be excluded from any development. ‘High sensitivity’ means a sensitivity rating that should influence the decision whether or not to proceed with the project.

The ten plant communities/habitats (with three sub-communities) that were distinguished on site (Figures 1, 2 & 3) were evaluated in terms of sensitivity (see Figures 20, 21 & 22). Red List 2009 species rated as ‘least concern’ are not included in the analysis.
Community 1: *Searsia marlothii*-Sarcostemma viminale sparse shrubveld of the granite inselberg

This habitat includes two NFA, two NCO, three CITES and three endemic plant species.

Threatened status of ecosystem: medium-high
Presence of rare species: medium-high
Protected trees: low-medium
Endemic species: medium
Terrain type: medium-high
Plant community species richness: medium-high
Constraints of ecological processes: high
Degree of fragmentation/connectivity/offset areas: medium-high

In summary, the sensitivity of community 1 is regarded as medium-high.

Community 2: Aloe asperifolia-Hoodia cf. currorii sparse shrubveld of rocky outcrops and schist ridges

This habitat includes four NCO, two CITES, one restricted endemic and seven endemic plant species.

Threatened status of ecosystem: medium
Presence of rare species: medium-high
Protected trees: low
Endemic species: medium-high
Terrain type: medium-high
Plant community species richness: medium-high
Constraints of ecological processes: medium-high
Degree of fragmentation/connectivity/offset areas: medium-high

In summary, the sensitivity of community 2 is regarded as medium-high.

Community 3: Zygophyllum stapffii-Brownanthus sp. sparse shrubveld of rocky ridges and ‘hardeveld’ along drainage lines

This habitat includes one NFA, two NCO, one restricted endemic and three endemic plant species.
Threatened status of ecosystem: low-medium
Presence of rare species: medium-high
Protected trees: low
Endemic species: medium
Terrain type: low
Plant community species richness: medium
Constraints of ecological processes: medium
Degree of fragmentation/connectivity/offset areas: low-medium

In summary, the sensitivity of community 3 is regarded as **medium**.

**Community 4**: *Acanthosicyos horridus*-Peuehl-loeschea leubnitziae riverbeds and washes

This habitat includes five NFA, one NCO and four endemic plant species.

Threatened status of ecosystem: medium
Presence of rare species: medium-high
Protected trees: medium-high
Endemic species: medium
Terrain type: medium-high
Plant community species richness: medium
Constraints of ecological processes: medium-high
Degree of fragmentation/connectivity/offset areas: low-medium

In summary, the sensitivity of community 4 is regarded as **medium-high**.

**Community 5.1**: *Arthraerua leubnitziae*-Salsola tuberculata-Gomphocarpus filiformis dwarf shrubland of the gravel plains

This habitat includes three endemic plant species.

Threatened status of ecosystem: low
Presence of rare species: low
Protected trees: low
Endemic species: medium
Terrain type: low
Plant community species richness: low
Constraints of ecological processes: low
Degree of fragmentation/connectivity/offset areas: low

In summary, the sensitivity of community 5.1 is regarded as low.

**Community 5.2: Arthraerua leubnitziae-Salsola tuberculata-Stipagrostis obtusa** sparse shrubveld of the gravel plains

This habitat includes three endemic plant species.

Threatened status of ecosystem: low
Presence of rare species: low
Protected trees: low
Endemic species: medium
Terrain type: low
Plant community species richness: low
Constraints of ecological processes: low
Degree of fragmentation/connectivity/offset areas: low

In summary, the sensitivity of community 5.2 is regarded as low.

**Community 5.3: Arthraerua leubnitziae-Citrullus ecirrhosus** sparse shrubland of gravel plains and sheetwashes

This habitat includes one NFA, two NCO and three endemic plant species.

Threatened status of ecosystem: low
Presence of rare species: medium-high
Protected trees: low
Endemic species: medium
Terrain type: low-medium
Plant community species richness: low
Constraints of ecological processes: low-medium
Degree of fragmentation/connectivity/offset areas: low-medium

In summary, the sensitivity of community 5.3 is regarded as low-medium.
Community 6: *Arthraerua leubnitziae-Welwitschia mirabilis* sparse dwarf shrubland of the northern gravel plains and sheetwashes

This habitat includes one NFA, two NCO and three endemic plant species.

Threatened status of ecosystem: medium-high  
Presence of rare species: medium-high  
Protected trees: low  
Endemic species: medium  
Terrain type: low  
Plant community species richness: low  
Constraints of ecological processes: low  
Degree of fragmentation/connectivity/offset areas: low

In summary, the sensitivity of community 6 is regarded as **medium**.

Community 7: *Zygophyllum stapfii-Arthraerua leubnitziae* dwarf shrubland of the gravel plains

This habitat includes two endemic plant species.

Threatened status of ecosystem: low  
Presence of rare species: low  
Protected trees: low  
Endemic species: low-medium  
Terrain type: low  
Plant community species richness: low  
Constraints of ecological processes: low  
Degree of fragmentation/connectivity/offset areas: low

In summary, the sensitivity of community 7 is regarded as **low**.

Community 8: *Salsola tuberculata* shrubland of river terraces and undulating plains and footslopes

This habitat includes two endemic plant species.

Threatened status of ecosystem: low  
Presence of rare species: low
Protected trees: low
Endemic species: low-medium
Terrain type: low-medium
Plant community species richness: low
Constraints of ecological processes: low
Degree of fragmentation/connectivity/offset areas: low-medium

In summary, the sensitivity of community 8 is regarded as **low**.

**Community 9: Arthraerua leubnitziae rocky ridges and dykes**

This habitat includes one endemic plant species.

Threatened status of ecosystem: low-medium
Presence of rare species: low
Protected trees: low
Endemic species: low
Terrain type: medium-high
Plant community species richness: low
Constraints of ecological processes: medium
Degree of fragmentation/connectivity/offset areas: medium-high

In summary, the sensitivity of community 9 is regarded as **medium**.

**Community 10: Barren gravel plains**

This habitat includes one endemic plant species.

Threatened status of ecosystem: low
Presence of rare species: low
Protected trees: low
Endemic species: low
Terrain type: low
Plant community species richness: low
Constraints of ecological processes: low
Degree of fragmentation/connectivity/offset areas: low-medium

In summary, the sensitivity of community 10 is regarded as **low**.
Figure 20 Sensitivity map for the INCA site (see legend Figure 21).
Figure 21 Sensitivity map for the TUBAS site

Legend: Sensitivity map
- HIGH
- MEDIUM-HIGH
- MEDIUM
- LOW-MEDIUM
- LOW
Figure 22 Sensitivity map for the SHIYELA site (see legend Figure 21).
7. IMPACTS

Impacts and the management thereof are often dependent on many factors, especially the type of operation and its location. One way of anticipating future environmental impacts and designing ways to avoid or minimizing such impacts, is to do an EIA prior to undertaking an activity, such as prospecting or mining (Mansfeld 2006). An EMP should also be in place prior to prospecting or mining of an area. Rehabilitation and restoration measures are an important part of the EMP.

In general all developments have a negative impact on the natural vegetation of the area. The scale depends on the surface area that will be destroyed and is not always easy to predict at the start of a project, such as mining. It is therefore important to monitor the impact of the mining activities over time and according to the recommendations in the environmental management plan.

The impacts of the proposed new mining activities on the vegetation of the gravel plains were assessed using the following guideline criteria (Friend 2010):

7.1 Nature or status of the impact (value rating indicated where applicable)

The type of effect the activity would have on the affected environment, rated as either positive (beneficial impact on the environment); neutral (no impact on the environment); or negative (adverse impact on and at a cost to the environment).

7.2 Extent or scale of the impact (E)

Indicates whether the impact will be either site specific (impact within the boundaries of the site) (1); local (within an area of 5 km of the site) (2); regional (Namib-Naukluft National Park) (3); on a national scale (Namibia) (4); or across international borders (southern Africa) (5).

7.3 Duration of the impact (D)

Indicates whether the lifetime of the impact will be either short-term (>0-5 years) (1); medium-term (>5-15 years) (2); long-term (where the impact will cease after the operational life of the activity, either because of natural processes or human intervention) (3); or permanent (where mitigation either by natural process or human intervention will not occur in such a way or in such a time span that the impact can be considered transient) (4).
7.4 Intensity or magnitude of the impact (I)

Establishment whether the impact is destructive or benign and is indicated as either low (where the impact affects the environment in such a way that natural, cultural and social functions and processes are not affected) (1); medium (where the affected environment is altered but natural, cultural and social functions and processes continue, albeit in a modified way) (2); high (natural, cultural and social functions and processes are altered to the extent that it will temporarily cease) (3); or very high (natural, cultural and social functions and processes are altered to the extent that it will permanently cease) (4).

7.5 Probability of the impact (P)

Describes the likelihood of the impact actually occurring and is indicated as either improbable (the possibility of the impact to materialize is very low, either because of design, historic experience or implementation of adequate corrective actions) (2); probable (there is a distinct possibility that the impact will occur) (4); highly probable (it is most likely that the impact will occur) (6); or definite (the impact will occur regardless of any prevention or corrective actions) (8).

7.6 Determination of significance (S)

After assessment of an impact in accordance to the preceding five criteria, the significance of an impact can be determined through a synthesis of the aspects produced in terms of their nature, extent, duration, intensity and probability.

\[
\text{Significance (S) = (E+D+L) x P}
\]

- Low significance = score of <25
- Medium significance = score of 25 – 50
- High significance = score of >50

7.7 Additional criteria:

7.7.1 Cumulative impacts, e.g. none expected; additive; interactive countervailing; and interactive synergistic.

7.7.2 Reversibility, e.g. complete (yes); intermediate (probable); and not possible (no).
7.7.3 Potential for resource loss, e.g. will not take place (no); there is a possibility of this happening (probable); and this will definitely happen (yes).

7.7.4 Level of confidence

Definite: no uncertainty is associated with the prediction of the impact and all necessary information was available.

High: the prediction was based on virtually all the necessary information being available, with the exception of insignificant information that will not materially affect the outcome of the prediction.

Medium: although the majority of the available information was available, there is some uncertainty associated with the impact predicted.

Low: there is a high degree of uncertainty associated with the impact predicted as certain key information was unavailable at the time of the prediction.

The project impacts are divided into three phases: construction phase, operational phase and decommissioning/rehabilitation phase.

7.8 Impacts of the mining on the biophysical environment:

7.8.1 Impact on the indigenous vegetation:

In fragile ecosystems, vegetation is easily disturbed, which often means that any disturbance to the environment will result in a loss of vegetation and flora. Little can be done to mitigate or minimize damage to the vegetation of the mining sites. Mining will most probably be done by conventional open pit excavation, digging and trenching, with the subsequent destruction of the whole ecosystem on site. The vegetation on the actual mining sites will therefore be totally destroyed, and protected and endemic species will be lost in the process. The presence of rare plant species, e.g. *Hoodia cf. currorii*, and the relatively high biodiversity of ridges, inselbergs and other rocky outcrops contribute to the high significance rating given above. The ridges, rocky outcrops and inselbergs (communities 1, 2 & 3, Table 1), have more than 70% of the total number of species recorded on site. These habitats are to be excluded from prospecting/mining.

The presence of the protected species *Welwitschia mirabilis*, especially in the Inca site, is cause for concern. The current exploration drilling occurs in that community and special measures should already be taken to conserve this species, especially because transplanting of mature specimens of this species has apparently met with little success in the past.
The slow-growing lichens in this desert environment cannot be relocated or planted anew after mining is complete. The exposure of soils due to mining may promote the establishment of weeds or invasive species.

### Environmental aspect

**Description:** Indigenous vegetation/plant communities

**Mitigation:** The prominent rocky ridges, rocky outcrops, inselbergs and main watercourses should not form part of any mining activities and should be regarded as no-go areas. Besides the no-go option, the next option is to identify particularly valuable plant species and to try to avoid areas in which they occur, e.g. *Welwitschia mirabilis* and significant lichen fields. Protected plant species may not be removed or damaged without permits issued by the relevant authorities.

Other aspects that should be addressed:

- Prevent needless loss or damage to flora particularly with regard to protected, endemic and rare species. Vegetation should be removed only where required.
- Siting of roads, buildings, tailings and other infrastructure should consider rare and endemic plant species, e.g. *Welwitschia mirabilis*.
- Avoid the introduction of alien invasive plant species to the area.
- Conserve rocky outcrops and drainage lines as these habitats are generally more species rich than the gravel plains and contain rare plant species.
- Ensure awareness among staff, contractors and visitors of rare flora and fauna.
- Illegal collecting of plants and firewood should be prohibited.
- If necessary, rare, protected and endemic plant species should be translocated/relocated to suitable areas under specialist supervision. e.g. succulent species such as *Aloe asperifolia*. However, uprooting and translocating desert plants usually meets with little success, especially in the case of *Welwitschia mirabilis*. Transplanting of *Welwitschia mirabilis* is consequently not recommended.
- Translocate/propagate the common plant species of the area for use in rehabilitation.
- Provide the NNBRI the opportunity to remove any specimens of species that are rare, endemic or have value as ornamental plants.

It is imperative to have undisturbed offset areas in the same area of at least the same size and of similar habitat to the mining sites, to allow for ecosystem functioning, vegetative cover and natural movement and re-colonization of displaced fauna. All surrounding areas unaffected by mining activities should therefore be protected.

### Evaluation of impacts

<table>
<thead>
<tr>
<th>Confidence level</th>
<th>Mitigation required</th>
<th>Nature</th>
<th>Extent</th>
<th>Duration</th>
<th>Intensity</th>
<th>Probability</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>medium</td>
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<td>negative</td>
<td>1</td>
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<td>3</td>
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</tr>
<tr>
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<td>yes</td>
<td>Cumulative impacts</td>
<td>yes</td>
<td>Reversibility</td>
<td>no</td>
<td></td>
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</tr>
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</table>

Ekotrust CC
### Vegetation

<table>
<thead>
<tr>
<th>Environmental aspect</th>
<th>Phase</th>
<th>Operational</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description: Indigenous vegetation/plant communities</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Mitigation:** The prominent rocky ridges, rocky outcrops, inselbergs and main watercourses should not form part of any mining activities and should be regarded as no-go areas. Besides the no-go option, the next option is to identify particularly valuable plant species and to try to avoid areas in which they occur, e.g. *Welwitschia mirabilis* and significant lichen fields. Protected plant species may not be removed or damaged without permits issued by the relevant authorities.

Other aspects that should be addressed:

- Prevent needless loss or damage to flora particularly with regard to protected, endemic and rare species. Vegetation should be removed only where required.
- Siting of roads, buildings, tailings and other infrastructure should consider rare and endemic plant species, e.g. *Welwitschia mirabilis*.
- Avoid the introduction of alien invasive plant species to the area.
- Conserve rocky outcrops and drainage lines as these habitats are generally more species rich than the gravel plains and contain rare plant species.
- Ensure awareness among staff, contractors and visitors of rare flora and fauna.
- Illegal collecting of plants and firewood should be prohibited.
- If necessary, rare, protected and endemic plant species should be translocated/relocated to suitable areas under specialist supervision. However, uprooting and translocating desert plants usually meets with little success, especially in the case of *Welwitschia mirabilis*. Transplanting of *Welwitschia mirabilis* is consequently not recommended.
- Translocate/propagate the common plant species of the area for use in rehabilitation.
- Provide the NNBRI the opportunity to remove any specimens of species that are rare, endemic or have value as ornamental plants.

It is imperative to have undisturbed offset areas in the same area of at least the same size and of similar habitat to the mining sites, to allow for ecosystem functioning, vegetative cover and natural movement and re-colonization of displaced fauna. All surrounding areas unaffected by mining activities should therefore be protected.

<table>
<thead>
<tr>
<th>Confidence level</th>
<th>Mitigation required</th>
<th>Evaluation of impacts</th>
<th>Nature</th>
<th>Extent</th>
<th>Duration</th>
<th>Intensity</th>
<th>Probability</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>high</td>
<td>yes</td>
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<td>1</td>
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<td>6</td>
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<td>Cumulative impacts</td>
<td>yes</td>
<td>Reversibility</td>
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</tbody>
</table>
### Environmental aspect

<table>
<thead>
<tr>
<th>Vegetation</th>
<th>Phase</th>
<th>Decom/Rehab</th>
</tr>
</thead>
</table>

**Description:** Indigenous vegetation/plant communities

**Mitigation:** The prominent rocky ridges, rocky outcrops, inselbergs and main watercourses should not form part of any mining activities and should be regarded as no-go areas. Rehabilitation should be initiated from the start of the mining operations. It should include aspects such as landscaping to recreate the original habitat, dressing with topsoil, re-seeding and transplanting if possible.

Other aspects that should be addressed:

- Prevent needless loss or damage to flora particularly with regard to protected, endemic and rare species. Vegetation should be removed only where required.
- Siting of roads should consider Red Data and other rare and endemic plant species, e.g. *Welwitschia mirabilis*.
- Avoid the introduction of alien invasive plant species to the area.
- Conserve rocky outcrops and drainage lines as these habitats are generally more species rich than the gravel plains and contain rare plant species.
- Ensure awareness among staff, contractors and visitors of rare flora and fauna.
- Illegal collecting of plants and firewood should be prohibited.
- If necessary, rare, protected and endemic plant species should be translocated/relocated to suitable areas under specialist supervision. However, uprooting and translocating desert plants usually meets with little success, especially in the case of *Welwitschia mirabilis*. Transplanting of *Welwitschia mirabilis* is consequently not recommended.
- Translocate/propagate the common plant species of the area for use in rehabilitation.
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It is imperative to have undisturbed offset areas in the same area of at least the same size and of similar habitat to the mining sites, to allow for ecosystem functioning, vegetative cover and natural movement and re-colonization of displaced fauna. All surrounding areas unaffected by mining activities should therefore be protected.

### Evaluation of impacts

<table>
<thead>
<tr>
<th>Confidence level</th>
<th>Mitigation required</th>
<th>Evaluation of impacts</th>
</tr>
</thead>
<tbody>
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<tr>
<td></td>
<td></td>
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**Potential for irreplaceable loss of resources**

<table>
<thead>
<tr>
<th>Nature</th>
<th>Extent</th>
<th>Duration</th>
<th>Intensity</th>
<th>Probability</th>
<th>Reversibility</th>
<th>显著度</th>
</tr>
</thead>
<tbody>
<tr>
<td>no</td>
<td>Cumulative impacts</td>
<td>yes</td>
<td>Reversibility</td>
<td>probable</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
7.8.2 Impact of vegetation removal through mining on faunal species

The destruction of the vegetative cover will impact on the habitat of fauna that are dependent on the vegetation for feeding, breeding, nesting and resting.

Environmental aspect | Vegetation | Phase | Construction
--- | --- | --- | ---

**Description:** Impact of vegetation removal on fauna

**Mitigation:** It is imperative to have undisturbed offset areas in the same area of at least the same size and of similar habitat to the mining sites, to allow for ecosystem functioning, vegetative cover and natural movement and re-colonization of displaced fauna. All surrounding areas unaffected by mining activities should therefore be protected.

<table>
<thead>
<tr>
<th>Confidence level</th>
<th>Mitigation required</th>
<th>Evaluation of impacts</th>
<th>Nature</th>
<th>Extent</th>
<th>Duration</th>
<th>Intensity</th>
<th>Probability</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
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<td>Cumulative impacts</td>
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<td>Reversibility</td>
<td>no</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Environmental aspect | Vegetation | Phase | Operational
--- | --- | --- | ---

**Description:** Impact of vegetation removal on faunal species

**Mitigation:** It is imperative to have undisturbed offset areas in the same area of at least the same size and of similar habitat to the mining sites, to allow for ecosystem functioning, vegetative cover and natural movement and re-colonization of displaced fauna. All surrounding areas unaffected by mining activities should therefore be protected.

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<th>Nature</th>
<th>Extent</th>
<th>Duration</th>
<th>Intensity</th>
<th>Probability</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>high</td>
<td>yes</td>
<td>Impact of vegetation removal on fauna</td>
<td>negative</td>
<td>1</td>
<td>3</td>
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<td>Reversibility</td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

Environmental aspect | Vegetation | Phase | Decom/Rehab
--- | --- | --- | ---

**Description:** Impact of vegetation removal on fauna

**Mitigation:** It is imperative to have undisturbed offset areas in the same area of at least the same size and of similar habitat to the mining sites, to allow for ecosystem functioning, vegetative cover and natural movement and re-colonization of displaced fauna. All surrounding areas unaffected by mining activities should therefore be protected.

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<thead>
<tr>
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<th>Nature</th>
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<th>Duration</th>
<th>Intensity</th>
<th>Probability</th>
<th>Significance</th>
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</tr>
</tbody>
</table>

Ekotrust CC
7.8.3 Impact of mining on the ephemeral drainage lines, especially clearly defined watercourses

This habitat is best developed along the Tumas River in the Tubas site with watercourses dissecting the plains and flowing from east to west. The drainage lines are for most years dry and flow only sporadically for short periods after rains. They are not considered to be wetlands in the strict sense of the word. Infrastructure and roads built in or across drainage lines and washes that block the free-flow of water will impair occasional streamflow and will affect the plant species dependent on this habitat, including *Welwitschia mirabilis*.

<table>
<thead>
<tr>
<th>Environmental aspect</th>
<th>Vegetation</th>
<th>Phase</th>
<th>Construction</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description:</strong> Ephemereral drainage lines/watercourses</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Mitigation:**
- Well-defined watercourses should be excluded from development. In general, drainage lines should not be re-directed, and flow of water should not be impeded by roads crossing the channels.
- Prevention of erosion and silt transport should be a high priority.
- A buffer zone of non-disturbance of at least 30 m along the main watercourses should be set aside. According to the NFA, all trees, bushes and shrubs within 100 m of rivers, streams or other watercourses are protected.

<table>
<thead>
<tr>
<th>Low</th>
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<table>
<thead>
<tr>
<th>Evaluation of impacts</th>
<th>Nature</th>
<th>Extent</th>
<th>Duration</th>
<th>Intensity</th>
<th>Probability</th>
<th>Significance</th>
</tr>
</thead>
</table>

Environmental aspect  Vegetation  Phase  Operational

**Description:** Ephemereral drainage lines/watercourses

**Mitigation:**
- Well-defined watercourses should be excluded from development. In general, drainage lines should not be re-directed, and flow of water should not be impeded by roads crossing the channels.
- Prevention of erosion and silt transport should be a high priority.
- A buffer zone of non-disturbance of at least 30 m along the main watercourses should be set aside. According to the NFA, all trees, bushes and shrubs within 100 m of rivers, streams or other watercourses are protected.

<table>
<thead>
<tr>
<th>Low</th>
<th>yes</th>
<th>neutral</th>
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<td>Reversibility</td>
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</table>
Environmental aspect: Vegetation

Phase: Decom/Rehab

Description: Ephemeral drainage lines/watercourses

Mitigation:
- Well-defined watercourses should be excluded from development. In general, drainage lines should not be re-directed, and flow of water should not be impeded by roads crossing the channels.
- Prevention of erosion and silt transport should be a high priority.
- A buffer zone of non-disturbance of at least 30 m along the main watercourses should be set aside. According to the NFA, all trees, bushes and shrubs within 100 m of rivers, streams or other watercourses are protected.

<table>
<thead>
<tr>
<th>Confidence level</th>
<th>Mitigation required</th>
<th>Evaluation of impacts</th>
</tr>
</thead>
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<td></td>
<td>Intensity: 2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Probability: 4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Significance: 24</td>
</tr>
</tbody>
</table>

7.8.4 Impact of vehicles, off-road driving and other forms of trampling and compaction on the vegetation and/or the soil surface.

Off-road driving is prohibited in Namibia’s parks (Mansfeld 2006). The vehicle traffic on site will have a negative impact on the flora in the area during the operation of the mine, and will also result in disruption of the surface microtopography, compaction and modification of the soil and damage of the soil crust, and may contribute to the introduction of alien flora (Mansfeld 2006). In the arid climate of the area, the recovery of soils from compaction may take several decades.

Lichen fields form a characteristic component of the Namib vegetation near the coast. Lichens occur throughout Namibia, with more than 100 species identified so far (Mansfeld 2006). These plants are considered the first colonists of bare habitats in the desert and therefore stabilize the soil and form a groundcover that prevents wind and water erosion by holding the soil together (Craven & Marais 1986, Lange et al. 1989). The gypsum crust in the fog zone support some of the most diverse lichen fields in the world.

The most important species on fine-grained soils and rocks in the Central Namib is the orange lichen Telochistes capensis, whereas many other species are prominent on loose pebbles, exposed stones and rocks. High fog precipitation is a prerequisite of the lichen fields, while the sand-blasting effects of strong easterly winds might explain the absence of...
lichen fields in some areas (Jürgens et al. 1997).

**Environmental aspect**

| Description: | Vegetation and flora assessment |

**Mitigation:**

- Planning of a limited and demarcated road network should be done prior to commencement of any mining activities to protect sensitive habitats and prevent unnecessary damage to the vegetation and terrain. Demarcation of roads should be done together with the park warden and should avoid ridges and drainage lines.
- Tracks should be limited to a few demarcated tracks, and turning points in least sensitive areas should be provided for vehicles. The top layer of the soils of the expansive gravel plains forms a gypsum crust and ‘foam layer’ that is most prominent in the fog belt near the coast (Robinson 1976, Burke 2003a, Grünert 2003) and vehicle tracks remain visible for decades (Seely & Hamilton 1978).
- Ensure trucks and other vehicles remain on demarcated roads and construction sites and off-road driving should be prohibited and penalties given for transgressions.
- Set speed limits and enforce it.
- Inform all staff about the sensitivity of the gravel desert to scarring.
- Dust suppression should be part of management of the site.
- Maintain the roads in good condition.
- Air pollution by gaseous emissions from diesel generators and other earthworking and excavating machinery should be restricted by regularly maintaining the vehicles and machinery and providing efficient filters.
- Roads not in use should be lightly scarified if necessary (where compaction occurred) and flattened by the tyre/grid method (Mansfeld 2006).
- Vehicles damage the soil crust when traveling over the gravel plains and the tracts remain visible for decades. Off-road and other heavy vehicles easily destroy the delicate lichen cover and promote soil movement (Wessels & Van Vuuren 1986). Damage to lichen fields takes decades to recover, if they recover at all. It is strongly advised that only a few dedicated and demarcated roads be used and vehicles should not venture off-road at all.
- It is imperative to have undisturbed offset areas in the same area of at least the same size and of similar habitat to the mining sites, to allow for ecosystem functioning, vegetative cover and natural movement and re-colonization of displaced fauna. All surrounding areas unaffected by mining activities should therefore be protected.

<table>
<thead>
<tr>
<th>Confidence level</th>
<th>Mitigation required</th>
<th>Evaluation of impacts</th>
</tr>
</thead>
<tbody>
<tr>
<td>medium</td>
<td>yes</td>
<td>Nature: negative 1 Extent: 3 Duration: 2 Intensity: 6 Probability: 6 Significance: 36</td>
</tr>
<tr>
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<td>probable</td>
<td>Cumulative impacts: yes Reversibility: probable</td>
</tr>
</tbody>
</table>
**Environmental aspect** | Vegetation | Phase | Operational
--- | --- | --- | ---

**Description:** Vehicles, off-road driving and other forms of trampling and compaction

**Mitigation:**
- Planning of a limited and demarcated road network should be done prior to commencement of any mining activities to protect sensitive habitats and prevent unnecessary damage to the vegetation and terrain. Demarcation of roads should be done together with the park warden and should avoid ridges and drainage lines.
- Tracks should be limited to a few demarcated tracks, and turning points in least sensitive areas should be provided for vehicles. The top layer of the soils of the expansive gravel plains forms a gypsum crust and 'foam layer' that is most prominent in the fog belt near the coast (Robinson 1976, Burke 2003a, Grünert 2003) and vehicle tracks remain visible for decades (Seely & Hamilton 1978).
- Ensure trucks and other vehicles remain on demarcated roads and construction sites and off-road driving should be prohibited and penalties given for transgressions.
- Set speed limits and enforce it.
- Inform all staff about the sensitivity of the gravel desert to scarring.
- Dust suppression should be part of management of the site.
- Maintain the roads in good condition.
- Air pollution by gaseous emissions from diesel generators and other earthworking and excavating machinery should be restricted by regularly maintaining the vehicles and machinery and providing efficient filters.
- Roads not in use should be lightly scarified if necessary (where compaction occurred) and flattened by the tyre/grid method (Mansfeld 2006).
- Vehicles damage the soil crust when traveling over the gravel plains and the tracts remain visible for decades. Off-road and other heavy vehicles easily destroy the delicate lichen cover and promote soil movement (Wessels & Van Vuuren 1986). Damage to lichen fields takes decades to recover, if they recover at all. It is strongly advised that only a few dedicated and demarcated roads be used and vehicles should not venture off-road at all.
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<thead>
<tr>
<th>Confidence level</th>
<th>Mitigation required</th>
<th>Evaluation of impacts</th>
</tr>
</thead>
<tbody>
<tr>
<td>medium</td>
<td>yes</td>
<td>Nature negative</td>
</tr>
<tr>
<td>Potential for irreplaceable loss of resources</td>
<td></td>
<td>Cumulative impacts</td>
</tr>
</tbody>
</table>
Environmental aspect | Vegetation | Phase | Decom/Rehab
--- | --- | --- | ---
**Description:** Vehicles, off-road driving and other forms of trampling and compaction

**Mitigation:**
- Planning of a limited and demarcated road network should be done prior to commencement of any mining activities to protect sensitive habitats and prevent unnecessary damage to the vegetation and terrain. Demarcation of roads should be done together with the park warden and should avoid ridges and drainage lines.
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<th>Nature</th>
<th>Extent</th>
<th>Duration</th>
<th>Intensity</th>
<th>Probability</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
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<td>3</td>
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<td>Cumulative impacts</td>
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<td>Reversibility</td>
<td>probable</td>
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<td></td>
</tr>
</tbody>
</table>

(Ekotrust CC)
7.8.5 Impact of alien invasive vegetation

Establish a policy and management plan to eradicate alien invasive plants. Very few individuals of *Prosopis* sp. were noticed in the drainage lines. Few alien species will be able to establish under the harsh environmental conditions on the gravel plains.

<table>
<thead>
<tr>
<th>Environmental aspect</th>
<th>Vegetation</th>
<th>Phase</th>
<th>Construction</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description:</strong> A small number of alien plants were identified on the property.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Mitigation:**
It is illegal to bring any alien fauna and flora into Namibian parks. These species should be controlled by mechanical and/or chemical means. Mechanical means include ringbarking (girdling), uprooting, chopping, slashing and felling. An axe or chain saw or brush cutter can be used. Stumps or ringbarked stems should be treated immediately with a chemical weedkiller. Follow-up treatment is sometimes needed.

<table>
<thead>
<tr>
<th>Confidence level</th>
<th>Mitigation required</th>
<th>Evaluation of impacts</th>
</tr>
</thead>
<tbody>
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<td>Nature</td>
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<tr>
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<td>Cumulative impacts</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Evaluation of impacts</th>
</tr>
</thead>
<tbody>
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<td>Nature</td>
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</table>

<table>
<thead>
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<th>Environmental aspect</th>
<th>Vegetation</th>
<th>Phase</th>
<th>Operational</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description:</strong> Alien plants</td>
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</tbody>
</table>

**Mitigation:**
It is illegal to bring any alien fauna and flora into Namibian parks. These species should be controlled by mechanical and/or chemical means. Mechanical means include ringbarking (girdling), uprooting, chopping, slashing and felling. An axe or chain saw or brush cutter can be used. Stumps or ringbarked stems should be treated immediately with a chemical weedkiller. Follow-up treatment is sometimes needed.

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<th>Confidence level</th>
<th>Mitigation required</th>
<th>Evaluation of impacts</th>
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<tr>
<td>high</td>
<td>yes</td>
<td>Nature</td>
</tr>
<tr>
<td>Potential for irreplaceable loss of resources</td>
<td>no</td>
<td>Cumulative impacts</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Evaluation of impacts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nature</td>
</tr>
<tr>
<td>positive</td>
</tr>
</tbody>
</table>
### Mitigation:

It is illegal to bring any alien fauna and flora into Namibian parks. These species should be controlled by mechanical and/or chemical means. Mechanical means include ringbarking (girdling), uprooting, chopping, slashing and felling. An axe or chainsaw or brush cutter can be used. Stumps or ringbarked stems should be treated immediately with a chemical weedkiller. Follow-up treatment is sometimes needed.

### Evaluation of Impacts

<table>
<thead>
<tr>
<th>Confidence level</th>
<th>Mitigation required</th>
<th>Nature</th>
<th>Extent</th>
<th>Duration</th>
<th>Intensity</th>
<th>Probability</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>high</td>
<td>yes</td>
<td>positive</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>6</td>
<td>18</td>
</tr>
<tr>
<td>Potential for irreplaceable loss of resources</td>
<td>no</td>
<td>Cumulative impacts</td>
<td>yes</td>
<td>Reversibility</td>
<td>yes</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
7.8.6 Loss of topsoil

Topsoil contains the majority of the living soil organisms and the organic material and seeds of plants. Organic material contributes to soil structure and soil water-holding capacity. The micro-organisms ensure that organic material is broken down and nutrients become available to plants. The topsoil layer is in general very shallow on the gravel plains except along the drainage lines. Loss of topsoil will result in loss of the seedbank and subsequently a decrease in plant cover and establishment of plants after rainfall.

<table>
<thead>
<tr>
<th>Environmental aspect</th>
<th>Vegetation</th>
<th>Phase</th>
<th>Construction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description:</td>
<td>Loss of topsoil</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Mitigation:**

- Topsoil should be removed only from the actual construction sites and not from habitats such as drainage lines.
- Topsoil should not be stockpiled but should be spread immediately onto newly landscaped sites that are prepared for rehabilitation.
- Rehabilitation should commence soon after prospecting and mining are initiated, thus minimizing the area affected. Once trenches and holes have been filled and landscaped, the topsoil should be distributed on top to facilitate plant establishment.
- Shade netting should be applied on areas to be rehabilitated to prevent topsoil from being blown away.
- Erosion of areas where topsoil is removed should be prevented.
- On slopes and drainage lines the use of gabions should be considered.

**Evaluation of impacts**

<table>
<thead>
<tr>
<th>Confidence level</th>
<th>Mitigation required</th>
<th>Nature</th>
<th>Extent</th>
<th>Duration</th>
<th>Intensity</th>
<th>Probability</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>high</td>
<td>Yes</td>
<td>negative</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>8</td>
<td>48</td>
</tr>
</tbody>
</table>

**Potential for irreplaceable loss of resources**

- Yes Cumulative impacts yes Reversibility probable
### Environmental aspect: Vegetation and flora assessment

#### Operational Phase

**Description:** Loss of topsoil

**Mitigation:**
- Topsoil should be removed only from the actual mine sites and not from habitats such as drainage lines.
- Topsoil should not be stockpiled but should be spread immediately onto newly landscaped sites that are prepared for rehabilitation.
- Rehabilitation should commence soon after prospecting and mining are initiated, thus minimizing the area affected. Once trenches and holes have been filled and landscaped, the topsoil should be distributed on top to facilitate plant establishment.
- Shade netting should be applied on areas to be rehabilitated to prevent topsoil from being blown away.
- Erosion of areas where topsoil is removed should be prevented.
- On slopes and drainage lines the use of gabions should be considered.

#### Evaluation of impacts

<table>
<thead>
<tr>
<th>Confidence level</th>
<th>Mitigation required</th>
<th>Nature</th>
<th>Extent</th>
<th>Duration</th>
<th>Intensity</th>
<th>Probability</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>medium</td>
<td>yes</td>
<td>negative</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>8</td>
<td>48</td>
</tr>
<tr>
<td>Potential for irreplaceable loss of resources</td>
<td>probable</td>
<td>Cumulative impacts</td>
<td>yes</td>
<td>Reversibility</td>
<td>probable</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

**Description:** Loss of topsoil

**Mitigation:**
- Topsoil should be removed and stockpiled only from the actual mine sites and not from habitats such as drainage lines.
- Topsoil should not be stockpiled deeper than 1 m and for not longer than a month. It should preferably be spread immediately onto newly landscaped sites that are prepared for rehabilitation (see Strohbach 2009).
- Topsoil should be used for rehabilitation as soon as possible after stockpiling (within one to two months), because it becomes sterile and barren over time. Rehabilitation should commence soon after prospecting and mining are initiated, thus minimizing the area affected and reduces the amount of stockpiles. Once trenches and holes have been filled and landscaped, the topsoil should then be distributed on top to facilitate plant establishment.
- Erosion of areas where topsoil is removed should be prevented.
- On slopes and drainage lines the use of gabions should be considered.

#### Evaluation of impacts

<table>
<thead>
<tr>
<th>Confidence level</th>
<th>Mitigation required</th>
<th>Nature</th>
<th>Extent</th>
<th>Duration</th>
<th>Intensity</th>
<th>Probability</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>medium</td>
<td>yes</td>
<td>positive</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>8</td>
<td>40</td>
</tr>
<tr>
<td>Potential for irreplaceable loss of resources</td>
<td>probable</td>
<td>Cumulative impacts</td>
<td>yes</td>
<td>Reversibility</td>
<td>probable</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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Ekotrust CC
7.8.7 Impact of dust levels on vegetation

Increased vehicle movement, blasting activities and mining and crushing of ore will elevate dust levels in the area. Damaging the topsoil crust may contribute to an increase in dust levels and increase the effect of wind erosion, especially during sand storms (east or bergwinds). Dust may also impact on the photosynthesis process in plants when significant amounts of dust settle on the leaves of plants. However, in the hot and dry environment, the loose sandy nature of the substrate and low vegetation cover, cause ambient dust levels in this area to be high (Mansfeld 2006). Vehicles moving at slow speeds would not be considered as major dust polluting agents.

<table>
<thead>
<tr>
<th>Environmental aspect</th>
<th>Mitigation</th>
<th>Vegetation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description: Dust levels</td>
<td>Mitigation:</td>
<td></td>
</tr>
<tr>
<td>• Ensure trucks and other vehicles remain on dedicated and demarcated roads and construction sites, and off-road driving should be prohibited and penalties given for transgressions.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Set speed limits and enforce it.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Maintain the roads in good condition.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Have dust suppression mechanisms in place.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Confidence level</th>
<th>Mitigation required</th>
<th>Nature</th>
<th>Extent</th>
<th>Duration</th>
<th>Intensity</th>
<th>Probability</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>high</td>
<td>yes</td>
<td>negative</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>20</td>
</tr>
<tr>
<td>Potential for irreplaceable loss of resources</td>
<td>no</td>
<td>Cumulative impacts</td>
<td>yes</td>
<td>Reversibility</td>
<td>yes</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Evaluation of impacts:
<table>
<thead>
<tr>
<th>Environmental aspect</th>
<th>Vegetation</th>
<th>Phase</th>
<th>Operational</th>
</tr>
</thead>
</table>

**Description:** Dust levels

**Mitigation:**

- Ensure trucks and other vehicles remain on dedicated and demarcated roads and construction sites, and off-road driving should be prohibited and penalties given for transgressions.
- Set speed limits and enforce it.
- Maintain the roads in good condition.
- Have dust suppression mechanisms in place.

<table>
<thead>
<tr>
<th>Confidence level</th>
<th>Mitigation required</th>
<th>Nature</th>
<th>Extent</th>
<th>Duration</th>
<th>Intensity</th>
<th>Probability</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>high</td>
<td>yes</td>
<td>negative</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>20</td>
</tr>
<tr>
<td>Potential for irreplaceable loss of resources</td>
<td>no</td>
<td>Cumulative impacts</td>
<td>yes</td>
<td>Reversibility</td>
<td>yes</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

<table>
<thead>
<tr>
<th>Environmental aspect</th>
<th>Vegetation</th>
<th>Phase</th>
<th>Decom/Rehab</th>
</tr>
</thead>
</table>

**Description:** Dust levels

**Mitigation:**

- Ensure trucks and other vehicles remain on dedicated and demarcated roads and construction sites, and off-road driving should be prohibited and penalties given for transgressions.
- Set speed limits and enforce it.
- Maintain the roads in good condition.
- Have dust suppression mechanisms in place.

<table>
<thead>
<tr>
<th>Confidence level</th>
<th>Mitigation required</th>
<th>Nature</th>
<th>Extent</th>
<th>Duration</th>
<th>Intensity</th>
<th>Probability</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>high</td>
<td>yes</td>
<td>negative</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>Potential for irreplaceable loss of resources</td>
<td>no</td>
<td>Cumulative impacts</td>
<td>yes</td>
<td>Reversibility</td>
<td>yes</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Rehabilitation

Indigenous vegetation should be introduced where possible to improve the biodiversity (fauna and flora) of the area. Because of the low rainfall in the area and the periodically strong and hot bergwind (east-wind) conditions, rehabilitation on the exposed gravel plains will be difficult and is not assured. Topsoil should be used as seed source for ephemeral vegetation. Shade-netting should be applied to reduce the influence of strong winds.

Monitoring

- Regular assessments of the impact of mining activities on the vegetation.
- Biodiversity baseline assessment and monitoring.
- Alien invasive plant monitoring, eradication and control programme.

Penalties

There should be set penalties, e.g. financial, for environmental transgressions by staff and contractors during all phases of the mining process, e.g. off-road driving, spillage, pollution, illegal dumping and littering.

Biodiversity offset areas

Because of the difficulties predicted with vegetation rehabilitation, it is essential that other areas of at least the same habitat and size of the mine areas be set aside and protected from all human activities.
8. ENVIRONMENTAL LEGISLATION

According to Brown (1993, cited by Mansfeld 2006), Namibia's environmental legislation is largely outdated, fragmented and incomplete. Legislation relevant to mining in parks (Mansfeld 2006) include:


Relevant clauses include Article 91 (c): The Ombudsman has the duty to investigate complaints concerning the over-utilization of living natural resources, the irrational exploitation of non-renewable resources, the degradation and destruction of ecosystems and failure to protect the beauty and character of Namibia.

Mining in parks must at all times occur in such a manner that the land does not become a wasteland, but can be utilized for other sustainable uses, for future generations to benefit from.

- The Minerals (Prospecting and Mining) Act (Act 33 of 1992)

The Act makes provision for any mining or prospecting company to conduct an EIA and if necessary an Environmental Management Plan. The agreement between the Ministry of Mines and Energy (MME) and the Ministry of Environment and Tourism (MET) is that, prior to any mining or prospecting licenses being approved, applications will be sent to the Department of Environmental Affairs (DEA) for an Environmental Clearance. Upon application for environmental clearance, the applicant will complete an environmental questionnaire, to provide background information for the Directorate. Completion of a screening questionnaire might also be required, however, in most cases for prospecting and mining in parks, an EIA will be required from the start (Mansfeld 2006).

Clearance will only be granted once the EIA has been conducted and indicates no fatal flaws, after which a comprehensive EMP is put in place, that will ensure best environmental practices at all times. EMPs and closure plans (decommissioning) are required to be set up prior to commencement of prospecting and mining. Decommissioning procedures include aspects such as filling in and rehabilitation of excavations, rehabilitation of vehicle tracks, clean up of oil and fuel spillages, dismantling of all infrastructure and burial of rubble, and removal of all wastes.

Bi-annual reports to the DEA should be completed covering all operations that have occurred in the previous six months.
Only once this clearance has been obtained from the DEA may the application be processed. Through the enforcement of the Minerals Act and the agreement between the MET and MME, mining in parks should only take place after satisfactory EIAs and EMPs have been developed.

It may sometimes happen that the MME takes its overriding power to issue licenses without environmental clearances as stated in the Minerals Act, so as to stimulate Namibia’s industry and promote growth (Mansfeld 2006).

- The Nature Conservation Amendment Act, 1996 (No 4 of 1975)

This Act was known as the Nature Conservation ordinance of 1975 (Ord 4 of 1975). This Act is presently the main environmental legislation in Namibia. Section 18 of the Act states that ‘no person shall without the written permission of the Executive Committee: ‘wilfully or negligently cause any veld fire or any damage to any object of geological, ethnological, archaeological, historical or other scientific interest within a game park or a nature reserve’

Sections 73 and 74 regulates the picking and transport of protected plants, and the sale, donation and removal of protected plants, in all cases a permit is the requirement.

According to Mansfeld (2006), this Act has no direct bearing on the activity of mining and prospecting, yet it has direct bearing on the access and peripheral activities of mining companies in parks. The conservation of flora and fauna is addressed in this Act, as are the rights of mining and prospecting companies once they have entered a protected conservation area.

Three policies have relevance to mining in Namibian Parks (Mansfeld 2006):

- Policy for Prospecting and Mining in Protected Areas and National Monuments

The policy aims at promoting sustainable development in Namibia by providing guidelines for prospecting and mining in protected areas. The policy states that no mining claim may be pegged in a park but that it is permissible for an Exclusive Prospecting Licence (EPL) and a Mining License (ML) to be granted. The policy defines the various types of licences required for mining and the conditions of operation within protected areas. Whether the exploration company is required to conduct an EIA and EMP is decided on a case by case scenario by
the MET and MPMRC. The MET makes recommendations to the MME on whether a license should be approved or rejected. The final decision lies with the MME.

- Namibian Environmental Assessment Policy (1994):

This policy sets out the rationale for EIAs in Namibia, the principles underpinning the policy, the approach to be taken in conducting EIAs, the process to be followed and the minimum standards required. Appendix B lists a number of activities that require EIA’s, among them ‘mining, mineral extraction and mineral beneficiation’.

In regarding mining and prospecting in parks, the Minerals Act, the Environmental Management Bill and the Parks and Wildlife Bill all require an EIA to be conducted, prior to any license being granted (Mansfeld 2006).

- Minerals Policy (2004):

In section 2.2.4: ‘In order to reconcile the objectives of mineral exploitation and environmental protection, it is essential that the negative impacts of prospecting or mining activities on the environment be avoided, minimized and mitigated in accordance with national policy and legislation, and international best practise.

International Conventions applicable:

- Convention on Biological Diversity (1992)
9. CONCLUDING REMARKS

A total of 72 plant species was identified on the three RUN sites. These included 17 tree and shrub species, eight dwarf shrub species, 14 succulent species, 23 forbs species, one geophyte and nine grass species. Two restricted endemics, eight endemic and 12 near-endemic species were identified on site. A total of 11 species have some form of protection. The most important plant species include *Welwitschia mirabilis*, and the succulents *Hoodia cf. currorii* and *Aloe asperifolia*. Other endemic species of note include *Capparis hereroensis* and *Acanthosicyos horridus*. The tree and shrub species are most abundant in the drainage lines and are not associated with the current exploration activities. However, *Welwitschia mirabilis* occurs in significant numbers in the northern parts of the Inca site where exploration activities currently occur. The presence of the protected species *Welwitschia mirabilis*, especially in the Inca site, and the probable impact on the species, is cause for concern. The current exploration drilling occurs in that community and special measures should already be taken to conserve this species, especially because transplanting of mature specimens of this species has apparently met with little success in the past.

The areas covered by plant communities 1, 2 & 4 are the most sensitive areas of the three RUN sites. These are the *Searsia marlothii-Sarcostemma viminale* sparse shrubveld of the granite inselberg in the western part of the Tubas site; the *Aloe asperifolia-Hoodia cf. currorii* sparse shrubveld of rocky outcrops and marble ridges; and the *Acanthosicyos horridus-Pechuel-loeschea leubnitziæ* riverbeds and washes.

The rocky outcrops, ridges and inselbergs are relatively species rich compared to the gravel plains. The granite inselberg in the western part of the Tubas site provides unique habitats for woody species that are not generally associated with the surrounding areas. These include *Searsia marlothii, Euclea pseudebenus, Cotyledon orbiculata* and *Euphorbia cf. chersina*.

The drainage lines forms part of the Tumas River, which drains the area westwards towards the coast. Most of the vegetation on site is associated with these drainage lines, while the gravel plains are mostly sparsely vegetated or bare. Species occurring in the drainage lines include species such as *Acacia enoloba, Acanthosicyos horridus, Capparis hereroensis, Tamarix usneoides, Faidherbia albida* and *Welwitschia mirabilis*.

Although protected and endemic species were recorded on site, they are mostly restricted to the rocky ridges and inselbergs, and in the ephemeral watercourses, both habitats to be avoided during the mining process. The exception is the presence of *Welwitschia mirabilis* in
the actual area envisaged for the mining operation.

Many of the rare species of the gravel plains have ranges extending beyond the site boundaries and for this reason impacts are not of high significance. The sensitivity of the 10 plant communities is as follows:

Communities 1, 2 and 4 have a medium-high sensitivity. Communities 3, 6 and 9 have a medium sensitivity. Subcommunity 5.3 has a low-medium sensitivity, while subcommunities 5.1 and 5.2, and communities 7, 8 and 10 have a low sensitivity rating.

The potential impact of mine activities on the vegetation on the three RUN sites was evaluated. The significance of the impacts on a number of issues is as follows (indicated for three phases, i.e. construction, operational and decommissioning/rehabilitation):

<table>
<thead>
<tr>
<th></th>
<th>construction</th>
<th>operational</th>
<th>decommissioning/rehabilitation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indigenous vegetation/plant communities</td>
<td>medium, high, low</td>
<td>medium, high, low</td>
<td>medium, high, low</td>
</tr>
<tr>
<td>Impact of vegetation removal on fauna</td>
<td>medium, medium, medium</td>
<td>low, medium, low</td>
<td>low, medium, low</td>
</tr>
<tr>
<td>Ephemeral drainage lines/water courses</td>
<td>medium, medium, medium</td>
<td>medium, medium, medium</td>
<td>medium, medium, medium</td>
</tr>
<tr>
<td>Vehicles, off-road travel, trampling and compaction</td>
<td>low, low, low</td>
<td>low, low, low</td>
<td>low, low, low</td>
</tr>
<tr>
<td>Alien plants</td>
<td>medium, medium, medium</td>
<td>low, low, low</td>
<td>low, low, low</td>
</tr>
<tr>
<td>Loss of topsoil</td>
<td>medium, medium, medium</td>
<td>low, low, low</td>
<td>low, low, low</td>
</tr>
<tr>
<td>Dust levels</td>
<td>low, low, low</td>
<td>low, low, low</td>
<td>low, low, low</td>
</tr>
</tbody>
</table>

The impacts on the vegetation on site will be severe because all vegetation in the mine path will be destroyed. However, the impact will be local and at this point in time a vast portion of the landscape is still protected in the Namib-Naukluft National Park. Vehicles, off-road travel and soil compaction, loss of topsoil, and the effect of removal of vegetation on fauna will have a medium but negative impact. The impact of vehicles on the soil crust and damage to the *Welwitschia mirabilis* population will have a negative impact and medium significance. The low impacts are associated with alien plants, wind erosion and dust levels. If the mining process does not involve the rocky outcrops and drainage lines, as recommended, then the impact on these communities will be low.

Management recommendations should be adhered to and conservation and preservation of all flora should be considered with every action taken on site. It is imperative to have undisturbed offset areas in the same area of at least the same size and of similar habitat to the mining sites, to allow for ecosystem functioning, vegetative cover and natural movement and re-colonization of displaced fauna. All surrounding areas unaffected by mining activities should therefore be protected.
The mining activities fall within the Namib-Naukluft National Park. The policy for Prospecting and Mining in Protected Areas and National Monuments in Namibia aims at promoting sustainable development in Namibia by providing guidelines for prospecting and mining in protected areas. The policy states that no mining claim may be pegged in a Park but that it is permissible for an Exclusive Prospecting Licence (EPL) and a Mining License (ML) to be granted. The policy defines the various types of licences required for mining and the conditions of operation within protected areas. Whether the exploration company is required to conduct an EIA and EMP is decided on a case by case scenario by the MET and MPMRC. The MET makes recommendations to the MME on whether a license should be approved or rejected. The final decision lies with the MME.
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Ekotrust CC


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SANBI 2009: Plants of southern Africa. www.posa.sanbi.org
APPENDIX A

Plant species list of the Reptile Uranium Namibia sites, Swakopmund

<table>
<thead>
<tr>
<th>Category</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trees</td>
<td>6</td>
</tr>
<tr>
<td>Shrubs</td>
<td>11</td>
</tr>
<tr>
<td>Dwarf shrubs</td>
<td>8</td>
</tr>
<tr>
<td>Succulents</td>
<td>14</td>
</tr>
<tr>
<td>Forbs</td>
<td>22</td>
</tr>
<tr>
<td>Geophytes</td>
<td>1</td>
</tr>
<tr>
<td>Grasses</td>
<td>9</td>
</tr>
<tr>
<td>Aliens</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>72</td>
</tr>
</tbody>
</table>

Trees

- *Acacia erioloba*
- *Commiphora saxicola*
- *Euclea pseudebenus*
- *Faidherbia albida*
- *Searsia marlothii*
- *Tamarix usneoides*

Shrubs

- *Acanthosicyos horridus*
- *Cadaba aphylla*
- *Capparis hereroensis*
- *Gomphocarpus filiformis*
- *Lycium cf. cinereum*
- *Lycium cf. tetrandum*
- *Orthanthera albida*
- *Pechuel-Loeschea leubnitziae*
- *Salsola tuberculata*
- *Tetragonia reduplicata*
- *Welwitschia mirabilis*

Dwarf shrubs

- *Arthraerua leubnitziae*
- *Asparagus pearsonii*
- *Blepharis obmitrata*
- *Euphorbia phylloclada*
- *Galenia papulosa*
- *Hermbstaedtia spathulifolia*
- *Monechma cleomoides*
- *Monechma genistifolium subsp. genistifolium*
- Succulents

Succulents

- *Aizoanthemum rehmannii*
- *Aloe asperifolia*
Brownanthus sp.
Cotyledon orbiculata
Euphorbia cf. chersina
Euphorbia lignosa
Hoodia cf. currorii
Kleinia longiflora
Psilocaulon cf. salicornioides
Sarcocaulon cf. marlothii
Sarcostemma viminale
Sesuvium sesuvioides
Zygophyllum simplex
Zygophyllum stapfii

Forbs

Chascanum garipense
Citrullus ecirrhosus
Forsskaolea candida
Gazania jurineifolia
Gazania sp.
Geigeria ornativa
Geigeria sp.
Helichrysum sp.
Heliotropium ovalifolium
Heliotropium cf. curassavicum
Hermannia sp.
Hypertelis salsoloides
Indigofera cf. auricoma
Jamesbrittenia barbata
Jamesbrittenia maxii
Kohautia caespitosa
Kohautia cynanchica
Launaea intybacea
Petalidium canescens
Radyera urens
Senecio cf. sarcoides
Tephrosia dregeana

Geophytes

Hexacyrtis dickiana

Grasses

Enneapogon desvauxii
Enneapogon scaber
Stipagrostis ciliata
Stipagrostis dinteri
Stipagrostis geminifolia
Stipagrostis hirtiglumma
Stipagrostis hochstetteriana
Stipagrostis obtusa
Stipagrostis uniplumis

Aliens

Prosopis glandulosa
APPENDIX B

DIFFERENTIAL TABLE OF THE VEGETATION OF RUN SITES
### Reptile Uranium Namibia

#### Vegetation and flora assessment

<table>
<thead>
<tr>
<th>Species group</th>
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#### Ekotrust CC

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| Species group 3 | Akti aequatorialis | Anosaura infrafasciata | Anosaura macrocephala | Anosaura rhinoceros | Anosaura rhombifrons | Anosaura robusta | Chamaeleo petersi | Chamaeleo togoensis | Chamaeleo vicina | Compsopis senegalensis | Coryphophyllum exoletum | Dendroaspis angusticeps | Dendroaspis polylepis | Dendroaspis polylepis | Dendroaspis polylepis | Dendroaspis polylepis | Dendroaspis polylepis | Dendroaspis polylepis | Dendroaspis polylepis | Dendroaspis polylepis | Dendroaspis polylepis | Dendroaspis polylepis | Dendroaspis polylepis | Dendroaspis polylepis | Dendroaspis polylepis | Dendroaspis polylepis | Dendroaspis polylepis | Dendroaspis polylepis | Dendroaspis polylepis | Dendroaspis polylepis | Dendroaspis polylepis | Dendroaspis polylepis | Dendroaspis polylepis | Dendroaspis polylepis | Dendroaspis polylepis | Dendroaspis polylepis | Dendroaspis polylepis | Dendroaspis polylepis | Dendroaspis polylepis | Dendroaspis polylepis | Dendroaspis polylepis | Dendroaspis polylepis | Dendroaspis polylepis | Dendroaspis polylepis | Dendroaspis polylepis | Dendroaspis polylepis | Dendroaspis polylepis | Dendroaspis polylepis | Dendroaspis polylepis | Dendroaspis polylepis | Dendroaspis polylepis | Dendroaspis polylepis | Dendroaspis polylepis | Dendroaspis polylepis | Dendroaspis polylepis | Dendroaspis polylepis | Dendroaspis polylepis | Dendroaspis polylepis | Dendroaspis polylepis | Dendroaspis polylepis | Dendroaspis polylepis | Dendroaspis polylepis | Dendroaspis polylepis | Dendroaspis polylepis | Dendroaspis polylepis | Dendroaspis polylepis | Dendroaspis polylepis | Dendroaspis polype