

**ANNEXURE N3:  
BIODIVERSITY STUDIES BY FAUNA &  
FLORA INTERNATIONAL, EEAN AND  
ANTJE BURKE**





**RIO  
TINTO**

**Review of the Biodiversity Assessment  
at Rössing Uranium, Namibia**

**Fauna & Flora International and Rio Tinto  
Biodiversity Partnership**

**Dr Rob Brett**

**18 May 2009**

## Preamble

Commissioned by Rössing Uranium Ltd (RUL) and Rio Tinto Health Safety & Environment (RT HSE) to the attached Terms of Reference, this is a brief review of the *Rössing Biodiversity Assessment* (RBA) report of Environmental Evaluation Associates of Namibia (EEAN 2008) and more specifically the biodiversity surveys that were undertaken at the Rössing mine site in mid-September 2007 to inform RUL over biodiversity risks associated with Phase I of a pending expansion of its operations.

The review was informed by an earlier biodiversity risk planning document (Ekstrom *et al* 2008), and phone conversations with Rainer Schneeweiss (RUL) and John Irish (EEAN) prior to drafting this review

## Approach

The review was done with attention to the following principles or assumptions:

- Actions to avoid, minimise or mitigate the biodiversity impacts of the expansion of Rössing (into the ore body SK4 in the eastern side of the Rössing mining licence area) should be guided and implemented on the basis of ‘minimum regret’<sup>1</sup>
- Irreversible loss or extinction of endangered species as a result of its operations is a significant risk to RUL and Rio Tinto, is contrary to RT’s biodiversity strategy and the declared aim of a net positive impact on biodiversity; thus to be avoided if at all possible
- Due attention be given the wider impacts of development and operations on key habitats and ecosystem processes, including the secondary impacts of mining operations
- Due attention be given to reputational issues associated with any species or habitats with perceived higher global or local value, particularly *flagship* or *signature* species that are popular, well-known by non-specialists or characteristic of the fragile biomes of the Central Namib

It was recognised the success of surveys in terms of species discovery or re-discovery (particularly for invertebrates) is related to their timing in relation to rains and associated increase in biological activity, and the unpredictability of rains at Rössing and the central Namib makes survey planning and implementation logistically problematic.

It was also recognised that biodiversity surveys in the Rössing area even in suitable conditions have a low probability of re-discovery of species that are naturally at very low density or very rare; this make the cost-effectiveness of surveys unpredictable (as discussed in the RBA, Appendix E). Equally, intensive biodiversity surveys restricted to an impact site within a biodiverse area have a high probability of finding new site endemic species, particularly where there is still an upward curve of identification of new species against cumulative survey effort; this is already a feature (and additional risk) at other RT sites located in or over critical habitats (e.g. *flora* and *herpetofauna* at QMM Madagascar, subterranean *stygofauna/troglofauna* at Pilbara Iron Australia), and emphasises the need for equivalent survey efforts to be allocated outside the area of impact (or licence) with the objective of reducing the number of species on the list of threatened taxa endemic to the RT site. Obtaining more incidence or observations of critical species (in terms of rarity or vulnerability) through surveys is vital to obtaining useful estimates of a species’ range or Extent of Occurrence (EOO) relative to the area(s) of permanent or irreversible impact at a mine site.

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<sup>1</sup> Also applicable as the Precautionary Approach, or Precautionary Principle (see [www.pprinciple.net](http://www.pprinciple.net))

Finally, given the large volume and backlog of material and specimens collected to date at Rössing (particularly from the 1984/85 surveys) which have still to have work allocated by specialists to enable their identification, taxonomic placement and conservation status assessment, further work on this material may result in discovery of further site endemics. This issue is part of the 'biosystematic crisis' (Irish, pers. comm.) that confounds efforts to make consistent or precise estimates of the number or status of species that are truly endemic to biodiverse and sensitive mine sites, particularly where there has been a disproportionate effort by a mining company to survey and understand its biodiversity risks within its impact or licence area relative to external areas.

The above issues do not diminish the need to continue to make the best quality surveys for biodiversity within and outside zones of impact before and over the lifetime of a mining operation, particularly due to the risks associated with not acting on the basis of existing data (e.g. on incidence, frequency and EOO of threatened endemics) and on the basis of 'minimum regret'.

## Review

### **Strengths of the RBA**

- The RBA report provides a comprehensive review on the full range of taxa and habitats found at Rössing, particularly in the valuable summary and evaluation of the material and results generated by the incomplete 1984/85 surveys. It was very useful and important to bring all the summary biodiversity information together within the Annexes to the RBA, and put the 1984/85 into the context of the more recent developments at Rössing and in particular use in qualifying the 2007 survey information (or lack of it).
- The RBA integrated survey information from 1984/85 and 2007 with the high quality information on plant habitats and biotopes (A Burke), usefully linking and confirming associations of plants biotopes with the coarser habitat classification (Rocky Hillside, Open Plains and Watercourse) which apparently show better prediction and association with faunal components. As far as possible, the RBA followed the sequence of actions given in the 3-month decision document (Ekstrom *et al* 2008), but sensibly and within the time available focused on habitats to link to faunal associations.
- Continuity of the 2007 surveys with the 1984/85 surveys was important for the invertebrate groups, which include most of the rarest and most threatened species found at Rössing; here the ongoing contribution of the invertebrate specialist (J Irish) will continue to be valuable in assessing the risks associated with the spider and solifugid species that comprise the majority of the list of species of conservation concern (RBA tables 6 and 9).
- The 2007 surveys assessed Biological Soil Crusts (BSC) for the first time at Rössing, and put into context their role within the ecosystem and relationship to micro fauna, sensitivity to pollution and disturbance, and role as indicators of environmental condition. The RBA also highlighted the potential impact of dust on BSC and other microhabitats of invertebrates on the conservation concern list.
- The RBA focused attention on the most diverse and vulnerable broad habitat type in and around the Rössing licence area (Rocky Hillside - RH), particularly in relation to its relatively small total area adjacent to the Khan and Swakop rivers (850 km<sup>2</sup>; RBA – Figure 9), the high representation of vulnerable site endemics found in this habitat, and the location of the expansion area (SK4) and dome within this habitat (RH).

- With information available on the known distribution, habitat preferences and EOO of critical species (e.g. Tables 6 and 9) located only in RH, and the proportion of the area of impact by the Phase I expansion in relation to the total, the conclusion of the RBA authors is valid - that it is possible, but unlikely, that the expansion phase I would cause the extinction of any critical or high priority species at Rössing.

### **Weaknesses**

- Notwithstanding the unpredictability of rains in the Central Namib and consequently of results in relation to survey effort in particular months, the timing, length and scope of the September 2007 surveys were inadequate. This is particularly evident in relation to the need to allocate most survey effort during the months that would maximise the probability of capturing the invertebrates in the more important habitats (RH) at times of maximum biological activity, either following rain or at seasonal peaks of cloud/fog formation over the Rössing site.
- The urgency of planning surveys (e.g. in relation to timing of critical path decisions) needed to be related to probability of highest returns (e.g. on incidence and collection of pitfall trap specimens) during or towards the end of rainy seasons. With hindsight, the months of March/April 2009 would have been ideal for timing of a major survey effort due to the exceptionally good rains that fell on the north and central Namib in February 2009.
- With the poor timing and limited period of the 2007 surveys, some taxa could not be covered (e.g. amphibians), with Water Courses and Open Plains not being sampled.
- There was limited attention to secondary impacts of the expansion of the mine, particularly on the extent and distribution of roads around SK4 and the dome, and their impacts on the more important habitats (Rocky Hillsides).
- The surveys of 1984/85 and 2007 surveys and their results were primarily taxonomic in nature, and there is continued need for complementary attention and dedicated studies to ecological links and dependencies (e.g. species associations) and critical conservation needs for any of the species within the high priority list. The report does give a useful evaluation of many of the critical species in relation to their importance (or keystone status) within the ecosystem, but for these species (e.g. spiders, scorpions) any summary of ecological studies on their ecological or habitat requirements (diet, predators, prey, e.g. from DRFN studies) would be a useful guide to the components (or co-dependent species) that are critical to their persistence within a given habitat.
- The RBA report notes that it was not able to show any relationship of the faunal biodiversity to the plant biotopes (A Burke), and thus the coarser categorisation of habitats (Rocky Hillsides, Open Plains and Watercourses) was used for this purpose. Although it is stated that each harbours a definably distinct faunal component, it is not clear (e.g. from RBA Appendix C) how these faunal associations are defined (e.g. for the taxa with clear preferences for one of these three habitats). The role of edge effects or the boundary/transition areas between habitats/biotopes for particular taxa (e.g. preference for slopes on the edge of watercourses) may be worth further study, particularly for the more common species as representatives of groups with rare/critical species (e.g. solifugids).

### **Gaps or omissions**

- A long-term approach to ecological monitoring at Rössing, and in particular the incidence, abundance and dynamics of species over time in relation to survey effort, has been lacking (or at least is not mentioned in the RBA, except where referencing useful long-term monitoring (e.g. pitfall trapping) at other sites in the Namib).
- The current knowledge and future status, distribution and abundance of different taxa found at Rössing needs to be evaluated further in relation to future direct and

indirect impacts of Climate Change, particularly where design of future survey may help provide future predictions on the range and preferred habitats of species in the critical/high priority category.

- Importantly, the 2007 surveys did not allocate any sampling to areas outside the expansion site (SK4 and dome) e.g. within a 10-20 km buffer of the SK4, given the need to extend the area and intensity of sampling (and potential EOO) for species in the critical category (RBA Tables 5 and 6).
- Although the development of a tailings facility (in the dome or eastern area) is mentioned in the 3-month decision document (Ekstrom *et al* 2007), the potential siting, extent of area, and extended impacts of this development are not covered within the RBA document.
- Although the impact of dust on habitats (e.g. within a 5 km buffer of the site) is usefully discussed and assessed, other wider impacts of the mining operations need to be assessed and survey effort allocated accordingly. Here the drainage or run-off of water and sediment from rock dumps (and tailings) into watercourses may need particular attention.

## Recommendations

These recommendations support and supplement those of the 3-month document (Ekstrom *et al* 2007), specifically Actions 1 (1.1, 1.2 completed), 2 (mostly complete), 3, 4 and 5; and also those of the RBA itself (Section 4.3).

### **Impacts of mine expansion**

#### Impact 1 – eradication and/or extinction of species occurring in SK and proposed rock dumps in the Dome area

- ☞ Avoid and minimise impacts on Rocky Hillside (RH) habitat, and scope areas outside the zone of impact of the Rössing mine for the development of a biodiversity offset site, the placement, extent, management and monitoring of which to be developed through a small consultative group of RUL staff, environmental specialists, community representatives, and government stakeholders.
- ☞ In future, focus complementary and simultaneous survey effort on the sampling areas external to the impact site (20 km buffer around SK4 and impacted portion of dome) as well as within it.
- ☞ Prioritise biodiversity surveys within RH habitat, with the objective of collecting and/or re-discovering the 18 invertebrate species within the **critical priority** category (Table below: Threatened site endemics; see also RBA tables 5, 6, 7 and 9).
- ☞ Place particular focus on discovery on the 4 critical priority spiders only found to date within the RH habitat (Table below, in red).
- ☞ Depending on local conditions (persistence of moist conditions and biological activity from Feb-Mar 2009 rainfall), within time available and as advised by taxon specialists, carry out surveys of invertebrates in first two weeks of June 2009, concentrating on areas outside SK4 and the dome.
- ☞ If no mid-2009 surveys are possible or advised, targeted surveys and sampling of areas external to expansion impact site (as above) should be planned and carried out when the best conditions arise (after next rains – Feb/Mar 2010?), taking advantage of any climatic periods suitable for invertebrate surveys
- ☞ If funds are available, re-analyse and update list of priority species on the basis of new taxonomic work on existing material (from the 1984/85 and 2007 collections) collected from taxa which comprise most of the high priority list (e.g. spiders, scorpions, solifugids)

- ☞ Based on the location and area/extent of the tailings facility to be developed as part of the expansion (dome, or eastern area), update the proportion of the RH habitat around Rössing (850 km<sup>2</sup>) to be impacted as part of the expansion.
- ☞ Institute long-term sampling and monitoring programme (to be carried out by RUL staff and external specialists (e.g. EEAN, A Burke) or partner institutions (e.g. DRFN) for the impact site (leading up to expansion operations) and for areas outside it (< 20km), within RH habitat, Open Plains and Water Courses. Prioritise invertebrate sampling, but design monitoring programme to include all taxa within Conservation Concern Priority List (RBA Table 6).
- ☞ Integrate long-term biodiversity monitoring (including pitfall trapping) within the EMS for Rössing expansion project.
- ☞ Define area of responsibility of RUL: all Rössing licence area, a zone of 10 km around impact site of the expanded mine and infrastructure, and within this zone 5 km perpendicular to all roads (e.g. leading to Rössing site)

Impact 2: Increased areas of accumulation of dust around the mining operations, which may reduce the productivity of plants, and reduce the abundance of soil crust organisms and small invertebrates

- ☞ Carry out pilot surveys to guide development of a long-term monitoring programme on impacts of dust and disturbance on biodiversity outside of expansion impact sites, including roads
- ☞ Identify and select indicator species (e.g. associated with BSC) for long-term monitoring of the impact of dust (5 km buffer from operational areas, pits, crushers, dumps and roads)
- ☞ Focus monitoring on spider and solifugids, applied to understanding the reasons underlying the low densities of these species (e.g. as recorded within the 2007 survey)
- ☞ Commission specific studies on the ecological relationships between BSC and its component organisms and microfauna, and species at higher trophic levels (particularly invertebrates: spiders and scorpions)

Other Impacts on other species of concern

- ☞ During expansion operations, use any opportunities for destructive sampling of habitats and associated studies to inform and add to the existing database on high priority species (RBA Table 6); where possible, translocate and protect individuals of two plant species of concern (*Adenia pechuelii* and *Lithops ruschiorum*)
- ☞ Include the two high priority reptile species (lizards: *Pedioplanis husabensis*, and *Meroles* sp) in future biodiversity surveys within and external to the impact site
- ☞ Circulate biodiversity information with other mining companies, in order to address the cumulative impacts of uranium mining on impacted species with larger ranges (e.g. *P. husabensis*), and link RUL's biodiversity database and information on biodiversity risks to the Central Namib Strategic Environmental Assessment (SEA)
- ☞ Use data from future biodiversity surveys (under Impacts 1 and 2, above) to inform monitoring programme and adaptive management for phase II of the expansion project at Rössing, in order to avoid and minimise impacts on critical habitats and species.
- ☞ Encourage continued taxonomy and analysis of existing invertebrate material and museum collections from previous biodiversity surveys at Rössing, in order to further update and refine the list of species on conservation concern.



**Table of species of critical priority conservation concern for RUL  
(Endemic to Rössing site, and IUCN Threatened status: CR, EN or VU)**

Common name	Genus, species	IUCN stat.	EOO (km <sup>2</sup> )	NOL	Habitat		
Tingle trapdoor spider	<i>Moggridgea eremicola</i>	CR	-	1	RH		
Velvet spider	<i>Seothyra anettae</i>	CR	-	1		OP	
Ant spider	<i>Cyrioceta namibiensis</i>	CR	-	1		OP	
Bee fly	<i>Pteraulacodes hessei</i>	CR	-	1		OP	
Sun spider	<i>Daesiella pluridens</i>	CR	-	1		OP	
Ant spider	<i>Caesetius sp. nov.</i>	CR	-	1			WC
Flower beetle	<i>Hedybius irishi</i>	CR	-	1			WC
Bee fly	<i>Heterotropus apertus</i>	CR	-	2		OP	
Prodidomid spider	<i>Namundra griffinae</i>	EN	-	2	RH		
Sun spider	<i>Blossia sp. Nov. A</i>	EN	-	2	RH		
Sun spider	<i>Blossia sp. Nov. B</i>	EN	-	2			WC
Flower beetle	<i>Metaphilehedonus swakopmundensis</i>	EN	5	3	RH		WC
Ant spider	<i>Heradida griffinae</i>	EN	11	3	RH	OP	WC
Silverfish	<i>Ctenolepisma sp. nov. nr. Pauliani</i>	EN	11	3		OP	WC
Sun spider	<i>Lawrencega sp. nov.</i>	EN	12	5	RH		
Jewel beetle	<i>Nothomorphoides irishi</i>	EN	13	3		OP	
Blister beetle	<i>Iselma deserticola</i>	EN	41	3	RH	OP	
Silverfish	<i>Ctenolepisma occidentalis</i>	VU	151	6		OP	WC
<b>Total</b>					<b>7</b>	<b>10</b>	<b>7</b>

### Documents consulted

EEAN (2008) Rössing Biodiversity Assessment (46 pp), plus Annexure (122 pp)

Ekstrom *et al* (2008) Biodiversity and the Rössing expansion '3-month decision': priority actions to manage biodiversity risk and opportunity with respect to the new tailings/expansion area (10 pp)

## **Terms of Reference**

### **Background**

Fauna & Flora International (FFI) has partnered with Rio Tinto to help the company develop a framework for managing biodiversity at mine sites. As part of the partnership, FFI is also keen to provide recommendations that inform the group's decision about a particular development in an attempt to mitigate any likely impacts on biodiversity and communities of a region.

### **Objective**

Rio Tinto has asked FFI to review the Biodiversity survey carried out in its subsidiary in Namibia. Rössing Uranium Limited (RUL, hereafter referred to as 'Rössing') has operated a uranium mine in the Erongo Region of Namibia, in the central Namib Desert, since 1976.

Rössing is considering a phased expansion of its operations. The current surveys have been carried out by the **Environmental Evaluation Associates of Namibia (EEAN)** group and any potential gaps identified during the FFI review will be addressed in further survey work to be carried in May 2009.

### **Contributors**

The review will be conducted by Dr Rob Brett, FFI's Director for Africa. Observing our confidentiality agreement with Rio Tinto, FFI will not share this request and any other information with third parties without prior authorization from Rio Tinto.

### **Expected Results**

Based on the review of the document provided, direct contact with mine site staff and potential contact with specialists, FFI will produce a concise report to inform and highlight to Rio Tinto, the main strengths and potential weaknesses of the biodiversity assessment, and identify gaps, if any, in the survey. FFI will also endeavour to provide a short list of recommendations based on the findings of the review.

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## Contents

1. Introduction .....	4
1.1 Background .....	4
1.2 Terms of Reference .....	5
1.3 Previous work .....	7
1.4 Project area .....	7
2. Methods .....	9
2.1 Inception visit .....	9
2.2 Student assistance .....	9
2.3 Area reconnaissance and study areas .....	9
2.4 Follow-ups of State Museum work .....	9
2.5 Taxa focused on .....	11
2.5.1 Biological soil crusts .....	11
2.5.2 Plants .....	12
2.5.3 Arachnids and other non-insect invertebrates .....	12
2.5.4 Insects .....	13
2.5.5 Amphibians and reptiles .....	13
2.5.6 Birds .....	13
2.5.7 Mammals .....	13
2.5.8 Aquatic organisms .....	13
3. Results .....	14
3.1 Habitat categorization .....	14
3.1.1. Aligning biotopes with broader habitat categories .....	14
3.1.2 Categorising habitat preferences for all species .....	18
3.2 Biodiversity inventory .....	18
3.2.1 Biological soil crusts .....	19
3.2.2 Plants .....	19
3.2.3 Arachnids and other non-insect invertebrates .....	19
3.2.3.1 Arachnids .....	19
3.2.3.2 Snails (Molluscs) .....	20
3.2.3.3 Centipedes and millipedes (Myriapods) .....	21
3.2.3.4 Crustaceans .....	21
3.2.4 Insects .....	21
3.2.5 Amphibians and reptiles .....	21
3.2.6 Birds .....	22
3.2.7 Mammals .....	22
3.3 Vulnerability and endemism of taxa .....	23
3.3.1 Categorisation of taxa using IUCN guidelines .....	23
3.3.2 Priority classification .....	26
3.3.3 Habitat preferences of high priority taxa .....	29
3.3.4 Ranking of Burke's biotopes .....	31

4. Summary and conclusions .....	32
4.1 Summary of habitat and biodiversity information .....	32
4.1.1 Habitats and biotopes .....	32
4.1.2 Biodiversity .....	32
4.1.3 Taxa of high priority .....	34
4.1.4 Habitat preferences of taxa of high priority .....	35
4.2 Conclusions regarding Rössing mine expansion .....	35
4.2.1 Impacts of mine expansion .....	35
4.2.1.1 Eradication and/or extinction of highly endemic animals .....	35
4.2.1.2 Dust accumulation .....	37
4.2.2 Confidence of our predictions .....	38
4.2.2.1 Quantifying risks with statistically perilous data .....	38
4.2.2.2 Strength and weakness of preliminary field observations .....	39
4.2.3 Options for mitigation .....	39
4.2.3.1 Minimise the new footprint .....	40
4.2.3.2 Translocation of plants .....	40
4.3 Recommendations for further work .....	40
4.3.1 Improve biodiversity data collection .....	40
4.3.2 Evaluate restoration and rehabilitation methods .....	41
4.3.3 Specifically evaluate impacts of dust on micro-habitats .....	41
4.4 Conclusions regarding Phase I expansion .....	42
5. Glossary .....	43
6. References .....	44

# 1. Introduction

## 1.1 Background

Rössing Uranium Limited (RUL, hereafter referred to as 'Rössing') has operated a uranium mine in the Erongo Region of Namibia, in the central Namib Desert, since 1976 (Figure 1). The mine comprises an open pit, rock dumps and tailings dam, and mine infrastructure associated with processing plants, manufacturing, maintenance and administrative operations (Figure 2), situated within the Mining Licence Area.

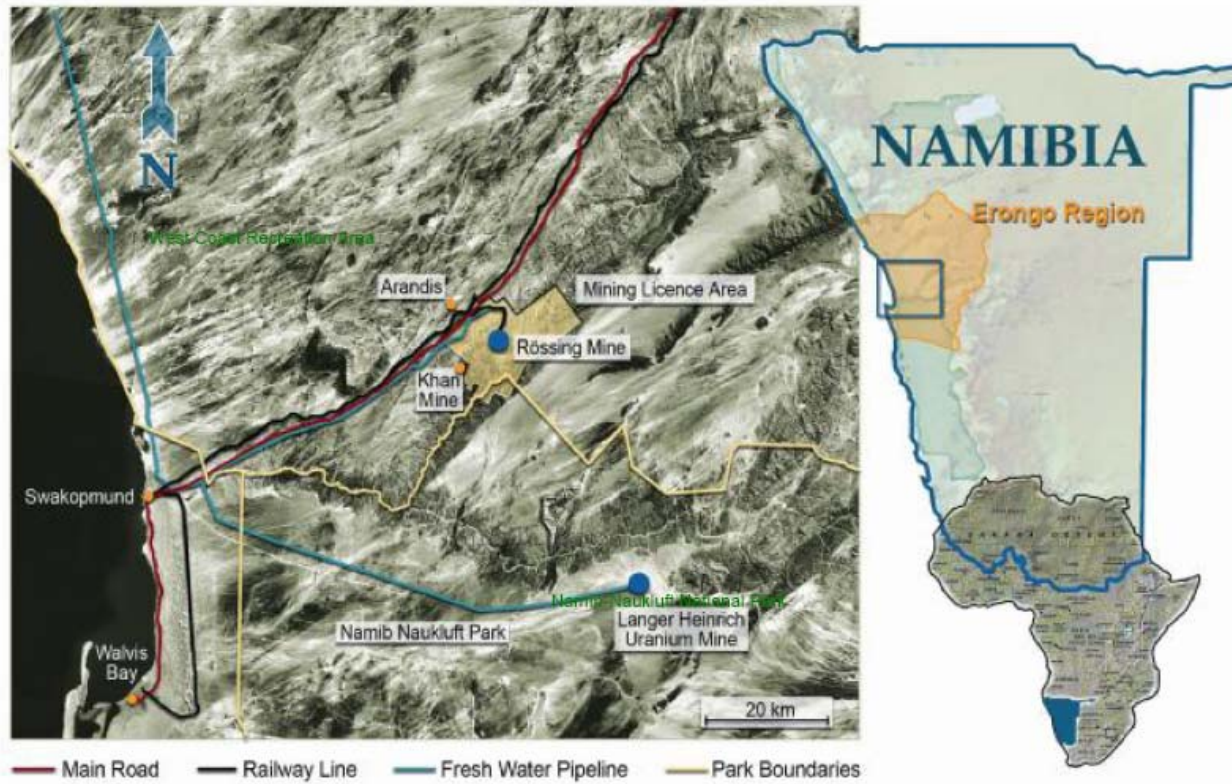


Figure 1: Location of the Rössing Uranium mine in the central Namib Desert, Erongo Region, Namibia. (Rössing Uranium Limited, August 2007).

Rössing is considering expansion of its operations that entail opening new pits with concomitant new disposal areas for waste rock, new or expanded processing plants, additional tailings dam capacity, and an increase in staff numbers and facilities. This will take place in a phased approach. Only three specific components, comprising Phase I, are being considered in the present EIA. These are:

- a sulphuric acid plant and associated storage and transport,
- a radiometric ore sorter plant and disposal of waste rock in the Dome area
- mining of an ore body known as SK4.

The acid plant and ore sorter will be situated on ground that is extensively disturbed by existing mine activities. In this phase, only the expansion into the SK4 area and Dome,

and establishment of infrastructures to them, constitute activities that will newly impact on biodiversity in the Rössing area.

The scope of the current work considers biodiversity in the wider area, namely the Rössing Mining Licence Area and the surroundings (up to about 10 km away). In addition, we make recommendations with regard to the proposed expansion into SK4, where impacts on biodiversity will be felt soonest.



Figure 2: Satellite image of the Rössing Mining License Area and Accessory Works Area, highlighting the proposed new mining areas named SH (yellow) and SK (blue). SK4, the western-most tip of SK, is the area to be directly impacted in Phase 1. (Rössing Uranium Limited, November 2007)

## 1.2 Terms of Reference

The Terms of Reference for this work comprised description of a procedure, defined by Rössing, that was to be followed to implement the project. This was accepted by EEAN after review and some refinement in joint discussion with Rössing. The procedure was as follows:

Action 1: Inception meeting and site visit. The team considers that it will be valuable to meet the Rössing team that will be directing the project, and to have access to as much information as possible from Rössing at the very start. This information includes aspects such as long-term weather, hydrological and groundwater records, and any previous work

of relevance such as the State Museum and other biodiversity projects. An inception meeting will facilitate exchange of information between the client and consulting teams, and will help to establish a common understanding of how this information will be used by the team.

Additionally, a preliminary visit to the project area and to the surroundings that will be included in the assessment, will be valuable. It will provide team members with a better idea of topography and habitats that will be encountered, and with at least some preliminary knowledge of the changes that would be expected, and where they would occur, from mine expansion.

This preliminary information-gathering exercise will also give a kick-start to the mapping work, as presumably some of the information is available in a GIS format that Rössing would want to build on.

Action 2: Status and distributional and ecological information pertaining to the known and expected animal species occurring in the area will be compiled into a format appropriate to the client's needs. Follow-up of the 1980s work has already been initiated by Dr John Irish and will be brought to a conclusion.

Action 3: Field surveys of the biological soil crusts and lichens, invertebrate pit-trapping and collecting surveys and small vertebrate censuses will be conducted to work over the area for information pertaining to the distribution and occurrence of the species listed in Action 2.

While on site, habitats encountered within the mining lease area and within a radius of about 10 km will be identified, mapped and described.

Action 4:

Species lists will be compiled, including distribution and habitat information for all known and expected species.

Species will be ranked according to the criteria of vulnerability and irreplaceability, to identify those that have high conservation priority.

Action 5: Information from Action 4 will be fed in to the growing database, thereby gradually building up a model of conservation priority of the different habitats, and the spatial occurrence of the various habitats known to host high-priority species. Once the high-priority habitats are recognisable in terms of topography, vegetation and other features, it will be possible to check outlying areas for the occurrence of similar habitats.

Likewise, the botanical survey conducted by Antje Burke will be fed into the database.

Action 6: Compile multi-layered maps and reports that will be easily interpreted by decision-makers involved in planning the mine expansion, and make oral presentations to Rössing management on the conclusions and recommendations of the project.



Information collected in the entire exercise will serve as a useful baseline for future monitoring of occurrence and abundance of high-priority species.

### **1.3 Previous work**

This report draws on biodiversity work done at Rössing over the last 23 years. Most important is the survey undertaken in 1984-1985 by State Museum staff, incorporating plants, terrestrial invertebrates and vertebrates and aquatic organisms, which is described fully in Irish 2007 (Appendix A). Different animal groups were surveyed with varying intensity and at six different sites in and around Rössing. For various reasons described in Appendix A, the work was not properly concluded. As far as is practically possible, this has now been done in the present study, although taxonomic work that progresses slowly but steadily will continue to add information to the current knowledge base in years to come.

A short spell of animal collecting was done for the current project, although it was recognized by both EEAN and Rössing management that the results from working in the hot dry season would not significantly add to the biodiversity information that existed already. A summary of the 2007 biodiversity sampling is provided in Irish *et al.*, 2007 (Appendix B). The main benefit of the work was to familiarize the team with the habitats in the Mining Licence Area and surrounds and to collectively consider the biodiversity impacts of mine expansion, with input from a range of specialists.

Rössing has, through the work of the botanist Dr Antje Burke, undertaken vegetation and biotope mapping in the area prior to this project (Burke, 2005), and as part of the current project (Burke, 2007). The results of this work are included in this report.

### **1.4 Project area**

As described in Section 1.1, the focus of the current fieldwork was to assess biodiversity in the areas likely to be most impacted by the proposed mine expansion. We therefore selected three sampling sites within the Mining Licence Area which were directly in the areas of impact or close to them (in Phases 1 and 2) and had habitat that was typical of the areas to be directly impacted.

More broadly, the Terms of Reference required the assessment of animal biodiversity to cover the area of direct impacts as well as surrounding areas, within a radius of about 10 km. This would reveal whether species that were found in the Rössing area only also occurred in surrounding areas beyond the boundaries of Rössing's Mining Licence and Accessory Works areas. However, because it was impossible to assess distributions of all species, particularly invertebrates and those animals that are naturally rare, species occurrence had to be linked to habitats. The focus of the project therefore concentrated on habitats, largely determined by topography, occurring in and around the Rössing area. Visualisation of the project area is shown in Figure 3.

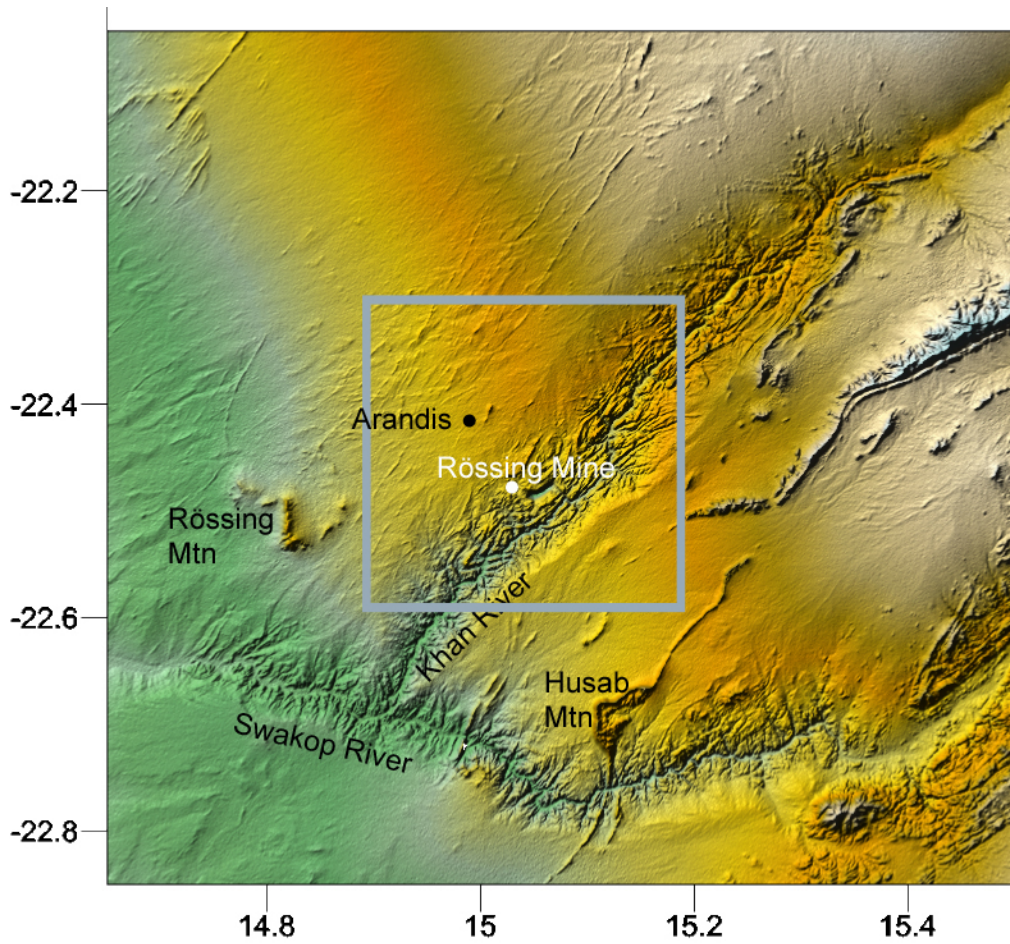


Figure 3: Rössing Uranium Mine in the context of the surrounding physical environment. The square delineates the project area. Shading from green to brown to grey indicates rising altitude.

## **2. Methods**

### **2.1 Inception visit**

The consulting team for the entire Social and Environmental Impact Assessment, led by Brett Lawson from Ninham Shand (Pty) Ltd., was introduced to the overall objectives of the project and the setting in which it would take place, during a two-day inception visit and mini-workshop. This took place on 17-18 September 2007, and involved only John Irish and John Pallett from EEAN. The proposed mine expansion process and desired goals were described by Rössing staff. A site visit was conducted, including a view over the SK4 area itself. All the consultants then described their individual components, information needs and expected deliverables. The schedule to have preliminary results available by early November, and final reports submitted by end November, was agreed.

### **2.2 Student assistance**

It is DRFN and Gobabeb policy to involve students and young interns in practical work wherever possible. The Gobabeb In-Service Training programme was hosting five final-year students at the time of the project, and they were included in the implementation of the fieldwork. This was to bring more eyes and hands to the fieldwork so that it could be done more effectively in the very short time available, and to give them experience in this small component of an EIA. Three were Nature Conservation students and two were studying Land-Use Planning, all at the Polytechnic of Namibia. Mini-projects were designed for each person to undertake in the course of the ten days of fieldwork.

### **2.3 Area reconnaissance and study areas**

Fieldwork took place from Monday 8 to Wednesday 17 October 2007, inclusive. After safety and administrative induction on the first day at Rössing, the 10-member team briefly visited the Dome study site, SK study site, and the following morning, SH study site (Figure 4, precise localities in Appendix B). This provided everyone with direct experience of what habitats they would encounter, and the opportunity to better plan their work and schedules. Three days of field collecting and habitat mapping was done at each of the SK and SH sites, while only two days were spent at Dome.

### **2.4 Follow-ups of State Museum work**

The precise locations of four of the six invertebrate pit-trapping sites were GPS-referenced in the current fieldwork (Appendix A), since the 1980s survey predated the availability of GPSs. Two of the sites could not be confirmed this way: one is now part of the Rock Africa granite quarry adjacent to Rössing, while the other is covered by a Rössing rock dump.

Reports from the State Museum work proved difficult to track down, and not all were complete. Appendix A contains the most up-to-date information from that survey, which can now be considered finished. As taxonomists continue to work on various animal groups, such as solifuges and huntsman spiders, so it can be expected that new species will be named and described. It is impossible to force the pace at which this happens, or to predict the outcome of such ongoing studies.

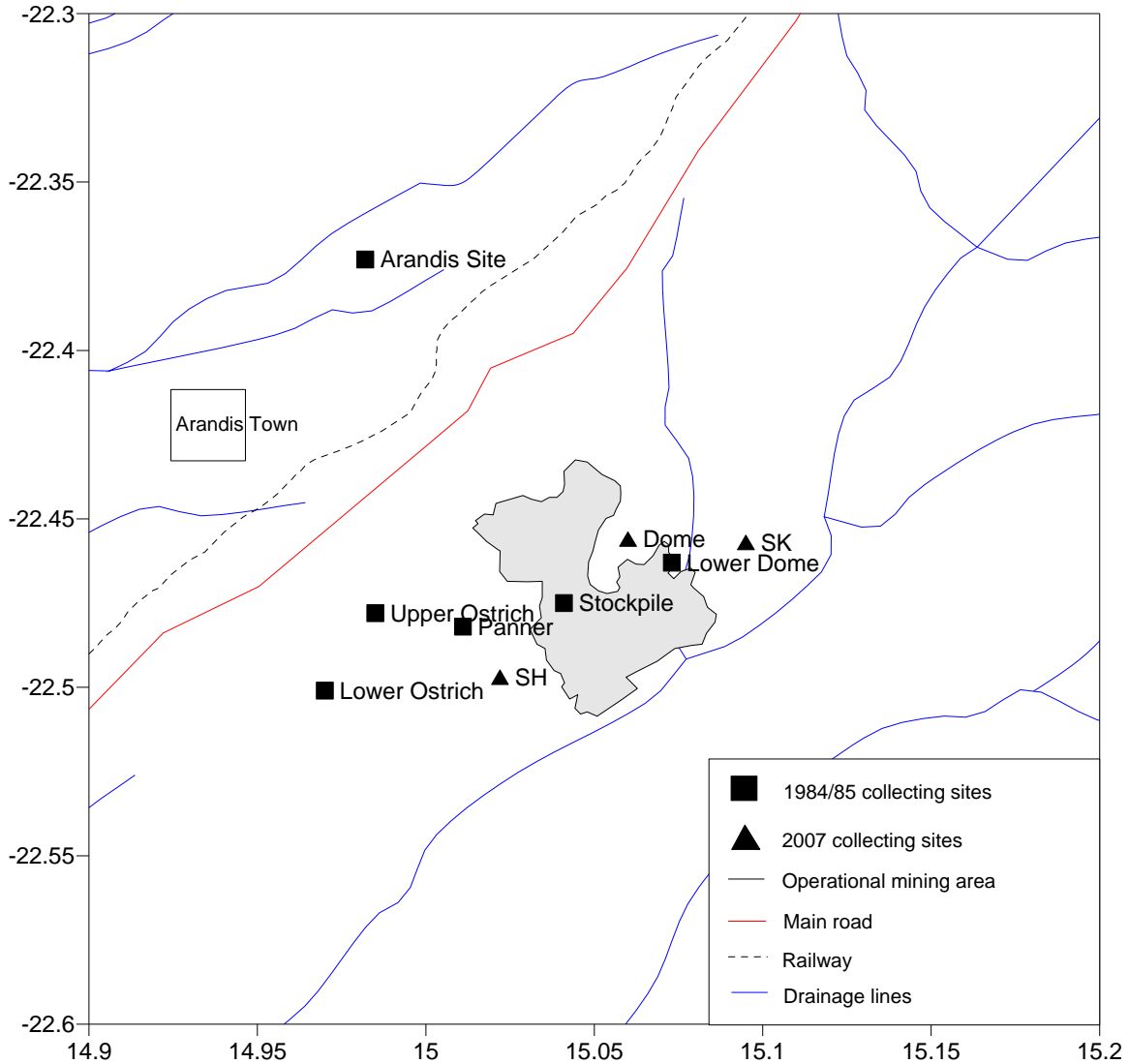


Figure 4: Location of animal biodiversity sampling sites during the 1984-1985 and 2007 fieldwork periods.

## 2.5 Taxa focused on

### 2.5.1 Biological soil crusts

Biological soil crusts (BSCs) are crucial features of desert ecosystems. Because their presence, importance and role is generally under-appreciated, or confined to lichens only, BSCs are given a short introduction here.

Biological soil crusts in the Namib comprise primarily lichens, microfungi, green algae and cyanobacteria (blue-green algae) in various proportions (Belnap & Lange 2001). Protozoans (single-celled animals), nematodes (roundworms and threadworms) and mites are often associated with them. BSCs are located on the surface to several millimeters into the ground or under translucent stones.



Figure 5: Close-up picture of a cross-section through brown biological soil crust on an open soil surface as seen on the Namib gravel plains north of Arandis.

In areas of the Namib where more conspicuous lichens do not dominate, a biological soil crust (BSC) can most easily be seen underneath stones and rocks that harbour *fensteralgen* (green diatoms) and blue-green algae (cyanobacteria, appear black in their dry state) (Rumrich *et al.* 1989, 1992; Büdel & Wessels 1991; Belnap & Lange 2001). These organisms find a home under translucent quartz and quartzite stones, and they can also grow as a near-surface ring around opaque or large stones (Warren-Rhodes *et al.* 2007). Stones trap moisture from fog or dew that condenses and runs down the sides to create a moist hypolithic (below-rock) environment, where photosynthesis is possible due to the sunlight that penetrates through them.

BSCs were assessed only in the 2007 fieldwork. We recorded the presence or absence of BSC under stones, and where present, we noted whether the colour was green or black (mixed colour was recorded as green), or whether the BSC comprised a layer of soil (brown BSC), often with fine filaments loosely binding soil and stones, possibly mycelia

of micro-fungi or filamentous cyanobacteria. These three “types” of BSC each comprise micro-communities, and our casual observations indicate that the complexity increases from brown to black to green (Rumrich *et al.* 1989, 1992; Büdel & Wessels 1991; Belnap & Lange 2001).



Figure 6: Top = brown BSC (with traces of green components); bottom left = green BSC; bottom right = black BSC.

BSCs are ecologically significant in stabilizing soil surfaces by protecting the soil from erosion, and in promoting water infiltration, seed germination and nitrogen and carbon fixation (Belnap & Lange 2001). They can act as biological indicators of environmental conditions. For example, lichens are sensitive to air pollution and can indicate the extent of terrestrial pollution (Hale, 1969). BSCs tend to be poorly established in areas with higher frequency of disturbance, i.e. an abundance of BSC indicates reduced disturbance (Eldridge & Greene, 1994).

### 2.5.2 Plants

A plant species inventory was compiled in the 1980s work. Subsequent botanical work by Burke (2005 and 2007) has concentrated on defining and describing biotopes in the Rössing area.

### 2.5.3 Arachnids and other non-insect invertebrates

Spiders, scorpions and sun-spiders (solifugids) were collected and recorded in both biodiversity surveys. Ticks and mites (Acari) and false scorpions (Pseudoscorpiones) were collected opportunistically, but were not focused on. Surveying the tiny

pseudoscorpions and mites would have required a very careful search of rock samples and could not be combined with the more extensive, rapid survey method applied in 2007, or the pit-trapping surveys in 1984. Furthermore, pseudoscorpions are not expected to be diverse and, because they are comparatively understudied, to identify them beyond order would require drawn-out involvement of international experts of these groups.

Centipedes and millipedes were collected in the various pitfall traps set out for other terrestrial taxa in the 1984-1985 survey. None were recorded in the 2007 fieldwork.

The presence of terrestrial snails was recorded in the 2007 fieldwork, in the process of searching underneath stones while assessing arachnids and soil crusts.

#### **2.5.4 Insects**

Insects were collected in a structured pitfall-trap sampling programme in 1984-1985 and again in the brief 2007 sampling period.

#### **2.5.5 Amphibians and reptiles**

Frogs were recorded in the Rössing area from observations and calls after rain in the 1984-1985 fieldwork, and from records of a MET biologist (Griffin 2007, pers. comm.). Lizards and snakes were sampled in pitfall traps in the 1984-1985 and 2007 fieldwork periods, and records were supplemented with information from Griffin.

#### **2.5.6 Birds**

Bird fauna was assessed by two ornithologists in the 1984-1985 work, confirmed in the 2007 fieldwork, and expanded through consultation of the Southern African Bird Atlas records (Harrison *et al.* 1997). In addition, a Birdlife International ornithologist did brief bird surveys in the Rössing area in 2005, 2006 and 2007 (Stacey 2007), and there has been recent follow-up on one enigmatic species by a Swakopmund-based ornithologist (Boorman pers. comm. 2007).

#### **2.5.7 Mammals**

A small mammal trapping survey in 1984-1985 sampled rodents, sengis (elephant-shrews) and shrews. Fieldwork in 2007 and input from the MET biologist (Griffin 2007, pers. comm.) broadened the mammal inventory to include larger terrestrial mammals such as antelope and baboons, as well as bats.

#### **2.5.8 Aquatic organisms**

Organisms expected from permanent or ephemeral waterbodies include snails, freshwater crustaceans such as seed shrimps and mussel shrimps, water mites and freshwater insects such as water beetles. Seven water bodies known to exist in the Rössing area were repeatedly sampled, and other *ad hoc* waterpoints as they were encountered, in the 1984-1985 survey. Unfortunately very few specimens from this work were accessible and the written records were largely unintelligible.

### 3. Results

#### 3.1 Habitat categorisation

##### 3.1.1 Aligning biotopes with broader habitat categories

The Terms of Reference specify that species in the area should be assigned to preferred habitats or biotopes. As a first step, a biotope classification for the Rössing area by Burke (2005 and 2007) was available.

Burke identified and mapped 19 plant-based biotopes:

1. *Aloe asperifolia* plains
2. *Arthroerua luebnitziae* plains
3. Central hills
4. Eastern hills
5. *Euphorbia virosa* belt
6. Gorges
7. Khan River
8. Khan River mountains
9. Marble hill
10. Marble ridge
11. Northern dome
12. Plain drainage lines
13. South-western hills
14. Undulating granite hills
15. Western granite hills
16. *Zygophyllum stapfii* plains
17. Northern tributaries
18. Southern tributaries
19. South-eastern gneiss hills

The main sampling sites from both the 1984-1985 and 2007 biodiversity survey work can be mapped to Burke's biotopes as follows (Table 1).

Table 1: Categorisation of the 1984-1985 and 2007 fieldwork sites according to Burke's biotopes.

Sample group	Sample Site	Burke (2007) biotope
1984/85	Arandis Site	Extralimital
1984/85	Upper Ostrich Site	<i>Zygophyllum stapfii</i> plains
1984/85	Panner Site	Gorges
1984/85	Lower Ostrich Site	Extralimital
1984/85	Stockpile Site	Central hills
1984/85	Lower Dome Site	<i>Euphorbia virosa</i> belt
2007	SK Sampling Area	Eastern hills
2007	SH Sampling Area	Central hills
2007	Dome Sampling Area	<i>Euphorbia virosa</i> belt



However, we encountered difficulties in relating animal biodiversity to these plant-centric biotopes. Despite harbouring recognisably different plant communities, many of Burke's biotopes are virtually indistinguishable when factors of relevance to animal life are considered.

As an alternative, we undertook an independent habitat categorization, employing different methods (Appendix D). We ended up with a coarser categorization, distinguishing just three habitat types in the Rössing area: rocky hillsides, open plains and watercourses (Figure 7). Each of these has its own distinctive food, shelter and refuge characteristics, and each harbors a definably distinct faunal component, therefore we used only these three main habitat types in further analysis.

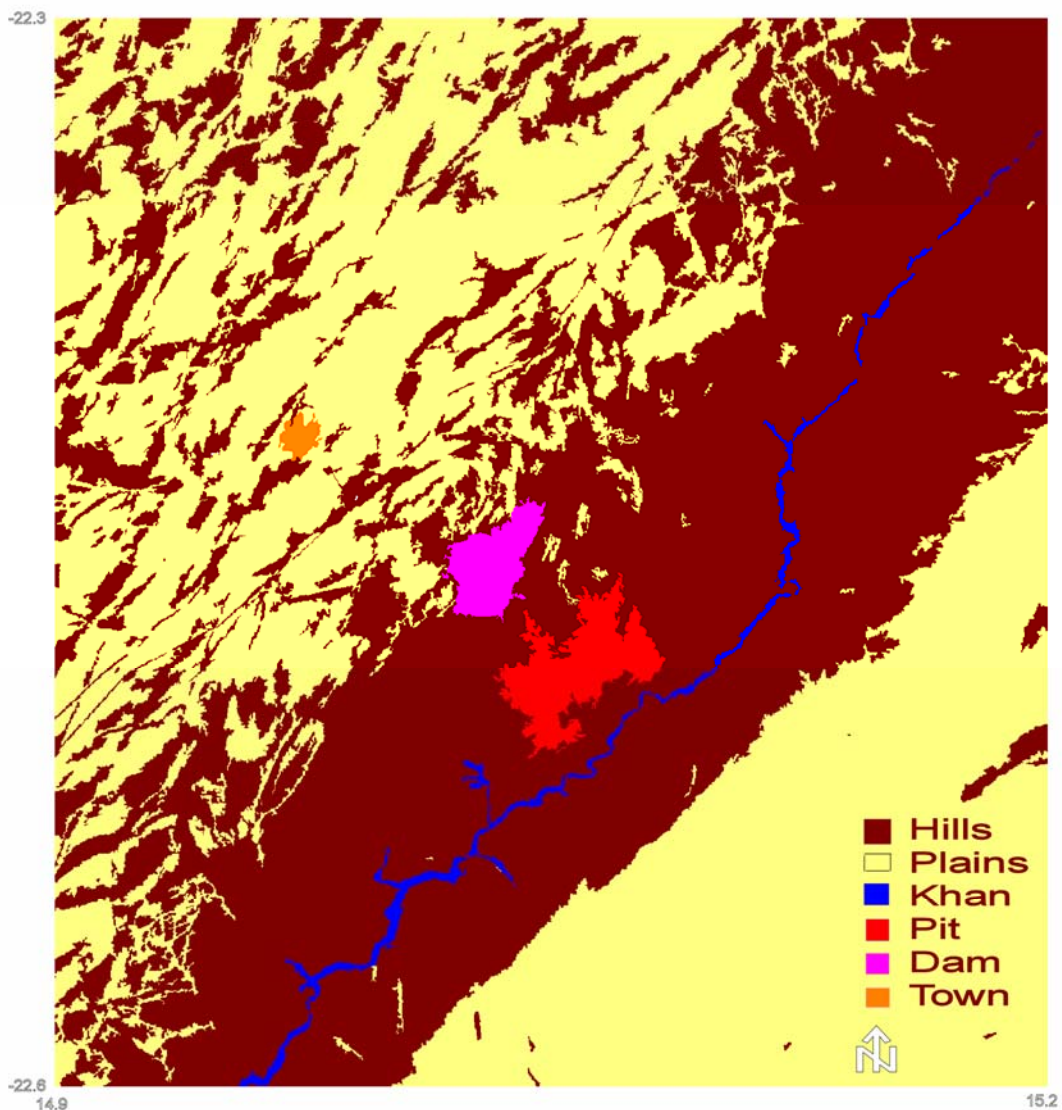


Figure 7. Habitat map of Rössing and surroundings, as used here.

Referring our habitats back to Burke’s biotopes, it becomes clear that the two approaches simply categorise the environment at different scales, and the high degree of mutual correspondence increases the confidence in both (Table 2 and Figure 8).

The only significant points of difference between the two schemes are:

- Our habitat classification shows that the plains are not homogenous, but include numerous, low rocky ridges. Experience bears this out.
- Our classification does not distinguish minor watercourses from the habitat they flow through.

These differences do not impact on the conclusions drawn from habitat preferences later.

Table 2. Alignment of Burke's (2007) biotopes with the habitat types used in this assessment.

<b>Burke (2005 and 2007) biotopes</b>	<b>Current habitat types</b>
<i>Aloe asperifolia</i> plains	Plains
<i>Arthroerua luebnitziae</i> plains	
<i>Zygophyllum stapfii</i> plains	
Central hills	Hills and mountains
Eastern hills	
<i>Euphorbia virosa</i> belt	
Khan River mountains	
Marble hill	
Marble ridge	
Northern dome	
South-western hills	
Western granite hills	
South-eastern gneiss hills	
Gorges	
Khan River	
Northern tributaries	
Southern tributaries	
Plain drainage lines	Plains + Watercourses
Undulating granite hills	Plains + Hills

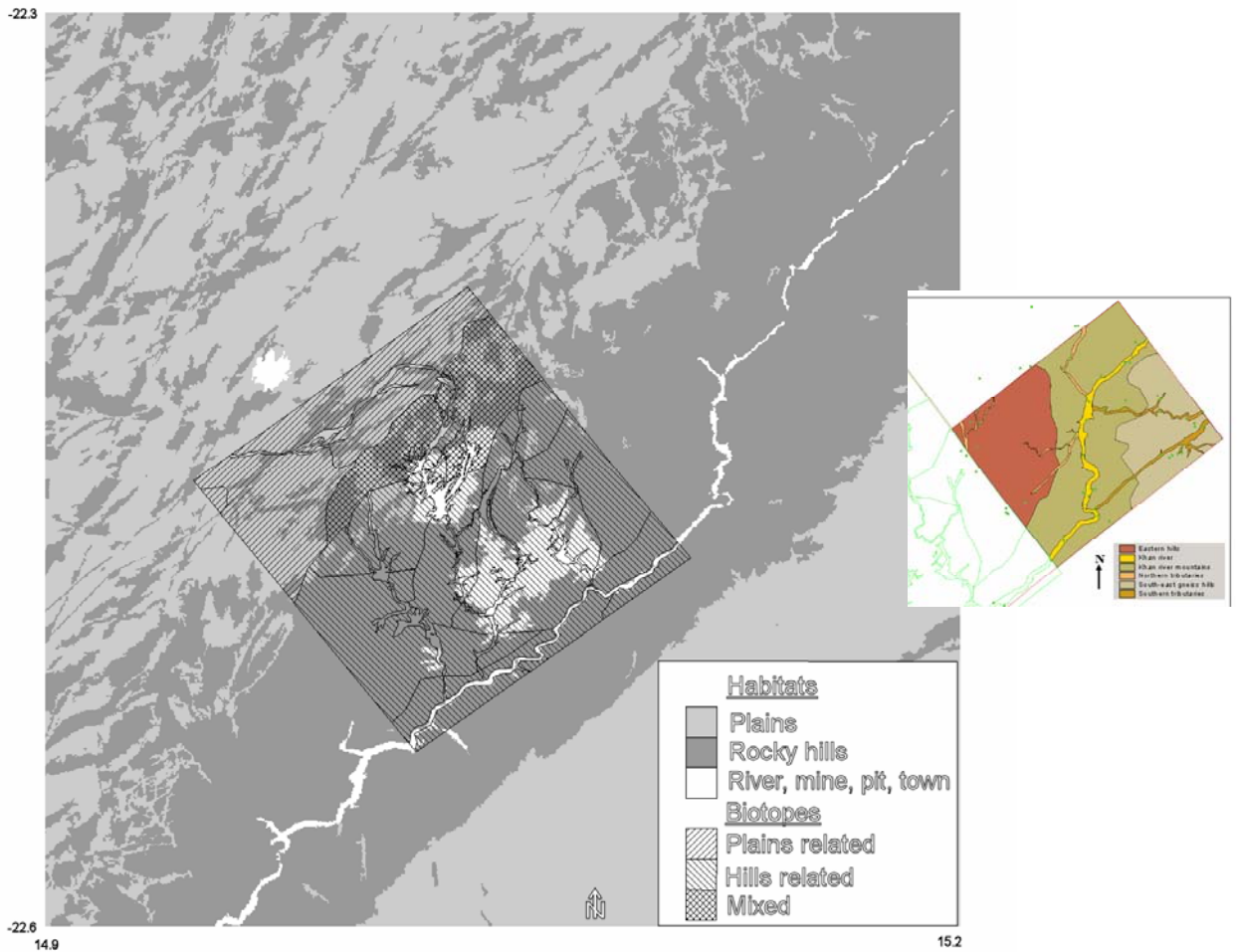


Figure 8. Comparison of habitat types used here with biotopes of Burke (2005, in main map) and Burke (2007, in inset). The inset map lies directly east and adjacent to the shaded biotopes square.

The 1984-1985 and 2007 sampling sites resolve to the following main habitat types (Table 3).

Table 3: Categorisation of the 1984-1985 and 2007 fieldwork sites according to our habitat types.

Group	Sampling site	Habitat type	Notes
1984/85	Arandis Site	Plains	
1984/85	Upper Ostrich Site	Plains	
1984/85	Panner Site	Watercourse	Surrounded by hills
1984/85	Lower Ostrich Site	Watercourse	Surrounded by undulating plains, hills nearby
1984/85	Stockpile Site	Hills	
1984/85	Lower Dome Site	Hills	
2007	SK area	Hills	
2007	SH area	Hills	Adjacent to watercourse
2007	Dome area	Hills	Adjacent to watercourse

### 3.1.2 Categorising the habitat preference for all species

In order to determine the habitat preference of a species, the locations from where the species was recorded were considered. Each location could be assigned to a habitat, and if a species was only or most commonly found at locations that had the same main habitat, that was considered to be its habitat preference. If known from more than one different habitat type, the proportion of individuals recorded from each habitat was considered, and the significantly higher proportion was selected as the habitat preference. In ambiguous cases, practical knowledge of habitat preference as determined during fieldwork was sometimes used to select one or the other type. Still, some taxa do occur in more than one habitat type, and some are widespread over the entire area, and they were listed as such.

The resultant habitat preferences for all species are listed in the species table in Appendix C.

### 3.2 Biodiversity inventory

Lists of species identified from the Rössing area, and their habitat affiliations, are provided in Appendix C. Sources of information for these lists are:

- Unpublished information from the 1980's Rössing environmental survey on file at the National Museum of Namibia, on file at Rössing Uranium Limited, or received from individual scientists that were involved at the time.
- At least 45 scientific papers that have since reported on material collected during the survey.
- Relevant excerpts from the National Museum collection catalogues.
- Database query on the National Herbarium holdings.
- Query on the Namibia Biodiversity Database.
- Results of 2007 animal fieldwork and 2004-2007 plant fieldwork
- Consultation with Mike Griffin, MET expert on small mammals and reptiles.

### **3.2.1 Biological soil crusts**

Biological soil crusts (BSCs) observed in the three study areas was exclusively hypolithic (below stones), mostly associated with quartz or quartzite stones. BSC was in general most abundant on the scree and bedrock areas (rocky hillsides) and was reduced in the watercourses. The overall occurrence of BSC was relatively infrequent compared to other undisturbed areas in the mid-zone of the Namib (e.g. north of Arandis and Aussinanis area near Gobabeb). The occurrence of BSC at the current Rössing sites was comparable to the frequency seen on gravel road banks. At Aussinanis (near Gobabeb), BSC increased with distance from a rarely-used gravel road (Aiyambo 2007), possibly correlating with a decrease in dust with distance.

The occurrence of lichen was negligible, and with our method of observation we also did not detect any epilithic BSC (on top of soil and stones) except for occasional perolithic BSC that extended for a short distance laterally from stones. Overall, the environment below stones appeared to be the only viable place for BSC to occur. BSC is therefore considered to be present in a somewhat reduced form compared to its occurrence in other nearby Namib habitats. A reduction in BSC could reduce the productivity of these desert habitats, as BSC is known to be very active in fixing and remobilising carbon and nitrogen in desert soils (Belnap 2001; Evans & Lange 2001).

Fine layers of dust caked many of the rocks and stones and sealed some of their lower extremities at the base. This would probably reduce the natural flow of condensed moisture to the hypolithic environment, resulting in drier microclimates. If this is the case, it could explain a reduction in the occurrence of hypolithic BSC. The extremely fine nature of the caked dust particles could possibly also affect the epilithic condition and explain the absence of epilithic BSC (the only lichen found occurred underneath rock overhangs without dust caking). This suggestion is offered as explanation for the reduced occurrence of BSC based on casual observations.

### **3.2.2 Plants**

214 species of plants are identified from the Rössing area. Most have not been evaluated for IUCN status and are only categorized according to the three main habitat categories described above. Their levels of endemism are tentatively recorded in Appendix C.

### **3.2.3 Arachnids and other non-insect invertebrates**

#### **3.2.3.1 Arachnids**

##### *Mites and ticks (Acari)*

Tentatively, four species of mites occur at Rössing, but they have been identified only to relatively high levels. Water mites, without further identification, were recorded in

ponds. Ticks, found in pitfall traps after falling from rodents inadvertently collected in the traps, have not been identified.

#### *Spiders (Araneae)*

Seventy-nine species of spiders are recorded from Rössing.

The general impression gained from the frequency of encountering spiders and observing their signs during the 2007 survey, compared to our work at other similar sites, is that overall there appear to be fewer individuals and fewer different taxa here than other comparable areas in the central Namib. This may indicate that the sites could already be somewhat depauperate. This impression is, however, qualified due to the very limited scope of the 2007 survey. Nevertheless, the array of different taxa at each location does indicate that SK and SH still have relatively good representation of this group of predators.

By comparison, the Dome area has severely reduced spider diversity and abundance. Near our Dome site, but in a different habitat, is the type locality (and only known occurrence, in 1984) of the trap-door spider *Moggridgea eremicola* (Migidae, Griswold 1987). This species is listed as Critically Endangered, and it is not known whether it still persists in this area. The general reduction of all arachnids at this site raises concern.

There is potential conservation concern of several of the observed spiders (e.g. one of the huntsmen and termite-eating spiders). Given that several other species with even higher conservation status were not recorded during the short 2007 survey, and the apparent suitability of the site for these species, it is highly recommended that further studies be conducted to confirm the status of spiders in the area.

#### *Scorpions (Scorpionida)*

Fourteen species of scorpions are recorded from Rössing. Given the limited amount of effort that has been devoted to assessing scorpions, it is not possible to make conclusions on their status.

#### *Sun-spiders or camel-spiders (Solifugae)*

Twenty-two species of solifuges are recorded from Rössing.

Solifuges are known to be diverse and fairly common in the central Namib, a world hotspot of solifuge diversity (Lawrence 1963; Wharton 1981; Griffin 1990, 1998). However, the 2007 survey revealed only one individual in the nine days of fieldwork. According to our previous experience in other nearby areas, this absence of solifuges is exceptional. This could be a seasonal effect, but solifuges were not even found below many hundreds of rocks that were examined. Further work will be required to establish the status of these predators at Rössing.

#### **3.2.3.2 Snails (Molluscs)**

Aquatic snails are only mentioned in the limnological notes, without any identifications.

During the 2007 work on soil crusts we incidentally found three shells of snails (no live animals) of different species under rocks at SK and Dome. None have been identified. Their presence indicates that these environments supported mollusks and perhaps still do, but this needs to be established with further studies. Snails are known to occur under stones in rocky habitats of the Central Namib in association with biological soil crusts (Seely 1987; Hodgson et al. 1994). The potential significance of these findings is that it indicates that populations of highly moisture-dependent organisms have the ability to survive at Rössing.

### **3.2.3.3 *Centipedes and millipedes (Myriapods)***

Three species of centipedes and one millipede represent this group at Rössing.

### **3.2.3.4 *Crustaceans***

Seed shrimps and mussel shrimps, without identifications, are recorded from Rössing waterbodies.

## **3.2.4 Insects**

Two hundred and seventy-one species of insects are recorded from Rössing. These cover ground-living species and some winged species that were accidentally collected in pitfall traps. Certain winged groups such as moths and butterflies (Lepidoptera) and lacewings (Neuroptera) remain largely unknown for this area on account of this sampling bias, but handcollecting and the specialized treatment that specimens need, were not possible in either of the surveys.

## **3.2.5 Amphibians and reptiles**

Three species of frogs are known to occur or are expected from the Rössing area.

Reptile diversity is high in the Namib Desert and the central Namib in particular has a surprisingly high diversity of lizards, especially geckos. The State Museum work, together with more recent literature (Griffin 2002 and Griffin 2007, pers. comm.), lists a total of 33 lizard species recorded or having a high probability of occurrence in the Rössing area. This comprises 15 Geckos, 2 Agamas, the Namaqua Chameleon, 7 Skinks, 7 Sand Lizards and one Plated Lizard. Of these 33 species, 8 are endemic to the Namib and one, the Husab Sand Lizard, has a distribution range that is restricted to the mountainous Rössing-Husab area.

During the initial phases of this assessment, concern was expressed about *Pedioplanis husabensis*, the Husab Sand Lizard, a range-restricted endemic from the Rössing area. Further investigation has shown that the species has an extent of occurrence of ca. 7800 km<sup>2</sup> (Griffin 2007, pers. comm.) and has been recorded from at least 47 locations in this

small area (Berger-Dell'Mour & Mayer, 1989), which by itself should evaluate to a non-Threatened status. However, the official status is 'Data Deficient' (Griffin 2007, pers. comm.). The reason for this is that the potential effect of uranium mining on the species is not yet known. The currently operational Rössing and Langer Heinrich Mines, as well as the proposed Valencia, Husab and Goanikontes Mines, in combination affect the entire distribution range of the species. This is a case that strongly argues for the central Namib uranium mining industry players to confront environmental issues collectively rather than individually: while mining at any particular site (e.g. SK4) may not have a particularly severe effect on overall *Pedioplanis husabensis* populations, the same cannot be said for the combined effect of mining at an increasing number of adjacent sites.

A further species of *Meroles* is newly described from work done outside of this study, and is categorized as Not Evaluated. On the basis of the precautionary principle it is classified as Threatened – Data Deficient.

With the exception of the latter species and the Husab Sand Lizard, all the above lizard species are categorized as Least Concern (Griffin 2007, pers. comm.). Apart from lizards, one other reptile is red-listed, namely Leopard Tortoise (Vulnerable). Occurrence of Leopard Tortoise in the Rössing area is possible but very unlikely, as this species generally prefers moister habitats. It might very rarely be found in the Khan River.

### **3.2.6 Birds**

The Rössing bird list records high diversity for an area this barren, largely due to the influence of the Khan and its tributaries as linear oases (Stacey 2007). There are no birds found in the area which are restricted to the area or threatened by the mine expansion. Two raptor species – Martial Eagle and Lesser Kestrel - carry IUCN Threatened status and another – Verreaux's Eagle – is Near-Threatened, but their populations are scattered over southern Africa, and the mine expansion will not significantly increase the factors causing their decline.

One species, Karoo Eremomela, has some taxonomic uncertainty as the central Namib population may be sufficiently genetically distinct to warrant sub-species or full species status. This is now being investigated with the assistance of local birder Mark Boorman and ornithology experts based in South Africa. Initial indications are that, even if the population is genetically distinct, it is distributed over an area exceeding 20,000 km<sup>2</sup>, in which its preferred habitat of thinly vegetated watercourses is abundant.

### **3.2.7 Mammals**

The mammals list shows medium diversity – 43 species – which is typical for the central Namib. While larger mammals such as kudu and baboon are conspicuous and quickly recognized by lay people, the mammal list includes 6 hoofed mammals, 9 carnivores, 11 bat species and 16 small terrestrial mammals including rodents and one each of shrew,



sengi (elephant shrew), hare, dassie and hedgehog. Many of these, particularly the carnivores, are naturally uncommon to rare, while a few others, such as hedgehog and fruitbats, are likely to occur only very rarely as vagrants linked to the Khan River linear oasis.

Eight of the mammal species are classified as Near-Threatened, one as Vulnerable and one as Endangered. The latter, Namibian Mountain Zebra, is confined to the Namib Desert. African Wild Cat, the Vulnerable species, is threatened most by hybridization with domestic cats. The latter are likely to occur in and around the Rössing buildings, but the existence or threat posed by feral cats at Rössing has not been assessed. The threat is probably low.

### **3.3 Vulnerability and endemism of taxa**

#### **3.3.1 Categorisation of taxa using IUCN guidelines**

The Terms of Reference require that all species occurring in the Rössing area be ranked for vulnerability by IUCN category. The IUCN (International Union for the Conservation of Nature) maintains global Red List data. It defines Red List categories, as well as the evaluation criteria to be followed before red listing a species (IUCN 2000, 2005).

Formal IUCN categorisation is not available for most Namibian animals. Only mammals (Griffin & Coetzee 2006) and some endemic plants (not all plants, or even all endemic plants) (Loots 2005) have been formally evaluated using the latest IUCN criteria and published. Reptile categorization has been done but is not published (Griffin 2007, pers. comm.). No evaluations are available for Namibian invertebrates, or, strangely enough, birds (excepting those few species occurring in Namibia that have been evaluated on a global level).

Categorisation of the invertebrates in particular, but of all taxa, is hampered by the low level of collecting and biodiversity sampling that has been done in the study area and surrounds. As a worst-case example, some taxa are known only from one specimen that was trapped during the 1980s work. With such specimens, on the basis of the precautionary principle, their conservation status must be judged as Critically Endangered, and distribution as being limited to the Rössing area only. Taxa known from three or more specimens at least can render a polygon area of occurrence using the sites where they were sampled. These examples provide a hint of the difficulties encountered in the assessment.

Since the bulk of biodiversity at Rössing is concentrated in the invertebrates, IUCN categorisation criteria had to be newly applied to arrive at vulnerability categories for those taxa not yet formally evaluated. A full explanation of the calculation of vulnerability and endemism using limited data is provided in Appendix E.

Table 4 shows those animal taxa categorized as Threatened (Critically Endangered, Endangered and Vulnerable), derived from the 1980s State Museum survey and the 2007 fieldwork. Information is drawn from data presented in Appendix C. No plants are sufficiently threatened to be included in the table (Loots 2005). Only one plant species – *Adenia pechuelii* – is classified as Near-Threatened, but it has a wide range in the Namib Desert and escarpment (Curtis & Mannheimer 2005).

Table 4: Threatened taxa occurring in the Rössing area.

IUCN statuses: CR = Critically Endangered;  
 EN = Endangered;  
 VU = Vulnerable.

EOO = extent of occurrence

NOL = number of locations where collected

Habitats: RH = Rocky hillsides;  
 OP = open plains;  
 WC = watercourses

Endemism: RA = Rössing area only;  
 CN = Central Namib Desert (ca. Kuiseb - Ugab);  
 CW = Central Western Namibia;  
 ND = Namib Desert (Orange - Kunene);  
 NA = Namibia;  
 empty cell = Widespread (not endemic to Namibia)

Common name	Genus, species	IUCN stat.	EOO (km <sup>2</sup> )	NOL	Habitat			Endemism
Tingle trapdoor spider	<i>Moggridgea eremicola</i>	CR	-	1	RH			RA
Velvet spider	<i>Seothyra anettae</i>	CR	-	1		OP		RA
Ant spider	<i>Cyrioctea namibiensis</i>	CR	-	1		OP		RA
Bee fly	<i>Pteraulacodes hessei</i>	CR	-	1		OP		RA
Sun spider	<i>Daesiella pluridens</i>	CR	-	1		OP		RA
Ant spider	<i>Caesetius sp. nov.</i>	CR	-	1			WC	RA
Flower beetle	<i>Hedybius irishi</i>	CR	-	1			WC	RA
Bee fly	<i>Heterotropus apertus</i>	CR	-	2		OP		RA
Prodidomid spider	<i>Namundra griffinae</i>	EN	-	2	RH			RA
Sun spider	<i>Blossia sp. Nov. A</i>	EN	-	2	RH			RA
Sand wasp	<i>Namiscophus pilosus</i>	EN	-	2		OP		CN
Sun spider	<i>Blossia sp. Nov. B</i>	EN	-	2			WC	RA
Flower beetle	<i>Metaphilehedonus swakopmundensis</i>	EN	5	3	RH		WC	RA
Ant spider	<i>Heradida griffinae</i>	EN	11	3	RH	OP	WC	RA
Silverfish	<i>Ctenolepisma sp. nov. nr. Pauliani</i>	EN	11	3		OP	WC	RA
Sun spider	<i>Lawrencega sp. nov.</i>	EN	12	5	RH			RA
Jewel beetle	<i>Nothomorhoides irishi</i>	EN	13	3		OP		RA
Jumping plant louse	<i>Crastina swakopensis</i>	EN	27	3			WC	CN
Blisters beetle	<i>Iselma deserticola</i>	EN	41	3	RH	OP		RA
Ant spider	<i>Diores Namibia</i>	EN	1084	3			WC	CW
Jumping plant louse	<i>Colposcencia australis</i>	EN	1336	4			WC	CN

Common name	Genus, species	IUCN stat.	EOO (km <sup>2</sup> )	NOL	Habitat			Endemism
Jumping plant louse	<i>Colposcения namibiensis</i>	EN	1336	4			WC	CN
Bee fly	<i>Parisus damarensis</i>	EN	1366	4		OP		CW
Sun spider	<i>Blossia planicursor</i>	EN	1609	5		OP		CN
Sun spider	<i>Hexisopus moiseli</i>	EN	1689	3			WC	CW
Centipede	<i>Cormocephalus pontifex</i>	EN	2127	3	RH	OP		CN
Toktokkie	<i>Horatoma deserticola</i>	EN	2347	3		OP		CN
Toktokkie	<i>Zophosis (Carpiella) latisterna</i>	EN	2776	5		OP		CN
Sun spider	<i>Lawrencega longitarsis</i>	EN	3895	5		OP		CN
Martial Eagle	<i>Polemaetus bellicosus</i>	EN						
Namibian Mountain Zebra	<i>Equus zebra</i>	EN			RH	OP		ND
Silverfish	<i>Ctenolepisma occidentalis</i>	VU	151	6		OP	WC	RA
Toktokkie	<i>Zophosis (Gyrosis) ornatipennis</i>	VU	357	9		OP	WC	CN
Sun spider	<i>Trichotoma michaelsoni</i>	VU	790	6		OP		ND
Scorpion	<i>Uroplectes pilosus</i>	VU	1003	6	RH	OP	WC	CN
Sun spider	<i>Lawrencega solaris</i>	VU	2824	6		OP		CN
Sun spider	<i>Lawrencega minuta</i>	VU	4754	6		OP		CN
Toktokkie	<i>Pachynoteles punctipennis</i>	VU	6228	6		OP	WC	CW
Scorpion	<i>Parabuthus namibensis</i>	VU	7653	7		OP	WC	CN
Sun spider	<i>Blossia rooica</i>	VU	7998	5	RH	OP	WC	CW
Scorpion	<i>Opisthophthalmus coetzeei</i>	VU	8581	9	RH	OP		CW
Jewel beetle	<i>Acmaeodera liessnerae</i>	VU	9411	5		OP	WC	CW
Sand wasp	<i>Miscophus sabulosus</i>	VU	13281	5				CN
Snout beetle	<i>Hyomora porcella</i>	VU	18592	8		OP		CN
Leopard Tortoise	<i>Geochelone pardalis</i>	VU					WC	
Lesser Kestrel	<i>Falco naumanni</i>	VU						
African Wild Cat	<i>Felis lybica</i>	VU					WC	

### 3.3.2 Priority classification

The two criteria of endemism (equated to irreplaceability in the Terms of Reference) and conservation status (equated to threat) can be combined to give an overall priority classification, from critical to minor, for all taxa. This is shown in Table 5, for only the taxa listed in Table 4. All other taxa are classified by this process as minor priority.

Table 5. Numbers of threatened taxa and their levels of endemism. CR = Critically Endangered; EN = Endangered; VU = Vulnerable.

<b>Vulnerability</b>	CR	EN	VU	Total
<b>Endemism</b>				
Endemic to Rössing area	Critical 8	Critical 9	Critical 1	18
Endemic to Central Namib	Critical 0	Essential 9	Major 7	16
Endemic to Central Western Namibia	Essential 0	Major 3	Medium 4	7
Endemic to Namib Desert within Namibia	Major 0	Medium 1	Significant 1	2
Endemic to geopolitical Namibia	Medium 0	Significant 0	Minor 0	0
Widespread	0	1	3	4
Total	8	23	16	47

Species in the upper left hand side of the matrix – those scoring critical, essential, major and medium priority – constitute our working list of key species of conservation concern. Those taxa in the lower right hand side of the matrix, scoring significant and minor priority – there is only one species, *Trichotoma michaelsoni* – are not regarded as taxa of conservation concern.

By this scoring process, the Husab Sand Lizard and the new species of *Meroles* sand lizard do not evaluate to being priority species. However, intuition and the precautionary principle dictate that these should be included. They are listed below as high undefined priority species (Table 6), together with all the taxa of key conservation concern.

Table 6: Names and preferred habitats of high priority taxa. RH = rocky hillsides, OP = open plains, WC = watercourses.

Priority level	Taxa	Habitat		
Critical priority	<i>Moggridgea eremicola</i>	RH		
	<i>Seothyra anettae</i>		OP	
	<i>Cyrioctea namibiensis</i>		OP	
	<i>Pteraulacodes hessei</i>		OP	
	<i>Daesiella pluridens</i>		OP	
	<i>Caesetius sp. nov.</i>			WC
	<i>Hedybius irishi</i>			WC
	<i>Heterotropus apertus</i>		OP	
	<i>Namundra griffinae</i>	RH		
	<i>Blossia sp. nov. A</i>	RH		
	<i>Blossia sp. nov. B</i>			WC
	<i>Metaphilehedonus swakopmundensis</i>	RH		WC
	<i>Heradida griffinae</i>	RH	OP	WC
	<i>Ctenolepisma sp. nov. nr. Pauliani</i>		OP	WC
	<i>Lawrencega sp. nov.</i>	RH		
	<i>Nothomorphoides irishi</i>		OP	
	<i>Iselma deserticola</i>	RH	OP	
<i>Ctenolepisma occidentalis</i>		OP	WC	
Essential priority	<i>Namiscophus pilosus</i>		OP	
	<i>Crastina swakopensis</i>			WC
	<i>Colposcencia australis</i>			WC
	<i>Colposcencia namibiensis</i>			WC
	<i>Blossia planicursor</i>		OP	
	<i>Cormocephalus pontifex</i>		OP	
	<i>Horatoma deserticola</i>		OP	
	<i>Zophosis (Carpiella) latisterna</i>		OP	
	<i>Lawrencega longitarsis</i>		OP	
Major priority	<i>Zophosis (Gyrosis) ornatipennis</i>		OP	WC
	<i>Uroplectes pilosus</i>	RH	OP	WC
	<i>Lawrencega solaris</i>		OP	
	<i>Lawrencega minuta</i>		OP	
	<i>Parabuthus namibensis</i>		OP	WC
	<i>Miscophus sabulosus</i>		OP	
	<i>Hyomora porcella</i>		OP	
	<i>Diores Namibia</i>			WC
	<i>Parisus damarensis</i>		OP	
<i>Hexisopus moisei</i>			WC	
Medium priority	<i>Pachynoteles punctipennis</i>		OP	WC
	<i>Blossia rooica</i>	RH	OP	WC
	<i>Opisthophthalmus coetzeei</i>	RH	OP	
	<i>Acmaeodera liessnerae</i>		OP	WC
	<i>Equus zebra</i>	RH	OP	
High undetermined priority	<i>Pedioplanis husabensis</i>	RH		
	<i>Meroles sp.nov.</i>			

Our assessment of vulnerability and endemism carries serious implications for the decisions that must be made regarding future mining expansion. The weight of these decisions prompted much discussion and self-evaluation of the methods. A case study of one of the Critical Priority species, the spider *Moggridgea eremicola*, elaborates the logical steps and background information that justify our categorization, and makes suggestions about the next steps that follow. It is presented in full in Appendix E.

### 3.3.3 Habitat preferences of high priority taxa

Table 7 shows the habitat preferences of the high priority taxa. Note that the totals are more than in Table 5 because some species occur in more than one habitat.

Table 7: Habitat preferences of high priority taxa at Rössing.

Habitat	Rocky hillsides	Open Plains	Water-courses
<b>Priority level</b>			
Critical	7	10	7
Essential	0	6	3
Major	1	8	5
Medium	3	5	3
High (undetermined)	1	0	0
Total:	12	30	18

While this information is based on very low sample numbers and therefore carries a low confidence level, it is all that is available.

The open plains are the habitat that supports half of the high priority taxa at Rössing. This habitat extends much further beyond the Rössing area, and is considered to be less likely to hold very range-restricted taxa. Species found in open plain habitat in the central Namib might be restricted by factors such as amount and frequency of fog and or rain, which would put broad east and west limits on their occurrence. North and south limits would be less restrictive. Burke (2005 and 2007) lists only three biotopes that accord to our plains habitat (Table 2), confirming the relative homogeneity of the plains. Where habitats are homogeneous and cover a large area, the likelihood of a species being confined to a small part of that area is very low.

Watercourses support just over a quarter of the high priority taxa at Rössing. These ephemeral river beds act as linear oases, as they have more and bigger plants than the surrounding plains, and provide more plant food to organisms higher up the food chain. The fact that the watercourses are joined with each other and that vegetation in them is similar upstream and downstream indicates that this habitat is also relatively widespread

and homogeneous. By the same argument used for open plains, we consider the likelihood of a species being confined to a small segment of a watercourse very low.

Rocky hillsides and steep terrain make a habitat that is relatively confined in this part of the central Namib (Figure 9). The outline of this habitat in Figure 9 encloses an area of 850 km<sup>2</sup>. A small terrestrial animal that lives in this area and requires a rocky habitat has only so much area to spread in to.

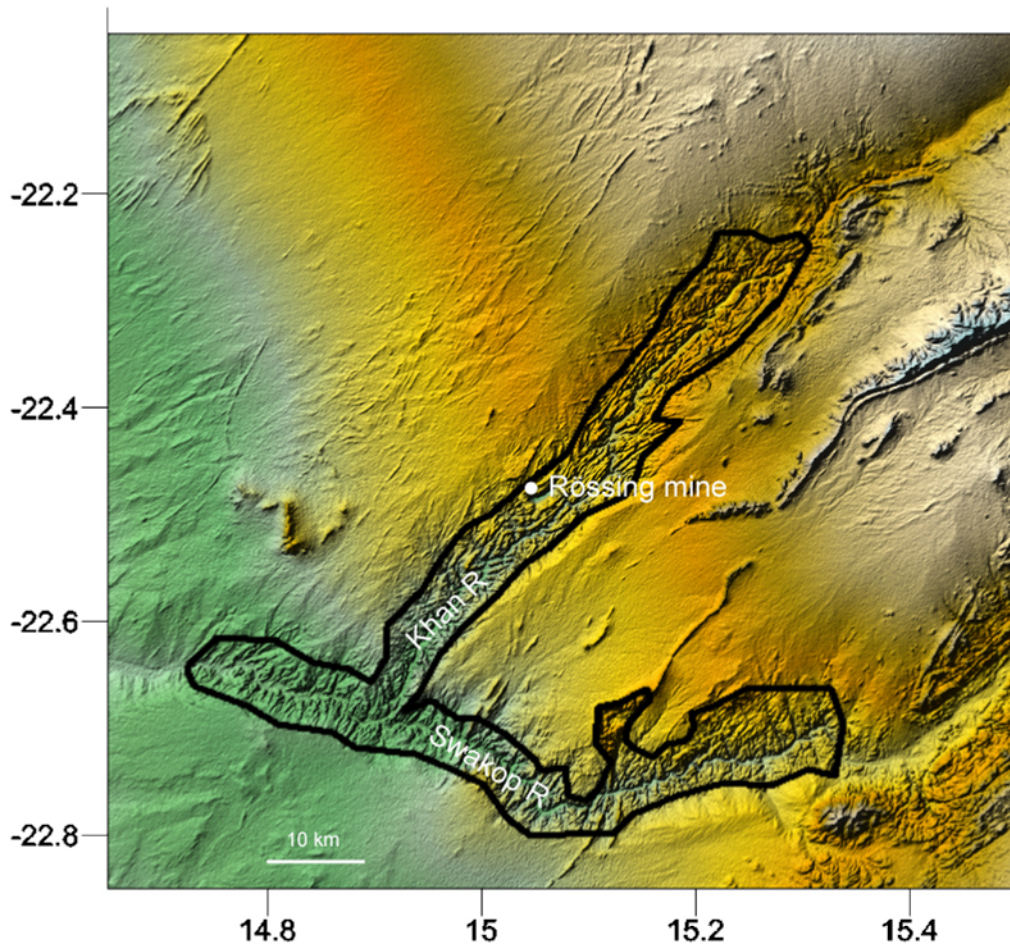


Figure 9: Satellite view of the Rössing mine area showing extent of the rocky hillside habitat associated with the dissected terrain of the Khan and Swakop Rivers.

Rocky habitats have much greater diversity of microhabitats than the plains, provided by slopes of different angles and attitudes, varying amounts of runoff from fog and rain, varying penetration of moisture, exposure to winds of different intensity and frequency, and more varied plant life. The greater number of biotopes listed by Burke (2005 and 2007) that occur on rocky and steep terrain (Table 2) reflects the diversity of habitats. Therefore distribution ranges of taxa preferring rocky habitat are more likely to be smaller and more restricted than distribution ranges of plains and watercourse species.



It must be remembered that ascribing a habitat preference to an animal on the basis of one or just a few specimens carries a very low confidence level. Recognising this, both the higher variety of microhabitats within rocky terrain and the restricted area in which these microhabitats are found, imply that the high priority taxa occurring in rocky terrain at Rössing are more likely to be range restricted. Therefore, to minimize serious negative impacts on biodiversity in the Rössing area, rocky hillsides are the habitat that should be the least disturbed.

### 3.3.4 Ranking of Burke's biotopes

Burke (2005 and 2007) follows a different method to arrive at a ranking of the identified biotopes that goes from critical to rare and then general. The ranking is based on the presence of selected indicator species that are red-listed (according to IUCN criteria, as shown in Appendix C) and that have designated levels of endemism. Based on the scores from the indicator plants, five biotopes emerge as critical (Table 8), four as rare and ten as general.

Table 8: Ranking of Burke's biotopes (2007) according to the scores of selected indicator plant species.

<b>Biotope</b>	<b>Assignment according to Burke</b>
Central hills	Critical
Eastern hills	Critical
<i>Euphorbia virosa</i> belt	Critical
Undulating granite hills	Critical
Western granite hills	Critical
Gorges	Rare
Khan River mountains	Rare
South-eastern gneiss hills	Rare
South-western hills	Rare
Khan River	General
Marble hill	General
Marble ridge	General
Northern dome	General
Plain drainage lines	General
<i>Aloe asperifolia</i> plains	General
<i>Arthroerua luebnitziae</i> plains	General
<i>Zygophyllum stapfii</i> plains	General
Northern tributaries	General
Southern tributaries	General

Significantly, all five of the critical biotopes are found in rocky habitat. This confirms our finding that rocky hillsides deserve the greatest protection from disturbance.

## **4. Summary and conclusions**

### **4.1 Summary of habitat and biodiversity information**

Biodiversity assessments made in 1984-1985 and in 2007, as well as other projects focusing on particular taxa, have produced a wealth of information on the plant and animal biodiversity occurring in the Rössing area. Rössing Uranium Limited deserves credit for initiating and supporting this important baseline environmental research.

This work stands out as a small focus of a lot of information in the wider area of the central Namib that is generally very poorly known in terms of biodiversity. Thus there are many species and unnamed or undescribed taxa that have been found in the Rössing surveys, and that are known only from those one or few localities. This apparent high level of endemism might be real or it might be from the sampling bias.

#### **4.1.1 Habitats and biotopes**

The habitats in the area are divided into

- (i) rocky hillsides with loose surface rocks and no soil or soil that is very shallow soil, and relatively the least vegetation.
- (ii) open plains with deeper soil and scattered bushes and shrubs. The plains are interrupted with rocky outcrops of varying sizes.
- (iii) watercourses that are normally dry but that carry water for very short periods during the rainy season. The watercourses are marked by having more bushes and scattered trees along their length, and the substrate is usually sandy and uncompacted.

The biotopes identified and mapped by Burke (2007) form subsets of these broad habitat types. The animal biodiversity data does not carry detailed habitat descriptions for each of the specimens, thus our understanding of each species' preferred habitat is at the level of broad habitat types, not biotopes.

#### **4.1.2 Biodiversity**

The biodiversity inventory can be summarized as follows:

Biological soil crusts, comprising lichens, micro-fungi, algae and blue-green algae (cyanobacteria) are present in a somewhat reduced form compared to their occurrence in other nearby Namib habitats. Lichens are largely absent, while hypolithic organisms (the green or black coating found underneath translucent quartz stones) are more abundant but relatively reduced. This is tentatively explained as a result of fine layers of dust coating rocks and stones and reducing the natural flow of condensed moisture to the hypolithic environment, resulting in drier microclimates.

Two plant species growing in the Rössing area are of concern. The charismatic ‘elephant’s foot’ *Adenia pechuelli*, occurs in relatively high concentrations on rocky hillsides here, whereas it is found more widely scattered and as isolated individuals elsewhere. It is classified as Near-Threatened and has a wide distribution in the Namib and escarpment. *Lithops ruschiorum* is listed as ‘Least Concern’ but it has a very restricted range and is sought after by collectors. Rössing possibly has the largest population of this plant ever recorded.

Spiders, scorpions and solifuges constitute a group of predators of smaller invertebrates that can give an indication of the state of populations of their prey. Recognising the shortcomings of the 2007 biodiversity fieldwork, preliminary indications are that the abundance and diversity of spiders is relatively lower than expected, and of solifuges is exceptionally low. The latter is particularly surprising given that the central Namib is known as a world hotspot of solifuge diversity. Seven taxa of the spiders, and 11 taxa of the solifuges, are classified as Threatened. It is not possible to draw conclusions on the status of scorpions, besides the fact that 14 species are known from the area, of which three are Threatened. Further work is required to establish whether arachnid populations are indeed diminished in and near the Rössing operations, and whether mining activities are responsible.

271 species of ground-living insects are recorded from Rössing, and this excludes flying groups such moths and lacewings. 20 species are Threatened.

Three species of frogs are known to occur or are expected from the Rössing area. None are Threatened.

Reptile diversity is high in the Namib Desert and the central Namib in particular has a surprisingly high diversity of lizards, especially geckos. 33 reptile species are known or expected to occur in the Rössing area. Of these, one (a tortoise) is classified as Threatened but it prefers moister habitat and its occurrence in the area is very marginal. The Husab Sand Lizard is classified as Data Deficient as its population in the relatively small area of occurrence – rocky terrain in the area of the lower Khan and Swakop Rivers – is not well known, yet faces fragmentation and disturbance from proposed mining operations. Another recently discovered species of Sand Lizard, also known only from the area immediately inland of Swakopmund, has not yet been evaluated for its conservation status, so by the precautionary principle is also classified as Threatened.

Birdlife in the Rössing area reaches relatively high diversity for an area this barren, largely due to the influence of the Khan and other smaller linear oases. While two species are classified as Threatened, there are no birds found in the area which are restricted to the area or threatened by the mine expansion.

Mammal diversity at Rössing is not very high, as is typical in the central Namib. The list includes two Threatened species. Mine expansion will probably incrementally increase the threats that face them, namely increased habitat fragmentation and expanded area of human influence and disturbance.

### 4.1.3 Taxa of high priority

Combining the criteria of IUCN status and the degree of endemism of taxa provides a way to score the priority that Rössing should accord to individual taxa. By this process, 44 taxa are scored as high priority – critical, essential, major, medium and undetermined. A breakdown of these taxa using common names of animal groups is shown in Table 9. No plants are sufficiently threatened or range-restricted to warrant inclusion in this list.

Table 9: Breakdown of the taxa of high priority in the Rössing area.

Priority level	Number of taxa	Taxa
Critical	18	Spiders – 6 Solifuges – 4 Beetles – 4 Silverfish – 2 Flies – 2
Essential	9	Solifuge – 2 Centipede – 1 Beetles – 2 Plant louses – 3 Wasp – 1
Major	10	Spider – 1 Solifuges – 3 Scorpions – 2 Beetles – 2 Wasp – 1 Fly – 1
Medium	5	Solifuge – 1 Scorpion – 1 Beetles – 2 Hoofed mammal – 1
Undetermined but high	2	Lizards – 2
Significant	1	Solifuge – 1
Minor	All other taxa	

#### 4.1.4 Habitat preferences of taxa of high priority

Five of the 19 biotopes identified in the Rössing area are ranked as critical. All five are found in rocky habitats.

The open plains are the habitat that supports half of the high priority taxa at Rössing. Watercourses support just over a quarter of the high priority taxa, and rocky hillsides just less than a quarter.

Compared to rocky hillsides, open plains and watercourse habitats are more widespread and more homogeneous. This is not the case with rocky terrain, which occupies a relatively small area - 850 km<sup>2</sup> of continuous habitat in the lower Khan and Swakop River gorges and linked with Husab Mountain. From the perspective of biodiversity, rocky hillsides are the habitat that should be the least disturbed. Avoidable disturbance in any of the three habitats should be minimized, since they all support taxa of high priority.

## 4.2 Conclusions regarding Rössing mine expansion

### 4.2.1 Impacts of mine expansion

The only component of Phase 1 expansion that has biodiversity impacts is the creation of a new open pit at SK4 and rock dumps in the Dome area. The new acid plant and ore sorter will be situated on ground that is already intensely disturbed, so no further biodiversity impacts are expected there.

SK4, an area of 0.2 km<sup>2</sup>, makes up a small proportion – 6.7% – of the whole SK. Since the habitat of SK4 is similar to the whole SK, direct biodiversity impacts in SK4 will be proportionally reduced in extent. The direct impact of eradication of animals is dealt with under Impact 1 below.

An indirect impact on biodiversity, namely the effect of dust on invertebrates and on productivity of plants, is dealt with under Impact 2.

#### 4.2.1.1 Eradication and/or extinction of highly endemic animals

<b>Impact 1</b> Eradication and/or extinction of animals occurring in SK and proposed rock dump sites in Dome area.
<b>Significance</b> This impact is highly significant as it carries the possibility of the project being fatally flawed by the fact that some species may become extinct from mine expansion.
<b>Nature of the impact</b>

Opening a new mining pit in SK, and covering a new area in Dome with rock debris, will decrease the known area of occurrence, the quality of rocky hillside habitat and the population size of many animal species. 44 known taxa are assigned as High Priority on the basis of their conservation status and area of occurrence. Very little is known about these taxa, but 18 of them are known from the Rössing area only. Of these, seven taxa are understood to live in rocky habitat.

**Extent of the impact**

Direct disturbance to the animals will occur in the mined area, the rock dumps and in the road and power servitude leading from existing facilities. In these areas, habitat will be completely destroyed. We believe that effects of blasting and noise decrease very rapidly away from the sites of direct disturbance. Dispersal of dust will be more widespread, but probably confined within a radius of 5 km from the mining activity.

This EIA is concerned only with the Rössing expansion, but cumulative impacts from similar developments must also be considered. Phase 1, involving SK4 only, directly affects an area of 0.2 km<sup>2</sup>. Further expansion of Rössing in subsequent phases will directly impact an additional 6 km<sup>2</sup>. Establishment of mines similar to Rössing at Valencia and Goanikontes within the next 5 – 10 years, will destroy greater areas and further fragment the rocky hillside habitat.

**Duration of the impact**

Permanent.

**Intensity of the impact**

The severity of the impact is difficult to assess. Seven species are listed in Table 4 as Threatened and occurring on rocky habitat in the Rössing area only. They are:

Tingle trapdoor spider	<i>Moggridgea eremicola</i>
Prodidomid spider	<i>Namundra griffinae</i>
Sun spider 1	<i>Blossia sp</i>
Sun spider 2	<i>Lawrencega sp</i>
Blister beetle	<i>Iselma deserticola</i>
Ant spider	<i>Heredida griffinae</i> (also on plains and watercourses)
Flower beetle	<i>Metaphilehedonus swakopmundensis</i> (also in watercourses)

So little is known about these animals that their role in the ecosystem is not known. The case study of the spider *Moggridgea* (Appendix E) indicates that, because of its rarity, it is not likely to be a 'keystone' species i.e. not one on which many others depend or which fills a critical niche in the ecosystem. (Animals which are vital to pollination of certain plants [e.g. wasps, bees], or which play a big role in cycling nutrients back into the soil [e.g. termites], are considered as keystone species.) While we cannot be certain, it is likely that the other six taxa, also known to be very rare, are not key components in the ecosystem. Caution in this prediction is deserved as examples are known of species whose importance has been realized after their extinction (e.g. the case of the seeds of a certain tree eaten by dodos, and no longer establishing young plants as the seeds no

longer pass through dodo guts (Gould 1980).

As an educated guess, eradication of a few species which are naturally rare in an arid ecosystem that naturally has very low productivity, will have a low to medium impact i.e. the environment will be altered but the ecosystem will continue to function, possibly in a modified manner.

While our prediction is a low to medium impact, the combination of Rössing expansion with other mines in the area will exacerbate the impact. It is impossible to predict how much it will be exacerbated.

#### **Probability of the impact**

SK and Dome constitute rocky hillside habitat. By our assessment, the total extent of this habitat in and around Rössing is 850 km<sup>2</sup>. The total area of direct disturbance to this habitat is 6 km<sup>2</sup>. As a direct proportion, the disturbed area is therefore less than 1% of this habitat.

Open plains and watercourse habitats cover a larger area in and around Rössing, so if there is any direct disturbance in them, it will be a smaller proportion than that of rocky hillsides.

The likelihood of causing any extinction from mining in SK and expanding rock dumps in Dome, is therefore very low.

#### **Degree of confidence in predictions**

The severe shortage of information leaves us with very little confidence in our predictions. This translates to the need for greater caution in our recommendations, as our judgements become based on worst case scenarios.

#### **Possibilities for mitigation**

Nothing can be done to reduce the severity of destroying an area by open pit mining or permanently covering it in rock debris. Infrastructures associated with the mining should be sited on lower-priority habitat, namely plains.

#### **4.2.1.2 Dust accumulation**

Indications from the 2007 fieldwork were that biological soil crust activity was reduced, and spider and solifuge populations were less than expected. While still inconclusive, these results might be early indications of habitat deterioration caused by Rössing mining activities, outside of the area of direct disturbance.

#### **Impact 2**

Increased area of accumulation of dust around the mining operations, which may reduce the productivity of plants, and reduce the abundance and diversity of soil crust organisms

and small invertebrates.
<p><b>Significance</b>  Medium to low significance. This impact has the potential to lower productivity of the ecosystem by reducing plant growth, reducing the cycling of nutrients through soil crust organisms, and reducing the ability of animals such as spiders and solifuges to survive in the area.</p>
<p><b>Nature of the impact</b>  It is suggested that dust, originating from blasting and earth-moving operations, is blanketing rocks on the soil surface, then during fog events being washed down the sides of stones and sealing the cracks and crevices around the base of stones. The mechanism by which this affects soil crust organisms is not known. For invertebrates such as spiders and solifuges, it possibly reduces their shelter and refuge places.</p>
<p><b>Extent of the impact</b>  Dispersal of dust was not assessed in this study. Sites within 2 km from the present open pit and rock dumps showed this feature. It is estimated that the impact could extend about 5 km away from dust-creating operations.</p>
<p><b>Duration of the impact</b>  During mining operations and for a few years, possibly decades, after the end of dust-creating operations.</p>
<p><b>Intensity of the impact</b>  This impact is indirect and probably low to medium severity. Further work is required to understand whether this is responsible for the low arachnid abundance recorded in 2007.</p>
<p><b>Probability of the impact</b>  Possible. At the present state of understanding, it is impossible to predict whether this impact is likely or unlikely.</p>
<p><b>Degree of confidence in predictions</b>  Dust accumulation is certain, yet its role in influencing invertebrate abundance and diversity is very uncertain. Our confidence in stating this impact is very low, hence the need for further work to assess its validity and importance.</p>
<p><b>Possibilities for mitigation</b>  Greater emphasis on dust suppression, and reduction of dust generation at source.</p>

#### 4.2.2 Confidence of our predictions

##### 4.2.2.1 Quantifying risks with statistically perilous data



Critical parts of this biodiversity assessment are bedeviled by inadequate information. Particularly, the very small sample sizes for some taxa, due to their inherent rarity, make our understanding of their extent of occurrence and habitat preference extremely limited.

The very significant consequence of this shortcoming is that our recommendations must err on the side of caution. As explained in Appendix E, the worst case scenario for the spider *Moggridgea* and the 17 other taxa known only from Rössing, is that the small area centred on the Rössing mine is their only area of occurrence, and their populations are severely threatened by mining operations. The best case scenario is that they occupy similar habitats within a radius of 20 – 40 km and, though they are rare, Rössing's impact on their populations is low. The truth probably lies somewhere between the two.

We have tried to quantify the risks to biodiversity according to areas of occurrence and preferred habitats, both of which are based on sample sizes that are statistically worthless. Practicality demands that our biodiversity and ecological expertise should inform our recommendations in the interest of doing least harm to the natural environment. Using this as a basis, the emphasis changes from concentrating on individual taxa, to the functioning of the ecosystem as a whole.

The information from the 1984-1985 and 2007 studies does show which taxa are common and which are rare. In terms of ecosystem functioning, the ones that are very rare are less likely to be 'keystone species'. Thus we can be reasonably confident that ecosystem functioning will be maintained even if slightly altered or deteriorated by the proposed Rössing expansions.

#### ***4.2.2.2 Strengths and weaknesses of preliminary field observations***

The tight schedule for this biodiversity assessment did not allow the second round of animal collecting in 2007 to be done in an appropriate season or over a more productive length of time. Yet observations were made and possible causes of worrying signs have been suggested. How worthy are they?

Preliminary indications of the impacts of dust from the 2007 fieldwork are exactly that – only preliminary, not well verified, and only indications, not proof. Yet the observations were made conscientiously and with scientific rigour, so deserve proper consideration. The suggestions for further biodiversity and ecological work at Rössing will help to assess whether the indications are borne out, and whether possibly unexpected impacts will be identified. If they are, they can contribute to improved environmental management of the mining activities.

#### **4.2.3 Options for mitigation**

Options for mitigation of the proposed mine expansion activities are severely limited.

#### ***4.2.3.1 Minimise the new footprint***

As a critical biotope will be directly affected by the planned mine extension, reducing the footprint of the expansion to a minimum is mandatory. This will require clearly demarcated access routes and stringently enforced track discipline. All work areas need to be clearly demarcated and sign-posted. Any movements outside these marked areas will require special permission involving Rössing's environmental staff. Further, waste and pollution management, water and energy usage will need to follow established procedures.

#### ***4.2.3.2 Translocation of plants***

The area ear-marked for mining harbours several large *Adenia pechuelii* plants, some of which may be directly affected by the future mine extension. As these are charismatic species of high conservation importance, transplanting trials would be a very valuable exercise enabling Rössing to demonstrate its commitment to biodiversity conservation. Once the site lay-outs for the extension area are available, affected specimens should be marked and a suitable site selected for a transplant trial. Involvement of the National Botanical Research Institute would be essential to obtain permits and relevant expertise.

While translocation or rescue operations can be worthwhile for plants and some large animals, this option is not practical for small animals such as scorpions or solifuges, especially rare ones. Firstly, capturing small fast moving or very cryptic or very scattered animals is impractical. Once caught, they have to be moved to another area of suitable habitat. Such habitat will already be occupied by other individuals of those species, and the new arrivals will face problems such as territoriality from the residents, inability to find or make adequate shelter, and consequent predation or death from being exposed. A high proportion of the newcomers are likely to die. Even if they do survive immediately, the final population size is closely related to the area of appropriate habitat, and the fact will remain that some of the appropriate habitat has been destroyed, so total population size will decrease proportionally. These are just a few of the obstacles that make translocation of very small animals an impossible or ineffective solution.

### **4.3 Recommendations for further work**

#### **4.3.1 Improve biodiversity data collection**

Although more intensive plant collecting over the past growing seasons have greatly improved overall plant data coverage, most parts of the Rössing extension area have only been surveyed once. Repeated sampling will be necessary, particularly in those mapping units that were only accessed along their margins, such as the Khan River mountains and south-east gneiss hills.

Long-term collecting of animals, especially invertebrates, in particular biotopes will shed more light on the habitat requirements of those species that exist in the Rössing area. As mentioned in Section 3.2.3.1 (arachnid results), questions have been raised about the status of arachnids, particularly solifuges, in the Rössing area. Fieldwork on an ongoing basis, to include rainy seasons and the periods of activity that follow rains, will be beneficial here. This will enable Rössing to better understand and possibly mitigate its negative impacts on arachnids as well as other animals.

The approach to biotope monitoring by Burke (2005 and 2007) is to monitor selected indicator plants. This approach could usefully be applied to animals too. Appropriate animal indicator species, such as solifuges which are readily trappable and hold relatively high positions in the food chain, should be identified and monitored.

At the same time, it must be recognized that more collecting is very likely going to reveal more new species, so the process is likely to answer some questions and open up some more. This is not a reason to avoid doing such work, as all of the information contributes to improved understanding of the central Namib ecosystem, for the benefit of sustainable management.

#### **4.3.2 Evaluate restoration and rehabilitation methods**

Special measures to facilitate the recovery of critical biotopes are required. Rehabilitation practices such as preserving and re-spreading topsoil, seeding and replanting with indigenous species will need to be tested and site-specific protocols developed for particular habitats. Presently very little is known about appropriate practices in this arid environment and setting up trials will be an essential part of Rössing's biodiversity strategy.

With regard to biological soil crusts, it will be useful to retain surface soil layers in areas to be newly disturbed. Experiments could reveal whether this assists restoration rehabilitation of disturbed areas, and could provide practical guidelines on how to most effectively maintain biological soil crusts. As a first lesson, always return BSC-bearing stones to their original place and orientation, so that the organisms are not killed by being dried out.

#### **4.3.3 Specifically evaluate impacts of dust on micro-habitats**

We suggest that dust could have a more profound effect on ecological processes than has been previously recognized. In this regard, it would be useful to monitor physical quantities of dust and its deposition in areas surrounding the mining areas, and associated features such as biological soil crusts, moisture below stones and rocks, and processes associated with them.

#### **4.4 Conclusions regarding Phase I expansion**

Opening up and mining of the SK4 area, expanding rock dumps in Dome and establishment of road and power infrastructure to the new pit, are the components of expansion in Phase I involving extension onto undisturbed land. It is possible, but unlikely, that any of the species recorded at Rössing will be eradicated by these expansions. Since the individuals of the taxa categorized as High Priority are naturally rare, it is unlikely that any of them can be considered 'keystone species', therefore functioning of the ecosystem will continue with little change.

Phase 2 expansion into the remainder of SK and into SH will slightly increase the likelihood of causing any extinctions, and will add to the cumulative impacts of habitat fragmentation and disturbance caused by other quarries and uranium mines in the surroundings. For this reason, further biodiversity sampling work and ecological investigations are urgently needed to improve our understanding of the species that are highlighted as High Priority, and of their ecological roles. Additionally, work on biological soil crusts and apparent scarcity of arachnids will reveal whether there are other features of mining activities at Rössing that require management.

## 5. Glossary

biological soil crust (BSC)	association in different proportions between soil particles and cyanobacteria, actinomycetes, microalgae, microfungi, lichens, mosses and liverworts in the top millimeters of soil surfaces or under translucent stones
black BSC	biological soil crust without active diatoms and green algae, this assumed to be dominated by cyanobacteria
brown BSC	soil-coloured crust adhering to stones/rocks and sometimes lightly bound with filaments that could be microfungal mycelia or filamentous cyanobacteria
green BSC	biological soil crust assumed to be dominated by diatoms / microalgae
cyanobacteria	blue-green algae that grow in crusts, filamentous aggregations or mats
epilithic	on top of stones/rocks
fensteralgen	hypolithic green algae and diatoms found under translucent stones
hypolithic	under stones/rocks
morphospecies	organisms that look alike and are probably the same species
perilithic	near-surface soil area around the base of stones/rocks
voucher specimen	a specimen collected for identification, and representing many other individuals of the same species that are not collected.

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Antje Burke

**More of the same – or new patterns?**

**Biotope assessment at Rössing Uranium  
during an exceptional season**

Final report

October 2011

## Summary

1. An exceptional rainy season in Namibia prompted a re-assessment of Rössing's biodiversity management tool – the biotope assessment – in 2011.
2. Some 21 biotopes were mapped and classified using the conservation status of plant species as indicators.
3. Four, largely hilly and mountainous habitats, were rated as “critical” biotopes: *Euphorbia virosa* belt, undulating granite hills, Khan river mountains and south-east gneiss hills.
4. Due to the exceptional season, species richness in the study area increased from 140 in 2005 to 253 in 2011, making the Rössing licence and accessory works area one of the most comprehensive inventories of flora in the central Namib.
5. Species of conservation importance in the study area increased from initially 24 to now 68 plant species, partly due to the new distribution records, and partly due to inclusion of protected and CITES species.
6. The biotope assessment is a dynamic tool which needs to incorporate new insights in biodiversity management when these become available. A re-assessment some time in the future should, if feasible, strive to also include indicators of ecological functioning.



## Contents

<b>Summary</b>	<b>2</b>
<b>Introduction</b>	<b>5</b>
Background	5
<b>The natural environment</b>	<b>6</b>
Locality and topography	6
Climate	6
Geology	7
Soils and habitats	7
Vegetation	7
<b>The history of biodiversity management at Rössing</b>	<b>8</b>
<b>The biotope method</b>	<b>9</b>
Approach	9
Field survey 2011	10
Data processing in 2011	10
Plant species of conservation importance	10
<b>What has changed? Comparison to previous surveys</b>	<b>13</b>
Biotope boundaries	13
Recorded plant species	13
Change in conservation status	14
Biotope assignments	14
Meeting expectations?	17
The contribution of the Rössing study area to biodiversity in the region	19
<b>Description of biotopes</b>	<b>21</b>
Plains	21
Aloe asperifolia plains	21
Arthroa leubnitziae plains	23
Drainage lines and rivers	25
Gorges	25
Northern tributaries	26
Plain drainage lines	27
Khan river	28
Southern tributaries	29
South-western rivers	29
Hills and mountains	31
Central hills	31
Eastern hills	32
Euphorbia virosa belt	33
Khan river mountains	34

Khan marble ridges	35
Marble hills	36
Marble ridge	36
Northern dome	38
South-east gneiss hills	39
South-western hills	40
Undulating granite hills	41
Western granite hills	42
<b>Conclusions</b>	<b>43</b>
Implications for biodiversity management	43
Strategic	43
Management	43
Research	44
Challenges	44
<b>References</b>	<b>45</b>
Acknowledgements	46
Annex 1	47



# Introduction

## Background

The management of impacts on biodiversity forms part of environmental management and receives a particular status in all Rio Tinto operations (Rio Tinto 2008). In this context Rössing Uranium has adopted the biotope method as a means to measure impacts on biodiversity (Kyläkorpi *et al.* 2005).

Rössing mine is situated in the central Namib Desert – an arid environment with naturally great variation in environmental conditions and associated biodiversity. Although biotopes had been delineated in Rössing's entire licence and accessory works areas over several years, the exceptional rainy season of 2011 provided an opportunity to obtain a near complete inventory of biodiversity indicators.

This document reports the outcome of the biodiversity assessment of 2011. It briefly summarises the approach and methodology, highlights changes to the previous surveys, describes the mapped biotopes and details implications for biodiversity management.



The pretty herb *Heliophila deserticola* was observed occasionally on the Khan river mountain slopes in 2011 – the first time recorded in the study area.

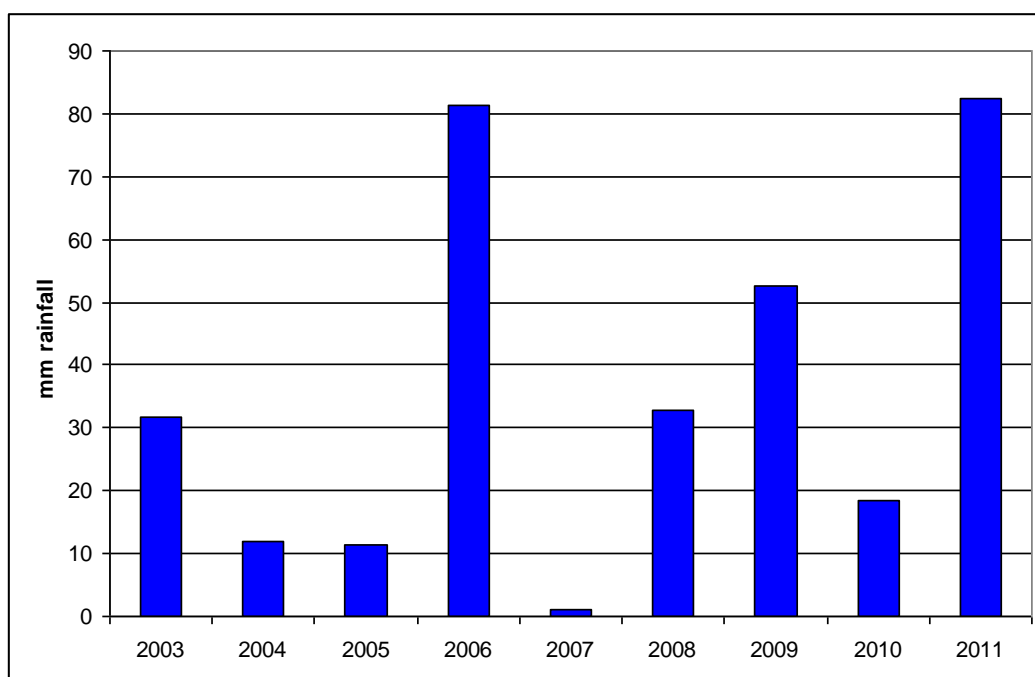
# The natural environment

## Locality and topography

The Rössing study area is located in the central Namib Desert, some 60 km east of the Atlantic coastline and comprises the licence area ML 28 and accessory works area. The mine is positioned approximately 575 m above sea level, with level plains dominating the north, north-west and north-eastern sections of the study area, and increasing relief towards the south. An extensive network of drainage areas originates on these plains, running south to south-west into the ephemeral Khan River. Topography changes from gentle, undulating hills to steep mountains flanking the north- and southbank of the Khan River. The mine's main impact area – the pit and waste rock dumps – is positioned in the hilly to mountainous central and southern portion of the licence area.

## Climate

Average rainfall at the mine is 30-35 mm, with most rains falling during February to April in the form of thunderstorms creating short and rapid run-off events (Ashton et al. 1991). Rainfall is highly variable between years (Figure 1) and very patchy. For example in the rainy season 2011 rainfall in the study area varied between 19.7 mm (tailings) and 122.3 mm (protection services) at different rainfall stations.



**Figure 1.** Total rainfall for the season July-June averaged across all RUL stations (based on Rössing unpublished data; the year indicates the end of the season (July)).

Local wind systems generate the dominant wind regimes in the study area, caused by sea-land breeze (south-westerlies), mountain-valley – and mountain-plain gradients (Ashton et al. 1991). During autumn and winter easterly berg winds develop which can be strong and hot and can carry large amounts of dust and sand. Ambient maximum daily temperatures average 39°C in January and 31.8°C in July, due to the influence of hot berg winds. Fog contributes only marginally to

moisture supply, as moisture-laden coastal fog occurs regularly only up to 30 km inland, while high fog regularly occurs up to 50 km inland (Hachfeld & Jürgens 2000). Fog occurs occasionally in the study area, well beyond the defined coastal and high fog zone, but this is not a regular event and thus only contributes some precipitation.

## Geology

Positioned within the late Precambrian Damara orogenic belt, biotite, granite-gneiss, gneiss, marble, quartzite, schist and tillite of different ages and origin, interspersed by intrusions of pegmatic granite (alaskite) and dolerite dykes, are exposed at the surface (Ashton et al. 1991).

## Soils and habitats

Soils on the plains are shallow, often saline (Scholz 1972), containing pebbles and calcrete depositions. There are aeolian sand deposits in the gorges and in the lee of mountains, while colluvium has been deposited at the base of hills and mountains. Alluvial, silty sands and gravel are deposited in the drainage lines and the Khan River (Ashton et al. 1991).

## Vegetation

The vegetation in Rössing's study area is characterised by sparsely scattered dwarf shrubs and ephemeral grasslands on the plains, undulating hills and mountains and sparse riparian woodland along the Khan River, near the southern boundary of the study area. In summary, *Arthroerua leubnitziae* (pencil bush), *Aloe asperifolia* (sand paper aloe) and *Zygophyllum stapfii* (dollar bush) are the key perennial plant species on the plains, while *Euphorbia virosa* (milk bush) and various *Commiphora* species (corkwood) are characteristic perennial plants on hillsides. The trees *Acacia erioloba* (camel thorn), *Acacia reficiens* (red umbrella thorn) and *Parkinsonia africana* (green-hair tree) are common in drainage lines. The Khan River supports riparian woodlands with the majestic tree *Faidherbia albida* (ana boom), *Tamarix usneoides* (tamarisk) and thickets of *Salvadora persica* (mustard tree).

# The history of biodiversity management at Rössing

Biodiversity management at Rössing started when the mine was established in the 1970ties with the rescue of the stem-succulent *Aloe dichotoma* (quiver tree) and other plants of conservation importance from the area that was going to become the pit and has since then always played a role in the mine's environmental management. However, formal biodiversity management was initiated by Rio Tinto's guidelines in 2004.

As environmental assessments were not required at the time of the mine's establishment no pre-mining baseline was undertaken. Nevertheless, supported by Rössing, the former State Museum (now National Museum) undertook an ambitious programme during 1984-1985 with the objective to catalogue key elements of biodiversity. This resulted in a fairly complete inventory for reptiles, amphibians, plants and birds, and some partial lists for insects and spiders and their relatives (arachnids).

The omission of a pre-mining baseline was addressed in 1991 by the compilation of an extensive environmental report (Ashton et al. 1991). However, the mine was at that time already fully established and the report provided a statement of the environmental conditions at that time and no maps of ecological units were included.

More than a decade later, with encouragement and guidance from Rio Tinto and Vattenfall – one of the mine's clients – it was recognised that biodiversity management at Rössing required a more systematic approach. A biodiversity assessment was commissioned in 2005 with the aim to delineate ecologically homogenous units, reconstruct pre-mining conditions and provide a biodiversity assessment of these mapped units. In collaboration with environmental staff at Vattenfall their "biotope method" for quantitative biodiversity assessment was adapted to the local conditions at the mine. The methodology was developed and tested over two years and finally resulted in a research publication in an international journal (Burke et al. 2008).

Based on landform and characteristic plant species, biotopes were delineated and used as the base units for biodiversity management. The core area of the mine was mapped and assessed in 2005 during a very dry season (total for season July 2004 – June 2005, averaged across all RUL stations: 11.5 mm), the SK extension in 2007 late after a poor season overall (total: 1.1mm), but a good season in 2006, and finally the licence area south of the Khan River in 2009 during a good season (total averaged across all RUL stations: 52.5 mm) (Figure 1). In between these surveys Rössing environmental staff continued plant collections during the rainy season and added new species to some biotopes.



# The biotope method

As the method has been described repeatedly and in detail in previous reports (Burke 2005, 2007, Burke et al. 2008), only the summary from Burke (2009) is provided here.

“The Biotope Method is a simple GIS-based tool that aims to quantify ecological changes (biotope or habitat changes) that take place when land is put to a new use. This method consists of a number of steps. (1) System boundaries are defined and then subdivided into discrete biotopes or habitats of site-specific ecological characteristics. (2) Biodiversity indicators suitable in the local context are selected to assign the relative importance of the biotopes. (3) Biotopes are grouped into four standard categories, (a) critical, (b) rare, (c) general biotopes, and (d) areas which no longer support biodiversity, termed technotopes (Kyläkorpi *et al.* 2005). (4) Once exploration and/or mining activities commence, comparing the assigned biotope categories “before” and “after” the impact (in hectares or as a percentage) provides a measure of the impact on the ecological mapping units which are rated according to biodiversity importance.”

Plant species are used as practical indicators for overall biodiversity in the central Namib for several reasons:

- Plants are the key component of most terrestrial ecosystems, providing food, shelter and habitat for many other living components of an ecosystem.
- They are the basis for all terrestrial food chains delivering primary production without which very little other biodiversity can thrive.
- Plant species in Namibia can be identified within a reasonable time frame (before the next season starts) and
- The conservation status of individual plant species is known and has been assessed nationally and internationally.

This does certainly not mean that other components of biodiversity are not important, and one cannot assume that all trends shown by plants will be the same for other biodiversity components (e.g. reptiles or insects), but on the current knowledge base plants prove a powerful proxy for biodiversity in most situations.

## Approach

Since the vegetation season 2010/2011 started very promising in the central highlands in December 2010 and a good season was predicted also for the rest of Namibia, a survey of under-collected biotopes was proposed for the 2011 season. Also the surveys in different parts of the study area, undertaken during different

seasons, created an imbalance and made it difficult to incorporate these new data in the overall biotope assessment. For example, many more species were recorded during a good season, but since the survey was only undertaken in one part of the study area, newly mapped biotopes (now with a different species composition due to seasonal effects) could not be incorporated in the previous assessment.

These shortcomings were addressed in a comprehensive re-assessment of all biotopes, with field work particularly focussing on previously under-collected biotopes, and a re-analysis of the previously collected data. Although most mapping boundaries remained, some adjustments had to be made in previously under-collected areas.

## **Field survey 2011**

During the fieldwork, plotless sampling was used to compile species lists for discrete biotopes, and/or habitats that were potentially considered to form new biotopes. A total of 133 sample points was added in 2011. All plants were identified in the field, and those requiring further investigation or likely presenting new distribution records were collected and deposited at the National Botanical Research Institute in Windhoek as voucher specimens.

## **Data processing in 2011**

The following steps were taken:

1. Adjustment of mapping units.
2. Allocation of all sample points to biotopes.
3. Compilation of species list for each biotope, including previous records.
4. Determination and rating of species of conservation importance.
5. Summing of scores for species of conservation importance per biotope.
6. Biotope assignment according to biodiversity value.
7. Rating of data quality per biotope.

## **Plant species of conservation importance**

The presence of endemic, red-list and protected plants in a mapping unit was used as indicators for biodiversity value. Red list status refers to the IUCN threat

status, “near threatened”, “vulnerable” or “threatened with extinction” (Loots 2005). Endemics were classified according to range, with those with the most restricted range receiving the highest rating on a three-point scale (Table 1).

**Table 1.** Rating of endemism (3 = highest, 1= lowest).

Range	Rating
central Namib	3
central Namib and one more region	2
central Namib and several other regions in Namibia	1

One change to the status of conservation importance of individual species was introduced. Proposed protected species (Forest Ordinance of 1952 and proclamation of the SWA Administration No. 486 in 1972, Nature Conservation Ordinance 4 of 1975 and 247 of 1977) and species listed in CITES (Convention on Trade in Endangered Species of Fauna and Flora Appendix 1 and 2) were now also included, provided they were not already listed as endemics or red-listed species. Also included in the list of species of conservation importance was the near-endemic *Commiphora oblancoolata* which is rare in the study area and at its southern-most distribution. It was previously red-listed as “near-threatened”, but has been downlisted in 2009, together with *Adenia pechuelii* (NBRI 2009). One new recorded species, *Lotononis tenuis*, is listed as “near-threatened” and now the only red-list species on Rössing’s current plant species list.

Appendix 1 provides the list of species of conservation importance used in the biotope assessment and their ratings.

The scores of conservation importance of individual species were added up per biotope. The scores ranged from 15 to 50 per biotope. This range was then divided into three equal intervals and biotope categories assigned in the following manner:

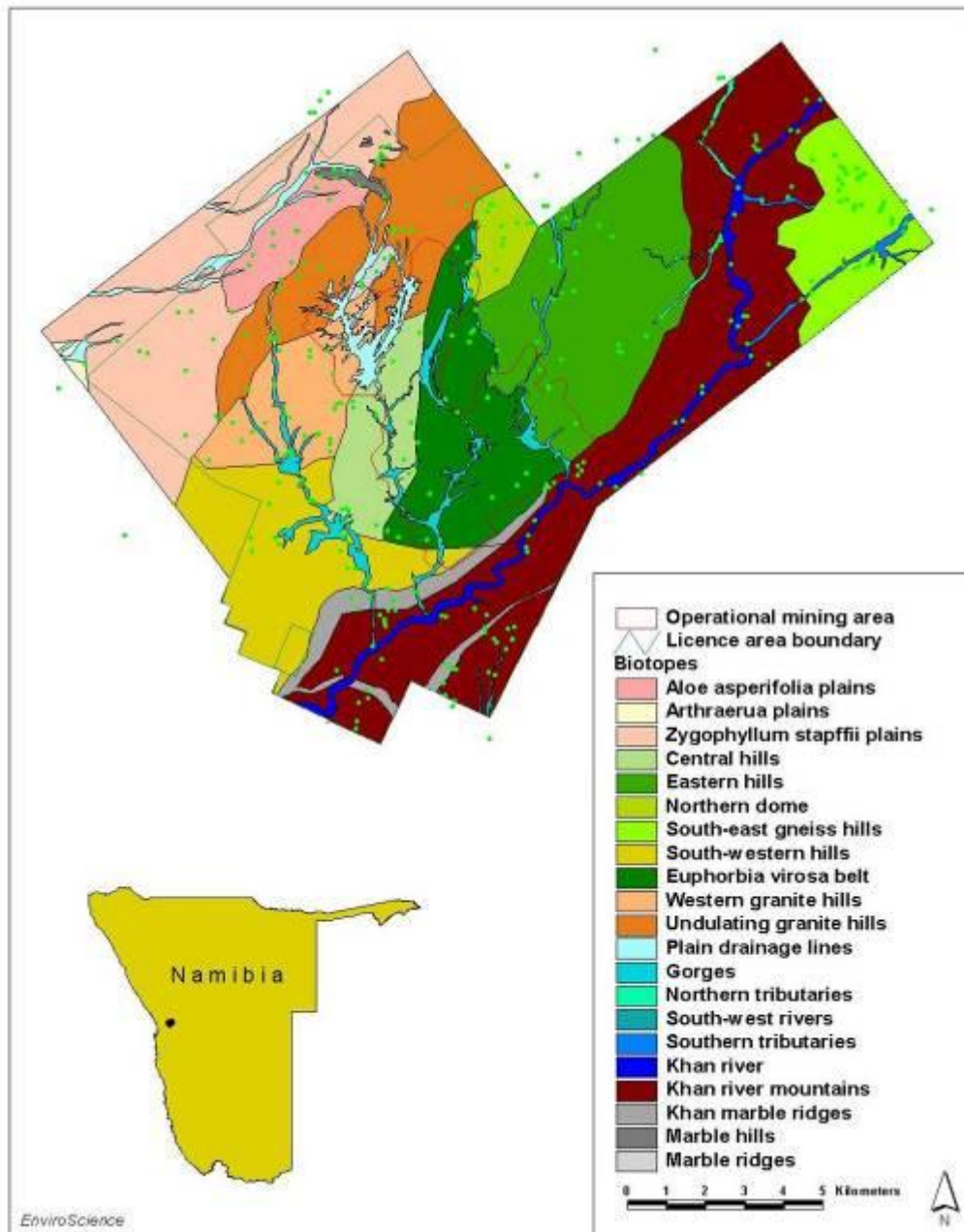
**Table 2.** Assignment of biotopes in the Rössing study area.

Score	Biotope
15-26	General
27-38	Rare
39-50	Critical

The assignment resulted in four “critical” biotopes, 1. Euphorbia virosa belt, 2. Khan river mountains, 3. south-east gneiss hills and 4. undulating granite hills. Seven

were rated as “rare” biotopes and all others received a “general” rating.

Data quality was rated in three qualitative categories (good, medium and poor) according to likely completeness of recorded plant species per biotope. It was rated “good” in all biotopes, except two, because of the exceptional rainy season and the fact that all biotopes could be accessed at several localities. Data quality was rated “medium” in the Khan river mountains, as not all areas planned for the 2011 survey could be accessed, and it was rated “medium” for the Euphorbia virosa belt, as a large part of this biotope was already disturbed at the time of the first assessment, thus accounting for a sampling bias (Figure 2).



**Figure 2.** Biotopes in the Rössing mining licence and accessory works area and position of the mining area in Namibia (green dots indicate the sampling points of the 2005-2011 field surveys).

# What has changed? Comparison to previous surveys

## Biotope boundaries

Although overall no new biotopes were added, some boundaries were adjusted.

1. Khan marble ridges were also introduced in the Khan river mountain biotope in the core area. This is a result of their mapping in the southern part of the licence area in 2009, and confirmation that this also warrants a separate unit north of the Khan River during fieldwork in 2011.
2. More large drainage lines were mapped in the northern part of the licence area.
3. The “marble hills” biotope in the north-eastern part of the licence area is more extensive than previously mapped.
4. The marble ridges near the tailings facility also extend further south-west and disappear underneath the tailings facility, which had previously not been recognised.
5. The western granite hill’s boundary was also extended slightly further south near the Panner Basin.

## Recorded plant species

The number of recorded plant species in the study area increased by over 100 species from 140 in 2005 to 253 in 2011. This is remarkably more than recorded during the initial baseline – part of the (then) State Museum survey – which was based on Herbarium and Prodrum records (Merxmüller 1966-1972) and field work during exceptionally good rains in February 1985 (Craven 1985), when a total of 182 plant species was recorded.

Now 68 plant species of conservation importance are included in the rating of biotopes (App. 1), which presented an increase of 280% from 24 species in 2005 (Table 3). New plant species in 2011, not previously recorded, included *Alectra pseudobarleriae*, *Amphiasma divaricata*, *Aptosimum arenarium*, *Chloris virgata*, *Cleome paxii*, *Dactyliandra welwitschii*, *Enneapogon cenchroides*, *Eragrostis biflora*, *Heliophila deserticola*, *Hibiscus elliotiae*, *Jamesbrittenia fleckii*, *Lotononis tenuis*, *Melolobium candicans*, *Oropetium capense*, *Pavonia rehmannii*, *Pegolettia senegalensis*, *Phyllanthus maderaspatensis*, *Polygala pallida*, *Schmidtia kalahariensis*, *Senecio eenii*, *Senna italica*, *Sonchus oleraceus* and *Tricholaena monachne*. In this assessment not all are necessarily of conservation importance.

## Change in conservation status

The increase in number of species of conservation importance was not only related to the new distribution records, but also to the fact that protected and CITES species, which were otherwise not listed, were now also included in the rating of biotopes. This resulted, for example, in the inclusion of all *Euphorbia*, *Hoodia* and *Lavrانيا* species as indicators of conservation importance.

On the other hand, as a result of a RUL-sponsored intensive field survey of *Adenia pechuellii* and *Lithops ruschiorum*, *Adenia pechuellii* was removed from the threatened category in Namibia's red-list (Loots 2009).

**Table 3.** Summary of key variables from the initial (2005) and final total after 2011 field survey.

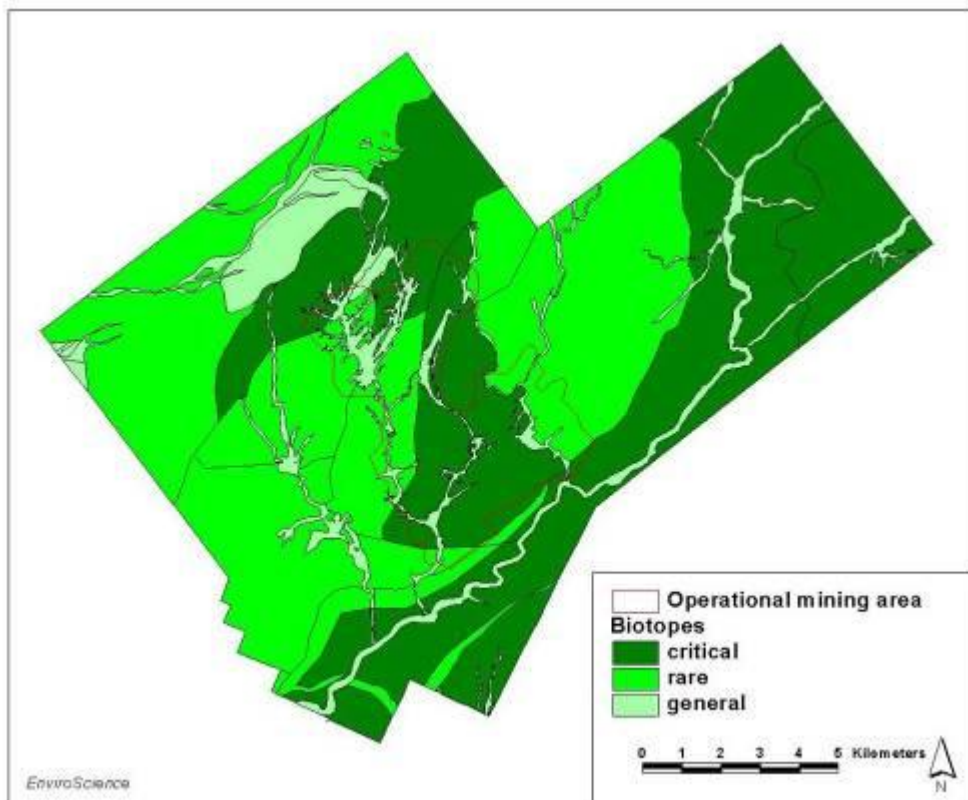
	2005	2011
Number of biotopes	16	21
Sample points	120	338
Species richness	140	253
Species of conservation importance	24	68
Range of scores	1-20	15-50
Area covered	12.5 km <sup>2</sup>	20.6 km <sup>2</sup>

## Biotope assignments

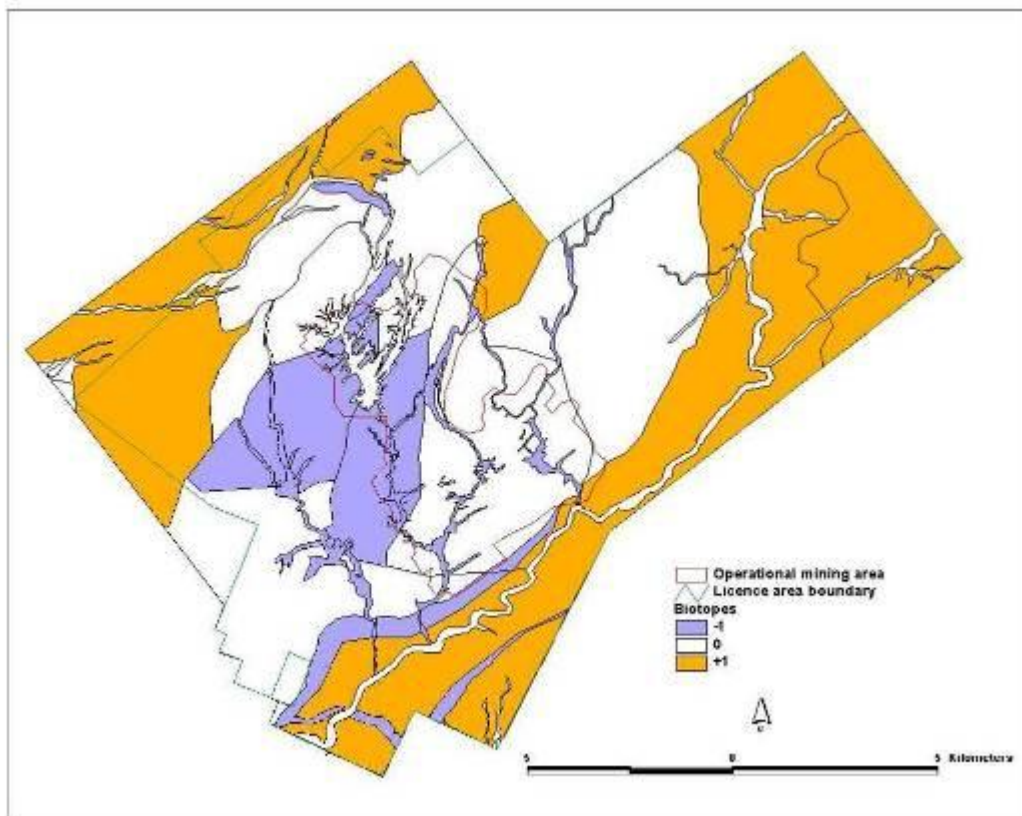
The new biotope assessment of 2011 resulted in 21 biotopes, four of which were rated as "critical" and seven as "rare" (Table 4 and Figure 3). Two biotopes – the *Euphorbia virosa* belt and undulating granite hills – remained as critical biotopes during all assessments, but two other biotopes changed. The 2011 assessment also resulted in more "rare" biotopes, one of which (Khan marble ridges) was a newly mapped unit in the core area. The number of "general" biotopes increased from seven in 2005 to ten in 2011.

**Table 4.** Critical and rare biotopes in 2005 and 2011 in Rössing’s study area.

	2005	2011
Critical biotopes	Euphorbia virosa belt	Euphorbia virosa belt
	Central hills	Khan river mountains
	Western granite hills	South-east gneiss hills
	Undulating granite hills	Undulating granite hills
Rare biotopes	Eastern hills	Central hills
	Gorges	Eastern hills
	Marble hills	Khan marble ridges
	Marble ridge	Northern dome
	South-western hills	South-western hills
		Western granite hills
		Zygophyllum stapffii plains



**Figure 3.** Biotope assignments after the 2011 field survey and biotope re-assessment.



**Figure 4.** Change of biotope assignments between the 2005, 2007 and 2009 surveys and 2011 (-1 = downgrading one category, 0 = no change, +1 = upgrading one category).

A change in biotope assignments was recorded in nearly half (10 out of 21) of the biotopes (Figure 4). A re-analysis in 2007 already resulted in the upgrading of the Khan river mountains from “general” to “rare” and a further upgrading to “critical” followed in 2011 (Figure 3 and 4).

## The importance of a biotope re-assessment

Although the biotope re-assessment during the exceptional season of 2011 resulted in a reasonably complete inventory of plant diversity in the study area and thus the best reflection of status of biotopes based on plant indicators possible to date, finding additional species, particularly during a rainy season with a different rainfall pattern, cannot be ruled out. This might affect three biotopes which are presently close to the upper limit of their assigned class (eastern hills, Khan marble ridges and plain drainage lines) which could shift into a higher class, should additional species of conservation importance be found in these biotopes in future.

Knowledge on biodiversity and ecological functioning is not static and new insights are gained regularly – in terms of local as well as international aspects. In line with adaptive management principles the biotope assessment is therefore a dynamic tool which needs to be adapted once a significant amount of new information becomes available and/or new findings in biodiversity management are available.



Including other indicators of biodiversity, and particularly some representing functional aspects, should be considered in future to obtain a more holistic approach to the assessment of biodiversity importance.

## Meeting expectations?

Some additional field observations during the 2011 season not captured and/or directly related to the biotope assessment are described here.

Mass recruitment?

Massive germination and establishment of new plants of the widely distributed dollar bush (*Zygophyllum stapfii*), sandpaper aloe (*Aloe asperifolia*), neat's foot (*Adenolobus pechuelii*) or other more common long-lived shrubs would be expected. This has always been accepted as a common pattern in desert areas: massive recruitment during exceptionally good seasons. This theory is based on the fact that many populations of long-lived desert plants show distinct age classes, rather than an even spread across all ages. It means many plants of the same age exist, but nothing in between. Yet none of this "mass recruitment" was evident in Rössing's licence area this year, so perhaps more than just one good season is necessary to trigger such events?

The desert in full bloom?

Spectacular flower displays may be a wishful expectation by casual observers in response to such good and prolonged rainfall. Yet, the majority of plants in the central Namib (in terms of biomass) are grasses, and they are aptly described by botanists as lacking colourful and conspicuous flowers. Although there were certainly some areas which may have presented beautiful flower displays, these are localized and usually restricted to short time spans.

Lilies – always the first?

Ecologists have observed that bulbs, lilies and the like are usually the first to appear after the first rains, while herbs and grasses respond much slower and need a few weeks rather than days to make an appearance. Thus during customary once-off surveys, the bulbs are often missed—not so this season. Although flowering bulbs were still largely restricted to the early part of the season, new bulb leaves still appeared in May, when they have usually retreated into hibernating mode below-ground.

Natural rehabilitation?

Rehabilitation of arid areas takes many decades. Yet, the healing power of nature with immediate effect could be observed in some disturbed areas that had not been utilised for a while. For example, the usually unsightly quarry to the east of the mine's entrance is now blanketed by a fair cover of grass, including some of the steep slopes. This makes the quarry blend in much better with its surrounding.

Unfortunately this mask is short-lived and the grass cover will disappear again. The question is how long it will take to get another good season, and particularly how long it will take for more permanent plant cover to establish. More lasting natural repair was, however, rendered to tracks and roads in drainage areas. Many tracks in washes and gorges were completely washed out, and – provided that these naturally restored areas are protected and the tracks not opened up again – Rössing could save many hundreds of thousands of N\$ that would need to be spent on track rehabilitation for mine closure. A season like 2011 is likely not to happen for another while and preserving effectively what has been restored is a crucial task.

Cryptic plants no longer so cryptic?

New localities of Rössing's flagstone plant (*Lithops ruschiorum*) popped up in many areas – despite an intensive and dedicated survey involving the National Botanical Research Institute, Rio Tinto and Flora & Fauna International some 2-3 years ago. This is however not a reflection of new established stone plants, but rather a result of them being much more easy to see when full of moisture and thus raised well above the ground.



Find the spot... a new population of the stone plant (*Lithops ruschiorum*) was discovered north of the entrance to the mine in 2011 – partly due to the fact that cryptic plants protruded much more above the surface than in a dry year.

## The contribution of the Rössing study area to biodiversity in the region

There is no question that the diverse habitats encompassed in Rössing's study area have resulted in very high plant species richness in this arid environment and make it an important sanctuary for the maintenance of biodiversity in the region.

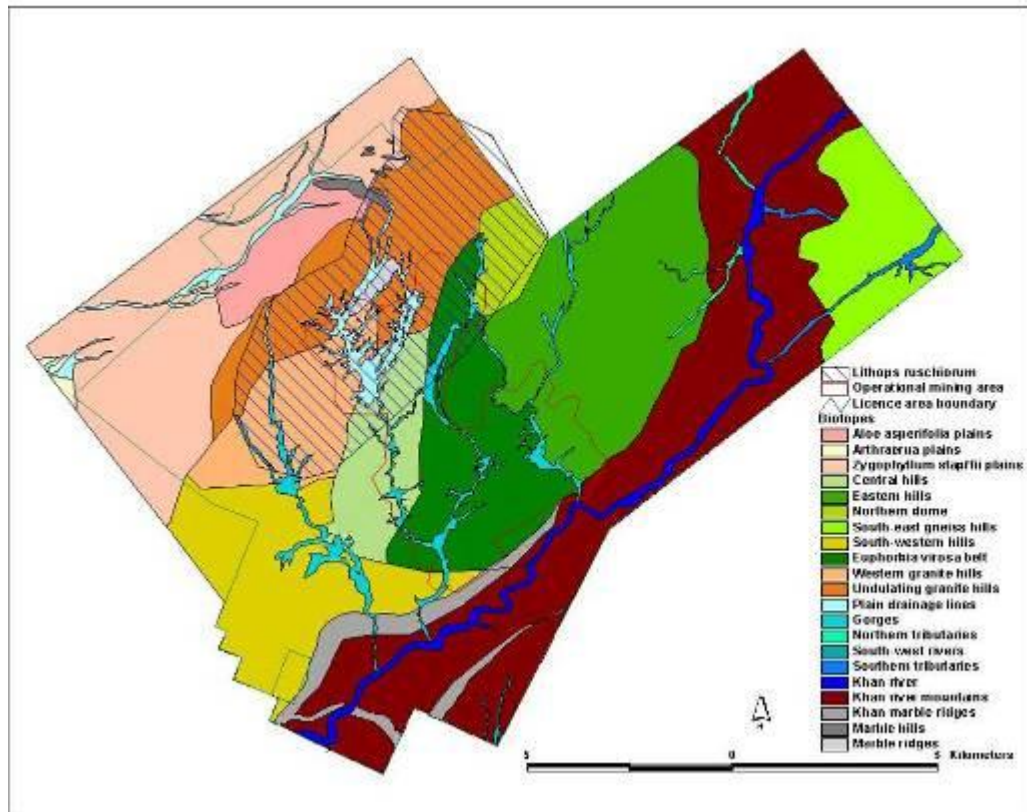
Quantifying Rössing's contribution, however, is difficult as readily available and published information on plant species distributions in this area reflects a significant sampling bias. The plant inventory at Rössing now stands out as one of the most comprehensive. For example plant species lists obtained from the Specimens Database of the National Botanical Research Institute for the quarter degree references covered by the study area list just over 100 plant species per quarter degree square, substantially less than now recorded in the study area. The closest well collected quarter degree square, the one including the Spitzkoppe inselbergs, supports well over 300 plant species. However, this area is not directly comparable to the study area, as it lies further north-east and thus receives higher rainfall and is a biodiversity hotspot in the central Namib (Burke 2003, 2008). The flora study for the environmental assessment at the neighbouring Valencia Mine, which is more comparable to the study area, only recorded just over 150 plant species, but this list was not based on a survey in an exceptional season (Digby, Wells & Associates 2008). The flora inventory at Langer Heinrich Uranium, further east and thus receiving higher rainfall, stands at 201 plant species (Strohbach 2009). Another well collected area at a comparable distance from the coast is the Gobabeb research station and surroundings. Although this includes some rocky habitat near the Kuiseb River, there are no mountain habitats like those in the Rössing study area. On the other hand Gobabeb includes dunes and the area covered was more than 10-times larger. Some 199 plant species were collected here in a period over nearly 50 years (Henschel et al. 2006).

Distributions of individual species of conservation importance, however, can provide some insight to the importance of the management of biodiversity at Rössing.

Two rare annual herbs *Cleome foliosa* var. *namibensis* and *Helichrysum marlothianum* have so far only been recorded in quarter degree squares in or near the Rössing study area. *Cleome foliosa* var. *namibensis* has been recorded in the study area, while the latter is known only from historical records. Except for in the study area, the near-threatened annual herb *Lotononis tenuis* is only known from two localities in the northern Namib, and therefore very rare. *Commiphora oblancoolata* is at its southern-most distribution boundary in the Rössing study area and is one of the less abundant *Commiphora* species. It therefore also deserves particular protection. These four species could thus be considered of particular importance for biodiversity management in Rössing's study area.

Two plant species of particular importance are also *Lithops ruschiorum* and *Adenia pechuelii*. A detailed field assessment of *Lithops ruschiorum* confirmed that Rössing harbours indeed nearly a quarter (24%) of the world's known populations

of this plant in its study area (Loots 2009). The plant is restricted to the coastal central and northern Namib and occurs largely in the northern and central section of the licence area (Figure 6). However, the formerly red-listed *Adenia pechuellii*, which was also assessed in a detailed field survey, is scattered throughout most biotopes in the study area, but occurs in much larger numbers outside Rössing's study area, for example at Valencia (Digby, Wells & Associates 2008) and has a far greater distribution throughout the Namib and adjacent areas in Namibia than *Lithops ruschiorum*. Nevertheless, both are considered species requiring special protection or management interventions.



**Figure 5.** The distribution of *Lithops ruschiorum* in Rössing's study area.

As indicated by other plant studies in the central Namib, species richness recorded in a particular season is directly related to rainfall, particularly at a distance of about 60 km from the coast, while the influence of rainfall on species richness lessens further east and near the coast (Hachfeld 2000). Seasonal effects are therefore very important in the study area.

## Description of biotopes

This section repeats descriptions from previous reports (Burke 2005, 2007 and 2009), but adds new information and revisions and provides all biotope descriptions in one comprehensive report. The biotopes are organised according to the main landforms (1) plains, (2) drainage lines and rivers, and (3) hills and mountains.

### Plains

The northern and north-western section of Rössing's licence area is covered by vast plains which are dissected by networks of drainage lines. The soils are shallow and poorly developed. These plains have been mapped as three separate units.

#### **Aloe asperifolia plains**

Some sections of level plains in the northern part of Rössing's licence area support a large population of *Aloe asperifolia* (sandpaper aloe). Although isolated individuals also occur in the neighbouring biotopes, the core of the population has been mapped as a separate biotope (Figure 6). This mapping unit is moderately species rich with 51 species recorded to date. Other conspicuous plants in this mapping unit are *Boscia foetida* (smelly shepherd's tree), *Commiphora saxicola* (rock commiphora) and *Zygophyllum stapffii* (dollar bush).

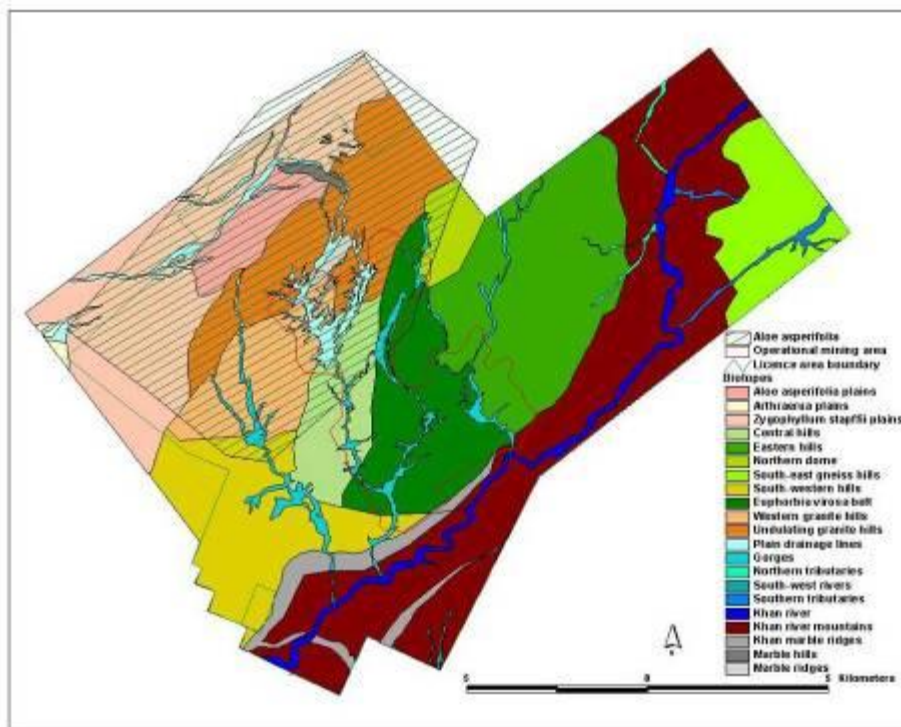
The biotope was rated "general", but data quality is good for this mapping unit.



During a poor season, like 2005, only perennials such as the succulent *Aloe asperifolia* are visible in this biotope. *Aloe asperifolia* grows mainly in a circular fashion, but is otherwise patchily distributed across this mapping unit.



The leaf-succulent *Aloe asperifolia* is endemic to the central and northern Namib and adjacent escarpment in Namibia.



**Figure 6.** The distribution of *Aloe asperifolia* in Rössing's study area.

## Arthroa leubnitziae plains

Only a small section of these plains dominated by the Namib endemic *Arthroa leubnitziae* (pencil bush) extends into the north-west corner of the Rössing licence area. However, the plains extend further west and north over vast stretches, forming the dominant plant cover in a large section of the central Namib (Hachfeld 1996). In the Rössing licence area these plains support 38 plant species, including some of conservation importance such as the endemics *Arthroa leubnitziae*, *Cleome carnos*a, *Commiphora saxicola*, *Hermbsaedtia spathulifolia*, *Jamesbrittenia barbata* and *Zygophyllum stapffii*. Because this biotope had only been surveyed in a very dry year before, 35 of the 38 plant species were added during the 2011 season.

Data quality is good for this mapping unit and this biotope was assigned a “general” biotope.



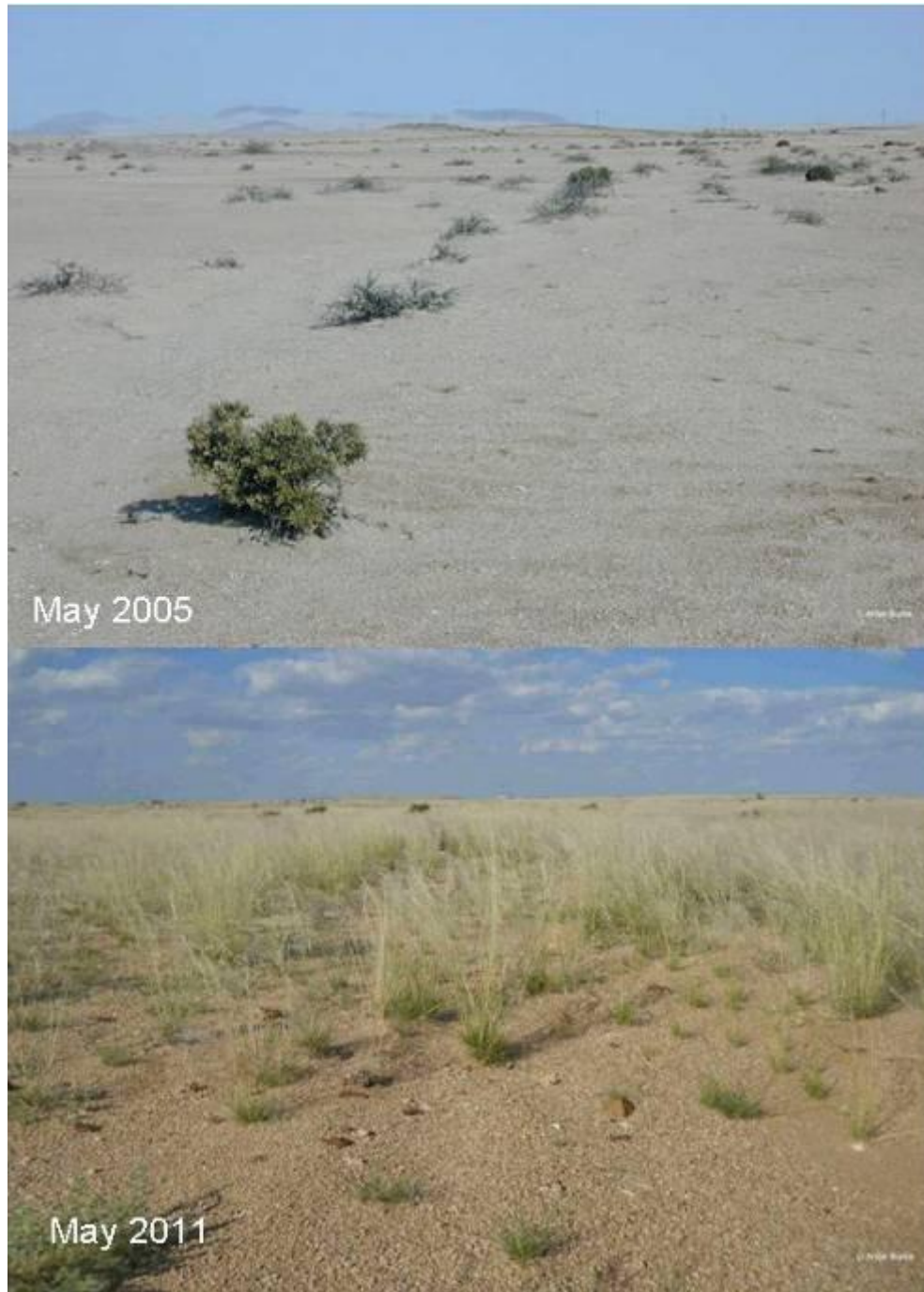
The pencil bush (*Arthroa leubnitziae*) relies largely on fog moisture and is therefore prominent in the fog zone of the central Namib.



Leaf-less, grooved branches and stems characterise *Arthroa leubnitziae*.

## Zygophyllum stapffii plains

One of the largest mapping units, these plains dominated by *Zygophyllum stapffii* (dollar bush) cover the northern and western plains of the licence area. Besides *Zygophyllum stapffii*, other conspicuous perennials are scattered individuals of *Aloe asperifolia*, *Boscia foetida*, *Calicorema capitata*, *Commiphora saxicola* and *Sarcocaulon marlothii*. During a good rainy season such as in 2011, the perennials are accompanied by a good cover of ephemeral (short-lived) grasses like *Stipagrostis ciliata* and *Stipagrostis hirtigluma* var. *pearsonii*. Some 61 plant species have been recorded so far. Data quality is good and this biotope was rated "rare".



Rössing's *Zygophyllum stapffii* plains in 2005 (above) and 2011 (below). Although the annual grasses are patchily distributed, even in a good season, only shrubs were present in the poor season of 2005.



## Drainage lines and rivers

Ephemeral rivers, drainage lines and washes are some of the key features in the study area. They equally dissect plain and mountainous habitats and were mapped according to their nature and position in the study area.

### Gorges

The lower sections of water courses draining towards the Khan River are lined by very steep mountains. These mostly sandy gorges support a range of plants typical of river courses in this area. *Acacia erioloba* (camel thorn), *Acacia reficiens* (red umbrella thorn), *Salvadora persica* (mustard tree) and *Tamarix usneoides* (tamarisk) are locally dominant. Other frequent species include *Adenolobus pechuelii*, *Boscia foetida*, *Calicorema capitata*, *Euclea pseudebenus* (wild ebony), *Kissenia capensis*, *Orphanthera albida*, *Parkinsonia africana* and *Ruellia diversifolia*. The occurrence of trees and freshwater seepages after good rains makes these gorges important habitats for animals.

The gorges are classified as “general” biotopes, although some 70 plant species have been recorded. Data quality is good.



Upper Dome Gorge experienced strong floods during the 2011 season and seepage areas will likely stay wet for a while.

## Northern tributaries

A number of drainage lines join the Khan River from the north in the north-eastern extension part of the study area. Many are dominated by *Stipagrostis damarensis*. Some 68 plant species have been recorded, but only some are of conservation importance serving as indicators for biodiversity value. These include *Hermannia amabilis* (white hermannia) and *Zygophyllum stapffii*. A diversified vegetation structure which includes trees and higher shrubs provides important habitat in the form of nesting sites and shelter for animals.

The biotopes assignment was “general”, but data quality is good.



Occasional trees and the large perennial grass *Stipagrostis damarana* are characteristic in the northern tributaries (to the Khan River).

## Plain drainage lines

The shallow drainage lines on the plains in the northern and western part of Rössing's study area are separated from those running south, eventually contracting in steep gorges near the Khan River. Although their transition to gorges is gradual, they nevertheless support a slightly different species mix and only support low trees. *Acacia reficiens*, *Parkinsonia africana* and *Salvadora persica* are locally dominant along stretches of these drainage lines. Higher perennial vegetation cover makes these important habitats for animals. Species richness is high (70 species have so far been recorded) and the biotope was assigned "general". Data quality was rated good.



Due to the force of floods the drainage lines do not show a remarkable difference between a dry year (above) and a wet year (below), but the banks are well vegetated in 2011 and almost bare in 2005.

## Khan river

The Khan River runs almost parallel along the southern boundary of the study area. The banks of the riverbed, which is dry most of the year, are lined with galleries of woodland largely comprised of the tall trees *Acacia erioloba*, *Faidherbia albida* (ana tree) and *Tamarix usneoides*. Dense thickets of *Salvadora persica* are locally dominant. A diverse assortment of herb, shrubs and grasses form the undergrowth in these riparian woodlands. The invasive alien *Prosopis glandulosa* (mesquite) and *Nicotiana glauca* (wild tobacco) are also present. The occurrence of large trees, shrubs and thickets, as well as freshwater seepage areas, particularly after good rains, make the Khan river an important habitat for wildlife.

Some 56 plant species were recorded to date and the biotope was rated “general”, largely due to the fact that relatively few species of conservation concern were recorded here. Data quality is good.



The Khan river is one of the few biotopes that always support green vegetation due to permanent access to subsurface water.

## Southern tributaries

Tributaries joining the Khan River from the south-east in the accessory works area have been mapped as a separate biotope. Filled with sand, gravel and occasional boulders, they are dominated largely by *Stipagrostis hochstetteriana* (gembok-tail grass) and *Blepharis pruinosa* (desert thistle) is locally dominant. Trees, such as *Acacia erioloba* (camel thorn) occur occasionally, attracting birds and other wildlife. Species richness is high (74) and data quality is good.

However, fewer species of conservation importance were recorded than on the adjacent slopes. These include, amongst other, *Anticharis imbricata*, *Stipagrostis damarensis*, *Stipagrostis hochstetteriana* and *Zygophyllum stapffii*. The biotope is assigned general.



Although 2007 was a dry year, the effect of the good rains in 2006 is still evident in the southern tributaries.

## South-western rivers

The two larger rivers draining into the Khan River were mapped as a separate biotope in the southern-most part of the study area. Filled with coarse sand, boulders and other erosion material and receiving most of the run-off from the mountains, they support different vegetation than the surrounding mountain slopes. The dwarf shrub *Zygophyllum stapffii* (dollar bush) was dominant in many sections of these rivers, but the herb *Cleome foliosa* var. *foliosa* and the tall, endemic grass *Stipagrostis damarensis* were also locally abundant. Tall trees such as *Acacia erioloba* (camel thorn), *Parkinsonia africana* and *Tamarix usneoides* (tamarisk) also occur in this biotope. Endemic species recorded were *Aizoanthemum dinteri*,

*Arthroerua leubnitziae*, *Hermbsstaedtia spathulifolia* and *Sesamum marlothii*. Some 45 species were recorded in this mapping unit.

The number of endemics was lower than on the rocky slopes and the biotope was rated “general”. Data quality is good. The occasional large trees, such as *Acacia erioloba*, attract wildlife.



Grass cover is high in the south-western rivers during a good season such as 2009.

## Hills and mountains

Hill and mountain habitats cover over half of the study area. They provide a range of different microhabitats and therefore many different niches for plant species due to the differences in underlying rock types, steepness and aspect of slope and drainage features.

### Central hills

A section of hills and ridges is present to the west and north of the current pit area. These hills support high plant diversity (85 species recorded so far), including conspicuous plants such as *Adenia pechuelii* (elephant's foot), *Arthroerua leubnitziae*, *Boscia foetida*, *Commiphora saxicola*, *Commiphora virgata* (twiggy commiphora), *Euphorbia virosa* (milk bush), *Hoodia gordonii* (Gordon's hoodia), *Parkinsonia africana* and *Sarcocaulon marlothii* (Marloth's bushman candle).

A "rare" biotope rating was assigned. Data quality is good.



Even during the above-average season of 2011, the central hills adjoining the west and north-western section of the pit show very low plant cover, but nevertheless high plant diversity.

## Eastern hills

These undulating hills in the south-eastern section of the licence area are species-rich – 99 species have been recorded to date – and are characterised by *Calicorema capitata* (grey desert broom), *Commiphora saxicola*, *Commiphora virgata*, *Petalidium canescens* and *Petalidium variabile* (variable petalidium). Plant species occur here which are more typical of the escarpment flora to the east, such as *Commiphora tenuipetiolata* (white-stem corkwood) and *Sterculia africana* (African star chestnut).

Species of conservation importance include, amongst others, *Adenia pechuelii* (elephant's foot), *Aizoanthemum dinteri* and *Petalidium canescens*. The charismatic *Aloe dichotoma* (quiver tree) and *Euphorbia virosa* (milk bush) also occur in this mapping unit. The biotope rating is “rare”, but data quality is good.

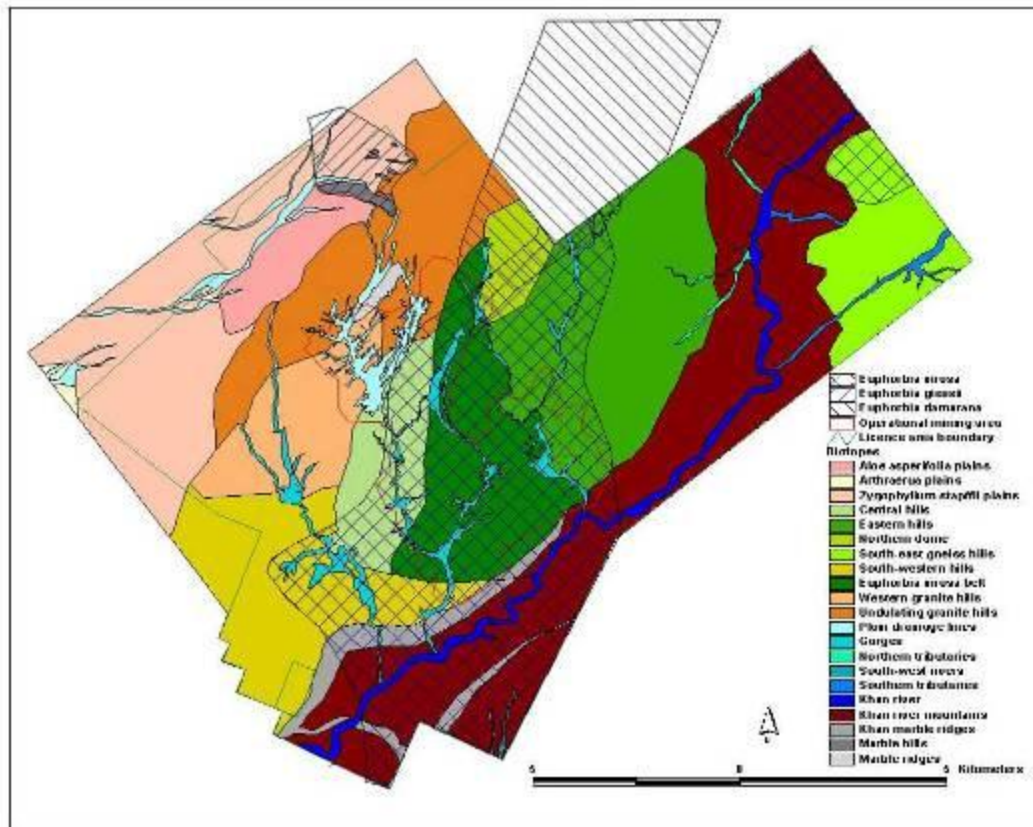


The transition from the Northern Dome (foreground) to the Eastern Hills biotope (middle ground and background) is gradual and shows no distinct change in vegetation.



In most years inconspicuous or absent, the grasses *Triraphis pumilio* and *Stipagrostis subacaulis* occurred in abundance in many biotopes in 2011.





**Figure 7.** The distribution of frequent *Euphorbia* species in the study area indicates two separate populations for *Euphorbia virosa*, a limited distribution for *Euphorbia giessii* and a marginal intrusion by *Euphorbia damarana* from the north.

## **Euphorbia virosa belt**

*Euphorbia virosa* is (and was likely) prominent in the central section of Rössing's study area, covering most of the current pit. Apart from *Euphorbia virosa*, other conspicuous plants, although widely scattered, are *Aloe dichotoma* (quiver tree), *Arthroaerua leubnitziae*, *Boscia foetida*, *Calicorema capitata* (grey desert broom), *Commiphora saxicola*, *Commiphora virgata*, *Euphorbia damarana* (Damara milk bush) (in the north-east), *Hoodia currorii* (Namib hoodia), *Hoodia gordonii*, *Kleinia longiflora*, *Maerua schinzii* (ringwood tree), *Parkinsonia africana* and *Sarcocaulon marlothii*. This mapping unit is species-rich (100 species), with many plants of conservation importance, including *Adenia pechuelii*, *Aloe dichotoma*, *Aloe asperifolia*, *Anticharis ebracteata*, *Hermbstaedtia spathulifolia*, *Lavrانيا sp.*, *Lotononis bracteosa*, *Tephrosia monophylla* and *Zygophyllum cylindrifolium*. Although this biotope had been well collected previously, the 2011 survey still added additional distribution records, mainly annuals and deciduous plants such as *Anticharis imbricata*, *Aristida parvula*, *Euphorbia glanduligera*, *Gisekia africana*, *Hermannia amabilis*, *Microcharis disjuncta*, *Stipagrostis subacaulis*, *Tephrosia dregeana* and *Triraphis pumilio*. However, a new population of *Lithops ruschiorum* (stone plant) was also added to the list of species of conservation importance. A high biodiversity value was assigned to this mapping unit, classifying it as a "critical" biotope. Data quality is rated medium – due to the fact that a large section

of this biotope comprises the disturbed pit area and associated waste rock dumps which were already established at the time of the first plant survey.



The slopes surrounding the northern and eastern part of Rössing's operational area are dominated by the conspicuous stem-succulent *Euphorbia virosa* and so named the "Euphorbia virosa belt".

## Khan river mountains

Steep mountains line the north- and south-banks of the Khan River. However, the mountains become lower and slope more gently towards the north-west and south-west. They are composed of rock types of the Kuiseb and Chuos formations, mainly schist, and are intruded by bands of granite and quartz. They rise up to approximately 400 m above the surrounding land surface. Deep channels incise these rocky slopes and seepage areas occur on the north-eastern section of these impressive mountain ranges. Drainage lines on these mountains have been included in this mapping unit, as they are similar in plant composition to the slopes. Not surprising their slopes and channels provide diverse microhabitats and support by far the highest number of plant species recorded in any biotope in the study area. Some 136 species have been recorded so far, and there is a good chance that more can be found during future surveys. Amongst this diversity it is difficult to pinpoint dominant plant species, as these change along the nearly 15 km stretch of mountain range in the study area, but several *Commiphora* species, *Euphorbia virosa*, *Maerua schinzii*, and *Sterculia africana* are some of the more conspicuous plants on these slopes. The dwarf shrubs *Petalidium canescens* (dark-red petalidium), *Ruellia diversifolia* and *Zygophyllum stapffii* are also very frequent. This biotope is rated "critical" and data quality medium, because data coverage is still too low for this diverse habitat.



The 2011 survey of the Khan river mountains confirmed that these need to be separated into 2 mapping units in the entire study area: the Khan marble ridges (above-right side of photo) and the Khan river mountains, composed of various rock types (below).

### **Khan marble ridges**

Bands of marble of the Karibib formation wind through the Khan River mountains. Their upper reaches are steep and trend mainly north-east to southwest through the study area. Although many of the same plant species as on the Khan River mountains occur here, there are some species that appear to be restricted to these marble ridges. *Aloe namibensis* (Namib aloe), *Commiphora oblancoolata* (Swakopmund corkwood) and *Euphorbia lignosa* (spiny milk-bush) were only found here, while *Adenia pechuellii* (elephant's foot), *Cotyledon orbiculata* and *Othonna lasiocarpa* (wool-fruit othonna) also occur in other biotopes, but were only

found on marble in the Khan river mountains. The dwarf shrubs *Petalidium canescens* and *Petalidium variabile* (variable petalidium) are locally dominant, and various *Stipagrostis* grasses covered most of the slopes after the good rains of 2011. With 88 plant species, species richness was high and because of the presence of many of endemics, the biotope was rated as “rare”.

## Marble hills

Several marble hills in the north-eastern section of the Rössing licence area support a population of the Namib endemic *Euphorbia giessii*, a stem-succulent which is largely restricted to marble in the central and northern Namib. Because of the dominance of this species, these marble hills were mapped separately from the marble ridge to the west where *Euphorbia giessii* does not occur. Conspicuous accompanying species on these marble hills are *Adenia pechuelii*, *Adenolobus pechuelii* (Namib neat's foot), *Aloe asperifolia*, *Commiphora saxicola*, *Othonna lasiocarpa*, *Sarcocaulon marlothii* and *Sarcostemma viminale*.

Data quality is now good, and 50 plant species have so far been recorded. This biotope was assigned “general”.



The Namib coastal endemic stem-succulent *Euphorbia giessii* characterises the marble hills in Rössing's north-eastern part of the licence area.

## Marble ridge

A marble ridge runs approximately west-east at the eastern margin of the current tailings area and disappears underneath the tailings. *Commiphora virgata* and *Stipagrostis ciliata* (tall bushman-grass) are the most frequent species in this

mapping unit. Also present are *Adenia pechuelii*, *Polygala guerichiana*, *Sarcocaulon marlothii* and *Zygophyllum stapffii*. Data quality is good and some 55 plant species were recorded, including a number of endemics. The biotope was classified as “general”.



The marble ridge which disappears westwards underneath the tailings facility, was found to be more extensive in the licence area than previously mapped.



A small population of *Lithops ruschiorum* was discovered on the marble ridge in 2011.

## Northern dome

A geological feature to the north-east of the pit, called the “dome”, harbours a population of *Euphorbia damarana* in its northern section, and has therefore been mapped as a separate unit. Other plants in this mapping unit are similar to those found on the neighbouring eastern hills and the *Euphorbia virosa* belt. They comprise amongst others, *Boscia foetida*, *Commiphora saxicola*, *Petalidium variabile* and *Zygophyllum stapffii*. This biotope is species-rich – 83 plant species have to date been recorded – and harbours many endemics. Data quality is good and the biotope was assigned “rare”.



The elephant's foot (*Adenia pechuelii*) occurs frequently in the Northern dome biotope.



The endemic parasite *Alectra pseudobarleriae* is a new distribution record in the study area and was added to the list of species of conservation importance in 2011.

## South-east gneiss hills

As the general elevation rises towards south-east of the Rössing accessory works area, the Khan river mountains gradually lose height and become less steep transforming into undulating hills. Although gneissic rocks are considered characteristic of these hills, many other rock types also occur and plants are not strictly associated with gneiss. Characteristic shrubs are *Petalidium canescens* and *Petalidium variabile*, and a healthy population of *Aloe dichotoma* (quiver tree) is noticeable in the eastern corner of this mapping unit. With some 116 species recorded to date, this biotope shows the second highest plant diversity in Rössing's study area. Apart from the diverse topography and different rock types providing many different habitats for plants, plants from the escarpment flora were likely distributed west with the good rains of 2006 and 2011, adding to the high plant diversity. Data quality is now considered good. Biodiversity value is high, assigning this area a "critical" biotope. Species of conservation importance include *Adenia pechuelii*, *Calostephane marlothiana* and *Sarcocaulon marlothii*.



The south-eastern gneiss hills support very diverse vegetation, including quiver trees (*Aloe dichotoma*).



The Namibian endemic *Pelargonium otaviense* (left) is one of the many plant species of conservation importance which occur in the south-east gneiss hills.

## South-western hills

Although showing much lower and very patchy plant cover, the south-western hills to the north of the Khan river mountains and west of the operational area of the mine, nevertheless support at least 71 plant species. More than half of these (40 species) were recorded during the 2011 survey. This included species of conservation importance such as *Arthraerua leubnitziae*, *Dauresia alliariifolia*, *Hermbstaedtia spathulifolia* and *Lotononis bracteosa*. Locally dominant perennials on the hillslopes are *Commiphora saxicola* and *Tetragonia reduplicata*.

This biotope was rated as “rare” and data quality is good.



With rains likely less frequent here, the slopes of the south-western hills show the lowest vegetation cover, but certainly not the lowest plant diversity in the study area.



## Undulating granite hills

The undulating granite hills in the northern part of the licence area form a transitional area between the level plains and the more rugged topography in the central study area. Dominant plants are *Adenolobus pechuelii* and *Zygophyllum stapffii*. Other obvious plants in this mapping unit are *Adenia pechuelii*, *Aloe asperifolia*, *Arthroerua leubnitziae*, *Boscia foetida*, *Calicorema capitata*, *Euphorbia gariopina* and *Parkinsonia africana*. Some populations of *Lithops ruschiorum* occur in this mapping unit. Data quality is good and some 89 plant species were recorded in this biotope, many of which are of conservation importance. These include the red-listed *Lotononis tenuis*, and the endemics *Aizoanthemum dinteri*, *Calostephane marlothiana*, *Lotononis bracteosa* and *Sarcocaulon marlothii*. Despite previously classified as well collected, the 2011 survey added 33 new species, including *Aizoanthemum rehmannii*, *Anticharis ebracteata*, *Hermbstaedtia spathulifolia*, *Ophioglossum polyphyllum*, *Petalidium canescens*, *Sesamum marlothii*, *Stipagrostis dinteri*, *Stipagrostis subacaulis* and *Triraphis pumilio*. This mapping unit was assigned a “critical” biotope.



Scattered shrubs characterised the undulating granite hills to the north of the operational area of the mine in 2005.



The delicate annual herb *Lotononis tenuis* has for the first time been recorded in the central Namib in Rössing's study area in 2011. Because of its rarity it has been listed as “near-threatened” (NBRI 2009).

## Western granite hills

Stretching from the current tailings area westwards, these granite hills support diverse assemblages of plants. Although granite is prominent, other rock types also occur here. Locally dominant are *Arthroerua leubnitziae*, *Euphorbia gariepina* and *Petalidium variabile*. Amongst others, *Adenia pechuelii*, *Aloe asperifolia*, several *Commiphora* species, *Sarcocaulon marlothii* and *Zygophyllum stapffii* add to the species spectrum. Several populations of *Lithops ruschiorum* occur in this mapping unit. Species richness is medium (75 species to date), but the biotope is rated “rare” because of several range-restricted plants. Data quality is good.



A population of the silver-grey succulent *Cotyledon orbiculata* (middle ground) grows on slopes of the western granite hills.



*Cotyledon orbiculata* occurs in some biotopes in the Rössing study area.

# Conclusions

The intensive field survey during an exceptional season and re-assessment of Rössing's biotopes resulted in a substantial change in the relative biodiversity importance of many biotopes. However, "critical" biotopes in the operational area remained as for the previous assessments, but mountain areas (Khan river mountains and south-east gneiss hills) were now added as "critical" biotopes, and two formerly "critical" biotopes (central hills and western granite hills) were downgraded from "critical" to "rare" (Table 4, Figures 3 and 4).

Species richness in the study area increased substantially as a result of the exceptional rains and subsequent intensive sampling and now stands at 253 species, a remarkable concentration of plant diversity for this arid area, compared to other well-collected parts of the central Namib (e.g. the surrounding of Gobabeb research station with 199 plant species).

With this Rössing has now one of the most comprehensive plant surveys in the central Namib and added several new distribution records to the national plant database.

## Implications for biodiversity management

### Strategic

- The biotope assessment is primarily a management tool to report on impacts on biodiversity in a systematic manner.
- The change in biotope assignments related to the now almost complete plant inventory will affect a change in the proportions of critical, rare and general biotopes that are not related to impacts caused by the operations. This will have to be clearly indicated in respective reports.
- The biotope method provides a tool to determine appropriate offsets, once these are in discussion.

### Management

- The biotope assessment helps to guide rehabilitation by determining the level of intervention required according to status of biotope. I.e. disturbed areas in "critical" biotopes are expected to receive more intervention than "general" biotopes. Rehabilitation in the Upper Dome Gorge touches critical (*Euphorbia virosa* belt), rare (Northern Dome) and general (gorges) biotopes. In addition to the clean-up and reshaping of landforms, restoring ecological functioning and biodiversity should thus receive some attention.
- Plant species of particular conservation concern which require special management (transplanting or re-vegetating methods) are *Adenia pechuelii*, *Commiphora ob lanceolata* and *Lithops ruschiorum*.
- All "critical" biotopes should receive particular attention, if new impacts are anticipated here. For example, baseline surveys should only be undertaken

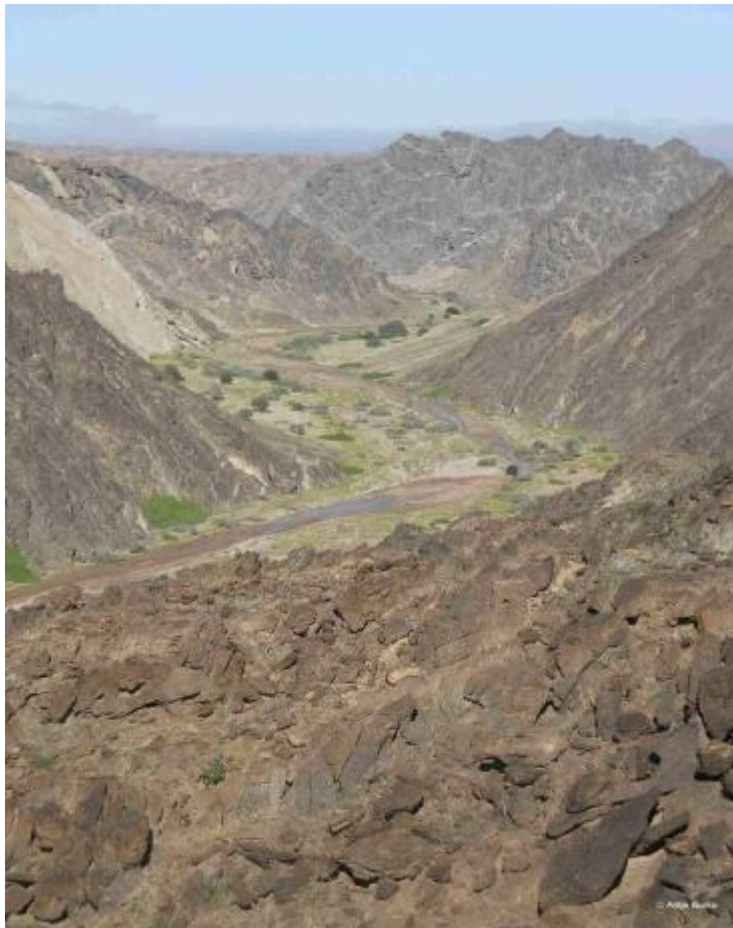
in the vegetation season to ensure optimal recording of species, populations of critical species must be protected, and transplanting of key species should be evaluated, if these cannot be avoided during the planned development.

## Research

- The biotope assessment can be further improved by including biodiversity indicators, other than plants. Particularly indicators that reflect ecological functioning and ecosystem services, e.g. process variables such as water- and nutrient cycling, are desirable to provide a more holistic biodiversity assessment. The further development of the biotope assessment could possibly draw from the proposed regional initiative to better understand ecological functions in the central Namib.
- The red-listed and/or rare annual herbs *Cleome foliosa* var. *namibensis*, *Helichrysum marlothianum* and *Lotononis tenuis* deserve particular attention in terms of sampling to improve their distribution records and thereby better assess their conservation status.

## Challenges

Adequate access to all biotopes proved the greatest challenge. Unfortunately some was man-made and, in my opinion not justified, i.e. the restriction that no camping was allowed in the study area, which resulted in a lot of time being spent travelling and losing the best part of the day for biodiversity survey work (early morning and late afternoon). In addition, access in the Khan River and adjoining mountains was also restricted because of river flow.



Many parts of the Khan River still retained water even during the last survey period in May-June, making access to these sections of the river and adjacent mountain slopes impossible.

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**Annex 1.** Endemic, red-listed, (proposed) protected and CITES plant species in the Rössing study area and their ratings (3 = highest, 1= lowest; protected and CITES species are only listed, if they were not already included as endemic or red-list species).

Endemic plant species	Range	Rating
<i>Aizoanthemum galenioides</i>	Central Namib	3
<i>Aloe namibensis</i>	"	3
<i>Cleome carnosae</i>	"	3
<i>Cleome foliosa var. namibensis</i>	"	3
<i>Aizoanthemum rehmannii</i>	Central Namib and one more region	2
<i>Anticharis ebracteata</i>	"	2
<i>Arthraerua leubnitziae</i>	"	2
<i>Calostephane marlothiana</i>	"	2
<i>Euphorbia giessii</i>	"	2
<i>Hermbstaedtia spathulifolia</i>	"	2
<i>Jamesbrittenia barbata</i>	"	2
<i>Jamesbrittenia fleckii</i>	"	2
<i>Jamesbrittenia hereroensis</i>	"	2
<i>Lithops ruschiorum</i>	"	2
<i>Lotononis bracteosa</i>	"	2
<i>Lotononis tenuis</i>	"	2
<i>Marcelliopsis splendens</i>	"	2
<i>Nolletia ericoides</i>	"	2
<i>Sarcocaulon marlothii</i>	"	2
<i>Tephrosia monophylla</i>	"	2
<i>Zygophyllum stapfii</i>	"	2
<i>Adenia pechuelii</i>	Central Namib and several other regions in Namibia	1
<i>Aizoanthemum dinteri</i>	"	1
<i>Alectra pseudobarleriae</i>	"	1

<i>Aloe asperifolia</i>	“	1
<i>Amphiasma divaricatum</i>	“	1
<i>Anticharis imbricata</i>	“	1
<i>Anticharis inflata</i>	“	1
<i>Aptosimum arenarium</i>	“	1
<i>Commiphora saxicola</i>	“	1
<i>Commiphora virgata</i>	“	1
<i>Dauresia alliarifolia</i>	“	1
<i>Euphorbia damarana</i>	“	1
<i>Euphorbia lignosa</i>	“	1
<i>Felicia smaragdina</i>	“	1
<i>Hermannia amabilis</i>	“	1
<i>Jamesbrittenia acutiloba</i>	“	1
<i>Monechma desertorum</i>	“	1
<i>Ornithogalum stapffii</i>	“	1
<i>Pavonia rehmannii</i>	“	1
<i>Pelargonium otaviense</i>	“	1
<i>Petalidium canescens</i>	“	1
<i>Polygala guerichiana</i>	“	1
<i>Psilocaulon salicornioides</i>	“	1
<i>Sesamum marlothii</i>	“	1
<i>Sesbania pachycarpa</i> subsp <i>dinteri</i>	“	1
<i>Solanum rigescentoides</i>	“	1
<i>Stipagrostis damarensis</i>	“	1
<i>Stipagrostis giessii</i>	“	1
<i>Stipagrostis hochstetteriana</i>	“	1
<i>Zygophyllum cylindrifolium</i>	“	1



<i>Commiphora ob lanceolata</i>	Near-endemic at distribution boundary	1
<b>Red-listed species</b>		
<i>Lotononis tenuis</i> <sup>1</sup>	Near-threatened	1
<b>Protected species</b>		
<i>Acacia erioloba</i>		1
<i>Aloe dichotoma</i>		1
<i>Anacampseros albissima</i>		1
<i>Combretum imberbe</i>		1
<i>Euclea pseudebenus</i>		1
<i>Faidherbia albida</i>		1
<i>Ficus cordata</i>		1
<i>Hoodia currorii</i>		1
<i>Hoodia gordonii</i>		1
<i>Lavrania sp</i>		1
<i>Maerua schinzii</i>		1
<i>Moringa ovalifolia</i>		1
<i>Ozoroa crassinervia</i>		1
<i>Parkinsonia africana</i>		1
<i>Sterculia africana</i>		1
<i>Welwitschia mirabilis</i>		1
<b>CITES species</b>		
<i>Aloe dichotoma</i> <sup>2</sup>	Cites 2	-

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<sup>1</sup> Score to be added to listing as endemic species.

<sup>2</sup> Also listed as protected species, thus no score is added.