Annex G.5

Flora Specialist Report

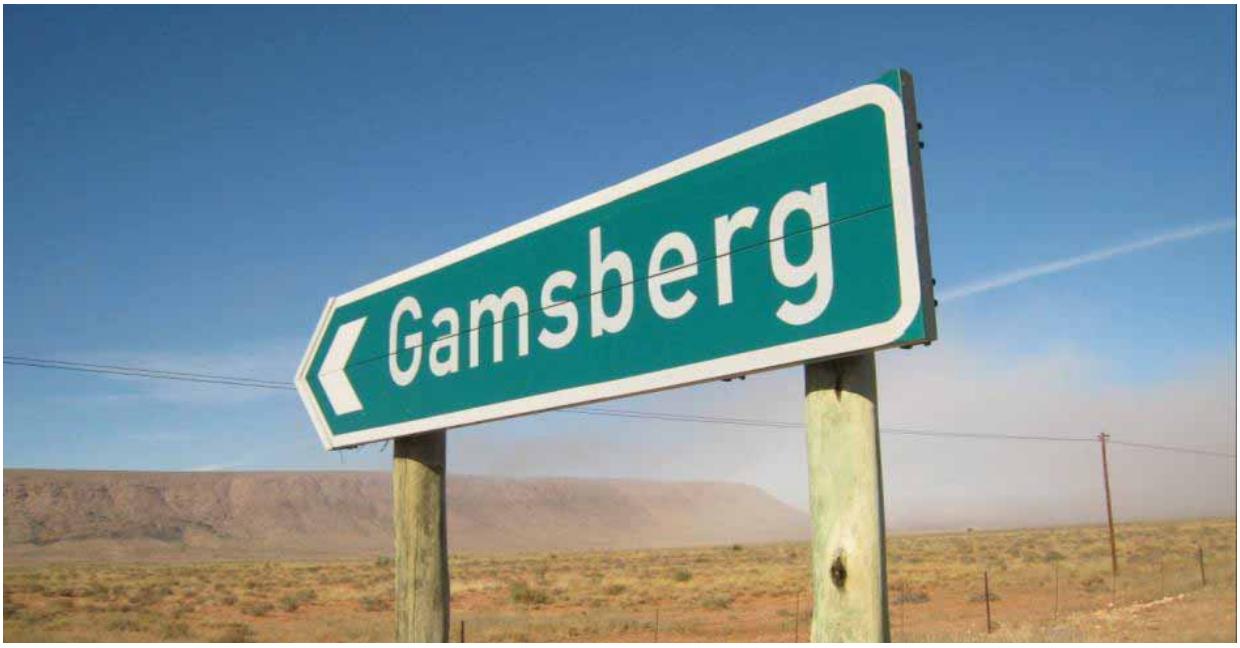
GAMSBERG ZINC PROJECT

VEGETATION BASELINE AND IMPACT ASSESSMENT REPORT

DRAFT 5

DR PHILIP DESMET

APRIL 2013



Morning fog in the Koa River valley shrouds the southern aspects of the Gamsberg (photograph: Philip Desmet)

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ABBREVIATIONS AND ACRONYMS

BCI – Bushmanland Conservation Initiative

BIR – Bushmanland Inselberg Region

CBA – Critical Biodiversity Area

PA – Protected Area

SANBI – South African Biodiversity Institute

1 DECLARATION OF INDEPENDENCE

The author of this report, Philip Desmet, does hereby declare that he is an independent environmental practioner appointed by ERM and has no business, financial, personal or other interest in the activity, application or appeal in respect of which he was appointed other than fair remuneration for work performed in connection with the activity, application or appeal. There are no circumstances that compromise the objectivity of the specialist performing such work. All opinions expressed in this report are his own.

2 SUMMARY

This report describes the baseline vegetation and impact assessment of the proposed Gamsberg mine-site located near the town of Aggeneys in the Northern Cape Province. Considerable botanical information for the area is available from previous studies and the findings of this study build on and support those made previously.

Six South African vegetation types are encountered in the study area: Aggeneys Gravel Vygieveld, Bushmanland Inselberg Shrubland, Bushmanland Inselberg Succulent Shrubland, Bushmanland Arid Grassland, Bushmanland Sandy Grassland, and Azonal vegetation. The Bushmanland Inselberg Succulent Shrubland is a new vegetation type described here to accommodate the Succulent Karoo vegetation found on south-facing slopes above 950m elevation. The Azonal vegetation type includes Kloof, Headwater Seep, Freshwater Spring, Temporary Rock Pools and Wash / Dry River habitats.

A total of 397 plant species are recorded from the study area, the highest species diversity of any inselberg in the region. Of these species 15 are assessed here as being species of conservation concern meeting criteria for threat and / or rarity. Based on the occurrence of these species and other criteria relating to habitat rarity or habitat ecological function, 11 habitats are recognised as being of conservation concern and key informants for the development constraints map. Based on regional-context data relating to biodiversity pattern and ecological process criteria the Gamsbergs is assessed as being the single most important inselberg for biodiversity in the region.

The estimated mine impact footprint or area of influence covers an area of 18717ha of which approximately 6817 ha has detectable impacts on biodiversity. The major impacts include habitat loss from mine physical footprint and acid surface water drainage, fugitive dust and groundwater drawdown. Of the 19 habitats mapped at the site one is currently assessed as being endangered. The mine impacts are predicted to be significant for 11 habitats as the impact is predicted to result in a change in their ecosystem status (2 VU, 4 EN and 5 CR). For the remaining 8 habitats there is no predicted change.

Even with extensive mitigation the residual impact of the mine given the unique biodiversity context of the site is predicted to be high and very significant. A biodiversity offset will be required for the 11 habitats and ecological processes for which the mine impact will be significant.

3 INTRODUCTION

This report contains the botanical baseline study and impact assessment for the Environmental and Social Impact Assessment (ESIA) for the Gamsberg Zinc Mine and associated infrastructure in Northern Cape, South Africa. This study was comissioned by Environmental Resources Management (Southern Africa) Pty Ltd (ERM) on behalf of the development proponent Vedanta Zinc International (PLC).

3.1 SCOPE OF STUDY

The scope of this investigation covered the affected project area comprising the mine concession area and adjacent areas (minesite) that may be impacted by the proposed Gamsberg Zinc Mine of the "northern" Gamsberg zine deposit; and, associated concentrator, waste rock dumps and tailing dams.

The study specifically EXCLUDES impacts related to:

- Non-minesite impacts resulting from the transport of ore product to port via Loop 10 and N14/7; water abstraction from the Orange River; power provision; and, worker housing.
- Future potential mining activities (underground and open pit) at the minesite related to the exploitation of the southern and eastern ore bodies.

Impacts associated with the above exclusions need to be acknowledged when considering cumulative imapcts and risk associated with this development.

The study area (minesite) is located in the Northern Cape Province of South Africa between the towns of Aggeneys and Pofadder. It includes four properties: Aroams (farm 57, 3860ha), Gams (farm 60/1, 3858ha), Gams (Farm 60/4, 5747ha) and Bloemhoek (farm 61/1, 1825ha) totalling 15290ha.

The Terms of Reference for the project include:

- Provide an overview of legislative and regulatory requirements pertaining to the loss or translocation of flora identified on site.
- Produce a fine-scale vegetation map to improve the boundary accuracy and thematic content of the current vegetation map product
- Undertake a field visit and develop a report to integrate all baseline information, including:
    - A vegetation map;
    - Identification of key flora issues;
    - A vegetation sensitivity map.
    - Produce a "biodiversity sensitivity map" that integrates all biodiversity and related environmental information (vegetation, fauna, hydrology, aesthetics, etc.) into a map(s) that rank areas based on biodiversity attributes and a clear set of quantitative or qualitative value objectives.
- Compile a botanical impact assessment report including consideration of project alternatives.
- Recommend mitigating measures to address predicted impacts

The study area is in a unique position as a considerable amount of botanical work has previously been done at the site and regionally. The previous two EIAs and the Bushmanland Conservation Initiative (BCI) generated considerable botanical

knowledge that is considered and integrated into this this report. Background baseline information includes:

- A baseline vegetation report for the western part of the Gamsberg (Anderson, 2000);
- A regional context study quantifying the floristic relationship between the Gamsberg and other inselbergs in the region (Desmet, 2000); and,
- A fine-scale vegetation map of the whole Bushmanland Inselberg Region (BIR) mapping habitat features found on the Gamsberg at a regional scale (Desmet *et al.*, 2005).

Within this context this study did not aim to duplicate these efforts, rather the focus of this study has been to:

- Gather floristic data for those parts of the study area not covered by previous studies.
- Re-interpret all existing floristic information and update the vegetation description to bring them in line with current vegetation concepts thereby allowing regional and national level comparisons to be made.
- Gather site-level information on the distribution of species of conservation concern and quantify the distribution and size of populations of some of these species.
- Assess species and habitats to identify features of conservation concern and to indicate these spatially.

4 REGULATORY AND LEGISLATIVE OVERVIEW

A summary of the relevant portions of the Acts that govern the activities and potential impacts to the environment associated with the development are listed below. Provided that standard mitigation and impact avoidance measures are implemented, not all the activities listed in the Acts below would necessarily be triggered.

National Environmental Management Act (NEMA) (Act No 107, 1998):

NEMA requires that measures are taken that "prevent pollution and ecological degradation; promote conservation; and secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development." In addition:

- That the disturbance of ecosystems and loss of biological diversity are avoided, or where they cannot be altogether avoided, are minimized and remedied:
- That a risk-averse and cautious approach is applied, which takes into account the limits of current knowledge about the consequences of decisions and actions; and
- Sensitive, vulnerable, highly dynamic or stressed ecosystems, such as coastal shores, estuaries, wetlands, and similar systems require specific attention in management and planning procedures, especially where they are subject to significant human resource usage and development pressure.

Environment Conservation Act (ECA) (No 73 of 1989 Amendment Notice No. R1183 of 1997)

This Act provides for the effective protection and controlled utilization of the environment. This Act has been largely repealed by NEMA, but certain provisions remain, in particular provisions relating to environmental impact assessments. The ECA requires that developers must undertake Environmental Impact Assessments (ESIA) for all projects listed as a Schedule 1 activity in the ESIA regulations.

National Environmental Management: Biodiversity Act (NEMBA) (Act 10 of 2004):

The National Environmental Management: Biodiversity Act (Act 10 of 2004) (NEMBA) provides for listing threatened or protected ecosystems, in one of four categories: critically endangered (CR), endangered (EN), vulnerable (VU) or protected. The Draft National List of Threatened Ecosystems (Notice 1477 of 2009, Government Gazette No 32689, 6 November 2009) has been gazetted for public comment. The list of threatened terrestrial ecosystems supersedes the information regarding terrestrial ecosystem status in the NSBA 2004. In terms of the ESIA regulations, a basic assessment report is required for the transformation or removal of indigenous vegetation in a critically endangered or endangered ecosystem regardless of the extent of transformation that will occur.

The Act also provides for listing of species as threatened or protected, under one of the following categories:

- **Critically Endangered:** any indigenous species facing an extremely high risk of extinction in the wild in the immediate future.
- **Endangered:** any indigenous species facing a high risk of extinction in the wild in the near future, although it is not a critically endangered species.
- **Vulnerable:** any indigenous species facing an extremely high risk of extinction in the wild in the medium-term future; although it is not a critically endangered species or an endangered species.
- **Protected species:** any species which is of such high conservation value or national importance that it requires national protection. Species listed in this category include, among others, species listed in terms of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).

NEMBA also deals with endangered, threatened and otherwise controlled species, under the TOPS Regulations (Threatened or Protected Species Regulations). These regulations deal with the hunting industry as well as any other activities, which involve the cultivation, keeping or impacting listed species. A permit is required for any listed activities involving protected or endangered species. These permits are usually administered by the provincial authorities and may take the form of an Integrated Permit, which covers both the provincial and national TOPS requirements.

Apart from the TOPS regulations NEMBA also provides for the regulation of certain activities, known as Restricted Activities. These activities may not proceed without environmental authorization. Those relevant to the current study are listed below.

Under the **Environmental Impact Assessment Regulations Listing Notice 1 of 2010** (No. R.544) the following activities are likely to be triggered:

Activity 1. The construction of facilities or infrastructure, including associated structures or infrastructure, for –

(k) the bulk transportation of sewage and water, including storm water, in pipelines with -

(i) an internal diameter of 0,36 meters or more; or

(ii) a peak throughput of 120 liters per second or more;

(l) the transmission and distribution of electricity above ground with a capacity of more than 33 kilovolts and less than 120 kilovolts;

(m) any purpose in the one in ten year flood line of a river or stream, or within 32 meters from the bank of a river or stream where the flood line is unknown, excluding purposes associated with existing residential use, but including -

(i) canals;

(ii) channels;

(iii) bridges;

(iv) dams; and

(v) weirs;

Activity 11 (Xi): The construction of infrastructure or structures covering 50 square meters or more where such construction occurs within a watercourse or within 32 meters of a watercourse, measured from the edge of a watercourse, excluding where such construction will occur behind the development setback line.

Under the **Environmental Impact Assessment Regulations Listing Notice 2 of 2010** (No. R.387) the following activities are likely to be triggered:

Activity 2. Any development activity, including associated structures and infrastructure, where the total area of the developed area is, or is intended to be, 20 hectares or more.

And, under **Environmental Impact Assessment Regulations Listing Notice 3** of 2010 (*R.546):*

Activity 12. The clearing of an area of 300 square meters or more of vegetation where 75% or more of the vegetation cover constitutes indigenous vegetation:

(b) Within critical biodiversity areas identified in bioregional plans

Activity 13. The clearing of an area of 1 hectares or more of vegetation where 75% or more of the vegetation cover constitutes indigenous vegetation:

(a) Within critical biodiversity areas and ecological support areas as identified in systematic biodiversity plans adopted by the competent authority.

Activity 16 IV: The construction of infrastructure covering 10 square meters of more where such construction occurs within a watercourse of within 32 meters of a watercourse measured from the edge of the watercourse, excluding where such construction will occur behind the development setback line. Within:

It is important to note that the above thresholds and activities also apply to phased developments "*where any phase of the activity may be below a threshold but where a combination of the phases, including expansions or extensions, will exceed a specified threshold."*

National Forests Act (No. 84 of 1998):

The National Forests Act provides for the protection of forests as well as specific tree species, quoting directly from the Act: "*no person may cut, disturb, damage or destroy any protected tree or possess, collect, remove, transport, export, purchase, sell, donate or in any other manner acquire or dispose of any protected tree or any forest product derived from a protected tree, except under a license or exemption granted by the Minister to an applicant and subject to such period and conditions as may be stipulated".*

Protected trees that will be affected by the development include *Acacia erioloba* and *Boscia albitrunca.*

Conservation of Agricultural Resources Act (Act 43 of 1983):

The Conservation of Agricultural Resources Act provides for the regulation of control over the utilization of the natural agricultural resources in order to promote the conservation of soil, water and vegetation and provides for combating weeds and invader plant species. The Conservation of Agricultural Resources Act defines different categories of alien plants and those listed under Category 1 are prohibited and must be controlled while those listed under Category 2 must be grown within a demarcated area under permit. Category 3 plants includes ornamental plants that may no longer be planted but existing plants may remain provided that all reasonable steps are taken to prevent the spreading thereof, except within the floodline of water courses and wetlands.

The abundance of alien species at the site is generally very low. Of concern is the presence of the tree *Prosopis glandulosa* in washes and dry-river beds, and the perennial grass *Pennisetum setaceum* in and around Aggeneys (see Section 12.4.1).

Northern Cape Nature Conservation Act, No. 9 of 2009:

The Northern Cape Nature Conservation Act provides inter alia for the sustainable utilization of wild animals, aquatic biota and plants as well as permitting and trade regulations regarding wild fauna and flora within the province. The Act also lists protected fauna and flora under 3 schedules ranging from Endangered (Schedule 1), Protected (schedule 2) to Common (schedule 3). The majority of mammals, reptiles and amphibians are listed under Schedule 2, except for listed species, which are under Schedule 1. A permit is required for any activities, which involve species listed under Schedule 1 or 2. Of relevance for the current development is the fact that several plant families and genera are listed in their entirety as protected, this includes, inter alia *Mesembryanthemaceae*, *Amaryllidaceae*, *Apocyanceae*, *Asphodeliaceae*, *Crassulaceae*, *Iridaceae* and *Euphorbia*. A permit obtainable from the DENC permit office in Kimberly would be required for the site clearing. A permit would also be

required to destroy or translocate any nationally or provincially listed species from the site. A single integrated permit, which covers all of these permitting requirements as well as meets ToPS regulations, is used.

Species listed in terms of this act are not considered in this report (Section 9.1). The criteria for identifying listed species in terms of this act are too broad and do not follow an explicit and objective framework similar to the threatened species criteria. Approximately one third of the species occuring at the site qualify as listed in terms of this act.

5 METHODOLOGY

5.1 DATA SOURCING AND REVIEW

Information on the local and regional distribution of plants in the BIR is contained in the "Gamsberg Database" created and mainained by the author. This database contains all point and releve plant distribution data eminating from the local- and regional- studies associated with the Gamsberg and Bushmanland Conservation Iniative since 1998 (Anderson 2000, Desmet 2000a&b, Desmet *et al.* 2005, Desmet 2006, Desmet 2010). All observation data gathered during the fieldwork associated with this project were added to this database. Collectively this database represents approximately 60 days of botanical sampling at the minesite since 1998. This database provides a comprehensive and accurate point-locality-level datasets with which to assess the flora of the minesite.

Additional quarter degree square regional context species distribution data was obtained from SANBI's PRECIS herbarium record database at http://sibis.sanbi.org

The vegetation map is based on the Anderson (2000), Desmet *et al.* (2005) and Desmet (2010) vegetation maps. Modifications were made based on field observations and new high-resolution satellite imagery obtained for this project (Worldview 60cm 2012).

The classification of vegetation units at the site follows a hierachical classification that is nested within the Mucina and Rutherford (2006) South African vegetation types. Mapped fine-scale habitat units are nested within South African vegetation types therefore all areas in the landscape can be related to the national vegetation classification system.

5.2 SAMPLING LIMITATIONS AND ASSUMPTIONS

The Gamsberg is located in an arid landscape. The flora is adapted to long periods of drought and episodic rainfall. Also, the flora is composed of elements quewed to the summer and winter rainfall cycles that intersect in the region. Most species are fairly plastic in terms of their growth and flowering period to be able take advantage of this variable rainfall. Consequently, obtaining a complete understanding of the sites complex and diverse flora requires time and continual sampling.

The Gamsberg site has been the focus of botanical investigation for at least the past 15 years yet still there are species new to the site being discovered. There are other species that have been seen only once in 15 years. In recent years both 2009 and 2012 field surveys were conducted in drought years, which was not conducive to botanical survey.

The long history of local- and reigonal-scale botanical sampling as well as the regional fine-scale vegetation mapping offset the limitations imposed by field sampling during the narrow time-period imposed by this project. Therefore, despite the extreme sampling limitations imposed by the environment of the site we are in a good position to make defendable value statements about the sites biodiversity.

Assumptions regarding the impact assessment are discussed in Section 12.2

5.3 Site Visit

Given the depth of existing botanical knowledge of the site a detailed sites visit was not required. The site was visited for 2 days in August 2012 with the primary focus being to fill data gaps identified by Desmet (2010). Specific activities included:

- Continue to survey calcrete gravel-patch specialist plant populations to gain a better understanding of the size and distribution of these species within the study area and region.
- Gather point locality species observation records for known species of conservation concern or species believed to be new to the site and habitats of conservation concern overlooked in previous studies.
- Assess the accuracy and refine the Desmet (2010) vegetation map with a particular focus on the habitats of special concern that have only been mapped from imagery and that have not physically been visited.

Four days was also spent in August 2012 visiting sites elsewhere in the BIR to continue gathering data on the regional distribution of plants and vegetation encountered on the Gamsberg.

5.4 Sensitivity Mapping & Assessment

Species were categorised as Species of Conservation Concern based on their regional rarity, site endemism or Threatened Species Status. The provincial Nature Conservation Ordinance (Act 9 of 2009) and the Forestry Act (Act 84 of 1998) schedules of protected species were not used as criteria for identifying species of conservation concern. The criteria used to identify these species are outdated and superceded by the current threatened species criteria and assessment.

Information on the Threatened Status of species was obtained from http://redlist.sanbi.org.

Habitats in the vegetation map were classified as Habitats of Conservation Concern based on the presence of Species of Conservation Concern, regional rarity or ecological process value. Habitats of Conservation Concern form the basis for the identification of sensitive areas within the minesite.

Areas mapped as Critical Biodiversity Area (CBA) as defined in the Namakwa District Bioregional Plan (Marsh *et al.* 2009) were also considered. Habitats of Conservation Concern are in essence the CBA's as reflected in the CBA map. The regional biodiversity corridor network provides useful context for the location of imporant ecological processes in the landscape. Information on CBAs was obtained from http://bgis.sanbi.org.

The location of protected area development zones has not been considered in this report. The Bushmanland Inselberg Region has been earmarked since the 1990s for

protected area development given the important biodiversity associated with the region. The National Protected Area Expansion Strategy (Jackelman *et al.* 2007) identifies this region as a national priority area and Desmet (2000a) provides a draft protected area design for the region that encompasses the core inselbergs around Aggeneys and the Koa River valley as well as linkages down to the Orange River.

The impact assessment methodology follows the standard ERM assessment protocol for ESIAs.

5.5 ALTERNATIVES CONSIDERED IN THE ASSESSMENT

Proposals for changing the mine and associated infrastructure layout to avoid sensitive habitats have been incorporated into the final design. For this reason, no alternative development proposals are considered in this report. With the design of the proposed mine layout plan the proponent has considered the existing botanical sensitivity information thereby avoiding where possible known sensitive areas in the landscape. A detailed description on how alternative mine layout options were considred to avoid areas of high botanical sensitivity is included in the ESIA report.

The underground versus open pit mining options are not considered here as underground was not considered as a viable economic option.

6 REVIEW OF PREVIOUS BOTANICAL WORK

There are several studies and reports that have direct relevance to the current project:

- Anderson (2000) is the original specialist botanical study done for the first EIA. This was a thorough study involving 32 days of fieldwork. The results of this study still hold but can be updated to include more recent information as well as update species names and vegetation concepts that have changed since this study was conducted. This document provides an excellent introduction to the national context for the Gamsberg and its importance in the Succulent Karoo as well as globally as a unique site for biodiversity. This study only covered the western half of the Gamsberg and the plains south of the N14 and not the entire study area as it is currently defined.
- During the first EIA process additional work was conducted by Anderson in the area north of the N14 when the proposed site for the tailings dam was moved to this area. A site visit was made to this area however this information is not contained in the Anderson (2000) report. Apparently this information is contained in Appendix D! to the Tailings Dam relocation amendment report.
- The regional and local context of the Gamsberg is quantified by Desmet (2000b). This was a specific regional context study that came about as a result of the preliminary findings of Anderson (2000) was well as requests from I&APs involved in the first EIA. The method focused primarily on comparing the occurrence of succulent plants between inselbergs in the Bushmanland Inselberg Region using these as indicator group of the broader trends in biodiversity in the region. Complete plant species information was only collected for a subset of the total number of inselbergs sampled. Limitations of the study include that it did not consider fauna nor did it sample over multiple time periods.

- The initial EIA research was followed by the Bushmanland Conservation Initiative (BCI). This conservation program funded by the Critical Ecosystem Partnership Fund through the Botanical Society of South Africa worked with Black Mountain mine to secure a biodiversity stewardship agreement with the mine to safeguard the biodiversity and proactively manage the Anglo American land holdings both at Black Mountain and the Gamsberg. Much of the spatial and other biodiversity information gathered, generated and collated as part of the BCI is summarized in Desmet et al. (2005). This work compliments and expands upon that of Anderson (2000) and Desmet (2000b). There is a large amount of useful spatial information in the dataset that accompanies this document. Of key importance to land use planning is the vegetation map and the associated sensitive area or land use zone classification. This map was the foundation on which the land use management zones were developed for the Black Mountain Biodiversity Action Plan.
- Black Mountain Biodiversity Action Plan (BAP) is a useful introduction document to the biodiversity of the Anglo land holdings at Aggeneys and Gamsberg. This document also contains a useful land use zoning plan and guidelines for the area based on the work done by the Bushmanland Conservation Initiative. The 2008 revision of the BAP that is available to this project does not appear to include a lot of the detail that could potentially be contained in the first version of the BAP prepared in 2005. The two documents need to be read in conjunction with each another. This document does contain useful land use planning zones and management guidelines that should be incorporated into the current EIA and mine planning process. The land use zones are based on the vegetation map for the area prepared by the author as part of the BCI project (see Desmet *et al.* 2005)
- The report by Desmet (2006) discusses the results of a field mapping exercise on the eastern plateau of the Gamsberg aimed at better mapping the extent of the fine-grained quartz patches that occur there. Regionally, these are the rarest plant habitats and are also home to many of the range restricted plants that the Gamsberg is renowned for. The existing vegetation map has not been updated with the spatial information gathered during this mapping exercise.
- SANBI's SIBIS web site (http://sibis.sanbi.org) whilst not directly related to the Gamsberg or Bushmanland provides an online portal to SANBI's PRECIS quarter-degree square herbarium specimen database. This information is invaluable in being able to assess the conservation importance of species recorded from the site through information such as number of existing collections (rarity), range size and threatened species status.

There are several other reports that are not relevant to this vegetation report but do place the site in a regional context from a **land use planning** perspective and could provide useful context information for mine-site planning. These documents include:

- Desmet (2000a) that presents a proposal for the development of a new national park centered on the Bushmanland inselbergs. This idea is still finding traction and has been incorporated into the vision for the tourism development of the lower Orange River valley (Cronwright and Desmet 2008).

- Marsh et al (2009) is the draft biodiversity sector plan document for the Namakwa District Municipality that provides guidance on appropriate land use based on the known distribution of biodiversity.
- Yates and Botha (2006) presents the BCI conservation vision for the BIR. This report contains sensitive information and permission will be required from BOTSOC to access this report.

The existing botanical information available for the Gamsberg provides a good basis for describing the vegetation, and assessing the local, regional and national context of the site. It also allows us to make an informed assessment of the significance of the proposed impacts. The most important existing information layers that have been added to in this project are:

1. The BCI fine-scale vegetation map (Desmet *et al.* 2005) mapped the vegetation for the entire BIR at a relatively fine-scale therefore it is possible to quantify at the level of the habitats discussed here the percentage of the global extent of a feature that falls within the study area. The fine-scale vegetation map is complemented by SANBI's national vegetation map that gives an indication of the global extent of vegetation types that are not endemic to the BIR.
2. The species distribution database (Gamsberg Database, Desmet unpublished data) contains all species occurrence records (relevé and point observations) for the BIR from all previous botanical studies relating to the Gamsberg EIA1 and BCI projects. This allows one to quantify at the species level the global extent of species of conservation concern that occur in the study area. The species distribution database is complimented by the SIBIS website.

The limitations of the existing information base with particular reference to the study site include:

- The eastern Gamsberg and areas north of the N14 were not considered, or were partly considered, in the original EIA.
- Information is located in several documents and needs to be integrated into a single document and updated to be in line with current vegetation concepts.

7 DESCRIPTION OF THE AFFECTED ENVIRONMENT-BASELINE

7.1 BROAD-SCALE VEGETATION PATTERNS (BIOGEOGRAPHICAL CONTEXT)

Anderson (2000) and Desmet (2000) provide a detailed introduction to biogeographical context of the study area. Only a brief summary is provided here for the benefit of readers not familiar with these reports.

The Gamsberg lies at the heart of what is termed the "Bushmanland Inselberg Region" (BIR). This region includes all the large, quartzite-capped inselbergs located in the northern Bushmanland plains in South Africa covering an area of about 6300km^2 (Figure 1). These inselbergs are distributed in an east-west line marking approximately the southern edge of the Orange River valley. A feature of all these inselbergs is their relatively flat, quartzite-capped plateaus and associated quartzite

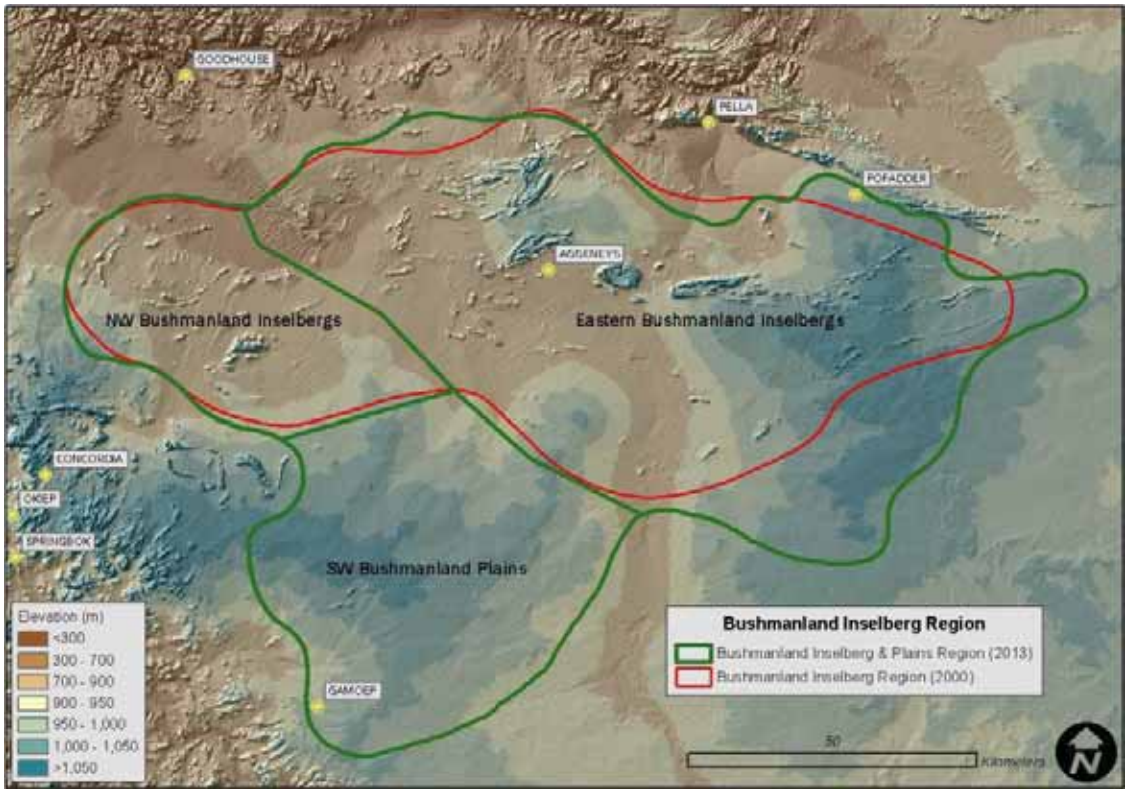
rock/boulder covered scree-slopes and aprons. The richness and diversity of the flora is dramatically associated with the presence of quartzite rock. The "BIR and plains region" (Figure 1) includes the Bushmanland plains as far south as Gamoep. The plains in the south-west shares flora affinities with the plains around the core area (e.g. *Ihlenfeldtia excavata, Conophytum calculus subsp. vanzylii, Titanopsis hugo-schlecterii*). The BIR boundary in the east is defined by the distribution of the Aggeneys Gravel Vygieveld vegetation types. This vegetation type is endemic to the BIR and its distribution is strongly linked to the influence of winter rainfall. The BIR could be regarded as that area of Bushmanland significantly under the influence of the winter rainfall climate.

The BIR is located on the boundary between winter and summer rainfall systems of southern Africa. The vegetation of the plains and warmer north-facing aspects is characteristic of the Nama Karoo Biome whereas that of cooler higher-elevation plains and south-facing aspects is characteristic of the Succulent Karoo Biome. The overlap of two biomes is a unique feature of the BIR flora and sets these inselbergs apart from other inselbergs elsewhere in the Nama Karoo.

Most rainfall arrives in the form of thunderstorms in late-summer/autumn and averages 70mm/year. The moisture regime of the inselbergs is augmented by fog during winter months coming from valley fog associated with the Koa River valley (see title page picture) or low cloud from passing winter cold fronts. Therefore, the vegetation of the inselbergs is adjusted to a narrow growth period from about February to May accommodating the grown requirements of both summer and winter rainfall species. The low annual rainfall; erratic timing of rainfall events; occurrence of fog; and, the availability of moisture in the late summer through autumn period are important determinants of the flora allowing both summer and winter rainfall floras to co-exist which in part contribute to the uniqueness of the BIR.

The flora of these inselbergs forms a distinct centre of plant endemism located within the larger Eastern Gariep Centre of Endemism. The Eastern Gariep Centre of endemism encompasses the arid Orange River valley between Vioolsdrif and Pofadder/Onseepkans. Although geographically close (<50km), the large mountains of the Orange River valley such as Pella Berg and Dabenoris are floristically distinct housing many Eastern Gariep endemics that do not occur outside the valley on the comparatively cooler Bushmanland inselbergs. There are many species endemic to the Bushmanland Inselbergs and the BIR in itself defines a distinct centre of endemism termed the "Bushmanland Inselberg Centre of Endemism" or sometimes the "Gamsberg Centre of Endemism" as this inselberg lays at the floristic centre of this region and also drawing attention to the fact that the endemism is associated with the inselbergs and not the sandy Bushmanland plains that comprise 90% of the region.

FIGURE 1: THE EXTENT OF THE BUSHMANLAND INSELBERG REGION (BIR) AS UPDATED FOR THIS STUDY.



The Bushmanland inselbergs effectively comprise an archipelago of rocky "islands" within a "sea" of sand. These "islands" share common floristic affinities but show distinct east-west and north south gradients in species turnover and population-level variation. The surrounding sandy plains form a continuous vegetation fabric that is widespread beyond this region. The inselbergs have almost no floristic affinities with the vegetation on the surrounding sandy plains – chalk and cheese!

The inselbergs at the core of the BIR are of significant conservation importance:

- The Gamsberg is the largest inselberg located in the center of a "Centre of Endemism" that includes the major inselbergs of (from east to west) Namies, Achab, Gamsberg, Aggeneyseberg, Witberg, Haramoep and Wortel. These inselbergs define the core area of the Bushmanland Inselberg Region.
- Relative to the surrounding sandy plains, and other world deserts, the inselbergs and associated rocky plains have very high levels of species diversity.
- Many species are range restircted being associated with specific regionally rare habitats mainly different types of gravel patches, namely quartz, calcrete and feldspar.
- Some of the azonal habitats assicated with the inselbergs such as the kloofs and freshwater springs are regionally very rare features and fulfil vital ecological process functions such as providing climate change refuges.
- The Gamsberg is the largest inselberg in Bushmanland and has the greatest diversity of habitats of conservation concern, the largest extent of these habitats and also the highest number of species compared to all other inselbergs in the BIR.

7.2 Fine-Scale Vegetation Patterns

This section provides an overview of the vegetation of the study area based on the current and previous vegetation studies. A challenge presented here is the re-interpretation and integration of the previous work into a harmonious hierarchical vegetation framework that nests within the current national vegetation type classification. This is important as criteria for assessing conservation importance of vegetation features such as Ecosystem Status (SANBI, 2008), relate to national vegetation units.

The Anderson (2000) vegetation descriptions used broad habitats as the basis for describing the vegetation. Desmet (2005) used a combination of broad habitats and what could be considered vegetation sub-types. Both of these approaches have been integrated here into a single framework using national vegetation types subdivided into broad habitats. Interpretation and description of vegetation concepts (e.g. communities, habitats, vegetations types or sub-types) change in time as the vegetation knowledge-base (e.g. new point species observations and relevé sample plots, better habitat mapping, new literature published, etc.) grows. Therefore the description of vegetation types or habitats presented here does differ from that presented by Anderson (2000) or Desmet et al (2005); however, the underlying species-level data remain valid. Interpretation of feature conservation significance may change though in the light of new data; for example, if a species threatened status is updated; a species is split into two new species changing the rarity status of one or both of the new species; or, better mapping allows for an improved assessment of a habitats global distribution.

A total of 397 plant species are recorded from the study area. This is an increase of 18% on the 337 recorded in the 2000 EIA (Anderson 2000). These species are found in six South African vegetations types that are recorded in the study area. Four of these are established vegetation types described in Mucina and Rutherford (2006). The fifth vegetation type, Bushmanland Inselberg Succulent Shrubland is new and is described here for the first time. This has been done to better accommodate the vegetation on the upper (>950m) south-facing slopes of the Gamsberg. The format for the descriptions of vegetation units follows that of Mucina and Rutherford (2006). Where endemic species are listed these are species endemic to the vegetation type but which are recorded from the study area.

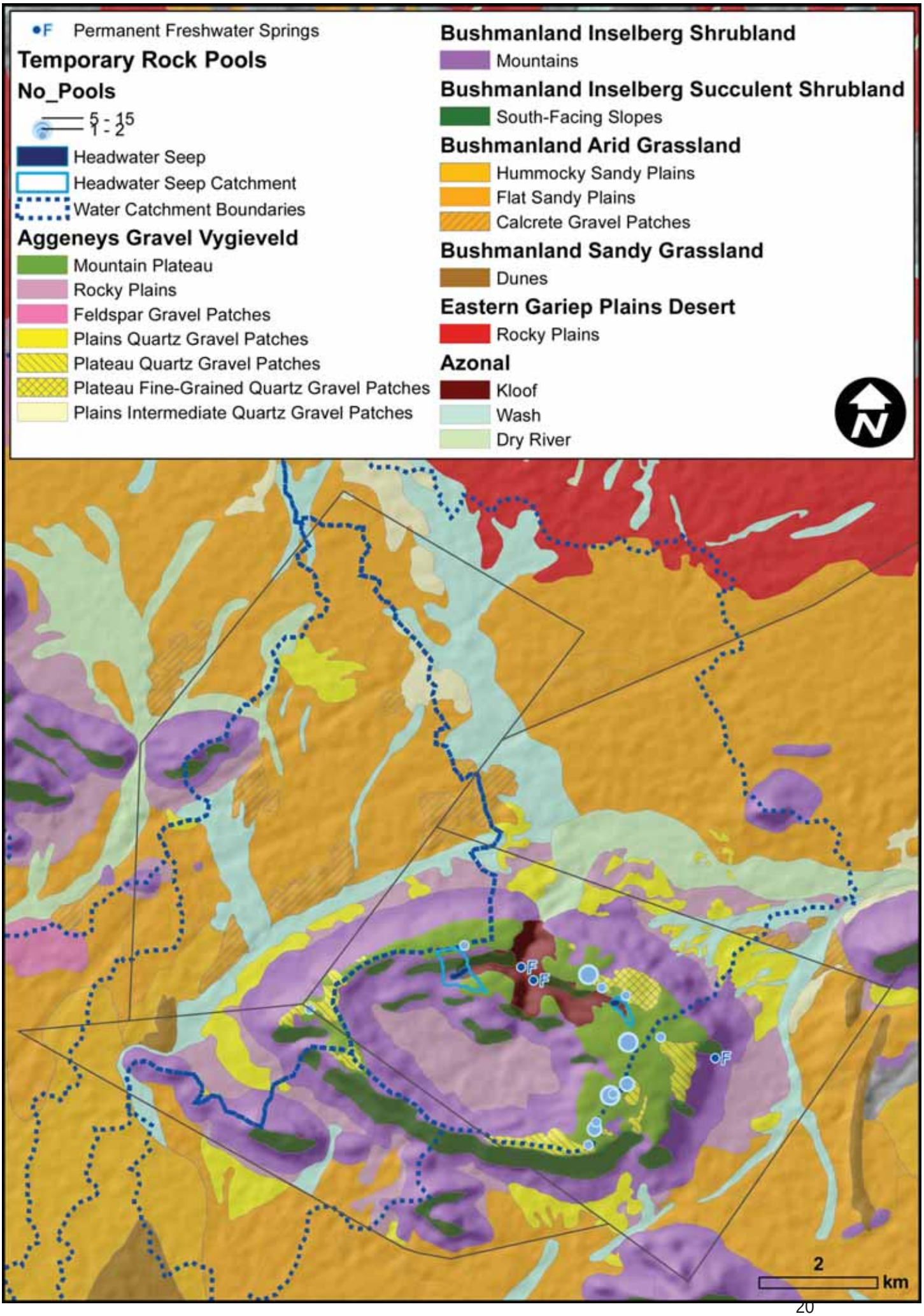
The vegetation map presented here is based on that produced for the BCI project by Desmet (2005) (Figure 2). This map has been updated to include the new vegetation type described but no other editing has been attempted due to lack of higher resolution aerial imagery. For the present this is not necessary, but for mine planning more accurate mapping of important biodiversity features will be necessary.

TABLE 1: A SUMMARY OF THE VEGETATION TYPES AND HABITAT UNITS ENCOUNTERED WITHIN THE STUDY AREA.

SA Vegetation Type	Habitat Unit
Aggeneys Gravel Vygieveld	Mountain plateau
	Plateau quartz gravel (includes "fine-grain" patches)
	Plains quartz gravel (includes "intermediate" patches)
	Plains feldspar gravel
	Plains rocky

Bushmanland Inselberg Shrubland	
Bushmanland Inselberg Succulent Shrubland	
Bushmanland Arid Grassland	Flat sandy plains
	Hummocky sandy plains
	Calcrete gravel plains
Azonal Habitats	Kloof (Watershed model)
	Wash
	River (Wash with subsurface flow)
	Headwater Seep Wetlands (Catchment)
	Permanent Freshwater Springs
	Temporary Rock Pools

FIGURE 2 (FOLLOWING PAGE): THE VEGETATION OF THE GAMSBERG BASED ON THE BCI VEGETATION MAP AND ADAPTED BY THIS PROJECT. ALSO INDICATED IS THE LOCATION OF OBSERVED ROCK (VERNAL) POOLS AND PERMANENT FOUNTAINS.


F Permanent Freshwater Springs
Temporary Rock Pools
No_Pools
5 - 15
1 - 2
Headwater Seep
Headwater Seep Catchment
Water Catchment Boundaries
Aggeneys Gravel Vygieveld
Mountain Plateau
Rocky Plains
Feldspar Gravel Patches
Plains Quartz Gravel Patches
Plateau Quartz Gravel Patches
Plateau Fine-Grained Quartz Gravel Patches
Plains Intermediate Quartz Gravel Patches
Bushmanland Inselberg Shrubland
Mountains
Bushmanland Inselberg Succulent Shrubland
South-Facing Slopes
Bushmanland Arid Grassland
Hummocky Sandy Plains
Flat Sandy Plains
Calcrete Gravel Patches
Bushmanland Sandy Grassland
Dunes
Eastern Gariep Plains Desert
Rocky Plains
Azonal
Kloof
Wash
Dry River
N
F
F
F
2
km

7.2.1 Aggeneys Gravel Vygieveld

Synonyms: VT 33 Namaqualand Broken Veld (92%) (Acocks 1953); LR 51 Orange River Nama Karoo (83%) (Low & Rebelo 1996)

Regional Distribution: Northern Cape Province: plains above 950m and plateau summits of inselbergs and koppies centred on Aggeneys including the major BIR inselbergs (Namies, Achab, Gamsberg, Aggeneysseberg, Witberg, Haramoep and Naip) and the rocky plains on Rosynebos. The regional extent of the vegetation types is approximately 16 200ha with 1556ha (9.6% of region) occurring in the study area. This vegetation units is subdivided into six habitat types, four of which occur in the study area: mountain plateaus (1790ha regionally, 583ha (32.6%) in the study area); quartz gravel plains (7800ha regionally, 600ha (7.7%) in the study area), plateau quartz gravel plains (507ha regionally, 208ha (41.2%) in the study area); and, intermediate quartz gravel plains (1340ha regionally, 163ha (12.2%) in the study area.

Study Area Distribution: Primarily on the plateau of the Gamsberg and the rocky apron or peneplain surrounding it (Figure 2).

Mapped Habitat Units: Six habitat units are mapped: four that occur in the study are mountain plateau and quartz, quartz plateau and quartz intermediate gravel patches. Two that occur to the east of the study area include feldspar gravel patches and rocky plains.

Vegetation: Sparse, low-growing vegetation with the perennial component dominated by small to very small succulent plants. Trees and grasses are generally absent or have low abundance and are confined to drainage lines. Large succulent species (e.g. *Aloe garipensis* or *Euphorbia avasmontana*) are generally absent. Vegetation composition is variable depending on habitat type but there is a strong Succulent Karoo affinity to this vegetation and the diversity of small/dwarf succulent plant species is distinctive. Two major habitat types are encountered in this vegetation unit: (1) Rocky plains is the basic habitat that characterises this vegetation type comprising a dense covering of pebbles and small to large mostly rocks on gentle slopes at elevations greater than approximately 950m on peneplains associated with the larger inselbergs or on the plateaus of inselbergs. The plateau rock plain occurs in the study area. The plains form does not occur in the study area only on plains to the east of the study area (see the notes section for discussion on the vegetation classification of rocky plains in the study area). The rocky plains of the mountain plateau is structurally very similar to the rocky plains except it is confined to the flat summits of the major inselbergs and floristically there are a number of elements confined to this habitat. (2) Gravel patches constitute the other major habitat type making-up this vegetation type. Four gravel plains types have been mapped: plains, plateau and intermediate quartz gravel patches, and feldspar gravel patches. Previously calcrete gravel patches were included here but reassessment of the floristic data suggests that they are better included in the Bushmanland Arid Grassland vegetation type. The surface of quartz gravel patches are characterised by a fairly uniform and dense layer (lag) of small quartz pebbles with rock and boulders absent or in low density. Quartz patches can be divided into plateau patches or fine-grained quartz patches with a dense pebble covering of often very small (<5mm diameter) and brilliant white pebbles. Plains quartz patches occur mainly on the lower foot slopes of larger inselbergs; and, intermediate patches appear physically

similar to the other quartz patches but are devoid of any of the characteristic plant species. Quartz gravel patches are always found in association with quartz or quartzite rocks. In contrast feldspar gravel patches are associated with the pink gneiss of the Hoogoor geological group and feldspar pebbles are the dominant lag pebble on the surface. This habitat occurs on the plains just east of the study area in the Rosynebos area and is not encountered in the study area.

Common Taxa: *Acanthopsis hoffmannseggiana, Aizoon asbestinum, Albuca spiralis, Aloe dichotoma, Anacampseros baeseckei, Anacampseros karasmontana, Aptosimum spinescens, Aristida adscensionis, Avonia papyracea subsp. papyracea, Avonia quinaria subsp. alstonii, Barleria rigida, Berkheya spinosissima subsp. spinosissima, Boscia foetida subsp. foetida, Brownanthus ciliatus, Brunsvigia comptonii, Ceraria fruticulosa, Chlorophytum sp., Conophytum maughanii subsp. maughanii, Cotyledon orbiculata var. orbiculata, Crassula alstonii, Crassula columnaris subsp. prolifera, Crassula corallina subsp. macrorrhiza, Crassula deltoidea, Crassula muscosa var. muscosa, Crassula sericea var. sericea, Dicoma capensis, Digitaria eriantha, Dinteranthus microspermus subsp. puberulus, Drosanthemum cf. breve, Drosanthemum hispidum, Drosanthemum karooense, Enneapogon scaber, Eragrostis annulata, Eriocephalus ambiguus, Euphorbia gariepina, Euphorbia gregaria, Felicia muricata, Galenia fruticosa, Gazania lichtensteinii, Helichrysum pumilio subsp. pumilio, Hereroa bergeriana, Hereroa puttkameriana, Hermannia dismerifolia, Hermannia stricta, Hermbstaedtia glauca, Hirpicium echinus, Hypertelis salsoloides, Kleinia longiflora, Lapeirousia plicata, Lavrania marlothii, Limeum aethiopicum subsp. namaense var. lanceolatum, Lithops olivacea var. olivacea, Microloma incanum, Monechma spartioides, Ornithogalum pruinosum, Osteospermum armatum, Osteospermum scariosum, Othonna protecta, Othonna sedifolia, Oxalis eckloniana var. eckloniana, Pegolettia retrofracta, Pelargonium spinosum, Pentzia argentea, Phyllobolus latipetalus, Piaranthus decorus subsp. cornutus, Psilocaulon coriarium, Psilocaulon subnodosum, Pteronia cf. unguiculata, Pteronia mucronata, Quaqua mammillaris, Rhus undulata, Ruschia divaricata, Ruschia griquensis, Ruschia muricata, Salsola aphylla, Sarcocaulon crassicaule, Sarcostemma viminale, Senecio radicans, Sericocoma avolans, Stipagrostis obtusa, Tetragonia reduplicata, Trachyandra cf. jacquiniana, Tripteris microcarpa subsp. microcarpa, Tylecodon reticulatus subsp. phyllopodium*

Important Taxa: See habitat descriptions below.

Endemic Taxa: *Adromischus nanus, Conophytum angelicae subsp. angelicae (plateau form), Conophytum calculus subsp vanzylii, Conophytum praesectum, Conophytum ratum (both forms), Dinteranthus microspermus subsp. puberulus, Mesembryanthemum inachabense, Trachyandra sp. nov*. Other known endemics to this vegetaiton type that occur nearby but DO NOT occur at this site include: *Conophytum achabense, Conophytum burgeri, Conophytum friedrichiae, Conophytum lydiae, Dinteranthus vanzylii var. lineata, Dinteranthus vanzylii var. vanzylii, Lapidaria margaretae, Lithops olivacea var. nebrownii.*

Notes: The rocky plains around the base of the Gamsberg have been classified here as Aggeneys Gravel Vygieveld despite them lying below 950m.a.s.l.. Floristically there is a continuum between what can be called Aggeneys Gravel Vygieveld and what can be called Bushmanland Inselberg Shrubland because they occur on the same substrate but at different elevations or aspects. Vegetation with Succulent Karoo affinities favour the cooler higher elevation with a strong winter precipitation element (i.e. fog from the Koa valley) and an autumn/spring growth peak whereas Nama Karoo vegetation favours warmer lower elevation plains and aspects and have a late summer growth peak. For the purposes of vegetation mapping a line has to be drawn somewhere, and the 950m contour in the Aggeneys area is a reasonable approximation of the ecotone on the plains between the two vegetation types.

Around the Gamsberg, however, the Aggeneys Gravel Vygieveld on the rocky plains around the inselberg extends below the 950m ecotone. This might be due to the mass of the Gamsberg acting as moisture-trap by attracting low cloud and fog thereby increasing precipiation on the plains immdeiately adjacent to the mountain.

Floristically and structurally this vegetation type can be considered a true Succulent Karoo vegetation type and thus, in conjunction with that found on the steep southern slopes of the larger inselbergs (Bushmanland Inselberg Succulent Shrubland), forms the eastern most extent of the Succulent Karoo biome in Bushmanland. Therefore this is a very interesting vegetation unit from a biogeographic perspective being the most easterly outpost of true Succulent Karoo vegetation in Bushmanland. Continuous Succulent Karoo vegetation effectively ends around Smorenskadu about 30km east of Springbok, after which one enters the Bushmanland sandy habitats. At Naip, on the flats around the southern base of the mountain, there is a small patch of this vegetation and then the jump to the Aggeneys area. Here this vegetation is confined to the crest of the Orange-Koa catchment divide at altitudes above about 950m. This is the highest area of plains habitat in the area. Most importantly this habitat is free of sand otherwise it would be replaced by Bushmanland grassy vegetation units. Thus the habitats in this vegetation unit are characterized by rocky plain substrates, except along or near washes, and consequently there is generally an absence of Bushman grasses (Stipagrostis species). The resurrection grass, *Eragrostis nindensis*, is however very characteristic of these rocky plains and gravel patches. The defining feature of this vegetation unit is the dominance of vygie shrubs and dwarf shrubs. In an area such as Rosynebos as soon as one moves north off the crest of the fluvial divide between the Koa and Orange systems toward Pella this dominance is lost despite the habitat being practically the same and one enters what is termed Eastern Gariep Plains Desert.

Anderson (2000) identified an important community occurring in the basin (V2 Basin community on quartz-muscovite-schists) based on the presence of numerous small succulent species. None of these species meet the criteria set for identifying features of conservation concern. The basin does however have high ecological process value as locally (new Camponotis ant species SEE FAUNA STUDY) and regionally (*Conophtum burgeri* at Aggeneys) they may be important for species evolution. Within the core BIR there are 5 roughly similar "basin" features in the landscape.

7.2.1.1 Mountain Plateau

In terms of physical habitat, and floristic composition and structure the mountain plateau and rocky plains are similar. There are, however, several species that are restricted to the cooler plateau habitat in the BIR and that are not encountered elsewhere in the landscape. These species point to the important "climate refuge" role that the plateau plays locally and hence very high conservation importance by providing an edaphically similar habitat to the rocky plains but with a moderated climate allowing species to persist locally where they could not do so on the plains below the plateau.

Plateau "climate refuge" species include: *Conophytum fulleri, Sarcostemma pearsonii, Stapelia similis, Chrysocoma microphylla, Helichrysum zeyheri, Lopholaena cneorifolia, Othonna quercifolia (caudiform), Othonna sp. nov. (PGD 2342), Crassula sericea var. velutina, Euphorbia spinea, Sarcocaulon salmoniflorum, Avonia recurvata subsp. minuta, Avonia recurvata subsp. recurvata, Cheilanthes namaquensis, Trachyandra sp. nov., Lachenalia giessii, Tritonia karooica*.

7.2.1.2 Plains Quartz Gravel Patches

These occur in flat or gently sloping areas where the surface is covered with a near continuous cover of small quartz rocks and pebbles. They are always associated with quartzite or quartz rocks as this provides the parent material for the patch formation. The formation of lag gravel surfaces is a fluvial process that effectively sorts pebbles into finer and finer grades depending on parent quartz rocks, slope angle and length, and time. Thus, one observes a progression in the quality of this habitat from recently formed patches containing less dense lag and mixed pebble sizes through to old patches that are covered with dense layers of well sorted and packed quartz pebbles. This rudimentary description does not do the quartz patches justice. Suffice to say, all quartz patches are not the same although they may appear so at a distance.

Quartz gravel patches on the plains in the BIR, and the study area, are mostly associated with the toe-end of the inselberg scree slopes where these meet washes or the sandy plains. The species composition is similar to that of plateau gravel patches, however, plains populations tend to be much smaller and lower density than on the plateau. There are some notable species absent from plains gravel patches such as *Conophytum angelicae* (dwarf form), *Conophytum ratum* (dwarf form) and *Adromischus nanus*. The only species restricted to plains gravel patches and which do not occur on the plateau are the diminutive annual succulent, *Mesembryanthemum inachabense*, and the multi-bodied polyploid form of *Conophytum angelicae* (which does not occur in the BIR).

Characteristic species of plains quartz gravel patches include: *Aizoon asbestinum, Albuca spiralis, Amellus tridactylus subsp. tridactylus, Amphiglossa triflora, Anacampseros baeseckei, Anacampseros karasmontana, Aridaria noctiflora subsp. straminea, Asparagus capensis, Avonia quinaria subsp. alstonii, Barleria rigida, Berkheya spinosissima subsp. spinosissima, Blepharis mitrata, Brunsvigia comptonii, Brunsvigia sp. nov.2, Conophytum maughanii subsp. maughanii, Conophytum ratum (plains from), Crassula alstonii, Crassula columnaris subsp. prolifera, Crassula deltoidea, Crassula subaphylla subsp. subaphylla, Dianthus namaensis, Digitaria eriantha, Drosanthemum cf. breve, Drosanthemum godmaniae, Enneapogon cenchroides, Eragrostis nindensis, Gorteria corymbosa, Hebenstretia namaquensis, Heliophila arenaria var. arenaria, Hereroa bergeriana, Hereroa puttkameriana, Hermannia disermifolia, Hermbstaedtia glauca, Ihlenfeldtia vanzylii, Jamesbrittenia aridicola, Lapeirousia plicata, Lavrania cactiformis, Leysera tenella, Lithops olivacea var. olivacea, Lotononis falcata, Mesembryanthemum inachabense, Ornithoglossum viride, Othonna protecta, Othonna sedifolia, Pegolettia retrofracta, Pelargonium spinosum, Pentzia argentea, Pentzia lanata, Phyllobolus latipetalus, Piaranthus decorus subsp. cornutus, Piaranthus geminatus, Portulaca collina, Pteronia glauca, Pteronia mucronata, Ruschia griquensis, Sarcocaulon crassicaule, Senecio radicans, Septulina glauca, Tetragonia reduplicata, Tripteris pinnatilobata.*

7.2.1.3 Plateau Quartz Gravel Patches

Associated with plateaus are quartz gravel patches. There is a continuum in the sorting and size of surface rock and pebble lag from rocky plains through to gravel patches. This continuum in its most "developed form" comprise a loose lag of very small, brilliant white to clear-quartz pebbles overlying a thin veneer of soil on the underlying bedrock. These have been term "fine-grained quartz gravel patches" (Desmet 2000), occur on inselberg plateaus and at a distance usually appear devoid of plant life. On the contrary these quartz patches support a diverse array of dwarf succulents very similar to quartz patches on the plains, but also a suite of species that hide away under the quartz lag and which are particular to the plateau. Notable

species include the dwarf form of *Conophytum angelicae* which is restricted to this habitat being a specialist of this "subterranean" existence and is colloquially termed the "Gamsberg Angel". This taxon has been recognised as a distinct species separate to the much larger, multi-bodied "Pofadder" form of *C. angelicae* that has been found to occur at the Gamsberg in quartz gravel patches at the base of the inselberg. Other specialist plateau quartz patch inhabitants include *Adromischus nanus* and the "Gamsberg onion", the dwarf form of *Conophytum ratum.* Like the angels, these are very rare species as their habitat is very restricted in the BIR. This habitat is by far the rarest non-aquatic plant habitat in Bushmanland and most important for conservation due to its diversity of range-and habitat-restricted species.

Species characteristic of the plateau gravel patches include: *Cephalophyllum fulleri, Cephalophyllum sp. nov. (2014), Conophytum angelicae subsp. angelicae (Plateau form), Conophytum calculus subsp. vanzylii "dwarf form", Conophytum ratum "dwarf form", Ihlenfeldtia excavata, Ruschia inclusa, Fockea comaru, Hoodia alstonii, Adromischus nanus, Crassula deceptor, Avonia ruschii, Bulbine striata, Crassula namaquensis subsp. namaquensis, Eriocephalus microphyllus var. pubescens, Conophytum maughanii subsp. maughanii, Hereroa puttkameriana, Piaranthus decorus subsp. cornutus, Crassula alstonii, Crassula columnaris subsp. prolifera, Anacampseros karasmontana, Avonia quinaria subsp. alstonii, Hirpicium alienatum, Lavrania marlothii, Eriocephalus ambiguus, Avonia papyracea subsp. papyracea, Aristida adscensionis, Psilocaulon coriarium, Othonna quercifolia (shrub), Eragrostis nindensis, Dicoma capensis, Anacampseros baeseckei, Sarcostemma pearsonii, Chrysocoma microphylla, Lachenalia giessii, Tritonia karooica, Bulbine aff. namaensis*

7.2.1.4 Plains Intermediate Quartz Gravel Quartz Patches

The intermediate quartz patch habitats mapped appears as quartz patches in the satellite imagery. On the ground observation indicates that these areas are indeed quartz patches, but they are almost devoid of plants except for perhaps a generalist gravel patch species such as *Avonia albissima*. This might relate to the age of the patch with these only having "recently" developed or there might be soil properties inhibiting plant colonisation (e.g. salinity – there are not saline quartz patch specialists in BIR unlike elsewhere in the Succulent Karoo). With time these areas may well be colonized by other quartz patch specialists and as such are important from a conservation perspective not from the species present, but for the potential they hold for housing species in the future. Within the context of this study this habitats is regarded as having low conservation value.

FIGURE 3 (FOLLOWING PAGE): AGGENEYS GRAVEL VYGIEVELD. (TOP) PLATEAU ROCKY PLAIN (RIGHT OF PICTURE) AND PLATEAU FINE-GRAINED QUARTZ GRAVEL PATCH (LEFT OF PICTURE). (MIDDLE) PLATEAU QUARTZ GRAVEL PATCH ON THE NORTH-EASTERN PLATEAU. (BOTTOM) PLAINS QUARTZ GRAVEL PATCH AT THE NORTH-EASTERN BASE OF THE GAMSBERG.

7.2.2 Bushmanland Inselberg Shrubland

Synonyms: VT 29 Arid Karoo and Desert False Grassveld (49%), VT 33 Namaqualand Broken Veld (33%) (Acocks 1953); LR 49 Bushmanland Nama Karoo (70%) (Low & Rebelo 1996)

Regional Distribution: Northern Cape Province: system of prominent "inselbergs" (solitary mountains) and smaller koppies exposed over surrounding flat plains between 850 and 1150 m alt. centred on the town of Aggeneys. Most important inselbergs include (from east to west) Namies, Achab, Gamsberg, Aggeneysseberg, Witberg, Haramoep, and Naip. Total area covered by the vegetation type is approximately 78 000ha of which 2545ha occurs in the study area or 3.2% of the regional extent.

Study Area Distribution: This vegetation unit occurs on the slopes of the inselbergs and koppies within the study area. The vegetation of the Gamsberg plateau is considered as Aggeneys Gravel Vygieveld. The upper south-facing slope of the Gamsberg on quartzite scree (above approximately 900m) is considered here as Namaqualand Klipkoppe Shrubland. This unit is mapped in the Anderson (2000) but not the Desmet *et al.* (2005) map.

Mapped Habitat Units: Anderson (2000): V1.2 Plateau darker quartzite sub-community, V2 Basin community on quartz-muscovite-schists, V3 Basin community, V4 Ecotone community on lower slopes (part), V5 Slope community on scree; and, Desmet et al. (2005): Mountains & Rocky Plains.

Habitats: Two main habitats can be distinguished: Mountains slopes and Rocky Plains.

Vegetation: Sparse to dense vegetation of variable composition; mixture of low-growing grasses (Eragrostis, Aristida, Digitaria, Enneapogon and Panicum); leaf-succulent karoo shrubs (Ruschia, Antimima, Drosanthemum, Psilocaulon), microphyllous and spinescent karoo shrubs (Acanthaceae, Asteraceae), succulent trees (Aloe, Ceraria, Euphorbia).

Common Taxa: *Eragrostis nindensis, Enneapogon desvauxii, Aristida congesta subsp. congesta, Oropetium capense, Digitaria eriantha, Aristida adscensionis, Chascanum garipense, Hermannia stricta, Aptosimum spinescens, Pappea capensis, Ceraria namaquensis, Ceraria fruticulosa, Dyerophytum africanum, Rogeria longiflora, Ficus ilicina, Ruschia robusta, Hereroa puttkameriana, Drosanthemum godmaniae, Nymania capensis, Hibiscus elliottiae, Pelargonium xerophyton, Pelargonium spinosum, Euphorbia spinea, Euphorbia gregaria, Euphorbia gariepina, Euphorbia avasmontana, Cucumis rigidus, Tylecodon rubrovenosus, Crassula sericea var. sericea, Crassula namaquensis var. namaquensis, Crassula garibina, Cotyledon orbiculata var. orbiculata, Adromischus trigynus, Salsola aphylla, Boscia foetida subsp. foetida, Boscia albitrunca var. albitrunca, Commiphora gracilifrondosa, Ehretia rigida, Rhigozum trichotomum, Helichrysum tomentosum subsp. aromaticum, Osteospermum armatum, Lopholaena cneorifolia, Kleinia longiflora, Hirpicium alienatum, Helichrysum herniarioides, Geigeria vigintisquamea, Eriocephalus scariosus, Eriocephalus pauperrimus, Eriocephalus microphyllus var. pubescens, Eriocephalus ambiguus, Dicoma capensis, Aloe gariepensis, Aloe dichotoma, Hoodia gordonii, Rhus undulata, Ozoroa dispar, Hermbstaedtia glauca, Tetragonia reduplicata, Galenia fruticosa, Galenia cf. meziana, Aizoon asbestinum, Monechma*

spartioides, Blepharis pruinosa, Blepharis mitrata, Blepharis micra, Acanthopsis hoffmannseggiana.

Important Taxa: *Brunsvigia comptonii, Pachypodium namaquanum* (not present in the study area), *Euphorbia virosa* (not preset in the study area).

Endemic Taxa: *Avonia recurvata subsp. minuta, Conophytum friedrichiae* (not present in the study area), *Conophytum fulleri, Conophytum marginatum var. karamoepense, Conophytum praesectum, Dinteranthus vanzylii var. vanzylii* (not present in study area), *Schwantesia pillansii*.

Notes: This unit shows intermediate floristic similarities between the Succulent and Nama Karoo biomes and the Gariep Stony Desert. With the removal the upper south-facing slopes and plateau communities from this vegetation unit many important and endemic taxa have been removed from this vegetation unit. Generally, all the species of conservation concern that occur on the Gamsberg are associated with the Aggeneys Gravel Vygieveld, Namaqualand Klipkoppe Shrubland and Azonal (Kloof) vegetation units.

7.2.2.1 Mountain slopes

These are hot dry habitats dominated by typically summer rainfall shrub and succulent species. Charismatic species include the distinctive tree-like succulent *Ceraria namaquensis*; the single-stemmed *Aloe gariepensis*; and, the large cactus-like *Euphoria avis-montana*. The species encountered in this habitat are generally widespread in the eastern Gariep valley region from as far east as Prieska to the Richtersveld in the west. Another large milkweed, *Euphorbia virosa*, is restricted to this habitat; however, it does not occur in the study area. The crest of the mountain slope is marked by the presence of small vertical cliffs. On north slopes this habitat is the sole home for one of the few species endemic to this vegetation unit, *Avonia recurvata subsp. minuta*. The other subspecies (*A recurvata subsp. recurvata*) is larger and occurs generally on plateaus, but for some reason the smaller of the two species prefers only these sun baked north facing cliffs.

FIGURE 4: BUSHMANLAND INSELBERG SHRUBLAND: ROCKY PLAIN AND NORTH-FACING MOUNT SLOPE.

Within the the study area all rocky plains area grouped with the Aggeneys Gravel Vygieveld vegetation type as they lie above approcximately 950m.a.s.l. The rock and pebble aprons around the inselbergs of the region are an extension of the mountain scree slopes (Bushmanland inselberg Shrubland) so there are significant floristic similarities between the two habitats. The greater abundance of dwarf succulent species particularly Mesembs justifies the current vegetation type grouping of habitats.

7.2.3 Bushmanland Inselberg Succulent Shrubland

Synonyms: Bushmanland Inselberg Shrubland (part) (Mucina and Rutherford, 2006), VT33 Namaqualand Broken Veld (part) (Acocks 1953), LR 56 Upland Succulent Karoo (part) (Low and Rebelo, 1996).

Regional Distribution: On upper south-facing slopes of larger inselbergs and koppies on quartzite rock and scree above approximately 950m within the Bushmanland Inselberg Region of the Northern Cape Province. The occurrence of this vegetation type on the Gamsberg and on other large inselbergs in the BIR represents a significant outlier of Succulent Karoo vegetation type that is closely related to Namaqualand Klipkoppe Shrubland that occurs in Namaqualand proper. The total extent of the vegetation type is approximately 4600ha in the BIR and the study area contains approximately 480ha (10.4% of region). The Gamsberg itself contains 400ha or 8,7% of the regional extent. The south-slopes of the Gamsberg contain the largest patch of this vegetation type (265ha).

Study Area Distribution: Restricted to the upper south-facing slopes (above approximately 950m) of the Gamsberg and adjoining inselbergs in the south of the study area where there is dense quartzite rock and boulder scree or cliff face.

Mapped Habitat Units: Anderson (2000): V6 – Southern Slope Community; Desmet et al. (2005): Bushmanland Inselberg Shrubland – Mountain Slopes (part).

Habitats: Two habitats can be distinguished here: South-facing Scree Slopes and South-facing Cliffs.

Vegetation: Dense coverage of leaf-succulent shrubs (Aizoaceae and Asteraceae), leaf-deciduous shrubs (Asteraceae), trailing stem succulents (Sarcostemma), and tree succulents (Aloe dichotoma). Conspicuous by their absence or lack of dominance are perennial and annual grasses.

Common Taxa: *Acanthopsis hoffmannseggiana, Blepharis mitrata, Tetragonia spicata, Drosanthemum godmaniae, Drosanthemum karooense, Phyllobolus latipetalus, Ruschia divaricata, Trichodiadema obliquum, Sericocoma avolans, Rhus undulata, Microloma incanum, Sarcostemma viminale, Aloe dichotoma, Berkheya canescens, Eriocephalus microphyllus var. pubescens, Eriocephalus scariosus, Euryops subcarnosus subsp. vulgaris, Felicia muricata, Osteospermum armatum, Pegolettia retrofracta, Pentzia lanata, Pteronia leucoclada, Senecio longiflora, Hirpicium alienatum, Boscia foetida subsp. foetida, Cadaba aphylla, Cotyledon orbiculata var. orbiculata, Crassula garibina, Crassula sericea var. sericea, Tylecodon rubrovenosus, Diospyros ramulosa, Euphorbia gariepina, Euphorbia rectirama, Pelargonium spinosum, Pelargonium xerophyton, Limeum aethiopicum subsp. namaense var.*

lanceolatum, Montinia caryophyllacea, Dyerophytum africanum, Digitaria eriantha, Panicum arbusculum, Ceraria fruticulosa, Hermannia spinosa, Chascanum garipense.

Other species: *Monechma spartioides, Crassula exilis subsp. sedifolia, Crassula muscosa var. muscosa, Crassula subaphylla subsp. subaphylla, Euphorbia mauritanica, Sarcocaulon crassicaule, Ornithogalum glandulosum, Ornithogalum pruinosum, Schizobasis sp., Stachys rugosa, Phyllobolus lignescens, Psilocaulon subnodosum, Ruschia robusta, Schwantesia pillansii, Hermbstaedtia glauca, Ozoroa dispar, Rhus incisa, Huernia campanulata subsp. ingeae, Lavrania cactiformis, Quaqua mammillaris, Aloe microstigma, Haworthia venosa subsp. tessellata, Berkheya spinosissima subsp. spinosissima, Chrysocoma ciliata, Cineraria alchemilloides, Didelta carnosa var. carnosa, Osteospermum scariosum, Othonna abrotanifolia, Othonna protecta, Othonna quercifolia shrub 2333, Senecio bulbinifolius, Senecio cephalophorum, Senecio radicans, Senecio sisymbriifolius, Adromischus alstonii, Cissampelos capensis, Antherothamnus pearsonii.*

Important Taxa: These are typical Succulent Karoo species and their occurrence here represent significant outlier populations well away from their core range: *Nymania capensis, Crassula brevifolia subsp. brevifolia, Dianthus namaensis, Othonna sedifolia, Crassula tomentosa var. glabrifolia, Tylecodon paniculatus, Tylecodon wallichii, Pelargonium crithmifolium, Whiteheadia bifolia, Anthospermum spathulatum subsp. spathulatum, Senecio sarcoides, Sceletium tortuosum.*

Endemic Taxa: *Lithops olivacea var. olivacea, Hesperantha rupicola, Othonna sp. nov. (PGD 3728), Brunsvigia sp. nov.1, Conophytum limpidum (diploid form), Adromischus diabolicus.*

Notes: There are close floristic similarities between this vegetation type and the Kloof vegetation type as both include significant areas of south-facing slopes.

This vegetation type and the large extent of it on the Gamsberg (the largest patch within the Bushmanland Inselberg Region group) is a remarkable outlier of Succulent Karoo vegetation. The combination of cool shaded slopes and availability of moisture in winter (late summer rains with soil moisture carrying over into autumn and the frequent occurrence of winter fog associated with the Kao river valley and westerly frontal systems) allow a vegetation type with a winter-peak phenology to existing within an otherwise typical summer rainfall environment. Therefore, numerous species occur on the Gamsberg far outside of their normal distribution range. This habitat is an example of what is termed a climate change refuge where the environmental parameters significantly moderate the ambient climate to allow a distinctly different suite of species to persist locally where they would not otherwise be able to. From an ecological process perspective this is an important habitat.

This unit is recognised as a distinct South African Vegetation type and not lumped with Bushmanland Inselberg Shrubland as before or Namaqualand Klipkoppe Shrubland to which it is floristically most similar for three reasons: (1) The geographic disjunction between the BIR sites and the core distribution of Namaqualand Klipkoppe Shrubland in Namaqualand; (2) The occurrence of many Nama Karoo taxa within this unit (i.e. north-facing slope species that co-occur but not dominate on the south slope); (3) The occurrence of many endemic species restricted to the Bushmanland Inselberg Region and not the whole extent of the Klipkoppe region.

FIGURE 5: BUSHMANLAND INSELBERG SUCCULENT SHRUBLAND ON THE SOUTH-FACING SLOPES OF THE GAMSBERG.

7.2.4 Bushmanland Arid Grassland

Synonyms: VT 29 Arid Karoo and Desert False Grassveld (36%), VT 32 Orange River Broken Veld (36%) (Acocks 1953); LR 51 Orange River Nama Karoo (51%) (Low & Rebelo 1996)

Regional Distribution: Northern Cape Province: spanning about one degree of latitude from Namaqualand in the west to Prieska in the east; the southern border of the unit is formed by edges of Bushmanland Basin while in the northwest this vegetation unit borders on desert vegetation in the Orange River valley (northwest of Aggeneys and Pofadder); the northern border (in the vicinity of Upington) and the eastern border (between Upington and Prieska) are formed with often intermingling units of Lower Gariep Broken Veld, Kalahari Karroid Shrubland and Gordonia Duneveld; most of the western border is formed by the edge of the Namaqualand hills (approximately 30km east of Springbok); altitude varies mostly from 600 to 1 200 m.

The global extent of the vegetation type is approximately 4 470 270ha of with 2968ha or 0.06% of the regional extent occurring in the study area. One of the habitats making up this vegetation unit, Bushmanland Inselberg Region calcrete gravel patches, has a regional extent of 892ha of which 211ha or 24% of regional extent occurs in the study area.

Study Area Distribution: The dominant vegetation on the sandy plains around the base of the Gamsberg as well the plains north of the N14. The calcrete gravel patches are scattered throughout this unit in slightly raised or eroding areas where the sandy surface has been stripped leaving a calcrete pebble lag and hardpan exposed.

Mapped Habitat Units: Anderson (2000): V7- Plains community; Desmet et al. (2005): Plains Sandy Flat, Plains Sandy Hummocky, Plains Gravel Calcrete.

Habitats: Three habitat types can be defined within the study area: Plains sand flat (Bushmanland Flat Arid Grassland), Plains hummocky (Bushmanland Hummock Arid Grassland) and plains gravel calcrete.

Vegetation: Extensive grass covered sandy plains on a gently sloping plateau dominated by five species – the Bushman Grasses *Stipagrostis ciliata, S. obtusa* and shrub-like *S. brevifolia* and the shrubs *Rhigozum trichotomum* (driedoring) or *Salsola aphylla* (gannabos). After good rains impressive "golden fields of wheat" stretch to the horizon in every direction, and when dry the standing grass biomass turn the plains an ash-grey colour, a state called "grysdak" by the local farmers. Trees such as *Parkinsonia africana* are generally absent and confined to deeper sand in washes. Succulent species are noticeable by their absence and only occur in numbers on the calcrete gravel patches.

Common Taxa: *Salsola aphylla, Stipagrostis obtusa, Stipagrostis ciliata, Stipagrostis brevifolia, Aridaria cf. serotina, Gazania lichtensteinii, Heliophila cf. acuminata, Hypertelis salsoloides, Eragrostis annulata, Schmidtia kalahariensis, Rhigozum trichotomum, Galenia sarcophylla, Oxalis obtusa, Sesamum capense, Enneapogon desvauxii*.

Other Taxa: *Avonia albissima, Monsonia parviflora, Ebracteola fulleri, Cotula microglossa, Indigofera cf. auricoma, Eragrostis nindensis, Oropetium capense, Schmidtia kalahariensis, Augea capensis, Tribulus cf. zeyheri, Psilocaulon coriarium, Acanthopsis hoffmannseggiana, Galenia africana, Mesembryanthemum guerichianum, Arctotis cf. leiocarpa, Berkheya canescens, Dicoma capensis, Foveolina albida, Parkinsonia africana, Tephrosia dregeana, Aristida congesta subsp. congesta, Sporobolus nervosus, Peliostomum leucorrhizum, Lycium cinereum, Lycium prunus-spinosa, Hoodia gordonii.* Taxa recorded only on calcrete patches: *Brownanthus ciliatus, Drosanthemum hispidum, Kleinia longiflora, Pteronia ciliata, Cucumis rigidus, Euphorbia gariepina, Euphorbia mauritanica, Euphorbia spinea, Sarcocaulon crassicaule, Avonia albissima, Ceraria fruticulosa, Zygophyllum cf. decumbens*.

Endemic Taxa Recorded on Site: Restricted to calcrete gravel patches -*Titanopsis hugo-schlechteri, Crassula mesembrianthemopsis, Anacampseros bayeriana, Lithops julii subsp. fulleri var. fulleri, Ruschia aff. divaricata (PGD 3764).*

Notes: This unit covers a very large area regionally; however, the calcrete patches have a much narrower distribution restricted to scattered patches within the BIR. Research has not been conducted to determine the composition of other calcrete patches within this vegetation unit. Based on what can be gained from the herbarium records all the endemic species listed here are endemic to the BIR.

Previously the calcrete patches were grouped with the Aggeneys Gravel Vygieveld vegetation type, however, based on the analysis of the relevé data these patches have most in common with the grassland within which it occurs.

Apart from the very unique calcrete patches this vegetation type is low in species diversity and relatively uniform over large areas.

7.2.4.1 Flat Sandy Plains

Grassy plains are a distinctive feature of the region and the plains in the west and north of the study area. The Bushmanland Arid Grassland vegetation type can be divided into two distinct grassland habitat types. Together with the Bushmanland Sandy Grassland vegetation type these form a group of three distinct grassland habitats that can be defined primarily by their catenal position (i.e. position on a slope).

Top slopes or valley interfluves are most exposed to wind and the sand here tends to be reduced to a fairly uniform and continuous covering of shallow sand with the underlying calcrete hardpan exposed sporadically. This is the "Plains Sandy Flat" or Bushmanland Flat Arid Grassland habitat characterised by a fairly uniform and continuous dominance of three species: the grasses *Stipagrostis brevifolia* and *S. ciliata* and the shrub *Rhigozum tricostatum*. Patchiness does arise where the plain is interrupted by washes or any drainage line or where calcrete begins to appear on the surface. Where this occurs Rhigozum is replaced by *Salsola aphylla* as the dominant shrub. The succulent species that occur in this habitat (e.g. *Ebracteola fulleri* and *Euphorbia Braunsii*) are widespread but generally restricted to sandy habitats.

7.2.4.2 Hummocky Sandy Plains

In mid to bottom slope areas the sand becomes deeper and takes on a distinctive undulating appearance with sandy hummocks (mini-dunes) and eroded slacks having an amplitude of less than 1m. The hummocks are dominated by *Stipagrostis brevifolia* and the slacks by *S. obtusa*. *S. ciliata* fills in the gaps and occurs in both habitats. Again the only shrub of any particular prominence is *Rhigozum tricostatum* which is restricted to the hummocks. The boundary between this vegetation unit and the previous one is quite diffuse and difficult to define precisely on the ground.

Both of these sandy habitats are widespread beyond the study area and do not have any unique, rare or endemic species.

7.2.4.3 Calcrete Gravel Patches

Much of the Bushmanland sand sea is underlain by a calcium-rich hard-pan layer of calcrete. Where ever this sand is eroded away exposes the white calcrete horizon creating a habitat comprising a lag of calcrete pebbles and exposed solid calcrete hardpan within a matrix of red sand. Calcrete lags on the surface are a common and widespread phenomenon across Bushmanland and arid areas in southern Africa, but the few calcrete gravel patches that occur in the BIR are floristically rich compared to those elsewhere and are how to at least four endemics species.

Floristically calcrete patches are somewhat different to the other gravel patch types being intermediate between the Succulent Karoo and the arid grassland vegetation sub-categories. Having a high proportion of sand on the surface favours bushman grasses with *Stipagrostis obtusa* being dominant and sometimes *S. ciliata*. A distinctive feature of the calcrete patch habitat is the dominance of the low shrub *Zygophyllum decumbens* (Zygophyllaceae). This distinctive yellowish woody-shrub can form near mono-specific stands on the calcrete patches.

The calcrete patches are interesting botanically not because of what you see standing in the veld, but from what you see on your knees growing between the pebbles and under the sand. The tortoise foot vygie *Titanopsis hugo-schlechteri* and beeskloutjie *Lithops julii subsp. fulleri var. fulleri* are two easily observed species. Both are endemic to calcrete in the BIR. Where as the Titanopsis is religious about occurring only on

large calcrete patches the Lithops is a good indicator of any calcrete in the lanscape and all will occur anywhere locally where calcrete appears on the surface.

Under the sand on calcrete patches reveals some of the more unusual species occurring in the study area. *Anacampseros bayeri* is probably the smallest known perennial succulent in the world having a rosette of leaves no more than a few millimetres in diameter attached to a small fleshy tap-root. It rarely if ever shows its head above the sand and grows quite happily protected from the harsh elements within its sand "greenhouse". Similar in habit, although somewhat larger is *Crassula mesembrianthemopsis*. This species only ever appears above the sand after good rains.

The species restricted to calcrete patches are endemic to the BIR and rare because their habitat is relatively rare in the BIR. This habitat is, unfortunately, highly favoured by small livestock as the vegetation is very palatable. Consequently, all calcrete pacthes visited in the region with the exception of those at the base of the Gamsberg are severly degraded with all populations of endemic species in visible decline. Calcrete patches are regarded as a very high priority habitat of conservation concern because of the endemic species present and threat to the habitats from livestock.

7.2.5 Bushmanland Sandy Grassland

Synonyms: VT 29 Arid Karoo and Desert False Grassveld (80%) (Acocks 1953); LR 49 Bushmanland Nama Karoo (71%) (Low & Rebelo 1996)

Regional Distribution: Northern Cape Province: The largest continuous tracts of this vegetation are found in the Koa River valley south of Aggeneys and Kaboep River valley north of Pofadder (northern Bushmanland). This vegetation unit can occur on any large sand dune within this area. Dune features are usually associated with wide valley bottoms (e.g. Koa River). The total extent of this vegetation unit is approximately 253 000ha of which 18ha occurs in the study area or <0.01% of the regional extent.

Study Area Distribution: Two small patches occur in the study area – one on the eastern boundary and one on the south western boundary. Note that the patch on the SW boundary is mapped by Anderson (2000) but is not mapped by Desmet et al. (2005).

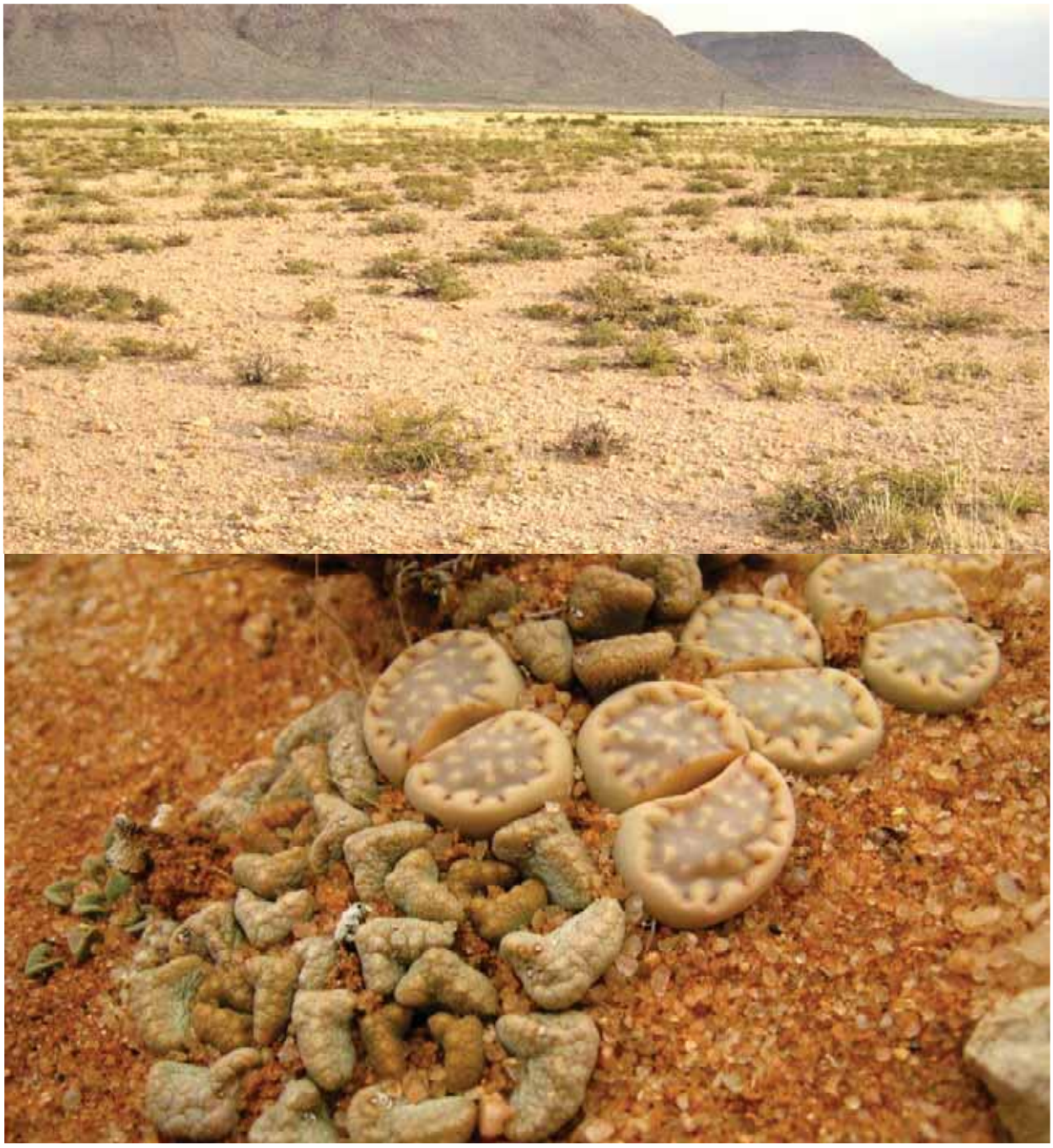
Mapped Habitat Units: Anderson (2000): V10- Dune community; Desmet et al. (2005): Plains Sandy Mobile Dunes.

Habitats: Two habitats can be distinguished: Dune crests and dune slacks.

Vegetation: Sparse to dense, loose sandy grassland on dune ridges and slacks dominated by Bushman grasses (Stipagrostis species) and abundant drought-resistant shrubs (Rhigozum, Lycium, Justicia, Hermannia) and trees (Acacia, Boscia, Parkinsonia); after rainy winter rich displays of ephemeral spring flora (*Grielum humifusum, Gazania lichtensteinii,* Arctotis) can occur.

FIGURE 6 (FOLLOWING PAGE) EXAMPLES OF HABITATS MAKING-UP THE BUSHMANLAND ARID GRASSLAND VEGETATION TYPE. (TOP) FLAT SANDY PLAINS HABITAT DOMINATED BY THE

GRASSES *STIPAGROSTIS CILIATA* AND *S. OBTUSA,* AND THE SHRUB *RHIGOZUM TRICHOSTATUM*. (MIDDLE) HUMMOCKY SANDY PLAINS WITH *STIPAGROSTIS BREVIFOLIA* DOMINATING ON A LOW HUMMOCK. (BOTTOM AND FOLLOWING PAGE TOP) EXAMPLES OF CALCRETE GRAVEL PATCHES WITH CHARACTERISTIC CALCRETE ROCKS AND PEBBLE ON THE SURFACE. THE LOW SHRUB *ZYGOPHYLLUM DECUMBENS* IS DIAGNOSTIC OF THIS HABITAT. (PAGE AFTER NEXT MIDDLE) THREE OF THE FOUR CALCRETE GRAVEL SPECIALIST GROWING TOGETHER UNDER A GRASS TUSSOCK (FROM LEFT TO RIGHT): CRASSULA MESEMBRYANTHEMOPSIS, TITANOPSIS HUGO-SCHECHTERII AND LITHOPS JULII SUBSP. FULLERI VAR. FULLERI.



Common Taxa: *Schmidtia kalahariensis, Stipagrostis brevifolia, S. obtusa, S. ciliata, S. namaquensis, Cladoraphis spinosa*

Other Taxa: *Microloma incanum, Asparagus cf. laricinus, Felicia namaquana, Gazania lichtensteinii, Hirpicium echinus, Wahlenbergia prostrata, Indigofera daleoides, Oxalis eckloniana var. eckloniana, Sesamum capense, Aristida congesta subsp. congesta, , Ophioglossum polyphyllum, Thesium lineatum, Manulea nervosa, Peliostomum leucorrhizum, Lycium cinereum, Hermannia cf. coccocarpa, Tribulus cf. zeyheri.* Trees: *Acacia erioloba, Boscia albitrunca subsp. albitrunca, Parkinsonia africana*

Endemic Taxa Recorded on Site: None know for the vegetation type.

Notes: This is the grassland of the valley bottoms occurring on mobile or semi-mobile transverse dune systems or lone dune ridges elsewhere. It is best exemplified by the Koa River valley. The amplitude between the dune crests and slacks can be as much as 20m. The distinguishing grass species of this vegetation type are *Stipagrostis namaquensis* and *Cladoraphis spinosa* (spiny love grass) on the dune crests with the other dominant Stipagrostis species of the area (*S. ciliata, S. obtusa, S. uniplumis* and *S. brevifolia*) occupying the dune slacks. Unlike the arid grassland types this vegetation has a high diversity of large woody shrubs which are not encountered elsewhere in the landscape. Being deep sandy soils located in valley bottoms this habitat also acts as an aquifer, thus the trees associated with the Bushmanland sandy plains, such as *Acacia erioloba* (Camel thorn), *Parkinsonia africana* (Lemoendoring) and *Boscia albitrunca* (Shepard tree), are most often encountered here and in some area can form vast "forests".

In the study area this vegetation type is restricted to two small patches and these are not particularly representative of the full diversity of this vegetation type.

This vegetation is poorly known generally and it is likely that many new and interesting discoveries wait to be made. The endemic Red Lark is unique to this vegetation unit but is in unlikely that the extent in the study area may be large enough to support this species.

7.2.6 Azonal Habitats

Azonal habitats include kloofs, washes (drainage lines), rivers (dry river beds with subsurface flow), headwater seeps and temporary rock pools. The vegetation of these habitats are grouped into an azonal vegetation type as it is typically composed of species or communities from surrounding vegetation types as well as species or habitat features (e.g. springs) that are restricted to the habitat. In the case of washes and kloofs the vegetation tends to be very heterogeneous due to topographically complex terrain, as in the case of a kloof, or a diversity of levels of disturbance or time since disturbance, as in the case of a wash, resulting in complex vegetation patterns.

Although saline pans are a feature of the Bushmanland plains landscape none occurs in the study area.

7.2.6.1 Kloof

Kloofs are one of the more serene habitats in the BIR characterized by deep, shaded ravines surrounded by high cliffs very often with long-standing pools of water after rain. The kloof on the northern portion of the Gamsberg inselberg is the largest in the BIR comprising three separate but interlinked kloofs: a main south-north kloof draining the basin in the interior of the inselberg; an eastern kloof draining the north-eastern plateau; and, a western kloof, the smallest of the three, draining the north-western plateau. In terms of vegetation, the kloof contains Bushmanland Inselberg Shrubland on north-facing slopes, Bushmanland Inselberg Succulent Shrubland on south-facing slopes and Wash / River vegetation in the floor of the kloof. In addition to these major vegetation elements the kloof contains the following habitats that are restricted to or associated with kloofs in the BIR:

- The thick rock and boulder scree on the sidewalls of the kloof and verges of the river channel support a diversity of tree species that utilise the sub-surface aquifer associated with the kloof. Some tree species such as *Ficus cordata, Azima*

tetracantha and *Buddleja saligna* are only found in association with the kloof or springs in the kloof and no where else in the BIR landscape.

- The river channel is a very heterogeneous habitat comprising many distinct physical features (e.g. deep sandy pools, rock pools, smooth bedrock, rock / boulder vegetated channels, sandy beds and seeps) Each is associated with different plant communities. Generally the vegetation of the channel is a combination of that which occurs on the surrounding slopes, typical wash species and then a group of species typical of aquatic habitats including: A diversity sedges (7 Cyperaceae and 1 Juncaceae species); at least 2 species of submerged aquatic plants (these were collected but not identified); *Phragmites australis* associated with a seep in the main channel between the confluence of the eastern and western side kloofs; and, at least 1 new species of "macro" algae (*Hydrodictyon sp.*) which could be endemic to the kloof.
- One permanent and one seasonal fresh-water spring are also associated with the kloof. The seasonal spring is located near the exit of the western side kloof and the permanent spring near the exit of the eastern kloof into the main kloof. This is represented by a permanent pool of fresh water. See discussion on Springs below.
- The many rock pools associated with the wash channel of the kloofs can contain water for considerable periods of time after rain, up to 4 months. These pools are filled primarily by stream flow from the "basin" associated with rainfall events and not ground-water discharge as in the case of the rock pools associated with the permanent springs. These rock pools are an important habitat for the aquatic plant and animal species associated with the kloofs.
- Of particular ecological importance in the kloofs are the permanently shaded south-facing slopes that support species that would otherwise not be able to exist in this arid landscape. These habitats, together with the shaded south-facing slopes of the inselberg act as a refuge for species accounting for some of the disjunct distributions seen in some of the plants. Moss and insect species recorded during the first EIA process demonstrated similar disjunct distribution patterns. Such habitats are termed climate change refugia. In the future these habitats will become even more important as local refugia for species in the face of climate change, offering more mesic environments relative to the surrounding landscape. These physical attributes of the kloof will not be impacted by mining in the long-term so long as the mining process can avoid changing the physical structure of the kloof.

Kloofs are important for biodiversity at the landscape-level because the unique physical / topographic structure of the kloof:

- Creates a diversity of physical habitats some of which are not encountereded outside of the kloof (e.g. permanently shaded slopes).
- Moderates the local climate from the climatic extremes of the broader landscape
- Focusses the flow of water in the landscape into a variety of unique habitats (springs, seeps, sub-surface river flow)

Mining will impact these abiotic attributes of the kloof at different spatial and temporal scales, and intensities. Some attributes may be permanently lost (e.g. springs) where as other components may only be temporally impacted or avoided.

7.2.6.2 Headwater Seeps

At the headwaters of both of the side kloofs there are small "headwater seeps" at the plateau / kloof interface. These seeps have shallow (<30cm), slightly humic loamy soils over an underlying layer of solid quartzite rock and gravel. After significant rainfall events these seeps appear to be waterlogged for several weeks and damp for several months. In both situations the seep is located at the base of a local valley and upstream of an exposed bedrock sill or nick-point below which the gradient of the stream increases and the character changes to a vegetated rock and boulder channel. The western seep is the largest being about 100m long and 5-10m wide. The eastern seep is significantly smaller been 20m long and 5m wide. The vegetation of both seeps is dominated by the geophyte *Eriospermum bakerianum* subsp. *bakerianum*, a species of cotton seed. This is a summer rainfall species found throughout Namibia and Botswana. It's occurrence on the Gamsberg represents the most southern known locality for this species making it very important at a regional level. Also, the density of the populations, particularly in the western seep which conservatively could number in the hundreds of thousands, is also remarkable for a geophyte in the BIR where geophytes usually to have low population densities. The seep is shared with other geophytes (possibly a species of Cyanella) and sedges. In the dry season these seeps are literally "mined" by porcupines feeding on the dense mass of cotton seed corms. No doubt these seeps comprise a keystone foraging resource for porcupines and perhaps baboons.

In the BIR this habitat appears to be restricted to the Gamsberg. A regional search for similar habitats and combination of species did not locate any other patches of similar vegetation. Given that the dominant species in the seep (*E. bakerianum*) is widespread in central Namibia it is likely that this habitat is a summer rainfall relic that could be common in south-central Namibia. This is important in assessing the impact significance of losing nearly the entire known extent of this habitat in South Africa.

The detailed species composition and ecology of this very unique ecosystem deserves further study.

7.2.6.3 Freshwater Springs

In addition to the two springs in the kloof there is a second permanent spring on the Gamsberg at the north-eastern base of the inselberg below a small ravine. This spring has been significantly altered by humans but still supports a diversity of aquatic and water-loving plants in particular the small population of the palaeo-relic tree *Azima tetracantha* (see Section 9.1). It is uncertain if this spring was ever represented by a permanent pool of water or if this was created by pastoralists to provide water for their stock. There is another seasonal spring located at the base of the small kloof / ravine on the southeastern corner of the Gamsberg. It is uncertain, however, if this spring is natural or created by pastoralists as there is no characteristic flora associated with the site.

No plant species were found that are exclusively associated with these springs (i.e. endemic species). Most species associated with the springs are widespread in southern Africa in more mesic areas outside of the BIR. The presence of freshwater springs in the landscape does represent one of the most ecologically important habitats in the BIR. This is a keystone refuge habitat for water dependent plant species (e.g. trees and aquatic plants). They are also likely a keystone habitat for fauna at the landscape level from a water provisioning perspective and aquatic habitat.

There are only four known freshwater springs in the BIR - two on the Gamsberg, one in the kloof at Achab and one on Naip. There is a permanent sulphur-spring associated with the Big Syncline on Aggeneryseberg, but this water is brack and not palatable. There is an unconfirmed occurrence of another freshwater spring near Lemoenplaas at Aggeneyseberg.

FIGURE 7: THE SEEP AT THE HEAD OF THE WESTERN KLOOF. (TOP) A VEW OF THE SEEP FROM THE HEADWATER LOOKING IN AN EASTERLY DIRECTION. (BOTTOM RIGHT) A CLOSER VIEW OF THE FLOWER OF *ERIOSPERMUM BAKERIANUM SUBSP. BAKERIANUM*. (BOTTOM LEFT) E. BAKERIAUM SUBSP. BAKERIANUM JUST PAST PEAK FLOWERING IN MARCH.

FIGURE 8: VIEWS OF THE MAIN KLOOF DURING A GOOD RAINFALL YEAR. (TOP LEFT) A LARGE POOL IN THE MAIN CHANNEL 2 MONTHS AFTER MAJOR RAINS IN 2009. (TOP RIGHT) THE MAIN KLOOF VIEWED FROM ABOVE. (BOTTOM) *HYDRODICTYON SP. NOV.* - A SUMMER GROWING ANNUAL "MACRO" ALGAE FOUND IN THE LARGER POOLS IN THE MAIN KLOOF.

FIGURE 9: FRESH WATER SPRINGS.(TOP LEFT) THE LARGEST SPRING ON THE GAMSBERG LOCATED IN A NARROW CAVEROUS KLOOF NEAR THE MOUTH OF THE EASTERN SIDE KLOOF – THIS POOL HAS NOT BEEN MODIFIED BY HUMANS AND REMAINS THIS SIZE EVEN IN DROUGHT YEARS (TOP RIGHT) THE PARADISE TOAD (*BUFO GARIEPENSIS*) INHABITS THE KLOOF IN LARGE NUMBERS. (BOTTOM LEFT AND RIGHT) THE SPRING AT THE BASE OF THE NORTH-EASTERN PLATEAU. THIS POOL HAS BEEN EXCAVATED AND ENLARGED BY HUMANS IN HISTORICAL TIMES.

FIGURE 10 A PARADISE TOAD PHOTOGRAPHED IN OCTOBER 2012 AT THE SPRING AT THE BASE OF THE EASTERN SIDE-KLOOF (TOP LEFT PHOTO IN PREVIOUS FIGURE). EVEN AFTER 3 YEARS OF DROUGHT THIS SPRING REMAINS STRONG AND MAINTAINS A LARGE POOL OF FRESH WATER. THE ECOLOGICAL IMPORTANCE OF THIS WATER RESOURCE SOURCE IN THIS ARID LANDSCAPE IS VERY HIGH.

7.2.6.4 Washes and Dry River Beds

Washes as they are defined and mapped here contain all drainage-lines in the study area. Washes and Dry River Beds are floristically and ecologically located at other ends of a drainage line development continuum. Larger drainage lines associated with larger catchments are associated with sub-surface water flow and as a result are characterised by the presence of larger trees. Sub-surface flow is typically absent from washes and hence trees are not absent but not characteristic of the habitat.

Drainage-lines on the Gamsberg, as with all inselbergs in the BIR, tend to be well defined, narrow with rock and boulder beds. On the plains washes tends to be wide, sandy and often very difficult to detect were it not for the presence of key indicator species (e.g. *Sisyndite spartea*). The vegetation of washes tends to be fairly heterogeneous due to a spatially and temporally dynamic and heterogenous environment. For the most part the vegetation of washes is most similar to that of the surrounding vegetation. Many species found growing on the surrounding plains or mountain slopes can be found growing in the washes, usually larger specimens. Added to this "back-ground" species mix are the wash specialist species, those adapted to high disturbance regimes and those dependent on the water associated with washes. Being exposed to periodic flooding, washes are naturally high disturbance habitats. Understandably the vegetation is characterized by weedy species adapted to a high disturbance regime. Also the greater amount of ground

water associated with these features also promotes phreatophytic species (deep-rooted plants that obtain water from a permanent ground supply or from the water table), mainly trees and large shrubs. Alien plants most often make their appearance in the landscape in these habitats due to the high disturbance regime and availability of water.

The characteristic species of the plains drainage lines are *Sisyndite spartea, Indigofera heterotricha, Salsola aphylla, Aptosimum indivisum, Aptosimum spinescens, Sesamum capense, Tribulus cf. zeyheri, Zygophyllum retrofractum* and *Zygophyllum simplex*. Common species include *Boscia foetida subsp. foetida, Euclea undulata, Lycium cinereum and L. prunus-spinosa, Zygophyllum retrofractum, Rhigozum trichotomum, Monechma incanum, Aptosimum spinescens, Geigeria plumosa, Gazania lichtensteinii, Hermbstaedtia glauca* and *Didelta carnosa*.

Characteristic species of the inselberg drainage lines include *Sericocoma pungens, Rosenia humilis, Zygophyllum retrofractum* and *Drosanthemum godmaniae*. Other common species include larger trees and shrubs such as *Boscia foetida subsp. foetida, Pappea capensis, Euclea undulata, Rhus burchellii, Ehretia rigida, Diospyros ramulosa, Montinia caryophyllacea* and *Nymania capensis*, as well as other large woody shrubs namely *Hermannia stricta, Lycium prunus-spinosa, Rhigozum trichotomum, Hermbstaedtia glauca*, and smaller shrubs and herb *Monechma spartioides, Geigeria plumosa, Gazania lichtensteinii,* and *Didelta carnosa*.

Although washes contain no species of conservation concern they are important from an ecosystem process perspective. Washes are the major conduits of water in the landscape and should be considered and avoided when developing a landscape so as to maintain this natural process. *A priorii* identification and mapping these features can save considerable cost later. The town of Aggeneys was built in the middle of a wash (sheet-wash plain). After Aggeneys was constructed berms had to be constructed around the town when the town was flooded after a thunderstorm event. If mine planners had been aware that were building their town in the middle of a river they may have sited the town in a more environmentally sensitive location.

Groundwater drawdown as a result of the pit will lower the level of permanent subsurface flow in the Dry River Beds. This will permanently negatively impact the survival and recruitment of tree species dependent on this resource. Trees in the desert landscape are a keystone ecological resource (forage, habitat, nest sites, etc.) and loss of trees form the system will impact the broader landscape.

7.2.6.5 Temporary Rock Pools

Temporary rock pools or vernal pools are shallow pan-line structures less than two meters in diameter that have standing water in them for long enough after rain for a distinct ephemeral pan ecosystem to develop. They are restricted to the flattest parts of the Gamsberg plateau. During the site visits in 2009 49 temporary rock pools were mapped, mostly on the eastern plateau of the Gamsberg (Figure 2). These pools are generally devoid of perennial plants except occasionally the succulent *Crassula deltoidea* is found growing in them. They have not been studied whilst inundated to determine the presence of plants during their wet phase.

Only in recent years has the existence of these features become apparent as they are mostly dry (at least 95% of the time) and easily overlooked. In April 2006 free

swimming crustaceans were observed swimming in these pools but no samples were taken for identification. A significant distinction between these pools or pans and pan on the Bushmanland plains, besides their diminutive size, is that the plateau pans are non-saline whereas the plains are hyper-saline suggesting that the crustacean community on the plateau are likely to be unique to the plateau and other similar fresh-water temporary pools elsewhere in the BIR.

There has been some research on similar mountain-plateau temporary rock pools elsewhere in South Africa (Vanschoenwinkel *et al.* 2008a, Vanschoenwinkel *et al.* 2008b, Vanschoenwinkel *et al.* 2009). They have been recognised as highly unique and complex ecosystems due to the unique faunal communities and extreme spatial and temporal heterogeneity and dynamics.

At present a biodiversity or ecological understanding of the temporary rock pools is a very limited. They are endorheic drainage systems (i.e. internal draining) therefore very sensitive to accumulation of toxic inputs. The Faunal Specialist Study does not address these features.

FIGURE 11: AN EXAMPLE OF A TEMPORARY ROCK POOL OR SMALL PAN (DASHED CIRCLE) ON THE EASTERN PLATEAU OF THE GAMSBERG.

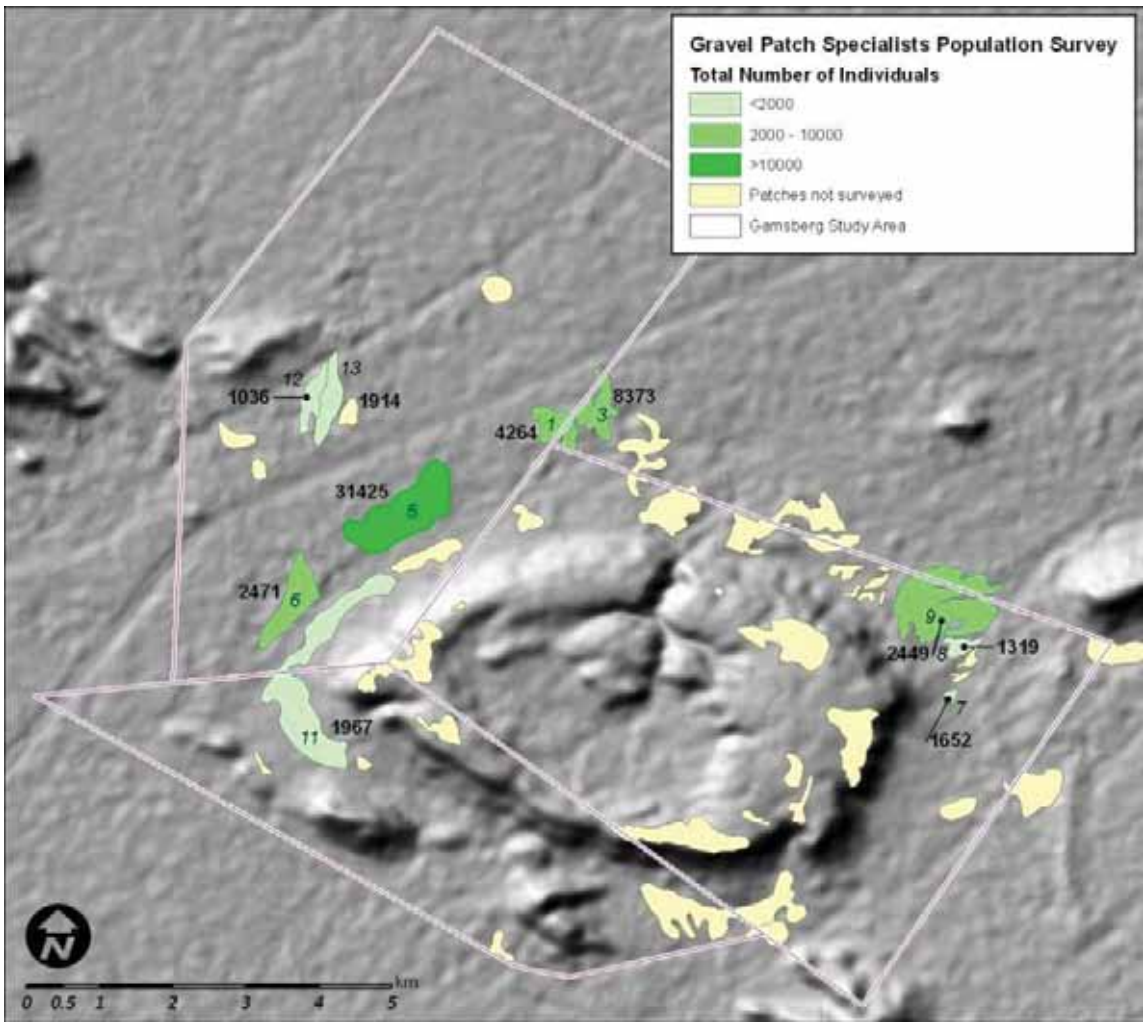
8 GRAVEL PATCH SPECIALIST POPULATIONS SURVEY

A brief plant population census was conducted to assess the relative population size of gravel-patch specialist species. A better understanding of between site variations in biodiversity attributes will benefit the ESIA process as it will be possible to rank sites based on these attributes thereby better quantifying relative impacts of alternative development scenarios.

In 2009 a total of 13 line-transects were walked in 11 patches totalling 14.5km in length (Figure 12). In 2012 a further 11 sites were visited but no quantitative data were collected. The population density and population size was estimated for each patch (Table 2).

Population density of gravel-patch specialist plant species and population sizes are very variable between sites (Table 2). Size of suitable habitat is a good predictor of population size with bigger patches having denser and bigger populations of specialist species. It is, however, very much a case of not all that glitters is gold – not all apparently suitable habitat is occupied equally by species. Calcrete gravel patch number 5 (Table 2) is clearly one of the more important gravel patches locally due to the significantly denser and larger populations of species. This is not the most densely populated gravel patch in the study area. The quartz gravel patch on the north-eastern plateau, although not surveyed here, is known to have comparatively much denser populations of specialist species numbering in the hundred of thousands.

FIGURE 12: THE RESULTS OF THE GRAVEL PATCH SPECIALIST PLANT SPECIES POPULATION SURVEY OF SELECTED GRAVEL PATCHES AROUND THE BASE OF THE GAMSBERG. NUMBERS IN ITALICS REFER TO PATCH NUMBER IN TABLE 2 AND NUMBERS IN BOLD THE TOTAL ESTIMATED NUMBER OF INDIVIDUALS OF ALL FOCAL SPECIES IN EACH PATCH.



Some general observations on the distribution of gravel patch specialist species:

- Livestock grazing significantly negatively affects populations of gravel ptach specialist plants. This is especially true for calcrete patches that appear to be favoured by stock.
- Populations of gravel patch specialist plants are generally denser on mountain plateaus than on the plains.
- Not all apparently suitable patches are occupied concurrently. Meta-poplation ecological processes such as variability in space and time and source-sink phenomena may be operating.

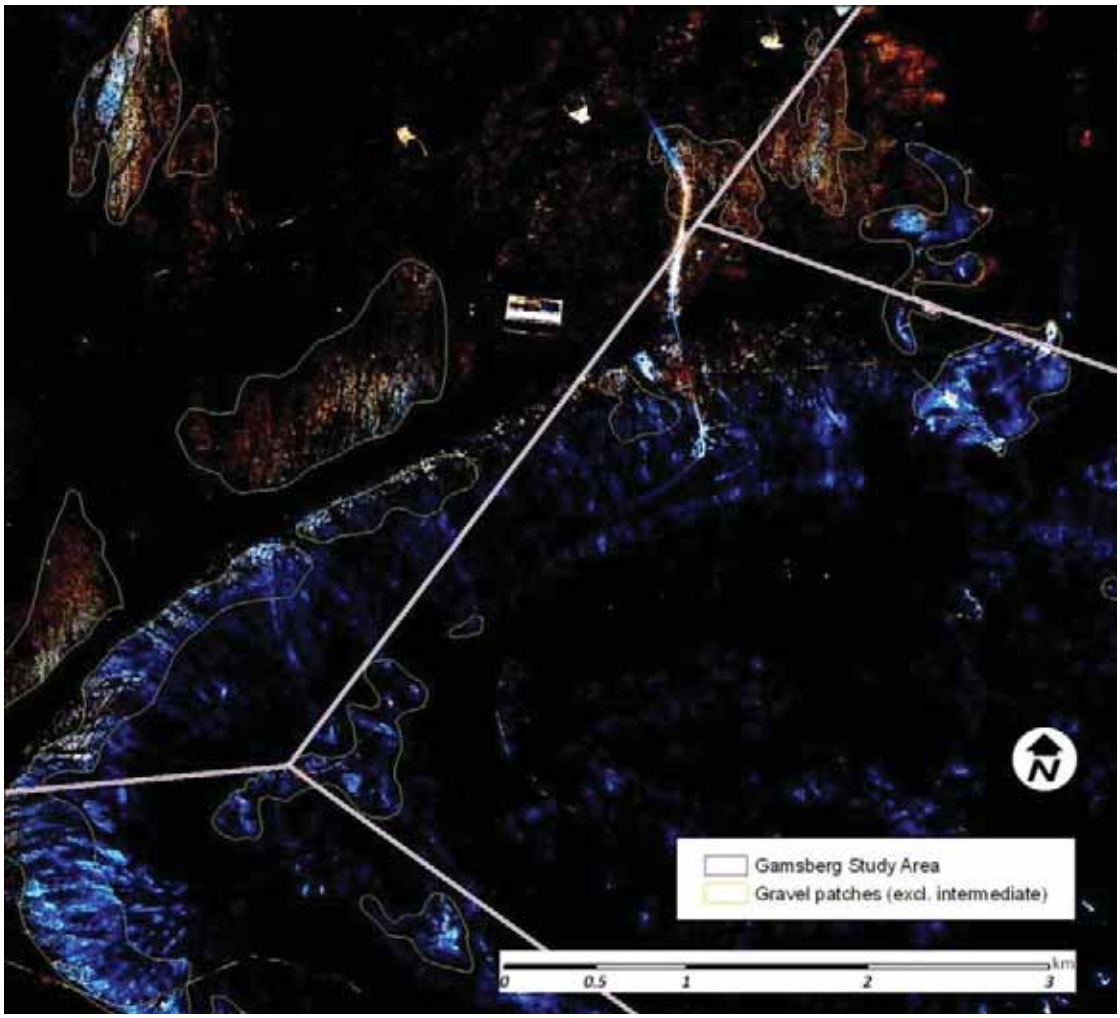


FIGURE 13: AN EXAMPLE OF USING HIGHER RESOLUTION IMAGERY TO BETTER MAP THE EXTENT OF GRAVEL PATCHES. IN THIS EXAMPLE SPOT5 RGB HAS BEEN ADJUSTED TO ACCENTUATE DENSE QUARTZ (BLUE) AND CALCRETE (WHITE-ORANGE) LAG SURFACES. THERE IS CONSIDERABLE VARIATION WITHIN THE MAPPED POLYGONS AND THERE IS OVER-MAPPING OF GRAVEL PATCHES. (IMAGERY COURTESY OF NORTHERN CAPE DETEC)

TABLE 2: A SUMMARY OF THE RESULTS OF THE GRAVEL-PATCH SPECIALIST PLANT SPECIES POPULATION SURVEY. COLUMN 1 IS PLANT DENSITY BASED ON THE NUMBER OF INDIVIDUALS OBSERVED PER SURVEY TRANSECT (NUMBER OF INDIVIDUALS/HA); AND COLUMN 2 IS TOTAL ESTIMATED NUMBER OF INDIVIDUALS BASED ON OBSERVED DENSITY AND CURRENTLY MAPPED EXTENT OF EACH PATCH.

Species	Anacampseros bayeriana		Crassula mesembrianthemopsis		Lithops julii subsp. fulleri var. fulleri		Titanopsis hugo-schlechteri		Conophytum ratum "large"		Conophytum ratum "dwarf"		Total Number of Plants
Patch No.	1[2]	2[3]	1	2	1	2	1	2	1	2	1	2	
1			23	536			160	3,728					4,264
3	8	224	16	447	77	2,149	199	5,553					8,373
5	low[1]		low[1]		86	7,766	262	23,659					31,425
6	2	79			61	2,392	low[1]						2,471
7									64	1652			1,652
8											13	1319	1,319
9									31	2449			2,449
10[2]					10	20							20
11[3]					17	1,967			low[1]				1,967
12					48	888	8	148					1,036
13	11	281			53	1,352	11	281					1,914

1: "Low" signifies that the species is present in the patch but was not sampled in the survey transect.
2: This was not a proper quartz patch but rather brilliant white quartz rock scree with a small calcrete-patch at the base, hence the occurrence of *Lithops julii*.
3: Patch 11 is a very variable gravel patch with rock scree, some fine-grained quartz patches (home to *C. ratum*), calcrete patches (home to *Lithops julii*) and intermediate quartz patch without any specialist.

9 FEATURES OF CONSERVATION CONCERN

The available biodiversity information is interpreted to identify features (species and/or habitats) of conservation concern based on a defined set of biodiversity criteria. The criteria are aimed at identifying those features that are threatened, rare, unique (endemic), play a keystone ecological role, or sensitive to perturbation. These features represent sensitive sites that should if possible be avoided by any development. These areas are essentialy Critical Biodiversity Areas as represented in the Namakwa District Bioregional Plan except mapped at a finer scale, as the criteria for their identification is the same.

In this assessment only species and habitats of conservation concern are identified. A further step of identifying sites of conservation importance to better differentiate between features of conservation concern based on their relative biodiversity importance is not undertaken.

9.1 LISTED PLANT SPECIES

Species of conservation concern are defined here as regionally rare, (near)endemic to the site or threatened plant species that meet the criteria listed in Table 3. In total 15 taxa are identified as meeting these criteria (Table 4). These species are used in this analysis to assess the relative biodiversity importance/sensitivity of habitats based on the occurrence of these species. To a large the degree the classification of species of conservation concern has already been done by the BCI project using the same criteria (see Desmet 2005). The list of species occurring in the study area was verified and updated by this project.

TABLE 3 CRITERIA FOR DETERMINING SPECIES OF CONSERVATION CONCERN.

1.	IUCN Threatened status (Red Data Listed species)
2.	Species triggered by IFC PS6 guidance notes: Range restricted distribution, endemic species to the core BIR, climate-change relic species.

TABLE 4 THE LIST OF SPECIES OF CONSERVATION CONCERN KNOWN TO OCCUR IN THE STUDY AREA AND THE HABITATS THEY ARE ASSOCIATED WITH.

Species Name	Category	Habitat
Anacampseros bayeriana	Rare & Vulnerable[1]	Calcrete gravel patches
Crassula mesembrianthemopsis	Rare & Vulnerable[1]	Calcrete gravel patches
Titanopsis hugo-schlechteri var. hugo-schlechteri	Rare & Vulnerable[1]	Calcrete gravel patches
Mesembryanthemum inachabense	Endemic	Plains quartz gravel patch
Trachyandra sp. nov.	Endemic	Plateau
Tylecodon sulphureus	Endemic	Plateau
Adromischus nanus	Endemic	Plateau quartz gravel patch
Conophytum angelicae subsp. angelicae (dwarf form)	Rare	Plateau quartz gravel patch
Conophytum ratum (dwarf/plateau form)	Endemic & Vulnerable	Plateau quartz gravel patch
Conophytum ratum (plains form)	Endemic & Vulnerable	Plains quartz gravel patches

Species Name	Category	Habitat
Aloe microstigma	Relic	South slopes
Conophytum limpidum (dwarf form)	Endemic	South slopes
Othonna sp. nov.	Endemic	South slopes
Azima tetracantha	Relic	Springs
Hydrodictyon sp. nov.	Endemic	Kloof

1: These are species occuring in calcrete gravel patches are currently not listed as threatened. Based on observations made during the fieldwork for this project these species meet the IUCN criteria for Vulnerable as thieir populations have an effective population range of less than 1000km^2 and populations have been reduced by at least 40% as a result of livestock targeting their habitat during the course of the current drought.

The criteria used to identify species of conservation concern are interpreted very narrowly here. BIR endemics are not included nor are Succulent Karoo relic species listed in the vegetation descriptions. The relic species listed here are characteristic of Succulent thicket vegetation in the Eastern Cape and not Succulent Karoo. If the Succulent Karoo relic species were included they would be located on southfacing slopes and fall within the Bushmanland Inselberg Shrubland vegetation unit.

The occurrence of only a few threatened species is not unusual as levels of transformation and other anthropogenic threats are very low in this landscape. Rare species, data deficient and currently not threatened species that may appear in the threatened species database have not been included.

9.2 HABITATS

Habitats are a higher or coarser-level for assessing biodiversity importance of areas. There are several approaches to identifying habitats of conservation concern. By relating species occurrence data (i.e. occurrence of species of conservation concern) to the habitats in which they occur, it is possible to “up-scale” from an incomplete point observation dataset to extrapolate the findings to a whole area or habitat. Other non-species based criteria can also be invoked such as such as habitat rarity; ecological considerations (ecological process associated with habitats or using habitats as a spatial surrogate for processes); and, degree of transformation (i.e. vulnerability) can also be invoked to identify habitats of conservation concern (Table 5). All these criteria rely to some degree on a good vegetation map and that is why it is important to accurately map vegetation or habitats in impact assessment studies and at a regional scale not just the study site.

Five criteria with which to assess the conservation importance of habitats were developed (Table 5). Based on these criteria eleven habitats of conservation concern are identified (Table 6) using criteria 1-4. Their distribution in the study area is mapped Figure 14. Criterion 5 is not applicable to whole habitats, only to patches of habitat, and is therefore not applied here.

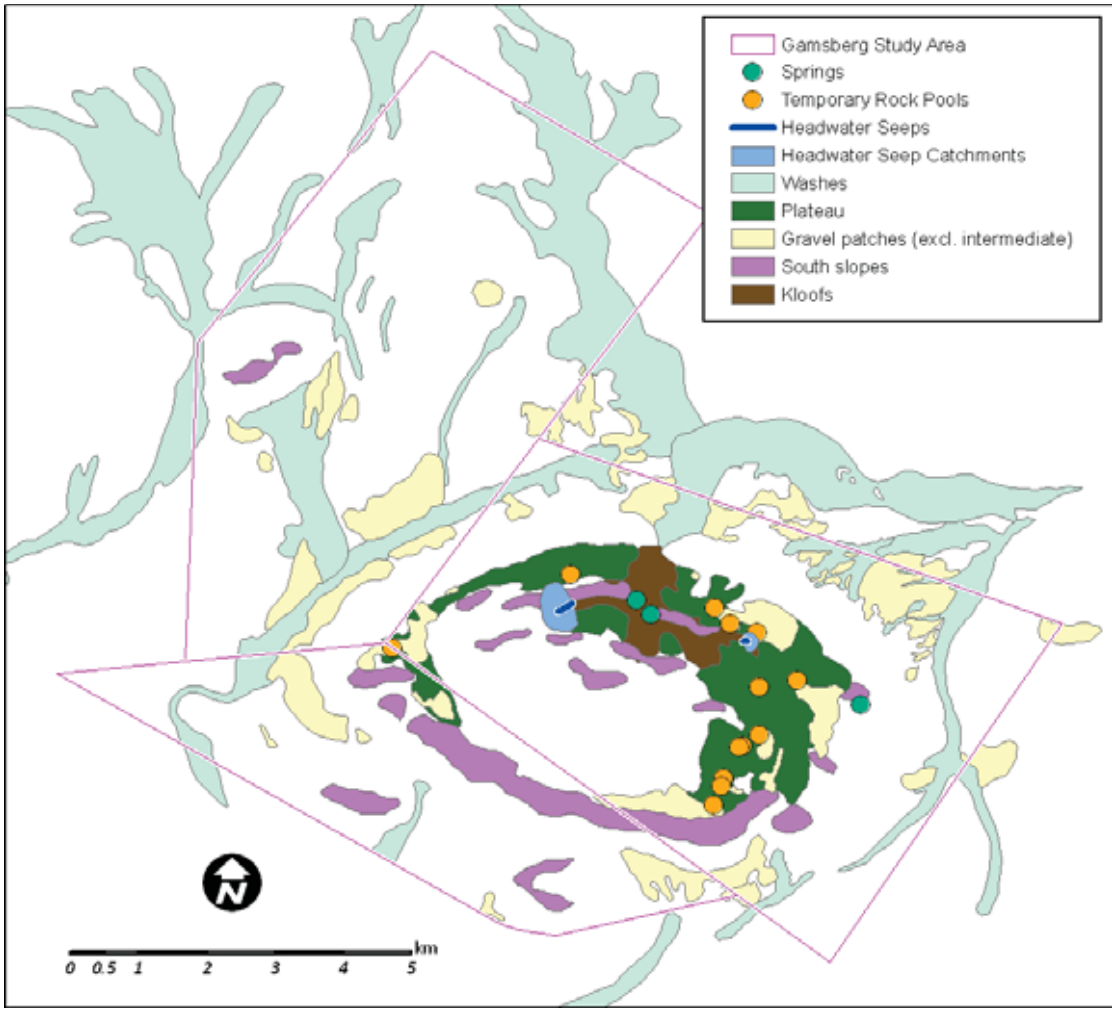
TABLE 5 POTENTIAL CRITERIA FOR DETERMINING HABITATS CONSERVATION CONCERN.

1	Habitat associated with occurrence of species of conservation concern
2	Habitat rarity (covers <10% of extent of vegetation type or <1% of region)
3	Ecosystem functioning considerations (location, presence of, size or other factor related to a habitat importance to ecological function of ecosystem as a whole, e.g. flow of water, climate refuge, water source, etc.)
4	Ecosystem status of habitats using Criteria for Threatened Ecosystems.
5	Area identified as a CBA in the Namakwa District Bioregional Plan (applicable to patches of habitat not the whole habitat)

TABLE 6: A LIST OF HABITATS OF CONSERVATION CONCERN THAT OCCUR IN THE STUDY AREA. CRITERIA RELATE TO CRITERIA 1-3 IN TABLE 5.

Habitat Name	Criteria				Criteria Notes
	1	2	3	4	
Kloofs	✓	✓	✓		Locally rare habitat, climate refuge, keystone resource (water)
Freshwater Springs	✓	✓	✓		Regionally rare habitat, climate refuge, keystone resource (water)
Headwater Seeps and associated catchment		✓	✓		Regionally rare habitat, keystone resource (forage)
Temporary Rock Pools		✓			Very rare habitat
Plateau Quartz Gravel Patches (including "fine-grained patches")	✓	✓			Endemic species and rare habitat
Plains Quartz Gravel Patches	✓				Endemic species
Plateau	✓	✓	✓		Climate refuge and rare habitat
Calcrete Gravel Patches	✓	✓		✓	Endemic and threatened species, rare habitat
South Slopes	✓		✓		Climate refuge
Washes and Dry River Beds			✓		Conduits for water movement in the landscape and keystone ecological resource

FIGURE 14 THE LOCATION AND EXTENT OF HABITATS OF CONSERVATION CONCERN IN THE STUDY AREA.



9.3 BROAD-SCALE ECOLOGICAL PROCESSES

A number of important landscape-level ecological processes and their spatial surrogates have been identified at the site. Ecological processes generally occupy larger areas than biodiversity pattern features. They are also more difficult to measure and map. For the purposes here inferred ecological processes are associated with whole habitats, specific habitat patches or any other part of the ladnscape that can be spatially defined and mapped.

Important ecological processes operating at the site include:

- Climate-change refuge habitats. These are areas or habitats that have moderated microclimates relative to the broader landscape and allow species to persist in a landscape that has otherwise incompatible climate. At the Gamsberg such habitats include:
    - The mountain plateau
    - South-facing slopes (Bushmanland Inselberg Succulent Shrubland) of which the Gamsberg has the largest contiguous patch of this vegetation type
    - The kloof

    - Freshwater Springs
- Dry rivers have permanent sub-surface water flow which supports trees in a landscape that is otherwise mostly devoid of trees. These trees are a keystone ecological resource for local biodiversity.
- Island biogeography. In nature size matters and larger patches of habitat support more species and are more resilient to ecological pertubation. The Gamsberg is the largest inselberg in the region with the largest patches of habitats of conservation concern and consequently the highest species diversity (Desmet 2000b). Any activity that reduces the overall size of (quartzite on) the Gamsberg or any of the important habitats (e.g. southfacing slopes) will have a disproportionately large regional ecolgical impact.
- Species movement. The Gamsberg is a species movement stepping stone located in the middle of the range of inselbergs in the core BIR. Activities that reduce the ability of the Gamsberg to facilitate species movement will have a disproportionaltely large regional impact on species movement simply because it is located in the middle of the inselberg archipelago.
- Speciation. The presence of a unique ant species in the Gamsberg crater (see Faunal Specialist Report) and a unique plant species, *Conophytum burgeri*, in a similar basin in the Aggeneys mountains suggest that the crater or basin in the center of the Gamsberg has ecological attributes that promote speciation.

9.4 CRITICAL BIODIVERSITY AREAS

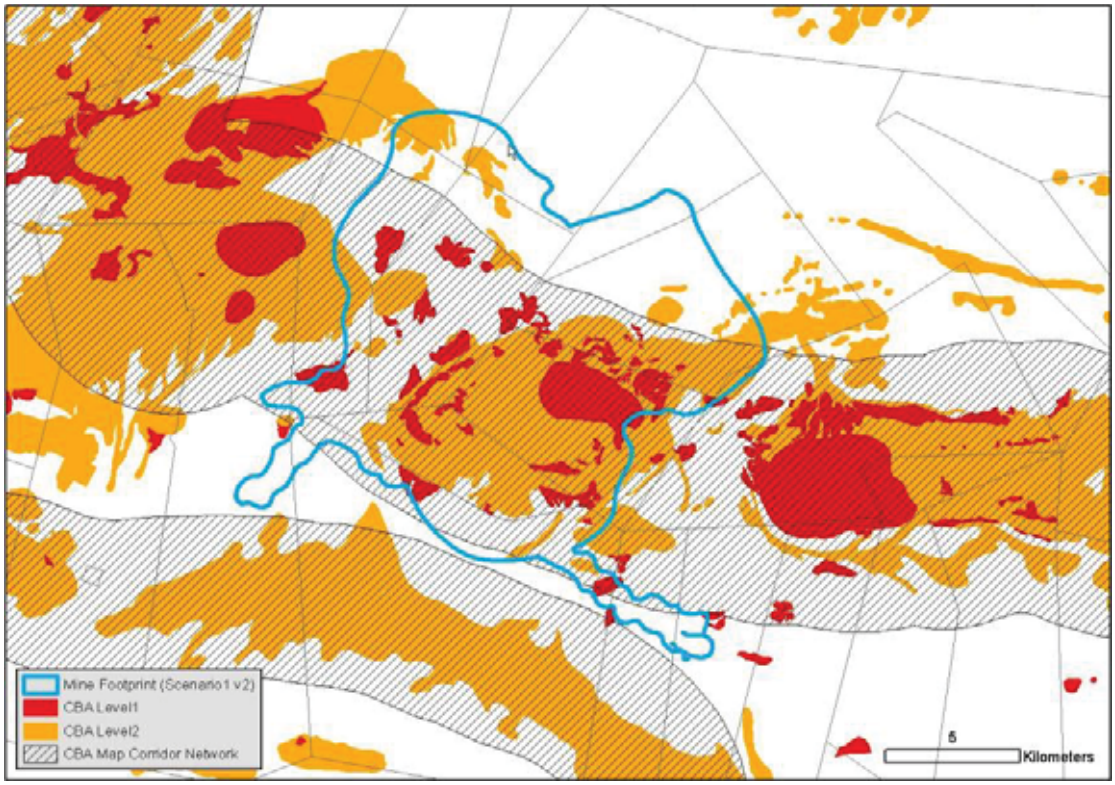
The majority of the mine site is earmarked as Critical Biodiversity Areas (CBAs) in terms of the Namakwa District Bioregional Plan (Marsh *et al.* 2009). This is not surprising given the biodiversity context of site. Two major landscape-level biodiversity corridors are also located in the area: one linking the inselbergs and the other located in the Koa River valley.

The core inselberg region is also earmarked for protected area development. In the 1980s the Gamsberg was first proposed as a natural heritage site. In 2000 Desmet (2000a) produced the first protected area design concept for SANParks that included the core inselbergs with linkages down to the Orange River. This protected area design is partly embodied in the CBA map. The protected area development zone can be defined as the CBAs and biodiversity corridors in the the core BIR PLUS a 5km[1] buffer to limit edge effects and viewshed pollution.

From a land-use planning perspective any activity that is not compatible with a protected area (both in terms of biodiversiy conservation AND economic development) should be discouraged within the protected area development zone. Of particular concern in this landscape are visual impacts of largescale developments such as this mine and also renewable energy power plants.

[1] 5km is the standard development buffer currently used around national parks in South Africa.

FIGURE 15 THE LOCATION OF THE MINE IMPACT AREA IN RELATION TO THE NAMAKWA DISTRICT MAP OF CRITICAL BIODIVERSITY AREAS.



10 REGIONAL SIGNIFICANCE

The regional significance of the Gamsberg inselberg has been well assessed by Desmet (2000b) and peer reviewed, and there is no need to repeat the findings in detail here. Based on multiple criteria with which to compare and rank sites (other inselbergs in the BIR) the study concluded that the Gamsberg is the single most important site for biodiversity the BIR (Table 7). Any new biodiversity information that has been gathered since this original study serves only to support this conclusion.

Desmet (2000b) makes the following conclusion regarding the regional significance of the Gamsberg inselberg based on a quantitative regional survey and assessment of the flora:

- The Gamsberg has the highest number of species of all sites surveyed. These plants are representative of the entire regional flora. No other site surveyed in the BIR has comparable patterns of diversity of plant species. Species diversity of the site is related to the diversity of habitats, the amount of each habitat and the overall size and location of the Gamsberg. Quality of plant populations observed at the site is related to the fact that the site has been a de-facto protected area for the past 40 years.
- Although the Gamsberg inselberg is effectively an island for the majority of plant species that occur there, the plant diversity is exceptional by local,

regional and global standards. Given the diversity of species, habitats, number of regionally rare species and size of specific plant populations, the Gamsberg is regarded as a "mainland" area of plant biodiversity in the region.

- The Gamsberg has the largest number of range restricted plants represented (six species) with two additional species presently known only to occur on this inselberg.
- The Gamsberg has 68% of the regional extent of fine-grain quartz patches. This habitat is regionally unique and supports a number of range restricted (unique) species. The Gamsberg also has the only know occurrence of Headwater Seep Habitat in the BIR. Similar habitats may occur in Namibia but its presence at the Gamsberg is of national importance.
- The Gamsberg, as with all the inselbergs in the region, plays a key role in buffering the regional flora against the negative impacts of global climate change. The Gamsberg is exceptional though because it has (1) the largest single patch of Bushmanland Inselberg Succulent Shrubland (a relic Succulent Karoo vegetation type); (2) largest extent of mountain plateau habitat; (3) largest kloof and one of only 2 in the BIR; and (4) most and largest freshwater springs. These are all important climate change refuge habitats and the Gamsberg has significantly more than any other inselberg in the BIR. On this criterion alone the Gamsbergs ranks as a site of international significance.

TABLE 7 THE REGIONAL IMPORTANCE OF INSELBERGS AND MOUNTAINS IN THE BIR BASED ON EACH SITE'S BIOLOGICAL ATTRIBUTES. DESCRIPTIONS OF THE EIGHT RANKING CRITERIA FOLLOW THE TABLE BELOW (FROM DESMET 2000).

Rank	Site	1	2	3	4	5	6	7	8	Summed score
1	Gamsberg	3	3	4	6	2	5	3	3	29
2	Achab	2	3	2	5	1	5	2	2	22
3	Pella se Berg East	3	3	2	4	2	5	3	0	22
4	Aggeneys	3	3	2	5	2	4	1	1	21
5	Namies	3	3	2	4	0	4	3	0	19
6	Naip	3	3	0	2	0	5	3	2	18
7	Witberg	3	3	0	3	1	4	3	1	18
8	Middle Berg	3	3	4	2	0	4	2	0	18
9	Soutkhoesberg	2	2	0	1	0	4	1	0	10
10	Houmoed	1	2	0	1	0	4	1	0	9
11	Noubestaan	1	2	0	1	0	4	1	0	9
12	Spitzkop	1	2	2	0	0	3	0	0	8
13	Witberg II	1	2	0	0	1	3	0	0	7
14	Amam se Kop	1	1	0	0	0	3	1	0	6

15	Oonab Noord	1	1	0	0	0	3	0	0	5

Criteria used to rank sites:

1. Size of inselberg or mountain (qualitative, 1= small, 3=large).
2. Number of succulent species (qualitative, 1=few, 3=many).
3. Number of species unique to the site (i.e. not known to occur at any other site) multiplied by 2 (quantitative).
4. Number of range-restricted plants (excluding category 3). These can be either Gamsberg Centre or Eastern Gariep quartz patch specialists or otherwise. Sites on the edge of the study area can contain species unique to the northern Namaqualand or Gariep River mountains. These are included for comparative purposes.
5. Known number of palaeo-relics plant species (quantitative).
6. Habitat complexity or number of broad habitat types represented (north slope, south slope, plateau, kloof, rocky plains) represented (quantitative, maximum score 5 = all habitats represented).
7. Size of plateau (qualitative, 1=small 3=large).
8. Size of fine-grain quartz patches (qualitative, 1=small 3=large).

The regional fine-scale vegetation map enables us to better quantify the regional significance of the study area as it provides a clear picture of the regional extent of the habitats represented at the site. The study area could be considered as being regionally significant if more than 5% of the global extent of that habitat occurs in the study area. Where the occurrence of a habitat in the study area is greater than 20% of the regional extent then the study area can be considered as being very significant in a regional context or of international importance. There are a number of habitat features in the study area whose occurrence is significant at the regional scale. Any developments that reduce the amount of these habitats or reduce their ecological functioning will have regional-scale biodiversity impacts (see Section 9.3).

TABLE 8: REGIONAL SIGNIFICANCE OF THE STUDY SITE (PROPORTION OF EACH HABITAT THAT OCCURS IN THE STUDY AREA RELATIVE TO THE KNOWN GLOBAL DISTRIBUTION OF THE HABITAT). ORANGE CELLS INDICATE HIGHLY SIGNIFICANT OCCURRENCE (>20%) AND YELLOW SIGNIFICANT (>5%).

SA Vegetation Type	Habitat Unit	% of Region
Aggeneys Gravel Vygieveld	Mountains Plateau	32.6
	Plains quartz gravel patches	7.7
	Plains intermediate quartz gravel patches	12.2
	Plateau quartz gravel patches	41.2
	Plateau fine-grained quartz gravel patches	84.5
Bushmanland Inselberg Shrubland		3.2
Bushmanland Inselberg Succulent Shrubland		10.4
Bushmanland Arid Grassland	Plains Sandy flat	>1
	Plains Sandy hummocky	
	Calcrete gravel plains	23.7
Bushmanland Sandy Grassland	Plains Sandy mobile dunes	>1
Azonal	Kloof	58.9
	Wash	7.1
	Permanent Freshwater Springs	66
	Temporary rock pools	No Data

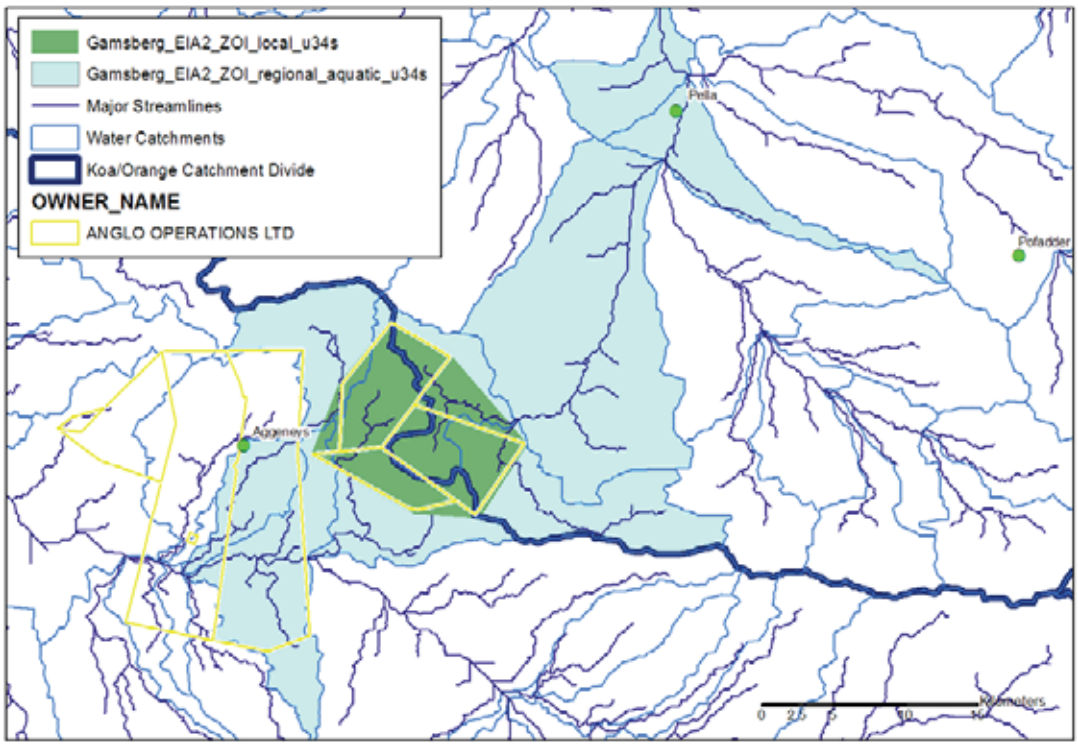
11 DEFINITION OF LOCAL AND REGIONAL AREAS OF INFLUENCE

For the purposes of assessing potential impacts related to the proposed mining activities in the study area three zones of influence (ZOI) are defined for the terrestrial and aquatic environments:

1. Local Scale: The area experiencing direct impacts on biodiversity pattern associated with mine footprint, dust fallout and water runoff. For the present this area is broadly delimited by the four properties that make up the study site (Figure 16). This ZOI could be better delimited based on the inputs from the dust and hydrological specialists.
2. Regional Scale: Indirect impacts primarily on ecological processes as a result of the local-scale impacts. These can be divided into an aquatic and terrestrial component:

a. Regional aquatic: Entire watersheds covered by the local ZOI to their drain-points in the Koa or Orange Rivers (Figure 16). These are areas where downstream impacts on hydrological processes can be expected. The study is unique in being located on the interfluves dividing the Orange and Koa drainage systems. There is the potential in mine-site planning to limit any aquatic impacts to a single drainage system (namely the Kao).
b. Regional terrestrial: Indirect impacts on ecological processes such as meta-population dynamics or species persistence due to the significant loss of a habitat or natural resources (e.g. kloof or spring). All the habitats identified as being of regional significance are endemic to the BIR therefore the BIR essentially defines the regional ZOI (Figure 1). The regional terrestrial zone of influence is the same as that defined for the previous EIA being: "…the inselberg region of northern Bushmanland is that part of the eastern Gariep Centre of Endemism that is influenced by winter rainfall and forms a distinct and unique biogeographical unit terms the Bushmanland Inselberg Region".

FIGURE 16 THE LOCAL ZOI DEFINED PRESENTLY AS THE THREE BMM COMPRISING THE STUDY SITE, AND THE REGIONAL AQUATIC ZOI BASED ON THE WATER CATCHMENTS THAT INTERSECT WITH THE LOCAL ZOI.



12 IMPACT ASSESSMENT

12.1 IMPACTS

The following impacts on plants / habitats / vegetation are considered:

1. Direct impacts considered include:
    a. Loss of habitat as a direct result of mining and associated infrastructure (Habitat Loss);
    b. Reduced ecological functioning of affected habitat as a result of mining and associated infrastructure namely due to fugitive dust and groundwater drawdown associated with the pit (Dust, Groundwater); and,
    c. Reduced or loss of landscape-level ecological functioning as a result of impacts on affected habitat (Landscape-level Ecological Processes).
2. Indirect impacts considered but not quantified include:
    a. Influx of people into the area
    b. Introduction and spread of alien plant species.

12.2 IMPACT ASSESSMENT ASSUMPTIONS

The following assumptions were made when quantifying the proposed mine's impacts on the vegetation. The calculation of the spatial extent of mining impacts is based on three input data variables:

1. Mine layout plan (AATS, version January 2013) with the following modifications:
    a. Processing plant stockpile increased by 3ha.
    b. 8ha concentrate stockpile and loading facility added.
    c. Mine plan explosives magazine area replaced with 5ha footprint on Barite / AA Exploration office site in crater.
    d. Northern and Southern haul-road footprints calculated based on 25° slope of repose and a cut-fill construction.
    e. Variable impact buffers (e.g. run-off, additional roads, diversion walls / trenches, dust) defined for all mine features based on anticipated boundary effects: mine haul roads 60m, other dirt roads 15m, conveyor 20m, infrastructure e.g. plant and contractor camp 50m, road connection to Loop 10 30m, tailings dam 100m, rock dumps 100m.
2. Dust dispersion model (DDA Environmental Engineers, version March 2013). Two significant impact cut-offs are used assuming a 200mg / m^2 / day background dust fallout rate:
    a. 20mg / m^2 / day or 10% deviation from daily rate for sensitive habitats such as gravel patches.
    b. 50mg / m^2 / day or 25% deviation for daily rate for all other habitats.
3. Groundwater drawdown model (ERM, version March 2013). Significant impact cut-off set at a drawdown of 10m 100 years post closure.

12.3 SPATIAL QUANTIFICATION OF IMPACTS

Based on the mine layout plan; dust dispersion model and groundwater drawdown model the estimated total area of direct ecological influence of the mine covers an area of 18 717ha (Figure 17, Table 9). This represents the total area where a change in the baseline condition is predicted to occur. The biodiversity in only a portion of this area is predicted to be adversely affected (i.e. change in baseline condition is greater than 10%) as dust and groundwater impacts are variable between habitats (i.e. some habitat are not impacted by ground water or are more resilient to fugitive dust) this does not represent the area of significant ecological impact (i.e. observable and measurable temporary or permanent change in baseline condition).

In Table 11 impact area is summarized according to habitat loss, and the effects of dust deposition and groundwater drawdown, taking into account whether an impact would be significant for that habitat or not (cells indicated in orange are considered significant). A significant impact is assumed where there is a direct loss of habitat (both in terms of the habitat type itself or its value to particular species of conservation concern) or there is a temporary/permanent measurable loss or reduction in ecosystem functioning.

Any impact that results in a change in the ecosystem status of a habitat using the nationally defined criteria for assessing Threatened Ecosystems (Table 10, DEA 2011) can be regarded as significant. Three of the criteria (A1, A2 and C) are applied here to the status quo, and to the 'status quo plus mining impact' scenarios. For the status quo one out of 19 habitats can be classified as Endangered (calcrete patches due to livestock grazing). Taking into account the area impacted by the proposed mine, two habitats will become Vulnerable; four Endangered; and, five Critical. The status of eight habitats remains unchanged (Table 11).

TABLE 9 SUMMARY OF TOTAL AREA INFLUENCED BY DIFFERENT MINING IMPACTS.

Impact Group	Impact Type	Area (ha)
Habitat Loss	Infrastructure	952
	Infrastructure Buffer	158
	Roads	145
	Roads Buffer	228
Dust	Dust: >20mg/m2/day	6857
	Dust: >50mg/m2/day	5193
Groundwater	Groundwater change 100years -10m	10326
Total Area of Influence		**18717**

FIGURE 17 THE ESTIMATED MINE FOOTPRINT AREA BASED ON THE MINE SITE PLAN, DUST GENERATION AND GROUND WATER DRAWDOWN MODELS.

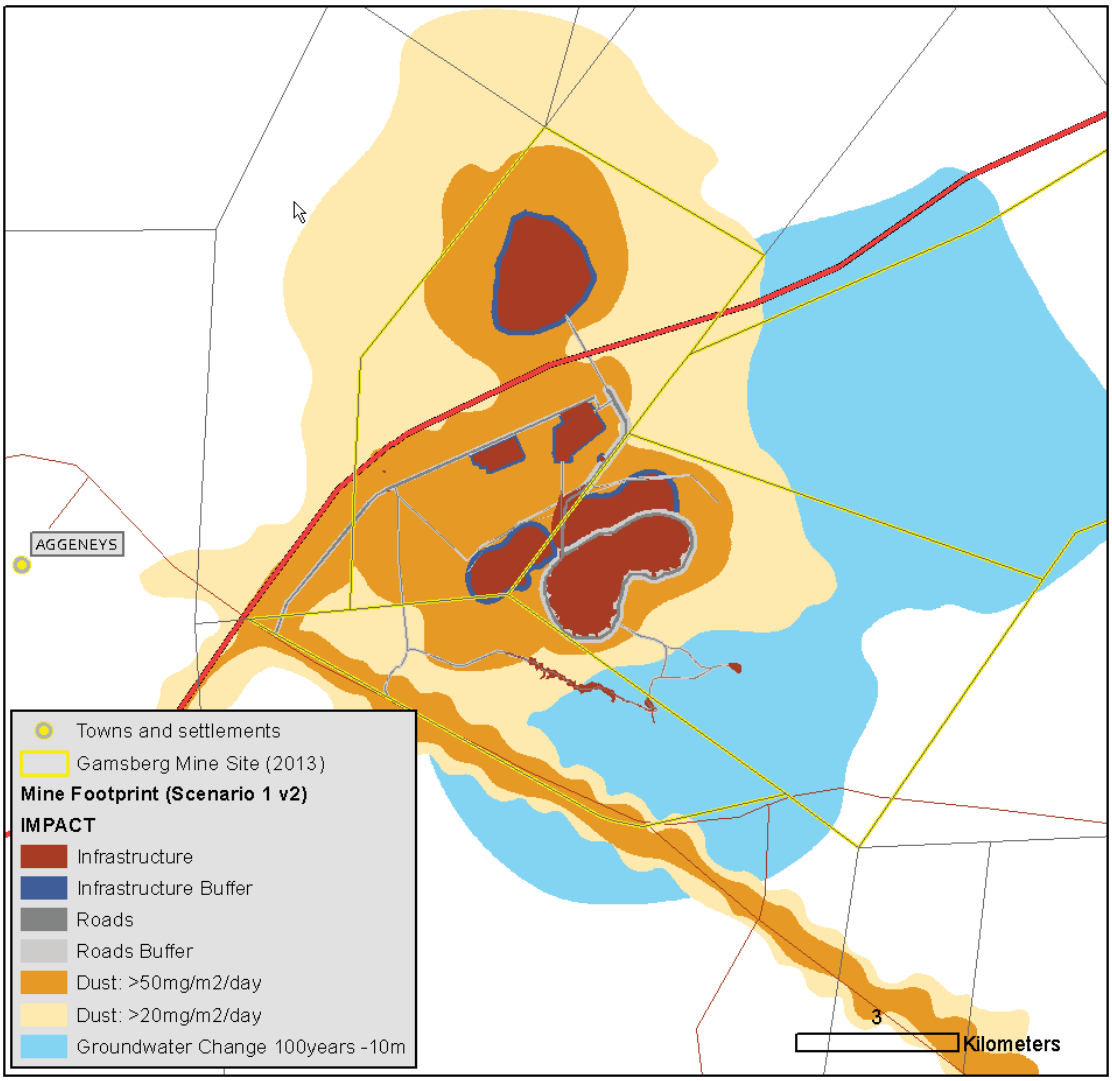


TABLE 10 CRITERIA USED TO DETERMINE ECOSYSTEM STATUS (DEA 2011).

Criterion	CR	EN	VU
A1: Irreversible loss of natural habitat	Remaining natural habitat ≤ biodiversity target	Remaining natural habitat ≤ (biodiversity target + 15%)	Remaining natural habitat ≤ 60% of original area of ecosystem
A2: Ecosystem degradation and loss of integrity*	≥ 60% of ecosystem significantly degraded	≥ 40% of ecosystem significantly degraded	≥ 20% of ecosystem significantly degraded
B: Rate of loss of natural habitat**			
C: Limited extent and imminent threat*	--	Ecosystem extent ≤ 3 000ha, and imminent threat	Ecosystem extent ≤ 6 000ha, and imminent threat
D1: Threatened plant species associations	≥ 80 threatened Red Data List plant species	≥ 60 threatened Red Data List plant species	≥ 40 threatened Red Data List plant species
D2: Threatened animal species associations**			
E: Priority areas for meeting explicit biodiversity targets as defined in a systematic biodiversity plan	Very high irreplaceability and high threat	Very high irreplaceability and medium threat	Very high irreplaceability and low threat
F: Fragmentation**			

TABLE 11 A SUMMARY OF THE AREA IMPACTED BY THE PROPOSED MINE THROUGH HABITAT LOSS, DUST DEPOSITION AND GROUNDWATER DRAWDOWN. FOR DUST DEPOSITION AND GROUNDWATER DRAWDOWN, SIGNIFICANT IMPACTS ON HABITATS ARE INDICATED IN ORANGE.

		Impact Area (ha)										Regional Extent				Impact as % of Core Regional Extent				Ecosystem Status			
SA Vegetation Type	Habitat Unit	Infrastructure	Infrastructure Buffer	Roads	Roads Buffer	TOTAL HABITAT LOSS	Dust >20mg	Dust >50mg	TOTAL DUST IMPACT	TOTAL GROUNDWATER IMPACT	TOTAL IMPACT	CORE REGIONAL EXTENT (ha)	Extent as % of Region	Extent protected in the region	Remaining extent in the region	HABITAT LOSS	DUST	GROUNDWATER	TOTAL IMPACT	Target 1: NSBA & NDM CBA map	Target 2: SKEP and NDM expert mapped areas	Current Ecosystem Threat Status	Ecosystem status WITH impact
Biodiversity Pattern Components (Region is Inselberg Region)																							
Aggeneys Gravel Vygieveld	Mountain plateau	87	6	17	17	**127**	118	59	**59**	**582**		1514	0.3	0.0	>99	8.4	3.9		12.3	18	100	LC	EN (C)
	Plateau quartz gravel	1	6	1	2	**10**	2	40	**62**	**152**		414	0.1	0.0	>99	2.4	15.0		17.4	18	100	LC	EN (C)
	Plateau quartz gravel (fine grain)						49		**49**	**49**	**49**	58	0.0	0.0	>99		84.5		84.5	18	100	LC	CR (A1)
	Plains quartz gravel	82	16	6	12	**116**	111	183	**294**	**521**	**410**	5143	1.0	0.0	>99	2.3	5.7		8.0	18	75	LC	VU (C)
	Plains quartz gravel intermediate						231	56	**56**	**250**	**56**	617	0.1	0.0	>99		9.1		9.1	18		LC	EN (C)
	Plains feldspar gravel						74	17	**91**		**91**	1237	0.2	0.0	>99		7.4		7.4	18	100	LC	EN (C)
	Plains rocky	32	15	11	14	**72**	559	161	**161**	**463**	**233**	8624	1.7	0.0	>99	0.8	1.9		2.7	18		LC	LC
Bushmanland Inselberg Shrubland		441	27	51	76	**595**	884	375	**375**	**2932**	**970**	28266	5.6	0.0	>99	2.1	1.3		3.4	34		LC	LC
Bushmanland Inselberg Succulent Shrubland		64	0	5	3	**72**	152	44	**44**	**476**	**116**	3869	0.8	0.0	>99	1.9	1.1		3.0	34	75	LC	VU (C)
Bushmanland Arid Grassland	Flat sandy plains	279	72	35	61	**447**	2084	1963	**1963**	**3853**	**2410**	41875	8.3	0.0	98.0	1.1	4.7		5.8	21		LC	LC

		Impact Area (ha)										Regional Extent				Impact as % of Core Regional Extent				Ecosystem Status			
SA Vegetation Type	**Habitat Unit**	Infrastructure	Infrastructure Buffer	Roads	Roads Buffer	**TOTAL HABITAT LOSS**	Dust >20mg	Dust >50mg	**TOTAL DUST IMPACT**	**TOTAL GROUNDWATER IMPACT**	**TOTAL IMPACT**	CORE REGIONAL EXTENT (ha)	Extent as % of Region	Extent protected in the region	Remaining extent in the region	HABITAT LOSS	DUST	GROUNDWATER	TOTAL IMPACT	Target 1: NSBA & NDM CBA map	Target 2: SKEP and NDM expert mapped areas	Current Ecosystem Threat Status	Ecosystem status WITH impact
	Hummocky sandy plains			6	11	**17**	447	348	**348**	**7**	**365**	20070	4.0	0.0	99.0	0.1	1.7		1.8	21		LC	LC
	Calcrete gravel plains			6	14	**20**	229	180	**409**	**157**	**429**	1486	0.3	0.0	95.0	1.3	27.5		28.8	21	100	EN (A2)	CR (A2)
Bushmanland Sandy Grassland							30	5	**5**	**18**	**5**	20000	4.0	0.0	>99				0.0	21		LC	LC
Eastern Gariep Plains Desert	Rocky plains						252			**121**	**0**	10000	2.0	0.0	>99				0.0	34		LC	LC
Azonal Habitats	Kloof (Watershed model)	54		10	16	**80**	186	131	**317**	**402**	**482**	847	0.2	0.0	>99	9.4	37.4	47.5	56.9		100	LC	CR (A1)
	Wash	8	17	10	17	**52**	929	446	**446**	**646**	**698**	13868	2.7	0.0	>99	0.4	3.2	4.7	5.1	30		LC	LC
	River (Wash with subsurface flow)						536	93	**93**	**470**	**470**	3489	<1.0	0.0	>99		2.7	13.5	13.5	30		LC	LC
	Headwater Seep Wetlands (Catchment)	22	1	3	5	**31**				**38**	**31**	38	0.0	0.0	99.0	81.6	0.0		81.6		100	LC	CR (A1)
	Permanent Freshwater Springs							1	**1**	**2**	**2**	3		0.0	100.0		33.3	66.7	66.7		100	LC	CR (A1)
	Temporary Rock Pools										**0**												
TOTAL AREA (ha)		1070	160	161	248	1639	6873	4102	4773	11139	6817												
Ecological Process Components (Extent is Core Inselberg Region)																							
Climate Refugia (patch position)	Mountain Plateau	88	12	18	19	**137**	169	99	**542**	**582**	**679**	1932	1.0	0.0		7.1	28.1	30.1	37.2				

		Impact Area (ha)										Regional Extent				Impact as % of Core Regional Extent				Ecosystem Status			
SA Vegetation Type	Habitat Unit	Infrastructure	Infrastructure Buffer	Roads	Roads Buffer	TOTAL HABITAT LOSS	Dust >20mg	Dust >50mg	TOTAL DUST IMPACT	TOTAL GROUNDWATER IMPACT	TOTAL IMPACT	CORE REGIONAL EXTENT (ha)	Extent as % of Region	Extent protected in the region	Remaining extent in the region	HABITAT LOSS	DUST	GROUNDWATER	TOTAL IMPACT	Target 1: NSBA & NDM CBA map	Target 2: SKEP and NDM expert mapped areas	Current Ecosystem Threat Status	Ecosystem status WITH impact
	South Slopes	64		5	3	**72**	152	44	**340**	**476**	**412**	3869	2.0	0.0		1.9	8.8	12.3	14.2				
	Kloof	54		10	16	**80**	186	131	**477**	**402**	**557**	847	0.4	0.0		9.4	56.3	47.5	65.7				
	Permanent Freshwater Springs							1		**2**	**2**	3											
Keystone Ecological Resource	River (Wash with subsurface flow)						536	93	**629**	**470**	**629**	3489	1.8	0.0			18.0	13.5	18.0				
Ecological Process Components (Extent is Core Inselberg Region)																							
Island Biogeography (patch size)	Whole Inselberg								**1**			6		0.0		0.0	16.7						
	Core South Slope of inselberg	11		2		**13**	24	4	**28**	**122**		607	0.3	0.0		2.1	4.6						
Species movement	Biodiversity corridor (sensu Namakwa CBA map)	6.5				**6.5**	13.5	10.5	**13.5**			10		0.0		65.0	135.0						
Speciation	Isolated "basins"	1				**1**		1	**1**			5		0.0		20.0	20.0						
Ecosystem Goods and Services																							
Basin water catchment																							
Protected Area Development Zone																							
Landscape aesthetic value																							

12.4 SUMMARY ASSESSMENT

12.4.1 Pre-Existing Threats

Pre-existing threats to vegetation and plant species at the mine site are very low. For at least the last 30 years the mine-owned area south of the N14 has been a de facto preserve for biodiversity.

Historic and current exploration and mining activities have been of limited extent with less than 30ha of the entire mine-site currently considered as "transformed" to non-natural landscapes. In some cases activities have had very limited environmental impact. The Anglo Exploration activities on the eastern plateau over the last 8 years have followed exemplary environmental control and rehabilitation protocols. In other cases, such as the current mining activities on the north of the mountain, there are visible and un-mitigated dust emissions and acid rock drainage whose magnitude has not been quantified.

The exclusion of domestic livestock for the last three decades has resulted in the site having the best examples of the respective habitats regionally. The calcrete patch plant population survey demonstrated that calcrete patch plant specialist have population sizes orders of magnitude larger in the area protected from livestock (i.e. mine site south of the N14) compared to sites exposed to regular grazing (i.e. mine site north of the N14). The drought over the last three years has exacerbated the decline of populations in calcrete patches regionally making the comparison to sites at the Gamsberg even more extreme. This trend of larger healthier plant populations holds for all habitats at the mine site. Whilst plant populations have suffered elsewhere in the region at the hands of livestock farming under conservation management and time they have the potential to recover to resemble what is currently observed at the Gamsberg.

Current threats to biodiversity from alien plant species are also very low. Presently, scattered individuals of *Prosopis glandulosa* (Mesquite) are present in the river and wash systems around the mountain but not in the basin or kloof. This tree represents a dormant threat that has the potential to become very significant in riparian areas if not eradicated. Russian thistle, *Salsola kali*, is widely present in disturbed places in the veld. This alien shrub is practically naturalized in karoo vegetation and does not pose a significant threat at this time.

Within the last decade fountain grass (*Pennisetum setaceum*) has become established throughout Aggeneys town especially water run-on areas such as road culverts. This species represents a highly significant and real threat for the aquatic ecosystems of the Gamsberg. Increased traffic volume from Aggeneys to the mountain will increase opportunities for seed dispersal to the site, and increased water availability from dust mitigation activities will create ample opportunities and niches for this species to establish on the mountain. Once established in the physical mining area it is highly likely that this species will colonize the seeps and springs in the kloof resulting in further indirect loss of biodiversity in the kloof.

An active alien species monitoring and control program will need to be an essential impact mitigation action.

Historically, the Gamsberg has been a popular botanical destination given the habitats and species present at the site. The effect of illegal plant on plant populations at the site has not been quantified, but it does have the potential to be significant for some species with very restricted populations or high horticultural desirability. Regulated access control to all areas of the mine site not critical to mining activities will an important mitigation measure.

12.4.1.1 Impact 1: Habitat loss - Site-Level Loss of vegetation/natural habitat

The most apparent and immediate impact of mining is the direct physical loss of natural habitat associated with the construction and operation of mine infrastructure (i.e. pit,

processing plant, roads, contractor camp, etc.). This is the hard mine footprint as defined in the mine layout plan. For this impact no distinction is made between different mining activities as the ultimate impact on the ecosystem is the same; it is immediate as soon as activity commences; and, is permanent and irreversible for all habitats.

For some activities that have a short duration time span (e.g. the contractor camp) post activity ecological restoration will return some elements of original ecosystem. It is assumed that restoration whilst being a very important component of impact mitigation can never return an area to its original ecological state.

The significance of this impact is relative to the habitat concerned

This impact has been spatially quantified based on the mine layout plan discussed in Section 12.2.

Impact Nature: Site construction and operation will result in loss of natural habitat.

Impact	*Nature*	*Extent*	*Duration*	*Intensity*	*Reversibility*	*Impact on Features of conservation concern*	*Probability*	*Significance*	*Confidence*
Without Mitigation	**Negative**	**Local**	**Long-term/ permanent**	**High**	**Low**	**High**	**Definite**	**Major**	**High**
With Mitigation	**Negative**	**Local**	**Long-term/ permanent**	**High**	**Low**	**Moderate**	**Definite**	**Major**	**High**

Mitigation Description:

- See Section 12.6

Residual Impact: Permanent and significant loss of all natural habitats impacted. The likelihood of restoring the original ecosystems is low.

Cumulative Impact:

12.4.1.2 Impact 2: Reduced ecological function and habitat degradation

Some mining impacts do not result in the immediate loss of natural habitat. These impacts are cumulative on the structure and function of ecosystems, and in some cases could ultimately result in permanent loss of natural habitat. The impacts of these activities are considered significant if there is an observable and measurable change (temporary or permanent) in the ecological properties of the affected habitats.

These impacts are a direct result of mining activities within the mine footprint. Three groups of impacts are considered here:

- Modified run-off (amount, rate, composition) from stream or surface flow diversion or from working surfaces;
- Dust generation and fallout from all activities;
- Acid rock drainage; and,
- Groundwater draw down associated with the pit over the life of mine until equilibrium at some point post mine closure.

These impacts affect the ecological functioning of ecosystems and may result in deterioration of habitats and loss of sensitive species. The impact could be temporary and reverse on mine closure (e.g. dust from roads) or could be permanent (e.g. ground-water dewatering) resulting in permanent changes in the ecosystem. While the activities causing the impacts happen on the site, they could result in regional effects.

Impact 2a: Modified Surface Run-Off

Impact Nature: Site construction and operation will change the natural flow regimes of the area.

Impact	*Nature*	*Extent*	*Duration*	*Intensity*	*Reversibility*	*Impact on Features of conservation concern*	*Probability*	*Significance*	*Confidence*
Without Mitigation	**Negative**	**Regional**	**Long-term**	**High**	**Low**	**Moderate**	**Definite**	**Major**	**High**
With Mitigation	**Negative**	**Local**	**Long-term**	**High**	**Medium**	**Low**	**Definite**	**Medium**	**High**

Mitigation Description:

- See Section 12.6
- Consider location of watercourses and avoid in the siting of mine infrastructure.
- Construct flood containment walls and retention ponds around all hard infrastructure.
- Construct sediment containment dams in crater water course to limit ARD producing material from the pit working area from entering the kloof system (see Section 12.6).
- Construct flood diversion walls around the pit to divert natural run-off.
- Contain the mine layout (excluding pit) to within a single water catchment.

Residual Impact: Modified flow regime within affected catchment. The likelihood of restoring the original flow regime is medium.

Cumulative Impact:

Impact 2b: Dust Generation

The dust produced from the mining process is acid generating and dark brown / black in color. Background dust is calcareous and red in color. Of concern with the dust impact is not the volume of dust but the physical color and chemical properties of the dust. The ecosystems at the site experience very erratic rainfall; are dominated by dwarf leaf-succulent plants, some only a few millimeters in size; the micro-climatic properties of quartz patches are a result of the white quartz insulating the soil and reflecting sunlight; and, moisture derived from mist is the dominant moisture source for the winter-rainfall component of the sites' flora. Therefore, it is likely that very small changes in the chemical and physical properties of background dust could result in significant changes in ecosystem structure and functioning.

Dust impacts are considered significant for sensitive habitats (quartz patches, kloof and south slopes) if the dust input from mining results in a 10% change in baseline dust deposition or 20mg / m^2 / day assuming a median monthly average of 200mg / m^2 / day. Dust impacts are considered significant for other habitats if the dust input from mining results in a 25% change in baseline dust deposition or 50mg / m^2 / day.

Uncertainty around the extent and magnitude of the dust impact is high. Fugitive dust negatively impacts ecosystem functioning. Given the particular nature of the fugitive dust associated with this mine and the very unique nature of the ecosystems being impacted, the levels of dust deposition at which unacceptable negative effects are manifest are likely to be far less than for habitats or vegetation types elsewhere and/or relative to international standards. The levels of dust fallout at which negative impacts become evident, as well as the severity of impacts, need to be established and quantified as part of the mine monitoring program.

Impact Nature: Dust deposition effects on habitat and species.

Impact	*Nature*	*Extent*	*Duration*	*Intensity*	*Reversibility*	*Impact on Features of conservation concern*	*Probability*	*Significance*	*Confidence*
Without Mitigation	**Negative**	**Regional**	**Long-term/ permanent**	**High**	**Low**	**Moderate / High**	**Definite**	**Major**	**Low**
With Mitigation	**Negative**	**Regional**	**Long-term/ permanent**	**Medium**	**Medium**	**Moderate /High**	**Definite**	**Major**	**Low**

Mitigation Description:

- See Section 12.6
- Effective dust suppression in and around the pit is essential.

Residual Impact: Long-term ecological impact of acid rock dust in this context is unknown. In some habitats (e.g. quartz patches, kloof and south slopes) life-of-mine plant population extinctions could result in predominance of common species or lead to species extinction for range-restricted species (e.g. Conophytum ratum, Conophytum angelicae "dwarf form"). There is a high risk of significant impacts.

Cumulative Impact:

Impact 2c: Acid rock drainage

ARD from working surfaces and rock dumps located within the kloof watercatchment will release acid leachate into this aquatic ecosystem. This will have a significant negative impact on aquatic communities in this ecosystem.

Impact Nature: Rock dumps will release acid leachate into surface water flow especially into the kloof ecosystem.

Impact	*Nature*	*Extent*	*Duration*	*Intensity*	*Reversibility*	*Impact on Irreplaceable Resources*	*Probability*	*Significance*	*Confidence*
Without Mitigation	**Negative**	**Local**	**Long-term**	**High**	**Medium**	**High**	**Definite**	**Major**	**High**
With	**Negative**	**Local**	**Long-**	**Low**	**Medium**	**Low**	**Definite**	**Low**	**High**

Mitigation			**term**						

Mitigation Description:

- Emphasis on runoff management through mine layout / design and stormwater management system to avoid contaminated runoff entering the kloof ecosystem.
- Avoid building rocks dumps within the kloof catchment containing ARD producing rocks.
- Manage all runoff from pit working area to flow away from kloof catchment.
- See Section 12.6

Residual Impact: None if mitigation measures implemented

Cumulative Impact:

Impact 2c: Groundwater Draw Down

Groundwater draw down associated with the open pit will significantly affect habitats dependent on this water. Of particular relevance are the seeps and springs around the inselberg and the riparian plant community, mainly trees, growing in the kloof and river north of the kloof.

Lowering of the water table in riparian areas will reduce the ability of tree species to regenerate. With time as established trees die they will not be replaced in the affected areas. The tree species affected are mostly widespread throughout southern Africa although locally they are rare or uncommon being confined to these habitats. These species are a keystone ecological resource so their loss will imply a permanent and irreversible loss of ecological function.

The freshwater springs are very rare regionally. Their loss will be a regional impact not because of the loss of biodiversity pattern (i.e. the actual spring) but for the ecological process impact. Permanent fresh water is very rare in this landscape and is a keystone ecological resource. Their presence could have wide reaching importance for fauna in this desert landscape.

Azima tetracantha is a tree growing in the spring on the eastern slopes of the mountain. It is a widespread species from the eastern Cape that is a palaeo-relic in this landscape from past climates. It is possible that it has been growing in this spot for at least the last 10 000 years. The loss of this spring is likely to result in the loss of this species at this site.

Impact Nature: The open pit will lower the water table around the mine site.

Impact	*Nature*	*Extent*	*Duration*	*Intensity*	*Reversibility*	*Impact on Features of conservation concern*	*Probability*	*Significance*	*Confidence*
Without Mitigation	**Negative**	**Local**	**Permanent**	**High**	**Low**	**High**	**Definite**	**Major**	**High**
With Mitigation	**Negative**	**Local**	**Permanent**	**High**	**Low**	**High**	**Definite**	**Major**	**High**

Mitigation Description:

- See Section 12.6
- No effective mitigation is envisaged for this impact. Provision of artificial water sources is not a sustainable long-term solution.
- Ex-situ conservation of the *Azima tetracantha* (e.g. propagated in the mine nursery as a

horticultural species, to which it is very suited) will at least preserve the unique genetic component of this individual.

- Detailed monitoring and documentation of the affected habitats will track loss and also quantify rate of change. This could provide insights for more effective mitigation.

Residual Impact: Permanent and significant lowering of groundwater affecting riverine vegetation downstream from the kloof. Permanent loss of 2 of the core BIRs' 3 freshwater springs.

Cumulative Impact:

12.4.1.3 Impact 3: Loss of Biodiversity

Location of mine infrastructure can avoid directly impacting any know populations of species of conservation concern. However, change in surface runoff water quality through the kloof and dust emissions could result in some plant species extinctions.

An aquatic species discovered in the kloof, *Hydrodictyon* sp., is possibly new to science and possibly restricted to this site. Change in water flow and / or quality in the kloof could result in this species becoming extinct.

Dust fallout on the eastern plateau will negatively affect the *Conophytum ratum* and *Conophytum angelicae* populations growing in the fine-grained quartz gravel patch there. This ecosystem and associated plants are assumed to have very low resilience to this type of perturbation. The populations of these two species at this locality represent 90-95% of the total numbers of individuals for these species summed across all known populations. This population is the source population for all other populations of these species in Bushmanland. Significant impacts on populations at this site would result in extinction of these species.

The proposed mine will destroy 81.6% of the known distribution of the headwater seep habitat in South Africa. At present, however, no species are known to be restricted to this habitat; it is not known if loss of the habitat would result in extinction of any species.

Impact Nature: Change in surface water runoff quality and dust fallout could result in plant species extinctions.

Impact	*Nature*	*Extent*	*Duration*	*Intensity*	*Reversibility*	*Impact on Features of conservation concern*	*Probability Likelihood*	*Significance*	*Confidence*
Without Mitigation	**Negative**	**Regional /Global**	**Permanent**	**Severely altered**	**Low**	**High**	**Possible**	**Major**	**low**
With Mitigation	**Negative**	**Local**	**Long-term**	**Noticeable**	**Moderate**	**Low**	**Possible**	**Moderate**	**low**

Mitigation Description:

- See Section 12.6
- Reduce dust emission
- Manage surface water quality run-off in the basin.
- Protect all know regional populations of species at risk via Biodiversity Offset to buffer species against possible loss of or changes in source populations.

Residual Impact: Moderate residual impact with mitigation.

Cumulative Impact: None

12.4.1.4 Impact 4: Third party access / Human influx

The influx of people during mine construction and operation will be significant and will have an impact on vegetation if site access outside of the construction / mining area is not regulated. Typical impacts include ad-hoc or professional collecting of flora; litter; and, creation of off-road tracks. Tracks can have significant impacts for flora as gravel patches are especially attractive to off-road enthusiasts.

Impact Nature: Mine operation will facilitate unwanted people access to the mine site.

Impact	*Nature*	*Extent*	*Duration*	*Intensity*	*Reversibility*	*Impact on Features of conservation concern*	*Probability*	*Significance*	*Confidence*
Without Mitigation	**Negative**	**Regional**	**Long--term**	**Low**	**High**	**High**	**Definite**	**Moderate**	**High**
With Mitigation	**Neutral**	**Local**	**Long-term**	**Low**	**High**	**Low**	**Definite**	**Negligible**	**High**

Mitigation Description:

- See Section 12.6
- Institute site access monitoring, controls and enforcement.
- All mine roads to be bounded with medium 4/5 strand livestock and locked gates leading off these roads.
- Training and education of all workers on environmental sensitivities of the site and appropriated behavior.

Residual Impact: No residual impact with mitigation.

Cumulative Impact: None

12.4.1.5 Impact 5: Spread of alien and invasive species,

Mining activities at the site will facilitate the influx and spread of alien species at the site. See Section 12.4.1 If fountain grass gets into the kloof, springs and remaining headwater seep on the Gamsberg it will have a very high negative ecological impact.

Impact Nature: Mine operation will facilitate spread of alien species to the mine site.

Impact	*Nature*	*Extent*	*Duration*	*Intensity*	*Reversibility*	*Impact on Features of conservation concern*	*Probability*	*Significance*	*Confidence*
Without Mitigation	**Negative**	**Local**	**Permanent**	**Medium**	**High**	**High**	**Definite**	**Moderate**	**High**
With Mitigation	**Neutral**	**Local**	**Permanent**	**Low**	**High**	**Low**	**Definite**	**Minor**	**High**

Mitigation Description:

- See Section 12.6

• Institute an Alien Plant and Animal Monitoring and Control program. • Use only approved indigenous species for all workplace and new housing greening • Training and education of all workers on environmental sensitivities of the site and appropriate behavior especially with regard species introductions.
Residual Impact: Low residual impact with mitigation.
Cumulative Impact: None

12.4.1.6 Impacts on Landscape-Level Ecological Processes

These impacts include:

- Disruption of ecosystem processes and habitat fragmentation
- Disruption of meta-population processes
- Reduction of ecological corridor function (Impacts on Conservation Areas)
- Reduction of ecological refuge function

Temporary or permanent loss of the populations of fine-grained quartz patch endemic species on the eastern Gamsberg could result in these species going extinct. Using a meta-population concept of population dynamics the populations on the eastern Gamsberg are the only source populations for *Conophytum angelicae* ("dwarf form") and *C. ratum*. All other populations in the BIR given their small size are considered sink populations.

The same holds for the calcrete patch endemic species: the populations at the Gamsberg are the largest in the region; however, their habitat is not as rare as the fine-grained quartz patches and the species distribution has been heavily affected by livestock grazing. Ecological restoration of calcrete patches elsewhere in the core BIR is a valid mitigation / offset measure to safeguard the persistence of these species.

The reduction in extent of refuge habitats important for climate change adaptation will increase the risk of species loss for the Bushmanland inselberg landscape due to climate change.

Mining will reduce the Gamsberg's ecological function as a movement / migratory stepping-stone / corridor for species between inselbergs. Additionally, being located in the middle of the archipelago of central Bushmanland inselbergs, its position is key to the east-west movement of species.

The mine impact area occupies 100% of the width of the ecological landscape corridor contained in the Namakwa District Map of Critical Biodiversity Areas (Figure 15). This corridor was designed to safeguard movement of biota between the Bushmanland inselbergs. This function will be partially lost during mine operation.

Corridor function can be partly mitigated by ensuring that areas to the north and south of the mine impact area remain permeable to biodiversity. This mitigation measure will only be effective for species of sandy habitats. For species dependent on rocky habitats there are no corridor alternatives and thus the mine represents a temporary and possibly permanent disruption in their movement pathways.

The core BIR is the focus of protected area development in the region around the inselbergs, CBAs and biodiversity corridors. The mine will impact on this plan but it can be compensated by ensuring that a biodiversity offset contributes to the establishment of an protected area in this region.

Impact Nature: Impacts on Landscape-Level Ecological Processes

Impact	*Nature*	*Extent*	*Duration*	*Intensity*	*Reversibility*	*Impact on Features of conservation concern*	*Probability*	*Significance*	*Confidence*
Without Mitigation	**Negative**	**Regional**	**Long-term/ permanent**	**High**	**Low**	**Moderate**	**Definite**	**Major**	**Medium**
With Mitigation	**Negative**	**Regional**	**Long-term/ permanent**	**High**	**Low**	**Low**	**Definite**	**Moderate**	**Medium**

Mitigation Description:

- See Section 12.6
- Maintain functional corridor width by ensuring that no other developments occur within a 5km buffer around the mine impact area. This can be implemented through the spatial design of Biodiversity Offset.
- Avoid constraining the movement of biodiversity on the mine site through ecologically sensitive mine design and architecture (e.g. minimal lighting, no hard or impermeable barriers to species movement, improve mine-site permeability to biodiversity by maintaining corridors of natural vegetation between infrastructure, etc.)
- Ensure that other large-scale development in the region is located outside of the protected area development zone (i.e. CBAs and biodiversity corridors in core BIR plus 5km buffer).

Residual Impact:

- Size of Gamsberg and other important habitat patches permanently reduced in size. The species relaxation effect associated with this reduction in "island size" will mean that in time the total species diversity of the Gamsberg will decline. This loss cannot be fully mitigated and is of moderate significance.
- Possibility of species extinction associated with the fine-grain quartz patches.

Cumulative Impact:

12.5 CUMULATIVE IMPACTS

There are three sources of cumulative impacts that are directly or indirectly related to this project and which will impact biodiversity in the region and specifically the ability to offset residual impacts and also achieve biodiversity conservation targets. Cumulative impacts include:

1. Offsite impacts of associated activities / facilities directly related to this development such as ore transport, worker housing, power supply, port loading facility, etc. Residual impacts from these activities may require biodiversity offsets.
2. Future onsite impacts from open pit mining as a result of expansion of mining operations into other known ore bodies. The ability to further offset open pit mining operations is severely constrained and may not be possible. Should underground mining options be adopted in future with associated infrastructure located in non-sensitive areas, then further

offsets may not be required. This limitation applies to other know ore reserves in the core BIR.

3. Offsite impacts due to other developments in the region namely renewable power generation plants. Any other extensive developments within the offset area / protected area development zone will compromise the offset goal of creating a contiguous and viable protected area in the core inselberg region. There is a historical precedent for creating a protected area around these inselbergs and this essentially implies the existence of an exclusive protected area development zone. Other extensive developments envisaged for this landscape need to be located well away from this development zone so as not to compromise the current land-use goal.

12.6 Recommendations for Avoiding and Mitigating Impacts

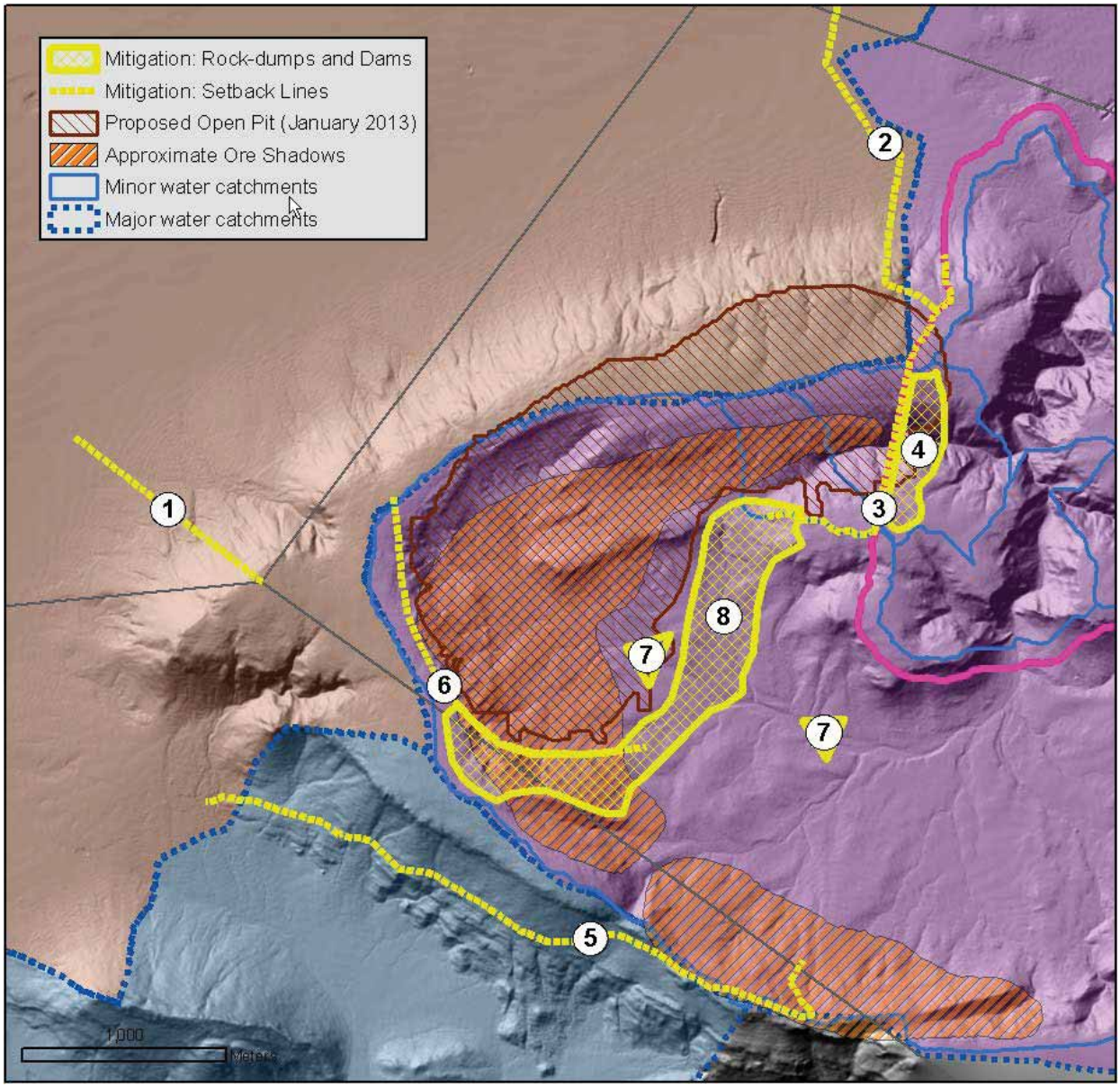
Planning Phase:

Mine Design: There is scope for the proposed mine plan to incorporate mitigation measures based on avoiding sensitive sites or reducing ecological impacts. Proposed amendments to the plan include:

1. Incorporating a setback line in the location of the western edge of the north-western rock dump to avoid the population of Conophytum ratum located on the inselberg foot-slopes approximately north-west of the radio tower (i.e. restrict rock dumps to the area east of the radio tower).
2. Incorporate a setback line for the maximum eastern extent of rock dumps to avoid contaminated runoff entering the Orange River catchment.
3. Incorporating a setback line in the location of the eastern edge of the pit to avoid contaminated runoff directly entering the catchment (slopes) of the main kloof.
4. Designing a rock dump comprising only quartzite rock to fill the remaining portion of the western kloof thereby shielding the main kloof from any direct impacts of mining activities in the pit. Careful placement of this barrier must be defined with input from a qualified botanist prior to the placement of the rock.
5. Design the southern approach road using built retaining walls and gabions rather than simple cut and fill method to minimize impact of road on the vegetation above and below the road. No rock should be pushed down the slope. The footprint of the road must be limited to the width of the road only.
6. Design a cut-off drain / berm around the southeastern edge of pit to channel uncontaminated upslope water away from the pit and into the kloof drainage system. It may be better not to allow this as water to entre the kloof system as it will be contaminated from dust fallout. The alternative is to let this water enter the pit and mine water treatment system to be discharged not into the kloof.
7. Construction of two run-off retention dams in the watercourse in the crater to catch sediment from the pit area during pit development. A hydrologist needs to advise on the dimensions of the impoundments.
8. Construct a rock-dump (or berm) in the crater to the south and south-eastern side of the pit to shield the remainder of the basin / crater from mining activities. The berm should be constructed to the same elevation as the plateau comprising a non-acid leaching rock core and a quartzite rock outer layer. Ideally this barrier should extent to the southern plateau but this may compromise future mining activities. Careful placement of this barrier must be defined with input from a qualified botanist prior to the placement of rock.

9. It is recommended that a biodiversity offset be developed for those habitats where the proposed impacts are significant (i.e. change in Ecosystem Status or located in a CBA).
10. It is recommended that (1) a competent environmental practitioner and (2) a mine surveyor jointly survey, map and physically demarcate by means of metal drums or stakes all setback lines.
11. No-go areas for mining or construction be clearly demarcated on the ground and on mine plans as well as access controlled by means of locked gates.

FIGURE 18 PROPOSED LOCATION OF MITIGATION RECOMMENDATIONS.



Construction Phase:

12. A detailed biodiversity management plan should be developed to ensure that the proposed avoidance and mitigation measures associated with mine construction are effectively implemented. The plan should include:

a. The involvement of a competent restoration ecologist in the development and implementation of this plan.
b. Education of construction staff on the biodiversity importance of the site and appropriate environmental work-place etiquette.
c. Translocation of flora is not viewed as a generally applicable ecologically viable mitigation measure. Translocation of plants to others areas in the BIR can lead to genetic pollution that is undesirable. Translocation for botanical gardens and landscaping around the mine is acceptable. Translocation for trade is not acceptable. Species with very limited numbers and of high conservation value (e.g. *Aloe microstigma*) can be translocated within the Gamsberg. In very limited cases (e.g. calcrete gravel patches) translocated plants can be used to restore degraded habitat within the offset area. Development of a detailed plant translocation plan should form part of the construction phase biodiversity management plan.
d. Ecological restoration of selected areas is possible post construction (e.g. contractor camp, southern approach road). Development of a detailed ecological restoration plan should form part of the construction phase biodiversity management plan.

Operational Phase:

13. Develop a mine biodiversity management plan that includes:
    a. On-going ecological restoration of impacted areas.
    b. Independent and on-going monitoring and inventory of the mine-sites biological and physical environments with a focus on monitoring dust baseline / impacts to improve the level of uncertainty with regard to dust impacts on sensitive habitats.
        i. Effectiveness of dust suppression measures can only be determined based on continuous monitoring of mine site and control sites, and relative to pre-determined ecological limits of acceptable change.
        ii. Monitoring should determine a-priori all limits of acceptable change for all environmental indications and then verify these through monitoring across the mine site and control sites located within the offset area.
    c. Active alien species management program.
    d. Education of mining staff on the biodiversity importance of the site and appropriate environmental work-place etiquette
    e. Incorporates the available biodiversity management guidelines and information such as Black Mountain Biodiversity Action Plan (BAP) and Bushmanland Conservation Initiative land-use zones.
14. Dust suppression of blasting and haulage activities in the pit will significantly mitigate mining impacts, as will dust suppression along unpaved roads and at stockpiles. These measures are crucial for minimizing dust fallout on critical habitats.

12.7 Residual Impacts

The following residual impacts are envisaged:

- Permanent and irreversible loss of habitat in all mining and associated infrastructure footprints.
- Permanent loss and / or degradation of habitat and reduced ecological functioning in the kloof, springs and river areas downstream of the kloof due to lowered ground water.

- Definite but possibly temporary reduction in ecological function in all areas affected by dust.
- There is the potential for species extinctions in the fine-grained quartz patch and kloof habitats due to dust deposition and groundwater drawdown.
- Ecological process impacts with regional-scale effects include:
  - Permanent loss and fragmentation of important habitat patches (reduction of patch size) and climate change refuge habitats (plateau, south slopes, kloof and springs)
  - Permanent fragmentation of ecological corridor of medium to high significance

The extent of the residual impacts on habitat is shown in Table 12. The residual impacts are significant and a biodiversity offset will be required in order to ensure persistence of biodiversity in the landscape. There is a material risk that mining will cause loss of irreplaceable natural resources

The concept of "no net loss" is untenable with this development as some features are being permanently reduced in extent below nationally accepted thresholds for their ecological persistence. For features such as the kloof, headwater seep, springs and gravel patches (Irreplaceable features in Table 12) there are no explicit national conservation targets as they are sub-vegetation type units. These are globally rare features with extents of only a few thousand hectares or less. They are associated with species of conservation concern or keystone ecological processes. Spatial biodiversity planning for the SKEP project and Namakwa District Bioregional Plan have explicitly considered these features and set targets of 100% for these features implying that they are irreplaceable. The alternative approach of looking at ecosystem status in terms of the criteria for assessing Threatened Ecosystems would mean that were the residual impact will result in a change in ecosystem status then there is a net loss relative to a nationally determined threshold for acceptable change.

Cumulatively, all features classified as irreplaceable in Table 12 account for less than 1% of the BIR landscape. Any loss of these features implies that "no net loss" cannot be achieved.

TABLE 12 OVERVIEW OF HABITATS AND EXTENT (HA) OF ECOLOGICALLY SIGNIFICANT IMPACT THROUGH THE MINING FOOTPRINT, DUST DEPOSITION AND GROUNDWATER LOSS

Vegetation Types, Habitat Units, Sensitivity & Ecosystem Status (including residual impact	Mine footprint	Dust Deposition		Groundwater Drawdown	Extent of Impact
		50 mg/m²/day	20 mg/m²/day		
Aggeneys Gravel Vygieveld					
Mountain plateau; Irreplaceable (EN)	123.2	58.5	117.1	280.8	181.7
Plateau quartz gravel; Irreplaceable (EN)	10.2	39.5	1.8	98.5	**51.5**
Plateau quartz gravel (fine grain); Irreplaceable (CR)			49.1		**49.1**
Plains quartz gravel; Irreplaceable (VU)	115.9	179.9	110.9	325.5	406.7
Plains quartz gravel intermediate; Flexible (LC)		56.5	231.0	240.4	56.5
Plains feldspar gravel; Irreplaceable (EN)		17.4	73.8		91.2
Plains rocky; Flexible (LC)	71.8	160.6	559.0	237.6	232.5
Bushmanland Inselberg Shrubland					
Mountains; Flexible (LC)	535.4	335.5	751.3	1 314.5	871.0
Bushmanland Arid Grassland					
Flat sandy plains; Flexible (LC)	447.5	1 947.0	2 083.6	3 038.3	2 394.5
Hummocky sandy plains; Flexible (LC)	17.2	316.8	447.4	0.0	334.0
Calcrete gravel plains; Irreplaceable (CR)	20.3	154.1	229.4	44.6	**403.7**
Bushmanland Sandy Grassland					
Mobile sandy dunes; Flexible (LC)		5.3	29.6	18.1	5.3
Eastern Gariep Plains Desert					
Plains Rocky; Flexible LC			252.1	120.7	
Bushmanland Inselberg Succulent Shrubland					

Southern Slopes; Irreplaceable (VU)	58.1	40.3	133.4	246.0	98.4
Azonal Habitats					
Kloof; Irreplaceable (CR)	27.8			148.9	**176.7**
Freshwater springs & Head-water Seep; Irreplaceable (CR)	-			-	**-**
River (Wash with sub-surface flow); Constrained (LC)	11.9			1 010.2	1 022.1
Wash; Constrained (LC)	39.9	442.4	928.9	276.5	482.3
TOTAL IMPACTED AREA (ha)					**6 857.1**

(a) Mine footprint includes pit, waste rock dumps, tailings, explosives magazine, plant, dams, administrative buildings, buffers on previous, roads and road buffers.
(b) Dust deposition is modeled extent of 50 mg/m²/day and 20 mg/m²/day. Habitats where dust exceeds 25% (50 mg/m²/day) of normal baseline are considered significantly impacted, similarly habitats where a high proportion of available habitat is affected by the 20 mg/m²/day dust zone.
(c) Groundwater drawdown based on the extent of the 10m drawdown after 100 years.
(d) Extent of Impact = sum of areas of affected habitats. (**Note:** Above areas exclude overlap and can be added)
LC – Least Concern; VU – Vulnerable; (VU) - VU implied by level of threat; EN – Endangered habitat.

Key to shading:	Habitat affected by respective impact	High proportion of available habitat affected	**Very high proportion of available habitat impacted**

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APPENDIX 1 SPECIES LIST

A global species for the study area based on relevés, habitat lists and point observations. Vegetation types: 1 – Bushmanland Inselberg Succulent Shrubland, 2 – Aggeneys Gravel Vygieveld, 3 – Bushmanland Inselberg Shrubland, 4 - Bushmanland Arid Grassland, 5 – Azonal.

	Vegetation Type	1		2				3	4			5			
FAMILY	Habitat	South-facing cliff	South-facing scree slope	Plateau	Quartz Patch Plateau	Quartz Patch Plains	Rock plain	North-facing scree slope	Calcrete patch	Sandy Plains	Dune	Wash	Kloof	Seep	Spring
	Species Name														
DICOTYLEDONS															
ACANTHACEAE	Acanthopsis annual									1					
	Acanthopsis hoffmannseggiana		1	1	1		1	1		1		1			
	Barleria rigida		1	1			1								
	Blepharis micra		1	1				1					1		
	Blepharis mitrata		1				1					1	1		
	Justicia thymifolia		1	1								1			
	Monechma spartioides		1	1			1	1				1	1		
AIZOACEAE	Aizoon asbestinum			1			1								
	Galenia africana		1									1			
	Galenia africana		1				1	1		1					
	Galenia cf. meziana		1				1	1		1					
	Galenia fruticosa		1	1			1	1		1		1	1		
	Galenia sarcophylla									1					
	Pharnaceum sp.											1			
	Tetragonia reduplicata		1	1	1		1						1		
	Tetragonia spicata		1				1	1					1		
	Trianthema parvifolium									1		1			
AIZOACEAE (MESEMBRYANTHEMACEAE)	Aridaria cf. serotina		1				1			1		1			
	Aridaria noctiflora subsp. noctiflora		1												

	Vegetation Type	1		2				3	4			5			
FAMILY	Habitat	South-facing cliff	South-facing scree slope	Plateau	Quartz Patch Plateau	Quartz Patch Plains	Rock plain	North-facing scree slope	Calcrete patch	Sandy Plains	Dune	Wash	Kloof	Seep	Spring
	Species Name														
	Aridaria noctiflora subsp. straminea						1								
	Brownanthus ciliatus		1	1	1		1	1							
	Cephalophyllum fulleri			1	1										
	Cephalophyllum sp. nov. (2014)			1	1										
	Conophytum angelicae (Pofadder form)					1									
	Conophytum angelicae subsp. angelicae (Plateau form)			1	1										
	Conophytum calculus subsp. vanzylii "dwarf form"			1	1										
	Conophytum fulleri			1											
	Conophytum limpidum (diploid form)		1	1				1					1		
	Conophytum marginatum var. karamoepense	1		1									1		
	Conophytum maughanii subsp. maughanii			1	1		1								
	Conophytum praesectum						1	1							
	Conophytum ratum (dwarf or plateau form)				1										
	Conophytum ratum (plains form)					1									
	Dinteranthus microspermus subsp. puberulus			1			1	1							
	Drosanthemum cf. breve		1	1	1		1								
	Drosanthemum godmaniae		1				1					1			
	Drosanthemum hispidum		1	1			1	1				1			
	Drosanthemum karooense	1	1	1	1		1	1							
	Ebracteola fulleri						1			1					
	Hereroa bergeriana			1			1								
	Hereroa puttkameriana			1	1		1								

	Vegetation Type	1		2				3	4			5			
FAMILY	Habitat	South-facing cliff	South-facing scree slope	Plateau	Quartz Patch Plateau	Quartz Patch Plains	Rock plain	North-facing scree slope	Calcrete patch	Sandy Plains	Dune	Wash	Kloof	Seep	Spring
	Species Name														
	Ihlenfeldtia excavata			1	1										
	Ihlenfeldtia vanzylii						1								
	Lithops julii subsp. fulleri var. fulleri						1		1	1					
	Lithops olivacea var. olivacea		1	1	1		1								
	Mesembryanthemum guerichianum		1				1	1		1			1		
	Mesembryanthemum inachabense						1								
	Mesembryanthemum longistylum							1				1			
	Phyllobolus latipetalus		1	1	1		1					1			
	Phyllobolus lignescens		1									1			
	Psilocaulon articulatum									1					
	Psilocaulon coriarium			1	1		1			1		1	1		
	Psilocaulon subnodosum		1	1	1		1	1				1	1		
	Ruschia aff. divaricata (PGD 3764)								1			1			
	Ruschia barnardii											1			
	Ruschia divaricata		1	1	1		1	1		1		1	1		
	Ruschia griquensis			1			1								
	Ruschia inclusa			1	1										
	Ruschia muricata			1			1			1					
	Ruschia robusta		1												
	Schwantesia pillansii	1											1		
	Schwantesia ruedebuschii			1				1					1		
	Titanopsis hugo-schlechteri var. hugo-schlechteri								1	1					
	Trichodiadema obliquum	1	1	1											
AMARANTHACEAE	Hermbstaedtia glauca		1	1			1					1	1		
	Sericocoma avolans		1	1	1		1	1					1		

	Vegetation Type	1		2				3	4			5			
FAMILY	Habitat	South-facing cliff	South-facing scree slope	Plateau	Quartz Patch Plateau	Quartz Patch Plains	Rock plain	North-facing scree slope	Calcrete patch	Sandy Plains	Dune	Wash	Kloof	Seep	Spring
	Species Name														
	Sericocoma pungens											1	1		
ANACARDIACEAE	Ozoroa dispar	1		1									1		
	Rhus incisa		1				1								
	Rhus undulata		1	1			1	1				1	1		
APOCYNACEAE	Fockea comaru			1	1										
	Hoodia alstonii			1	1										
	Hoodia gordonii		1				1	1		1		1			
	Huernia campanulata subsp. ingeae		1	1	1										
	Lavrania cactiformis		1				1								
	Lavrania marlothii			1	1		1	1							
	Microloma incanum		1	1	1		1	1		1	1	1	1		
	Piaranthus decorus subsp. cornutus			1	1		1								
	Piaranthus geminatus						1								
	Quaqua mammillaris		1	1			1	1							
	Sarcostemma pearsonii				1										
	Sarcostemma viminale		1	1	1		1	1					1		
	Stapelia similis			1											
ASTERACEAE	Amellus tridactylus subsp. tridactylus						1								
	Amphiglossa thuja		1	1									1		
	Amphiglossa triflora		1				1								
	Arctotis cf. leiocarpa									1					
	Arctotis sp1									1		1			
	Berkheya canescens		1				1	1		1			1		
	Berkheya spinosissima subsp. spinosissima		1	1			1					1	1		
	Chrysocoma ciliata		1	1				1							
	Chrysocoma microphylla				1										

	Vegetation Type	1		2				3	4			5			
FAMILY	Habitat	South-facing cliff	South-facing scree slope	Plateau	Quartz Patch Plateau	Quartz Patch Plains	Rock plain	North-facing scree slope	Calcrete patch	Sandy Plains	Dune	Wash	Kloof	Seep	Spring
	Species Name														
	Chrysocoma sparsifolia	1													
	Cineraria alchemilloides	1													
	Cotula microglossa									1					
	Dicoma capensis			1	1		1	1		1		1			
	Didelta carnosa var. carnosa		1				1	1		1			1		
	Eriocephalus ambiguus			1	1		1	1							
	Eriocephalus microphyllus var. pubescens		1		1								1		
	Eriocephalus pauperrimus		1	1				1							
	Eriocephalus scariosus		1				1	1					1		
	Eriocephalus sp.											1			
	Euryops subcarnosus subsp. vulgaris		1	1	1								1		
	Felicia cf. clavipilosa											1			
	Felicia muricata		1	1	1		1	1				1	1		
	Felicia namaquana										1				
	Felicia sp.												1		
	Foveolina albida									1					
	Gazania lichtensteinii		1	1			1	1		1	1	1	1		
	Geigeria vigintisquamea						1	1		1		1	1		
	Gorteria corymbosa						1					1	1		
	Helichrysum herniarioides									1					
	Helichrysum pentzioides												1		
	Helichrysum pumilio subsp. pumilio		1	1	1		1	1					1		
	Helichrysum zeyheri			1											
	Hirpicium alienatum		1		1			1							
	Hirpicium cf. gazanioides									1		1			
	Hirpicium echinus		1	1			1				1	1	1		

	Vegetation Type	1		2				3	4			5			
FAMILY	Habitat	South-facing cliff	South-facing scree slope	Plateau	Quartz Patch Plateau	Quartz Patch Plains	Rock plain	North-facing scree slope	Calcrete patch	Sandy Plains	Dune	Wash	Kloof	Seep	Spring
	Species Name														
	Kleinia cephalophora	1											1		
	Kleinia longiflora		1	1	1		1	1				1	1		
	Leysera tenella						1								
	Lopholaena cneorifolia			1									1		
	Osteospermum armatum		1	1	1		1	1				1	1		
	Osteospermum pinnatum var. breve						1	1				1	1		
	Osteospermum scariosum		1	1			1	1				1			
	Othonna abrotanifolia	1													
	Othonna cf. cuneata												1		
	Othonna floribunda											1			
	Othonna protecta		1	1	1		1						1		
	Othonna quercifolia (caudiform)			1									1		
	Othonna quercifolia (shrub)	1			1		1	1							
	Othonna sedifolia		1	1			1						1		
	Othonna sp. nov. (PGD 2342)			1									1		
	Othonna sp. nov. (PGD 3728)		1												
	Pegolettia retrofracta		1	1	1		1								
	Pentatrichia petrosa	1											1		
	Pentzia argentea			1			1								
	Pentzia lanata		1				1					1	1		
	Pteronia acuminata											1	1		
	Pteronia cf. unguiculata		1	1	1		1	1							
	Pteronia ciliata							1	1						
	Pteronia glauca						1					1	1		
	Pteronia leucoclada		1							1		1			
	Pteronia mucronata		1	1	1		1						1		

	Vegetation Type	1		2				3	4			5			
FAMILY	Habitat	South-facing cliff	South-facing scree slope	Plateau	Quartz Patch Plateau	Quartz Patch Plains	Rock plain	North-facing scree slope	Calcrete patch	Sandy Plains	Dune	Wash	Kloof	Seep	Spring
	Species Name														
	Pteronia sp.								1						
	Rosenia humilis									1					
	Senecio bulbinifolius		1	1	1			1							
	Senecio radicans		1	1	1		1						1		
	Senecio sarcoides	1	1	1									1		
	Senecio sisymbriifolius		1										1		1
	Tripteris microcarpa subsp. microcarpa		1	1			1	1		1		1			
	Tripteris pinnatilobata						1					1			
	Tripteris sinuata			1						1		1			
	Ursinia nana									1					
BIGNONIACEAE	Rhigozum trichotomum		1				1	1	1	1		1			
BORAGINACEAE	Ehretia rigida						1					1	1		1
	Trichodesma africanum		1									1	1		
BRASSICACEAE	Coronopus integrifolius												1		
	Heliophila arenaria var. arenaria						1						1		
	Heliophila cf. acuminata		1				1	1		1					
	Heliophila deserticola							1					1		
	Heliophila trifurca	1	1				1								
BURSERACEAE	Commiphora gracilifrondosa							1							
CAMPANULACEAE	Wahlenbergia cf. nodosa												1		
	Wahlenbergia oxyphylla												1		
	Wahlenbergia prostrata										1				
	Wahlenbergia sp.												1		
CAPPARACEAE	Boscia albitrunca var. albitrunca		1				1	1		1		1	1		1
	Boscia foetida subsp. foetida		1	1			1	1				1	1		
	Cadaba aphylla		1										1		

	Vegetation Type	1		2				3	4			5			
FAMILY	Habitat	South-facing cliff	South-facing scree slope	Plateau	Quartz Patch Plateau	Quartz Patch Plains	Rock plain	North-facing scree slope	Calcrete patch	Sandy Plains	Dune	Wash	Kloof	Seep	Spring
	Species Name														
	Cleome cf. oxyphylla												1		
CARYOPHYLLACEAE	Dianthus namaensis		1				1						1		
CHENOPODIACEAE	Chenopod sp.												1		
	Salsola aphylla			1			1	1	1	1		1			
	Salsola kali						1								
	Salsola sp.2							1							
CRASSULACEAE	Adromischus alstonii	1													
	Adromischus diabolicus												1		
	Adromischus marianiae "hallii ovate"												1		
	Adromischus nanus			1	1										
	Cotyledon orbiculata var. orbiculata		1	1	1		1	1					1		
	Crassula alstonii			1	1		1								
	Crassula brevifolia subsp. brevifolia	1	1	1									1		
	Crassula columnaris subsp. prolifera			1	1		1								
	Crassula corallina subsp. macrorrhiza			1			1			1					
	Crassula deceptor			1	1										
	Crassula deltoidea		1	1	1		1						1		
	Crassula exilis subsp. sedifolia	1		1									1		
	Crassula garibina	1	1	1											
	Crassula mesembrianthemopsis								1	1					
	Crassula muscosa var. muscosa		1	1			1	1					1		
	Crassula namaquensis subsp. namaquensis			1	1								1		
	Crassula sericea var. sericea		1	1	1		1	1					1		
	Crassula sericea var. velutina			1									1		
	Crassula subaphylla subsp. subaphylla		1				1						1		
	Crassula tomentosa var. glabrifolia		1	1									1		

	Vegetation Type	1		2				3	4			5			
FAMILY	Habitat	South-facing cliff	South-facing scree slope	Plateau	Quartz Patch Plateau	Quartz Patch Plains	Rock plain	North-facing scree slope	Calcrete patch	Sandy Plains	Dune	Wash	Kloof	Seep	Spring
	Species Name														
	Tylecodon paniculatus		1												
	Tylecodon reticulatus subsp. phyllopodium		1	1			1								
	Tylecodon rubrovenosus		1					1							
	Tylecodon sulphureus var. sulphureus		1	1	1										
	Tylecodon wallichii		1												
CUCURBITACEAE	Corallocarpus dissectus							1							
	Cucumis rigidus						1		1	1		1	1		
EBENACEAE	Diospyros lycioides														1
	Diospyros ramulosa	1	1				1					1	1		
	Euclea undulata											1	1		
EUPHORBIACEAE	Euphorbia avasmontana							1							
	Euphorbia braunsii									1		1			
	Euphorbia decussata							1							
	Euphorbia gariepina		1	1	1		1	1		1			1		
	Euphorbia gregaria		1	1			1	1				1			
	Euphorbia guerichiana							1				1			
	Euphorbia mauritanica		1												
	Euphorbia rectirama	1	1				1	1				1	1		
	Euphorbia spinea			1											
FABACEAE	Acacia erioloba										1				
	Acacia karoo											1			1
	Indigastrum argyroides									1					
	Indigofera cf. auricoma									1		1	1		
	Indigofera daleoides										1				
	Indigofera heterotricha			1	1			1				1	1		
	Indigofera sp.							1							

	Vegetation Type	1		2				3	4			5			
FAMILY	Habitat	South-facing cliff	South-facing scree slope	Plateau	Quartz Patch Plateau	Quartz Patch Plains	Rock plain	North-facing scree slope	Calcrete patch	Sandy Plains	Dune	Wash	Kloof	Seep	Spring
	Species Name														
	Lebeckia spinosa											1			
	Lessertia brachypus									1		1	1		
	Lotononis falcata		1				1								
	Lotononis furcata									1					
	Lotononis rabenaviana						1	1				1			
	Melolobium candicans						1			1		1	1		
	Parkinsonia africana									1		1			
	Prosopis glandulosa									1					
	Sutherlandia frutescens									1		1			
	Tephrosia dregeana									1		1	1		
GENTIANACEAE	Chironia sp.									1			1		
GERANIACEAE	Monsonia parviflora								1	1					
	Pelargonium cf. carnosum												1		
	Pelargonium crithmifolium		1	1									1		
	Pelargonium sp.								1						
	Pelargonium spinosum		1	1			1						1		
	Pelargonium xerophyton	1	1	1									1		
	Sarcocaulon crassicaule		1	1			1								
	Sarcocaulon salmoniflorum			1											
HYDNORACEAE	Hydnora africana						1								
HYDROPHYLLACEAE	Codon royenii						1	1				1	1		
LAMIACEAE	Stachys rugosa	1		1									1		
LOGANIACEAE	Buddleja saligna												1		
LORANTHACEAE	Septulina glauca						1					1			
MALVACEAE	Abutilon pycnodon												1		
	Hibiscus engleri												1		

	Vegetation Type	1		2				3	4			5			
FAMILY	Habitat	South-facing cliff	South-facing scree slope	Plateau	Quartz Patch Plateau	Quartz Patch Plains	Rock plain	North-facing scree slope	Calcrete patch	Sandy Plains	Dune	Wash	Kloof	Seep	Spring
	Species Name														
MELIACEAE	Nymania capensis		1				1					1	1		
MENISPERMACEAE	Cissampelos capensis		1									1	1		
MOLLUGINACEAE	Adenogramma sp.									1					
	Hypertelis salsoloides		1	1	1		1	1		1		1	1		
	Limeum aethiopicum subsp. namaense var. lanceolatum		1	1	1		1	1				1	1		
MONTINIACEAE	Montinia caryophyllacea	1	1				1					1	1		1
MORACEAE	Ficus cordata												1		1
	Ficus ilicina			1									1		1
NEURADACEAE	Grielum humifusum									1		1			
OXALIDACEAE	Oxalis annae	1		1									1		
	Oxalis eckloniana var. eckloniana		1	1	1		1			1	1				
	Oxalis obtusa						1			1		1	1		
	Oxalis pulchella		1												
PEDALIACEAE	Rogeria longiflora			1						1			1		
	Sesamum capense		1				1			1	1	1	1		
PLUMBAGINACEAE	Dyerophytum africanum		1				1	1				1	1		
POLYGALACEAE	Polygala seminuda		1				1			1		1			
PORTULACACEAE	Anacampseros baeseckei			1	1		1								
	Anacampseros filamentosa							1							
	Anacampseros karasmontana			1	1		1								
	Anacapseros bayeriana								1						
	Avonia albissima						1	1		1					
	Avonia papyracea subsp. papyracea			1	1		1	1							
	Avonia quinaria subsp. alstonii			1	1		1						1		
	Avonia recurvata subsp. minuta			1									1		

	Vegetation Type	1		2				3	4			5			
FAMILY	Habitat	South-facing cliff	South-facing scree slope	Plateau	Quartz Patch Plateau	Quartz Patch Plains	Rock plain	North-facing scree slope	Calcrete patch	Sandy Plains	Dune	Wash	Kloof	Seep	Spring
	Species Name														
	Avonia recurvata subsp. recurvata			1									1		
	Avonia ruschii			1	1										
	Ceraria fruticulosa		1	1	1		1	1					1		
	Ceraria namaquensis		1	1			1	1					1		
	Portulaca collina						1								
RUBIACEAE	Anthospermum spathulatum subsp. spathulatum	1											1		
	Kohautia sp.									1					
SALVADORACEAE	Azima tetracantha														1
SANTALACEAE	Thesium lineatum		1				1				1	1	1		
SAPINDACEAE	Pappea capensis	1										1	1		1
SCROPHULARIACEAE	Antherothamnus pearsonii												1		
	Aptosimum annual									1		1			
	Aptosimum indivisum									1		1			
	Aptosimum spinescens		1	1	1		1	1		1		1	1		
	Dischisma sp.											1			
	Hebenstretia namaquensis		1				1					1	1		
	Jamesbrittenia aridicola						1								
	Manulea nervosa										1	1			
	Manulea sp.												1		
	Nemesia sp.									1		1			
	Peliostomum leucorrhizum									1	1				
	Selago namaquensis	1											1		
	Sutera ramosissima						1	1					1		
	Sutera tomentosa		1				1	1					1		
	Walafrida cf. geniculata									1					

	Vegetation Type	1		2				3	4			5			
FAMILY	Habitat	South-facing cliff	South-facing scree slope	Plateau	Quartz Patch Plateau	Quartz Patch Plains	Rock plain	North-facing scree slope	Calcrete patch	Sandy Plains	Dune	Wash	Kloof	Seep	Spring
	Species Name														
	Zaluzianskya cf. villosa									1					
SOLANACEAE	Lycium cf. bosciifolium		1									1			1
	Lycium cinereum		1				1	1		1	1	1	1		
	Lycium prunus-spinosa									1		1			
	Solanum burchellii	1					1						1		
	Solanum giftbergense						1								
	Solanum nigrum														1
STERCULIACEAE	Hermannia cf. coccocarpa									1	1				
	Hermannia disermifolia		1	1			1								
	Hermannia gariepina									1					
	Hermannia minutiflora		1	1									1		
	Hermannia spinosa		1				1	1		1		1	1		
	Hermannia stricta		1	1	1		1			1		1			
TAMARICACEAE	Tamarix usneoides												1		
URTICACEAE	Forsskaolea candida		1				1	1				1	1		
VERBENACEAE	Chascanum garipensis		1				1			1		1			
VISCACEAE	Viscum capense		1									1			
	Viscum rotundifolium		1									1			
ZYGOPHYLLACEAE	Augea capensis						1			1					
	Fagonia capensis		1				1	1		1					
	Sisyndite spartea											1	1		
	Tribulus cf. zeyheri		1				1	1		1	1	1			
	Zygophyllum cf. decumbens		1				1	1	1			1	1		
	Zygophyllum cf. meyeri											1			
	Zygophyllum cf. microphyllum												1		
	Zygophyllum retrofractum			1						1		1	1		

	Vegetation Type	1		2				3	4			5			
FAMILY	Habitat	South-facing cliff	South-facing scree slope	Plateau	Quartz Patch Plateau	Quartz Patch Plains	Rock plain	North-facing scree slope	Calcrete patch	Sandy Plains	Dune	Wash	Kloof	Seep	Spring
	Species Name														
	Zygophyllum simplex									1					
MONOCOTYLEDONS															
AMARYLLIDACEAE	Brunsvigia comptonii			1			1								
	Brunsvigia sp. nov.1	1													
	Brunsvigia sp. nov.2						1								
ANTHERICACEAE	Chlorophytum sp.		1	1	1		1	1							
ASPARAGACEAE	Asparagus capensis						1						1		
	Asparagus cf. laricinus										1				
	Asparagus retrofractus						1	1		1					
	Asparagus sp.	1													
ASPHODELACEAE	Aloe dichotoma		1	1	1		1	1				1			
	Aloe gariepensis		1												
	Aloe microstigma	1													
	Bulbine namaensis				1						1				
	Bulbine striata			1	1										
	Haworthia venosa subsp. tessellata		1	1											
	Trachyandra cf. jacquiniana		1	1	1		1	1							
	Trachyandra sp. nov.			1											
COLCHICACEAE	Ornithoglossum viride						1								
CYPERACEAE	Bulbostylis hispidula												1	1	
	Cyperus bellus												1	1	
	Cyperus marginatus												1		1
	Cyperus squarrosus												1	1	
	Mariscus cf. aristatus												1		
	Schoenoplectus cf. erectus													1	
	Schoenoplectus muricinux													1	1

	Vegetation Type	1		2				3	4			5			
FAMILY	Habitat	South-facing cliff	South-facing scree slope	Plateau	Quartz Patch Plateau	Quartz Patch Plains	Rock plain	North-facing scree slope	Calcrete patch	Sandy Plains	Dune	Wash	Kloof	Seep	Spring
	Species Name														
DRACAENACEAE	Sansevieria aethiopica											1	1		
ERIOSPERMACEAE	Eriospermum bakerianum subsp. bakerianum												1	1	
	Eriospermum pusillum	1											1		
HYACINTHACEAE	Albuca spiralis			1			1								
	Drimia sp.		1	1											
	Lachenalia giessii				1										
	Ledebouria sp.									1					
	Ornithogalum glandulosum		1				1			1					
	Ornithogalum pruinosum		1	1	1		1			1					
	Ornithogalum sp.									1					
	Schizobasis sp.		1												
	Whiteheadia bifolia	1	1										1		
IRIDACEAE	Gladiolus saccatus							1					1		
	Hesperantha rupicola		1	1	1										
	Lapeirousia plicata			1			1								
	Moraea fugax												1		
	Tritonia karooica				1										
JUNCACEAE	Juncus krausii												1		1
POACEAE	Aristida adscensionis			1	1		1	1							
	Aristida congesta subsp. congesta		1				1	1		1	1				
	Aristida sp		1									1			
	Cenchrus ciliaris												1		
	Digitaria eriantha	1	1	1	1		1							1	
	Ehrharta calycina												1		
	Enneapogon cenchroides						1								

	Vegetation Type	1		2				3	4			5			
FAMILY	Habitat	South-facing cliff	South-facing scree slope	Plateau	Quartz Patch Plateau	Quartz Patch Plains	Rock plain	North-facing scree slope	Calcrete patch	Sandy Plains	Dune	Wash	Kloof	Seep	Spring
	Species Name														
	Enneapogon desvauxii						1			1					
	Enneapogon scaber		1	1	1		1	1					1		
	Eragrostis annulata		1	1	1		1	1		1		1	1		
	Eragrostis curvula												1	1	1
	Eragrostis nindensis		1		1			1		1		1		1	
	Oropetium capense						1			1					
	Panicum arbusculum		1				1	1				1	1		
	Phragmites australis												1		
	Schmidtia kalahariensis									1	1	1			
	Sporobolus nervosus						1			1					
	Stipagrostis aff. namaquensis												1		
	Stipagrostis anomala							1							
	Stipagrostis brevifolia		1						1	1	1	1			
	Stipagrostis cf. uniplumis				1										
	Stipagrostis ciliata		1				1	1	1	1		1	1		
	Stipagrostis namaquensis											1			
	Stipagrostis obtusa			1			1		1	1	1	1	1		
	Stipagrostis sp.											1			
	Stipagrostis uniplumis var. uniplumis									1		1			
FERNS															
PTERIDOPHYTA	Ceterach cordatum												1		
	Cheilanthes deltoidea		1	1									1		
	Cheilanthes namaquensis			1									1		
	Ophioglossum polyphyllum										1				
	TOTAL	**33**	**150**	**144**	**82**	**2**	**168**	**99**	**16**	**99**	**22**	**118**	**163**	**9**	**16**

APPENDIX 2: SPATIAL DATA

The following spatial data sets are available in GIS shapefile format (projection UTM34s):

1. Study area vegetation (based on the BCI vegetation map)
2. Bushmanland Inselberg Succulent Shrubland vegetation type (south slopes)
3. Features of conservation concern:
   - 3.1. Kloof
   - 3.2. Springs (point)
   - 3.3. Headwater seeps (line)
   - 3.4. Headwater seep catchments (polygon)
   - 3.5. Temporary rock pools (point)
   - 3.6. Plateau quartz gravel patches
   - 3.7. Plateau rocky plains
   - 3.8. Plains quartz gravel patches
   - 3.9. Calcrete gravel patches
   - 3.10. Washes
4. Bushmanland Inselberg Region outline