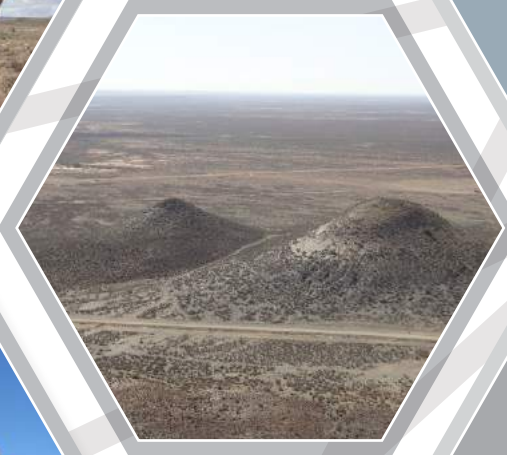


Integrated Environmental Management Plan for the South African mid-frequency array of SKA Phase 1 2018-2023



Integrated Environmental Management Plan for the South African mid-frequency array of SKA Phase 1

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Abbreviations / Acronyms

African Large Predator Research Unit	ALPRU
Agri South Africa	AgriSA
Agricultural Research Council	ARC
Agri Northern Cape	AgriNC
Air Traffic and Navigation Control Service	ATNS
Armaments Corporation of South Africa	Arm Scor
Environmental Management Framework	EMF
Astronomical Society of Southern Africa	ASSA
Astronomy Geographic Advantage	AGA
Basic Assessment	BA
Birdlife South Africa	BLSA
C-Band All Sky Survey	C-BASS
Civil Aviation Authority	CAA
closed-circuit television	CCTV
Council for Geoscience	CGS
Council for Scientific and Industrial Research	CSIR
Critical Biodiversity Area	CBA
Department of Agriculture Forestry and Fisheries	DAFF
Department of Cooperative Governance and Traditional Affairs	CoGTA
Department of Defence	DoD
Department of Energy	DoE
Department of Environmental Affairs	DEA
Department of Environmental Affairs: Enterprise Geospatial Information Management	DEA:EGIM
Department of Environmental Affairs: Integrated Environmental Management Services	DEA:IEMS
Department of Environmental Affairs: Protected Areas	DEA:PA
Department of Mineral Resources	DMR
Department of Rural Development and Land Reform	DRDLR
Department of Science and Technology	DST
Department of Telecommunication and Postal Services	DTPS
Department of Trade and Industry	DTI
Department of Transport	DoT
Department of Water and Sanitation	DWS
Diesel rotary uninterruptible power supply	DRUPS
District Municipality	DM
Electrical Grid Infrastructure	EGI
Electromagnetic interference	EMI
Endangered Wildlife Trust	EWT
Environmental Assessment Practitioners	EAP
Environmental Authorisation	EA
Environmental Control Officer	ECO
Environmental Impact Assessment	EIA
Environmental Manager	EM
Environmental Management Programme	EMPr

Expanded Public Works Programme	EPWP
Geographic Information System	GIS
Global Positioning System	GPS
Government Notice	GN
Human Capital Development Programme	HCDP
Hydrogen Epoch of Reionization Array	HERA
Independent Communications Authority of South Africa	ICASA
Integrated Environmental Management Plan	IEMP
International Civil Aviation Organization	ICAO
International Square Kilometre Array Steering Committee	ISSC
International Telecommunication Union	ITU
International Union for Conservation of Nature	IUCN
Karoo Array Telescope	KAT
Karoo Central Astronomy Advantage Area	KCAA
kilometre	km
Light Detection and Ranging	LIDAR
Major Hazard Installation	MHI
Management Unit Control Planning	MUCP
Member of the Executive Council	MEC
Mineral and Petroleum Resources Development Act	MPRDA
National Aeronautics and Space Administration	NASA
National Council of Provinces	NCOP
National Development Plan	NDP
National Environmental Management Act	NEMA
National Environmental Management: Biodiversity Act	NEMBA
National Environmental Management: Protected Areas Act	NEMPAA
National Freshwater Ecosystem Priority Area	NFEPA
National Heritage Council South Africa	NHCSA
National Heritage Resources Act	NHRA
National Infrastructure Plan	NIP
National Protected Area Expansion. Strategy	NPAES
National Research Foundation	NRF
National Road Traffic Act	NRTA
National Spatial Development Perspective	NSDP
National Water Act	NWA
Natural Resource Management Programmes	NRMP
Non-Governmental Organization	NGO
Northern Cape Department of Environment and Nature Conservation	NCDENC
Northern Cape Department of Roads and Public Works	NCDRPW
Occupational Health and Safety Act	OHSA
parts per million	ppm
Plants of South Africa	POSA
Presidential Infrastructure Coordination Committee	PICC
Radio Frequency Interference	RFI
South African National Standards	SANS

SKA mid-frequency dish array	SKA1_MID
SKA Organisation	SKAO
South African SKA Office	SKA SA
SKA Science and Engineering Committee	SSEC
South African Air Force	SAAF
South African Astronomical Observatory	SAAO
South African Bat Assessment Advisory Panel	SABAAP
South African Biodiversity Information Facility	SABIF
South African Bird Atlas Project	SABAP
South African Council for Natural Scientific Professionals	SACNASP
South African Environmental Observation Network	SAEON
South African Heritage Resources Agency	SAHRA
South African Local Government Association	SALGA
South African National Biodiversity Institute	SANBI
South African National Parks Agency	SANParks
South African National Roads Agency Limited	SANRAL
South African National Standards	SANS
South African Plant Invaders Atlas	SAPIA
Special Advisory Committee	SAC
Square Kilometre Array	SKA
Strategic Environmental Assessment	SEA
Strategic Integrated Projects	SIPs
Succulent Karoo Programme	SKEP
very small aperture terminal	VSAT
Working for Water programme	WfW

Definitions

Alien species: plants, animals, pathogens and other organisms that are non-native to an ecosystem, and which may cause economic or environmental harm or adversely affect human health.

Assembly area: area used for the assembly of infrastructure prior to its erection.

Borehole: in terms of the National Water Act (NWA) [Act No. 36 of 1998], includes a well, excavation or any artificially constructed or improved underground cavity which can be used for the purpose of - (a) intercepting, collecting or storing water in or removing water from an aquifer; (b) observing and collecting data and information on water in an aquifer; or (c) recharging an aquifer.

Borrow pit: area where construction material, such as sand or gravel, is extracted for use at another location.

Clearing: clearing and removal of vegetation, whether partially or in whole, including trees and shrubs.

Construction camp: area designated for key construction infrastructure and services, including but not limited to offices, accommodation, parking areas, ablution facilities, and wastewater treatment plant.

Contamination incident: any incident that may cause or has caused damage to or the contamination of the natural environment.

Endemic species: plants and animals that exist only in one geographic region .

Environment: the surroundings within which humans exist. It comprises:

- The land, water and atmosphere of the earth;
- Micro-organisms, plant and animal life;
- Any part or combination of i) and ii) and the interrelationships among and between them; and
- The physical, chemical, aesthetic and cultural properties and conditions of the foregoing that influence human health and well-being (*i.e.* the social environment).

This is a definition that encompasses many different facets, including biological, physical, social, economic, cultural, historical and political components.

Environmental agreement: provides for an acknowledgement of the Environmental Management Programme and the environmental controls and stipulations therein.

Environmental auditing: a systematic, documented, periodic and objective evaluation of environmental compliance and management system implementation gaps, along with related corrective actions.

General waste: waste that does not pose an immediate hazard or threat to health or to the environment, and includes (a) domestic waste; (b) building and demolition waste; (c) business waste; and (d) inert waste;

Hazardous substances: substance governed by the Hazardous Substances Act, 1973 (Act No. 15 of 1973) as well as the Hazardous Chemical and Substances Regulations, 1995.

Hazardous waste: waste that contains organic or inorganic elements or compounds that may, owing to the inherent physical, chemical or toxicological characteristics of that waste, have a detrimental impact on health and the environment.

Heritage resource: in terms of the National Heritage Resources Act (No 25 of 1999), means all those heritage resources that are of cultural significance or other special value for present and future generations, and which are accordingly considered part of the National Estate. In this regard, the National Estate includes those items identified in terms of Section 2 of National Heritage Resources Act No. 25 of 1999.

Indigenous species: plants and animals that are naturally found in an area.

Leaching: removal of mineral compounds from ground particles by direct contact with a solvent.

Method Statement: written submission in response to the Environmental Management Programme. The statement sets out as a minimum, the location of the works, plant, materials, labour, method and schedule that will be used to carry out an activity on the development site as well as any permit, licence and authorisation required to carry out the activity. The Method Statement will be done in such detail that it can be assessed against the requirements of the Environmental Management Programme. All method statements and any amendments must be reviewed and approved by the authority pre-defined by the developer.

Mitigation measures: measures designed to avoid, reduce or remedy the adverse environmental impact of a project/activity.

Monitoring: maintain regular surveillance over the progress or quality of an activity/plan/process over a period of time; keep under systematic review.

Natural environment: a natural environment is one in which human impact is kept under a certain limited level.

Natural resources: materials or substances occurring in nature which can be exploited for economic gain.

Remedial action: response required to address an environmental problem that is in conflict with the requirements of the Environmental Management Programme. The need for corrective action may be determined through monitoring, audits or management review.

Sensitive area: any area that is denoted as sensitive due to its particular attributes, which could include the presence of rare or endangered vegetation, the presence of heritage resources (e.g. archaeological artefacts or graves), the presence of a unique natural feature, the presence of a watercourse or water body, the presence of steep slopes (in excess of 1:4).

Stakeholders: individuals whose interests may be positively or negatively affected by a proposal or activity and/or who are concerned with a proposal or activity and its consequences.

Storm water management: management actions implemented to manage surface runoff.

Sustainable development: development that is planned to meet the needs of present and future generations (e.g. basic environmental, social and economic services). Sustainable development includes using and maintaining resources responsibly.

Waste: in terms of the National Environmental Management: Waste Act [Act No. 59 of 2008] (NEMWA), any substance, whether or not that substance can be reduced, re-used, recycled and recovered-

- (a) that is surplus, unwanted, rejected, discarded, abandoned or disposed of;
 - (b) which the generator has no further use of for (he purposes of production;
 - (c) that must be treated or disposed of; or
 - (d) that is identified as a waste by the Minister by notice in the Gazette,
- and includes waste generated by the mining, medical or other sector, but (i) a by-product is not considered waste; and (ii) any portion of waste, once re-used, recycled and recovered, ceases to be waste.

Waste management activity: in terms of NEMWA [Act No. 59 of 2008], any activity listed in Schedule 1 or published by notice in the Gazette under section 19, and includes

- (a) the importation and exportation of waste;
- (b) the generation of waste, including the undertaking of any activity or process that is likely to result in the generation of waste;
- (c) the accumulation and storage of waste;
- (d) the collection and handling of waste;
- (e) the reduction, re-use, recycling and recovery of waste;
- (f) the trading in waste;
- (g) the transportation of waste;
- (h) the transfer of waste;
- (i) the treatment of waste; and
- (j) the disposal of waste.

Waste treatment facility: in terms of NEMWA [Act No. 59 of 2008], any site that is used to accumulate waste for the purpose of storage, recovery, treatment, reprocessing, recycling or sorting of that waste.

Watercourse: in terms of NWA [Act No. 36 of 1998], (a) a river or spring; (b) a natural channel in which water flows regularly or intermittently; (c) a wetland, lake or dam into which, or from which, water flows; and (d) any collection of water which the Minister may, by notice in the Gazette, declare to be a watercourse; and including, where relevant, its bed and banks.

Water resource: In terms of NWA [Act No. 36 of 1998], includes a watercourse, surface water, estuary, or aquifer.

Water use: in terms of NWA [Act No. 36 of 1998], any activity which involves:

- a. Taking water from a water resource;
- b. Storing water;
- c. Impeding or diverting the flow of water in a watercourse;
- d. Engaging in a stream flow reduction activity;
- e. Engaging in a controlled activity identified and declared as such in terms of the Act;
- f. Discharging waste or water containing waste into a water resource through a pipe, canal, sewer, sea outfall or other conduit;
- g. Disposing of waste in a manner which may detrimentally impact on a water resource;
- h. Disposing in any manner of water which contains waste from, or which has been heated in, any industrial or power generation process;
- i. Altering the bed, banks, course or characteristics of a watercourse;
- j. Removing, discharging or disposing of water found underground if it is necessary for the efficient continuation of an activity or for the safety of people; and
- k. Using water for recreational purposes.



CHAPTER 1: INTRODUCTION



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I. Astronomy in South Africa

1. Development of Astronomy in South Africa

South Africa's national research and development strategy, published in 2002 by the Department of Science and Technology (DST), identified five Science Focus Areas for long-term action amongst which is "Astronomy and Earth Observation".

DST further underlines that the development of Astronomy in South Africa is essential *"to use South Africa's geographical and specific knowledge advantages on a sustainable basis to create global appreciation for South African science"*.

In support of the realisation of the National Research Development Strategy, DST included two *Grand challenge outcomes* in its ten-year (2008-2018) plan:

- (1) to *"become the preferred destination for major astronomy projects and associated international investment in construction and operations"*; and
- (2) to *"have constructed a powerful radio-astronomy telescope and used it for world-class projects"*.

In order to further this goal the South African government decided to build the Karoo Array Telescope (KAT) consisting of 20 receptors which was then expanded to the MeerKAT telescope, consisting of 64 receptors (a receptor is the complete antenna structure, with the main reflector, sub-reflector and all receivers, digitisers and other electronics installed). KAT-7, the seven-dish MeerKAT precursor array, was primarily built as a precursor to the 64-dish MeerKAT radio telescope array and to demonstrate South Africa's ability to host the Square Kilometre Array project (SKA).

The KAT-7 and MeerKAT telescope are located in the Karoo region of the Northern Cape on two farms of approximately 13 500 hectares. In 2007, the South African government put into effect the Astronomy Geographic Advantage Act [Act No. 21 of 2007], which declares the Karoo region of the Northern Cape an "Astronomy Advantage Area", giving the Minister of Science and Technology powers to protect the area from future radio interference.

2. Astronomy Geographic Advantage Act

The Astronomy Geographic Advantage Act was adopted as a comprehensive long term instrument to protect astronomy in all its forms in South Africa, in particular but not limited to the MeerKAT project to be developed in the Northern Cape Province.

The Astronomy Geographic Advantage Act provides for a wide range of requirements for the advancement and protection of astronomy including the development of skills, capabilities and expertise; the identification and protection of areas in which astronomy projects can be undertaken; the provision of a framework for the establishment, protection, preservation and maintenance of a national system of Astronomy Advantage Areas highly suitable for astronomy; and the regulation of activities which cause or could cause interference.

3. The Karoo Core Astronomy Advantage Area

The Astronomy Advantage Area where the KAT-7 and MeerKAT telescope are located consists of two land parcels acquired by the National Research Foundation (Losberg Farm and Meysdam Farm, as shown in Figure 1-1). This Astronomy Advantage Area was declared the Karoo Core Astronomy

Advantage Area in 2010¹. Consequently, the establishment and operation of MeerKAT were declared as astronomy and related scientific endeavours for radio astronomy purposes in 2010². A co-management agreement was entered into for the management of the Karoo Core Astronomy Advantage Area between the Astronomy Management Authority³ (Department of Science and Technology), and the National Research Foundation, in terms of Section 18 of the Astronomy Geographic Advantage Act.

Duties of the National Research Foundation⁴ (organ of state⁵) are prescribed in Section 47 of the Astronomy Geographic Advantage Act. The Karoo Core Astronomy Advantage Area is subject to the Core Astronomy Advantage Area regulations promulgated in 2012⁶ which prohibit any transmissions in the radio frequency spectrum from 9 kilohertz to 3 000 gigahertz within the area and the ownership, possession or control of any device, equipment or instrument within this spectrum unless it is required for radio astronomy purposes. The regulations further prohibit any of the activities listed in section 23(1) of the Astronomy Geographic Advantage Act relevant to radio astronomy unless it is required for radio astronomy purposes. Access to the Karoo Core Astronomy Advantage Area is governed by section 20 of the Astronomy Geographic Advantage Act.

4. The Karoo Central Astronomy Advantage Areas

In 2014, following a public participation process undertaken in terms of Section 42 of the Astronomy Geographic Advantage Act, read with the Promotion of Administrative Justice Act, the Minister of Science and Technology declared the Karoo Central Astronomy Advantage Areas 1, 2 and 3 for the purpose of radio astronomy and related scientific endeavours⁷:

- Karoo Central Astronomy Advantage Area 1 extent includes approximately 123 456 square kilometres (km²),
- Karoo Central Astronomy Advantage Area 2 extent includes approximately 79 963 km² and
- Karoo Central Astronomy Advantage Area 3 extent includes approximately 44 602 km².

In 2015, the Minister of Science and Technology published the draft Karoo Central Astronomy Advantage Areas Regulations⁸ in order to protect the Karoo Central Astronomy Advantage Areas from radio interference. The draft Karoo Central Astronomy Advantage Areas regulations intend to prescribe specific protection measures for the use of the radio frequency spectrum and to prescribe standards and conditions that must be complied with in conducting activities declared in terms of subsections 23(1) (b), (i) and (k) of the Astronomy Geographic Advantage Act.

The Karoo Central Astronomy Advantage Area 1 is the largest of the Karoo Central Astronomy Advantage Areas and includes four District Municipalities: Namakwa District Municipality, Pixley Ka Seme District Municipality, Siyanda District Municipality, and Central Karoo District Municipality.

¹ Declared in terms of section 7 of the Astronomy Geographic Advantage Act on 20 August 2010.

² Declared in terms of section 28(1) of the Astronomy Geographic Advantage Act on 15 October 2010.

³ Declared in terms of section 15(2) of the Astronomy Geographic Advantage Act on 3 December 2010.

⁴ Constituted in terms of the National Research Foundation Act.

⁵ As defined in terms of section 239 (1) of the Constitution of South Africa.

⁶ Promulgated in terms of section 22 and 23, read with section 50, of the Astronomy Geographic Advantage Act on 22 June 2012.

⁷ Declared in terms of section 9 (1) and (2) of the Astronomy Geographic Advantage Act and published in the *Government Gazette* number 37397, under Notice number 141, on 28 February 2014.

⁸ Published in the *Government Gazette* number 39442, under Notice number 1166, on 23 November 2015. The notice requested submissions from interested and affected parties on the draft regulations.

The study area of the Strategic Environmental Assessment for the South African mid-frequency array of SKA Phase 1 is included within the Karoo Central Astronomy Advantage Area 1 as illustrated in Figure 1-1. The Karoo Central Astronomy Advantage Areas 1, 2 and 3 are also illustrated in Figure 1-1 below.

5. South Africa to host the Square Kilometre Array

The history of the SKA dates back in the 1990's with an international effort to build the world's largest and most sensitive radio telescope to help better understand the history of the universe. In 1993 the International Union of Radio Science established the Large Telescope Working Group to begin a worldwide effort to develop the scientific goals and technical specifications for a next generation radio observatory. From 1997 to 2007, an international collaboration⁹ led to the establishment of the International Square Kilometre Array Steering Committee (ISSC) and the preparation of an International Collaboration Agreement for the SKA Program, which became effective on 1 January 2008. This Agreement established the SKA Science and Engineering Committee¹⁰ (SSEC) as a replacement to the ISSC and was signed by the European, United States, and Canadian SKA Consortia, the Australian SKA Coordination Committee, the National Research Foundation in South Africa, the National Astronomical Observatories in China, and the National Centre for Radio Astrophysics in India. In 2003, five countries responded to an invitation to submit proposals to host the SKA. The bid proposal was endorsed by the South African Cabinet in 2003 in line with the national research and development strategy, published in 2002 and the Government's Astronomy Geographic Advantage Programme, which aims to establish a hub of world-class astronomy facilities in southern Africa. The application process to host the SKA ended in 2005, and from the applicants, South Africa and Australia had been short listed as contenders. In 2011, the SKA Organisation¹¹ was established to formalise relationships between the international partners and centralise the leadership of the project. The final South African bid proposal to host the SKA in Africa was submitted by South Africa and its eight partner countries (Botswana, Ghana, Kenya, Madagascar, Mauritius, Mozambique, Namibia and Zambia) to the SKA Siting Group in 2011.

In 2012, based on an objective technical and scientific assessment of the sites in South Africa and Australia, the independent SKA Site Advisory Committee selected Africa as the preferred site¹². However in order to maximise the use of the investments already made at both the African and Australian sites, the SKA Organisation decided that the SKA should be co-hosted by South Africa along with its African Partner Countries and Australia. Subsequently the International SKA Organisation announced that the extensive SKA mid-frequency dish array¹³ would be developed in Africa, and the more compact low-frequency aperture array¹⁴ would be constructed in Australia. This decision was made on the basis of its analysis of technical and scientific factors, cost factors, and implementation plans.

⁹ Including eight institutions in 1997 (Australia, Canada, China, India, the Netherlands, and the United States), then eleven institutions in Australia, Canada, China, Germany, India, Italy, the Netherlands, Poland, Sweden, the United Kingdom, and the United States in 2000 and finally. Source: www.skatelescope.org

¹⁰ The SSEC acts as the primary forum for interactions and decisions on scientific and technical matters for the SKA among the signatories to the International Collaboration Agreement. Source: www.skatelescope.org

¹¹ The SKA Organisation is a private UK company limited by guarantee. Source: www.skatelescope.org

¹² Extract of a statement to the press by Minister of Science and Technology Naledi Pandor (25 May 2012).

¹³ The SKA mid-frequency dish array will cover a wide-range of radio frequencies from 350 megahertz upwards.

¹⁴ The SKA low-frequency dish array will cover the lowest frequency band from 50 megahertz up to 350 megahertz.

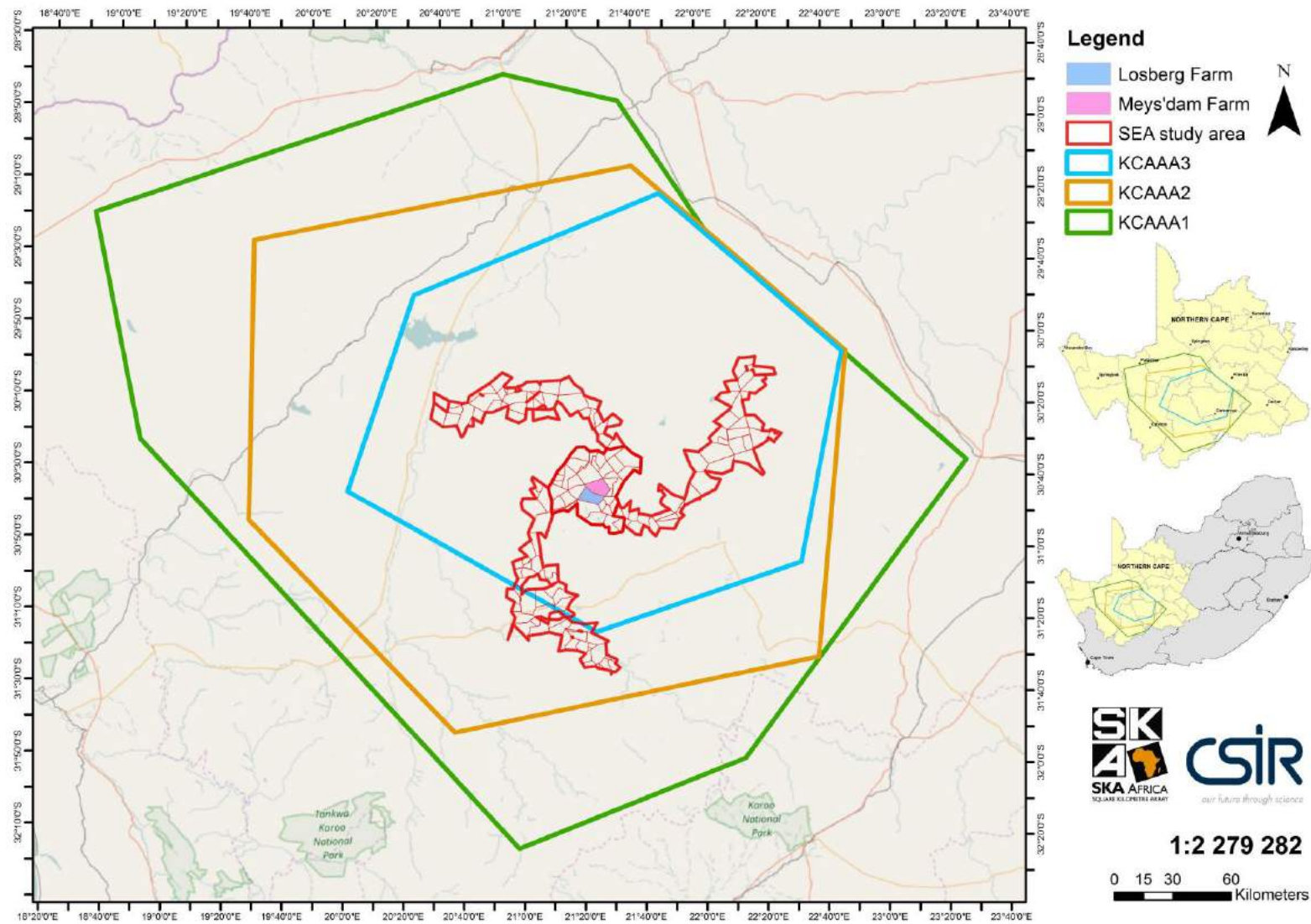


Figure 1-1: Karoo Central Astronomy Advantage Areas

6. The MeerKAT telescope

The MeerKAT telescope ("MeerKAT") is an array of 64 interlinked receptors¹⁵ being constructed in the Karoo region in the Northern Cape Province by South African scientists and engineers, as a critical step towards the implementation of the SKA. The MeerKAT is located on two farms (Losberg and Meysdam farms) currently owned by the National Research Foundation near Carnarvon in the Karoo. The extent of Losberg and Meysdam farms is approximately 13 500 hectares. The highest density of MeerKAT receptors (48 of the 64 receptors) will be concentrated in a 1 kilometre (km) diameter core (centre point: approximately 30°42'48.55"S (latitude) and 21°26'33.62"E (longitude)) and the remaining receptors will extend out 8 km diameter within the boundaries of these two farms. Figure 1-2 below illustrates the MeerKAT telescope and the 64 interlinked receptors configuration within the Losberg and Meysdam farms in the Karoo region.



Figure 1-2: MeerKAT telescope within the Losberg and Meysdam farms (Photo: SKA South Africa)

Based on environmental impact assessments, expert studies and geotechnical and hydrogeological studies, MeerKAT received environmental authorisation to be built in 2009 and is currently under construction in the Karoo. Three Environmental Authorisations and one Amendment were issued to the Northern Cape Department of Education (which included "Science and Technology" at Provincial level) in 2007, 2008, 2009 and 2012 for the construction and operation of MeerKAT and associated activities. By conducting the required Environmental Assessments for MeerKAT, the Northern Cape

¹⁵ A receptor is the complete antenna structure, with the main reflector, sub-reflector and all receivers, digitisers and other electronics installed. The MeerKAT antennas are dish-type radio telescope.

Department of Education demonstrated its support for MeerKAT which was falling under the mandate of the Northern Cape Province. The following authorisations/permits and licenses have been issued to approve the construction and operation of MeerKAT in South Africa:

- Permit 25/2007: Environmental Authorisation reference number NAT/NC/PS/CAR1/06/06, issued on 30th May 2007 by the Director of the Northern Cape Department of Environment and Nature Conservation Mrs P/M.N. Mokhall; Permit 25/2007 issued to the Northern Cape Department of Education for undertaking Activities (Government Notice 386) 12, 14, 15, 16 and (Government Notice 387) 2 of 2006 on the Losberg Farm, Bloupits Farm, Rooizand Farm, Meysdam Farm and Brakputs Farm;
- Permit 72/2008: Environmental Authorisation reference number NC/PIX/MEER1/2008, issued on 7th October 2008 by the Director of the Northern Cape Department of Tourism, Environment and Conservation Mr JJ Mutyorauta; Permit 72/2008 issued to the Northern Cape Department of Education for undertaking Activity 14, Activity 15, Activity 16 of Government Notice 386 on the Farms Losberg and Meysdam;
- Permit 41/2009: Environmental Authorisation reference number NC/PIX/KAR/TEL3/20/2008, issued on 6th July 2009 by the Director of the Northern Cape Department of Tourism, Environment and Conservation Mr JJ Mutyorauta; Permit 41/2009 issued to the Northern Cape Department of Education for amendment: for undertaking Activity 2 of Government Notice 387 of 21 April 2006 on the Farms Losberg and Meysdam;
- Amendment to Permit 41/2009: Environmental Authorisation reference number NC/PIX/KAR/TEL3/20/2008, issued on 10th February 2012 by the Director of the Northern Cape Department of Tourism, Environment and Conservation Mr JJ Mutyorauta; Permit 41/2009 issued to the Northern Cape Department of Education for amendment: GNR386 and GNR 387 for undertaking Activities 7, 12, 13, 14, 15, 16(b), 17 of Government Notice 386 of 21 April 2006 and Activity 2 of Government Notice 387 of 21 April 2006 on the Farms Losberg and Meysdam;
- Approved Environmental Management Plan in terms of section 39 (4)(A)(I-III) of the MPRDA [Act 28 of 2002] for mining permit application in respect of gravel on certain portion of the farm Meysdam;
- Approval (reference number 16.8.1.1) from the Karoo Hoogland Municipality for rezoning from Agricultural Zone I to Zone Special for an "Astronomy Advantage Area" limited to the construction of a radio telescope and related buildings, structures and infrastructure, on the farms Losberg remainder and part 1 of Losberg;
- Approval (reference number 15.1.2) from the Kareeberg municipality for rezoning;
- Water use licence reference number 14/D54E/A/1911 issued on 29 August 2012 to the National Research Foundation for Losberg Farm, for water use 21(a) and 21(g) of the National Water Act No. 36 of 1998;
- Water use licence reference number 14/D54E/ACGI/1012 issued on 29 August 2012 to the National Research Foundation for Meysdam Farm, for water use 21(a), 21(c), 21(i) and 21(g) of the National Water Act;
- Waste management licence reference number 12/9/11/L817/8 issued to the National Research Foundation/South African SKA Office for the Meysdam wastewater treatment works on Meysdam Farm, for undertaking Activities 11 and 18 listed in Category A of government notice 718 dated 3 July 2009;
- Mining Permits No. MP19/2012, No. MP20/2012, and No. MP21/2012 for mining activities on Farm Meysdam;
- Mining Permits No. MP29/2012, No. MP18/2012, No. MP24/2012, No. MP17/2012, No. MP23/2012, and No. MP28/2012 for borrow pits on Farm Meysdam;
- Mining Permit No. MP16/2012 for a borrow pit on ERF353; and
- Mining Permit No. MP22/2012 for a stone quarry on Farm Saaifontein.

7. Phased development

The SKA will be developed in a phased manner, with the first phase due to be constructed between 2018 and 2023. For SKA Phase 1, Australia will host the low-frequency aperture array telescope¹⁶ whilst South Africa will host an array of 197 dish-antennas (Figure 1-3), incorporating the 64 dish-antennas MeerKAT precursor telescope. In the final phase, it is proposed to complete the telescope arrays at both of the sites, with high and mid frequency dish-antennas, aperture arrays¹⁷ and low frequency antennas. At present, this final phase is a high level concept and a detailed description is not available in the public domain. It will be designed based on the lessons learnt from the development and operation of SKA Phase 1. It is however planned that the highest density of dish-antennas will be located in the SKA core (i.e. Meysdam and Losberg farms) and that the remote SKA stations will extend to other African countries.



Figure 1-3: Proposed design for the mid to high frequency dish-antennas in South Africa (Photo: Artist's impressions of design concepts by SKA Organisation)

¹⁶ More information at <https://www.skatelescope.org/lfaa/>

¹⁷ More information at <https://www.skatelescope.org/mfaa/>

II. Strategic environmental assessment

1. The Strategic Integrated Project (SIP) 16: SKA and MeerKAT

In 2012, the South African Government adopted the National Development Plan as long term strategy to address economic growth and broaden socio-economic transformation in the country. A fundamental component of this overarching plan is the National Infrastructure Plan which aims to catalyse economic development and job creation through infrastructure development. The Presidential Infrastructure Coordination Commission, as the coordinator and facilitator of the National Infrastructure Plan, subsequently identified 18 Strategic Integrated Projects (SIPs) which are large-scale infrastructure projects of national importance and located across all nine provinces aimed at unlocking the development potential in the country. Amongst the 18 SIPs, the Presidential Infrastructure Coordination Commission established two Knowledge SIPs:

- SIP 15: Expanding access to communication technology, which aims at providing for broadband coverage to all households by 2020; and
- SIP 16: SKA and MeerKAT, which aims at providing an opportunity for Africa and South Africa to contribute towards global advanced science projects.

The National Infrastructure Plan led to the promulgation of the Infrastructure Development Act (Act No. 23 of 2014) in 2014. The Infrastructure Development Act codifies into law the Presidential Infrastructure Coordination Commission and the National Infrastructure Plan as key mechanisms to co-ordinate and drive infrastructure development in South Africa¹⁸. The Act aims to facilitate infrastructure development which is of significant economic or social importance to the Republic, by prioritizing the planning, approval and implementation of strategic infrastructure development and improving the management of such infrastructure during all life-cycle phases, including planning, approval, implementation and operations. The Act endeavours to address the lack of co-ordination across the state to ensure common priorities and the management of trade-offs around infrastructure projects, to ensure a sufficiently strong level of public investment, and to improve capacity for managing all phases involved in the development of infrastructure. The planning, approval and implementation of strategic infrastructure developments such as the SKA project require a “business unusual” approach, as recommended by Mr. Trevor Manuel, chairperson of the National Planning Commission, in order to facilitate efficient implementation. The assessment of the environmental impacts of these strategic infrastructure developments therefore needs to take a “business unusual” approach and the SIPs provide this opportunity. This led to the Department of Environmental Affairs committing to support the efficient implementation of the National Development Plan by undertaking Strategic Environmental Assessments to integrate the regulatory environmental requirements for the SIPs.

2. The Strategic Environmental Assessment Process

An independent and objective strategic level assessment was conducted for the South African mid-frequency array of SKA Phase 1 (SKA1_MID)¹⁹ with the mission to provide a platform to coordinate research and data collection within the proposed development area of SKA1_MID and integrate the environmental authorisation process ensuring that environmental factors are adequately considered and environmental principles implemented at the strategic planning stage.

¹⁸ http://www.gov.za/sites/www.gov.za/files/37712_2-6_Act23of2014InfrastrucDevelop_a.pdf

¹⁹ “SKA1_MID” is the abbreviation used by the SKA organisation for the “South African mid-frequency array of SKA Phase 1”.

The stakeholder engagement conducted during the Strategic Environmental Assessment process was intended to raise a diversity of perspectives but not to force consensus amongst stakeholders. With a focus on the decisions relating to environmental management issues and socio-economic opportunities, stakeholders' inputs, issues and concerns were recorded and analysed to inform the Strategic Environmental Assessment of SKA1_MID.

The Strategic Environmental Assessment process was guided by a Special Advisory Committee including key government departments and state agencies. In addition to consultation with the Special Advisory Committee, dedicated provincial and local government consultations were undertaken to further inform local and provincial authorities. Focus group meetings were organised with key stakeholders from conservation agencies and representatives from other key sectors (e.g. Civil Aviation, Defence, Heritage Resources) to share information and obtain inputs and expert advice on specific issues/technical aspects of the Strategic Environmental Assessment.

The local communities, other interested and affected parties, and the wider public were engaged through various communication channels e.g. a project webpage, public meetings, posters, phone calls, bulk sms notifications and advertisements in selected local and regional newspapers. The stakeholder engagement process included a range of techniques for sharing information and providing opportunities to all interested and affected parties to engage effectively, efficiently and equitably. The public meetings notes, official communiques, comments/questions and responses trails and other stakeholder engagement process are included in the Strategic Environmental Assessment Report.

Specialists' scoping level pre-assessments were undertaken for agriculture, heritage (including archaeology, palaeontology, cultural heritage and visual/landscape aspects), terrestrial ecology and biodiversity including avifauna, aquatic ecosystems, and socio-economic aspects. Additional studies were conducted during the Strategic Environmental Assessment including a survey of endangered species present within the study area (Riverine Rabbit), screening of the potential sensitivities related to the presence of bats within the study area and screening of the risks associated with on-site diesel storage within the SKA core area.

Further aspects of sensitivity in terms of aviation, defence, telecommunication, weather services, mining, water use, waste management, noise and traffic effects were investigated during the Strategic Environmental Assessment in consultation with the relevant authorities and stakeholders. The specialist reports were reviewed by independent experts who provided inputs and contributed to improving the results of the scoping level pre-assessments.

Details of the specialists and reviewers who participated to the Strategic Environmental Assessment are included in Chapter 3. The identified sensitivities and no-go areas were subsequently combined and used to revise the preliminary configuration of the South African mid-frequency array of SKA Phase 1 to avoid areas potentially unsuited for development (i.e. no-go areas and areas of Very High sensitivity).

3. The outputs of the Strategic Environmental Assessment

The findings and outputs of the Strategic Environmental Assessment were compiled into two reports:

- an **Integrated Environmental Management Plan (IEMP)** which establishes the geographical and activity scope, the minimum requirements for the construction and operation phases of SKA1_MID, environmental principles, environmental management outcomes and mitigation

actions as well as long-term research monitoring programmes to be implemented on the SKA site; and

- a **Strategic Environmental Assessment Report** which includes details about the timeline and activities, stakeholder engagement, and specialist studies conducted during the Strategic Environmental Assessment process.

This **IEMP** is being submitted formally to the Minister of Environmental Affairs for consideration for adoption as an environmental management instrument in terms of section 24(2)(e) of the NEMA, which will allow for the development of the identified activities associated with the development of the SKA in the geographical location identified in this document, without environmental authorisation, but in line with the environmental management principles and measures of this plan. These principles and management measures have been proposed based on the assessment of possible environmental sensitivities and impacts and their mitigation and management measures undertaken through a strategic environmental assessment process. This IEMP must be used for strategic environmental decision making on the development of the SKA and legally implements the Strategic Environmental Assessment's outputs.

The **IEMP** comprises five chapters:

- Chapter 1: Introduction;
- Chapter 2: Project Scope;
- Chapter 3: State of the Environment;
- Chapter 4: Environmental Management Programme; and
- Chapter 5: Long term research and monitoring programmes.

The **Strategic Environmental Assessment Report** is a separate report intended to provide supportive information for all interested and affected parties on the overall Strategic Environmental Assessment process and key milestones and the engagement with interested and affected parties undertaken during the Strategic Environmental Assessment. The Strategic Environmental Assessment Report will not be gazetted as it does not form part of the legal implementation of the Strategic Environmental Assessment's outputs.



CHAPTER 2: PROJECT SCOPE





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I. Geographical scope

This Integrated Environmental Management Plan (IEMP) has been developed based on a Strategic Environmental Assessment process and includes the project scope, the current state of the environment, areas identified as unsuitable for development within the geographical scope, an Environmental Management Programme and long-term research and monitoring programmes. The Strategic Environmental Assessment has assessed the impacts of the South African mid-frequency array of SKA Phase 1 (SKA1_MID) over a study area of approximately 627 857 hectares. This study area can be split into two sub-areas, as illustrated in Figure 2-1, which consists of a "core" including 38 land parcels and covering approximately 131 000 hectares and three "spiral arms" including of 131 land parcels and covering approximately 496 657 hectares.

The study area of the Strategic Environmental Assessment was investigated by specialists through desktop geographic information system (GIS) analysis and site visits from November 2015 to May 2016. The two land parcels acquired by the National Research Foundation for the MeerKAT radio telescope (Meys'dam and Losberg farms) are located within the geographical scope of SKA1_MID.

The SKA organisation is in process of finalising the footprint of the SKA1_MID and the requirements for the acquisition of farms for the SKA telescope core (32 land parcels as of December 2016) and for the negotiation of servitude for the SKA1_MID spiral arms (73 land parcels as of December 2016).

The study area is located in the Karoo region in the Northern Cape Province of South Africa and across the Kareeberg Local Municipality (NC074), Hantam Local Municipality (NC065), Siyatemba Local Municipality (NC077) and Karoo-Hoogland Local Municipality (NC066). These municipalities fall under the Namakwa District Municipality (DC6) and Pixley Ka Seme District Municipality (DC7). The nearest towns in the region are Carnarvon and Williston, Van Wyksvlei and Brandvlei.

The SKA1_MID will consist of a total of 197 dish-antennas and will consist of:

- the 64 dish-antennas already approved and currently being constructed for the MeerKAT project;
- an additional 112 dish-antennas to be erected in the SKA telescope core ; and
- an additional 21 dish-antennas to be erected outside the SKA telescope core in three spiral arms (7 dish-antennas per spiral arm).

The 112 dish-antennas to be erected in the SKA telescope core will be connected with underground (trenched) electricity distribution infrastructure and underground (trenched) fibre-optic cables. More details on the infrastructure required for the SKA1_MID are provided in the following sections.

Existing infrastructure currently in operation/in construction in the SKA telescope core includes:

- the Losberg site complex (see Section III-1); and
- the Losberg and Meys'dam construction camps (see Section III-2)
- MeerKAT, KAT-7 and other astronomy instruments (see Section III-3), and
- supporting infrastructure (e.g. power grid, security, measurement instruments).

Each of the three spiral arms will include seven dish-antennas connected with electricity distribution infrastructure and fibre-optic cables. It is currently planned that the last three dish-antennas of each spiral arm may be supplied with electricity generated from small-scale solar photovoltaic plants. The dish-antennas to be erected in the three spiral arms will be less sensitive to radio-frequency

interference¹ because the dish-antennas will be sparsely scattered in the landscape and thus any radio noise pollution will be less detrimental to the overall functioning of the project. Therefore the National Research Foundation does not intend to acquire the land, but intends to secure the footprint of the servitude required for the construction of the dish-antennas and associated infrastructure through servitude agreements with local land owners.

The dish-antennas along the 3 spiral arms will be secured with new 2,5 metre high perimeter fencing (400 metres per station). Each dish-antenna will be fenced separately and will have 6 metre wide access gates with two 6 metre wide removable panels on either side of the gate (for easy access and maintenance) as well as visual monitoring equipment.

The road network within the core area and the three spiral arms will consist of a combination of new roads to be built and existing roads to be upgraded. Any material required for the construction and upgrade of roads will be extracted from borrow pits and quarries within or in close proximity to the study area. The design of SKA1_MID and associated infrastructure as of September 2016 is illustrated in Figure 2-2. The highest concentration of dish-antenna will be located in the SKA telescope core, which is located on Meys'dam and Losberg Farms. The various components and activities planned for the development of SKA1_MID and associated infrastructure are described in the following sections of this Chapter.

¹In terms of the Government Notice 1166 of the DST, released in 2015, "radio frequency interference" (RFI) also called Electromagnetic interference (EMI) means the detrimental effect of received radio signals that exceed the protection levels prescribed in the Radio Astronomy Protection Levels Regulations, 2012, for more than 5% of the time over a 24 hour period.

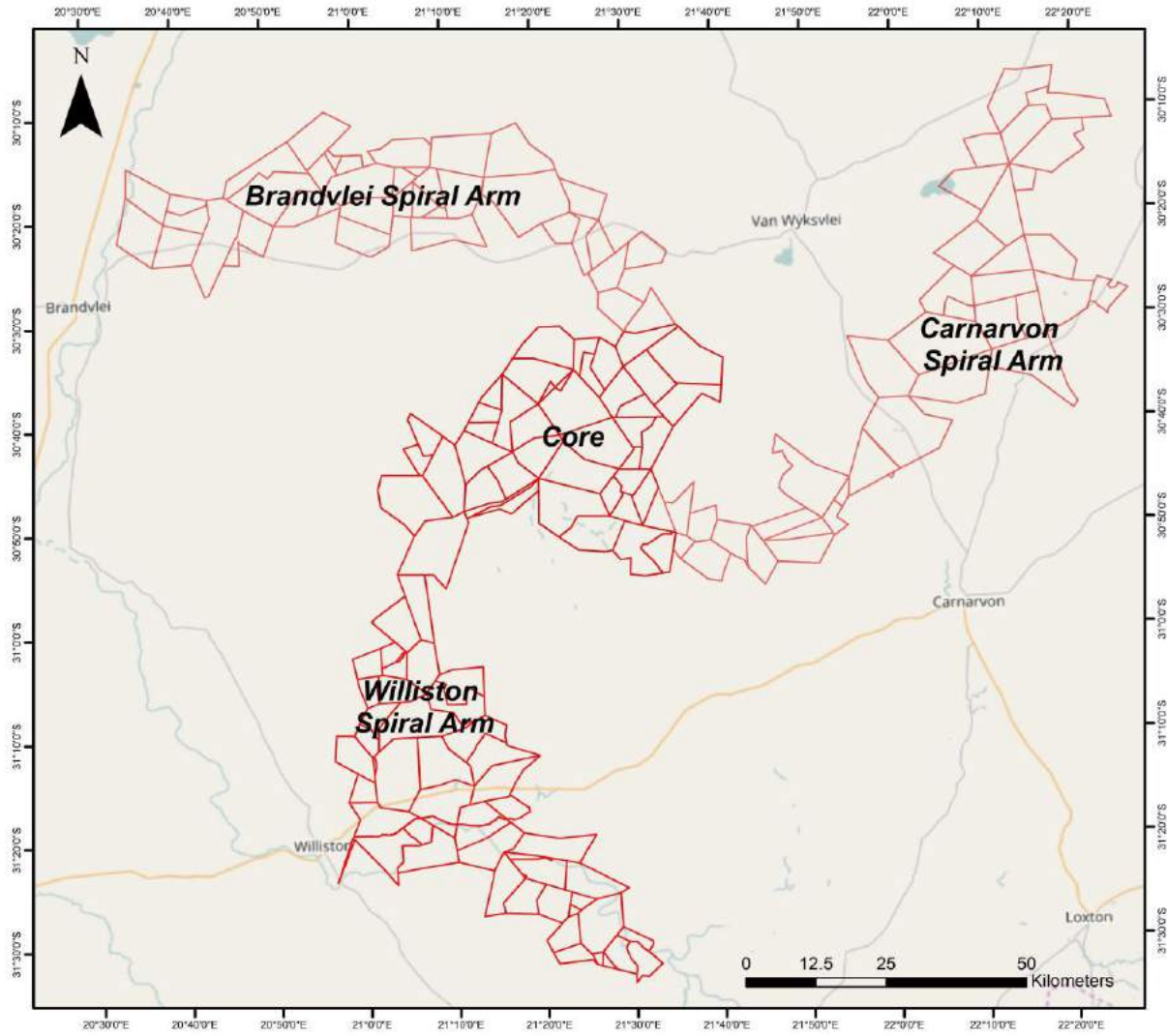


Figure 2-1: Study area for the Strategic Environmental Assessment

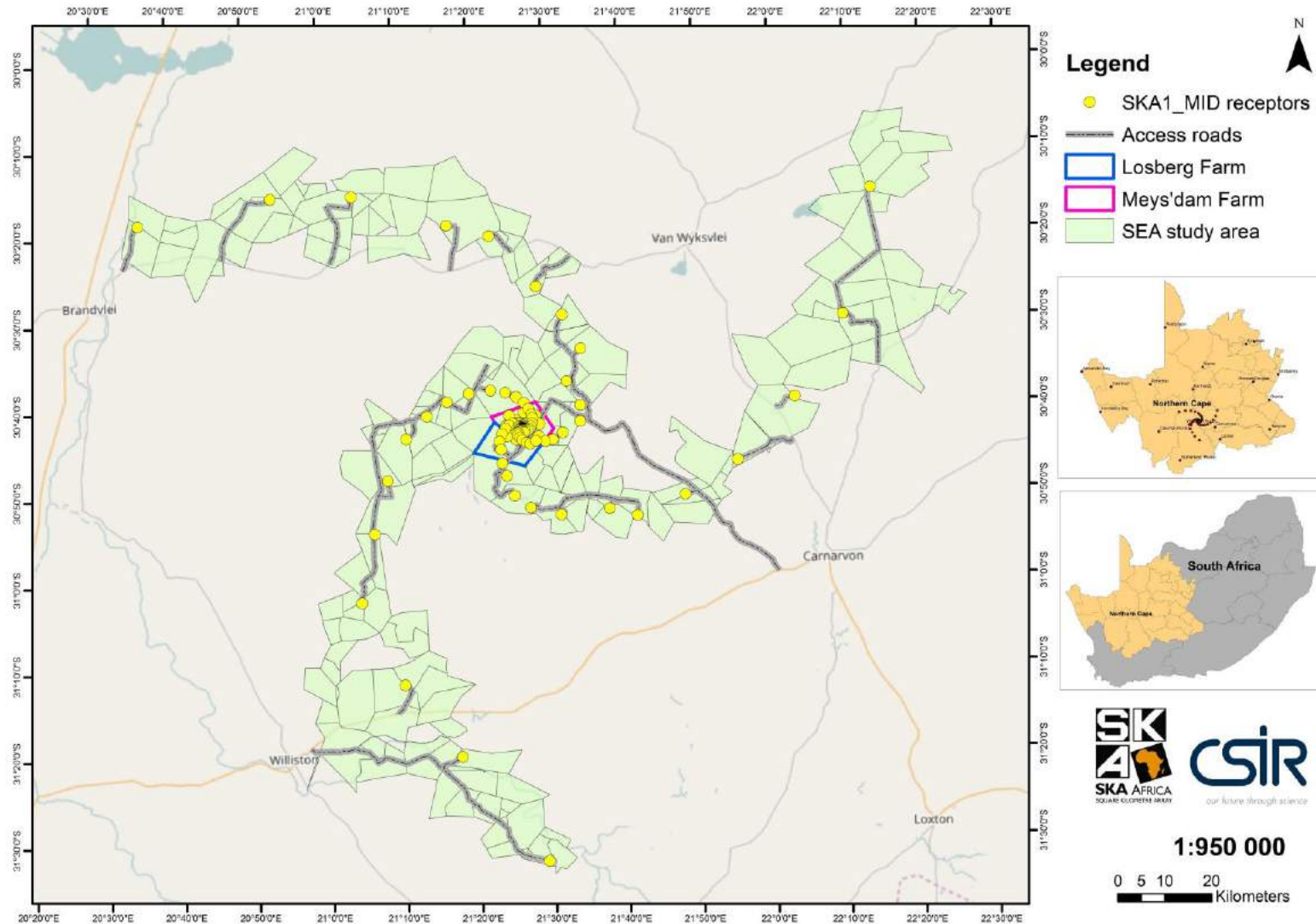


Figure 2-2: Design of the South African mid-frequency array of SKA1_MID and associated infrastructure as of September 2016

II. Legal implementation mechanism

The Constitution of the Republic of South Africa Act [Act No. 108 of 1996], which is the supreme law of the Republic of South Africa, provides the legal framework for legislation regulating environmental management in general, against the backdrop of the fundamental human rights. Section 24 of the Constitution states that:

"Everyone has the right:

- (a) to an environment that is not harmful to their health or well-being; and*
- (b) to have the environment protected, for the benefit of present and future generations through reasonable legislative and other measures that –*
 - (i) prevent pollution and ecological degradation;*
 - (ii) promote conservation; and*
 - (iii) secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development."*

Section 24 of the Bill of Rights therefore guarantees the people of South Africa the right to an environment that is not detrimental to human health or well-being, and specifically imposes a duty on the State to promulgate legislation and take other steps that ensure that the right is upheld and that, among other things, ecological degradation and pollution are prevented. The key environmental management objective of SKA will be to protect ecologically sensitive areas and support sustainable development and the use of natural resources throughout the lifetime of SKA, whilst promoting justifiable socio-economic development in the towns in close proximity to the SKA development site.

South Africa's National Environmental Management Act (NEMA) [Act No. 107 of 1998] promotes the integrated environmental management of activities that may have a significant effect (positive or negative) on the environment. Section 24(1) of the NEMA states that *"in order to give effect to the general objectives of integrated environmental management laid down in this Chapter, the potential impact on the environment of listed activities must be considered, investigated, assessed and reported to the competent authority charged by this Act with granting the relevant environmental authorization."* The reference to "listed activities" in Section 24 of the NEMA relates to the Environmental Impact Assessment Regulations and associated listing notices promulgated in Government Notices 982, 983, 984 and 985 which came into effect on 8 December 2014. All activities listed under the relevant Government Notices require Environmental Authorisation from the competent authority prior to commencement. Some of the identified activities associated with the development of SKA1_MID are listed in the Government Notices 982, 983, 984 and 985, and therefore authorisation is required from the Minister of Environmental Affairs prior to commencement of these listed activities. As such, an environmental management instrument was prepared in terms of section 24(2)(e) of the NEMA for the strategic environmental decision making on the development of SKA1_MID.

This IEMP (environmental management instrument) will be submitted to the Minister of Environmental Affairs for consideration for adoption as an environmental management instrument in terms of section 24(2)(e) of the NEMA, which will allow for the development of the listed activities associated with the development of the SKA1_MID in the geographical scope identified in this chapter, without environmental authorisation, but in line with the environmental management principals and measures of this plan. These principles and management measures have been proposed based on the assessment of possible environmental sensitivities and impacts and their mitigation and management measures undertaken through a strategic environmental assessment process. This IEMP must be used

for strategic environmental decision making on the development of the SKA and legally implements the Strategic Environmental Assessment's outputs.

The exclusion is considered on condition that the National Research Foundation will comply with the adopted IEMP [where the National Research Foundation is currently the over-arching legal entity that includes the South African SKA Office business unit and that this condition will be incumbent upon other legal entities responsible for implementing SKA in South Africa].

Should the Minister adopt this IEMP, the National Research Foundation will commit to conducting a review and audit of this IEMP at a frequency defined in the most recently published EIA Regulations (but as a minimum every 5 years). The review and audit of this IEMP will be captured in a report containing, as a minimum, the following information:

- a confirmation of compliance with the requirements of this IEMP;
- reporting on the management of impacts within the development area;
- non-compliances and proposed corrective actions;
- any changes in the Project Scope and associated possible impacts on the environment, describing the findings of further assessments by suitably qualified and independent practitioners as is required;
- the progress and results of the long term research and monitoring programme; and
- the strategic plan for the next 5 years.

The review and audit report will be submitted to the relevant compliance monitoring unit as prescribed in the notice of adoption.

III. Existing SKA infrastructure

The existing SKA infrastructure is located on Meys'dam and Losberg farms and includes the Losberg site complex, the Losberg and Meys'dam construction camps, KAT-7, MeerKAT, Hydrogen Epoch of Reionization Array (HERA), power grid network, security infrastructure (e.g. guardhuts and boom gates), weather monitoring and radio-frequency interference monitoring stations, a Local Area Network and a surfaced aircraft landing strip. This existing SKA infrastructure is described below.

1. The Losberg site complex

The Losberg site complex, displayed in Figure 2-3- A and B, was constructed during the MeerKAT project and consists of the pedestal integration shed, dish-assembly shed (Figure 2-4), Karoo Array Processor Building and power facility, chemical store room, diesel storage area (Figure 2-5), carport, sewage and wastewater treatment plant, and the temporary on-site accommodation. The design of the site complex (30 45'15.16"S; 21 25'52.54"E) includes a 3m high reinforced galvanised steel fencing in order to comply with the National Key Point Act No. 102 of 1980. The Losberg site complex layout is illustrated in Figure 2-6.



Figure 2-3: Labelled photo of the Losberg site complex (Legend key for Image A: 1-Dish Assembly Shed, 2-Pedestal Integration Shed, 3- Karoo Array Processor Building, 4-Accommodations, 5-Offices, 6-Diesel Storage Area) (Photo: SKA SA)

The total dish assembly shed (Figure 2-4) length is approximately 81 metres with a maximum width clearance of approximately 18 metres and includes a main working area of 987 square metres (where the dishes will be assembled) and ancillary areas (foam cutting area; foam store; dispensing room; glass store; consumable store and storage area for sub-reflectors). Different equipment/material stores

are included in the building and each store has its own roller shutter door. The Dish Assembly Shed is fitted with two overhead gantry cranes with a crane-hook height of 8 metres.

The pedestal integration shed is where all antenna components are integrated, and is located 40 metres to the North of the dish assembly shed. It consists of a main working area of 274 square metres with a lean-to structure to its north which consists of 51 square metres offices, a store of 41 square metres and ablution facilities. Its floor level is nominally higher than that of the dish assembly shed in order to facilitate unobstructed movement to and from the dish assembly shed. An uncovered concrete slab is located to the west of the pedestal integration building for integration of the sub reflector with the dish support structure and initial alignment of the dish. The pedestal integration shed is fitted with a 10 tonne overhead crane with a maximum hook height of 12 metres. Maximum entrance width into the pedestal integration building is about 18 metres.



Figure 2-4: The dish assembly shed (Photo: SKA SA)

In order to minimise radio-frequency interference from the dish assembly shed and the pedestal integration shed, specific policies have been implemented for the electrical wiring, lights and network connections. Earthing, bonding and lightning protection is provided to protect the buildings against lightning strikes. Between the pedestal integration shed and the dish assembly shed there is a loading yard. Two fibre-optic cable sleeves connect the pedestal integration shed to the Karoo Array Processor Building as well as the dish assembly shed and the chemical store to the Karoo Array Processor Building. The electrical cable and fibre sleeve routes are combined in a common trench. The distribution board is supplied from the low voltage distribution kiosk located near the building.

The chemical store is located to the west of the dish assembly shed. In order to fulfil the requirements of the fire-safety by-laws and regulations for the storage of chemicals, it is located 4.5 metres away

from all other buildings. The structural concrete floor is lowered beneath the natural ground level and a steel mesh floor is installed 425 millimetres above in order for spills to be contained and removed in the gap. The building has weatherproof louvres in the walls of all the facades (on a lower and higher level) to ensure adequate ventilation. The building has a flat concrete roof with the appropriate rain water outlets, overflows and waterproofing. The building has been designed for 200 litre drums that are double stacked. A waste disposal area has been provided to the north west of the chemical store. This area is accessible from the side of the chemical store and shielded with a screen wall.

The Karoo Array Processor Building is located to the north-east of the dish assembly shed. It is the on-site facility that currently houses the centralised telescope equipment for MeerKAT. The building footprint of the Karoo Array Processor Building consists of four areas: (1) radio-frequency interference-screened Data Rack Area, (2) Power Section, (3) Service Area and (4) Karoo Array Processor Building Ancillaries Area. The Karoo Array Processor Building and the adjacent power facility have been constructed 5 metres underground, in a bunker. The soil that was excavated to create the bunker site has been used as an earth berm (Figure 2-6) to further shield the radio telescope antennas from the radio-frequency interference generated by the equipment in the site complex buildings. This type of construction has been used for various reasons including thermal performance of the building (keeping external temperature fluctuations to a minimum) and radio-frequency interference shielding advantages (the fact that the building is buried contributes to the overall radio-frequency interference shielding). In addition, the doors, penetrations for power, cooling and fibre optic connections to the building are also shielded and screened to prevent radio-frequency interference. The Data Rack Area houses all the computing, data management and data transmission equipment. It has a raised access floor with some services run below the floor (power and cooling air) and some services above in racks, i.e. trays for fibre optic cables, lights, fire detection and fire suppression. The total internal floor area measures 369 square metres. This entire area is radio-frequency interference shielded. The Power Facility consists of a main switch room, a transformer room with two 33/22 kilovolt transformers and two 22 kilovolt /400 volt transformers, a power room, where Rotary Uninterruptible Power Supply units and ancillaries are located, a power control room with low voltage distribution panels and control panels for the Diesel rotary uninterruptible power supply (DRUPS)² units and 22 kilovolt controllers for switchgear are located, and a switch room where all 22 kilovolt switching panels are located. The Power Facility distributes power to the Losberg site complex, KAT 7, MeerKAT and HERA. The Karoo Array Processor Building Ancillaries area includes a laboratory, control room, ablution facilities, store room, boardroom, an Optic Distribution Framework Room and an open courtyard. The Optic Distribution Framework room provides space for the splicing trays and patch panels to connect the fibre optic cables external from the Karoo Array Processor Building to the fibre optic cables internal to the Karoo Array Processor Building. Installation of new equipment and services inside the existing Karoo Array Processor Building (such as additional equipment in the Data Rack Area) will not require additional external building works.

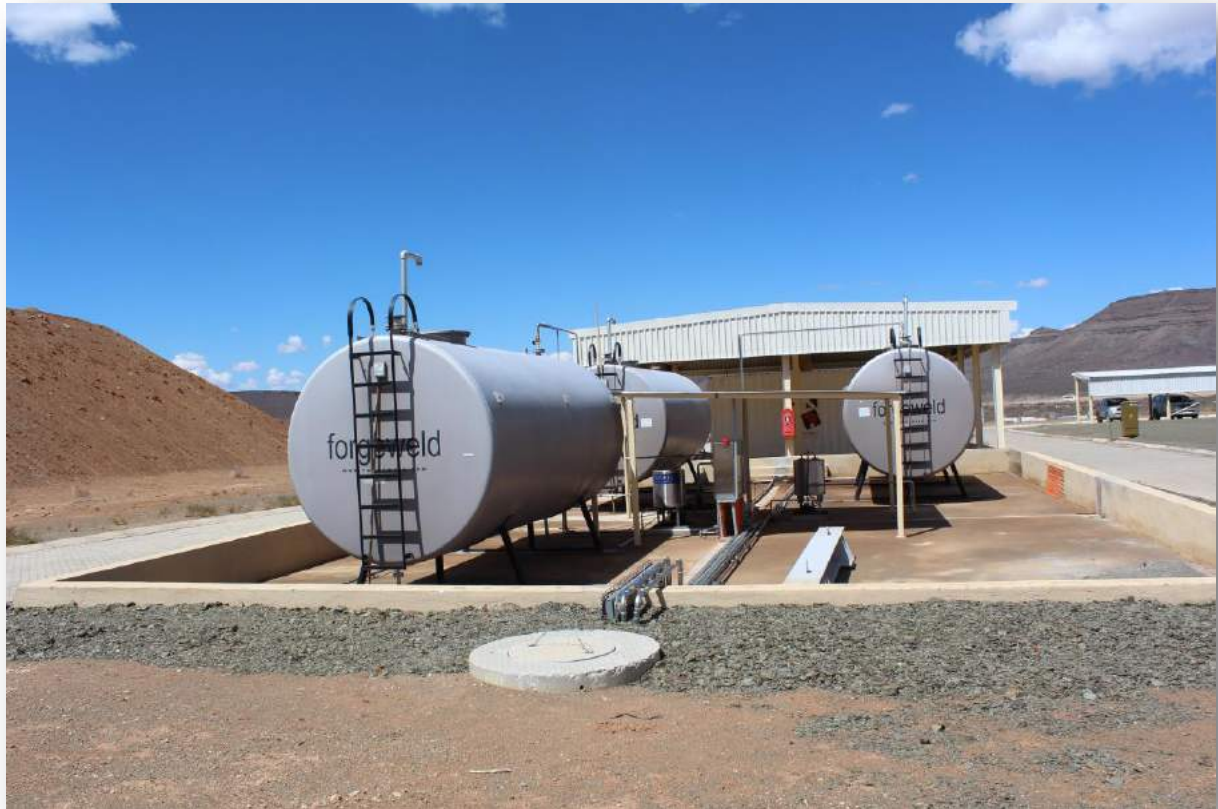
Extensive earthing, bonding and lightning protection is provided to limit radio-frequency interference and to protect the building against direct lightning strikes including earth mat and outside ring trench earth conductor with earth rods, earth bars in cable trenches, earthing of cables entering and exiting the building, additional bonding of re-enforcing structural steel in columns, structural walls and floor screeds, and lightning down conductors. A concrete manhole has been constructed outside the Karoo Array Processor Building which accommodates 12 x 110 millimetre incoming ducts from the receptors.

The Losberg site complex already has an existing septic tank in place situated at the lower side of the site. The toilets and hand basins inside the Karoo Array Processor Building are drained to a sump from

² Diesel rotary uninterruptible power supply devices (DRUPS) combine the functionality of a flywheel-powered uninterruptible power supply device and a diesel generator. When mains electricity supply fails, stored energy in the flywheel is released to drive the electrical generator, which continues to supply power without interruption.

where it is pumped through a 63 millimetres diameter pipe to a manhole situated within the main sewer pipeline system from where it will gravitate to the existing septic tank. Sewer drainage from the other buildings collects in one 110 millimetres diameter sewer pipe line which will be connected to the existing system.

There are currently three diesel tanks of a capacity of 23 cubic metres each installed above ground at the Losberg site complex (Figure 2-5). The diesel is stored on site to generate electricity in the event of loss of power from Eskom.



**Figure 2-5: Three diesel storage tanks currently in the Losberg Site Complex
(Photo: SKA SA)**



Figure 2-6: Losberg site complex layout. Note the earth berm at top right.

2. The Losberg and Meys'dam construction camps

There are two existing construction camps on the farms owned by the National Research Foundation (Meys'dam and Losberg Farms). The Meys'dam construction camp (30°43'33.52"S; 21°27'26.82"E) will be decommissioned on the completion of MeerKAT construction due to the close proximity to the core and potential radio-frequency interference that could be generated by the camp. The Losberg construction camp (approximately 30°45'41.35"S; 21°24'25.43"E) is proposed to be re-used and expanded, as this camp is shielded by the Losberg Hill which provides topographical screening from the radio telescopes to reduce any radio frequency interference. The expansion works on the Losberg construction camp are described in Section IV-3 below.

3. KAT-7, MeerKAT and HERA

KAT-7 was primarily built as a precursor to the 64-dish MeerKAT radio telescope array and to demonstrate South Africa's ability to host the SKA. KAT-7 is considered a compact radio telescope, since its antennas all lie within an area only 200 metres across (see Figure 2-7 below), and has proved to be a pioneering scientific instrument in its own right.



Figure 2-7: KAT-7 telescopes dish-antennas (Photos: SKA SA)

The Hydrogen Epoch of Reionization Array (HERA) (Figure 2-8) is an international science and technology collaboration to build a telescope array with the ability to detect and characterize the power spectrum of the epoch of reionization³. HERA will be able to provide the key measurements needed to advance our understanding of early galaxy formation and cosmic reionization. HERA roadmap is a staged plan to use the unique properties of the 21 centimetre "spinflip" line from neutral hydrogen to probe our cosmic dawn, from the birth of the first stars and black holes through to the full reionization of the primordial intergalactic medium. It is a multibeam, waveguide superconductor–insulator–superconductor tunnel junction receiver that greatly improves mapping speed in various observing modes and also provides possibilities for new high-sensitivity observing of small sources⁴.

³ <http://reionization.org/>

⁴ Schuster, K.F., Boucher, C., Brunwig, W., Carter, M., Chenu, J.Y., Foullieux, B., Greve, A., John, D., Lazareff, B., Navarro, S., Perrigouard, A., Pollet, J.L., Sievers, A., Thum, C., Wiesemeyer, H., 2004: A 230 GHz heterodyne receiver array for the IRAM 30 m telescope, *Astronomy and Astrophysics*, 423, 1171-1177.

HERA has now been recognized as a pathfinder instrument for the SKA as the higher sensitivity of the HERA project will be used to improve understanding of the birth of the first galaxies and black holes⁵. HERA currently consists of a 19 element prototype array and it is planned to expand it to 350 of these instruments to support SKA science as it will investigate one of the two SKA key science cases (Cosmic Dawn and Epoch of Reionization). Figure 2-9 below shows the location of HERA, KAT-7, and the MeerKAT on the National Research Foundation-owned Losberg and Meys'dam farms.



Figure 2-8: The Hydrogen Epoch of Reionization Array (HERA) (Photo: SKA SA)

⁵ DeBoer, D., Bowman, J.D., Jacobs, D., Parsons, A., Liu, A., Werthimer, D., Ali, Z., Carilli, C.L., Chiang, C., Sievers, J.L., Furlanetto, S.R., Hewitt, J.N., Tegmark, M., Dillon, J.S., Bradley, R.F., Moore, D., Aguirre, J.E., Bernardi, G., Walbrugh, W., Morales, M.F., Poer, J., 2014: HERA: Chasing Our Cosmic Dawn, *Bulletin of the American Astronomical Society*, 46 (3).

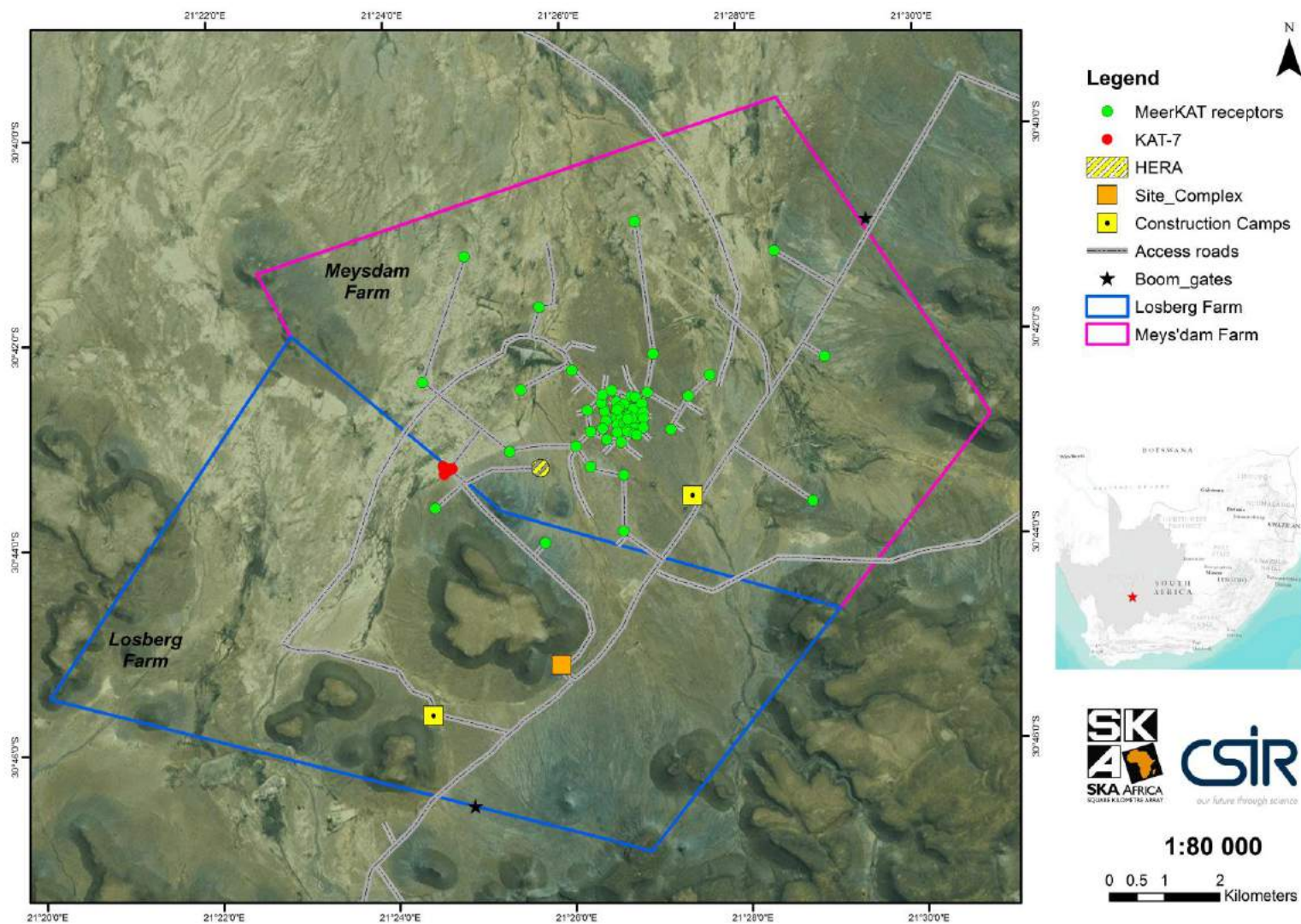


Figure 2-9: HERA, KAT-7, and the MeerKAT on the National Research Foundation-owned Losberg and Meysdam farms

4. Grid power network

The existing grid power is supplied by the Eskom Karoo Substation located in Carnarvon (30°52'24.5"S; 22°09'6.15"E) via an overhead 33 kilovolt line with a capacity of 4.5 Mega Volt Amp. The first voltage regulator is located outside of the Eskom Substation regulating the power at 33 kilovolts and giving SKA more control over the line and power supply. Once the 33 kilovolt line passes through the first voltage regulator the line runs for approximately 25 kilometres to the Klerefontein Support Base⁶. The second voltage regulator is located within 30 kilometres of the core, where power is stepped up by a constant percentage ensuring a supply of 33 kilovolts and minimising radio frequency interference. Once the line passes through the second voltage regulator it runs to the construction camps as well as the Losberg site complex. At the Losberg site complex the 33 kilovolt power supply is connected to the power facility adjacent to the Karoo Array Processor Building. Within the power facility the power is stepped down to 22 kilovolts and the line then moves through the DRUPS units. Once the power supply has moved through the DRUPS units it is no longer affected by the uncertainties of Eskom grid power. From this point, the power is transformed to 400 volts and supplied to the site complex and Karoo Array Processor Building. The peak power consumption of the construction and operation phases of SKA1_MID and associated infrastructure is estimated at 5.2 Mega Volt Amp.

5. Security infrastructure

The following security and access control infrastructure is located within the SKA telescope core:

- two guardhuts located at separate booms, one stationed at the northern boom near the Meys'dam Farm, and one stationed at the southern boom (near the Losberg Farm); and
- a guardhut at the entrance to the Losberg site complex.

Where practical, possible and subject to the Republic of South Africa Hosting Agreement, the existing MeerKAT security infrastructure including guardhuts will be re-used for the SKA. All guardhuts will be fully equipped with electricity, ablutions and emergency communication radios and are guarded 24 hour every day of the week.

6. Local Area Network (LAN)

The existing Local Area Network installed for MeerKAT will be re-used and expanded for the SKA. Expansions will include the upgrade of five 24 port switches to 48 port switches, the addition of four 10 Gigabit Ethernet blades to the core switches in the Karoo Array Processor Building and the addition of 20 network points (CAT 7 cable). The Local Area Network currently enables the transfer of MeerKAT scientific data to Cape Town, the control and monitoring of MeerKAT telescopes, voice, Closed-circuit television (CCTV), building management system, video conferencing and general IT data. The existing telephone network provides Voice over Internet Protocol telephones to the Cape Town office, the Rosebank office, the Karoo Klerefontein Support Base, the Losberg and Meys'dam construction camps, and the Karoo Losberg site complex including the Karoo Array Processor Building. The current Voice over Internet Protocol network will be extended to all buildings on site and Voice over Internet Protocol network points will be provided by the Signal and Data Transport/DISH elements in each dish-antenna pedestal. Provision has been made by the Infrastructure and Power Element for ten portable Voice over Internet Protocol telephones which can be connected in each dish pedestal as and when required. The radio communications system consists of Very High Frequency (VHF) radios that operate in the 66-88 megahertz band. The radio network consists of a number of repeater stations that are linked together with radio links. Each repeater station has two frequencies, one for transmit and

⁶ The Klerefontein Support Base was established by the National Research Foundation and is not part of this Project Scope.

one for receive. In addition to the various frequencies, there are separate channels (networks) that can be programmed on the system. The vehicles are fitted with mobile radios, handheld radios are also available as base stations (e.g. at buildings), all these radios can be programmed to any one of the frequencies or channels. For Safety and reliability there are two repeaters at each of the remote stations. It is assumed that the existing Karoo Radio Astronomy Observatory emergency communication system installed for MeerKAT will be re-used for SKA1_MID. The existing network will be extended to provide coverage to the three spiral arms and the core. Further propagation modelling has been undertaken to determine the best location for additional repeater stations for SKA1_MID. It is currently assumed that there will be one additional repeater station for each spiral arm. The National Research Foundation is also investigating the possibility of a trunked communication⁷ network instead of the emergency communication network depending on the outcome of on-going tenders.

Existing high masts in the towns of Carnarvon, Williston, Brandvlei and Van Wyksvlei will be used to deploy the radio communication infrastructure. There is, however, a need for an additional mast within the SKA telescope core with a height of approximately 40 metres. As part of the Project Scope for SKA1_MID, the erection of a mast of any material or type used for radio transmission purposes where the mast is to be placed on a site not previously used for this purpose; and will exceed 15 metres in height is a listed activity in terms of Section 24 of the NEMA⁸. The location and the height of the mast will be selected to ensure compliance with the Astronomy Advantage Area regulations⁹ while providing adequate radio frequency signal for the local community and SKA1_MID activities.

7. Weather and radio-frequency interference monitoring stations

There is already an existing permanent radio-frequency interference monitoring station on the Losberg Hill and a weather station in the core which will be re-used for SKA1_MID. In addition to weather station in the core, there are five weather stations associated with the spiral arms:

- Williston Weather Station – recording weather data since 2005;
- Van Wyksvlei Weather Station – recording weather data since 2004;
- Brandvlei Weather Station – recording weather data since 2004;
- Carnarvon Weather Station – recording weather data since 2006; and
- Kenhardt Weather Station – recording weather data since 2007.

8. Landing strip

There is a surfaced landing strip on the Meys'dam Farm within the SKA telescope core (30°41.163'S; 21°27.051'E). The SKA landing strip is 1300 metres long, 18 metres wide, with a taxiway connecting a 35 metre x 60 metre apron. Based on the design of SKA1_MID and associated infrastructure as of September 2016, the development of additional aircraft landing strips and runways or the expansion of this landing strip is not required.

The SKA landing strip constitutes an "aerodrome" as defined in the Civil Aviation Act [Act No. 13 of 2009] and was designed to accommodate a Pilatus PC-12 (design aircraft) or similar. Based on the

⁷ A trunked radio system is a computer-controlled two-way radio system that allows sharing of relatively few radio frequency channels among a large group of users. Trunked radio system is usually used by government entities e.g. fire departments, police and other municipal services.

⁸ Government Notice 985 dated 4 December 2014

⁹ Astronomy Geographic Advantage Act No. 21 of 2007, Core Astronomy Advantage Area regulations (promulgated on 22 June 2012), Draft Karoo Central Astronomy Advantage Areas Regulations (Government Gazette number 39442, under Notice number 1166, on 23 November 2015)

International Civil Aviation Organization (ICAO) classification, it is a reference code 1B aircraft. The Pilatus PC-12 is a single engine aircraft seating 8 passengers with a wing span of 16.23 metres and a length and height of 14.4 metres and 4.27 metres respectively. It has a maximum take-off weight of 4500 kilograms.

The SKA landing strip does not require an aerodrome licence from the Civil Aviation Authority as in terms of the civil aviation regulations (2011), a licence is only required for aeroplane with a maximum certified mass exceeding 5700 kilograms or when the aeroplane is used in commercial air transport operations.

IV. Proposed SKA activities and infrastructure

1. Establishment of SKA dish-antenna including platforms and foundation

The 15 metre diameter dish-antenna design¹⁰ is illustrated in Figure 2-10. The dish-antenna platforms will consist of a ripped and compacted *in-situ* material with a 150 millimetre gravel layer, with a minimum radius of 26.5 metres, with a minimum slope of 1 per cent (%) to the perimeter to improve drainage. The platform radius will accommodate a turning dish-antenna transporter, thus allowing for an efficient installation of the dish-antenna, with a bell mouth radius of 24 metres and a keep out zone of 15 metres. As part of the Project Scope for SKA1_MID, vegetation clearance will be undertaken for the establishment of the dish-antenna in the core and spiral arms and the clearing of more than 20 hectares of indigenous vegetation within the proposed project development area is a listed activity in terms of Section 24 of the NEMA¹¹. The clear zone will be marked with large stones as is the case with the KAT-7 dish-antennas platforms (see Figure 2-11).

¹⁰ More information at <https://www.skatelescope.org/news/ska-selects-final-design-ska-dish/>

¹¹ Government notices regulation 984 and regulation 985 dated 4 December 2014

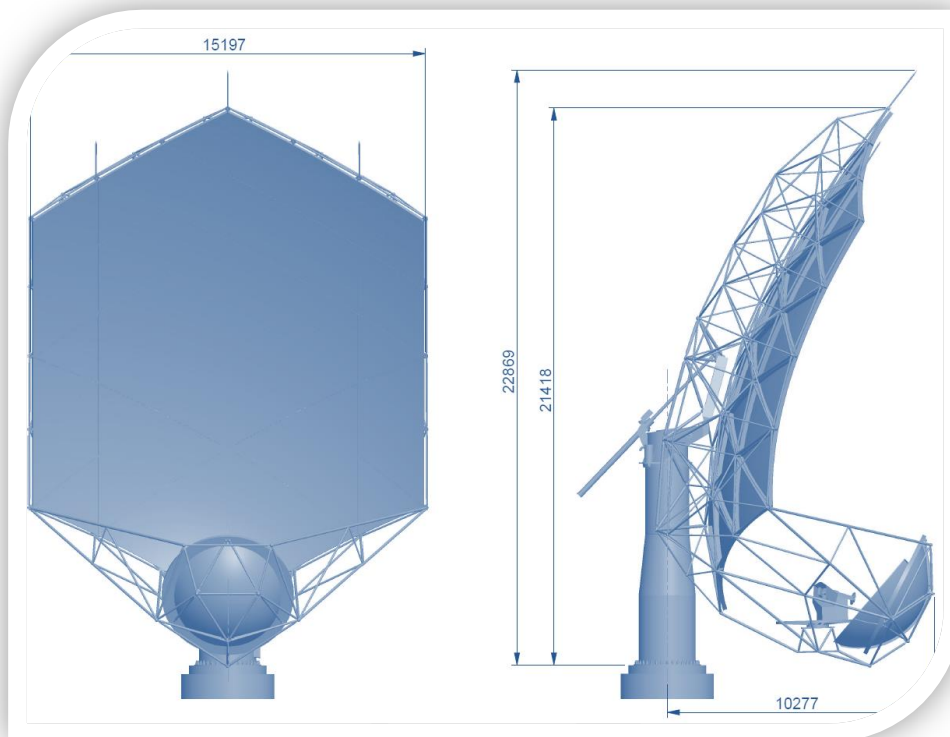


Figure 2-10: SKA1_MID preliminary antenna design (Source: SKA SA)

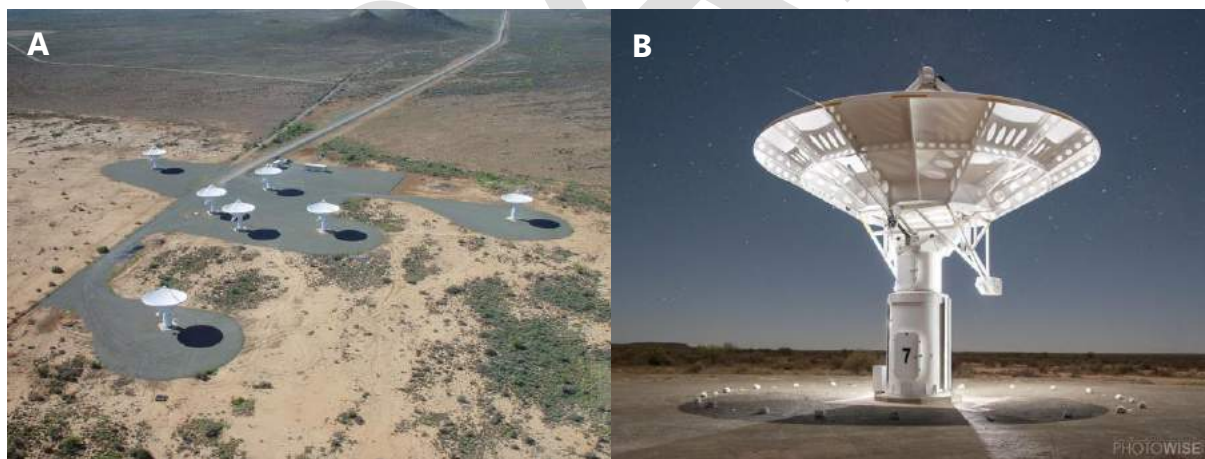


Figure 2-11: A-overview of the KAT-7 dish-antennas platforms clear zone and B- platform marked with large stones (Photos: A- Prof Claude Carignan and B-Sarel van Staden)

The proposed design for the dish-antenna foundation is an cast in-situ concrete pile cap with reinforced concrete piles and is being developed to cater for a variety of geotechnical conditions, evaluated as being appropriate for preliminary design of piling within the study area. The MeerKAT antenna foundation design consisted of eight 750 millimetre diameter piles with a 5.2 metre x 5.2 metres x 1.25 metre pile cap. The only significant change expected for the SKA1_MID antenna foundation design will be the depth of the piles used. The infrastructure and power element construction of the foundation will involve:

- Antenna foundations (for a total of 133 additional dish-type antennas) – 8 x 900 millimetre diameter piles per foundation, drilled up to approximately 10.5 metres or refusal;
- a 7 metre diameter, 1.5 metre deep pile cap with 40 millimetre diameter hold-down bolts fixed to a steel ring in the foundation;
- a 110 millimetre diameter Kabelflex sleeve to house the 2 x 40 millimetre diameter fibre optic sleeves, cast into the pile cap, extending 30m from the centre of the foundation to the battery position, at the platform edge;
- a 110 millimetre diameter Kabelflex sleeve to house the electrical supply cable, cast into the pile cap, extending 30 metres from the centre of the foundation to the battery position, at the platform edge; and
- Earthing and lightning protection system.

The specified materials, with the exception of steel reinforcement, plastic sleeves and shutters, will be sourced from borrow pits or quarries on the development site or from any of the four surrounding towns. In the case where a stone quarry cannot be established, the aggregate for the concrete will be sourced from a commercial source. The activities of material extraction from borrow pits and quarries are discussed in section 11 below.

DRAFT



Photo 1: MeerKAT antenna foundation piles



Photo 2: Earthing and lightning protection scheme



Photo 3: Pile cap reinforcement



Photo 4: Pile cap reinforcement incorporating bolt assembly cage



Photo 5: Completed MeerKAT foundation after stripping of formwork



Photo 6: MeerKAT antenna on a foundation

Figure 2-12: MeerKAT foundation construction activities (Photos: SKA South Africa)

2. Electrical and fibre-optic reticulation network

The electrical reticulation to the SKA dish-antennas in the field will be facilitated via a combination of medium voltage and low voltage, underground and overhead power lines with a capacity of 22 kilovolt or less. An overview of the proposed power reticulation as of November 2016 is illustrated in Figure 2-17, with a detail of the core in Figure 2-18. The electrical reticulation is designed to prevent and minimise potential radio-frequency interference from the electrical infrastructure. As part of the Project Scope for SKA1_MID, the development of infrastructure with a physical footprint of 100 square metres or more occurring within 32 metres from the edge of a watercourse (e.g. drainage line) is a listed activity in terms of Section 24 of the NEMA. The 33 kilovolt incoming supply will be stepped down and conditioned at the power facility on the Losberg site complex before being distributed to the core area and spiral arms. The final detailed design of the core and spiral arms electrical and fibre-optic reticulation network will be available in May 2017.

Underground (trenched) powerlines and fibre-optic cables

All cables within 5 kilometres of the highest density of dish-antennas in the SKA telescope core will be installed underground in trenches and installed in compliance with the South African National Standards (SANS) 10198¹² and 10142¹³. Where possible, the additional loads will be added to the underground cabling reticulation trenched for MeerKAT. All cables within 2 kilometres of the dish-antennas in the spiral arms will also be installed in trenches. New trenching activities required for the provision of power to the dish-antennas in the core area include 1 metre trenches for approximately 8 kilometres of additional medium voltage underground cabling; and 0.7 metre trenches for approximately 22 kilometres of additional low voltage underground cabling. All underground medium voltage cables will be trenched at a depth of at least 800 millimetres as illustrated in Figure 2-13. Cable markers will be installed along all underground routes, at all changes in direction, at the beginning and ends of cable runs and above all joints and at intervals not exceeding 50 metres. The low voltage underground electrical reticulation will be trenched at a depth of at least 500 mm (Figure 2-14). The low voltage underground cable installation will include the reticulation from the miniature substations to the distribution kiosk and then from the distribution kiosks to the dish-antennas. The design of the low voltage electrical reticulation network will prevent unnecessary encroachment on other services such as roads, communication networks and other underground infrastructure. Cable markers will be installed along all underground routes, at all changes in direction, at the beginning and ends of cable runs and above all joints and at intervals not exceeding 50 metres.

In order to limit costs and environmental damage through excessive trenching, the fibre optic cable will be located within the same servitude as the power cables where possible. An overview of the proposed fibre-optic reticulation as of November 2016 is illustrated in Figure 2-19, with a detail of the core in Figure 2-20. The core fibre optic reticulation will utilise a 'multi-way' sub-duct system to provide flexibility and reduce the requirement for standard-width traditional fibre optic trenches, utilising power trenches wherever these are appropriate. The fibre optic cables are manufactured in compliance with International Telecommunication Union (ITU) standards whereby consideration is given to distance, bandwidth, patch leads, splicing and future proofing requirements of the cable. These fibre cables are single cables spliced to fibres in a single tube of the backhaul cable.

¹² SANS 10198: The selection, handling and installation of electric power cables of rating not exceeding 33 kilovolts

¹³ SANS 10142: Wiring of premises

There will only be one joint (fibre splicing) location in the field to reduce the numbers of splices. It is planned to use two different fibre optic cables:

- G552D low loss single mode fibre optic will be used in SKA1_MID core and spiral arms; and
- G657 single mode fibre will be used to access the Karoo Array Processor Building to provide flexibility for access to the radio-frequency interference shielded room.

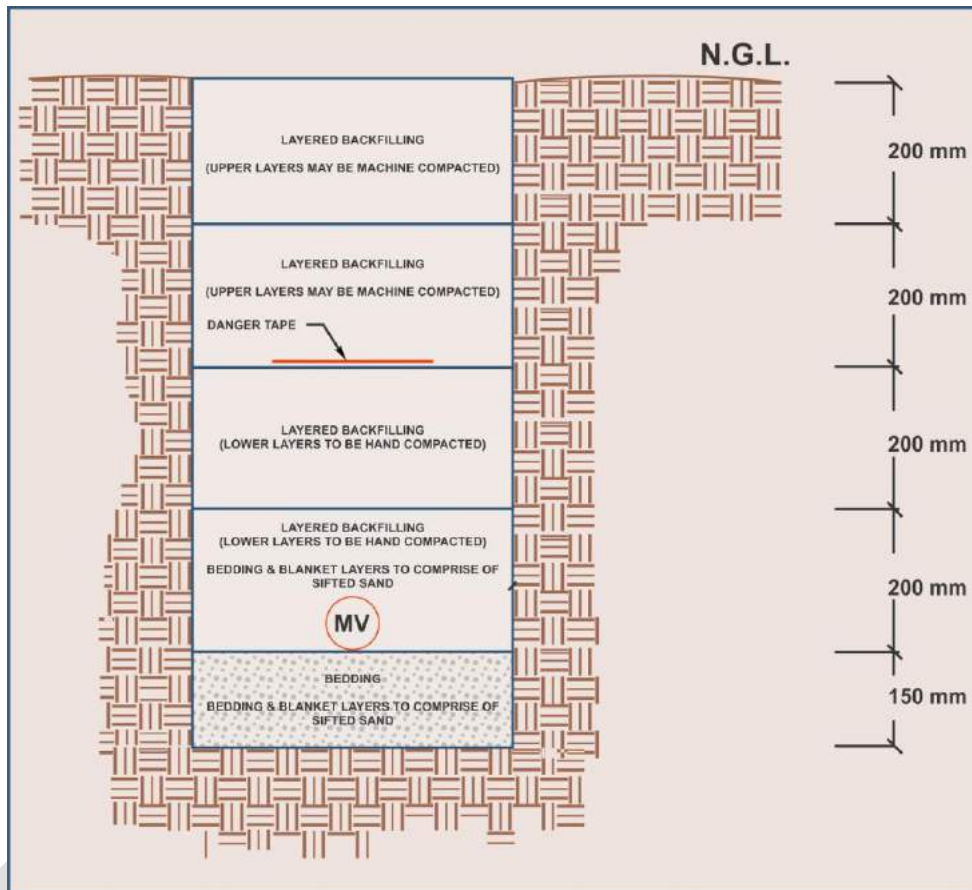


Figure 2-13: Typical section through medium voltage cable trench (Source: SKA SA).

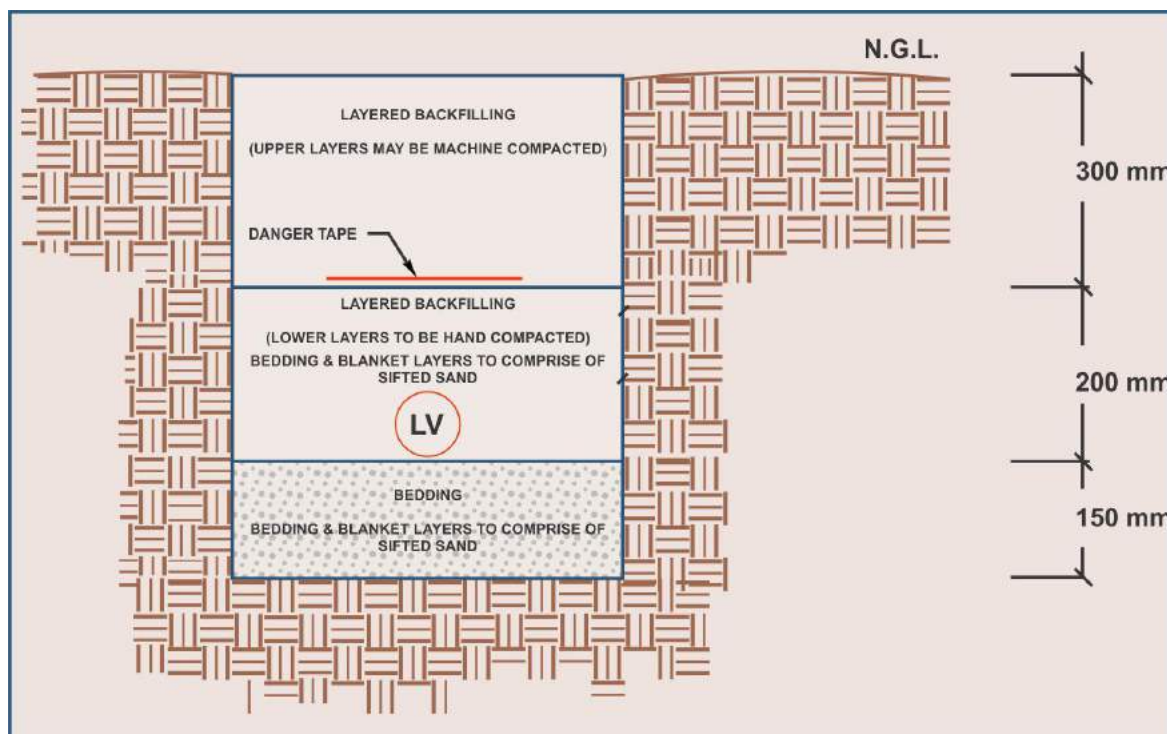


Figure 2-14: Typical section through low voltage cable trench (Source: SKA SA).

The cables connecting the visual monitoring equipment required for SKA1_MID will also be placed in the common trench with the power cables and fibre optic cables. A one metre diameter 'Rocla-type' concrete manhole will be located adjacent to each dish-antenna to provide an interface with the backhaul cable route. These manholes provide the useful function of terminating the backhaul cable route, as well as provide the interface to the dish antenna foundation to accommodate installation schedule disparities between the signal and data transport roll-out and the SKA infrastructure. Power will be provided to the site monitoring equipment i.e. weather stations, visual monitoring, radio frequency monitoring stations and mobile radio repeater stations via three phase 400 volt distribution kiosks strategically placed within the study area. These distribution kiosks will be fed directly via the various miniature substations and ground mounted transformers.

Overhead powerlines and fibre-optic cables

In the SKA telescope core, all cables located between 5 kilometres and 30 kilometres from the highest density of dish-antennas will be overhead 22 kilovolt lines suspended on steel monopole structures (Figure 2-15). The steel structures reduce sparking related noise and allow for minimal special maintenance. All cables located further than 30 kilometres from the highest density of dish-antennas in the SKA telescope core will be overhead 22 kilovolt lines suspended on wood pole structures (Figure 2-16). In the spiral arms, the electrical reticulation will be overhead except within 2 kilometres of any dish-antennas where underground cables must be installed. The 22 kilovolt steel monopole overhead line will also comprise two main structure types:

- intermediate structures which consist of a single steel pole with three stand-off insulators used to support the phase conductors; and
- strain structure which consist of a guyed steel monopole onto which the strain assemblies are attached (Figure 2-15). Strain structures will make use of silicone composite long rod

insulators. These insulators will be connected to the phase conductors via a thimble clevis and guy-grip dead end. Intermediate structures will make use of silicone composite stand-off post insulators. The line post insulators will be supplied with trunion clamps to connect the phase conductors to the post insulator. Armour rods will be installed where the trunion clamp attaches to the conductor to protect the conductor against bending, compression and abrasion.

The 22 kilovolt wood pole overhead line will comprise two main structure types:

- intermediate structures which consist of a T-frame (Figure 2-16) comprising a single woodpole with a 2 metre steel crossarm; and
- strain structures which consist of a guyed H-pole structure with a steel crossarm. Strain structures will make use of silicone composite long rod insulators. These insulators will be connected to the phase conductors via a thimble clevis and guy-grip dead end. Intermediate structures will make use of a single 22 kilovolt post insulator mounted on the top of the single wood pole for the centre phase conductor, while two suspension insulators will be installed on the steel crossarm for the two outer phases. Both insulator types will be silicone composite.

The design of both overhead line technologies will comply with the latest version of SANS 10280-1 which highlights the relevant legal requirements with regards to the design and construction of overhead lines in South Africa.



Figure 2-15: Steel monopole strain structure showing silicone rubber composite longrod insulator.

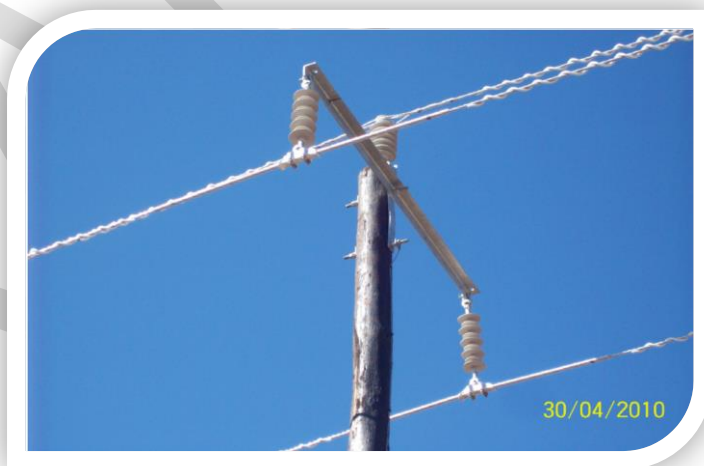


Figure 2-16: Woodpole T-frame intermediate structure showing post type and suspension type insulators.

Associated grid network infrastructure

There are currently twenty-one 315 000 volt amp miniature substations in use for MeerKAT (type B miniature substations, approximately 9.93 cubic metres or 3.08 metres x 1.61 metres x 2 metres). Five of these will be upgraded to 500 000 volt amp units and the remaining 16 will be re-used. In addition 14 new miniature substations will be added to cater for the additional dish-antennas in the SKA telescope core. From the mini substations a number of distribution kiosks will be connected. The number of distribution kiosks supplied by each mini substation varies depending on the density of dish-antennas around the kiosk – each mini substation will be approximately 0.44 cubic metres or 1.92 metres x 0.57 metres x 0.4 metres. As part of radio-frequency interference mitigation measures, no digital electronic devices will be installed in any of the miniature substations. The majority of the existing low voltage distribution kiosks in the core area will be equipped with additional low voltage miniature circuit breakers to facilitate supply to the additional dishes in the core area. The existing low voltage distribution kiosks only have sufficient spare capacity to supply up to six dishes. The positioning of all new kiosks will take into account the proximity of the dish-antennas to be supplied in order to reduce the length of low voltage cable runs as well as any nearby access roads or other services which could interfere with the satisfactory operation of the distribution kiosk. Each dish-antenna in the spiral arms will have its own mini transformer and distribution kiosk that will step down the power supplied by the 22 kilovolt line to 400 volts and supply power to the dish-antenna. The layout of the distribution equipment for each dish-antenna in the spiral arms is illustrated in Figure 2-21. In accordance with the radio-frequency interference mitigation measures, no digital electronic devices will be installed in the miniature substations.

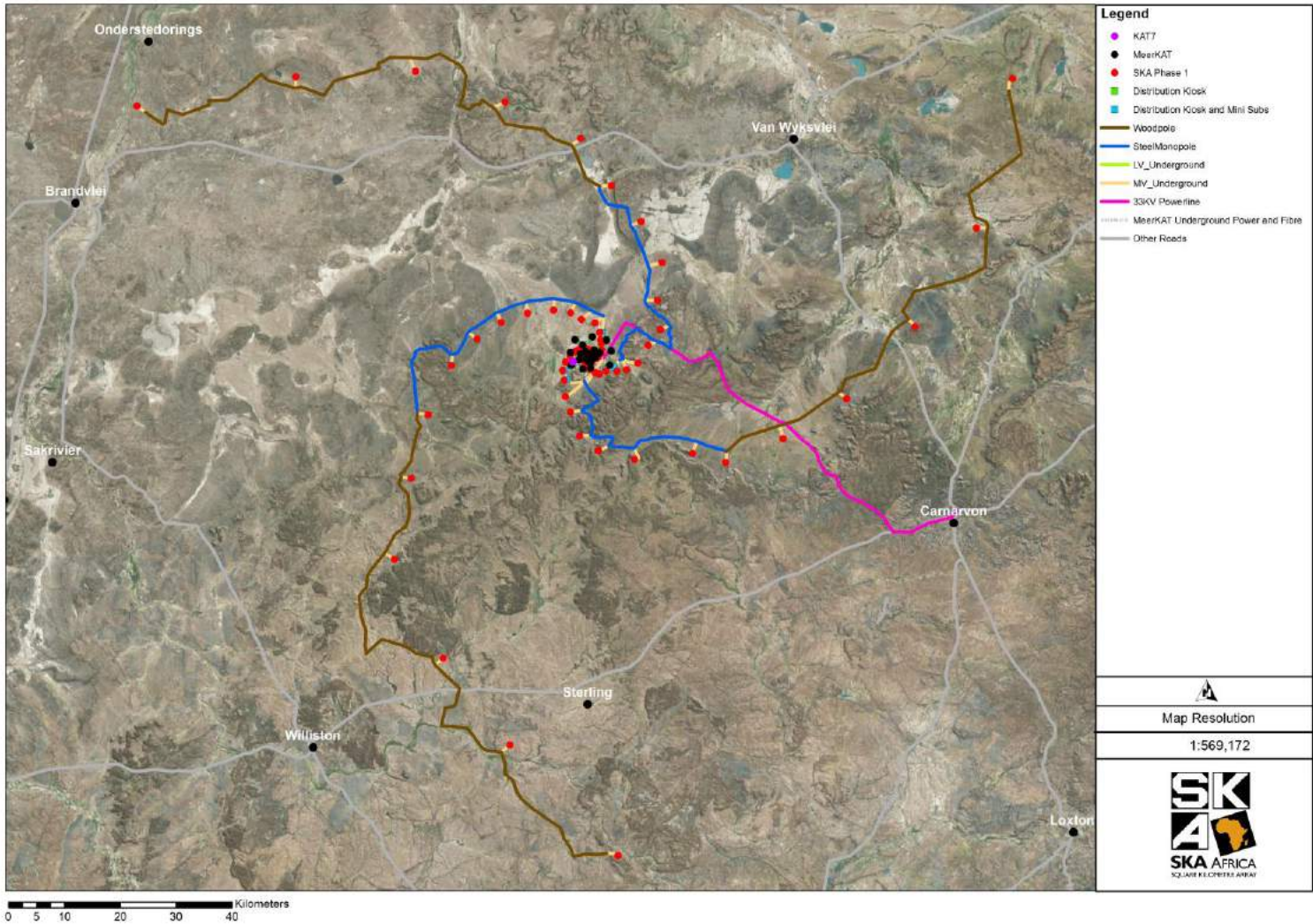


Figure 2-17: Overview of the proposed power reticulation as of November 2016

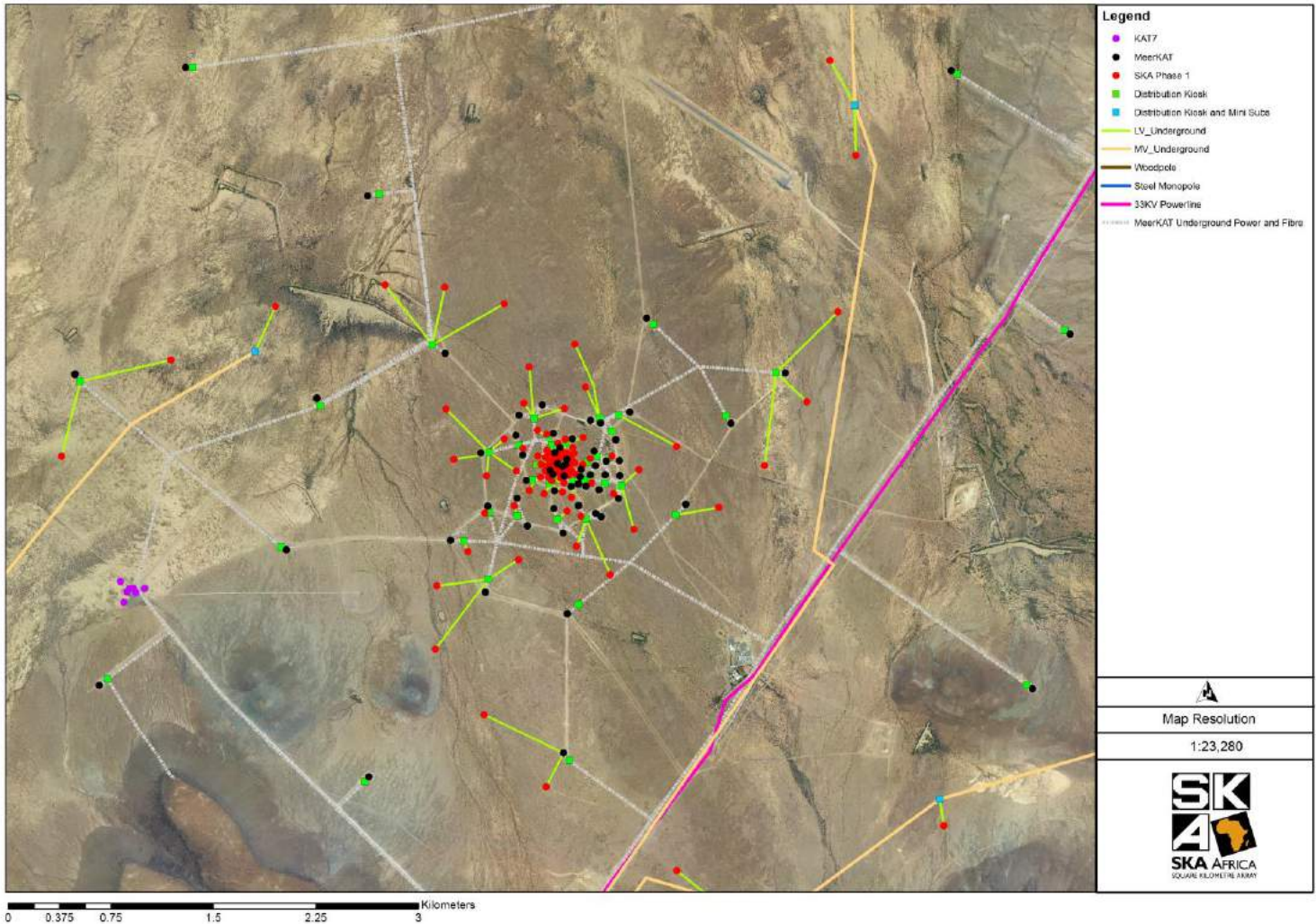


Figure 2-18: Proposed power reticulation in the SKA telescope core as of November 2016

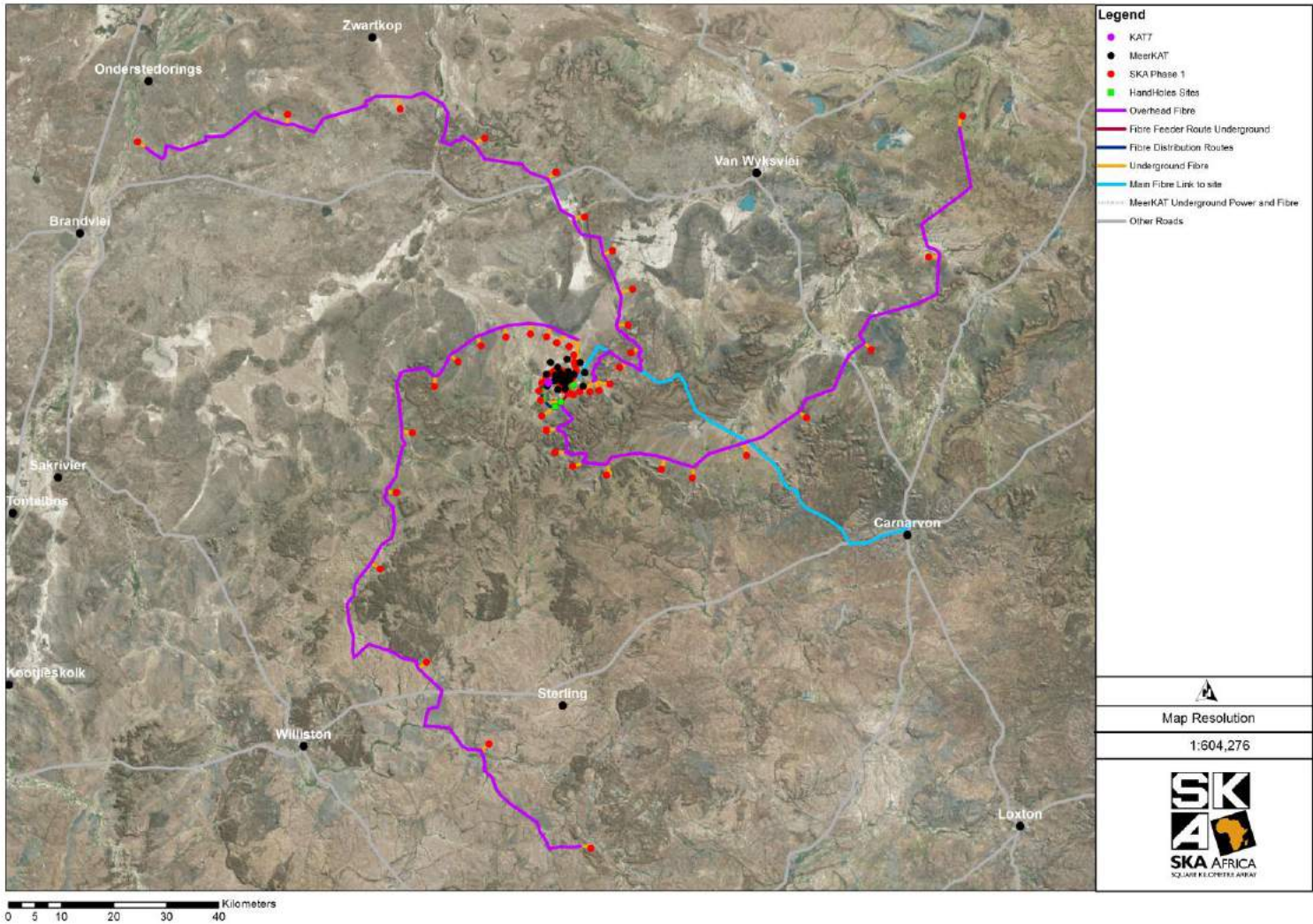


Figure 2-19: Overview of the proposed fibre-optic reticulation as of November 2016

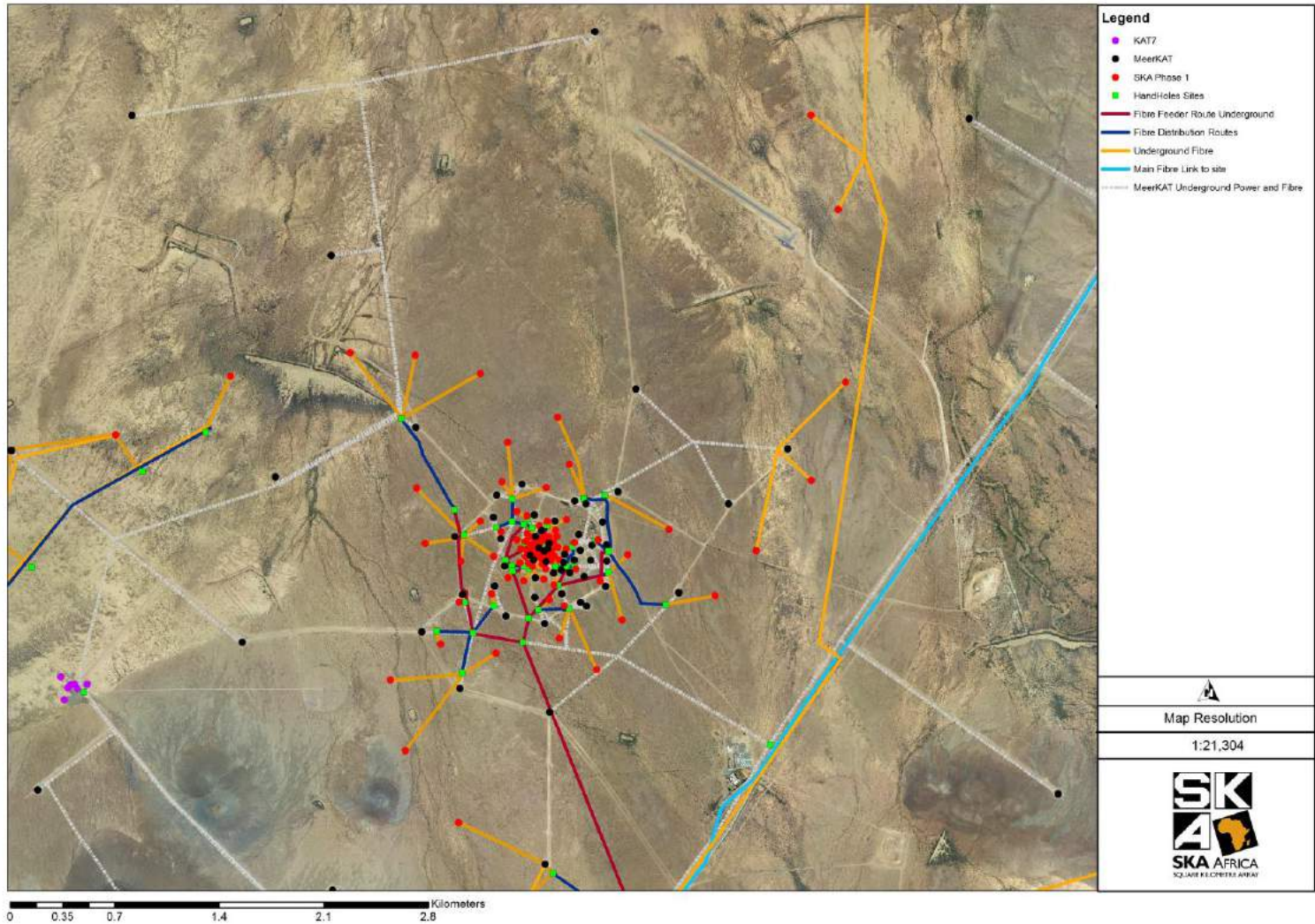


Figure 2-20: Proposed fibre-optic reticulation in the SKA telescope core as of November 2016

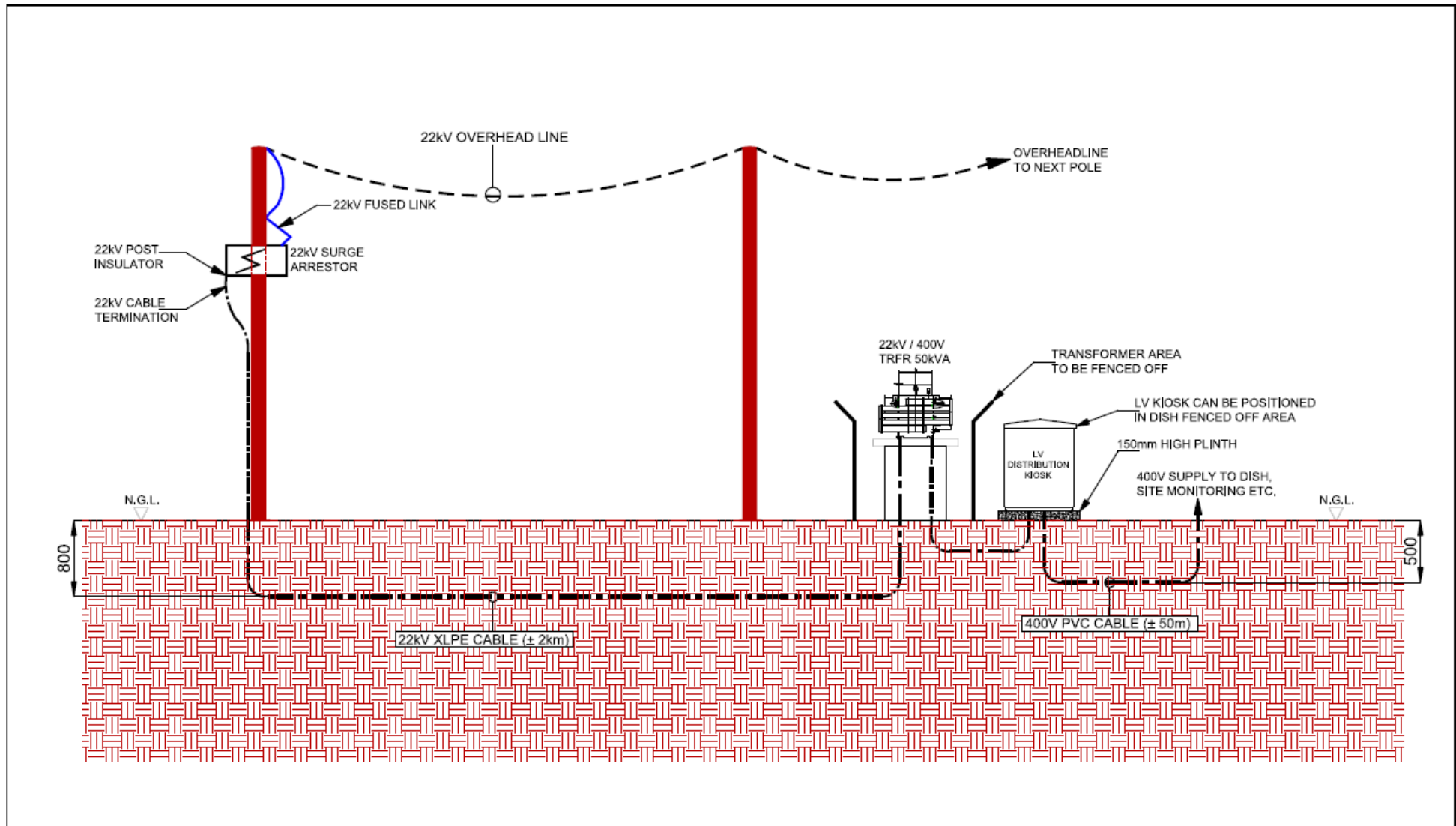


Figure 2-21: Layout of the distribution equipment for each dish-antenna in the spiral arms (Source: SKA SA).

Alternative electricity generation and distribution in the spiral arms

The National Research Foundation is investigating the possibility of generating electricity at the extremity of the three spiral arms with small solar photovoltaic plants with a generation capacity of less than 1 megawatt. The photovoltaic panel would be an array of Copper Indium Selenium or polycrystalline solar cells mounted in an aluminum frame. A diesel hybrid solution is also under consideration. The configuration considered is a free-standing power plant with PV modules oriented towards the north and fixed-mounted at an optimum angle. Inclination of the modules is optimized to harvest maximum energy over the year i.e. to maximize annual energy yield. For the study area the optimum angle is 29° based on optimal row spacing¹⁴ to avoid losses by inter-row shading.

The SolarGIS® data and software were used to obtain the mean annual Global Horizontal Irradiation for the study area. The model calculates the annual average over the climate period from 1994 to 2013 (20 years). Solar radiation is calculated by numerical models, which are parameterized by a set of inputs characterizing the cloud transmittance, state of the atmosphere and terrain conditions. The mean annual Global Horizontal Irradiation (total amount of shortwave radiation received from the sun by a surface horizontal to the ground) in South Africa ranges from 1550 to 2300 kilowatt-hour per square metre per annum with the highest measured solar irradiation in the Northern Cape, North West Province and the Free State. In the SEA study area, the Global Horizontal Irradiation level is very high with a mean annual value ranging from 1990 to 2 230 kilowatt-hour per square metre (Figure 2-22). The photovoltaic power production has been calculated using numerical models implemented by GeoModel Solar¹⁵. The electricity production for an open-space photovoltaic system, assuming crystalline silicon panels inclined to the north at the optimum angle, is estimated to be 1920-2005 kWh (electrical) per kWpeak (installed) per annum (Figure 2-23).

Depending on the final detailed design of SKA1_MID, which will be available in October 2017, the the SKA Organisation will decide whether it is necessary to build 9 or 15 small solar photovoltaic plants in the three spiral arms. These small-scale photovoltaic plants will have a generating capacity of less than 1 megawatt each with a footprint per station of less than 1 hectare in extent and will be used to feed electricity to the dish-antennas in the three spiral arms that are located far from the SKA telescope core. As part of the project scope for SKA1_MID, the construction of the small-scale solar photovoltaic plants represents a phased development, i.e. an activity that is developed in phases over time on the same or adjacent properties to create a single or linked entity¹⁶; and the development of these small scale facilities for the generation of electricity from a renewable resource where the combined electricity output may exceed 10 megawatts (in the case of 15 small scale solar photovoltaic plants being built) with a combined extent of more than 1 hectare is a listed activity in terms of Section 24 of the NEMA¹⁷.

In the case that the SKA organisation decides to build nine small-scale solar photovoltaic plants in total, there will be three small-scale solar photovoltaic plants located at the last dish-antenna on each of the three spiral arms as illustrated in Figure 2-24, to supply electricity to these dish-antennas for their operation. In the case that the National Research Foundation decides to build fifteen small-scale solar photovoltaic plants in total, there will be five small-scale solar photovoltaic plants located at the last five dish-antennas on each spiral arms as illustrated in Figure 2-25, and supplying electricity to these dish-antennas for their operation.

¹⁴ row spacing leads to electricity losses due short-distance shading, these losses can be avoided by optimising distances between rows of module tables

¹⁵ 15-minute time series of solar radiation and air temperature data, representing last 19 years, are used as inputs to the simulation of PV power production.

¹⁶ Government Notice 982 dated 4 December 2014

¹⁷ Government Notice 983 dated 4 December 2014

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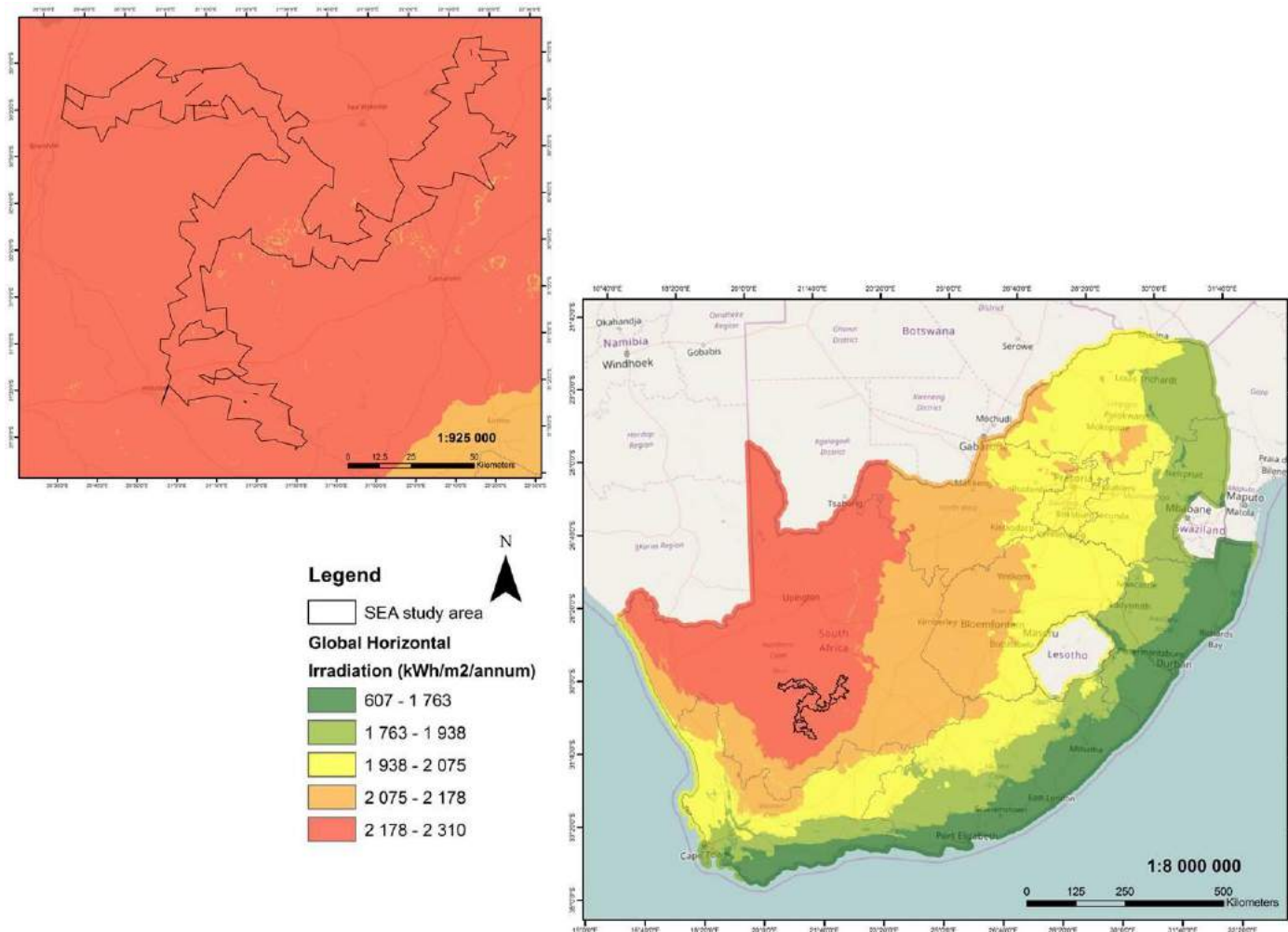


Figure 2-22: Global Horizontal Irradiance for South Africa and for the Strategic Environmental Assessment's study area in units of kWh/m²/annum. Resolution 250m x 250m. Source: SolarGIS map © 2013 GeoModel Solar.

Integrated Environmental Management Plan 2018-2023

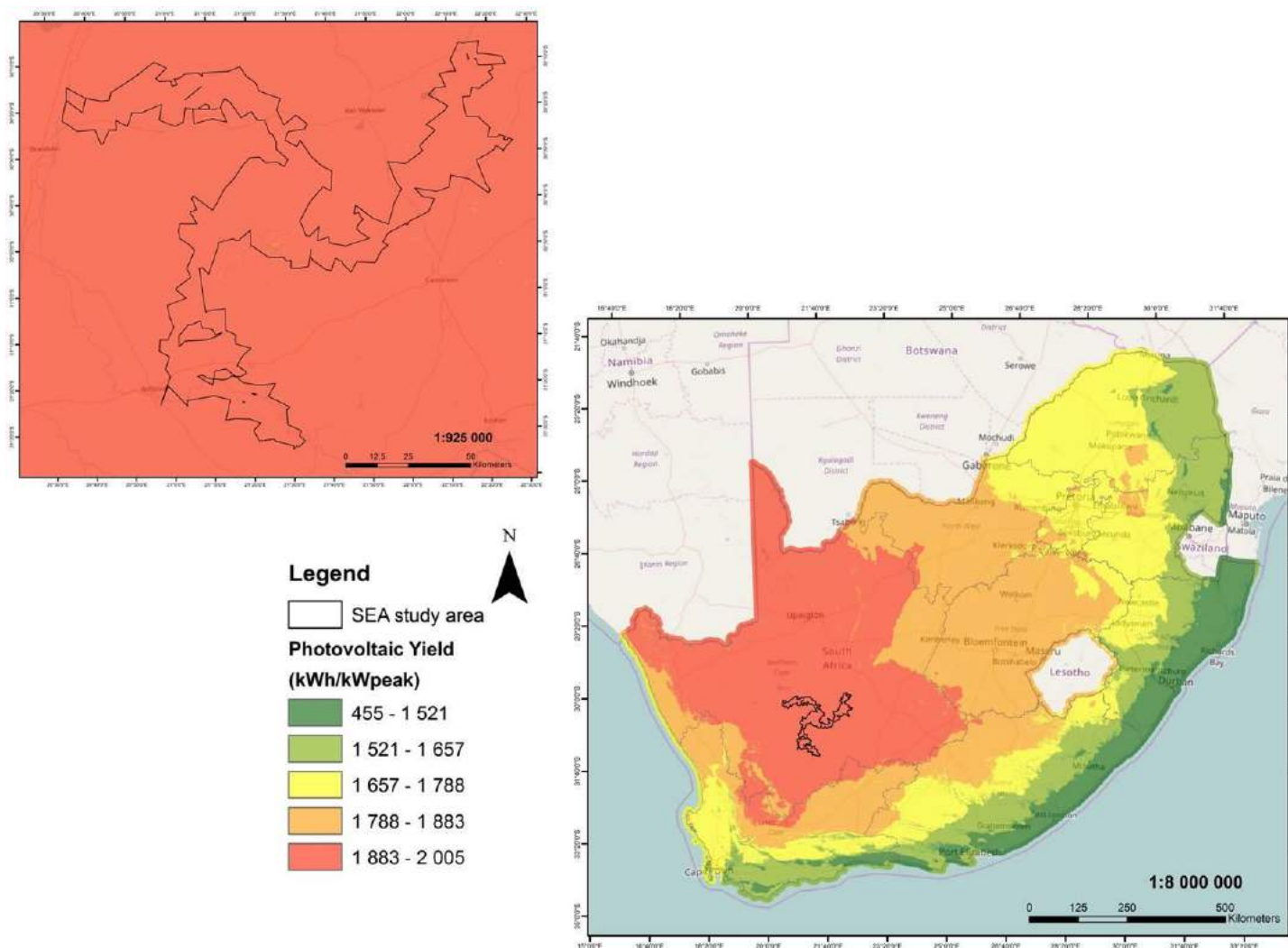


Figure 2-23: Photovoltaic Yield of a typical Crystalline Silicon panel on a fixed tilt optimally inclined plane for South Africa and for the Strategic Environmental Assessment's study area in units of kWh (electrical)/kWpeak(installed)/annum. Resolution 250m x 250m. Source: SolarGIS map © 2013 GeoModel Solar.

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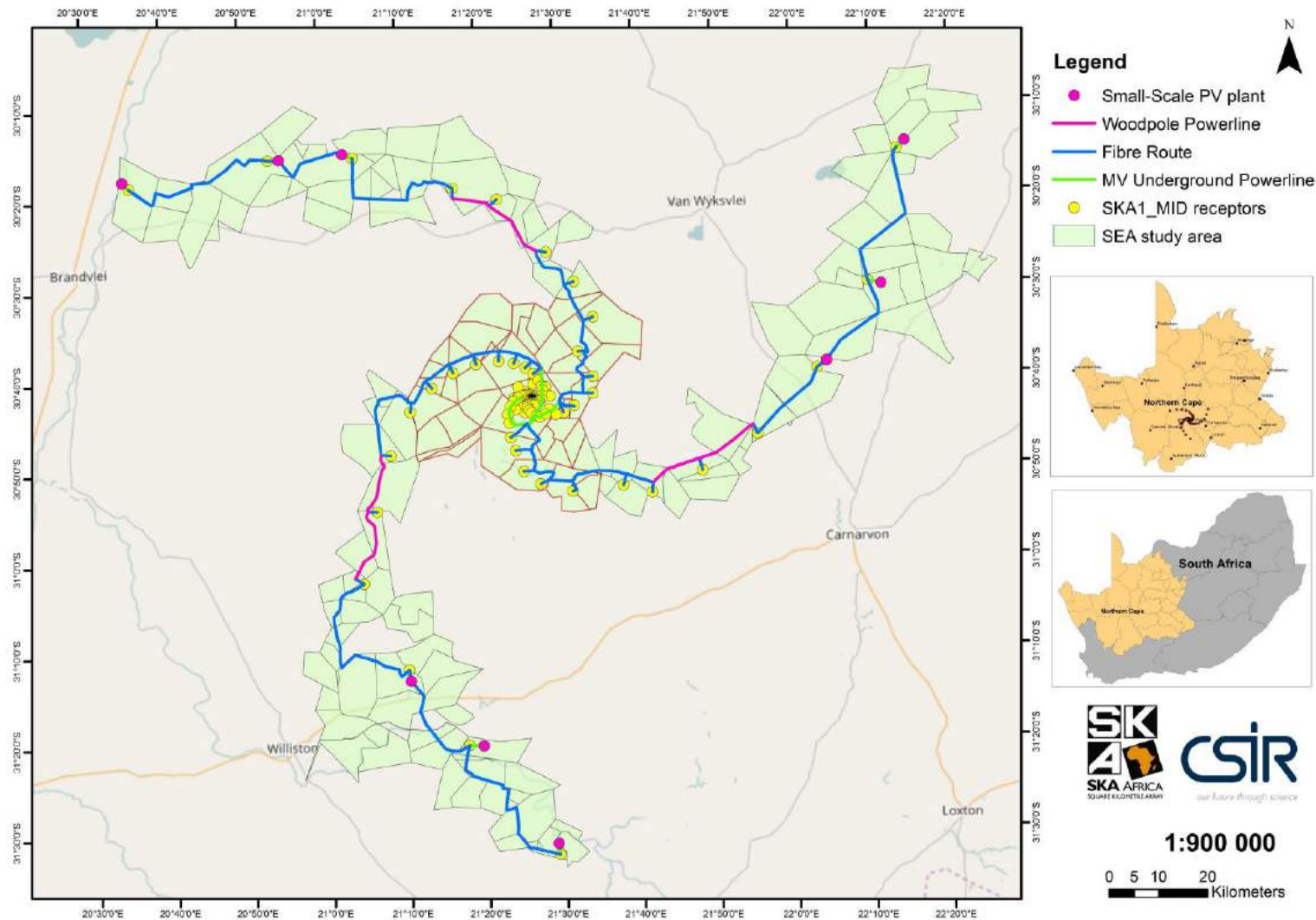


Figure 2-24: Three small-scale solar photovoltaic plants located at the last three dish-antennas on each spiral arms based on the SKA1_MID layout as of September 2016

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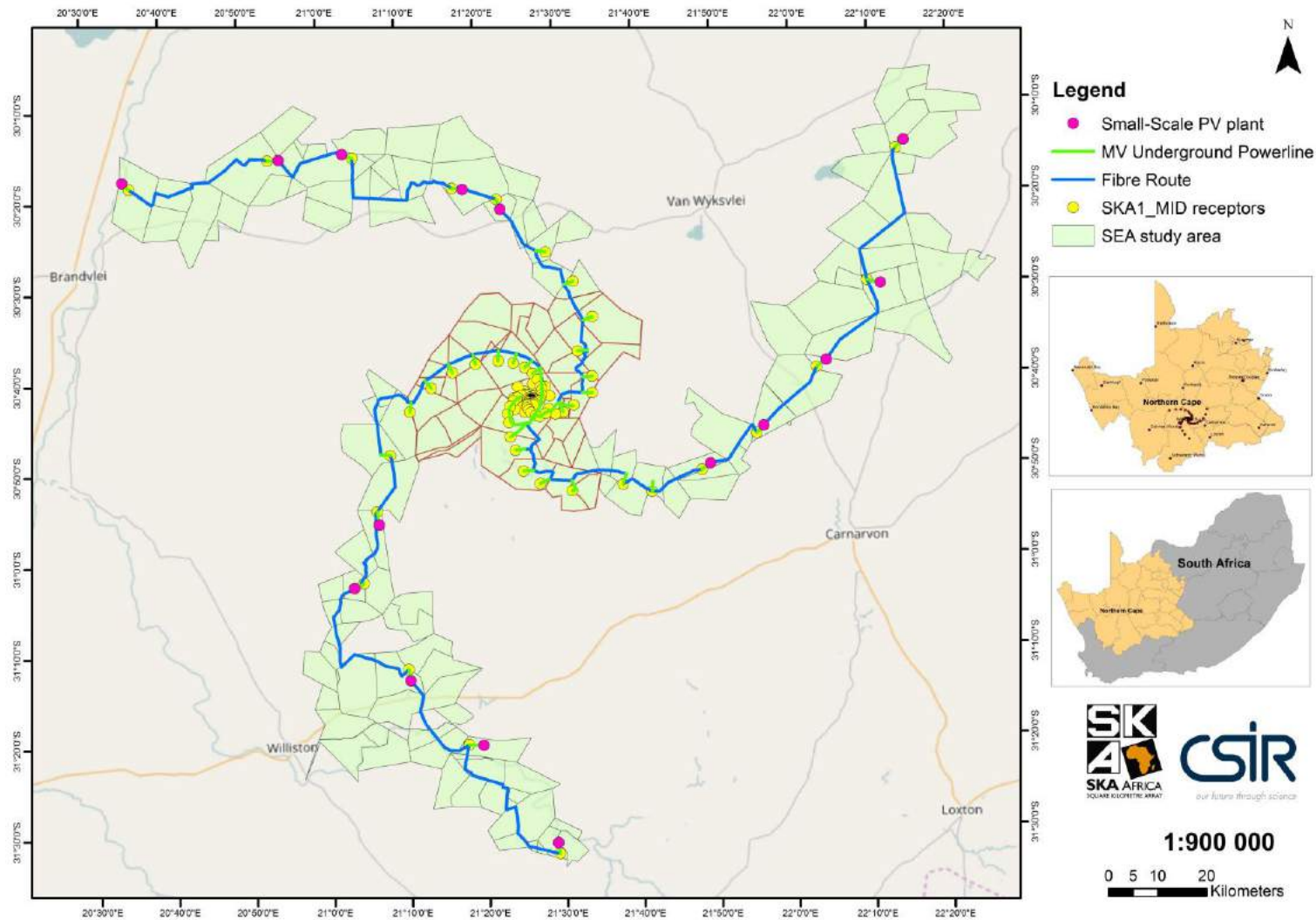


Figure 2-25: Five small-scale solar photovoltaic plants located at the last three dish-antennas on each spiral arms based on the SKA1_MID layout as of September 2016

3. Construction camps

Two new construction camps will be established for SKA1_MID. These construction camps are currently planned to be located on Swartfontein (30°41'2.67"S; 21°33'31.40"E) and Bergsig (30°39'59.78"S; 21°31'47.38"E) farms both within a distance of 15 kilometres from the SKA telescope core. The construction camp site must be cleared, levelled and surfaced with a lightly compacted gravel wearing course. The footprint of the construction camps' facilities on the Swartfontein and Bergsig farms include buildings and water and sanitation infrastructure. One earth dam (evaporation dam) and one waste water treatment plant will be built on each of the construction camps. The overall footprint of the proposed Bergsig construction camps is approximately 4 hectares and the proposed Swartfontein construction camps is approximately 1.5 hectares. The Swartfontein and Bergsig construction camps are illustrated in Figure 2-28 and Figure 2-29 below. The two farms were chosen based on the following:

- both farms have been identified for purchase as part of the SKA land acquisition programme;
- both farms are located next to the access road to site (provincial road "P02996"), which will be upgraded by March 2017;
- the proposed camps are located at least 10 kilometres from the SKA telescope core; and
- they are both located next to the 33 kilovolt powerline to site.

The Losberg, Bergsig and Swartfontein camps combined will accommodate 740 people during the peak period of construction. This number is based on the estimated 540 people for the infrastructure and power elements and an additional 200 people for the other telescope elements. All construction camps will be surrounded by perimeter fencing.

Power for the Swartfontein and Bergsig construction camps will be supplied in a manner similar to that for the Klerefontein Support Base whereby a mini substation steps down the power load to 400 volts to provide power for the base. The power supply to the camps will be tapped off from the existing 33 kilovolt power line to a mini-substation and thereafter to distribution kiosks within the camps. From the mini substation located at each camp one or two distribution kiosks will be connected.—An allowance will be made for new diesel generators for provision of power to the water and sanitation pumps in the event of a mains failure. The fibre optic connection will tap off from the existing fibre optic cable that is strung on the 33 kilovolt power line. Contractors will connect at locations to be identified for distribution within the camps.

The Swartfontein and Bergsig construction camps will have the following infrastructure:

- Bulk services, including water supply, sanitation, power supply , and fibre optic connection;
- Stormwater management systems;
- Workshop and waste management facilities
- Perimeter fencing and access gates; and
- A cleared site with a lightly compacted gravel wearing course.

The expansion works at the existing Losberg construction camp include a new accommodation area and water and sanitation infrastructure upgrades. The existing power supply (including back-up power) at the Losberg construction camp will be re-used during the SKA1_MID construction phase. The electrical infrastructure for the Losberg construction camp will be expanded by installing three additional low voltage kiosks at strategic locations around the camp to provide power to staff quarters. The contractor's electrician will be responsible for facilitating supply from these low voltage distribution kiosks to the relevant park homes etc. The expansion of the accommodation area at Losberg construction camp is illustrated on Figure 2-26.



Figure 2-26: New accommodation area at the Losberg construction camp

The expansion and upgrade of the water and sanitation infrastructure planned for the Losberg construction camp are illustrated in Figure 2-27 and includes:

- Two additional evaporation dams for collection of treated effluent water and washing bay water with a surface area of 1000 square metres;
- Two additional wastewater treatment plants with a capacity of 17.5 kilolitres per day;
- One chlorination room and a reverse osmosis plant with a minimum treatment capacity of 7 kilolitres per day; and
- One chlorination room and a reverse osmosis plant with a minimum treatment capacity of 10 kilolitres per day.

During the construction phase, portable toilets will also be provided along the spiral arms, and moved as the works progresses, the number and position of these toilets is yet to be decided upon. The contractors will be responsible for providing all sanitary arrangements for his staff and any sub-contractors team; as well as for keeping the toilets in a clean, neat and hygienic condition. The contractors must service the chemical portable toilets regularly and dispose of the waste generated by the toilets appropriately. A minimum of one chemical portable toilet must be provided per 10 persons and must be easily accessible (ideally within 50 metres from the construction working area).

Further details on water supply and on wastewater and waste management for all three construction camps are given in Section V of this Chapter: "Proposed water use and waste management".

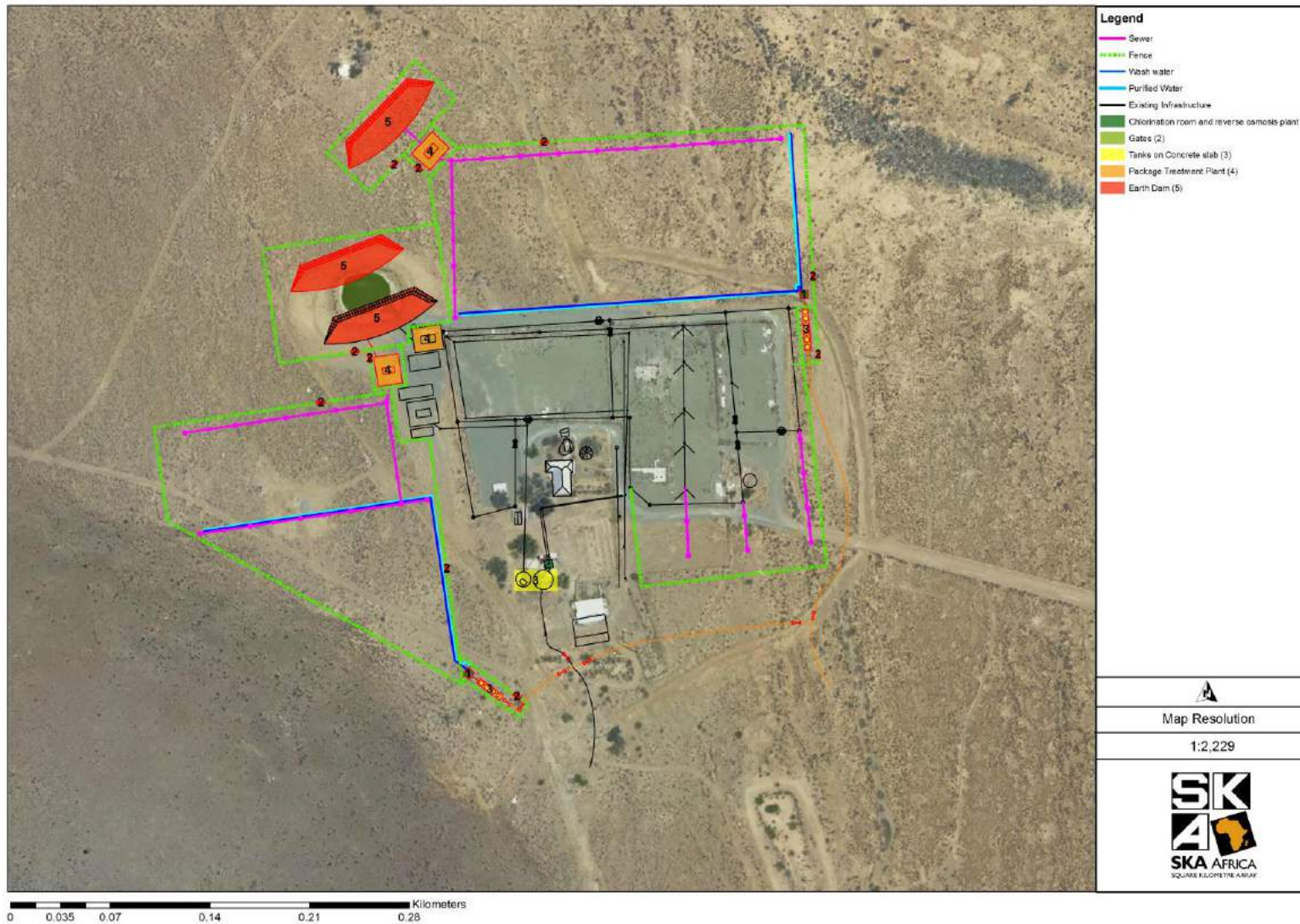


Figure 2-27: Water and sanitation infrastructure expansion works at the Losberg construction camp

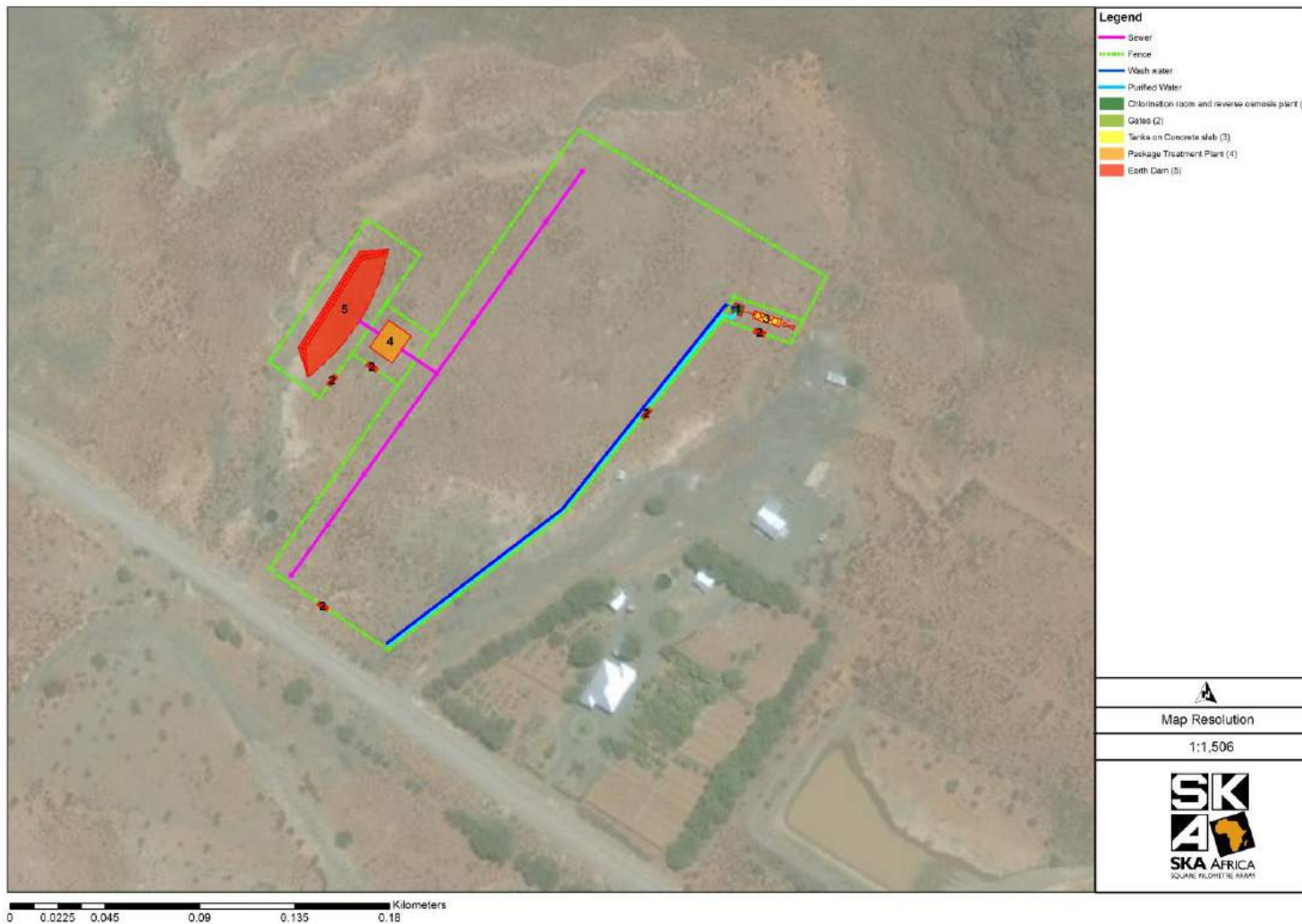


Figure 2-28: Construction works planned for the Bergsig construction camp

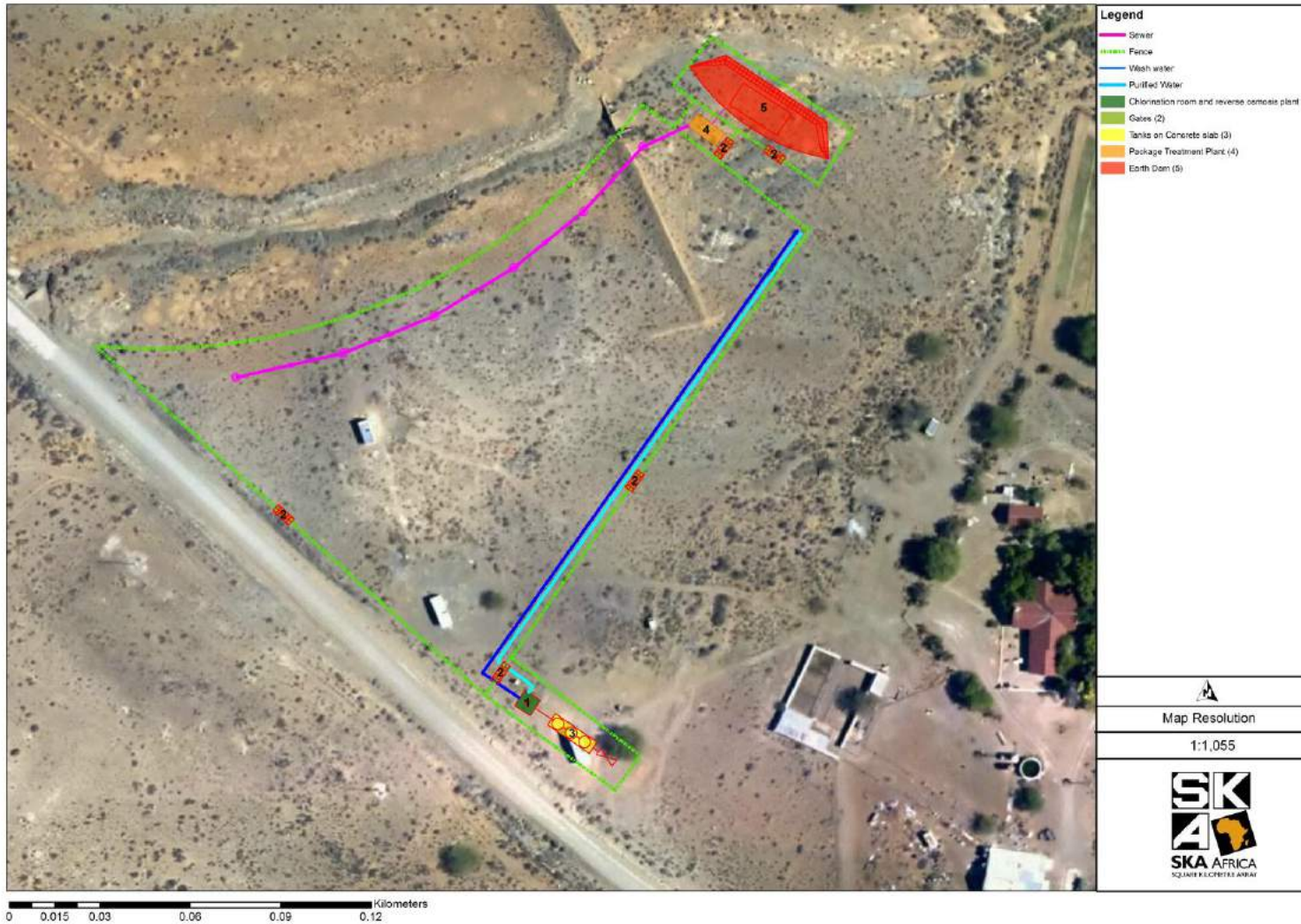


Figure 2-29: Construction works planned for the Swartfontein construction camp

4. Additional diesel storage at Losberg site complex

An additional five diesel fuel tanks of a capacity of 23 cubic metres each will be installed at the Losberg site complex next to the existing three diesel tanks to cater for the new DRUPS units and other diesel requirements. As part of the Project Scope for SKA1_MID, the development of facilities or infrastructure for the storage, or storage and handling of diesel where such storage occurs in containers with a combined capacity of 80 cubic metres or more but not exceeding 500 cubic metres is a listed activity in terms of Section 24 of the NEMA¹⁸. The total of 8 diesel tanks (i.e. the existing 3 diesel tanks plus these additional 5 diesel tanks) with a combined total a capacity of 184 cubic metres will provide sufficient diesel capacity to allow all four DRUPS units to run at full load for up to 133 hours.

In terms of the Section 2 of the Major Hazard Installation (MHI) Regulations Government Notice 692 of 2001, a development is classified as a Major Hazard Installation if the health and safety of both workers and the public is affected. A screening risk assessment was conducted by RISCO (Pty) Ltd to assess the potential risks associated with the storage and handling of diesel (classified as hazardous substances) in the the SKA telescope core.

The main aim of the investigation was to determine if the proposed SKA infrastructure would require a MHI risk assessment in accordance to the legislation. The study simulated potential blasts from the storage and concluded that:

- no material to be stored on site is listed as notifiable in terms of the General Machinery Regulation 8 and its Schedule A on notifiable substances;
- no jet fires were predicted from the simulations;
- no flash fires were predicted from the simulations;
- no explosions were predicted for the storage of diesel;
- no boiling liquid expanding vapour explosions were predicted from the simulations;
- the worst-case (maximum distance) 10 kilowatt per square metre thermal radiation isopleths, representing a 1% fatality, for diesel would not extend beyond the site boundary that could involve people in a major incident.

In the case of the planned storage and handling of diesel in the SKA telescope core, as the health of the public would not be affected, the scope of application of the Major Hazard Installation Regulations would not apply and the facility would not be considered a major hazardous installation.

5. Weather and radio-frequency interference monitoring stations

An additional weather station will be installed within the SKA telescope core and two additional weather stations per spiral arm. Each weather station will consist of sensors providing weather data including wind, temperature and humidity. The weather data will be sent to the Telescope Manager via the SKA Signal and Data Transport network. The weather stations located on each spiral arm will be within the fenced area of the SKA1_MID dish-antennas outer station. The construction requirements for the weather station will include:

- Masts – 10 metre high sectional pole masts;
- Mast foundations – 2000 cubic metres (2 metres x 2 metres x 500 metres);

¹⁸ Government Notice 983 dated 4 December 2014

- Earthing and lightning protection – 10 ohm spec;
- Power – 200 metres of 3 phase 400 volts power cabling (10 millimetres) from the closest kiosk to the weather station;
- Fibre optic cabling – 200 metres of fibre optic cabling, radio-frequency interference screened junction box and splice dome;
- Fibre ducting – 200 metres of 40 millimetre fibre ducting from the closest antenna to the wind sensor;
- Trenching – 200 metres of common trenching which houses the power cables and fibre optic cables; and approximately 1.6 kilometres of fibre optic cable between each weather station and the closest dish.

An additional tropospheric monitoring station including the antenna and associated equipment will be added to the existing Site Test Interferometer equipment currently located in the SKA telescope core. The construction requirements will include:

- Foundations – 500 cubic metres (1 metres x 1 metres x 500 metres);
- Connection boxes and fibre splice domes;
- Fibre ducting – 40 millimetres fibre optic duct (estimate 200 metres);
- Fibre cabling – 200 metre fibre optic cable;
- Trenching – 200 metres common trench which houses the power cable and fibre optic cable;
- Power - 3 phase, 4 wire, 400 volts, 200 metres from the closest kiosk; and
- Monitoring equipment

Two additional permanent radio frequency interference monitoring stations will be located at the KAT-7 Antenna Services Container. Supervision of the permanent radio frequency interference monitoring stations will be done by telescope operators from the Karoo Array Processor Building as well as from the Cape Town SKA office through the existing local area network. The construction requirements for the additional permanent radio frequency interference monitoring stations include:

- Mast – lattice mast, 10 metres in height;
- Mast foundation – 1280 cubic metres (1.6 metres x 1.6 metres x 500 metres);
- Earthing and lightning protection – 10 ohm spec;
- Fibre optic cabling – 100 metres of fibre optic cabling;
- Fibre sleeve – 100 metres of 40 millimetre fibre optic sleeve from current webcam position to radio-frequency interference monitor;
- Trenching – 100 metres of common trenching which houses the power cables and the fibre optic cables;
- Power – 100 metres of 3 phase 400 volt power cabling (10 millimetres) from the current MeerKAT webcam position to the radio-frequency interference monitor position; and
- radio frequency interference monitoring equipment.

Additional radio frequency interference monitoring will be undertaken using mobile radio frequency interference measuring equipment and the radio frequency interference data captured by mobile vehicles will be fed into the existing local area network.

6. Security infrastructure

Two additional guardhuts with boom gates will be established on the provincial access road to site. Visual monitoring equipment consisting of closed-circuit television (CCTV) cameras mounted on masts

will be installed to monitor the state of the dish-antennas in the core and the spiral arms. The following construction measures will need to take place to set-up the visual monitoring devices:

- 10 metre high section pole masts
- Mast foundations – 781.25 cubic metres (1.25 metres x 1.25 metres x 500 metres);
- Power – 200 metres of 3 phase 400 volt power cable (10 millimetres) from closest kiosk to the wind sensor;
- Earthing and lightning protection – 10 Ohm (Ω);
- Trenching – 200 metre common trench which will house the power cables and fibre optic cables;
- Fibre optic cabling – 200 metres Fibre optic cable, radio-frequency interference screened junction box and splice dome;
- Fibre optic ducting – 200 metres of 40 millimetres fibre ducting from the closest antenna to the wind sensor; and
- fibre optic cable between each camera and the closest dish.

7. Water use

A total of 24 boreholes on Meys'dam and Losberg farms are being utilised for the MeerKAT construction phase with varying depth from 15 metres to over 50 metres. The current boreholes potential yield is approximately 575 kilolitres per day. The peak water demand of MeerKAT construction phase is approximately 326,8 kilolitres per day which includes the water required at the site complex, the construction camps, the road and platform construction, the concrete work, the dust control and the road maintenance activities.

Two water use licences were issued to the National Research Foundation on 29/08/2012 for a period of 20 years for the Losberg Farm and the Mey' s Dam Farm respectively, in terms of Section 21(a) of the Act: "Taking water from a water resource as defined in the licence".

Licence No: 14/D54E/A/1911 granted the abstraction of 102 937 cubic metres of water per annum from groundwater resources (13 boreholes) on Losberg Farm:

- During construction phase: 5 576 cubic metres per annum for domestic use; 90 161 cubic metres per annum for construction of satellite dishes and dust suppression; and
- During operation phase: 1 306 cubic metres per annum for domestic use.

Licence No: 14/D54E/ACGI/1012 granted the abstraction of 15 865 cubic metres of water per annum from groundwater resources (7 boreholes) on Meys'dam Farm:

- During construction phase: 2960 cubic metres per annum for domestic use; 10 025 cubic metres per annum for construction purposes and dust suppression; and
- During operation phase: 871 cubic metres per annum for domestic use.

Licence No: 14/D54E/ACGI/1012 also granted:

- the crossing of unnamed drainage lines at 5 points on the Meys'dam property in terms of Section 21 (c): "Impeding or diverting the flow of water in a watercourse"; and
- the use of gravel and culverts to construct roads in terms of Section (i): "Altering the bed, banks, course and characteristics of a watercourse".

Further water uses granted by Licence No: 14/D54E/A/1911 and Licence No: 14/D54E/ACGI/1012 associated with the disposing of waste in terms of section 21 (g) of the Act are discussed in Section V-2 below.

The construction and operation of SKA infrastructure will result in:

- consumptive water uses i.e. additional water to be abstracted;
- wastewater to be treated and discharged; and
- non-consumptive water uses i.e. activities that could impede or divert flow, and alter the bed, banks, course or characteristics of a number of watercourses (e.g. road crossings).

Impacts on the integrity and function of water resources and the overall quality of the resource, specifically Section 21 (c) and (i) of the National Water Act (Act 36, 1998), must be authorised as a water use by the Department of Water and Sanitation (DWS) or competent authority (such as a Catchment Management Agency). As such the National Research Foundation must submit applications for water use licenses for SKA1_MID activities and infrastructures which may impact on the integrity and function of water resources as identified in this Chapter. The regulated area of a watercourse as per Section 21 (c) and/or (i) of the National Water Act means:

- a 500 metre radius from the delineated boundary (extent) of any wetland or pan;
- the outer edge of the 1 in 100 year flood line and/or delineated riparian habitat, whichever is the greatest distance, measured from the middle of the watercourse of a river, spring, natural channel, lake or dam; and
- in the absence of a determined 1 in 100 year flood line or riparian area, the area within 100 metres from the edge of a watercourse where the edge of the watercourse is the first identifiable annual bank fill flood bench (subject to compliance with section 144 of the Act).

The water supply at the Losberg, Bergsig and the Swartfontein camps will be pumped from the existing boreholes to storage tanks located within each of the three camps. All water extracted from boreholes and used for drinking and cooking at the construction camps will be chlorinated with an in-line chlorinator and a reverse osmosis system¹⁹ at all construction camps and at the site complex in order to reduce the possible effects of high fluorine levels and bacteria (coliform) in the water. The water supply for non-consumptive tasks such as washing construction vehicles will not be treated, and will be stored in the storage tanks and sourced by the contractors as and when required. Water will be stored in plastic water storage tanks at the three construction camps and booster pumps and pressure vessels (bladder tanks) will be incorporated with the storage tanks to provide sufficient pressure to the site. From the tanks, water will be treated for domestic purposes and thereafter reticulated around the camps in 110 millimetre diameter uPVC pipes. Backup power will be provided to the booster pump by portable diesel generators in case of a power failure. As part of the Project Scope for SKA1_MID, the development of reservoirs for bulk water supply at the three construction camps on Losberg, Swartfontein and Bergsig farms with a total capacity of more than 250 cubic metres is a listed activity in terms of Section 24 of the NEMA²⁰.

The estimated maximum daily water demand for the construction of the South African mid-frequency array of SKA1_MID and associated infrastructure are included in Table 2-1 below.

¹⁹ Flynn, DJ., 2009: *The Nalco water handbook [online]*. New York: McGraw-Hill. Available: <http://www.accessengineeringlibrary.com/html/viewbookdetails.asp?bookid=20018751>

²⁰ Government Notice 985 dated 4 December 2014

Table 2-1: Maximum daily Water Demand for the construction phase of SKA1_MID

Location/Activity	Maximum daily demand in kilolitres
SKA site complex	10
Meys'dam Farmhouse	3
Losberg Camp	65
Swartfontein Camp	20
Bergsig Camp	20
Road construction and road maintenance	120
Concrete Works	485
Construction Dust Control	100
Road Maintenance	120

8. Waste management

During construction, general waste will be generated as listed in Table 2-2 below including domestic waste (e.g. food and disposable items); uncontaminated building and demolition waste; office waste not containing hazardous waste; hazardous wastes; uncontaminated excavated earth / garden waste and sewage treatment (e.g. domestic sewage). The hazardous wastes to be disposed during the construction phase are associated with the use and maintenance of on-site vehicles and office equipment. All solid wastes should be stored in securely lidded bins in designated areas until disposed of at an appropriate Licenced landfill facility. The National Research Foundation is responsible for making the necessary arrangements with Licenced landfill facilities (e.g. Carnarvon waste disposal site) for solid waste disposal.

During the operation phase, limited domestic waste will be produced due to the limited number of people authorized to be on the site for research or maintenance activities. This domestic waste should be stored onsite in designated areas in securely lidded bins until disposed at Licenced landfill facilities. Organic waste will be appropriately composted on site. Due to the remote location of the project, waste management must be dealt with carefully to ensure that all waste (construction, domestic, effluent etc.) is disposed of appropriately. All efforts will be made to reduce the production of waste. Spillage and pollution will be managed and monitored according to the SKA waste operating procedure and no waste will be disposed of on-site.

Table 2-2: Waste stream identification and characterisation

Type	Description / Content
Domestic Waste	Paper and cardboard; and Non-hazardous, compatible canteen and tearoom waste, e.g. food, disposable cups, teabags, etc.
Non-hazardous Waste	General building rubble: Non-hazardous, non-compactable waste, e.g. wood, cardboard, plastic, cans, packing material, builder's rubble, etc.
Hazardous Wastes	Used oil and grease, oil-contaminated wastes (e.g. brooms, sawdust, sorbents), rags, degreasing or solvent containers, oil contaminated water, etc.; Fluorescent tubes; glass fibre and Batteries (Lead Cell, Nickel, Cadmium, etc.).
Sewage	Domestic sewage generated during the construction and operation phase.
Other waste	Garden waste

The National Research Foundation will at all times ensure pollution prevention, reduction of impacts resulting from waste management and water treatment, and responsible discharge or disposal of waste and/or wastewater.

As described in Section III-2, the Meys'dam construction camp and the associated wastewater treatment works will be decommissioned on completion of MeerKAT construction due to the close proximity to the core and potential radio-frequency interference that could be generated by the camp.

The Losberg construction camp will be kept for the SKA1_MID construction phase with a water and sanitation infrastructure upgrade including a new evaporation dam, wastewater treatment plant, chlorination room and reverse osmosis plant (see map in Section IV-3 of this chapter). The construction works planned for the Swartfontein and Bergsig construction camps also include waste management facilities, wastewater treatment plant and associated infrastructure. The sewage discharged from the construction camps will flow into a wastewater treatment plant at each camp. The treated water will be pumped into an evaporation dam, formed by a berm on the downstream side of the wastewater treatment plant. An alternative use of this treated water consists of re-use for dust suppression during the construction phase. The evaporation dam will be lined with a thick layer of compacted clay to prevent seepage of treated wastewater into the groundwater system. The brine residue from the reverse osmosis plant, depending on quantity, will be disposed of at an appropriate hazardous facility. Any solids remaining after evaporation has occurred will be removed by a suitable waste removal company as and when necessary. The lining with a thick layer of compacted clay will prevent damage to the dam floor when solids are being removed. The wastewater treatment plant will be constructed above-ground. During MeerKAT, a Lilliput® wastewater treatment plant was constructed. Information on the operation of the Lilliput® wastewater treatment plant is described here to provide an indication of the water treatment process in such a plant (Figure 2-30). Raw sewage is pre-digested in a 'full kit' surface plant, in Lilliput® tanks, by anaerobic bacteria, converting most of the complex organic matter into simple but toxic chemicals. At times of surge flow excess effluent is returned to the septic tank to ensure complete treatment. A clarifier is used to extract excess solids and return them to the septic tank. The final stage of treatment is disinfection, which ensures that any pathogens are removed.

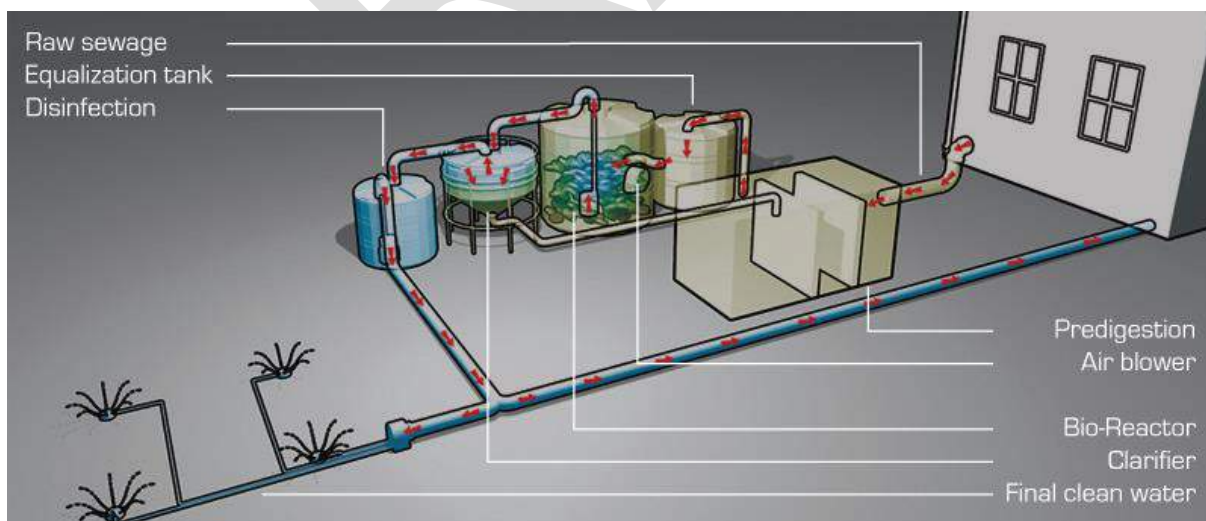


Figure 2-30: Lilliput wastewater and sewage treatment process

The effluent will be tested on a regular basis to ensure compliance with applicable standards. Septic or conservancy tanks are also present on site. However, due to the capacity needed for the number of people to be serviced during the construction phase, the septic tanks will not be able to support the

volume of sewage generated. Effluent from the washing bays will not enter the sewage system and instead provision has been made for the water to drain towards the evaporation dam. Wastewater from workshop and washing bays will go through an oil/water separator to reduce residual level of oils below 15 parts per million (ppm), before being discharged in the dam.

As discussed above, two water use licences were issued to the National Research Foundation on 29/08/2012 for a period of 20 years for the Losberg Farm and the Meys'dam Farm respectively. The following activities were granted in terms of section 21 (g) of the Act: "disposing of waste in a manner which may detrimentally impact on a water resource":

- Licence No: 14/D54E/A/1911 granted the disposal of 7200 cubic metres of wastewater per annum into an evaporation dam on the Losberg property; and
- Licence No: 14/D54E/ACGI/1012 granted the disposal of 2880 cubic metres of wastewater per annum into an evaporation dam on the Meys'dam property.

Waste management Licences for the wastewater treatment works on Mey'sdam Farm and on Losberg Farm were issued to the National Research Foundation on 27 March 2012, in terms of section 49 of the National Environmental Management: Waste Act [Act No. 59 of 2008] (NEMWA) (Licence number 12/9/11/L817/8, class H:H and Licence number 12/9/11/L758/8, class H:H respectively). The wastewater treatment facility on Mey'sdam Farm will be decommissioned. For the Losberg facilities, these waste management Licences are valid for a period of 20 years and permit the following waste management activities as listed in Category A of the List of waste management activities that have, or are likely to have a detrimental effect on the environment (Government Notice 718 dated 3 July 2009):

- Category A – Activity (11): the treatment of effluent, wastewater or sewage with an annual throughput capacity of more than 2 000 cubic metres but less than 15 000 cubic metres; and
- Category A – Activity (18): the construction of facilities associated with Activity (11).

Note that following an amendment to Government Notice 718 dated 3 July 2009²¹, the treatment of effluent, wastewater or sewage was excluded from Category A of activities requiring a basic assessment as part of a waste management licence application. A licence for this activity is therefore no longer required in terms of Government Notice 921 dated 29 November 2013²². Should the on-site storage of general waste exceed 100 cubic metres or the on-site storage of hazardous waste exceed 80 cubic metres, for more than 90 consecutive days, Category C of the List of waste management activities that have, or are likely to have a detrimental effect on the environment (Government Notice 921 dated 29 November of 2013) will be triggered and the National Norms and Standards for the Storage of Waste (Government Notice 926 dated 29 November 2013) must be adhered to.

As part of the project scope for SKA1_MID, the development of infrastructure for the bulk transportation of water or storm water, sewage, effluent and wastewater, exceeding 1 000 metres in length with an internal diameter of 0,36 metres or less on Losberg, Swartfontein and Bergsig farms is a listed activity in terms of Section 24 of the NEMA²³. Additional studies including geohydrological and geotechnical investigations are being conducted to further inform the detailed design stage of the stormwater infrastructure and sewage system upgrades. The sewer network will be designed and constructed in accordance with the following standards:

²¹ Government Gazette No. 32368: List of waste management activities that have, or are likely to have, a detrimental effect on the environment

²² Government Gazette No. 37083: Amended list of waste management activities that have, or are likely to have, a detrimental effect on the environment

²³ Government Notice 983 dated 4 December 2014

- Pipe material: uPVC 'Maincore' (or similar);
- Manholes: Precast concrete rings;
- Spacing of manholes: 80 metres (maximum);
- Minimum pipe size: 160 millimetre diameter;
- Minimum cover: 1.5 metres for road reserves and 1.2 metres for other areas;
- Pipe location: Within the boundaries of the construction camp; and
- Velocity: Minimum 0,7 metres per second. Where this is not possible due to low flows, the gradient is at least 1:80.

9. Transport of SKA infrastructure to the construction site

The SKA dish-antennas components will be manufactured off-site and transported in standardized shipping containers on standard flatbed vehicles from a port to the SKA Karoo site using public roads. The transport vehicles will consist of two step deck trailers and two normal flat deck trailers (tri-axle) as illustrated in Figure 2-31, and all loads will be abnormal loads thus requiring appropriate escorts on the roads during transport. When dish-antennas are erected in the SKA telescope core, the pedestals will be pre-assembled in the existing dish-shed at the Losberg site complex. Once completed, the pre-assembled pedestals will be transported to their final location, where they will be erected using cranes. The elevation assembly, which is everything that is mounted on the pedestal including the dish, boom, sub-reflector and indexer, will also be pre-assembled in the existing dish-shed at the Losberg site complex, from where they will be transported to their final location and lifted onto the pedestal using cranes. Other equipment installation (Feeds, Receivers, fibre optic cables etc.) will occur directly at the dish-antenna site. The dish-antennas to be erected in the spiral arms will be entirely assembled at the final location of the dish-antenna, on a temporary compacted platform next to the dish-antenna site. The compacted platform will be removed and the site rehabilitated once the erection of the antenna is completed. The four containers will be transported to the dish-antenna site, unpacked and assembled using cranes, cherry pickers and electrical tools. The pedestal will first be erected, followed by the on-ground assembly of the elevation assembly and lifting of the elevation assembly onto the pedestal. Finally, the equipment (Feeds, Receivers, fibre optic cables, etc.) will be directly fitted onto the dish-antenna.

SKA LOAD DIMENSIONS

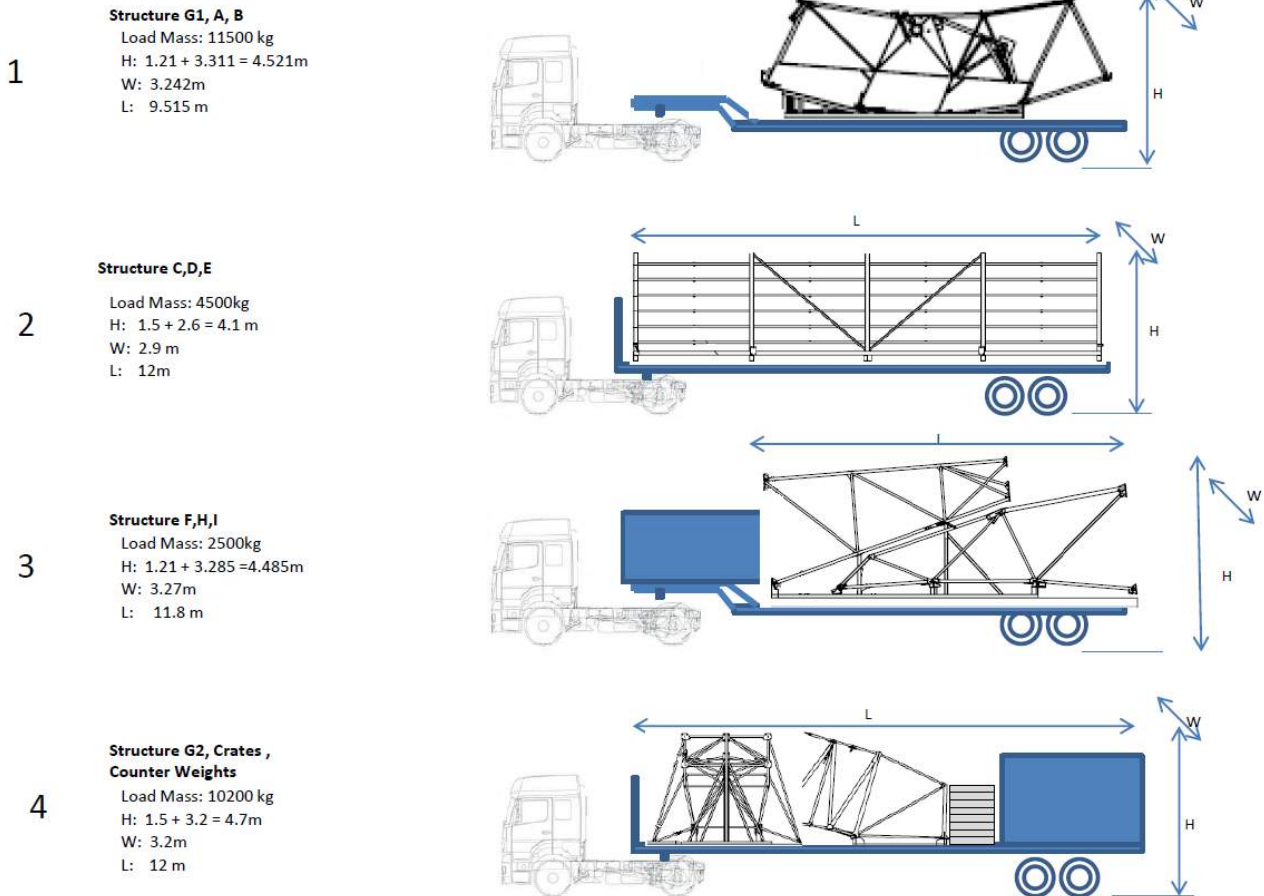


Figure 2-31: Vehicles for the transport of SKA infrastructure to the construction site

The existing 10 metres wide gravel provincial road providing access to the SKA telescope core from the town of Carnarvon is currently being upgraded into a tar road under a Memorandum of Agreement with the Northern Cape Department of Roads and Public Works (NCDRPW). After the upgrade has been completed the tar road will remain a public road and the use of this road by the public will not be restricted. Due to the proximity and security requirements of the SKA telescope core, two access boom gates with security guardhuts will be established along the provincial road to control access to the site. One will be stationed at the intersection of the provincial road "P02996" and the regional road "R357", and the other will be stationed at the intersection of the provincial road "P02996" and the regional road "R3005" on a 24 hour basis. As indicated in Section III-5, the guardhuts will be equipped with power, ablutions, and SKA emergency communication radios. Two guards (on twelve hour shifts) will be stationed at each hut on a 24 hour basis (two shifts of 12 hours each per day for seven days a week, including public holidays). The upgrade of the road is planned to be completed by the end of March 2017. The ongoing maintenance of the provincial road once tarred will be the responsibility of the Northern Cape Province.

10. Access roads to the dish-antennas

As part of the Project Scope for SKA1_MID, the development of new access roads (gravel) 5 metres wide in 10 metre servitude with some of the existing roads being lengthened by more than 1000 metres is a listed activity in terms of Section 24 of the NEMA²⁴. Approximately 12 kilometres of new roads will be constructed in the core (Figure 2-32 and Figure 2-33) with an average width of 5 metres. The basic farm roads will consist of an *in-situ* rip and compacted roadbed, with a 150 millimetre thick gravel wearing course. To channel stormwater flow to the concrete drifts from the farm roads, earth cut-off drains and channels cut by a grader will be used in order to minimise erosion of the gravel layer. The standard gravel roads will consist of a minimum of a 150 millimetre thick *in-situ* selected layer, a 150 millimetre thick sub-base layer, 150 millimetre thick base and a gravel wearing course. Stormwater systems for the gravel roads will be provided by a combination of earth channels, concrete channels, culverts, berms and concrete drifts. The stormwater system will be designed to cater for a 1 in 10 year flood interval.

Approximately 398 kilometres of pre-existing farm and district roads will be upgraded (Figure 2-32 and Figure 2-33) to improve access to the SKA dish-antennas which will be erected in the spiral arms. The reconstruction of roads will target road sections that have significantly deteriorated and roads susceptible to flooding. Existing private roads in the spiral arms have access gates which will now be shared with the land owners. The SKA organisation will undertake the upgrade and reconstruction of the required access roads and cover the cost of such activities. The roads remain the property of the land owners and as such formal agreement for the ongoing maintenance of these gravel roads will be set up by the National Research Foundation for the duration of the SKA project.

In addition to these existing access roads, approximately 150 kilometres of new roads will be constructed in the spiral arms (Figure 2-32 and Figure 2-33) including a combination of basic farm roads and standard gravel roads, with an average width of 5 metres and similar characteristics as the new roads in the core described above. The final location of the new access roads will be based on the geotechnical and geohydrological studies currently being conducted by the South African SKA Office. The areas marked for the construction of roads and the establishment of laydown areas will be cut and filled as required. The new roads in the spiral arms that are within privately owned land will require new gates and cattle grids (i.e. newly constructed roads that lead to the dish-antennas) to prevent outside access. These roads will be shared with the land owners on whose properties they traverse. The SKA organisation will undertake the construction of the required new access roads and cover the cost of such construction activities. The maintenance of privately owned on-site roads will be undertaken by the SKA operator and will require approximately 30 000 cubic metres of material from borrow pits for re-gravelling of existing roads on site (once every 5 years).

²⁴ Government Notice 985 dated 4 December 2014

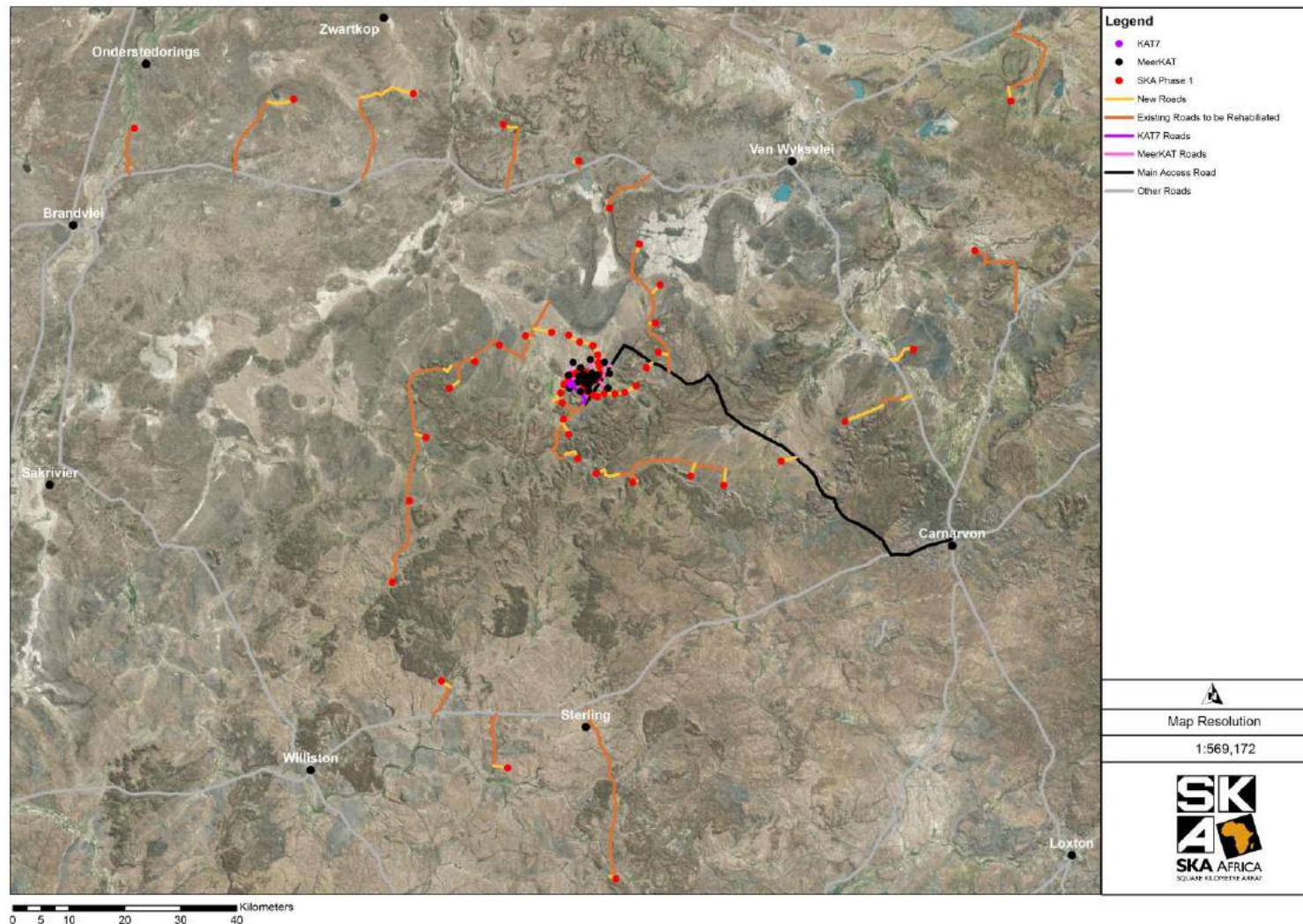


Figure 2-32: Overview of the proposed road network as of November 2016

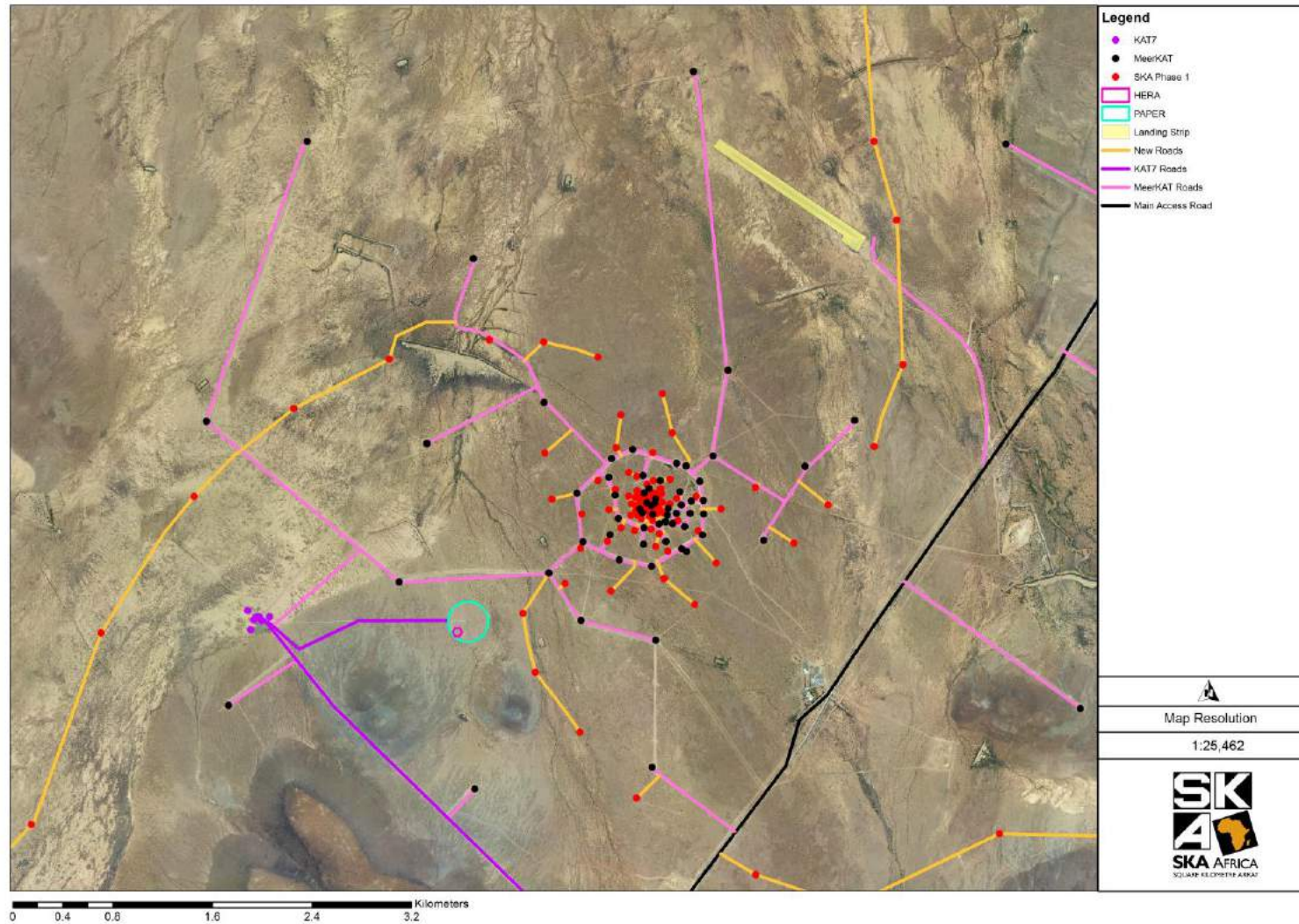


Figure 2-33: Proposed road network in the SKA telescope core as of November 2016

11. Borrow pits and quarries

There are currently four Licenced borrow pits near the core site which have been used to supply gravel material for the MeerKAT project. The total estimated material required for SKA1_MID is estimated at 242 000 cubic metres. It is envisaged that an additional 10 borrow pits (at approximately 22 000 cubic metres per borrow pit) will be required for the construction of platforms and access roads according to the design of SKA1_MID and associated infrastructure as of September 2016. The locations of the borrow pits and detailed design stage of the roads along the spiral arms will be based on geotechnical investigations and the Light Detection and Ranging (LIDAR) survey²⁵ conducted in the study area.

All borrow pits will be established within 20 kilometres of any road section. The product will be transported with trucks to the site of use. An internal road will be constructed from the main access roads to the location of the gravel quarry. The material from the borrow pits will predominantly be calcrete gravels. Based on the trial holes excavated to date (within Losberg and Meys'dam Farms), some shale has also been found which would also be suitable for gravel road construction. As part of the Project Scope for SKA1_MID, the removal and disposal of minerals (construction material sourced from stone quarries and borrow pits) contemplated in terms of section 20 of the Mineral and Petroleum Resources Development Act, 2002 (Act No. 28 of 2002) is a listed activity in terms of Section 24 of the NEMA²⁶.

Mining of borrow pits for granular (alluvial) materials will be by means of bulldozing and /or excavating after the securing of the particular area /perimeter. The material will be loaded into haul trucks at the borrow pit site. The mining activities will not use water. Furthermore it is planned that a total of four stone quarries ideally located within the same farms as the borrow pits and as close as possible to the SKA telescope core will be established. The material from the stone quarries is expected to be dolerite and will be used for concrete works and for improvement of poor gravel material. Blasting will take place for the stone quarries. The existing quarry in Carnarvon is another option for the supply of stone aggregate however this would imply the haulage of aggregate over approximately 80 kilometres. Dust may be generated during the removal of topsoil and excavation of gravel from the gravel quarries. The mining activities will utilise diesel-powered earthmoving and mining equipment. Noise emissions from these sources may lead to an elevation in ambient noise levels in the area. No beneficiation works or washing will take place.

The impact will be limited to the close proximity of the gravel quarries. Domestic waste and/or general waste will be generated and contained in skips or bins. On completion of construction activities, the mining activities will be rehabilitated to such an extent that the mining area can be fully utilized as the land use determined. Further details and management objectives are included in Chapter 4 of this IEMP.

The Mineral and Petroleum Resources Development Act explicitly states that a mining right or permit is required for the establishment and operation of borrow pits and stone quarries depending on the extent of the operation. The Act, however, also states that in terms of section 106 (1), "the Minister may by notice in the Gazette, exempt an organ of state from the provisions of section 16, 20, 22 and 27 in respect of any activity to remove any mineral for road construction, building of dams or other

²⁵ LIDAR—Light Detection and Ranging—is a remote sensing method used to examine the surface of the Earth.

²⁶ Government Notice 984 dated 4 December 2014.

purpose which may be identified in such notice²⁷. The intention is for the Department of Mineral Resources and the National Research Foundation to enter into a Memorandum of Understanding to provide an administrative framework for the National Research Foundation to be exempt from the need for a mining permit in terms of sections 16, 20, 22 and 27 of the Act for the utilization of borrow pits and stone quarries for the SKA1_MID construction activities, and from the financial provisions in terms of Section 41(1) of the Act. In the case that such exemption is not allowed, the National Research Foundation will apply for the relevant mining right or permit for the establishment and operation of borrow pits and stone quarries depending on the extent of the operation.

12. Establishment of a Protected Area in the SKA telescope core ²⁸

The National Environmental Management: Protected Areas Act (NEMPAA), No. 57 of 2003 is the primary statute for the governance, management, regulation and monitoring of protected areas. NEMPAA provides for the protection and conservation of ecologically viable areas that are representative of South Africa's biological diversity and its natural landscapes and seascapes. In terms of NEMPAA in accordance with the National Environmental Management: Biodiversity Act of 2004, all formally protected areas should contribute meaningfully to the aims and objectives of the Protected Areas Act, which inter-alia include the following purposes:

- To protect ecologically viable areas representative of South Africa's biological diversity, and its natural landscapes and seascapes, in a system of protected areas;
- To preserve the ecological integrity of those areas;
- To conserve biodiversity in those areas;
- To protect areas representative of all ecosystems, habitats and species naturally occurring in South Africa;
- To protect South Africa's threatened or rare species;
- To protect an area which is vulnerable or ecologically sensitive;
- To assist in ensuring the sustained supply of environmental goods and services;
- To provide for the sustainable use of natural and biological resources;
- To create or augment destinations for nature-based tourism;
- To manage the interrelationship between natural environmental biodiversity, human settlement and economic development;
- Generally to contribute to human, social, cultural, spiritual and economic development; and
- To rehabilitate and restore degraded ecosystems, and promote the recovery of endangered and vulnerable species.

The establishment of a Protected Area within the Strategic Environmental Assessment study area would be required to abide by NEMA Act 107 of 1998 (Amended 2014) and other relevant national legislation including the National Environmental Management: Protected Areas Amendment Act 31 of 2004, National Forests Act (Act 84 of 1998); the World Heritage Convention Act (Act 49 of 1999) and the Mountain Catchment Areas Act (Act 63 of 1970).

²⁷ The Minister has on three previous occasions granted exemption of these provisions of the Act to Organs of State, including the Department of Water Affairs and Forestry, National Parks Board, SANRAL, National Ports Authority of South Africa, Spoornet and Airports Company of South Africa. These exemptions were granted in notices published under Government Notice R762 (Government Gazette 26501 of 2004); Government Notice 852 (Government Gazette 29133 of 25 August 2006) and Government Notice R446 (Government Gazette 29881 of 18 May 2007) respectively.

²⁸ The SKA telescope core refers to the land being acquired by the National Research Foundation and should not be confused with the Karoo Core Astronomy Advantage Area.

The management of protected areas is also regulated by various statutes at provincial level. Section 7 of the Protected Areas Act regulates the interaction of national and provincial statutes as follows:

- Where a provision of the Protected Areas Act specifically concerns the management or development of protected areas and there is a conflict with other national legislation, the relevant section of the Protected Areas Act prevails;
- If the Protected Areas Act conflicts with provincial legislation, the conflict must be resolved in terms of Section 146 of the Constitution; and
- Where there is a conflict with a municipal by-law, the relevant section of the Protected Areas Act prevails.

The success of the protected area system is dependent on the maintenance of key partnerships between the various organs of state directly responsible for protected area management, other relevant organs of state, other relevant government-led programmes, major non-governmental organizations (NGO) in the conservation sector, relevant commercial production sectors, and private and communal landowners.

The regulation, planning and management of provincial nature reserves in the Northern Cape are the function of the provincial department of Environment and Nature Conservation. At the local level, several local and district municipalities have established a nature conservation function to administer and manage (local) nature reserves within their municipal jurisdiction. In the case that private land has been declared as a protected area, the private landowner (individual, business, joint venture, or community) may be designated as the responsible management authority, with planning, financial and/or technical support from the relevant protected area agency. As biodiversity stewardship programmes are rolled out across the provinces, this institutional arrangement may become increasingly common for the management of different categories of protected areas.

An application will be lodged for declaring the SKA telescope core (land acquired by the National Research Foundation) as a Special Nature Reserve in terms of NEMPAA. The National Research Foundation will sign a Memorandum of Understanding with the South African National Parks Agency (SANParks) or other appropriate organ of state or agency for the management of the natural environment. The remainder of the land within the Karoo Central Astronomy Advantage Area 1 will remain in private ownership and be managed mainly as extensive game or livestock farms. Based on an assessment conducted in the SKA telescope core, the South African Environmental Observation Network (SAEON) confirmed that the formal recognition of the SKA telescope core as a protected area is considered appropriate and warranted.

A review of existing literature on the declaration of protected area in South Africa led to the identification of the special nature reserve type of protected areas as listed under the NEMPAA as the most appropriate type for the formal declaration of the SKA telescope core as a protected area. As it is the case for the Prince Edward Islands Special Nature Reserve, human access to the SKA telescope core Special Nature Reserve would be restricted to research and conservation management only. Proposals for SAEON long term research and monitoring programmes to be conducted within the SKA telescope core Special Nature Reserve are described below (Section VII and VIII of this Chapter).

A Special Nature Reserve is intended to protect highly sensitive, outstanding ecosystems, species, geological or physical features in the area, and to make the area primarily available for scientific research or environmental monitoring (NEMPAA, Act No. 57 of 2003, Section 18)²⁹. The declaration as

²⁹ South African national Antarctic Programme - Prince Edward Islands Management Plan - DST- National Research Foundation Centre of Excellence for Invasion Biology at Stellenbosch University.

Special Nature Reserve is the highest state of formal protection afforded to any natural area under South African law, restricting human access to the protected area for research and conservation management only. General public visits and commercial tourism is not permitted.

The legal characteristics of the Special nature reserve (source: National Protected Area Expansion Strategy Resource Document 2009) are:

- Objective: To protect highly sensitive, outstanding ecosystems, species or geological or physical features in the area. To make the area primarily available for scientific research or environmental monitoring;
- Management authority: Designated by the Minister in terms of an approved Management Plan that may include co-management agreements;
- Use restrictions: Strict access restrictions that include aircraft restrictions. No mining. No commercial activities specifically provided for. Additional restrictions may be imposed by management authority; and
- Withdrawal: Requires resolution of Parliament.

The NEMPAA deals with the manner in which an area may be declared a special nature reserve, National Park, nature reserve or protected environment. The Minister of Environmental Affairs is responsible for declaring a special nature reserve by notice in the Government Gazette. In the case of the declaration of private land as special nature reserve the landowner consent to the declaration must be provided in the form of a written agreement entered into with the Minister (special nature reserve).

The declaration of the SKA telescope core as a protected area may be initiated by the Minister, subject to the following:

- If the land in question is privately owned, the declaration may be initiated by the landowner (e.g. in the form of a request by the landowner to the Minister);
- If the area consists of, or includes, land owned by the State, the Minister may make the declaration only with the agreement of the Cabinet member or Member of the Executive Council (MEC) responsible for the administration of that land; and
- If the area consists of, or includes, land which is held in trust by the State or an organ of state for a community or other beneficiary, the Minister may make the declaration only with the concurrence of the trustee and the community involved.

Before the Minister or Member of the Executive Council (MEC) may issue a notice in the relevant Gazette declaring a special nature reserve, the Minister must follow a consultative process prescribed in the Act and a public participation process prescribed in the Act.

V. PROPOSED DEMOLITION ACTIVITIES

The following infrastructure will however be decommissioned during the construction and operation phase of SKA1_MID (i.e. short to medium term decommissioning activities):

- The Meys'dam Construction Camp will be decommissioned at the end of the construction of MeerKAT (end 2017) and the land will be used as an open store. Should SKA Phase 2 not proceed, the following three Construction Camps (Losberg, Swartfontein and Bergsig) will also be decommissioned at the end of the SKA1_MID construction phase. All infrastructure that can be re-used, will be removed and used as a spare for other projects in accordance with the National Research Foundation Supply Chain Management Policy.
 - All buildings not kept for storage purposes will be demolished.
 - Diesel tanks will be removed.
 - Optic fibers and underground cables will be disconnected and remain in situ.
 - Wastewater treatment plants will be removed and use as a spare elsewhere.
 - Evaporation dams will be demolished and rehabilitated.
 - All man-made dams not retained for the storage of water for the construction and operation of SKA1_MID will be demolished and rehabilitated.
- The farmhouses / outbuildings acquired by SKA which are not declared a heritage site and will not be utilised by the SKA South Africa (as stores, logistics) will be decommissioned and demolished.
- Boreholes that will not be utilised for the construction and operation of SKA1_MID will be decommissioned (pumps removed and lids placed over holes and locked). Those windmills that will not be retained for use by the project will be disassembled and pumps removed.
- Where not retained for research purposes, farm fences within the SKA core area will be removed and disposed of in accordance with the National Research Foundation Supply Chain Management Policy.
- Borrow pits and quarries not retained for the operation phase will be decommissioned and rehabilitated at the end of the construction phase.

All management actions outlined in Chapter 4 of this IEMP for the construction and operation phases of the proposed SKA1_MID project must be considered and implemented, where applicable, during the demolition of the above infrastructure, in particular management actions for Stakeholder engagement, Environmental awareness, Responsible behaviour of staff, Emergency Action Response plan, Waste management, Stormwater and wastewater management, Protection of flora and fauna, Hazardous substances management and Revegetation and habitat restoration.

1. Construction camps

The Meys'dam Construction Camp will be decommissioned at the end of the construction of MeerKAT (end 2017). This Construction Camp is currently being utilised by StratoSAT (Pty)Ltd (contractor). The Construction Camp facilities and decommissioning activities are indicated in Table 2-3:

Table 2-3: Meys'dam Construction Camp Facilities

Description	Decommissioning Activity	Timeline
Farmhouse	Farmhouse will be used for office storage, consumables and library for hard copy drawings	December 2016
Outbuildings	Stores for on-site equipment. Civil vehicles and cranes will still park in one outbuilding	Will be retained
Wastewater Treatment Plant and Evaporation Dam (sewerage plant)	Once contractor has left, the plant will be switched off, cleaned and disconnected. The wastewater treatment plant equipment will be removed and used as a spare for the other construction camps for SKA1_MID. A grader will be used to demolish the evaporation dam which will then be rehabilitated	1 month after contractor leaves site
Water supply	Water supply to be retained for farmhouse. Water supply to construction camp will be turned off.	Retained
Man-made Dam	Man-made dam will be retained for water supply for construction and operations	Retained
Electrical supply	Electrical supply will be retained for boreholes and farmhouse. Electrical supply to construction camps will be disconnected at mini-substation at the farmhouse and Certificate of Compliance will be issued for disconnection. Power cables will be retained underground.	2 months after contractor leaves site
Data Connectivity	Data connectivity to farmhouse will be disconnected by December 2016. Disconnect fibre optic cable connection at patch panel to construction camps. Fibre optic cable to be retained underground.	December 2016 and 1 month after contractor site
Diesel Tanks	Contractor to remove diesel tanks from site (fuel to be pumped out of tanks and removed from site). Bund walls to be demolished and area rehabilitated	2 months after contractor leaves site
Construction Camp	All portacabins will be removed. Land will be used as an open store	When contractor leaves site (end 2017/2018)
Fencing around camp	To be retained	Retained

As described in Section IV-3 of this Chapter, three construction camps will be utilised for the construction of SKA1_MID:

- Losberg Construction Camp (to accommodate 540 people)
- Swartfontein Construction Camp (to accommodate 100 people)
- Bergsig Construction Camp (to accommodate 100 people)

Should SKA Phase 2 proceed, these Construction Camps will be retained and maintained until the commencement of construction for Phase 2. In the case where Phase 2 does not materialize, these three Construction Camps will be decommissioned. Decommissioning Activities will be the same as indicated for the Meys'dam Construction Camp in Table 2-3.

2. Farmhouses and graves included in the SKA land acquisition programme

A total of 32 farms is being acquired as part of the SKA Land Acquisition Programme. As part of the property valuation process, the farmhouses, other houses and facilities and bulk infrastructure have been included in each farm’s valuation. The Global Positioning System (GPS) coordinates of each farmhouse will be mapped on the SKA GIS. The South African Heritage Resource Authority (SAHRA) will identify any buildings that are older than 60 years old and graves which must be declared a heritage site on the SAHRA database and which must be preserved with the establishment of a long-term heritage sites maintenance plan. The South African SKA Office further indicated that two farmhouses and outbuildings will be identified by the SKA South Africa as locally based-offices for the SAEON long-term environmental research and monitoring and for the appointed Land Manager. South African SKA Office and SAEON / the appointed Land Manager will sign a Memorandum’s of Agreement, to formally establish that the maintenance of these facilities will be the responsibility of SAEON and the appointed Land Manager. With SAHRA’s permission, all farmhouses / outbuildings which will not be utilised during the SKA (as stores, logistics) will be decommissioned and demolished. The decommissioning activities are listed in Table 2-4.

Table 2-4: Farmhouse / outbuilding

Description	Decommissioning Activity	Timeline
Farmhouse and outbuilding	The South African SKA Office will undertake a final inspection of the farmhouse and all fixed / loose fittings will be removed	January 2018 – June 2018
	Any reusable fittings will be stored at a pre-identified SKA store	
	The South African SKA Office will utilize its in-house staff and heavy duty machinery/equipment to demolish the house and outbuildings in accordance with pre-defined procedures	
Electrical/ solar connections	All electrical installations will be inspected and decommissioned (disconnected) by the South African SKA Office Electrical technician and a Certificate of Compliance issued	January – February 2018
Removal of building rubble	Pits will be excavated by the South African SKA Office with machinery and the rubble will be buried	June 2018 – Dec 2018

3. Man-made dams

All man-made dams will be inspected to determine which dams will be retained for the storage of water for the construction and operation of SKA1_MID. All dams will be mapped on the SKA GIS with GPS coordinates. The South African SKA Office will engage with the departments of Environmental Affairs and Water and Sanitation once a detailed list and map of dams located in the SKA telescope core is available, in order to determine which dams can be demolished and which dams must be left to decay naturally in order to assist animals to get used to the progressive removal of artificial water source in the SKA telescope core. All building rubble generated during the demolition of the dams will be buried in existing excavation pits.

4. Closure of boreholes and removal of windmills

All boreholes that have been identified as part of the SKA1_MID geohydrological investigation to be utilised for the construction and operations of SKA1_MID will be retained. Pumps will be retained and meters will be installed to measure monthly consumption rates of water used from these boreholes. Water usage will be monitored by the Department of Water and Sanitation every three months and the use of boreholes will be alternated as agreed with the Department of Water and Sanitation. Water-use Licences will be obtained for these boreholes. Boreholes that will not be utilised for the construction and operation of SKA1_MID will be decommissioned (pumps removed and lids placed over holes and locked). Those windmills that will not be retained for use by the project will be disassembled and pumps removed. The windmills will be disposed of in accordance with the National Research Foundation Supply Chain Management Policy. Alternative options will also be considered to provide windmills through the asset disposal strategy for the benefit of emerging farmers and the Department of Agriculture, Forestry and Fisheries (DAFF) in the area.

5. Fencing

A discussion will be held with SAEON to agree on which areas they will require farm fencing to be retained to undertake specific environmental research and monitoring. All remaining farm fences within the area owned by the National Research Foundation will be removed and disposed of in accordance with the National Research Foundation Supply Chain Management Policy. Fencing around the boundary of National Research Foundation-owned land will be retained. Inspections will be undertaken and these fences repaired and maintained by the appointed Land Manager (jackal-proof fencing).

6. Borrow pits / Stone Quarries

All borrow pits /stone quarries identified for the construction of SKA1_MID will be mapped in the SKA GIS. The South African SKA Office will obtain mineral permits for the use of these borrow pits /stone quarries if the South African SKA Office does not receive an exemption from applying for permits from the Department of Mineral Resources in terms of the Mineral and Petroleum Resources Petroleum Development Act No. 28 of 2002. All borrow pits and stone quarries that are only used for the construction phase will be rehabilitated in accordance with an approved Environmental Management Plan and inspected by the Department of Mineral Resources. Those borrow pits /stone quarries that need to be retained for operations and maintenance of SKA1_MID will be done in accordance with the Environmental Management Programme (see Chapter 4 of this IEMP).

7. Construction haul roads

All haul roads will be indicated on a construction plan prior to construction and agreed with the South African SKA Office. These roads will be ripped up in accordance with the IEMP on completion of construction of SKA1_MID.

8. Telephone poles

Walk-throughs will be undertaken of all farms acquired as part of the SKA land acquisition programme to identify existing unused telephone pole infrastructure. Permission will be requested from Telkom to remove telephone poles and cables. Once approval is obtained, the poles and cables will be disposed of in accordance with the National Research Foundation Supply Chain Management Policy.



CHAPTER 3: STATE OF THE ENVIRONMENT





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This chapter of the Integrated Environmental Management Plan provides an overview of the state of the environment within the Strategic Environmental Assessment study area. The information contained in this chapter was informed by the biophysical and socio-economic specialist studies conducted during the Strategic Environmental Assessment of the South African mid-frequency array of SKA Phase 1 (SKA1_MID) and associated infrastructure. All recommendations, mitigation measures and management actions prescribed by the specialists are included in Chapter 4 of this Integrated Environmental Management Plan. The full specialist study reports are available on the project website for download.

Table 3-1 below lists the authors and peer-reviewers for all the specialist studies undertaken as part of the SKA1_MID Strategic Environmental Assessment.

Table 3-1: Specialist study authors and peer-reviewers

Author		Peer-reviewer	
Terrestrial ecology and biodiversity assessment			
Dr Sue Milton	Director at RENU-KAROO Veld Restoration cc. SACNASP Professional Natural Scientist (Reg. No. 400047/08).	Dr Joh Henschel	Manager at SAEON Arid Lands Node
		Lydia Cape	Environmental Scientist at CSIR SACNASP Professional Natural Scientist (Reg. No. 400359/13)
Freshwater aquatic ecosystems assessment			
Kate Snaddon	Senior Consultant and Partner at the Freshwater Consulting Group and director at the Freshwater Research Centre. SACNASP Professional Natural Scientist (Reg. No. 400225/06).	Dr Wietsche Roets	Specialist Scientist: In-stream Water Use at the Department of Water and Sanitation. SACNASP Professional Natural Scientist (Reg. No. 400191/10).
Dean Ollis	Consultant at the Freshwater Consulting Group and at the Freshwater Research Centre. SACNASP Professional Natural Scientist (Reg. No. 400102/06).	Dr Betsie Milne	Postdoctoral Fellow: Wetland Ecologist at SAEON Arid Lands Node. DST- National Research Foundation Professional Development Programme.
Tumisho Ngobela	Consultant at the Freshwater Consulting Group and at the Freshwater Research Centre. SACNASP Candidate Natural Scientist (Reg. No. 100010/15).		
Fine-scale habitat mapping and baseline of the SKA telescope core			
Simon Todd	Ecologist at SAEON Arid Lands Node. SACNASP Professional Natural Scientist (Reg. No. 400425/11).	Dr Joh Henschel	Manager at SAEON Arid Lands Node
Endangered species survey			
Bonnie Schumann	Senior Field Officer at the Endangered Wildlife Trust (EWT) Drylands Conservation Programme.	Cobus Theron	Programme Manager at the EWT Drylands Conservation Programme.
Esté Matthew	Field Officers at the Endangered Wildlife Trust (EWT) drylands Conservation Programme	Lydia Cape	Environmental Scientist at CSIR SACNASP Professional Natural Scientist (Reg. No. 400359/13)
Bat fauna sensitivity study			
Kate MacEwan	Director at Inkululeko Wildlife Services. Chairperson at the South African Bat Assessment Advisory Panel. SACNASP Professional Natural Scientist (Reg. No. 400123/05).	Professor David Jacobs	SARChI Research Chair in Animal Evolution and Systematics at the Department of Biological Sciences of the University of Cape Town.
		Patrick Morant	Specialist scientist. SACNASP

			Professional Natural Scientist (Reg. No. 401514/83).
Avifauna sensitivity study			
Dr W. Richard Dean	Research Associate at the DST/NRF Centre of Excellence at the Percy FitzPatrick Institute of African Ornithology at the University of Cape Town. Co-director at RENU-KAROO Veld Restoration cc.	Dr Penn Lloyd	Principal Ecologist and Director at Biodiversity Assessment and Management Pty Ltd.
		Patrick Morant	Specialist scientist. SACNASP Professional Natural Scientist (Reg. No. 401514/83).
Heritage assessment (including archaeology, palaeontology, cultural heritage and landscape)			
Kyla Bluff	Cedar Tower Services. Association for Southern African Professional Archaeologists (Reg. No. 358).	Natasha Higgitt	Heritage Officer: Impact Assessment at the South African Heritage Resources Agency.
Nicholas Wiltshire	Cedar Tower Services. Association for Southern African Professional Archaeologists (Reg. No. 359) and Association of Professional Heritage Practitioners member.	Ragna Redelstorff	Heritage Officer: Permit Officer – Palaeontology at the South African Heritage Resources Agency.
Jenna Lavin	Cedar Tower Services. Association for Southern African Professional Archaeologists (Reg. No. 327) and Association of Professional Heritage Practitioners member.	Phillip Hine	Heritage Officer: Permit Officer – Archaeology at the South African Heritage Resources Agency.
Jayson Orton	ASHA Consulting. Association for Southern African Professional Archaeologists (Reg. No. 233) and Association of Professional Heritage Practitioners member.	Itumeleng Matiseng	Heritage Officer: Burial Grounds and Graves Unit at the South African Heritage Resources Agency.
John Almond	NaturaViva. Palaeontological Society Southern Africa Membership, Association of Professional Heritage Practitioners member.		
Bernard Oberholzer	BOLA Landscape Architect. Professional Member of the SA Council for the Landscape Architectural (Reg. No. 87018), Fellow of the Institute of Landscape Architects of SA.		
Quinton Lawson	MLB Architects. Professional Member of the SA Council for the Architectural Profession (Reg. No. 3686), Member of the Cape Institute for Architects, Member of the Impact Assessment Review Committee of Heritage Western Cape.		
Soils, erosion and agricultural potential assessment			
Johann Lanz	Soil Scientist SACNASP Professional Natural Scientist (Reg. no. 400268/12)	Anneliza Collett	Department of Agriculture, Forestry and Fisheries - Directorate: Land Use and Soil Management
		Dr Andrei Rozanov	Senior Lecturer in Soil Sciences at Stellenbosch University.

Agricultural economics study			
Professor Johann Kirsten	Director of the Bureau for Economic Research of the University of Stellenbosch and chairperson of the Karoo Development Foundation.	Professor Anthony Leiman	Associate Professor at the School of Economics of the University of Cape Town (Environmental and resource economics; cost-benefit analysis; informal sector).
		Professor Beatrice Conradie	Associate Professor at the School of Economics of the University of Cape Town (Farm labour markets; women in agriculture).
		Dr Emma Archer	Chief Researcher in Sustainable agriculture, managed ecosystems, Climate Studies, Modeling & Environmental Health at the Council for Scientific and Industrial Research.
Review of existing socio-economic surveys			
Professor Doreen Atkinson	C2 National Research Foundation-rating Researcher, Department of Development Studies, NMMU; and Trustee of the Karoo Development Foundation.	Professor Cheryl Walker	DST/NRF SARChI Chair at the Department of Sociology and Social Anthropology of Stellenbosch University.
Socio-Economic Assessment¹			
Professor Doreen Atkinson	C2 National Research Foundation-rating Researcher, Department of Development Studies, NMMU; and Trustee of the Karoo Development Foundation.	Dr SW van der Merwe	Senior planner and manager of the Environmental planning department at Dennis Moss Partnership.
Rae Wolpe	Managing Director of Impact Economix.	Professor Anthony Leiman	Associate Professor at the School of Economics of the University of Cape Town (Environmental and resource economics; cost-benefit analysis; informal sector).
Adv Hendrik Kotze	Professor extraordinaire at the Africa Centre for Dispute Settlement (ACDS) at the University of Stellenbosch Business School.	Dr Hugo van der Merwe	Transitional Justice Programme Manager at the Centre for the Study of Violence and Reconciliation in South Africa.
Screening major hazard installation risk assessment			
Michael Paul Oberholzer	Director, Risk Assessor and Chemical Engineer at RISCO (PTY) LTD, SANAS facility accreditation No MHI0013, approved signatory for MHI risk assessments, Registered Professional Engineer (Registration No.: 910085) with the Engineering Council of South Africa, Approved Inspection Authority for MHI Risk Assessments South Africa.	Annick Walsdorff	Chemical Engineer (Environmental Engineering) and Principal Environmental Assessment Practitioner at the Council for scientific and Industrial Research

¹ With inputs and fieldwork assistance of Mrs Caroline Poole, Mr Sindisile Madyo and Mr Lindile Fikizolo.

I. Geology, topography, drainage and soils

The landscape of the study area comprises abrupt ridges and conical hills scattered across extensive sandy and silty plains. The altitude ranges from 1500 metres above sea level on the escarpment in the South (Fraserburg) to 900 metres above sea level on the pans between Brandvlei and Van Wyksvlei. There is thus a gentle gradient of 0.6 kilometres over a distance of 300 kilometres. The study area consists of sedimentary deposits from the Dwyka Group, Ecca Group and Beaufort Group as illustrated in Figure 3-1. These three groups are part of the Karoo Supergroup. The Dwyka Group is the earliest and lowermost of the Karoo Supergroup of sedimentary deposits, it is overlaid by the Ecca Group which in turn is overlaid by the Beaufort group.

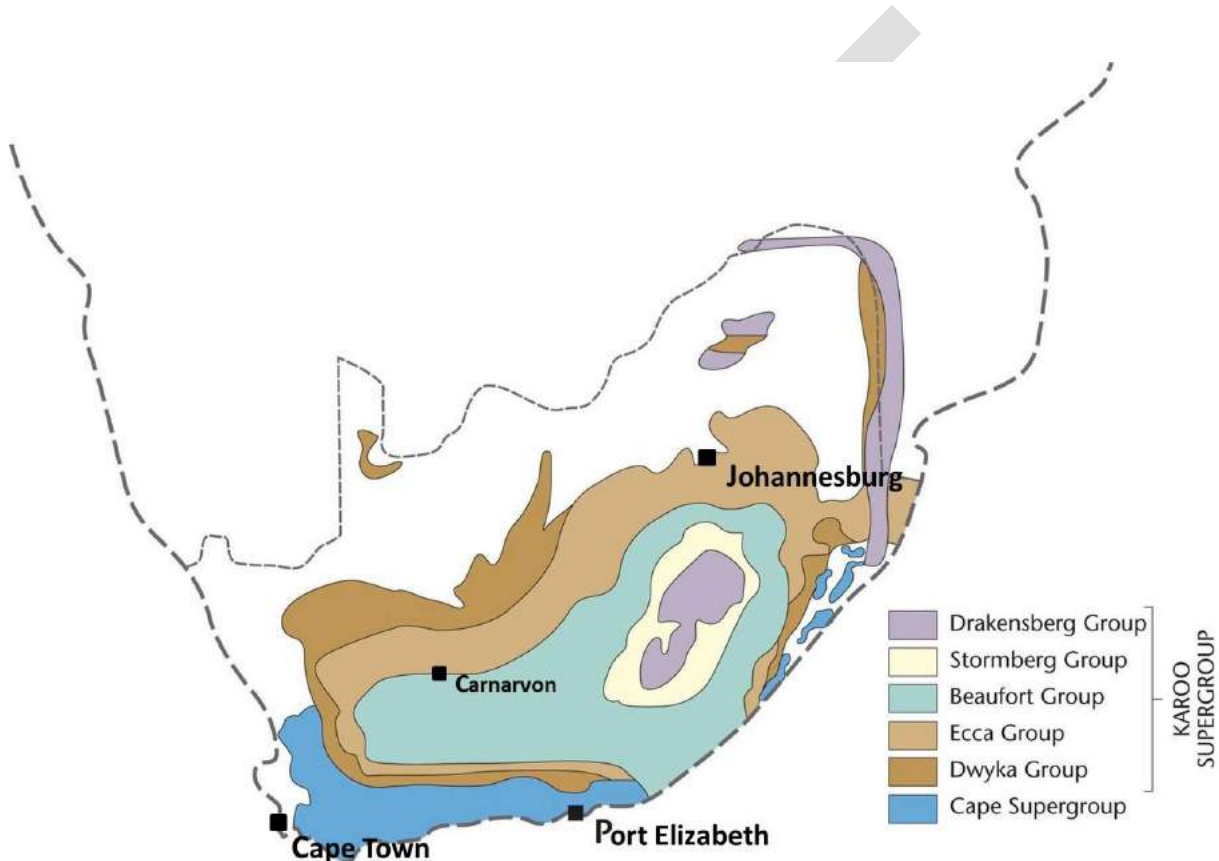


Figure 3-1: Karoo Supergroup sedimentary deposits

The Beaufort group consists of alternating mudstone (red in places) and sandstone. The sandstones represent river channel deposits and the mudstones, floodplain deposits. The mudstone and sandstone rocks, derived from marine sediments, are relatively soft and erode to form stony plains and flat or rounded hills. Dolerite (an igneous rock) has intruded through the sedimentary deposits to form dykes and pipes and groundwater collects in the crevices around dolerite pipes, sills and dykes. The dolerite causes metamorphosis of the adjacent host rocks. Mudstone is altered to hornfells and the sandstones develop a quartzitic appearance. Where dolerite intrusions overlie softer sediments, the hard capping results in formation of flat-topped ridges and mesas. The characteristic flat-topped mountains and hills of the Karoo are characterised by fairly well-rounded cobbles and boulders composed largely of dolerite. These features are the most visible remnant of the dolerite's tough sills, protecting the underlying sandstone from erosion (Figure 3-2).

Other deposits include calcrete, alluvium and debris. Calcrete (also called Hardpan) is a sedimentary rock, formed of calcareous materials as a result of climatic fluctuations in arid regions. It is a hardened natural cement of calcium carbonate that binds other materials such as gravel, sand, clay, and silt. In the study area the calcrete occurs directly on the bedrock and has also formed extensive deposits within some larger areas of alluvium, attaining a maximum thickness of a few metres. Alluvium comprises loose eroded sediments, usually made of fine particles of silt and clay and larger particles of sand and gravel, reshaped by water and redeposited. The alluvium presents a low susceptibility to erosion and embraces both alluvial slopes (sheet wash) and alluvial valley (channel-related) deposits.



Figure 3-2: Dolerite boulders in the SKA telescope core (Photo: Lydia Cape)

The study area is characterised by an arid climate with very little summer rainfall. The rainfall statistics illustrated in Figure 3-3 to Figure 3-5 were captured at the weather stations located in Williston, Van Wyksvlei, Brandvlei and Carnarvon for each month of the year (mean per day, absolute maximum daily rainfall over the days of the month, and absolute maximum rainfall in 1 hour burst in that month). The overall mean annual rainfall for the study area is less than 200 millimetres with peak rainfall occurring in March (mean annual rainfall at Brandvlei 127 millimetres and Carnarvon 209 millimetres). The annual evaporation rate is approximately 2 300 millimetres which is much higher than the mean annual rainfall. Summers are typically hot and dry, whereas winters are icy and dry with dew and frost being typical during the night.

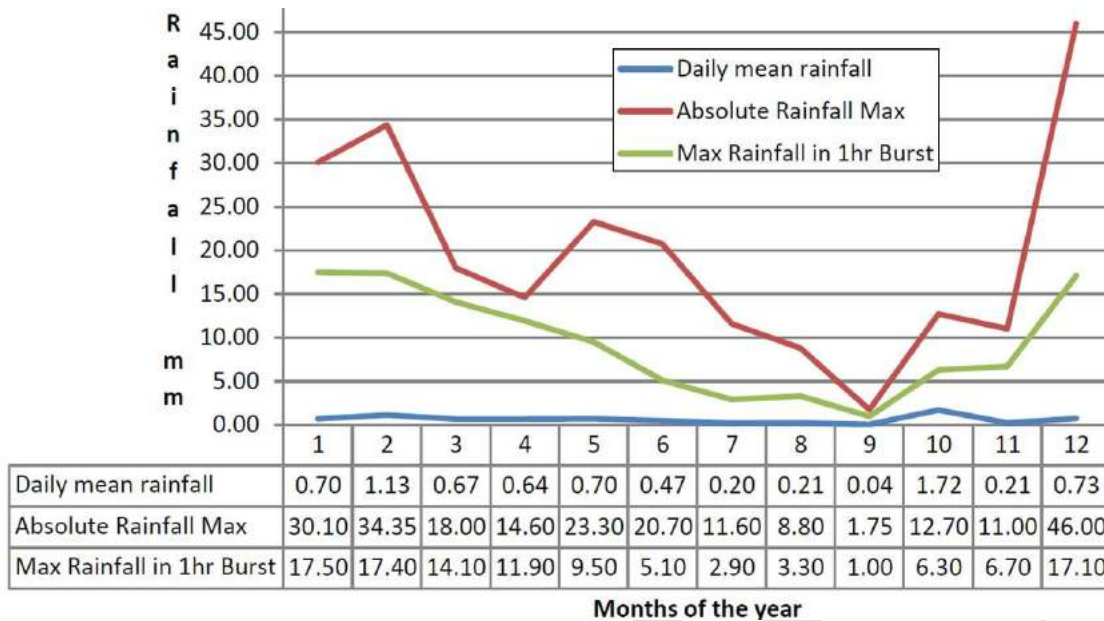


Figure 3-3: Rainfall data for the Williston Spiral Arm for the year 2010

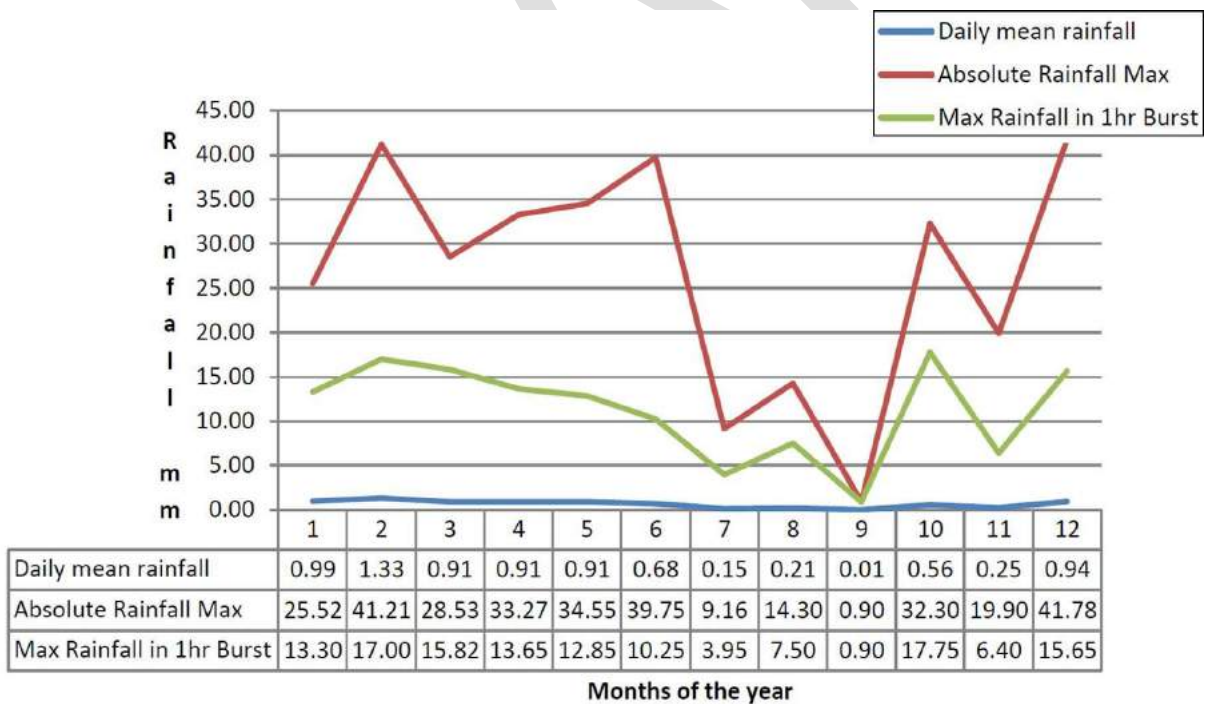


Figure 3-4: Rainfall data for the Carnarvon/van Wyksvlei Spiral Arm for the year 2010

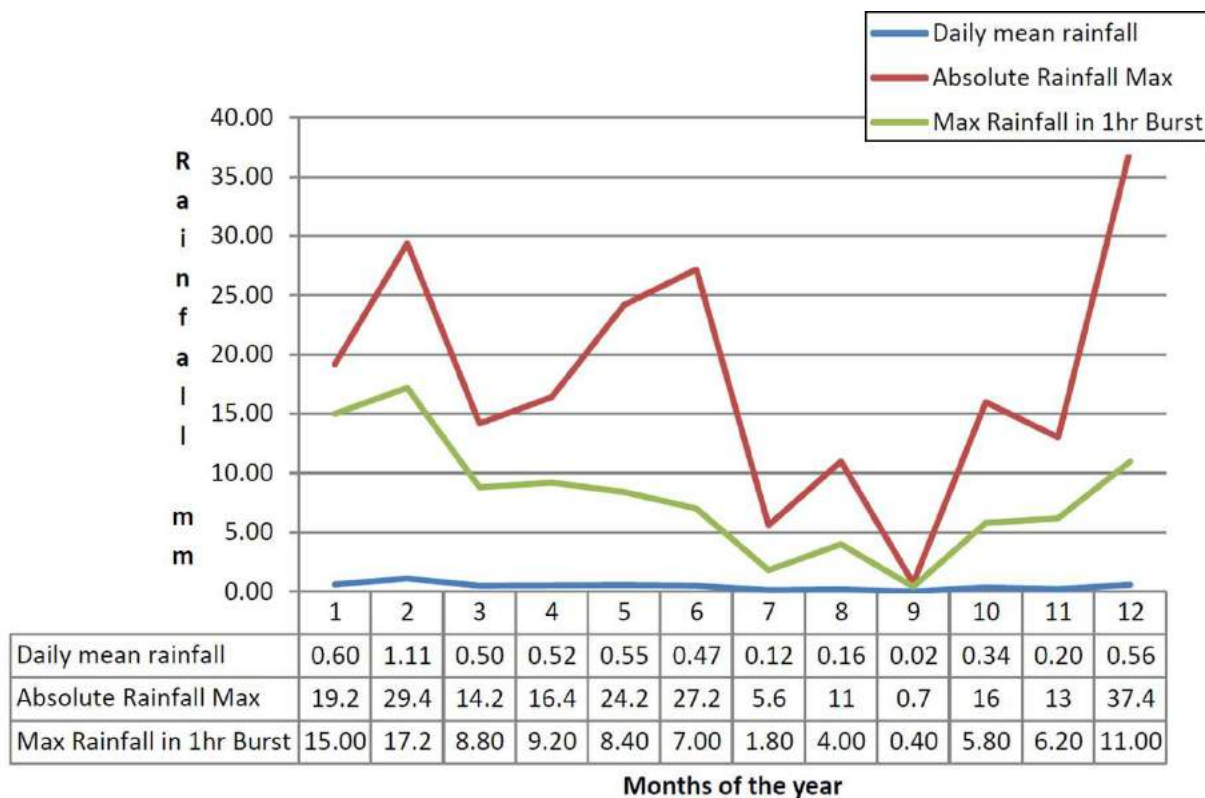


Figure 3-5: Rainfall data for the Brandvlei Spiral Arm for the year 2010

Drainage is mostly endorheic rivers arising on the escarpment (e.g. Sakrivier) and off ridges and hills, flow northwards and discharge into the pans (Brandvlei, Verneukpan, Van Wyksvlei) where the water evaporates. Although the soils of the plains are generally shallow to skeletal, wind and water-borne sediments have accumulated in parts of the landscape. In the area where the Van Wyksvlei/Carnarvon spiral arm is located, many stony plains are devoid of soil whereas wind-blown sand has elsewhere accumulated to form dunes that overlie the mudstone plains and dolerite outcrops in some places.

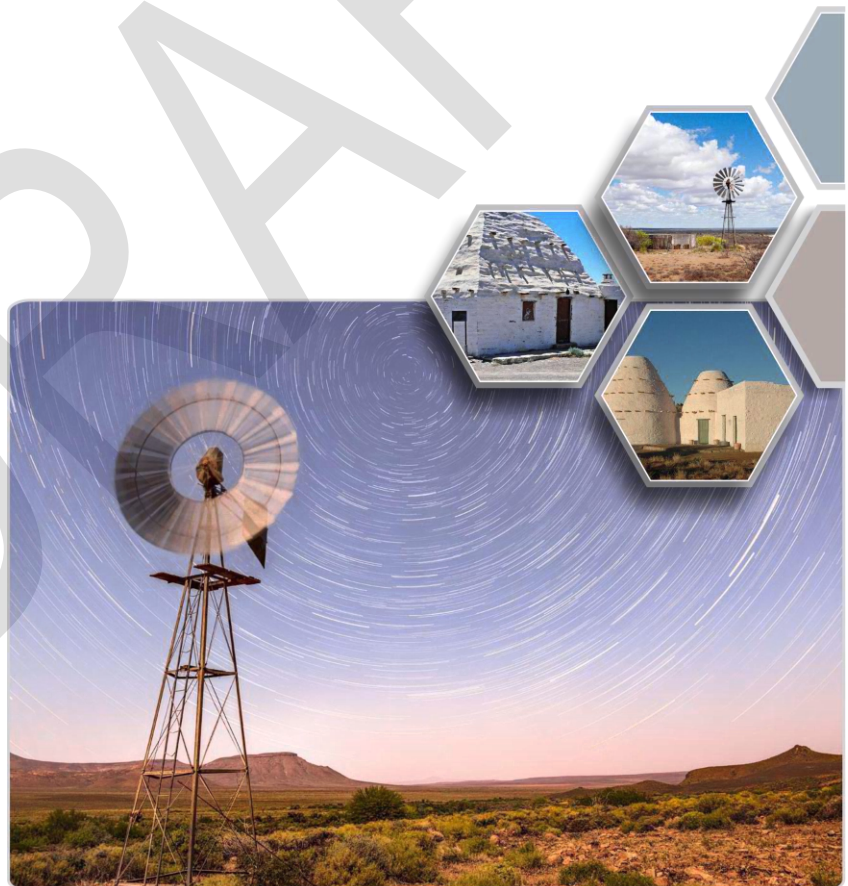
According to the generalized soil pattern data from the Southern African Agricultural Geo-referenced Information System (AGIS), six soils types are found in the study area (Figure 3-6):

- Red and yellow, well drained sandy soils with high base status² (AR2 on the map);
- Soils with negligible to weak profile development, usually occurring on deep alluvial deposits (FL on the map);
- Soils with minimal development, usually shallow, on hard or weathering rock, with or without intermittent diverse soils. Lime generally present in part or most of the landscape (LP2 on the map);
- Soils with a marked clay accumulation, strongly structured and a reddish colour. Prismaeutanic and/or pedocutanic diagnostic horizons dominant (PL1 on the map);
- Rock with limited soils (R on the map); and
- Strongly saline soils generally occurring in relatively deep deposits in low lying arid areas (SC on the map).

These six soil types are usually found in the arid parts of the country.

² Base status is a ratio relating the major nutrient cations (Ca, Mg, K and Na) to the clay percentage in the soil. It is used as an indicator of soil fertility.

The agricultural landscape of the Strategic Environmental Assessment study area is dominated by the aridity of the climate, with a mean annual rainfall of less than 200 millimetres. Agriculture is almost exclusively sheep farming throughout the area. There are small patches of cultivated land that make up an extremely small proportion of the total agricultural area (0.20 %). Patches of land that may, depending on the particular season, receive and retain sufficient soil moisture for crop growth, are used for the production of supplementary fodder crops for sheep. These are not cultivated annually, but only when the weather (rainfall) allows, particularly when there is sufficient (above average) rainfall, at a suitable time of the season for optimal crop growth. An assessment of the agricultural potential within the study area in terms of soil types and erosion was conducted as part of this Strategic Environmental Assessment. The moisture availability is an indicative measure of the climatic moisture that is available for plant growth in any environment. The proposed development site falls within moisture availability class 6 which is the most arid and described as a very severe limitation to agriculture. Within this environment of general aridity, small scale variations in climate across the study area and other climate parameters (such as temperature) are not very significant in determining agricultural potential and therefore influencing agricultural impact. As grazing is the overwhelmingly dominant agricultural land use, the most indicative measure of agricultural potential and productivity across the study area is the grazing capacity potential. The study area is an area of relatively low grazing capacity (within a national context) but is an area that is suitable for successful sheep farming.



³ Photo: Dewald Kirsten

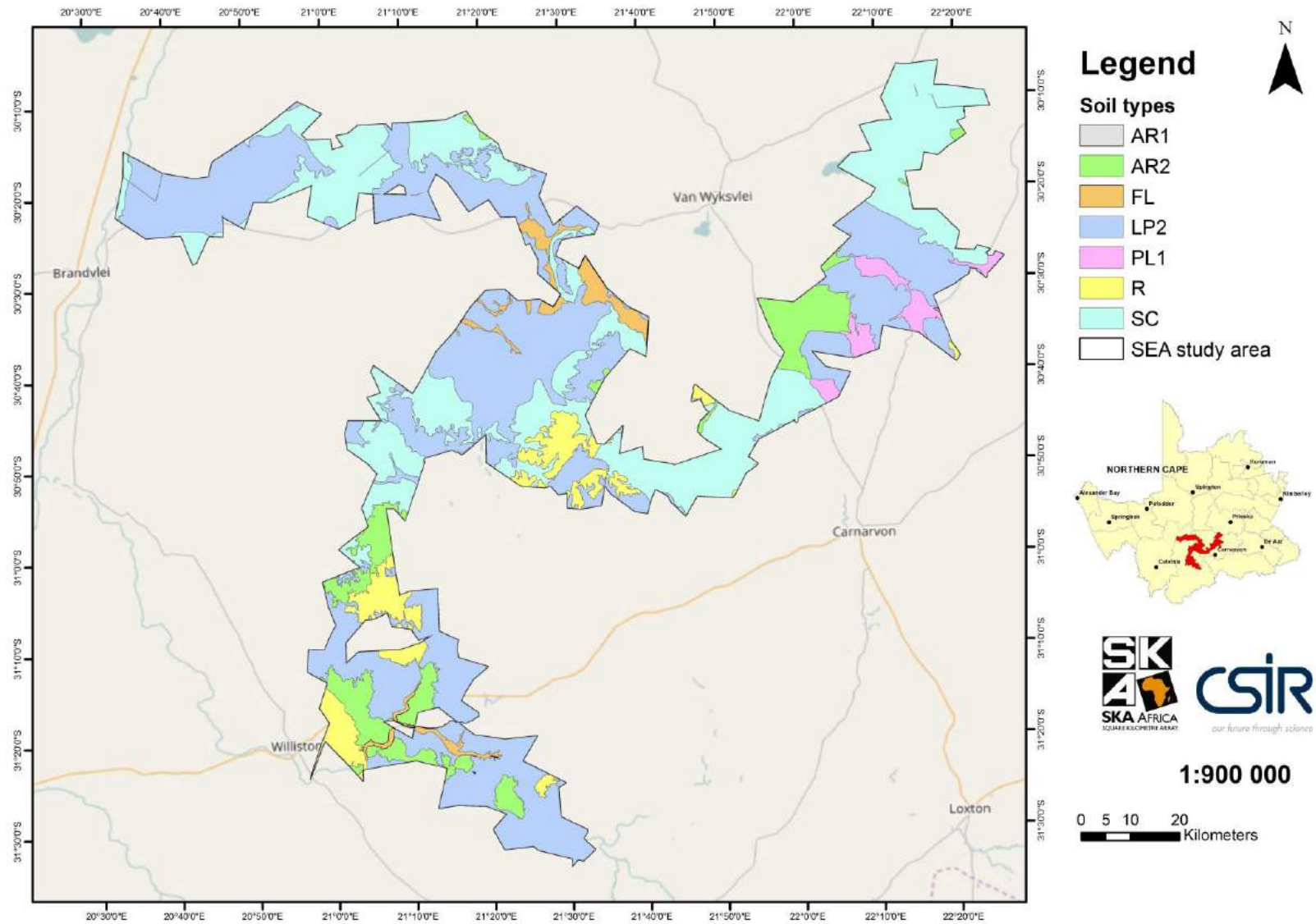


Figure 3-6: Soil types from the Southern African Agricultural Geo-referenced Information System (AGIS)

Vegetation types are closely linked to soil type, soil depth, rockiness, slope and aspect. Finer soil types with smaller grains (such as clay) generally retain moisture better than coarse-grained soils. In soils with very high clay content water may be retained so well that it is unavailable for absorption by plant roots. Clay also forms a compacted surface more easily, causing water to run off rather than penetrate deeply into the soil. Deep soil, if it is too sandy does not retain water as well as rocky soils. Vegetation growing on rocky soils is therefore more resilient to the effects of drought and grazing. Deep Karoo soils are very easily eroded by wind and water if denuded of a healthy vegetation layer, leading to even more degraded veld with poor fodder production for herbivores. The orange sand dunes are habitat for the endemic Red Lark. Silt and clay has accumulated in shallow valleys to form extensive level pans (vloëre) between Brandvlei and Van Wyksvlei (Figure 3-7). Deep silty friable alluvium flanks the Sakrivier and its tributaries creating a suitable habitat for the Critically Endangered Riverine Rabbit.



Figure 3-7: Pans (vloëre) between Brandvlei and Van Wyksvlei (Photo: Dr Sue Milton)

II. Terrestrial ecology and biodiversity

Two Biomes occur within the Strategic Environmental Assessment study area, namely the Azonal Vegetation Biome (which is part of the Inland Saline Vegetation Bioregion) and the Nama-Karoo Biome (which is part of the Bushmanland Bioregion and Upper Karoo Bioregion). Each biome contains several vegetation types which are described below. The spatial extent of each vegetation type within the Strategic Environmental Assessment study area is illustrated in Figure 3-8 below.

The azonal vegetation type occurring in the study area is the Bushmanland vloëre (pans) which is characterised by taller, woodier vegetation including trees (*Rhus lancea*), tall shrubs (*Salsola*, *Lycium*, *Tripteris*), and tall grasses (*Stipagrostis namaquensis*). In particular, *Xerocladia viridiramis* occurring in the northern part of the SKA telescope core and in the Brandvlei spiral arm, is a spiny leguminous shrub characteristic of deeper channels in endorrheic drainage features. The Bushmanland vloëre (pans) is found on deep silty to sandy soils in dry river beds and pans. All pans occurring in the study area are classified as azonal vegetation which has Least Threatened Status. Azonal habitats are severely threatened by invasion by *Prosopis glandulosa* and its hybrids. The pans follow drainage features through the Upper Karoo vegetation types.

The Northern Upper Karoo vegetation type, the Upper Karoo hardeveld vegetation type and the Western Upper Karoo vegetation type, are part of the Upper Karoo Bioregion. The Upper Karoo vegetation types are made up of succulent and non-succulent shrubs up to 0.5 metres high on stony ground and patches of grasses on sandy soil. This vegetation type occurs on sedimentary and dolerite rock and on calcrete. The dominant plant families are Asteraceae, Chenopodiaceae, Fabaceae, Poaceae, and Scrophulariaceae. The most commonly encountered species are *Pentzia incana*, *Eriocephalus ericoides*, *Rhigozum obovatum* and *Lycium species*. Endemic species occur within the Amaryllidaceae, Asphodelaceae, Crassulaceae, Fabaceae and Malvaceae plant families. All Upper Karoo vegetation types included in the study area have Least Threatened Status, but all are poorly conserved (Rouget et al. 2004⁴).

The Bushmanland arid grassland vegetation type, the Bushmanland basin shrubland vegetation type, and the Bushmanland sandy grassland vegetation type, are part of the Bushmanland Bioregion. The Bushmanland Arid Grassland vegetation types are dominated by desert grasses, with Karooid and woody shrubs in the Asteraceae, Bignoniaceae, Fabaceae, Scrophulariaceae and Zygophyllaceae plant families with abundant annual forbs and grasses after rain. The vegetation occurs on Kalahari Sands on plains, dunes and outcrops of calcrete and dolerite. The most abundant species are *Rhigozum trichotomum* and *Stipagrostis ciliata*. The few endemic species are from the Mesembryanthemaceae, Fabaceae and Scrophulariaceae plant families. All Arid Grassland vegetation types included in the study area have Least Threatened Status, but all are poorly conserved (Rouget et al. 2004).

⁴ Rouget, M., Reyers, B., Jonas, Z., Desmet, P., Driver, A., Maze, K., Egoh, B. & Cowling, R.M. 2004. South African National Spatial Biodiversity Assessment 2004: Technical Report. Volume 1: Terrestrial Component APPENDIX A. Pretoria: South African National Biodiversity Institute

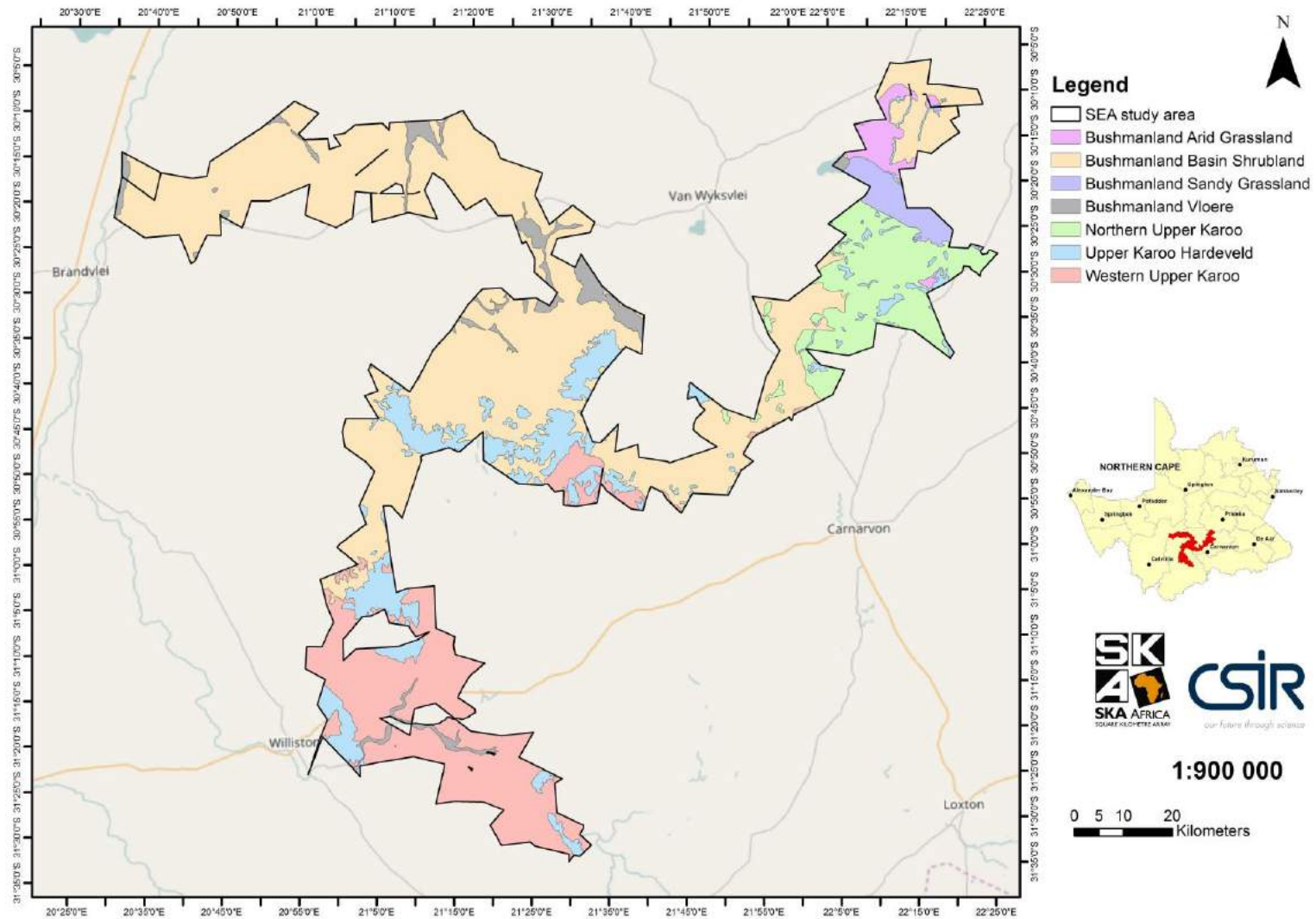


Figure 3-8: Vegetation map of the Strategic Environmental Assessment study area

Amongst the vegetation types described above, 89 records of 47 plant species of conservation concern were recorded in the study area. The plant families with the most species of conservation concern are Iridaceae, Amaryllidaceae and Apocynaceae. These three plant families are geophytes or small shade succulents and difficult to detect in field surveys during dry periods. Three plant species of conservation concern occur within the SKA telescope core, namely *Aloe dichotoma* (Figure 3-9, vulnerable), *Hoodia gordonii* (data deficient, declining), and *Acacia erioloba* (declining). The following plant species defined in the Northern Cape Nature Conservation Act⁵ as specially protected and protected, are present in the study area:

- slow-growing trees (*Boscia* species, *Acacia erioloba*),
- geophytes in the Amaryllidaceae, Hyacinthaceae, Iridaceae, Oxalidaceae plant families,
- succulents in the Apocynaceae, Asphodelaceae, Crassulaceae, Euphorbiaceae, Geraniaceae, Portulacaceae plant families, and
- certain medicinal plant species (*Harpagophytum* sp., *Sutherlandia* sp.).



Figure 3-9. *Aloe dichotoma*⁶ (quiver tree) forest in the SKA telescope core (Photo: Lydia Cape)

⁵ Northern Cape Nature Conservation Act 9/2009 (Provincial Gazette 1566 dated 19 December 2011)

⁶ Note that since 2015, the name *Aloe dichotoma* has changed to *Aloidendrum dichotomum* (Van Jaarsveld, E. and Judd, E (2015). Tree Aloes of Africa. Cape Town, Penrock publications, 74pp). However, for the purpose of this report, the name *Aloe dichotoma* has been kept.

The fine-scale habitat map of the SKA telescope core (Figure 3-10) illustrates the high degree of landscape heterogeneity and associated habitat diversity of the SKA telescope core. These characteristics makes the SKA telescope core a desirable area for conservation purposes as it represents a functional system in which most relevant ecological processes can operate without undue external influence or reliance. The SKA telescope core contains a full representation of the range of species, habitats and ecosystems present in the Upper Karoo area of the Northern Cape region. The declaration of the SKA telescope core as a formal protected area would contribute significantly to meeting conservation goals in the Upper Karoo since, in terms of the National Protected Areas Expansion Strategy (NPAES), the extent of the Upper Karoo Focus Area is 320 954 hectares and the protection of the SKA telescope core would provide approximately 131 000 hectares (approximately 41%) of the Upper Karoo target. This habitat diversity is also important for the fauna of the area and provides for greater resilience for fauna in the face of a fluctuating environment and global climate changes.

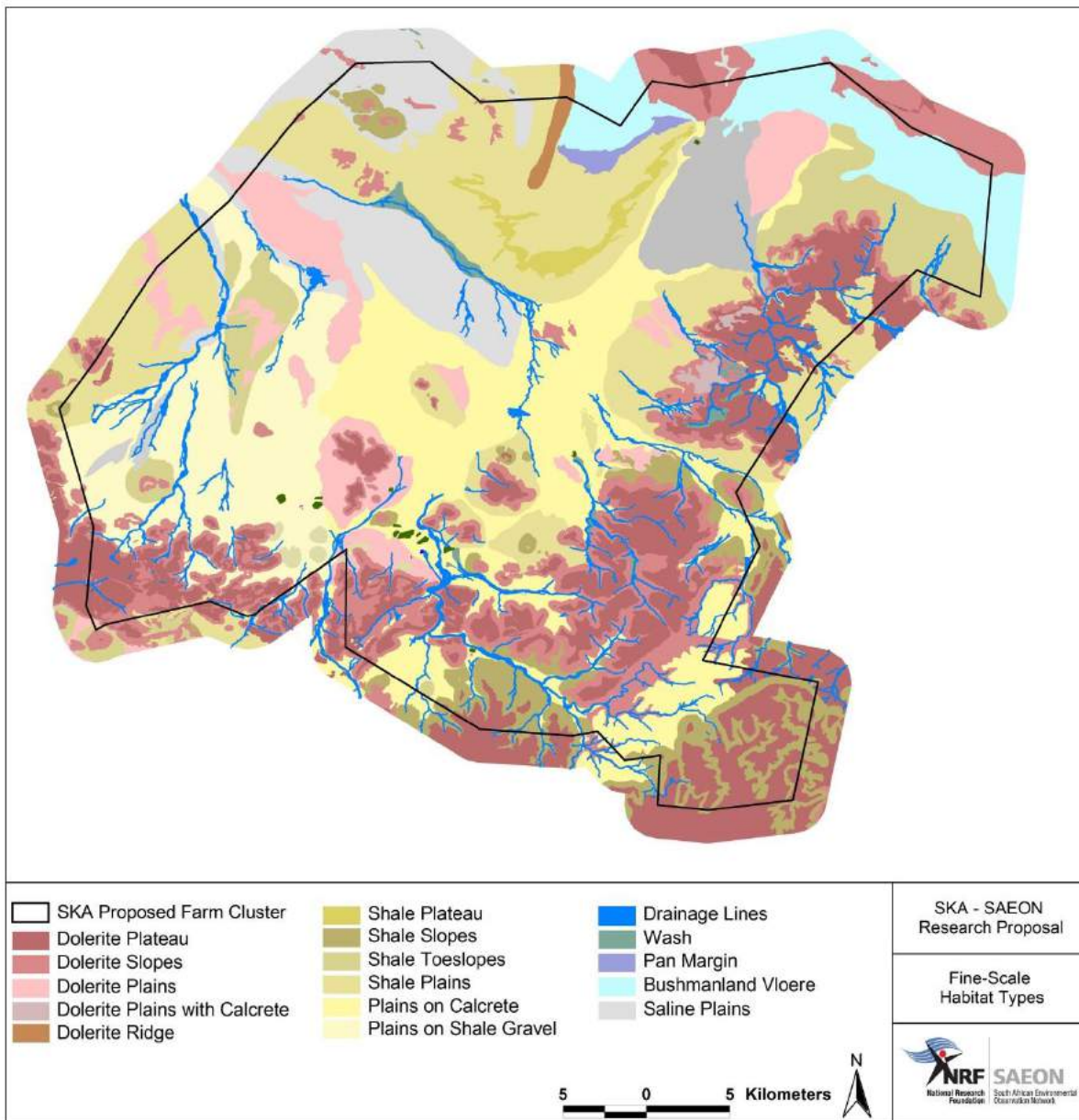


Figure 3-10: Fine-scale habitat map of the SKA telescope core

A site survey was conducted by Strategic Environmental Focus (Pty) Ltd (SEF) in December 2006 on the proposed Karoo Array Telescope (KAT) site which covers an area of approximately 20 square kilometres on the land owned by the National Research Foundation (Meys'dam and Losberg farms). SEF report that the study site consisted of six major faunal habitat types such as *Rhigozum trichotomum* and *Salsola species* dominated plains, dolerite hills and inselbergs, calcrete and shale plains, riparian vegetation and severely degraded areas. The *Rhigozum trichotomum* plains are plains or flatlands dominated by *Rhigozum trichotomum*. These plains are generally floristically poor and of low spatial heterogeneity, therefore not likely to support a diverse faunal assemblage. The *Salsola sp.* plains are restricted to the brackish and silty flats and contain small drainage lines or areas with high clay content and characterised by higher vegetation diversity. The dolerite hills, inselbergs and pediments (Figure 3-11), although relatively sparse in vegetation, provides for a greater diversity of microhabitat types due to the abundance of rock fissures and crags.



Figure 3-11: Rounded inselbergs in the SKA telescope core (Photo: Lydia Cape)

The habitats with high ecological sensitivity include riparian vegetation (dry watercourses) which are important movement corridors for faunal with a preference for temperate conditions (e.g. shrews). Riparian vegetation occurs in drainage lines which consist of defined non-seasonal channels bordered by both woody and grassy elements. The sand washes or larger drainage lines are dominated by *Stipagrostis namaquensis* with *Lebeckia spinescens*, *Cenchrus ciliaris* and scattered *Searsia (Rhus) lancea* trees. These habitat types span a large surface area (although of linear configuration), thereby enhancing re-colonisation by taxa during favourable conditions. Furthermore some of the watercourses, in particular those occurring to the north of the study site provide potential habitat for the "Critically Endangered" Riverine Rabbit (*Bunolagus monticularis*) and the "Near-Threatened" Giant Bullfrog (*Pyxicephalus adspersus*).

A survey using camera traps was conducted by the Endangered Wildlife Trust during the strategic environmental assessment in May-June 2016 to investigate the presence of the Riverine Rabbit (*Bunolagus monticularis*) within the SKA telescope core and is discussed in more detail further in this chapter. The particular focus of this study was to determine whether the Riverine Rabbits - a keystone conservation species for the riparian shrubland associated with the seasonal drainage system of the Karoo - occurs within the SKA telescope core. During the six- week survey and 725 nights of camera trap observations, no Riverine Rabbits were detected within the habitat surveyed by the Endangered Wildlife Trust nor were any seen by the Drylands Conservation Programme field officers when setting and checking cameras. It can, therefore, be concluded with a fair degree of certainty, that Riverine Rabbits do not occur on the area surveyed.

The dolerite outcrops, inselbergs and shale pediments were rated as Medium-High Ecological Sensitivity habitat as the rocky crevices and boulders provide niches with the ability to sustain a faunal assemblage (mainly mammal species) not likely to be encountered on the plains. Dolerite hills, inselbergs and pediments of exposed dolerite sills and dykes have sparse vegetation cover. Vegetation includes a number of protected plant species (*Aloe dichotoma*, *Boscia albitrunca*) as well as *Rhigozum obovatum*. The dolerite-shale interface facilitates animal dispersal to other rocky outcrops and ridges and functions as an important ecological linkage.

Finally the habitats of low ecological sensitivity include the *Rhigozum trichotomum* plains, *Salsola species* plains and areas which have been disturbed by grazing. The gravel plains are similar to the pediment or footslopes of most of the inselbergs but differ in supporting an open cover and a slightly different species complex (e.g. a higher diversity of *Mesembryanthemaceae*). The gravel plains below the flat-topped hills are dominated by *Rhigozum trichotomum* with *Lycium*, *Salsola aphylla*, and a grassy understorey of *Stipagrostis obtusa* with *Aridaria noctiflora*, *Asparagus retrofractus*, *Drosanthemum*, *Lebeckia*, *Leysera*, *Lycium cinereum*, *Malephora crocea*, *Osteospermum scariosum*, *Pentzia incana*, *Pteronia*, *Ruschia spinescens*, *Salsola tuberculata*, *Zygophyllum microphyllum* and the invasive alien *Atriplex lindleyi*. The calcrete plains have even lower, sparser vegetation similar in composition to gravel plains but with a greater abundance of *Salsola tuberculata*. The silt plains are characterised by *Salsola aphylla* with *Lycium cinereum*, *L. oxycarpum* and an understorey of succulents, forbs and a few grasses (*Drosanthemum*, *Malephora crocea*, *Ornithogalum*, *Setaria verticillata*, *Stipagrostis ciliata*, *S. obtusa*, *Mesembryanthemum guerichianum*). Invasive alien species such as *Prosopis glandulosa* var. *torreyana* (mesquite) and *Atriplex lindleyi* subspecies *inflata* (blasiebrak) occur in these habitats within the SKA telescope core (Figure 3-12). These habitats are disturbed systems and consist of a low structural and floristic diversity and support few faunal species of conservation concern. The areas which have been disturbed through livestock grazing are associated with farm dams and boreholes and characterised by large trees (mainly invasive alien *Prosopis glandulosa*) and herbaceous indigenous and alien plants.

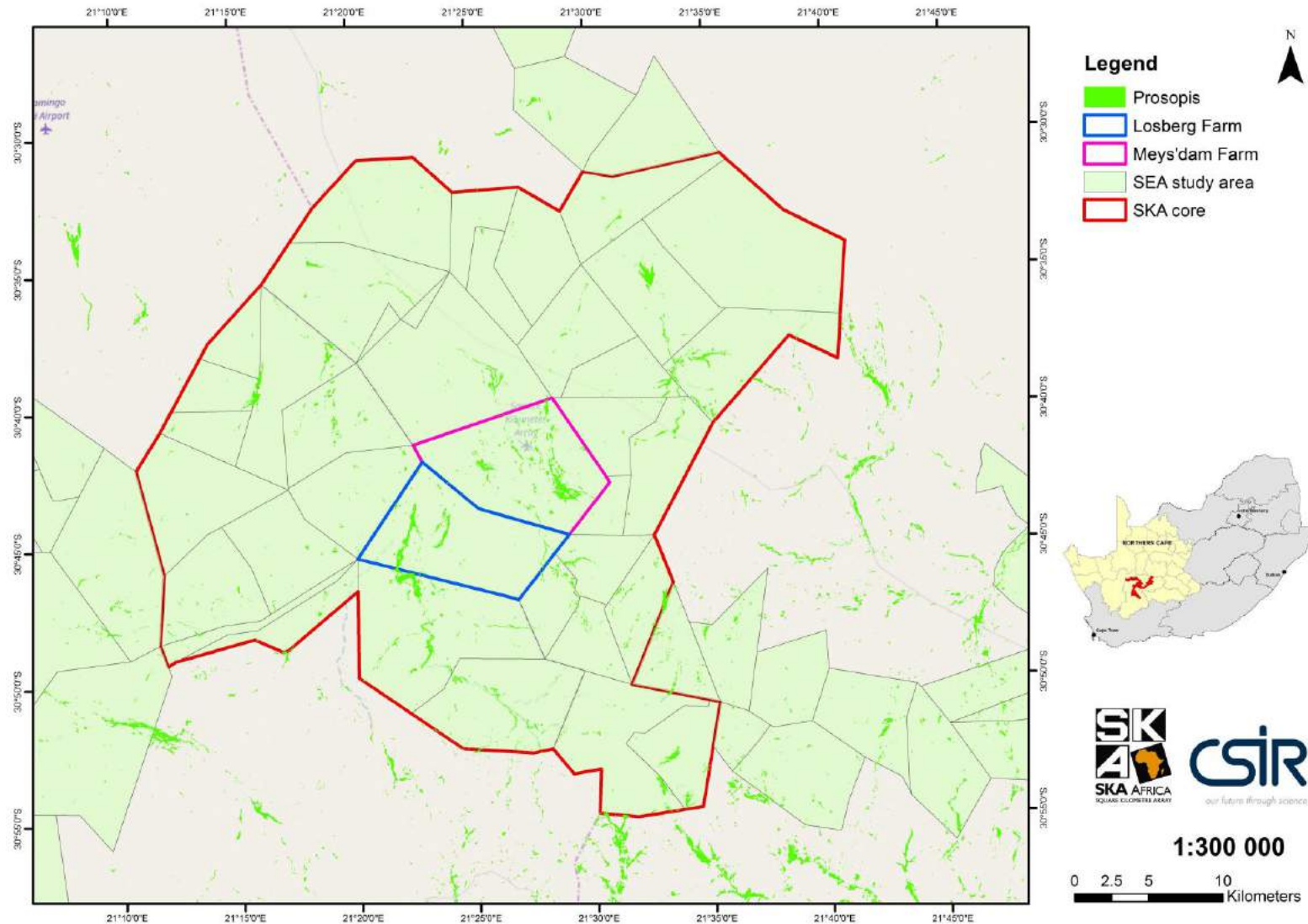


Figure 3-12: Invasion by *Prosopis glandulosa* and its hybrid in the SKA telescope core

The study site supports a high diversity of mammal species, particularly rich in small carnivores and rodents. Most of the species were widespread and not considered to be of any conservation concern. The survey conducted by the Endangered Wildlife Trust in 2016 confirmed the presence of several small carnivores, insectivores and rodents including mongoose, caracal, black backed jackal, aardvark, steenbok, kudu and common hares in the SKA telescope core (Figure 3-13 to Figure 3-17). In addition to this, the SEF survey in December 2006 recorded the presence of the African wild cat (*Felis silvestris lybica*), the steenbok (*Raphicerus campestris*), the striped mouse (*Rhabdomys pumilio*) and the Karoo Bush Rat (*Otomys unisulcatus*) in the SKA telescope core. Other species that were flagged as potentially present in the study area but not recorded during field surveys include the Litledales's Whistling Rat (*Parotomys littedalei*), the Honey Badger (*Melivora capensis*) and the Lesueur's Wing-gland Bat (*Cistugo lesueuri*), all three rated as Least Concern status on the International Union for Conservation of Nature (IUCN)⁷ Red List of Threatened Species^{8, 9, 10}. Furthermore a survey was conducted by the Endangered Wildlife Trust in May and June 2016 to confirm that the Riverine Rabbit (*Bunolagus monticularis*), which is critically endangered status on the IUCN Red List of Threatened Species, does not occur within the study area.

A bat fauna sensitivity study was also conducted as part of this Strategic Environmental Assessment and identified that several small roosts are likely to occur in the rocky outcrops on the scattered rocky hills throughout the site and in the ridges occurring more densely in the southern areas; however the foraging potential for bats is low across most of the Strategic Environmental Assessment study area due to the arid conditions.



Figure 3-13: A hare (*Lepus saxatilis* or *Lepus capensis*) (Photo: camera trap NV125 on 28/05/2016)

⁷ The IUCN Red List is a world standard for evaluating the conservation status of plant and animal species. The IUCN Red List determines the risks of extinction to species, and gives information and analyses on the status, trends and threats to species; and thus plays an important role in guiding conservation activities of governments, NGOs and scientific institutions.

⁸ Coetzee, N. & Griffin, M. 2008. *Parotomys littedalei*. The IUCN Red List of Threatened Species 2008

⁹ Jacobs, D. 2008. *Cistugo lesueuri*. The IUCN Red List of Threatened Species 2008

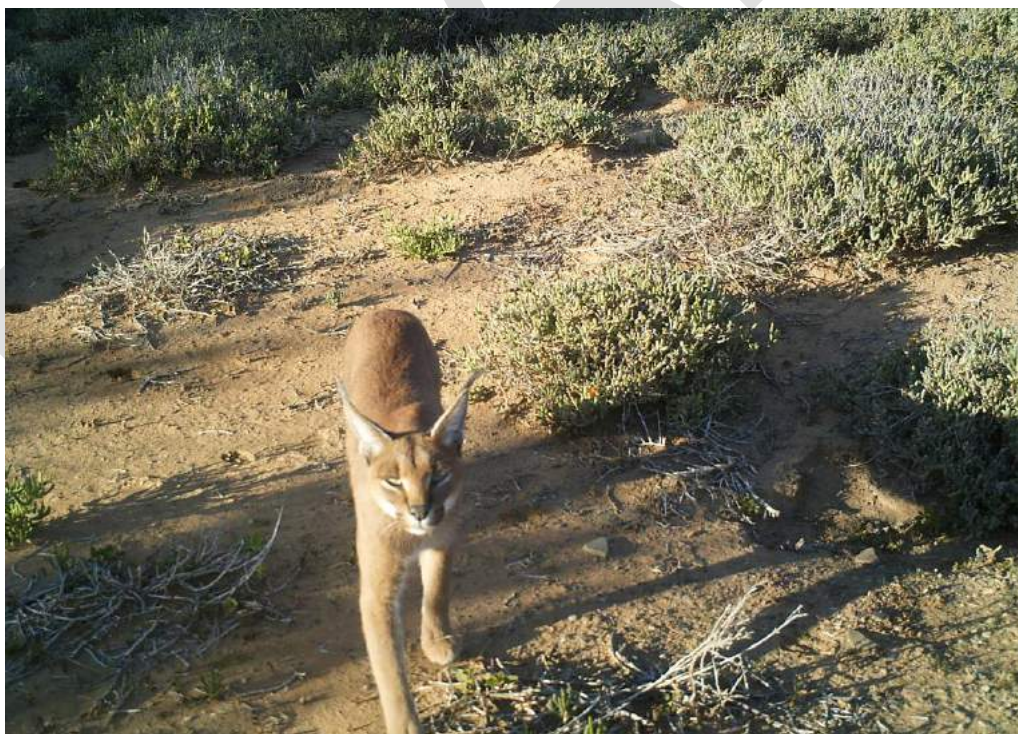
¹⁰ Do Linh San, E., Begg, C., Begg, K. & Abramov, A.V. 2016. *Mellivora capensis*. The IUCN Red List of Threatened Species 2016



Bushnell (M) NV120 75°F23°C

05-28-2016 16:25:52

Figure 3-14: A bat-eared fox (*Otocyon megalotis*) (Photo: camera trap NV120 on 28/05/2016)



Bushnell (M) NV124 50°F10°C

05-26-2016 09:48:17

Figure 3-15: A Caracal (*Felis caracal*) (Photo: camera trap NV124 on 26/05/2016)



Bushnell (M) NV123 42°F5°C ●

01-17-2012 06:41:37

Figure 3-16: A kudu (*Tragelaphus strepsiceros*) (Photo: camera trap NV213 on 21/06/2016¹¹)



Bushnell (M) TC128 60°F15°C ●

05-12-2016 13:54:08

Figure 3-17: A Porcupine (*Hystrix africaeaustralis*) (Photo: camera trap TC128 on 12/05/2016)

¹¹ Incorrect date indicated on photo due to reset to factory defaults during the survey

The most important habitat type for reptiles in the SKA telescope core and the dolerite outcrops and inselbergs due to their ability to provide numerous niches and protective features. The study area is fairly rich in tortoises and lizards but snake diversity is low in comparison with higher rainfall areas. The Fisk's House Snake (*Lamprophis fiskii*) which could occur in the SKA telescope core is listed as Vulnerable. The only species of conservation concern is the Karoo padloper (*Homopus boulengeri*) tortoise which occurs in the south of the study area, and is Near-Threatened according to the assessment by Bates et al. (2014)¹². This species would probably benefit from reduced grazing by domestic livestock and a reduction in the populations of Pied Crows that appear to be increasing in response to increased traffic and associated roadkill (Dean et al. 2005)¹³.

The dolerite sills and rock faces provide breeding, roosting and foraging habitat for a number of bird species, most notably threatened species such as Verreaux's Eagles (*Aquila verreauxii*), the "Near-Threatened" Lanner Falcon (*Falco biarmicus*) and the endemic Jackal Buzzard (*Buteo rufofuscus*). The grey shale pediments also provide an ideal nesting platform for the near-endemic Sclater's Lark (*Spizocorys sclateri*). An avifauna specialist study was conducted in the SKA telescope core in 2007, indicating that 189 bird species are expected to occur in the study area of which 33 were confirmed during the survey period¹⁴. During this study, 13 Red Data birds with distribution ranges sympatric to the study area were identified of which 4 species were allocated low probabilities of occurrence and considered vagrant in the study area. The remaining nine Red Data birds are the Martial Eagle (*Polemaetus bellicosus*); Lesser Kestrel (*Falco naumanni*); Kori Bustard (*Ardeotis kori*); Ludwig's Bustard (*Neotis ludwigii*); Red Lark (*Certhilauda burra*); Black Stork (*Ciconia nigra*); Secretary Bird (*Sagittarius serpentarius*); Lanner Falcon (*Falco biarmicus*); and Sclater's Lark (*Spizocorys sclateri*). In 2016, an avifauna sensitivity study was prepared as part of this Strategic Environmental Assessment. The number of species recorded within the Strategic Environmental Assessment study area is 264, of which only 152 species can be considered resident, and the remainder are breeding migrants (19 species), non-breeding migrants (32 species), nomads (37 species) and vagrants (15 species). Most nomadic species associated with aquatic habitats may be resident for a time when the ephemeral water bodies (vleis and pans) are flooded, and would remain until the area dried out, however the core area has relatively few suitable aquatic habitats for birds. Observations in the field were conducted by a birding team led by Etienne Marais in August 2016. The fieldwork was conducted using Birdclasser¹⁵, and resulted in the compilation of an SKA Atlas and Biobash including 156 records of bird species for the Strategic Environmental Assessment study area. The Near-Threatened species recorded within the study area include the European Roller (*Coracias garrulous*), Ludwig's Bustard (*Neotis ludwigii*), Karoo Korhaan (*Heterotetrax [Eupodotis] vigorsii*), Eurasian Curlew (*Numenius arquata*), Chestnut-banded Plover (*Charadrius pallidus*), Double-banded Courser (*Rhinoptilus africanus*), Greater Flamingo (*Phoenicopterus ruber*), Lesser Flamingo (*Phoeniconaias minor*) and Sclater's Lark (*Spizocorys sclateri*). The vulnerable species recorded within the study area include the African Grass-Owl (*Tyto capensis*), Verreaux's Eagle (*Aquila verreauxii*), Burchell's Courser (*Cursorius rufus*), Secretarybird (*Sagittarius serpentarius*), Lanner Falcon (*Falco biarmicus*), Black Stork (*Ciconia nigra*) and Red Lark (*Calendulauda burra*). The endangered species recorded within the study area include the Kori Bustard (*Ardeotis kori*), Black Harrier (*Circus maurus*) and Martial Eagle (*Polemaetus bellicosus*).

¹² Bates, M.F., Branch, W.R., Bauer, A.M., Burger, M., Marais, J., Alexander, G.J., & de Villiers, M.S. 2014. Atlas and Red List of the Reptiles of South Africa, Lesotho and Swaziland. Suricata 1. South African National Biodiversity Institute

¹³ Dean, W.R.J., Milton, S.J. and Anderson, M.D. 2005. Use of road kills and roadside vegetation by Pied and Cape Crows in semi-arid South Africa. Ostrich 77: 102-104

¹⁴ Strategic Environmental Focus (Pty) Ltd site survey and Environmental Assessment Report, 2006-2007

¹⁵ Mobile phone application to capture bird sightings in the field with GPS precision

The highest priority resident species within the study area is the Red Lark (*Certhilauda burra*). For this species, protection of the remaining habitat is especially urgent. Populations of the Red Lark are fragmented within the present distribution range of the species. There is some evidence to show that the Red Lark is threatened by domestic livestock in its optimal habitat and that numbers have been reduced by overgrazing (Dean et al. 1991). The highest priority endemic and nomadic species in the Karoo is the Sclater's Lark (*Spizocorys sclateri*). The Sclater's Lark occurs on arid to semi-arid stony plains with scattered shrubs, grasses and bare patches (Hockey et al. 2005). Sclater's Lark is a nomadic, endemic species categorised as Near-threatened by BirdLife South Africa. The birds occur at a fairly low density mainly on gravel plains with very little vegetation. A third priority species, the endemic and resident Cinnamon-breasted Warbler (*Euryptila subcinnamomea*) is confined to inselbergs and rocky ridges in the Succulent and Nama Karoo. The entire population is fragmented into metapopulations throughout its distribution range. The Ludwig's Bustard (*Neotis ludwigii*) was recorded about three times as frequently and at a higher density than the Kori Bustard. It is unlikely that dish-antenna structures would be a hazard for this species, nor will the construction phase be any threat to the species in the area. However Ludwig's Bustards fly long distances, often in the dawn or dusk in low light conditions (Shaw 2013) and consequently have a high susceptibility to collisions with power lines.

Based on the terrestrial ecology and biodiversity assessment undertaken as part of this Strategic Environmental Assessment, areas assessed to be unsuitable for development were identified within the study area. These sites are habitats that are essential for the survival of rare plant or animal species and practically impossible to restore once they have been destroyed. These areas were demarcated and will be avoided during SKA construction and operation activities. The extent and mapping of these areas assessed to be unsuitable for development (very high environmentally sensitive areas) will be verified by expert fieldwork prior to the construction phase. These areas are illustrated in Figure 3-18 and include:

- exposed mudstone rock sheets (because these features are home to rare succulents and reptiles);
- hills and steep slopes (because these features cannot be restored once destroyed by blasting, trenching or road building);
- pans and wetlands (because development may change drainage patterns and affect the wildlife especially birds, amphibians and fish that use the pans after rain); and
- red sand-dunes (because these features are habitat of the narrow range endemic and substrate-restricted Red Lark).

The potential negative impacts associated with SKA activities and infrastructure will result from the construction and operation of the road network, trenching for installation of fibre-optic and electrical cables, construction of the dish-antennas, associated construction camps and borrow pits, overhead electrical infrastructure, and people on site during the construction and operational phases (with a limited number of persons accessing the site during operation phase), and the reduction of water sources from the removal of wind mills and the closure of farm dams. Potential negative impacts which could result from the construction activities and require mitigation and management activities include:

- removal of vegetation,
- damage to sensitive habitats,
- displacement of fauna and destruction of rare plants,
- increased risk of soil erosion through road construction on inclines or poor management of runoff from telescopes,
- roads or other hardened surfaces,
- alteration of drainage patterns and
- acceleration of the spread of invasive alien plant species.

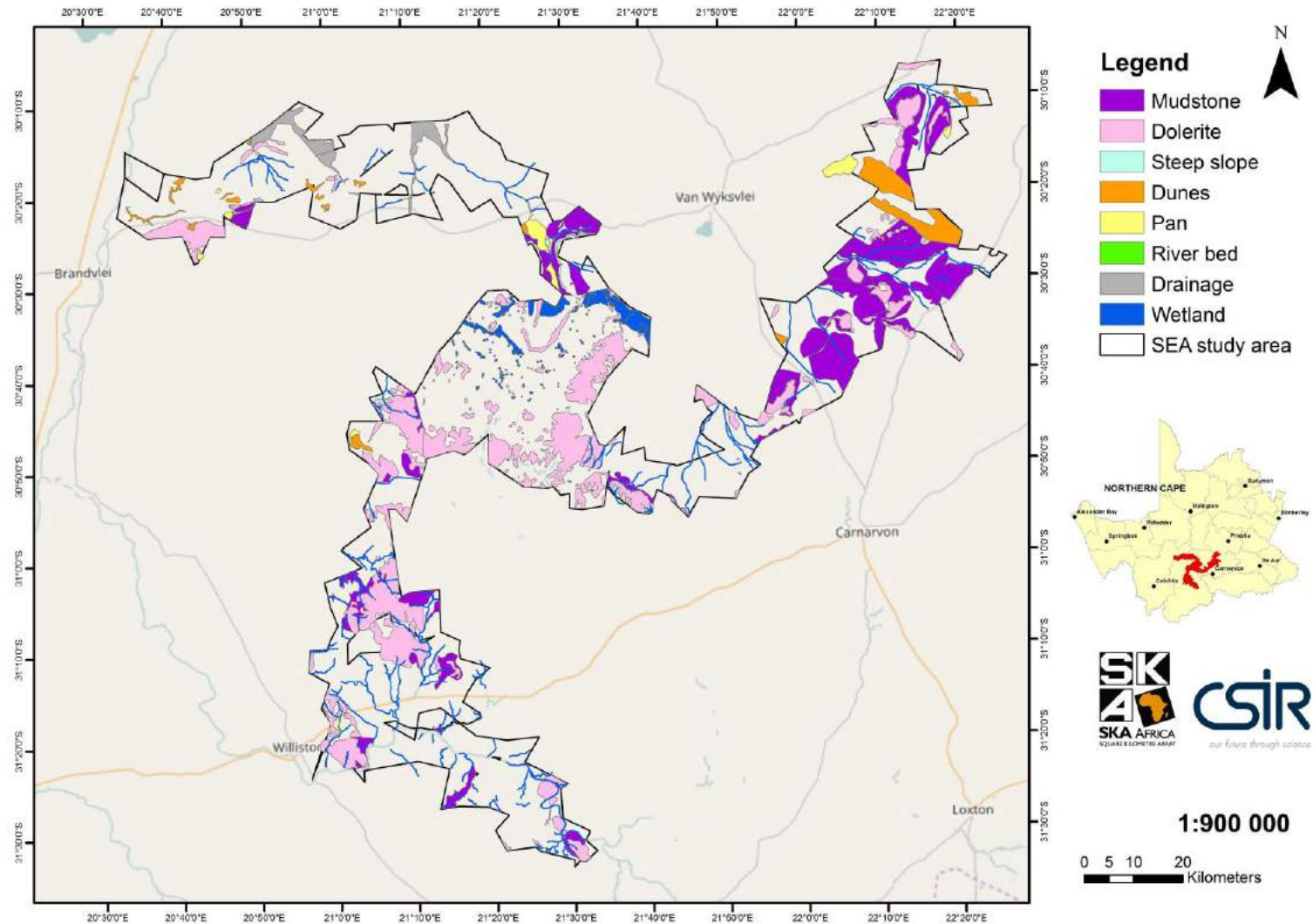


Figure 3-18: Very High sensitivity terrestrial ecology and biodiversity features within the study area

In terms of fauna, indirect potential negative impacts could result from bird strikes or electrocution on overhead powerlines, spread of invasive alien plant species, and fragmentation of populations of some reptiles (tortoises, snakes, monitor lizards) and mammals (aardvark, pangolin) as a result of fencing. These impacts would mainly occur during the operation phase of SKA1_MID.

The terrestrial ecology and biodiversity specialist identified potential positive ecological and environmental impacts resulting from the construction and operation of SKA, including:

- the release of the core area from its current grazing regimes (livestock ranching), and
- the initiation of programmes to control invasive alien plant species, particularly *Prosopis spp.* that has invaded drainage lines and pans, and is posing a threat to water resources and biodiversity; and
- long term research and monitoring programmes to study the impacts of climate change and study animal movements within the core area.

The declaration of the SKA telescope core as a protected area represents a significant opportunity for ecosystem conservation. The long-term research and monitoring programmes, proposed in the SKA telescope core and described in Chapter 5 of this Integrated Environmental Management Plan, have a great potential for stimulating research on ecology, biodiversity and ecological restoration in the Central Karoo.



III. Aquatic ecosystems

The Strategic Environmental Assessment study area lies completely within the Lower Orange Water Management Area (WMA14) in the D54E quaternary catchment, and almost entirely within the Nama Karoo Level 1 ecoregion¹⁶. Over large areas, groundwater is the only source of water. It is of major importance in the Lower Orange Basin. Groundwater sources provide approximately 60% of the available water within the Orange River tributaries sub-area. The Orange River provides most groundwater in the localised vicinity available for abstraction. Current groundwater use is deemed to be roughly in balance with the sustainable yield within the Water Management Area. The characteristics of the Karoo Level 1 ecoregion are:

- diverse topography dominated by plains with a moderate to high relief and lowlands, hills and mountains with moderate to high relief;
- seasonal to ephemeral rivers, such as the Hartbees and Sak rivers. Perennial rivers that traverse this region include the Riet (tributary of the Vaal River located in the eastern part of the ecoregion) and Orange rivers;
- moderate to low rainfall (around 500 millimetre per year) in the east, decreasing to arid in the west (around 70 millimetre per year). Coefficient of variation of annual precipitation is moderate to high in the east to very high (30 to 40%) in the west, and
- low drainage density but medium to high in some parts.

The Karoo landscape is heavily influenced by the occurrence of dolerite dykes, sills and rings, which control drainage patterns and the occurrence of wetlands¹⁷. Surface-groundwater interactions are thought to be important in dry environments such as the Karoo for sustaining surface water ecosystems, while evaporation is the dominant component of the water balance¹⁸. Most of the surface water ecosystems are intermittent or ephemeral, being inundated only for brief periods each year, with periods of drought that are unpredictable in duration. Various rivers in the study area seem to disappear underground (percolation of surface water assumed). However, imagery such as the Digital Elevation Model, 1:250 000 scale geological map and LANDSAT indicates the continuation of these channels downstream (CGS, 2005). This continuation may indicate the channels to be palaeochannels or more likely channels utilised during flood and exceptional rainfall events.

The ephemeral rivers of the Karoo are highly dependent on groundwater discharge, which occurs at springs and when groundwater recharge (through precipitation at higher elevations) allows the water table to intersect with the river channel. Groundwater discharge in this manner will deplete groundwater storage and discharge will cease at some point. There are numerous drainage lines across the flat landscape, draining water off slopes, and more slowly across plains or basins. Due to the low gradient of most of the terrain, these drainage lines proliferate, sometimes with a number of lines running more or less in parallel across the plains, creating a wash effect¹⁹. Drainage patterns are also fairly dynamic due to the lack of gradient, as a small obstruction to flow (plant roots, rocks, burrows) can change the way water moves across the flat surface. In many instances, water flows into flat endorheic pans.

¹⁶ Kleynhans, CJ, Thirion, C and Moolman, J (2005). A Level I River Ecoregion classification System for South Africa, Lesotho and Swaziland. Report No. N/0000/00/REQ0104. Resource Quality Services, Department of Water Affairs and Forestry, Pretoria, South Africa.

¹⁷ Woodford, A.C and Chevallier, L., 2002. Hydrogeology of the main Karoo Basin: Current Knowledge and Future research needs. Water Research Commission Report No TT 179/02, 466pp

¹⁸ Allan DG, Seaman MT, Kaletja B. (1995). The endorheic pans of South Africa. In: Cowan, GI. (Eds), *Wetlands of South Africa*. Department of Environmental Affairs and Tourism, Pretoria, South Africa. 75-101

¹⁹ MacDonald, D. 2009. Botanical Assessment of proposed site for the MeerKAT radio astronomy facilities on the farms Losberg and Meys'dam near Carnarvon, Northern Cape. Report submitted to SKA, July 2008, 30 pp

A Freshwater Aquatic Ecosystems assessment was undertaken during the Strategic Environmental Assessment in order to identify, delineate and describe the different types of freshwater aquatic features (i.e. wetlands including pans and watercourses) occurring within the study area. The freshwater aquatic ecosystems assessment led to the delineation of 11 wetland types and seven river types in, and immediately adjacent to, the study area. Most of the surface water ecosystems are intermittent or ephemeral, being inundated only for brief periods each year, with periods of drought that are unpredictable in duration. A dominant feature of the Karoo landscape is the alluvial floodplains or washes. Ephemeral rivers (Figure 3-19) and wetlands (Figure 3-20) are particularly vulnerable to changes in hydrology and water quality, as they are specifically adapted to brief periods of inundation and flow, and pollutants and sediments entering these watercourses are not regularly diluted or flushed from them, thus leading to a lack of resilience against pollution, erosion and sedimentation. Many of the wetlands and rivers are endorheic. The more perennially inundated Sak and Riet-Vis rivers lie to the south and west of the study area. The rivers and wetlands in the study area are mostly in good condition, with a Present Ecological Status (PES) of A or B, due to the low level of impact from the extensive rather than intensive human activities in the area. The aquatic ecosystems of the Northern Cape are poorly protected or, in the case of all of the wetland types identified in this study, not protected at all. The proposed clearing of mesquite trees (*Prosopis spp.*) from the study area and the potential declaration of the SKA telescope core as a protected area in terms of the National Environmental Management: Protected Areas Act, 2003 are potential positive impacts of the project.



Figure 3-19: Ephemeral watercourse in the Brandvlei spiral arm (Moffys Dam Farm)
(Photo: Kate Snaddon)



Figure 3-20: Ephemeral wetland in the Brandvlei spiral arm (Dubbelde Vlei Noord Farm) (Photo: Kate Snaddon)

Sensitivity ratings were established based on the condition and ecological importance of the aquatic features of the region, as well as their sensitivity to potential impacts associated with the design, construction and operation of SKA. Since most impacts are closely tied to the location and layout of dish-antenna sites and the associated infrastructure, the freshwater aquatic feature sensitivity assessment informed the proposed design of the South African mid-frequency array of SKA Phase 1.

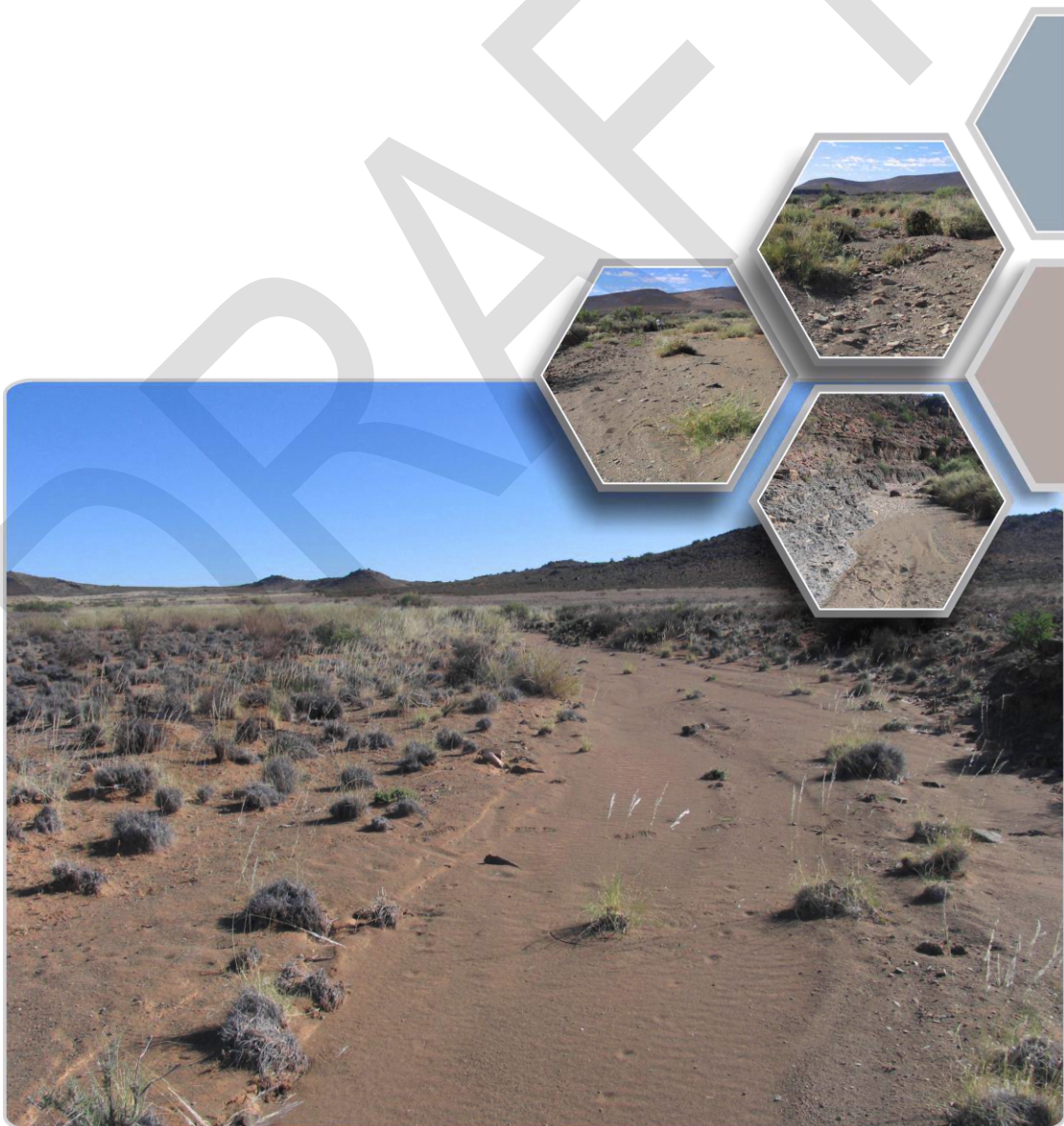
The areas assessed to be unsuitable for development (very high environmentally sensitive areas) are the depressional wetlands, the seep wetlands and the wetland flats (Figure 3-21). These wetlands tend to be discrete wetland features, with fairly clear boundaries. These areas were demarcated and will be avoided during SKA construction and operation activities. The remaining wetland types, all of which are riverine (i.e. floodplain and valley-bottom wetlands) occupy a large proportion of the study area, and are more difficult to delineate, both on a map and in the field. The wetland characteristics of these features are difficult to determine, and it would not be possible to avoid these features when building linear infrastructure in the area. Although more difficult to delineate, the floodplain and valley-bottom wetlands as well as all river reaches remain sensitive features and are illustrated in Figure 3-22.

The SKA activities that are most likely to impact on freshwater ecosystems include:

- Locating antenna sites, and associated infrastructure in or close to surface freshwater ecosystems;
- Construction activities, especially those that require the removal of earth (e.g. borrow pit sites), re-shaping of beds and banks of watercourses or wetlands (e.g. for road construction), or in-filling (e.g. for levelling of antenna sites);
- Trenching and soil compaction, for the burial of cables close to dish-antennas;
- Stormwater generation from roads and hardened surfaces, and stormwater management, and
- Crossing of roads and services over wetlands and watercourses.

The potential negative impacts which could result from the construction activities listed above and require mitigation and management activities include:

- Hydrological alteration which includes largely the interruption of natural surface and/or subsurface passage of flow and the concentration of flows due to roads or services across wetlands or watercourses;
- Erosion caused by loss of vegetation cover as a result of site clearing, and consequent sedimentation of aquatic ecosystems. Erosion is particularly a high risk in steep environments, and in drainage lines that lack channel features and are naturally adapted to lower energy runoff with dispersed surface flows (such as unchannelled valley-bottom wetlands);
- Physical destruction or damage of surface freshwater ecosystems by workers and machinery operating within or in close proximity to wetlands or watercourses;
- Drawdown of groundwater causing a cone of depression in the vicinity of boreholes;
- Pollution (water quality deterioration) of freshwater ecosystems and groundwater through spillage and/or runoff of contaminants such as fuel, oil, concrete, wash-water, sediment, and hazardous chemicals; and
- Interception of subsurface flow by compaction of soil above cables, and creation of preferential flowpaths around pipes/cables.



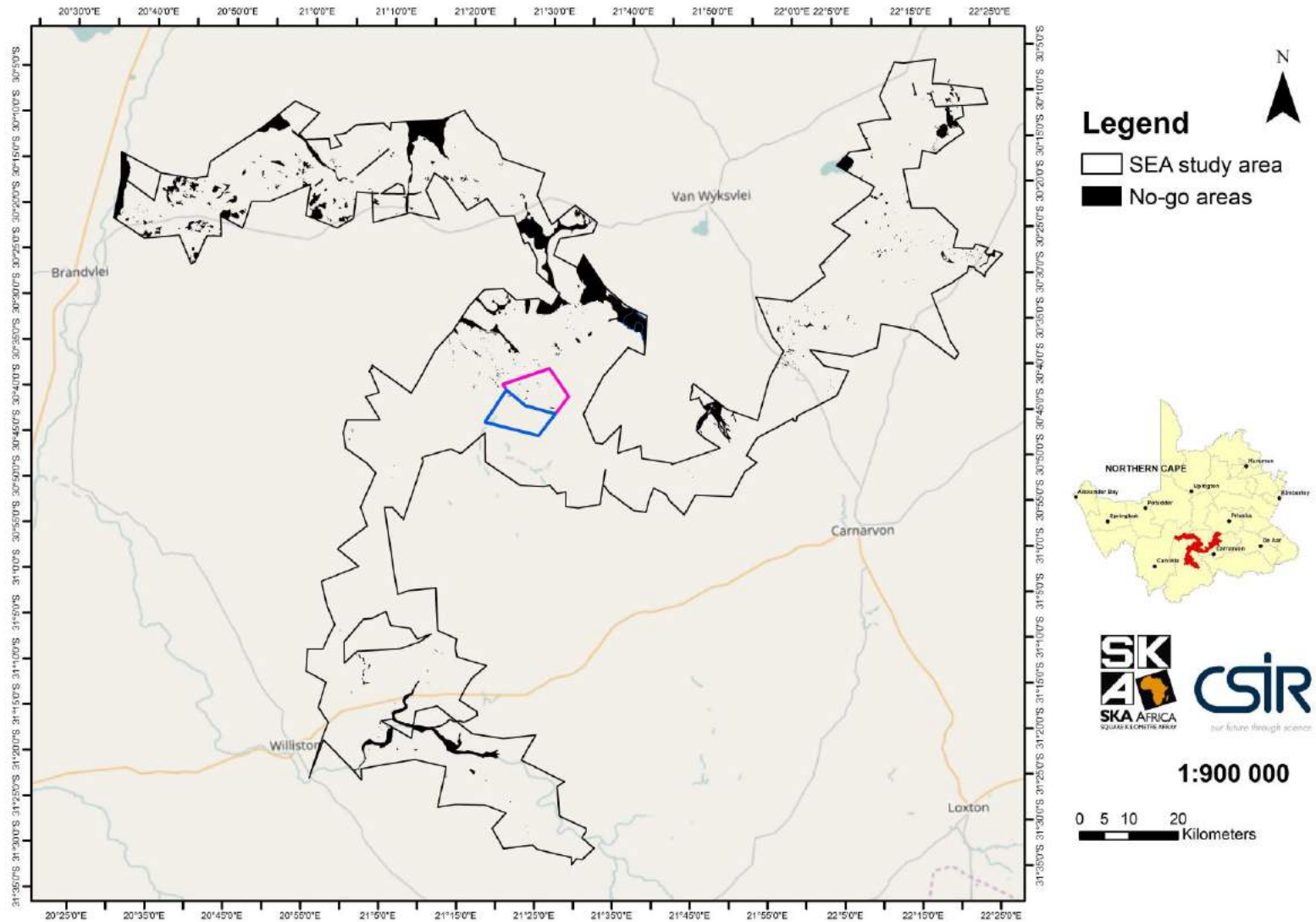


Figure 3-21: Very high sensitivity aquatic ecosystem features (unsuitable for development)

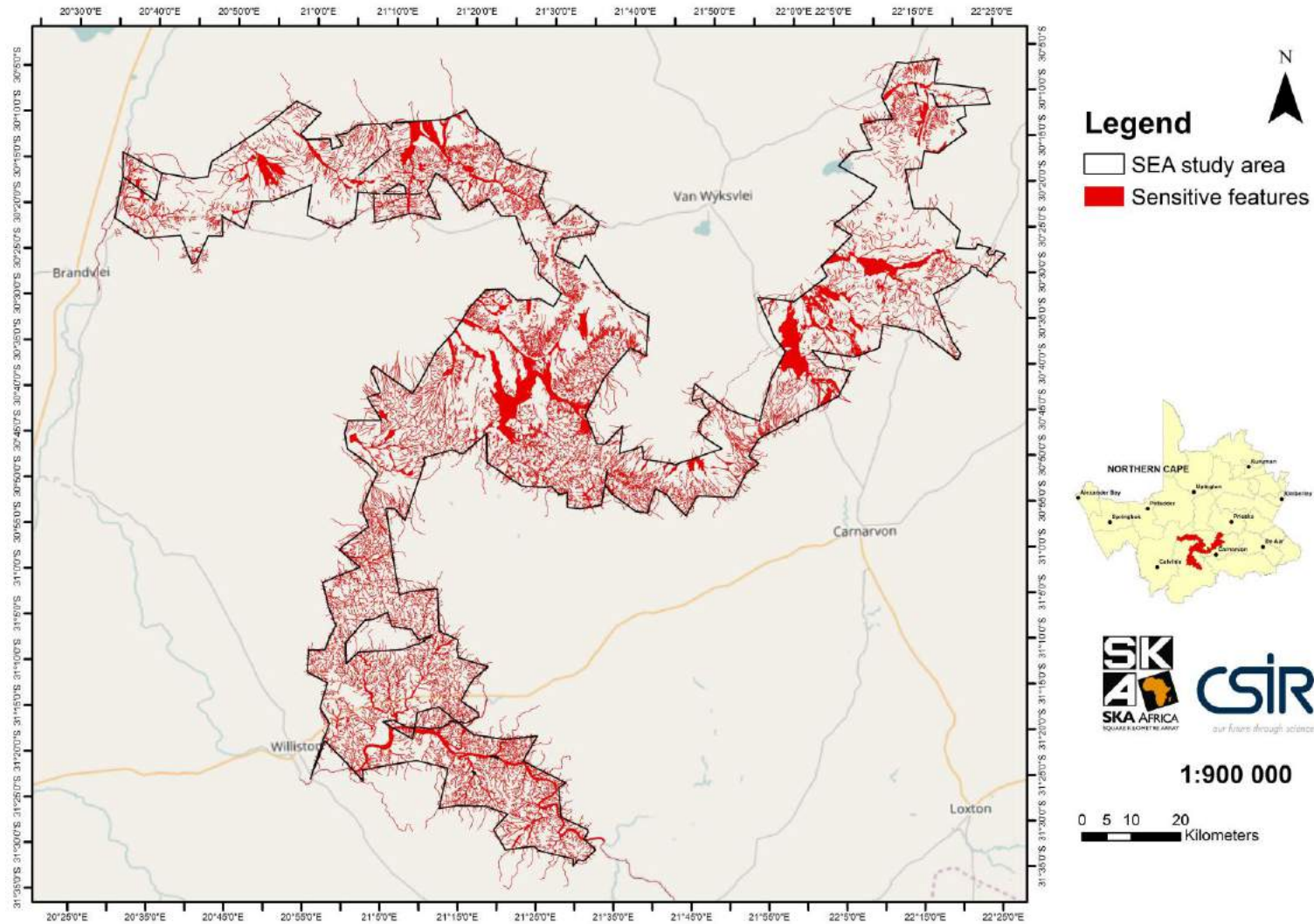


Figure 3-22: Sensitive aquatic ecosystem features (valley-bottom wetlands and floodplain wetlands, watercourses)

IV. Archaeology, palaeontology and cultural heritage

South African legislation (National Heritage Resources Act (Act No. 25 of 1999),) defines heritage resources and provides protection to all heritage resources of significance including places or objects of aesthetic, architectural, historical, scientific, social, spiritual, linguistic or technological value or significance. All heritage assessments, including scoping assessments, should therefore take into consideration all heritage resources including archaeology, shipwrecks, battlefields, graves, and significant structures, historical settlements, landscapes, geological sites as well as palaeontological sites and objects.

The Strategic Environmental Assessment study area is located in the Bo-Karoo (Upper Karoo), a vast semi-arid area, which falls within the southern Bushmanland regions of the Northern Cape, on the north-western margins of the Main Karoo Basin. The Karoo is richly littered with heritage resources, ranging from geological and meteorological heritage sites, to palaeontological and archaeological resources covering millions of years of history. Typical heritage features expected to occur in the study area include Karoo- style architecture (corbelled houses); kraals; Early-, Middle- and Later Stone Age artefacts (stone tools and engravings/rock art); graves; a wide variety of fossils of the renowned Karoo fossil record; meteorites and geologically significant landforms.

The word Khoekhoe from which is derived the word 'Karoo' means 'hard' or 'dry', which broadly describes this harsh arid, semi-desert region²⁰. Research suggests that the Karoo formed part of the heartland occupied by the Later Stone Age /Xam San between the end of the 18th century and the beginning of the 19th century. The passage of different cultural groups, such as the Trek Boers and Xhosa refugees, through this area during colonial times resulted in competition for scarce resources between these groups²¹. The San people left traces of their presence throughout the Karoo, mainly in the form of rock art (painted and engraved) and cultural material such as stone tools and other artefacts. The various cultural heritage layers are encountered within the Strategic Environmental Assessment study area with occasional large Early Stone Age tools such as hand axes which date from at least 2 million years ago. Middle Stone Age sites dating between 300 000 and 30 000 years ago are usually found in deflated palaeosurface contexts or in relatively stratified deposits around the many pans characteristic of the area. Later Stone Age sites from the last 30 000 years are more common and stone tools made by San hunter-gatherers and Khoekhoen herders have been found relatively in situ on the Kalahari sands or in close association with the many rock engraving sites made at dolerite outcrops.

A strategic level assessment of the heritage resources (archaeological, palaeontological and other cultural resources including visual resources) and sensitivities within the Strategic Environmental Assessment study area was undertaken by a team of experts in the fields of archaeology, palaeontology, cultural heritage, built environment and landscape/visual resources. The majority of the archaeological sites in the Strategic Environmental Assessment study area are Early, Middle and Later Stone Age stone artefacts and cultural materials such as ostrich eggshells and pottery with a denser concentration of Stone Age scatters around wetlands and rivers as well as Karoo dolerite outcrops. A total of 105 sites were identified during the heritage assessment:

²⁰ Raper, P.E. 1989. Dictionary of Southern African place names. Cape Town: Jonathan Ball Publishers.

²¹ Prins, F.E. 2008. Cultural Heritage Impact Assessment of the KAT Development Site. Report No: 502131. Strategic Environmental Focus (Pty) Ltd, Durban.

- 6 Grade II sites of high provincial or regional significance (unsuitable for development) including:
 - 3 corbelled buildings declared Provincial Heritage Sites on the farms Grootfontein, Arbeidsfontein and Stuurmansfontein: no impacts on these sites are anticipated; and
 - 3 culturally significant places not formally protected: Hartogskloof, Groot Pardekloof and Abiquaputs.

- 99 Grade III sites worthy of conservation including:
 - 42 Grade IIIa sites of high local significance: burial grounds, rock paintings, historical buildings, stone age artefacts and monuments;
 - 20 Grade IIIb sites of moderate local significance: rock art sites and archaeological sites; and
 - 37 Grade IIIc sites of low local significance: these resources must be recorded satisfactorily before destruction is allowed.

It is expected that additional heritage features will be identified during further ground work and site visits. About 95% of recorded sites were deemed as having local significance (Grade III) with approximately 40% of high local significance and approximately 55% of medium or low local significance. Three of the Grade II sites, which consist of corbelled buildings on the Grootfontein farm, Arbeidsfontein farm and Stuurmansfontein farm are declared Provincial Heritage Sites (Figure 3-23, Figure 3-24) and thus have the highest proclaimed significance in terms of the National Heritage Resources Act. Other grade II sites are located on the Hartogskloof farm; Groot Pardekloof farm and Abiquaputs farm as indicated in the Bleek and Lloyd texts²², are not formally protected under section 27 of the National Heritage Resources Act but have been identified as having provincial significance (Grade II). The Grade II sites (Figure 3-25) are very high sensitivity heritage features and were assigned a buffer of 1 kilometre.



²² Deacon, J. 1986. "My place is the Bitterpits": the home territory of Bleek and Lloyd's /Xam San informants. *African Studies* 45: 135155



Figure 3-23: Stuurmansfontein Corbelled House (Photo: Jens Friis)



Figure 3-24: Abandoned farmstead with corbelled house (Grade IIIa) in the Williston Spiral Arm (Photo: Cedar Tower Services, ASHA)

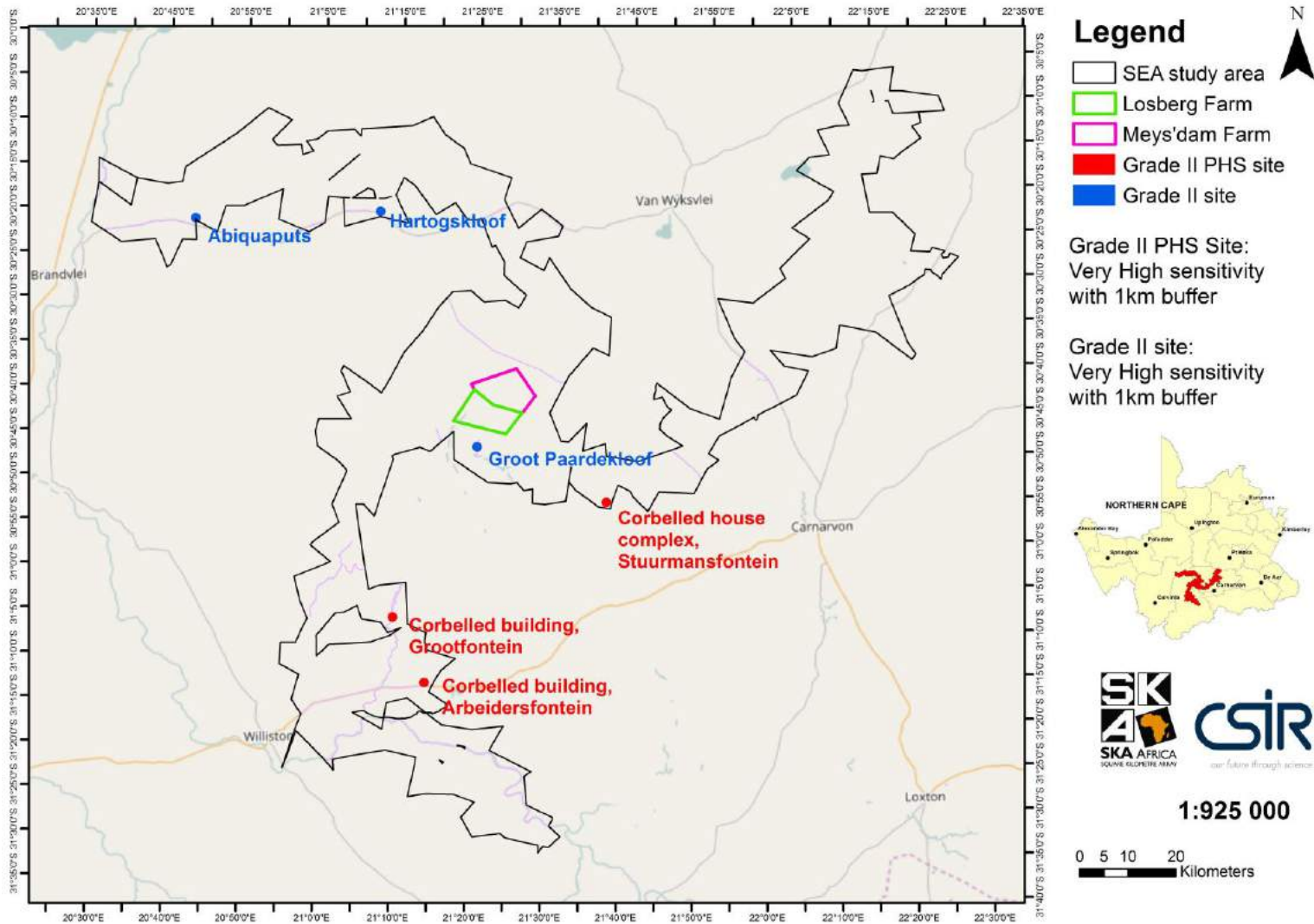


Figure 3-25: Grade II sites within the Strategic Environmental Assessment study area

All grade IIIa heritage resources mapped in Figure 3-27 are rated of high local significance and should be avoided as much as possible during the construction phase of SKA. Burial grounds and graves may, at times, be relocated if impacts from construction cannot be avoided. Ten formal and informal graves have been identified in the study area. Most of these graveyards are currently not maintained and isolated precolonial graves are generally completely unmarked and cannot be identified at the surface. The heritage specialists provisionally graded the farmsteads in the SKA telescope core as Grade IIIa ("Historical Building" on the map below). Furthermore twenty-six rock engravings sites have been recorded within the study area and more sites are likely to be encountered on the numerous dolerite outcrops (Figure 3-26). It is expected that most of the impacts on heritage resources resulting from SKA1_MID will occur during construction. Indirect impact during the operation phase may occur due to the decommissioning and abandonment of farmsteads in the SKA telescope core. No major impacts on paleontological resources was identified during the heritage assessment however the Abrahamskraal formation represents a sensitive feature which will require a field assessment if impacted upon.



Figure 3-26: Rock Art: engraving of an ostrich on a dolerite boulder (Grade IIIa) in the Williston Spiral Arm (Photo: Cedar Tower Services, ASHA)

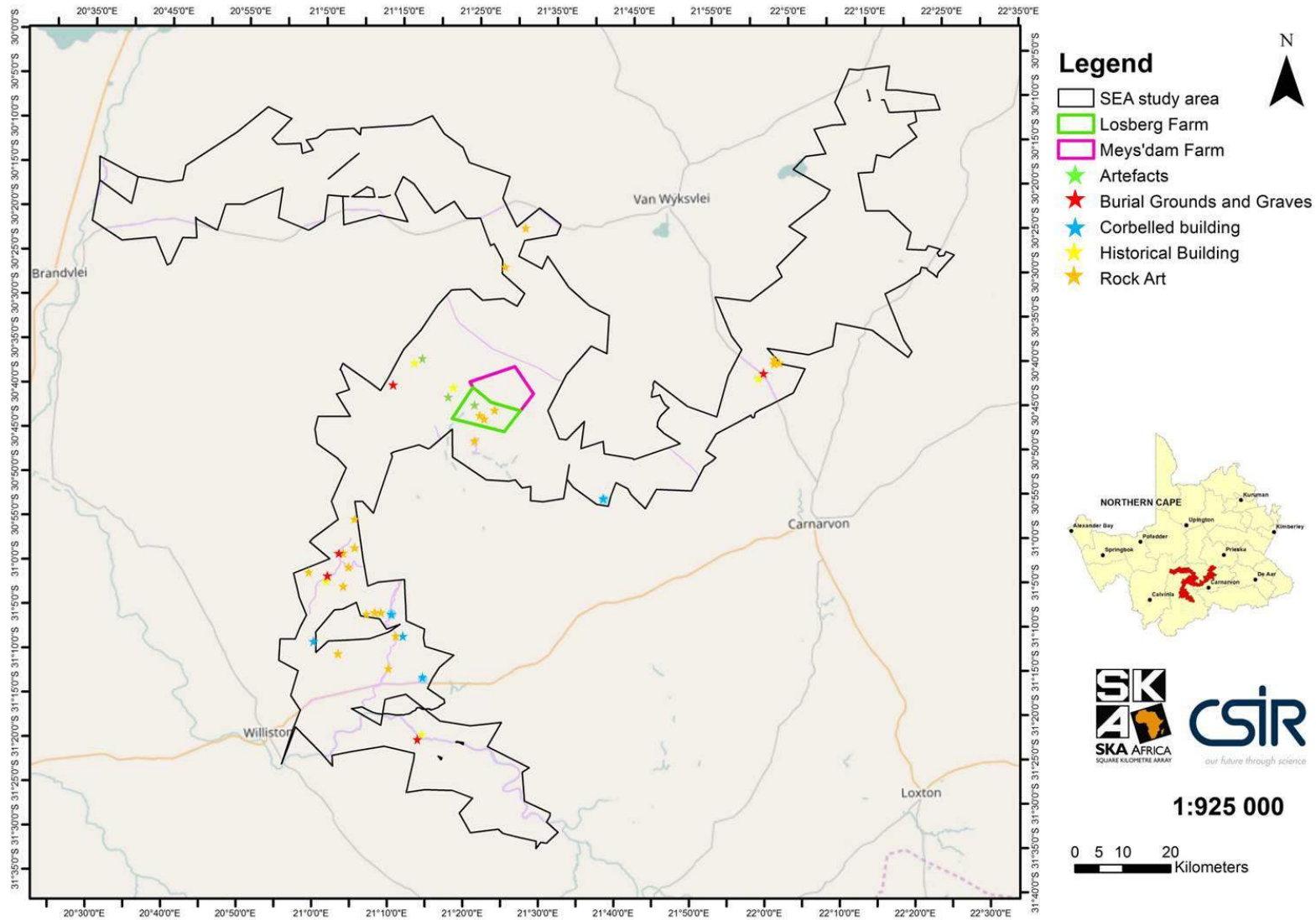


Figure 3-27: Grade IIIa sites within the Strategic Environmental Assessment study area

The Karoo scenery is typically characterised by flat-topped koppies, extensive sandy to gravelly vlaktes (flats) and water courses that flow only in response to summer rain storms. The generally low, sparse vegetation means that the landforms and rock formations tend to be more pronounced in the Karoo than in other parts of South Africa. The landscape of the Strategic Environmental Assessment study area consists largely of flat plains, with some low sandstone and doleritic mountains in a sparsely populated area (mainly farmsteads). In terms of the cultural heritage and visual resources identified during the heritage assessment, the main scenic resources are concentrated in the mountainous terrain across the middle of the study area, where peaks, ridgelines, scarp edges, steep side slopes and dolerite rock outcrops are potentially visually sensitive, particularly in terms of structures on the skyline. Using a geomorphological approach, the visual specialists identified three broad landscape types each with its own scenic characteristics within the study area. These three landscape types are described in Table 3-2 and illustrated in Figure 3-28 below.

Table 3-2: Study area landscape types

Landscape Type	Characteristics	Significant Visual Features
<p>A. Southern plain: Beaufort Group, Adelaide Formation mudstones, sandstones and shales.</p>	<p>Broad plain intruded in places by dolerites, and incised in the southwest corner of the study area by the Sak River and the Brak River. The elevation varies from 1100 to 1400 metres</p>	<p>Generally dry river courses and minor dolerite koppies. Koppies are visually sensitive, and the plains visually exposed. Travellers on the R63 Route and a number of farmsteads are the main visual receptors.</p>
<p>B. Mountainous terrain: Ecca Group, Canarvon Formation sandstones and shales with dolerite intrusions.</p>	<p>The harder, more weather-resistant sandstones and dolerites are responsible for the koppies and ridges, including the Kareeberge, with elevations ranging from 1300 to 1500 metres This is the most scenic part of the study area.</p>	<p>Scenic dolerite ridges and koppies, with a few small poorts. The ridge skylines are visually sensitive, while the varied topography is more visually absorptive than the plains. There are a small number of farmsteads, mainly in the more fertile valleys near sources of water.</p>
<p>C. Northern plain: Ecca Group, Tierberg Formation shales.</p>	<p>Broad and largely featureless plain at an elevation of 1000 metres, with some dolerite outcrops and several pans. Patches of alluvium, sand and calcrete occur to the north.</p>	<p>Fairly featureless, except for minor dolerite koppies and a series of linked pans, and dry river courses. Visually exposed. A number of farmsteads are widely spread in the area.</p>

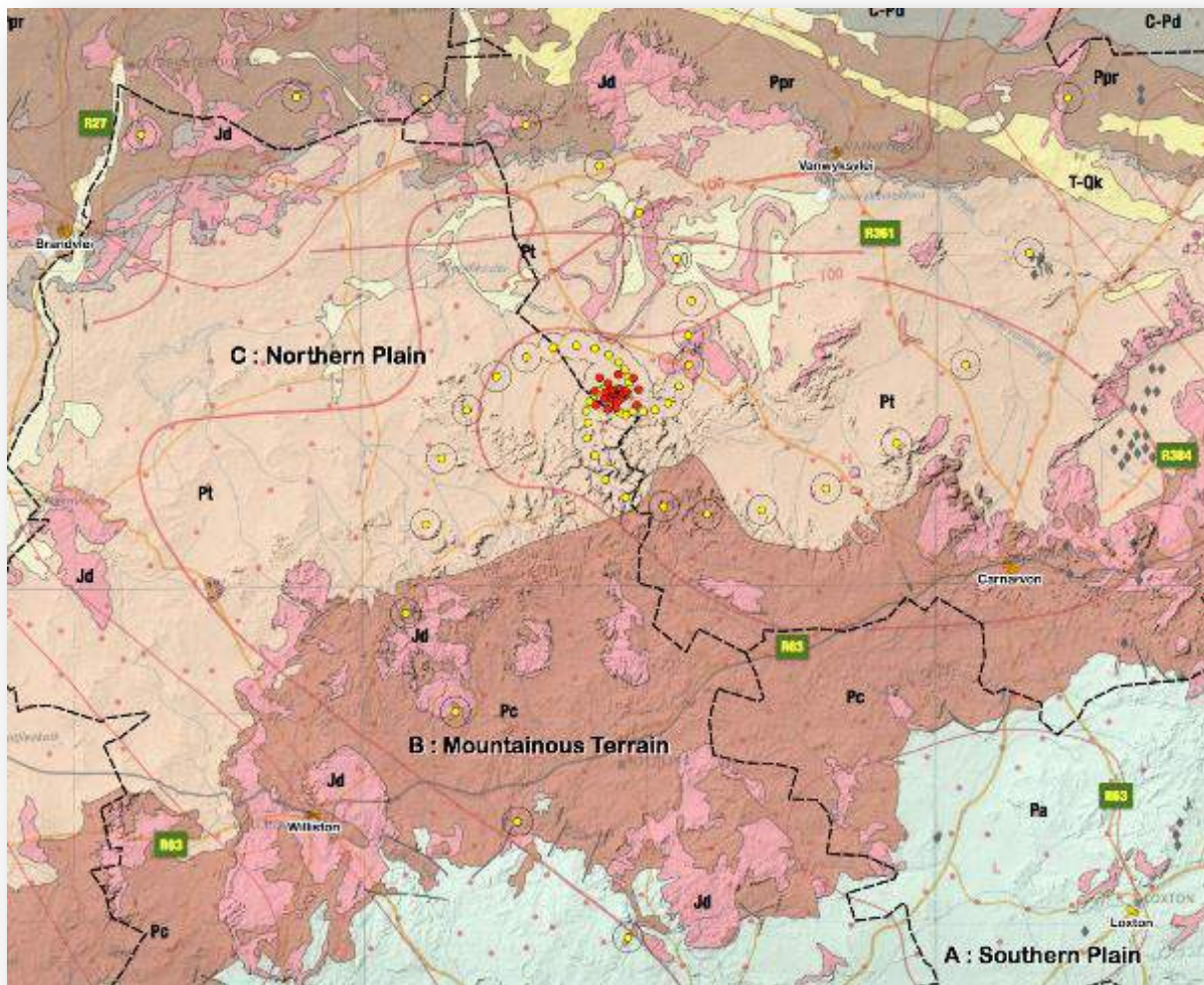


Figure 3-28: Landscape types of the study area with the proposed layout of SKA_MID receptors as of 1 September 2016 (yellow dots) and MeerKAT (red dots)

The exposed nature of the landscape suggests that the dish-antennas could be highly visible up to 1 kilometre, but only marginally visible beyond 5 kilometres (Figure 3-29). The related infrastructure (access roads, powerlines and substations) would present a lower risk than the dish-antennas because of their smaller size visually. The construction phase would also have a lower risk because it is short term, but could continue with future phases of the SKA. There are no major settlements or roads, (except for the R63), within the study area, and the farmsteads are spread relatively far apart. The areas with high and moderately high visual sensitivity are mountainous terrain and near farmsteads. Some of the farmsteads directly affected by the SKA activities and infrastructure appear to not be permanently inhabited. The potential cumulative visual impacts could result from the increase of SKA infrastructure over time. Proposals for future phases of the SKA are not known at this stage and would need to be assessed for possible cumulative visual impacts as part of the rollout of SKA1_MID. Infrastructure related to SKA1_MID include the access roads and powerlines to the dish-antennas, which seen together could also result in additional cumulative visual impacts representing an industrialised landscape.

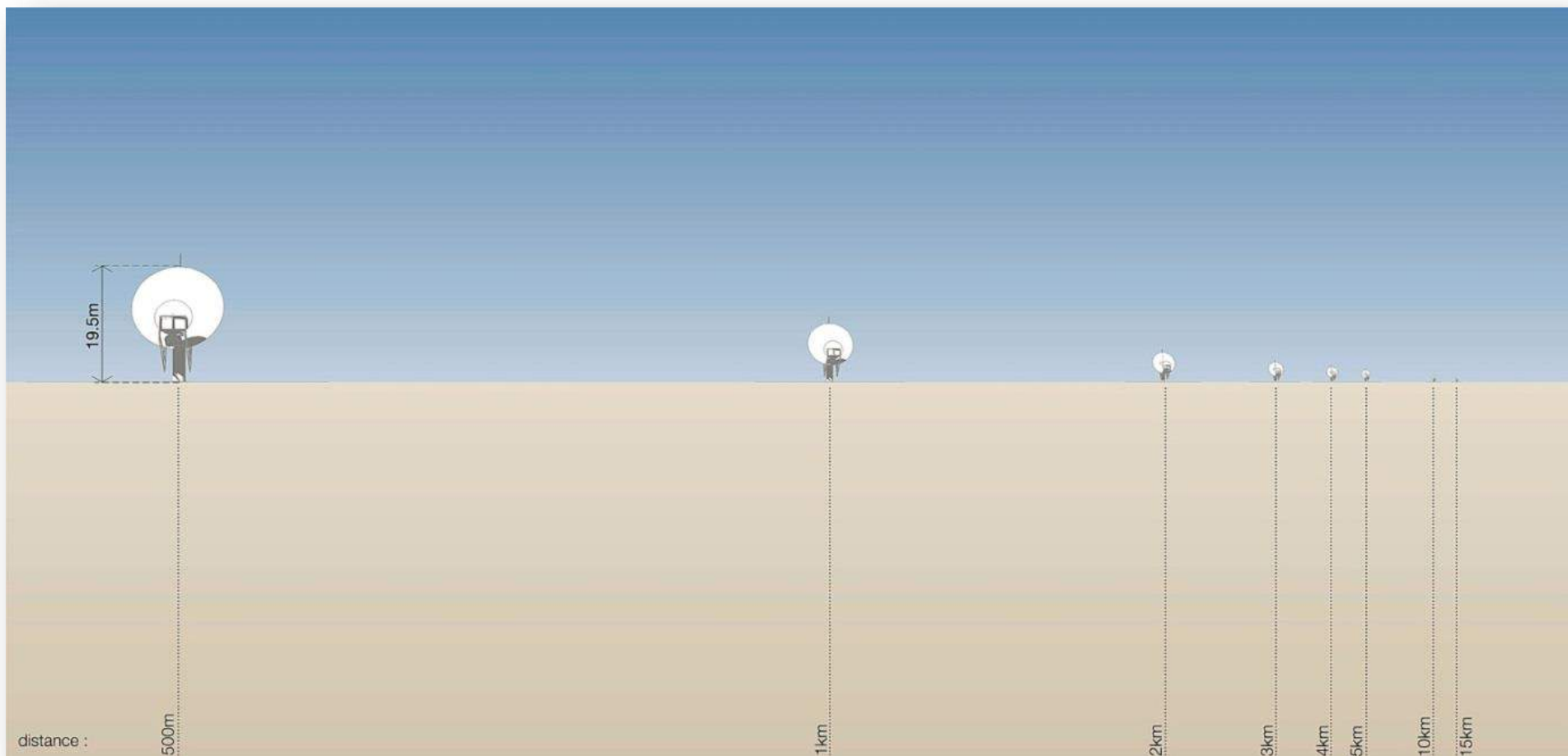


Figure 3-29: Visibility of a SKA dish-antenna at distance ranges

V. Combined sensitivity map

The sensitivities described in section I, II, III and IV of this chapter are illustrated in Figure 3-30 below.

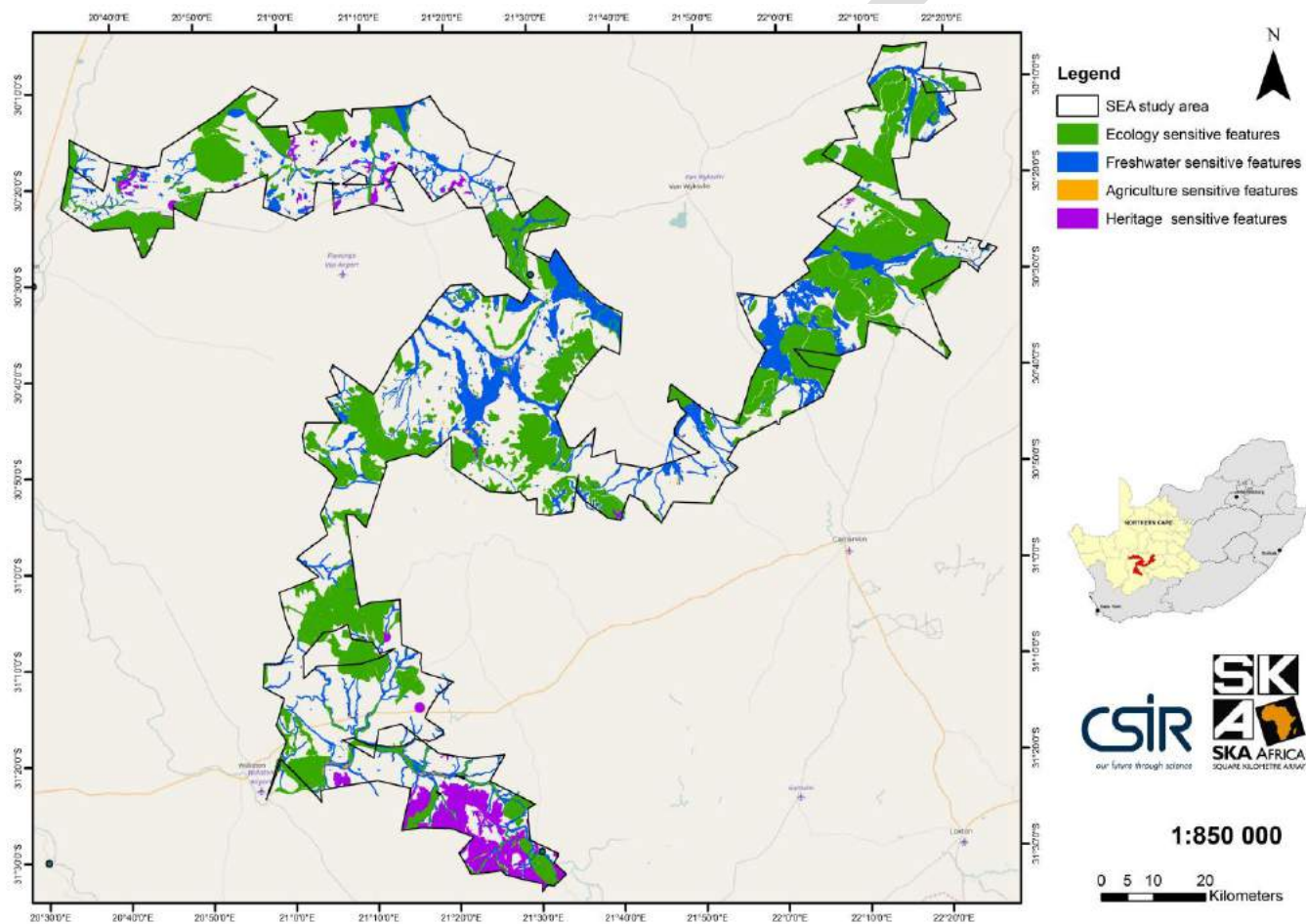


Figure 3-30: Combined sensitivities map for the Strategic Environmental Assessment study area

VI. Society and Economy

The direct socio-economic “footprint” for the socio-economic assessment was defined as an Astro-Region, and includes SKA1_MID footprint area as well as surrounding towns such as Carnarvon, Van Wyksvlei, Loxton, Sutherland, Vosburg, Copperton, Swartkop, Victoria West Fraserburg, Williston, and Brandvlei in the Northern Cape Province. The Astro-Region crosses multiple municipal jurisdictions, and includes the western parts of the Pixley ka Seme District Municipality and the eastern parts of the Namakwa District Municipality. The Astro-region currently hosts two major astronomy projects:

- The Southern African Large Telescope (SALT) in Sutherland, and
- MeerKAT, located north-west of Carnarvon.

The Astro-Region towns can be grouped in different categories according to their main economic and social characteristics:

- SKA Hub: Carnarvon (most direct point of SKA-related investment);
- Gateway towns: Williston, Vosburg, Loxton, Victoria West (towns which can build on SKA-related investments in terms of tourism and local business);
- Towns with thematic links to SKA: Sutherland and Fraserburg (SALT and Karoo Highlands Tourism Route“);
- Towns facing economic decline due to SKA: Brandvlei, possibly Van Wyksvlei (remote towns with fairly good infrastructure, but situated far from the SKA “hub”, and likely to be affected by the decline in agriculture and restrictions on radio-wave technologies); and
- Dormitory towns: Van Wyksvlei, Copperton, Swartkop (remote villages, with very limited infrastructure likely to remain dormitory towns for children, the elderly and spouses)

The general picture is of these Karoo towns is that they have a fairly solid social base, with fairly well developed infrastructure and functioning social services (schools, clinics, post offices and municipalities). There is widespread poverty, as well as a “culture of poverty”, which describes behavioural problems in certain sectors of the community, and which tends to reinforce existing levels of poverty. The most prevalent forms of crime in the Karoo municipalities are alcohol and drug-related crimes and sex-related crimes (Atkinson et al 2016:27). Nevertheless, there is also a significant sector of the community which participates actively in the economy, in various roles (government officials, staff in businesses, independent professionals and tourism operators). There is some degree of in-migration of investors, particularly in the tourism sector which brings valuable capital, skills and urban networks to the region. There are fairly robust social networks (churches, NGOs, civil society groups) which strengthen families and help people to get a foothold in the local economy. The local population is becoming culturally more diverse.

The following infrastructural challenges were identified in the municipal integrated development plans of the Astro-Region:

- In the Kareeberg local municipality (Carnarvon, Vosburg, Van Wyksvlei): streets and rural roads in poor condition, and lack of storm water management destroys roads;
- In the Karoo-Hoogland local municipality (Williston, Fraserburg, Sutherland): roads and streets in poor condition, insufficient staff and budget, and shortage of bulk water; and
- In the Ubuntu local municipality (Victoria West, Loxton, Richmond): inadequate bulk water supply, poor water quality, old water infrastructure, insufficient telecommunications network (also degraded due to vandalism), gravel roads in poor condition; and poor management of waste sites.

As a result of SKA1_MID development, the municipalities of the Astro-Region may thus require new or expanded services, and the administrative capacity, staffing levels, equipment, and outside expertise needed to meet those demands. The towns have experienced economic diversification in terms of tourism, business services, and technical services with an increase in full-time employment in:

- Trade sector (retail and wholesale);
- Finance and Business sector (banks, professional services and micro-lenders);
- Construction sector;
- Tourism and hospitality sector; and
- Transport sector.

Commercial agriculture plays an important economic role in sustaining the “society” of the Astro-Region which is well known for the well-respected and valuable Karoo Lamb meat product. The Karoo Lamb brand recently became recognised as South Africa’s first Geographical Indication in the food industry. Commercial farmers are generally highly professional, modern, productive, and innovative, in a highly competitive world. The semi-arid nature of the region provides adequate conditions for extensive sheep production and although there has been a long-term trend towards declining farm jobs, the agricultural sector provides for a significant level of household income, food security and retail multipliers in the local towns of the Astro-Region. Financial institutions, hardware stores as well as construction entrepreneurs also see the farmers as the most important market for their products and services. Subsidiary professions related to farming include mechanics, borehole experts, solar energy experts, hunters (for predators), livestock fertility testing, stud breeders, fence makers, transport providers, and livestock marketing agents. The knowledge of farmers and their mentorship role in the Karoo region also play a key role in local organisations and institutions (annual town festivals, the regional show, the church and the old age home and a number of charities) which is core to the social fabric of any rural town.

The Northern Cape Department of Tourism is currently planning the establishment of a Science Visitor Centre in Carnarvon which is likely to have regional impacts and become the official tourist information Centre of the Astro-Region. Until the construction of the Science Visitor Centre is completed, the SKA South African Office will establish two temporary visitor centres late in 2016/17 or early 2017/18: one in Williston and one in Carnarvon. The buildings or office space that will be rented for the temporary visitor centres will be secured in Carnarvon and Williston. When the Visitors Science Centre is completed the temporary visitor centre in Carnarvon will be used as offices.

Radio-based communications (including data transfer) has become a major component of modern life and the economy. Rural areas such as the Astro-Region also experienced the rapid development of radio-communication technologies, and the massive investment of social energies into connectivity, to the extent that a lack of access to communication networks can now be described as a major disability for people in their livelihoods and quality of life. The impact of restrictions on the use of telecommunication services and devices prescribed by the Astronomy Advantage Area draft regulations is likely to restrict the use of common communication tools and use of certain farming and household equipment in close proximity to SKA1_MID.

As of January 2017, the SKA South African Office has subsidised VSAT²³ broadband services for up to 300 installations that provide internet and voice connectivity (with more than 190 VOX© satellite dish installed). A mobile trunked communication network has been established and will be deployed at

²³ very small aperture terminal (VSAT): two-way satellite ground station with a dish antenna that is smaller than 3 meters.

higher frequencies to take advantage of technology advances. On-going research and tenders are focusing on the identification of cost efficient and modern technology options to be adopted as well as the deployment of appropriate technologies that will increase mobility of cell phone usage for rural farmsteads. The SKA South African Office will review, on an ongoing basis, the telecommunication needs of the community and ongoing technology developments, to ensure appropriate technology solutions and utilisation that is relevant, affordable, and up to date, in line with the requirements of the Astronomy Geographic Advantage Act.

Rural aviation, like cell phone technology, is growing at a rapid pace (Atkinson 2016a) and the Carnarvon airfield is already fairly well developed, and likely to attract additional aviation traffic in future. Although prescribing the establishment of measures of protection from general aviation in the immediate vicinity of the SKA telescope core, the Astronomy Advantage Area draft regulations as published are very specific in identifying aviation as an essential service, and the need to enable the continued operation of the aviation radio communication services. The SKA South African Office further stated that no restrictions will be implemented for the use of the Carnarvon airfield.

Since 2010, the SKA South African Office has implemented several initiatives with primary and secondary schools in the Astro-Region to improve the access to basic educational material and level of scientific teaching in this remote area of South Africa. The SKA South African Office further created an artisan training programme in order to address the difficulties of sourcing competent technical staff locally. Since 2015, 351 training opportunities were created, which were made available to 350 people, of whom 203 were 35 years and younger.

A detailed development programme was prepared by the SKA South African Office for the farm workers who will lose their employment as a result of the SKA land acquisition programme. The farm workers will be offered an opportunity for a career in SKA in both the SKA Land Management programme as well as artisan training to undertake MeerKAT and SKA telescope and infrastructure maintenance. Opportunities will also be offered to the farmworkers' spouses who may be accommodated by the SKA through the expansion of the housekeeping staff which is required for MeerKAT and for SKA1_MID and to the farmworkers' children who may become part of the SKA Human Capital Development programme.

It is critical for South Africa to participate within the global system of innovation and the global knowledge economy, in order to participate within a global trade market that is increasingly becoming knowledge intensive, and achieve economic growth without undermining local or regional livelihoods. The socio-economic specialists have identified two important conflict issues, namely (1) Conflict around land acquisition and servitudes and (2) Conflict around the social and economic impact of SKA1_MID on local stakeholders. There is however a clear understanding of many of the negative impacts of SKA1_MID, and also an understanding of the possible positive spin-offs.

The following key positive impacts were identified by the socio-economic specialists:

- 1.** International recognition of the South African scientific and skills capabilities in Astronomy and Physics Sciences and contribution to major advances in scientific data methods and computational power (optic fibre networks and big data science, theoretical modelling and simulation, instrumentation, infrastructure investments) and international collaboration on astronomy-focused SKA research;
- 2.** National economic benefits due to the net positive foreign direct investment and spending in South Africa (including local contracts/service level agreements, possible exports of products, the licensing of intellectual property as well as the structure of SKA funding protocols and the

proposed institutional structures i.e. international treaty organisation status and legislative frameworks);

3. National development benefits through enhanced SA engineering capabilities (which could be applied in other African countries) and the engineering and scientific breakthroughs available for other sectors, e.g. medicine and which enhance innovation, competitiveness;
4. National and local development benefits through the Human Capacity Development Programmes: National and international academic bursaries, Research Chairs initiative, Visiting and Joint Professorships Senior fellowships, Postdoctoral fellowship , Research groups, Science and engineering skills development, National Diploma bursary, Further Education and Training (FET) bursary and Young Professionals Development Programme;
5. Local development benefits through the Schools Bursary Programme and collaboration with the Northern Cape Department of Education and to upgrade the Carnarvon High School buildings and equipment (e.g. hostel), E-Schools Programme at Carnarvon Primary School, Carnarvon High School, Van Wyksvlei Intermediate School, Nico Bekker Intermediate School and Williston High School, and the Community Knowledge Centre in Carnarvon;
6. Local development benefits through infrastructure upgrade in the towns surrounding SKA1_MID: road upgrade, schools upgrade and the hospital in Carnarvon;
7. Regional and Local development benefits through the Science and Mathematics Outreach Programme, Artisan training programme, and farm workers development programme;
8. Local economic benefits due to SKA work Opportunities, Spend at Local Suppliers, Spend through appointment of local and emerging contractors in the area and training, Boost to construction industry and hospitality industry in the Astro-Region; and
9. Creation of a rural regional development hub in the Astro-Region due to establishment of the Science Visitor Centre in Carnarvon and tourism growth.

The following key negative impacts were identified by the socio-economic specialists:

1. Difficulties in social development of the Astro-Region especially in the towns due to the insufficient participation and involvement of the Northern Cape Departments of Education, Health and Economic Development in terms of infrastructure, service delivery and job opportunities;
2. Disturbance of lifestyle and social unrest due to restrictions prescribed by the Astronomy Advantage Area draft regulations on existing modern telecommunication devices and services in the Astro-Region (including impacts on ecotourism in remote areas and farms experiencing loss of existing internet and cellphone services);
3. Establishment of measures of protection from general aviation in the immediate vicinity of the SKA telescope core;
4. Reduction in the amount of land available to sheep-farming in the Astro-Region due to the acquisition of 32 land parcels in the SKA telescope core in addition to the two farms Meysdam and Losberg owned by the National Research Foundation, and possible impacts on the Karoo lamb brand in the Astro-Region;
5. Changes to existing activities and economy of farmers' unions and farm-related businesses in the Astro-Region (e.g. abattoirs, transport of animals to towns, veterinary and retail services to farmers);
6. Loss of jobs in the agricultural sector (especially farm workers);
7. Increased pressure on towns for services delivery (e.g. electricity, sewage and water) and infrastructure (e.g. housing);
8. Impacts on local economy and social development due to insufficient engagement and coordination from the Northern Cape Government in terms of regional tourism marketing and science education in the Astro-Region; and

9. Impacts on municipal systems and local communities due to the insufficient participation and coordination from local authorities in terms of effective spatial development and efficient spatial planning in the Astro-Region.

VII. Fundamental environmental principles

A sustainable development process aims to meet the necessary human development goals while maintaining the ability of natural systems to continue to provide the natural resources and ecosystem services upon which the economy and society depend²⁴. In order to achieve this target, a balance between social, economic, and environmental objectives (and needs) must be achieved in the process of decision making especially for national-scale strategic infrastructure development and strategic socio-economic initiatives.

The ecological integrity, biodiversity and physical attributes of the Karoo must be protected and sustainably utilised, and a high degree of environmental awareness must be encouraged amongst all interested and affected parties. The declaration of the SKA telescope core as a special nature reserve provides a unique opportunity to contribute to environmental research and the environmental knowledgebase in the Karoo. The public environmental awareness can be encouraged through long term environmental research programmes and the publication of environmental studies to benefit the scientific community and add to the environmental knowledge base of the Central Karoo.

The conservation of biodiversity and natural habitats must be encouraged taking into consideration the needs of the local community. The use of primary raw materials and energy, for instance, should be monitored and suitable principles for reduction, re-use and recycling should be implemented across all SKA1_MID activities to minimise waste and pollution of the natural environment. Dust generation must be minimised, where possible, to prevent harm to local flora and disturbance to local communities. The removal of alien plant species must be prioritised, with the support of the Working for Water programme and through a proactive and shared responsibility approach with local communities and authorities. The land management authority appointed by the South African SKA Office to manage the acquired land will ensure that environmental protection activities and sustainable development guiding principles are incorporated in daily Land Management practices.

Water quality and availability will likely be the most significant impacts within the study area of the Strategic Environmental Assessment of SKA1_MID. A significant trend for increasing temperatures has already been shown by weather stations in the Northern Cape which have been tracking temperature data from 1960²⁵. Existing low rainfall patterns and water constraints limit the ability of municipalities to deliver water services to local inhabitants effectively. As low rainfall has a significant negative impact on the ability of vegetation to recover after disturbance, any activity resulting in disturbance to vegetation should be limited and mitigated.

The Science Visitor Centre in Carnarvon will promote environmental awareness through events and exhibition to reach tourists, local schools and businesses and local inhabitants. The National Research Foundation will also increase awareness of SKA environmental impacts amongst SKA employees, facility users, tenants and contractors, as well as organisations that the SKA funds.

²⁴ The World Commission on Environment and Development defines sustainable development as a "development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

²⁵ A. C. KRUGER* and S. SHONGWE, "TEMPERATURE TRENDS IN SOUTH AFRICA: 1960–2003", *International Journal of Climatology* 24: 1929–1945 (2004). DOI: 10.1002/joc.1096

Climate change²⁶ can reduce the ability of biodiversity and ecosystems to provide ecosystem services which are essential to human life on Earth e.g. clean drinking water, climate regulation, soil formation and disaster risk reduction. Due to its impacts on ecosystem services, climate change threatens food security, poverty alleviation and sustainable socio-economic growth. Promoting activities and behaviour which contribute to climate change resilience and human adaptation to the impacts of climate change is an important starting point. Several important natural features in the Karoo can support resilience of biodiversity to climate change and must be protected. These features include:

- riparian corridors and buffers;
- areas with temperature, rainfall and altitudinal gradients;
- areas of high diversity;
- areas of high plant endemism;
- refuge sites including south-facing slopes and kloofs; and
- priority large unfragmented landscapes

Through education and environmental awareness, Karoo stakeholders must be encouraged to preserve these areas in a natural or near-natural state. The conservation of healthy landscapes will maintain the ability of ecosystems to continue providing ecosystem services to communities. Ecosystem-based adaptation²⁷ refers to natural solutions to extreme weather problems e.g. creating a buffer of natural vegetation along riparian corridors and around wetlands can mitigate floods, reduce erosion and improve water quality. These environmentally-friendly solutions are often more effective and less costly than artificial engineered solutions and can be easily applied in rural landscapes. The implementation of these techniques at regional scale in the Karoo as well as national scale can be easily aligned with job creation and other projects with significant social benefits.

Local government must ensure the implementation of sustainable and environmentally-friendly practices through the preparation of sector-specific strategies for adaptation to climate variability e.g. consultation with farmers to develop best practices for land management including restoration and maintenance of key ecosystem services (grazing land, rivers, and wetlands).

²⁶ Climate change, also called global warming, refers to a rapidly changing global climate associated with a rise of the Earth's temperature observed over the past 1,300 years.

²⁷ The Convention on Biological Diversity (CBD) defines ecosystem-based adaptation as "the use of biodiversity and ecosystem services as part of an overall adaptation strategy to help people adapt to the adverse effects of climate change".



CHAPTER 4: ENVIRONMENTAL MANAGEMENT PROGRAMME



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I. Scope

This Environmental Management Programme (EMPr) is prepared as part of the environmental instrument, to ensure that environmental impacts related to the SKA1_MID project are appropriately managed and the requirements of NEMA¹ in terms of sustainable development are met.

The EMPr compiles the mitigation measures and management actions to be implemented during the final design phase, construction phase and operation phase of SKA1_MID in order to achieve the environmental management outcomes prescribed in this document. The pre-construction and construction environmental management requirements prepared for MeerKAT (including the Karoo Array Telescope) on the farms of Losberg and Meys'dam have also been considered when compiling this EMPr.

The National Research Foundation commits that the EMPr forms part of all SKA project tenders, project construction contracts and project design documents, to be incorporated in line with the general project specifications and South African National Standards (SANS) 1200 A or SANS 1200 AA, as applicable.

II. Roles and Responsibility

The roles and responsibilities of the persons responsible for the implementation of the environmental management requirements prescribed in this document must be allocated to the relevant individuals prior to the commencement of the construction phase. Key role players include the Project Manager, the Environmental Manager, the Environmental Control Officer and Contractors:

- the Project Manager is accountable for implementation of the IEMP (including the EMPr) and compliance with management requirements prescribed in the notice of adoption;
- the Environmental Manager² is responsible for environmental management and monitoring activities in compliance with this EMPr;
- the Environmental Manager is responsible for updating the management actions of the EMPr as required during the SKA1_MID development phases;
- Environmental control officer (ECO) is an independent environmental consultant appointed by the Project Manager to conduct a yearly independent audit. The Environmental Control Officer must inform the Department should non-compliance be detected; and
- External contractors must ensure compliance with this Environmental Management Programme while performing the onsite activities.

III. Monitoring and Auditing

The SKA Environmental Manager must conduct a monthly Internal Environmental Audit throughout the construction phase and submit the internal audit report to the Project Manager. The Internal Environmental Audit report must include detailed environmental monitoring activities as well as any recorded environmental incidents and relevant corrective actions.

¹ This EMPr satisfies the requirements of Appendix 4 of the Government Notice 982 (Government Gazette 38282 dated 4 December 2014) which regulate and prescribe the content of any Environmental Management Programme.

² The Environmental Manager will be appointed as a permanent staff of the South African SKA office and must have suitable qualification and experience in environmental management practices.

The SKA Environmental Manager must compile a photographic record of the SKA1_MID construction footprint area including:

- all areas designated as work areas, camp areas and facilities, construction sites and storage areas taken before, during and after the set-up of these sites - including temporary working areas before, during and post rehabilitation;
- Fences and fencing equipment that will be impacted by the SKA project, before, during and after the installation or removal;
- Access roads before, during and after the construction/upgrading of roads;
- Topsoil and storage areas before, during and after the removal; and
- Waste management sites before, during and after the set-up of these sites.

During the operation phase the SKA Environmental Manager must conduct quarterly site inspection to monitor the extent to which natural re-growth has occurred; any erosion resulting from the preceding season, taking into consideration climatic factors; and the need for additional erosion protection or re-vegetation.

The photographic record will be used to show the state of the environment on the development site before, during and after the rehabilitation activities.

All environmental incidents regardless of severity must be reported to the SKA Environmental Manager during all phases of the SKA project for inclusion into the Environmental Incident Log. The Environmental incident Log will provide a description of the environmental incidents and the corrective actions that were taken to mitigate the incident; and will inform the internal Environmental Audit Report. Environmental incidents are defined as environmental impact resulting from deviation (non-compliance) from the environmental management outcomes and mitigation actions prescribed in the EMPr.

The SKA Stakeholder Manager will maintain a complaints register during all phases of the SKA project including, but not limited to complaints received from adjacent landowners, local stakeholders and local/district/provincial authorities. The register will contain the detailed description of all complaints with supporting documentation and the written response to each complaint with a description of any corrective action implemented as a result of the complaint. In the event of a claim for damages the SKA Stakeholder Manager will evaluate the claim and associated damages and submit the recommended way forward to the Project Manager. Following consideration by the Project Manager's team, the claim is to be resolved and settled as soon as possible, or the reason for not accepting the claim communicated in writing to the claimant.

An annual external environmental audit must be conducted by an independent auditor (e.g. Environmental Control Officer):

- at the end of the construction phase: the acceptance and approval of the Final Environmental Audit Report will constitute the completion of the Environmental Management Programme's construction phase;
- after 5 years from the date of the Gazette containing the Minister decision for the exclusion in terms of Section 24 (2)(e) of NEMA; and
- thereafter, at a frequency defined in the most recently published EIA Regulations (but as a minimum every 5 years).

Where an amendment is required to the impact management actions of an EMPr, such amendments may immediately be effected, provided that such amendment is reflected in the very next

environmental audit report submitted. The independent auditor will send his audit reports to the SKA Environmental Manager for consideration and to implement corrective actions where required.

IV. Preparation of Method Statements and activity-specific management plans

Method Statements and/or Management Plans must be submitted by the Contractor to the SKA Project Manager and SKA Environmental Manager for approval for the following activities prior to any construction commencing on site:

- Construction camp locality and layout plans;
- Land Management plan;
- Lighting plan;
- Stormwater management at the construction camp/s and at the construction areas;
- Construction of water crossings;
- Erosion Management;
- Waste Management including management, use and storage of hazardous substances;
- Traffic Management;
- Workshop maintenance and cleaning of equipment;
- Refuelling activities under normal and emergency situations;
- Spill Contingency Plan;
- Construction works at watercourse crossings;
- Alien invasive Plant Management Plan; and
- Emergency Response Procedures.

Method Statements must address the following aspects:

- What – a brief description of the work to be undertaken;
- How – a detailed description of the process of work, methods and materials;
- Where – a description of the location of the work (if applicable); and
- When – the sequencing of actions with commencement and completion date estimates.

The SKA Environmental Manager must monitor the implementation of the Method Statements and activity-specific management plans during the construction and operation phases of the project.

V. Permit Requirements

The activities requiring a permit, licence, authorisation or consent from permitting authorities and governmental bodies relevant to SKA activities and infrastructure are listed in Table 4-1 below. The necessary permits must be obtained by the SKA Project Manager and Contractor prior to the commencement of any activities requiring such a permit.

Table 4-1: Activities requiring a permit, Licence authorisation or consent use.

Activity	Type of permit/ Licence/consent required	Relevant Legislation	Issuing Authority
Change in land use for the one hectare dish-antenna plots as well as for roads and power lines outside of the core area	Letter of exemption	Subdivision of Agricultural Land Act, Act 70 of 1970	Department of Agriculture, Forestry and Fisheries
Taking water from a water resource (abstraction from boreholes)	Licence	National Water Act 36 of 1998	Department of Water and Sanitation
Storing water (reservoirs)	Licence	National Water Act 36 of 1998	Department of Water and Sanitation
Impeding or diverting the flow of water in a watercourse	Licence	National Water Act 36 of 1998	Department of Water and Sanitation
Removing, discharging or disposing of water found underground if it is necessary for the efficient continuation of an activity or for the safety of people (e.g. dewatering during excavation)	Licence	National Water Act 36 of 1998	Department of Water and Sanitation
Disposing of waste in a manner which may detrimentally impact on a water resource (e.g. disposal of wastewater in an evaporation dam)	Licence	National Water Act 36 of 1998	Department of Water and Sanitation
Use of treated wastewater (dust suppression)	Letter of Approval	National Water Act 36 of 1998	Department of Water and Sanitation
Storage of general waste and hazardous waste in excess of 100 cubic metres and 80 cubic metres respectively, for a period exceeding 90 days.	Comply with the National Norms and Standards for the Storage of Waste (published on 29 November 2013 under GN 926)	National Environmental Management: : Waste Act 59 of 2008, List of Waste Management Activities that have or are likely to have a detrimental effect on the environment, Category C (GN 921, 2013)	Department of Environmental Affairs
Destroy, translocate, transport or cultivate protected and specially protected plant species	Permit	Northern Cape Nature Conservation Act 9 of 2009	Northern Cape Province: Department of Environmental Affairs and Nature Conservation /Relevant Provincial Authority
Retain Alien Invasive Plant Species Categories 2 or 3 in demarcated areas. Permits are also required for biological control reserves (where alien invasive plants can be	Permit	National Environmental Management: : Biodiversity Act 10 of 2004, Alien and Invasive Species List, 2014 (GG No. 37886)	Department of Environmental Affairs

maintained for breeding of biocontrol organisms)			
Destroy, damage, excavate, alter, deface or otherwise disturb any archaeological or palaeontological site.	Permit	National Heritage Resources Act 25 of 1999	South African Heritage Resources Agency (or relevant provincial heritage authority)
Destroy, damage, excavate, remove from its original position, collect or own any archaeological or palaeontological material or object.	Permit	National Heritage Resources Act 25 of 1999	South African Heritage Resources Agency (or relevant provincial heritage authority)
Destroy, damage, alter, exhume, remove from its original position or otherwise disturb any grave or burial ground older than 60 years which is situated outside a formal cemetery administrated by a local authority.	Permit	National Heritage Resources Act 25 of 1999	South African Heritage Resources Agency (or relevant provincial heritage authority)
Access to and intersection with provincial roads, services infrastructure in provincial road reserves.	Way leave application	Municipal by-laws	Department of Transport
Commencement of construction activities.	Notify one week before commencement	National Environmental Management Act (NEMA) 107 of 1998, EIA Regulations and associated listing notices (2014)	Department of Environmental Affairs
Demolition of any building.	Written permission	National building regulations and building standard Act 103 of 1977	Local Municipality
Erecting a new building or improving or adding to an existing building (including diesel fuel storage tanks)	Approval of building plans	Municipal by-laws	Local Municipality
Operation of abnormal vehicles on public roads	Permit ³	National Road Traffic Act (Act 93 of 1996) and Regulations (GN 225 of 2000)	Department of Transport
Storage and handling of hazardous substances	To be confirmed once final design of SKA1_MID is available	Occupational Health and Safety Act of 1993 and NEMA 107 of 1998, Environmental Impact Assessment Regulations and associated listing notices (2014)	Department of Health and Department of Environmental Affairs

³ Note: when the movement of an abnormal load is considered to be in the economic and/or social interest of the country a special permit may be issued to allow it to operate on a public road for a limited period).

Storage of flammable liquids	To be confirmed	Municipal by-laws	Local Municipality
Construction and use of borrow pits and quarries	Mining permit (<5 hectares) or a mining Licence (>5 hectares)	NEMA (No 107 of 1998), and Mineral and Petroleum Resources Development Act (No 49 of 2008) Regulation 52	Department of Mineral Resources

Future phases of the SKA project or changes to the configuration and activities of the SKA1_MID may require additional permit, licence, authorisation or consent from permitting authorities and governmental bodies and must be identified and added to this table. The SKA Organisation and its contractors must ensure that the activities performed comply with the relevant legislation and the necessary permits are in place prior to the commencement of the specific activity triggering the need for the relevant Licence or approval.

VI. Amendments to the EMPr

This EMPr outlines the environmental practices and mitigation measures to be adhered to during the final design, construction and operation phases, in order to curtail and/or minimise potential negative impacts and promote sound environmental practices.

This EMPr is a dynamic outcome-based environmental management tool. As such the environmental management outcomes must be complied with as prescribed in this EMPr, however the impact management actions can be amended, if required, in order to achieve the management outcomes.

Amendments to the EMPr will require consultation with relevant independent suitably qualified experts and approval from the relevant compliance monitoring unit as prescribed in the notice of adoption.

VII. FINAL DESIGN PHASE EMPr REQUIREMENTS

1. Construction areas and onsite facilities

Management Outcome:

- All areas delineated as unsuitable for development are avoided in the final design of SKA1_MID, including red dunes, large dolerite hills and sandstone rock sheets, populations of Aloe dichotoma, depressions and pans, seep wetland⁴s and watercourses, and Grade II and IIIa heritage features.
- Existing infrastructure, access roads and working areas are used as much as possible in the final design of SKA1_MID to avoid new disturbance.
- The extent of disturbance associated with new construction areas is minimised as much as possible in the final design of SKA1_MID.
- Sensitive environmental features are avoided where possible in the final design of SKA1_MID and where impacts to these features cannot be avoided, the impacts are mitigated with implementation of the prescribed management actions. Sensitive features include populations of Acacia erioloba and Hoodia spp, protected and listed faunal species⁵, floodplain wetlands (river beds), valley bottom wetlands, major drainage lines, riparian zones, ridges and high lying areas, prominent and quartz outcrops, and dolerite gravel plains, Grade IIIb & IIIc rock art sites.

Impact Management Actions	Implementation		Monitoring		
	Responsible persons	Timeframes	Methodology	Frequency	Responsible person
<ul style="list-style-type: none"> • Walk-through of the development site, by suitably qualified specialists, to ensure that final footprint of 	SKA Head of Construction	Prior to commencement of construction: detailed	Walk-through with final layout	Once off prior construction	SKA Environmental

⁴ “wetland” means land which is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is periodically covered with shallow water, and which land in normal circumstances supports or would support vegetation typically adapted to life in saturated soil.

⁵ For example: Northern Cape Nature Conservation Act 9/2009 and the NEMA Biodiversity Act 10 of 2004 (Notice 389 of 2013)

<p>SKA1_MID will not encroach on areas delineated as unsuitable for development and avoids sensitive environmental features where possible.</p> <ul style="list-style-type: none"> • Review of final footprint of SKA1_MID with site visit by SKA Environmental Manager to ensure optimal use of already disturbed areas and minimal indigenous vegetation clearance, including but not limited to offices, vehicle parking areas, construction camp, workshop, stockpile and lay down areas, hazardous materials storage areas (including fuels), batching plant, access roads, equipment cleaning areas, staff accommodation, cooking and ablution facilities, wastewater treatment plants. • Haulage and construction access roads must be carefully planned to utilise existing roads wherever possible. • Review of final footprint of SKA1_MID with site visit by SKA Environmental Manager to ensure that new access roads follow contours in hilly areas as far as possible and that impacts on drainage lines is minimised. • No excavation or construction activity (structures, pipelines, roads, etc.) will be undertaken within the 1:100 year flood line or riparian zone. • No excavation or construction activity (structures, pipelines, roads, etc.) will be undertaken within 500m radius from the boundary of a wetland without a water 	<p>& SKA Infrastructure Manager & SKA Logistics Manager & Suitably qualified specialist</p>	<p>design will be available by end 2017</p>	<p>maps Verify all required licences and permits</p>		<p>Manager</p>
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use licence in terms of the National Water Act (Act No. 36 of 1998).					
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2. Safety and Emergency Response Action Plan

Management Outcome:

- Establish appropriate emergency procedures to enable a rapid and effective response to all types of environmental emergencies.
- The site, the construction camps and onsite accommodation are planned according to the requirements of the Occupational Health and Safety Act (Act No. 85 of 1993).

Impact Management Actions	Implementation		Monitoring		
	Responsible person	Timeframes	Methodology	Frequency	Responsible person
<ul style="list-style-type: none"> • All unattended open excavations must be adequately fenced or demarcated. • Compile and implement an Emergency Response Action Plan for accidents, potential spillages, contamination of the ground and fires; in line with relevant legislation. The plan must clearly indicate the steps to be followed in case of each emergency. • SKA SHEQ Manager must designate an onsite Fire 	SKA Safety, Health and Quality Manager	Prior to the construction phase	Review Emergency Response Action Plan. Monitor compliance with the requirements of the Occupational Health and Safety Act. Review of basic fire safety training and fire safety requirements	Monthly during the construction phase	SKA Environmental Manager

<p>Control Officer.</p> <ul style="list-style-type: none"> • Basic fire-fighting equipment must be to the satisfaction of the Local Fire Services. • SKA SHEQ Manager must ensure that emergency telephone numbers (including emergency centre, police and ambulance services) are kept up to date and that all numbers and names are posted at relevant locations throughout the construction sites and the construction crew camps. • Identify fire hazards, demarcate and restrict public access to these areas as well as notify the local authority of any potential threats e.g. large brush stockpiles, fuels etc. • All fire requirements must be carried out as contained in the National Building Regulations SABS 0400 and the safety code of the National Fire Protection Association. • Correct fire-fighting equipment must be available on site and within easy access in case of emergency. • Provide basic fire safety training to security staff. • A portable bioremediation kit (to remedy chemical spills) is to be held on site and used as required. 					
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3. Visual Impacts

Management Outcome:					
<ul style="list-style-type: none"> To maximise the compatibility of the development with the surrounding landscape. Visual intrusion of SKA dish-antennas and associated infrastructure in the landscape is reduced. Impact of night lighting (light spill and glare) of structures and buildings associated with the SKA dish-antennas and associated infrastructure on the surrounding nightscape and visual receptors, including surrounding and adjacent properties, is minimised. 					
Impact Management Actions	Implementation		Monitoring		
	Responsible person	Timeframes	Methodology	Frequency	Responsible person
<ul style="list-style-type: none"> Materials, coatings and paints must be chosen based on minimal reflectivity and colours of buildings and structures must blend in with the landscape background where this is technically feasible and where it will not affect the functionality of the structures (e.g. earth-coloured paint). Screening of highly reflective material must be given particular attention. Measures to manage litter and dust must be in place at all times. Neatness and tidiness on site at all times must be implemented throughout the lifecycle of the project. The implementation of a lighting plan for SKA1_MID dish-antennas and associated infrastructure must ensure: <ul style="list-style-type: none"> Additional light pollution (night glow) in the regional nightscape must be minimised 	SKA Environmental Manager	Prior to commencement of construction	Review and monitor the implementation of the lighting plan	Once off prior construction	SKA Environmental Manager

<ul style="list-style-type: none"> ○ The erection of lighting must be undertaken in such a manner as to preclude the lighting from becoming intrusive. ○ Lighting of the facility must not exceed, in number of lights and brightness, the minimum required for safety and security. ○ Uplighting and glare (bright light) must be minimised using appropriate screening. ○ Low-pressure sodium light sources must be used to reduce light pollution. ○ Light fixtures must not spill light beyond the project boundary. 					
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4. Traffic Management

Management Outcome:

All potential impacts as a result of the construction related activities are minimized by establishment of an efficient and pro-active traffic management plan. Compliance with the local authority by-laws and any other statutory requirements relating to traffic is ensured.

Impact Management Actions	Implementation		Monitoring		
	Responsible person	Timeframes	Methodology	Frequency	Responsible person
<ul style="list-style-type: none"> • Preparation of a Method Statement for traffic control. 	SKA Environmental Manager	Prior to commencement of construction	Review method statement. Record minutes of	Once off prior construction	SKA Environmental Manager

<ul style="list-style-type: none"> • Appropriate traffic routing and scheduling of construction related vehicles will be carried out in consultation with a competent traffic engineer. • The contractor must provide a competent traffic marshal for situations where heavy construction traffic may impede normal traffic flows on any roads adjacent to the site. • All vehicles will be legally compliant. The Contractor must ensure that all construction vehicles are in a road-worthy condition. • All drivers will be competent and in possession of an appropriate valid driver's license. • All vehicles travelling on site will adhere to the specified speed limits (construction vehicle movement within the construction area must be restricted to 25km/hr). • The movement of all vehicles will be controlled such that they remain on designated routes. • No loose materials may be transported onto or off the site without the load being secured. • All un-surfaced roads on site must be damped down on a regular basis to reduce the levels of 			<p>meeting with SANRAL on the necessity of a Transport Traffic Plan. Conduct an audit of all required permits.</p> <p>Ensure that requirements for use of Transnet Service Roads are addressed and considered in the design, as and where applicable.</p>		
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<p>dust created by construction vehicles.</p> <ul style="list-style-type: none"> • Construction warning signs must be utilised including warning signage at the site's access and exit points for traffic to slow down. • No member of the workforce will be permitted to drive a vehicle under the influence of alcohol or narcotic substances. • If a Transnet Service Road will be used as the designated access road, the registration details of all vehicles that will make use of the road must be provided to Transnet, in order to obtain official permits. • Consult with the South African National Roads Agency Limited (SANRAL) to confirm whether a Transport Traffic Plan is required. • Permit needs must be obtained from the Provincial Government Northern Cape (PGNC) Department of Public Works, Roads and Transport for transport of abnormal loads to the site by road. 					
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5. Land Management

Management Outcome:

The land management authority appointed to manage the acquired land ensures that environmental protection activities and sustainable development guiding principles are incorporated in daily tasks on site.

Impact Management Actions	Implementation		Monitoring		
	Responsible person	Timeframes	Methodology	Frequency	Responsible person
<ul style="list-style-type: none"> Develop a detailed Land Management plan in light of environmental best practice principles 	SKA Land Management Authority	Prior to commencement of construction	Review and approve the detailed Land Management plan	Once off prior construction	SKA Environmental Manager

6. Alien invasive plant species control

Management Outcome:

Alien invasive vegetation removed from the construction area within 5 years and prevention of spreading of existing and new alien invasive plant species on disturbed sites.

Impact Management Actions	Implementation		Monitoring		
	Responsible persons	Timeframes	Methodology	Frequency	Responsible person
<ul style="list-style-type: none"> Implement Alien invasive species control and monitoring activities specified in Chapter 5 of this IEMP. Appoint suitably qualified specialist to implement detailed alien invasive plants eradication and management programme, within all SKA1_MID construction areas, in compliance with the Alien and Invasive Species Regulations under the National Environmental Management Biodiversity Act (Act 10 of 2004). All listed alien invasive plants within 50 metres of all working areas must be recorded (photographs, location and density) and cleared prior to the commencement of construction. 	SKA Environmental Manager & Suitably qualified specialist	Prior to commencement of construction	Review and monitor the implementation of the Alien invasive species management plans, including the available alien invasive plant species maps. Site visit to verify recordings of all listed alien invasive plants (photographs, location and density) within all SKA1_MID construction areas.	Once off prior construction	SKA Environmental Manager

<ul style="list-style-type: none"> • All herbicide treatments applied to alien Invasive plants must comply with the South African National Standards for handling, storage and disposal of Pesticides (SANS 10206:2010, Edition 2.2). Only herbicide registered for a particular plant species are to be used. Where no herbicide has been registered, use the least hazardous herbicide registered⁶ for a similar plant species (i.e. another species of tree or shrub). • Based on available <i>Prosopis</i> population density map in the SKA telescope core, a systematic clearing programme prioritizing the lower-density edges of the invasion, very small areas of high density invasion (<1 hectare), and areas subject to high levels of SKA-related activity for clearing must be implemented. 					
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⁶ See Hazard ratings for common commercial herbicides in Chapter 5 of the IEMP.

7. Stormwater and wastewater management

Management Outcome:					
<ul style="list-style-type: none"> • Negative impacts on channelling of flow (concentration of flow and speeding up velocity) and associated down slope erosion are avoided. • No discharge of contaminated water in into the natural environment, e.g. watercourses. • Natural base flows within these systems i.e. hydrological regime (water quantity and quality) are maintained. • Wastewater quality complies with relevant environmental standards and guidelines prior to be discharged in the evaporation dams. 					
Impact Management Actions	Implementation		Monitoring		
	Responsible person	Timeframes	Methodology	Frequency	Responsible person
<ul style="list-style-type: none"> • Prepare a detailed stormwater management plan outlining appropriate temporary or permanent measures to address runoff from construction areas and roads and to prevent discharge of water containing polluting matter or visible suspended materials into watercourses or water bodies, including drainage lines. • Use berms to divert and spread stormwater away from construction camps, construction sites, evaporation dam and borrow pits or from any excavations. • Implement measures that allow for flow attenuation and control of velocities (e.g. flow as diffuse or sheet flow, energy dissipation structures), and for the capture of sediment upstream of natural water courses. • Wherever possible, stormwater must be allowed to soak into the land in the area on which the water fell, e.g. retention ponds or areas with rock rip-rap (or similar). These could be used to 	SKA Infrastructure Manager	Prior to commencement of construction	Sign off stormwater plan and ensure all environmental requirements are complied with.	Once off prior construction	SKA Environmental Manager

<p>enhance the sense of place, if they are planted with indigenous vegetation.</p> <ul style="list-style-type: none"> • Ensure that flows are not diverted from their natural flow pathways, thus depriving downstream watercourses of water. • Runoff must not be redirected into populations of plants that are protected or of conservation significance. A competent ecology specialist must be consulted in case of any drainage alteration to sensitive plant populations on development site. • Access roads must not prevent stormwater to flow over the road along the drainage line. • Where significant erosion potential exists on sloping roads constructed with cut and fill, additional erosion protection must be implemented. • Sewage from the construction camps will be treated at each construction camp, using a Wastewater treatment package plant and thereafter will be pumped into a lined evaporation dam. • Wastewater from the cement/concrete batching areas and workshop areas will be sent to an oil separator before being pumped into a lined evaporation dam. • Evaporation dams must be lined to prevent seepage of treated wastewater into the groundwater system and berms and/or trenches will be provided to prevent stormwater from entering the evaporation ponds. 					
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8. Design of water crossings

Management Outcome:

All water crossings appropriately designed on the development site:

- to prevent erosion of banks of watercourses upstream and downstream of crossings as well as associated sedimentation,
- to minimise the alteration of surface and sub-surface flow, and
- to minimise the concentration of flow.

Impact Management Actions	Implementation		Monitoring		
	Responsible person	Timeframes	Methodology	Frequency	Responsible person
<ul style="list-style-type: none"> • Prepare a Method statement for the construction of water crossings. • Temporary crossing surface must be constructed for the crossing of sandy river beds, moderately marshy or soft soil areas that cannot support construction vehicles (drift crossing with no hardened surfaces are recommended). • The Construction of drifts must be aligned with stream bottoms. • All diversions must be in place, water diverted away from the Working Area and the area properly stabilised prior to excavations commencing. • No fill material may be placed where it will impede the natural flow of water in a river. 	SKA Infrastructure Manager	Prior to commencement of construction	Review method statement Verify construction schedule to ensure that river levels are at their lowest during planned construction.	Once off prior construction	SKA Environmental Manager

<ul style="list-style-type: none"> • When cutting through the embankments of watercourses erosion must be prevented from spreading in the direction of the road. • Ensure that the alteration of surface and sub-surface flow is minimised in order to retain connectivity and avoid fragmentation of ecosystems. • If a low level bridge or culvert crossings is to be constructed, the combined diameters of the pipes in the bed stream must be equal to the width of the water course, that is, the distance from one embankment to the opposite embankment, and have a diameter of approximately the depth of the 1 in 5 to 10 year flood level. • Bank stabilisation measures (e.g. gabions, eco logs, geofabric, sediment fences) are required when wetland or watercourse banks steeper than 1:5 are denuded during construction. 					
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9. Protection of flora and fauna

Management Outcome:

- All plants of high conservation significance and plants protected by national or provincial legislation⁷ that cannot be avoided and that are likely to be damaged during construction are successfully translocated to appropriate area.
- Collision risks to large birds are minimised with markers on powerlines.
- All disturbed areas to be rehabilitated are clearly demarcated and an efficient plan is in place to rehabilitate those areas in a timeous manner.

Impact Management Actions	Implementation		Monitoring		
	Responsible persons	Timeframes	Methodology	Frequency	Responsible person
<ul style="list-style-type: none"> • Review and update Plant Rescue and Protection Plan in Chapter 5 of this IEMP with site visit by suitably qualified ecology specialist. • Review and update Revegetation and Habitat Restoration Plan in Chapter 5 of this IEMP with site visit by suitably qualified ecology specialist. • Apply for required permit to remove, translocate, transport or cultivate indigenous, protected and specially protected plants on construction sites prior 	SKA Environmental Manager & Suitably qualified specialist	Prior to commencement of construction	Sign off the Plant Rescue and Protection Plan. Sign off the Revegetation and Habitat Restoration Plan. Review and approve translocation of endangered species likely to be damaged during construction. Check permits to remove, translocate, transport or cultivate indigenous, protected and specially protected plants.	Once off prior construction	SKA Environmental Manager

⁷ For example: Northern Cape Nature Conservation Act 9/2009 and the NEMA Biodiversity Act 10 of 2004 (Notice 389 of 2013)

<p>to cutting or clearing the affected species.</p> <ul style="list-style-type: none"> • Use underpasses in combination with fencing on stretches of roads with anticipated high road kill frequency. • Walk-through of the final grid network to identify optimal position of bird flappers. • Position markers⁸, particularly on powerlines adjacent to seasonally flooded areas (pans) or wetlands, since several “water birds” travel at night. Fit spikes or bird discouragers on vulnerable poles in wetland areas • On wood pole section of line, ensure that birds with wingspans >2.0 metres (vultures, martial eagles) cannot breach the gap between 2 live conductors or between live and earth phases⁹. 					
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⁸ Suggested markers are Bird Flight Diverters (brightly coloured plastic spirals 1m long, 30 cm in diameter), placed (attached) every 5 metres, static fibreglass plates such as yellow, spiral vibration dampers, 112 -125 cm long, placed at 3.3 metres intervals, or plates of yellow fibreglass 30.5 x 30.5 cm with a 5 cm diagonal black strip, placed at 23-32 metres intervals, and moving markers (flappers).

⁹ It is recommended that the electrical contractors seek advice from ESKOM on appropriate pole structures (Eskom 2011. Land_and_Biodiversity_Standard. Ref 32-815. Report compiled by R. Kruger, Land and Biodiversity task team, ESKOM).

<ul style="list-style-type: none"> Ensure appropriate spacing between photovoltaic panels to allow for sunlight to reach the groundcover to promote ecological succession and animal re-colonisation. 					
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10. Protection of Heritage Resources

Management Outcome:					
All heritage resources are mapped and appropriate management and mitigation measures are in place in accordance with the National Heritage Resources Act 25 of 1999.					
Impact Management Actions	Implementation		Monitoring		
	Responsible persons	Timeframes	Methodology	Frequency	Responsible person
<ul style="list-style-type: none"> The final footprint of infrastructure i.e. roads, powerline and cable trenching to be placed on the Lower Beaufort Group geological formation (Abrahamskraal Formation) must be verified by a professional palaeontologist before construction commences. Any consolidated alluvial deposits along major water courses such as the Sakrivier (including elevated calcretised terrace gravels) that are to be directly impacted by the proposed development must be assessed by a suitably qualified expert before construction commences. 	Suitably qualified specialist & Contractors	Prior to commencement of construction: detailed design will be available by end 2017	Ground-truthing surveys Review and implement the Conservation Management Plan	Once off prior construction	SKA Environmental Manager

<ul style="list-style-type: none"> • Full recording and grading (descriptively and spatially) of the historical farmsteads in the SKA construction footprint area, including their associated outbuildings, stone walling and cemeteries, as well as corbelled buildings must be undertaken by suitably qualified built heritage specialist and compiled into a conservation management plan. The grading process will earmark those resources worthy of conservation which is particularly relevant for sites to maintain. • If Grade IIIc heritage resources to be removed or destroyed within the construction areas the site must be recorded by a suitably qualified heritage specialist. • All Grade IIIb heritage resources within the construction areas must be assessed and recorded by a suitably qualified heritage specialist. Where applicable, annual monitoring of the condition of the heritage feature must be undertaken in compliance with the Conservation Management Plan as part of the Land Management Plan. 					
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11. Socio-Economic Development Initiatives and Communication Strategy

Management Outcome:

- Appropriate socio-economic development initiatives to be implemented during the lifetime of the SKA1_MID are established and reviewed by interested and affected stakeholders for additional inputs/comments.
- All interested and affected parties are informed and participate to the investigation on optimal communications technology alternative.
- An efficient and comprehensive stakeholder engagement framework to be implemented during the lifetime of the SKA1_MID is prepared and reviewed by interested and affected stakeholders for additional inputs/comments. See draft stakeholder engagement framework in Section X of this EMPr.
- A detailed development programme for farm workers who would be affected by the land purchase scheme is in place.
- National and local awareness of the SKA Human Development Capital Programme (HCDP) and educational opportunities offered by the programme is promoted and the public is informed of new opportunities and performance results of the SKA HCDP.

Impact Management Actions	Implementation		Monitoring		
	Responsible persons	Timeframes	Methodology	Frequency	Responsible person
<ul style="list-style-type: none"> • Consult interested and affected stakeholders on the Stakeholder engagement programme for SKA1_MID and include relevant comments and inputs into final programme. • Maintain a database of all interested and affected parties who have registered their interest in the SKA project 	SKA Stakeholder Manager & SKA Communication Manager	Prior to commencement of construction	Review and approve the Socio-Economic Development Initiatives and associated records of consultation with interested and affected stakeholders.	Once off prior construction	SKA Project Manager

<ul style="list-style-type: none"> • Develop and implement a collaborative and constructive approach to conflict resolution as part of the external stakeholder engagement process • SKA SA must ensure provision of telecommunication services through a variety of technical solutions that will increase mobility of cell phone usage for rural farmsteads. • SKA SA must establish and maintain internal resources to identify and establish alternative means of telecommunication services. • SKA SA must review, on an ongoing basis, the telecommunication needs of the community and ongoing technology developments, to ensure appropriate technology solutions and utilisation that is relevant, affordable, and up to date, in line with the requirements of the Astronomy Geographic Advantage Act. • SKA SA will confirm the number of farmworkers that will be retrenched (including spouses and number of children) and conduct one-on-one engagement with farmworkers and their families to determine various aspects of their life situation, including age profiles of farmworker, spouse and children; work experience, skills and responsibilities; interest in being employed by SKA; current wages and benefits (including accommodation and food); children's schooling and town location; preferred town of residence for relocation; and current housing situation. • SKA Human Resources will conduct a first-order assessment of skills and experience to enable match and placement within 			<p>Review and approve the Stakeholder engagement framework and associated records of consultation with interested and affected stakeholders.</p> <p>Review and approve the communications technology alternative plan and associated records of consultation with interested and affected stakeholders</p> <p>Review and approve the farm workers development programme and associated records of consultation with relevant stakeholders.</p> <p>Review and approve the schedule for the update of the social studies</p>		
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<p>positions in the SKA, including salary packages.</p> <ul style="list-style-type: none"> • Human Resources will assess training required for farmworkers to be match and placed in positions in the South African SKA Office (this could include artisan-training and further agricultural/land management training). • SKA will determine the accommodation requirements of farm workers in local towns (taking into account logistical arrangements for transport to working site). • Due to the current shortage of housing in Carnarvon for SKA staff, the SKA business management team will explore business models on how new accommodation can be provided to accommodate SKA staff in future. • SKA will determine whether farmworkers' spouses can also be accommodated by SKA through the expansion of the housekeeping staff which is required for MeerKAT and for SKA1_MID. • SKA will determine the children's education circumstances and current school location; and identify schooling requirements and potential to participate in the SKA Schools Programme. • Work with the Municipalities to establish properly constituted stakeholder engagement forums in all towns 					
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<ul style="list-style-type: none"> • Establish required stakeholders forums to keep communities in the surrounding towns informed and obtain stakeholders inputs for the final design phase. • Enhance collaboration with Northern Cape government to promote national and regional awareness of the SKA Human Development Capital Programme and establish a long-term strategic plan to optimise and align the various SKA Human Development Capital Programme investments already made by SKA and other state agencies in the Astro-Region. • Establish a schedule for regular socio-economic surveys in Carnarvon, Williston and Victoria West to monitor and report on socio-economic impacts resulting of the SKA1_MID over long term. • Maintain SKA presence in the regional area to facilitate stakeholder engagement and promote regional awareness of the SKA1_MID development and associated programmes (HCDP, farm worker development programme, land management programme, alien invasive plants management programme, etc). • As part of the requirement in terms of NEMA Section 24(2)(e), the SKA Stakeholder Manager must organise public meeting(s) at least once a year in Carnarvon and/or Williston to report back on the implementation of the IEMP (including the EMPr) and the progress of the long term research and monitoring programmes conducted in the SKA telescope core. 					
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VIII. CONSTRUCTION PHASE EMPr REQUIREMENTS

1. Construction areas and onsite facilities

Management Outcome:

- All areas delineated as unsuitable for development are avoided during construction activities, including red dunes, large dolerite hills and sandstone rock sheets, populations of *Aloe dichotoma*, depressions and pans, seep wetlands and watercourses, and Grade II and IIIa heritage features.
- Existing infrastructure, access roads and working areas are used as much as possible to avoid new disturbance.
- The extent of disturbance associated with new construction areas is minimised as much as possible.
- Sensitive environmental features are avoided where possible and where impacts to these features cannot be avoided, the impacts are mitigated with implementation of the prescribed management actions. Sensitive features include populations of *Acacia erioloba* and *Hoodia spp*, protected and listed faunal species¹⁰, floodplain wetlands (river beds), valley bottom wetlands, major drainage lines, riparian zones, ridges and high lying areas, prominent and quartz outcrops, and dolerite gravel plains, Grade IIIb & IIIc rock art sites.

Impact Management Actions	Implementation		Monitoring		
	Responsible persons	Timeframes	Methodology	Frequency	Responsible person
<ul style="list-style-type: none"> • No excavation or construction activity (structures, pipelines, roads, etc.) must be undertaken within 500m radius from the boundary of a wetland without a water use licence in terms of 	SKA Head of Construction	Prior to commencement	Site inspection	Monthly	SKA Environmental

¹⁰ For example: Northern Cape Nature Conservation Act 9/2009 and the NEMA Biodiversity Act 10 of 2004 (Notice 389 of 2013)

<p>the National Water Act (Act No. 36 of 1998).</p> <ul style="list-style-type: none"> • No excavation or construction activity (structures, pipelines, roads, etc.) will be undertaken within the 1:100 year flood line or riparian zone. • Designated parking areas must be identified and demarcated with applicable signage. • All concrete and cement batching area, including the storage of bagged cement, must be placed further than 100 metres of sensitive areas such as drainage lines, sensitive natural vegetation, etc. • Empty cement bags must be secured with adequate binding material to prevent spread of cement dust, if these will be temporarily stored on site prior to adequate disposal. • Sand, stone and cement must be stored in demarcated areas, and covered or sealed to prevent wind erosion and resultant deposition of dust on the surrounding indigenous vegetation. • Temporary chemical toilets must be supplied by the Contractor within the development sites. 1 toilet per 20 staff members must be provided for. • Weekly servicing of chemical toilets needs to be undertaken by a licenced Service Provider and service records must be filed at the site office. • Toilets must be located at least 100 metres from any 	<p>& SKA Infrastructure Manager & SKA Logistics Manager & Contractors</p>	<p>ent of construction</p>	<p>Verify all required licences and permits</p> <p>Visual inspection of applicable signage on roads and at parking areas</p> <p>Site inspection for signs of erosion along roads</p>	<p>Manager</p>
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<p>watercourse or wetland system and outside of the 1:100 year floodline. No septic tanks must be established closer than 50 metres to aquatic ecosystems.</p> <ul style="list-style-type: none"> • The construction of "long drop" toilets is forbidden. • Under no circumstances may neighbouring, open areas or the surrounding bush, be used as a toilet facility by contractors and workers. • Toilets must be kept in a clean, neat and hygienic condition, and sufficient supply of toilet paper at all toilets ensured at all times. • Undertake environmentally-friendly pest control in the camp area. • All fencing and barriers must be maintained in good working order for the duration of construction activities. Where possible, use existing gates to gain access to all parts of the working areas. • Designate restricted eating areas for eating during normal working hours. Adequate closed refuse bins must be provided and cleaned on a daily basis. • All access routes are to be flagged to enable visitors and suppliers to reach specific dish-antenna/tower locations and construction camps on the accepted access route. • All access and haul roads within the site need to be maintained 					
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<p>in a good condition.</p> <ul style="list-style-type: none"> • Access roads are not allowed to be utilised for recreational activities. Security personnel must be informed and ensure that this is enforced. • Unnecessary compaction of soil on site by heavy vehicles must be avoided. • Construction vehicles need to be restricted to demarcated access, haulage routes and turning areas. • Only approved borrow pits must be utilised to source material for the establishment of access roads. 					
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2. General Stockpile Management

<p>Management Outcome:</p> <p>All material excavated during the construction phase are appropriately managed to ensure that compaction of soils, and erosion and sedimentation are minimised within construction areas.</p>					
Impact Management Actions	Implementation		Monitoring		
	Responsible person	Timeframes	Methodology	Frequency	Responsible person
<ul style="list-style-type: none"> • Stockpiles must be placed in an area that will not obstruct the natural water pathways / flows on site. • No stockpile of any type must be located within 100 metres of a 	SKA Head of Construction & SKA	During the construction phase	Visual inspection of stockpiles (location, erosion, runoffs, height, weeds).	Monthly	SKA Environmental Manager

<p>watercourse</p> <ul style="list-style-type: none"> • Stockpiles must be positioned in an area that will prevent dust particles being blown on to the adjacent residents. • Stockpiles must be located outside of the 1:100 year floodline. • Topsoil removed during the establishment of borrow pits and quarries must be stored in a bund wall. • All stockpiles must be effectively stabilised and protected from erosion. • Obstruction to traffic or line of sight must be avoided, in particular at intersections and sharp corners. • Stockpiles must not exceed 2 metres in height to avoid compaction thereby maintaining the soil integrity and chemical composition. • All stockpiled material must be maintained and kept clear of weeds and alien vegetation growth by undertaking regular weeding and control methods. • Any topsoil stockpiles must be kept separate from other stockpiled materials for later use in rehabilitation requirements. • Soil stockpiles from areas with alien invasive plants must not be placed in areas free of alien invasive plants. • In case of windy conditions or heavy rain, stockpiles must be 	<p>Infrastructure Manager</p>				
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<p>protected by vegetation using an indigenous grass seed mix or cloth, depending on the duration of the time which the stockpiles will remain.</p> <ul style="list-style-type: none"> • Dust suppression in the form of watering must be implemented on all soil stockpile areas during windy conditions. The construction of a berm consisting of sand bags, or a low brick wall, can also be installed around the base of the stockpile for soil retention purposes. • Stormwater runoff from the stockpile sites and other related areas must be directed into the stormwater management system and may not run freely into the immediate and surrounding environments. • Compacted areas caused by stockpiling must be ripped and rehabilitated as construction progresses. 					
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3. Environmental Awareness

Management Outcome:					
<ul style="list-style-type: none"> Environmental awareness program is implemented during construction activities. The SKA staff and all Contractors are familiar with the EMPr requirements and have, at a minimum, a basic level of Environmental Awareness Training. 					
Impact Management Actions	Implementation		Monitoring		
	Responsible person	Timeframes	Methodology	Frequency	Responsible person
<ul style="list-style-type: none"> All staff is made aware of their individual roles and responsibilities in achieving compliance with the EMPr and any required permit or licence (e.g. Water use licence). Environmental awareness information posters must be displayed at key locations on site in all applicable languages. The Contractor's Environmental Manager must undertake Environmental Awareness Induction Training prior to the start of any construction activities on site. The induction must include as a minimum the following: <ul style="list-style-type: none"> How construction activities can impact on the environment, and what measures can be taken to mitigate against these impacts; Awareness of emergency and response 	SKA Environmental Manager	During the construction phase	Review and approve content of Environmental Awareness Induction Training Review records and attendance registers of all Environmental Awareness Induction Training Visual inspection to check that environmental awareness information posters are visible and maintained at key locations on site.	Monthly during the construction phase	SKA Environmental Manager

<p>procedures;</p> <ul style="list-style-type: none"> • Prevention of pollution and litter control and the minimization of disturbance to sensitive areas; • Social responsibility during construction (no excessive noise (e.g. shouting/hooting), a "clean site" policy, no alcohol / drugs and no firearms permitted on site, no harvesting of fruit or firewood from the site or from areas adjacent to it); • Use of facilities provided for workers (forbidden use of alternatives such as bush as toilet facility or fires for warmth or cooking); • No trespassing on private / commercial properties bordering the site; • Environmental Awareness Induction Training material must be available and presented in all applicable languages. 					
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4. Staff behaviour onsite

Management Outcome:					
<ul style="list-style-type: none"> Contractors monitor the performance of workers to ensure compliance with good environmental practices and general conduct. Safe working environment for all staff on site through the reduction of risks of diseases, injuries, fire, spills, environmental degradation and other types of incidents 					
Impact Management Actions	Implementation		Monitoring		
	Responsible persons	Timeframes	Methodology	Frequency	Responsible person
<ul style="list-style-type: none"> Trapping, snaring or feeding of animals is forbidden. Encourage the use of energy saving equipment at the site camp site (such as low voltage lights and low pressure taps), promote recycling, and minimised water use. Only dedicated ablution facilities must be used (use of mobile chemical toilets in area where no permanent ablution facilities are available with a minimum of one mobile chemical toilet per 10 persons.) Information and education relating to sexually transmitted diseases must be 	SKA Environmental Manager & SKA Safety, Health and Quality Manager	During the construction phase	Visual inspections of construction areas and surroundings to ensure that there are no visible or measurable signs of littering or environmental pollution. Regular audits of water systems to identify possible water leakages. Audit the complaint register and check that all complaints have been addressed.	Monthly during the construction phase	SKA Environmental Manager

made available to staff and contractors.					
<ul style="list-style-type: none"> Medical support must be made available by the contractor for all contractor staffs. 					

5. Safety and Emergency procedures

Management Outcome:					
<ul style="list-style-type: none"> Emergency procedures are in place to enable a rapid and effective response to all types of environmental emergencies. The site, the construction camps and onsite accommodation are managed in strict accordance with the Occupational Health and Safety Act (Act No. 85 of 1993). 					
Impact Management Actions	Implementation		Monitoring		
	Responsible person	Timeframes	Methodology	Frequency	Responsible person
<ul style="list-style-type: none"> All unattended open excavations must be adequately fenced or demarcated. Ensure structures vulnerable to high winds are secured. Ensure all staff wears appropriate personal protective equipment. Adequate protective measures must be implemented to prevent unauthorised access to the construction sites and camps, i.e. the boundary of National Research Foundation-owned land, construction sites for dish-antennas and construction camps will be fenced. 	SKA Safety, Health and Quality Manager	During the construction phase	<p>Conduct an audit of all incidences to ensure these are reported and efficiently resolved.</p> <p>Visual inspection of open excavations to ensure these are fenced and/or demarcated</p> <p>Visual inspection of fences to check their integrity.</p> <p>Monitor compliance with the</p>	Monthly during the construction phase	SKA Environmental Manager

<ul style="list-style-type: none"> • Contractors must maintain an incidents and complaints register in which all incidents or complaints involving employees or the public are logged. • Contractors must take all reasonable and active steps to avoid increasing the risk of fire through their activities on site. • Fire-fighting equipment must be made available at various appropriate locations on the construction site and in all vehicles. Fire extinguishers must be serviced and accessible. • Contractors must be in possession of and know how to use an emergency spill kit (including absorbent material, adequate spill containment and clean-up equipment) • A portable bioremediation kit (to remedy chemical spills) is to be held on site and used as required. • All spills of hazardous substances must be recorded, documented and reported to the SKA Environmental Manager and SKA Project Manager. • All spills over 20 litres must be reported as an environmental incident to the SKA Environmental Manager. • In the case of pollution of any surface or groundwater, the Regional Representative of the Department of Water and Sanitation (DWS) must be informed immediately. 			<p>requirements of the Occupational Health and Safety Act.</p> <p>Monitor Emergency Response</p> <p>Visual inspection of fire-fighting equipment</p> <p>Inspection of emergency spill kits.</p> <p>Site inspections and an audit of reported spills.</p>		
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6. Vegetation Clearance

Management Outcome:

- Vegetation clearing during construction is restricted to the footprint of the proposed infrastructure only.
- Indigenous vegetation, including protected or endangered species, outside the construction footprint is left undisturbed.
- All the necessary permits or licences for the removal of protected, indigenous vegetation are in place prior to any clearing.

Impact Management Actions	Implementation		Monitoring		
	Responsible person	Timeframes	Methodology	Frequency	Responsible person
<ul style="list-style-type: none"> • Retain as much existing vegetation along the boundaries of the construction site as possible, as intact vegetation adjacent will assist in the control of sediment dispersal from exposed areas, thus reducing erosion risks. • Translocation areas must be mapped, photographed and monitored, and records kept. • Searching, rescue and replanting of all protected and endangered species or species of conservation concern likely to be damaged during construction must be completed prior to any construction or clearing. • The use of herbicides, where required, must comply with the Fertilisers, Farm, Feeds, Agricultural Remedies and Stock Remedies Act, 1947 (Act 36 of 1947). Only a registered pest control operator must 	SKA Environmental Manager	During the construction phase	<p>Visual inspections of translocated plants and audit records.</p> <p>Visual checks of construction areas to ensure debris are appropriately disposed of.</p> <p>Review of required use of herbicides and herbicide register.</p>	Monthly during the construction phase	SKA Environmental Manager

<p>apply herbicides on a commercial basis.</p> <ul style="list-style-type: none"> • After salvaging protected plants, scrape remaining vegetation into windrows or remove it with the topsoil. The dead vegetation is valuable as a source of seeds, mulch and plant nutrient during rehabilitation. • During clearing of vegetation, remove topsoil and store it in low berms adjacent to the construction area and upslope for re-spreading during rehabilitation. • Following the clearing of an area, the surfaces of all exposed slopes must be roughened to retain water and increase infiltration. • Rivers, watercourses and other water bodies must be kept clear of felled trees, vegetation cuttings and debris. Debris resulting from clearing and pruning must be disposed of at a licenced waste disposal facility. • Where clearing for access purposes is essential, the maximum width to be cleared within the servitude must be in compliance with Electrical Machinery regulations (GNR 1593 of 12 August 1988 in terms of OHS Act 85 of 1993). 					
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7. Alien invasive plant species control

Management Outcome:

Alien invasive vegetation removed from the construction area within 5 years and prevention of spreading of existing and new alien invasive plant species on disturbed sites.

Impact Management Actions	Implementation		Monitoring		
	Responsible persons	Timeframes	Methodology	Frequency	Responsible person
<ul style="list-style-type: none"> Implement Alien invasive species control and monitoring activities specified in Chapter 5 of this IEMP. Suitably qualified specialist will implement detailed alien invasive plants eradication and management programme, within all SKA1_MID construction areas, in compliance with the Alien and Invasive Species Regulations under the National Environmental Management Biodiversity Act (Act 10 of 2004). The management of Alien Invasive Plant Species on construction sites must follow the Working for Water Operation Standards¹¹ and 	SKA Environmental Manager & Suitably qualified specialist	During the construction phase	Regular inspection of construction sites to monitor any spread of new or existing alien invasive plants. Regular inspection of borrow pits, quarries and sand mines to ensure it remains free of alien invasive plants. Report on the success of areas where control measures were implemented (e.g. % of new alien invasive plants-free site), the season during which the control measures was implemented, the herbicide used and the successful	Monthly	SKA Environmental Manager

¹¹ https://www.environment.gov.za/sites/default/files/legislations/project_operation_standards.pdf. Note: an updated version of the Operational Standards Alien Invasive Plant Species.xls is available from <https://sites.google.com/site/wfwplanning/implementation> via a Dropbox account

<p>species-specific treatment recommendations¹² including disposal of (seed bearing) alien invasive plants material in a sustainable manner and to prevent further spreading.</p> <ul style="list-style-type: none"> • Clear all listed alien invasive plants within 50 metres of all working areas prior to the commencement of construction and ensure that a rapid response plan for clearing newly established invasive alien plants is in place. • Ensure that materials extracted from borrow pits, quarries and sand mines, for construction activities and rehabilitation, originate from alien invasive plants-free sites. • All construction machinery and plant equipment delivered to site for use during the construction phase must be cleaned in order to limit the introduction of Alien Invasive Plant Species. 			<p>application method.</p>		
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¹² Working for Water species and herbicide list v4 (xls) Compiled by D. Sharp adapted from T. Bold and updated 2012 <https://sites.google.com/site/wfwplanning/implementation>
 Sharp, D. 2011 Terrestrial herbicides and growth forms (V3) <https://sites.google.com/site/wfwplanning/implementation>

8. Protection of flora and fauna

Management Outcome:

- Impacts on flora and fauna are minimised during the construction activities.
- Poaching/hunting/intentional killing of any animal is not tolerated under any circumstances.
- Rehabilitation of disturbed areas adheres to the approved Re-vegetation and Habitat Restoration Plan.

Impact Management Actions	Implementation		Monitoring		
	Responsible person	Timeframes	Methodology	Frequency	Responsible person
<ul style="list-style-type: none"> • Access to all areas delineated as unsuitable for development (red dunes, large dolerite hills and sandstone rock sheets, populations of Aloe dichotoma, depressions and pans, seep wetlands and watercourses, and Grade II and IIIa heritage features) and sensitive environmental features (populations of Acacia erioloba and Hoodia spp, protected and listed faunal species , floodplain wetlands, valley bottom wetlands, major drainage lines, riparian zones, ridges and high lying areas, prominent and quartz outcrops, and dolerite gravel plains, Grade IIIb & IIIc rock art sites) must be restricted to avoid environmental incidents. • Collection of rare, endangered and endemic plants for own use or sale for their medicinal, rarity or ornamental values, is forbidden. • No interference with livestock must occur without the 	SKA Environmental Manager	During the construction phase	<p>Site inspection to ensure that restricted areas are clearly delimited and that staff remain within demarcated construction areas</p> <p>Adhoc site inspections to ensure responsible behaviour of staff (no collection of plants, no hunting/poaching, killing, no interference with livestock)</p> <p>Monitor bat activity levels within footprint area.</p> <p>Site inspection to identify potential erosion</p>	Monthly	SKA Environmental Manager

<p>landowner's written consent.</p> <ul style="list-style-type: none"> • Poaching/hunting/killing of animals is strictly forbidden and constitute a criminal offence. • In case of a problem animal, e.g. venomous snake, encountered onsite a suitably qualified specialists must safely relocate the animal. • Ensure small animals are not trapped in open trenches. • The breeding sites of raptors and other wild birds' species must be kept intact and undisturbed during construction. • Any bats roosts discovered during construction must be kept intact and undisturbed. • Ensure that minimal soil compaction occurs and that undisturbed land is not used as thoroughfare to prevent reduction of soil infiltration capacity and soil erosion. • All slopes disturbed during construction must be reinforced to prevent erosion (e.g. with re-vegetation of slope). • Implement erosion control measures in case of excessive erosion, loss of soils and creation of gulleys, to reduce surface flow velocity and allow for settlement on site of silt laden surface waters. 			<p>Inspections of backfilled trenches.</p>		
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9. Water use, Water Quality and Soil Contamination

Management Outcome:					
<ul style="list-style-type: none"> • Pollution and contamination of the water surfaces, ground water and soils as well as potential erosion are prevented. • Soil, surface water and groundwater contamination is prevented during maintenance and washing of vehicles and equipment as well as during parking of vehicles. 					
Impact Management Actions	Implementation		Monitoring		
	Responsible persons	Timeframes	Methodology	Frequency	Responsible person
<ul style="list-style-type: none"> • Suitable water meters will be installed and regular audits of water systems will be undertaken to identify possible water leakages (develop a water balance). • Cleaning methods utilised for cleaning vehicles, equipment, floors, must minimise water use. • Every precaution must be taken to ensure that any chemicals or hazardous substances do not contaminate the soil, surface or groundwater on site. • Ensure that the mixing of all chemicals and hazardous materials takes place on a tray or impermeable surface. Waste generated from these activities must then be disposed of at a registered landfill site. • Ensure that all storage tanks are properly designed and managed in order to prevent pollution of surface and 	SKA Infrastructure Manager & Contractors	During the construction phase	Conduct an audit of abstraction points or boreholes to ensure that all registered with the DWS and that boreholes are not located within 50 metres radius from the boundary of a wetlands and watercourses. Monitor volumes of water abstraction/ usage. Monitor quality of boreholes water (used for domestic purposes) to determine level of treatment necessary.	Monthly	SKA Environmental Manager

<p>groundwater, and soils.</p> <ul style="list-style-type: none"> • Ensure that use and storage of fuels and chemicals that could potentially leach into the ground is properly controlled. Fuel and chemical storage containers must be set on a secure bunded platform. • Adequate spillage containment and clean-up measures must be implemented at all time. • Cement batching activities must be undertaken in a controlled manner in order to contain spillages and prevent contamination of soil, surface water and groundwater. • Concrete mixing must be carried out in a bunded area and on an impermeable surface (such as on mortar boards or similar structures). • Vehicles and equipment used at concrete batching plants must be cleaned in demarcated wash bays, using cleaning trays where appropriate. Wastewater treated prior to disposal in an evaporation dam. • All construction vehicles wash areas must have oil traps installed before draining into the sewer system. • No storage of hazardous construction materials whatsoever, or placement of temporary ablution facilities, must take place within 100 meters of a watercourse or wetland, or within the 1:100 year floodline. 			<p>Visual inspection to ensure that contaminated ground has been appropriately treated or removed.</p> <p>Conduct an audit of waste manifests or waybills to ensure appropriate disposal</p> <p>Visual inspection for visual signs of water pollution.</p> <p>In case of contamination, monitor quality of groundwater before and after treatment.</p> <p>In case of contamination, monitor surface water quality upstream and downstream before and after treatment.</p> <p>Review method statement.</p> <p>Visual inspection of refuelling and cleaning procedures.</p>		
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<ul style="list-style-type: none"> Contaminated water storage facilities must not be allowed to overflow and appropriate protection from rain and flooding must be implemented. Contaminated soils must be analysed in terms of the 2014 National Norms and Standards for the Remediation of Contaminated Land and Soil Quality (i.e. GN 331). Appoint suitably qualified contractors to remove any residue of hazardous substance spillages from site. Contaminated soil must be disposed of at a registered waste facility designated for this purpose No natural watercourse or water body must be used for the purposes of swimming, personal washing and the washing of machinery or clothes. Any irrigation of the development area for landscaping or dust control purposes being passed into natural drainage lines must be controlled. The quality of the groundwater abstracted must be regularly monitored. Groundwater quality monitoring must include: pH, Electrical conductivity, Total dissolved solids, total suspended solids, soap, oil and grease, total alkalinity, free and saline ammonia, ortho-phosphate, Sulphate, Nitrate, Fluoride, Chloride, Sodium, Magnesium, Calcium, Potassium, Aluminium, Iron, Manganese, Lead. Surface water quality must be regularly monitored where roads 			<p>Conduct an audit of the maintenance log (vehicles, pipes, connectors etc.).</p> <p>Visual inspection of used oils and lubricants storage area.</p>		
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<p>sections cross drainage lines or other water resources.</p> <ul style="list-style-type: none"> • The contractors must compile a method statement for the workshop maintenance and cleaning of equipment as well for refuelling activities under normal and emergency situations. • All maintenance of vehicles and equipment must be undertaken in a dedicated workshop area, fitted with a bund wall and a grease trap oil separator. • If on-site servicing and refuelling is required in emergency situations, a mobile refuelling unit and appropriate ground protection such as drip trays must be used. • Adequate containers for the cleaning of equipment and materials (paint, solvent) must be provided as to avoid spillages. • Leaking equipment must be repaired or removed from site to facilitate repair. Regular visual inspections of pipes and connectors to identify wear and tear must take place. • Drip trays must be placed under all unused equipment and vehicles parked outside to avoid leakage of oil and fuel. • Workshop areas must be monitored for oil and fuel spills and such spills must be cleaned and remediated. • Used oils and lubricants must be transferred to special waste oil collection drums regularly to prevent accumulation and potential contamination at the work site. 					
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10. Stormwater and wastewater management

Management Outcome:					
<ul style="list-style-type: none"> An effective system of stormwater run-off control is implemented. Impacts to the environment (in particular water resources) caused by stormwater and wastewater discharges during construction are avoided. 					
Impact Management Actions	Implementation		Monitoring		
	Responsible person	Timeframes	Methodology	Frequency	Responsible person
<ul style="list-style-type: none"> The implementation of the stormwater management plan/system must be monitored to ensure that the peak storm water discharge from the site has not increased as a result of construction activities. Revegetate bare areas around construction sites as soon as possible to prevent accelerated runoff from construction activities. Sediment barriers/controls must be installed on eroded areas. Erosion gullies and rills within the construction site must be rehabilitated. Wastewater must be kept separate from clean stormwater and must not run freely into any of the surrounding naturally vegetated areas. Treated wastewater must be reused where possible for non-consumption activities such as dust suppression and cleaning of 	SKA Infrastructure Manager	During the construction phase	<p>Undertake a periodic site inspection to verify and inspect the effectiveness and integrity of the run-off control system and to specifically record the occurrence of any erosion on site or downstream.</p> <p>Monitor the quality of treated wastewater/ effluent before entering the evaporation dam to ensure compliance to applicable standards.</p> <p>Audit waste manifests or waybills as a proof of adequate disposal.</p>	Monthly	SKA Environmental Manager

<p>vehicles.</p> <ul style="list-style-type: none"> • Any modification or damage to the banks or bed of streams, rivers, wetlands, other open water bodies and drainage lines adjacent to, or within the designated working area are forbidden except if an environmental permit allows such activity. • Earth, stone and rubble must not be placed in stormwater channels, drainage lines or rivers. • No storage of any materials whatsoever will occur on or within 50 metres of a natural drainage system. • Stormwater outfalls must be designed in a way to reduce flow velocity and avoid stream banks and soil erosion. • Un-channelled flow must be controlled to avoid erosion. • Where the surface run-off is concentrated, the flow must be attenuated (e.g. by contouring with hay bales/berms). Concentrated flow must be channelled into detention/attenuation ponds or areas protected with hay bales for flow minimisation and sediment trapping. • All storm water channels must be inspected regularly to ensure that they are not blocked and/or obstructed to ensure their efficient operation. • Separate stormwater collection areas and interceptors must be installed at fuel storage areas and batching plants. 					
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11. Solid and Hazardous Waste Management

Management Outcome:

- An efficient recycling of all recyclable waste generated at the site is facilitated.
- The disposal to landfill of any general waste generated at the site is minimised.
- The potential health, safety and environmental risks associated with the incorrect disposal of hazardous waste are minimised.
- Wastes are appropriately stored, handled and safely disposed of at an appropriate licensed waste facility.

Impact Management Actions	Implementation		Monitoring		
	Responsible persons	Timeframes	Methodology	Frequency	Responsible person
<ul style="list-style-type: none"> • Recyclable and non-recyclable waste must be separated in clearly labelled and closed (lid-secured) bins. • Non-hazardous waste generated on site must be disposed of at a registered landfill site and waybills filed at the site office for auditing purposes. • Hazardous waste - including (but not limited to) used oil and lubricants, paint, empty tins, fuel spillages, contaminated materials, oil and grease containers, fluorescent tubes and batteries (e.g. Lead Cell, Nickel, Cadmium, etc. - must be stored in leak-proof secured storage containers/bins. 	SKA Infrastructure Manager & Contractors	During the construction phase	<p>Visual site inspection to monitor the condition of the construction camp and construction areas.</p> <p>Visual inspection of the temporary storage and handling of waste on site (waste segregation, storage, etc.).</p> <p>Monitor waste generation (record amount of each</p>	Monthly	SKA Environmental Manager

<ul style="list-style-type: none"> • Ensure all staff is aware of correct waste segregation/disposal methods. • Ensure that the designated area for wastes (i.e. skips and waste collection bins) is inspected on a daily basis to verify its condition and integrity, particularly after rainfall events. • Waste collection bins and skips must be covered with suitable material. • Contractors must ensure that all litter is collected daily from working areas. Similarly, all bins and/or skips must be regularly emptied and their waste disposed of at a registered landfill site. All waybills are to be filed at the site office. • If the on-site storage of general waste or hazardous waste exceeds 100 cubic metres or 80 cubic metres respectively for more than 90 consecutive days, the National Norms and Standards for the Storage of Waste (published on 29 November 2013 under GN 926) must be adhered to. • No waste must be disposed of, burned or buried on site, with the exception of biodegradable waste that can be buried in a pit excavated for that purpose and covered with layers of soil, incorporating a final 0,5 metre thick layer of topsoil. • The burning of waste is forbidden. • Any solids remaining in the evaporation dam after evaporation has occurred will be removed by an approved waste 			<p>type of waste generated) Conduct an audit of the waste manifests.</p> <p>Audit the chosen waste disposal site to ensure that it is functioning correctly.</p> <p>Visual inspection of the hazardous substances storage area to ensure it complies with the requirements of the OHSA 85 of 1993 (restricted access, bunds, etc.).</p> <p>Conduct an audit of the Hazardous Chemical Substance control sheet and Material Safety Data Sheet to ensure it is up to date and readily available. Adhoc visual inspection to ensure staff wears the appropriate personal protective equipment when required.</p>		
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<p>management Contractor as and when necessary.</p> <ul style="list-style-type: none"> • Illegal dumping of waste is strictly forbidden. • Ensure that all waste emanating from the construction phase is removed from site prior to the commencement of the rehabilitation and operation phase. • Compliance with the Occupational Health and Safety Act No 85 of 1993 is monitored and the necessary permits/licences and authorisation from the relevant authorities (e.g. Flammable Liquid License for diesel volumes greater than 200 litres, Environmental Authorisation for the storage of dangerous goods greater than 30 000 litres) are in place. • Hazardous substances are handled in a safe manner and stored in suitable bunded storage areas, >100 metres away from watercourses to prevent soil and groundwater contamination and environmental degradation. • All hazardous substances (such as fuel, oil, paint, herbicide and insecticides) must be stored in suitable clearly labelled containers (indicating the contents, quantities and safety requirements) and in a locked well-ventilated area. • All storage areas/tanks must be situated on a smooth impermeable surface (concrete) with a permanent bund to contain a spill/leak from the stored containers and in a way that does not pose a danger of pollution even during times of high rainfall. The floor of the bund must be sloped, draining to an oil 					
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<p>separator.</p> <ul style="list-style-type: none"> • Establish an Alphabetical Hazardous Chemical Substance control sheet to be kept up to date on a continuous basis. All hazardous chemicals that will be used on site will have Material Safety Data Sheets which must be updated as required • Employees handling hazardous substances / materials must be trained in the safe use of the substance and must be aware of the potential impacts and follow appropriate safety measures. Appropriate personal protective equipment must be made available. • Hazardous storage areas must display the required safety signs depicting "no smoking", No Naked lights" and "Danger". • Adequate fire-fighting equipment must be made available at all hazardous storage areas. • No unauthorised access into the hazardous substances storage areas must be permitted. 					
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12.Dust / Air Pollution Impacts

Management Outcome:

Air quality impacts due to the generation of dust as a result of construction activities and vehicles are minimised. Effective air quality management practices are implemented throughout the construction phase.

Impact Management Actions	Implementation		Monitoring		
	Responsible person	Timeframes	Methodology	Frequency	Responsible person
<ul style="list-style-type: none"> The site must be dampened with a water bowser or sprinklers, as necessary to minimise dust problems. Alternatively chemical soil stabilisers must also be used for dust suppression. Vehicles and machinery must be kept in good working condition and must be legally compliant. In case of excessive emissions the Contractor must repair and service the problematic equipment. No fires, whatsoever, are to be permitted on the development site. Should burning be required, the necessary written approval must be obtained from the SKA Project Manager and SKA Environmental Manager prior to any burning and all the necessary precautions must be taken to avoid any potential damage occurring to surrounding land owners or environment. All forms of dust pollution must be managed in terms of the Atmospheric Pollution Prevention Act, 1965 (Act No. 45 of 1965) and all required licences/permits have been obtained (e.g. water 	SKA Site Manager	During the construction phase	Visual inspection of areas where dust-dampening measures are implemented.	When required	SKA Environmental Manager

<p>use licence).</p> <ul style="list-style-type: none">• Excavation, handling and transport of erodible materials is avoided under high wind conditions or when a visible dust plume is present.• Note that concrete dust is toxic and damages soil properties. Therefore watering to prevent dust spread must not be done where concrete dust has fallen or it will infiltrate into the soil.					
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13.Noise

Management Outcome:

- Effective noise mitigation measures are implemented throughout the construction phase.
- Ensure compliance with all legal requirements, including the local authority bylaws and any other statutory requirements relating to noise impacts.

Impact Management Actions	Implementation		Monitoring		
	Responsible person	Timeframes	Methodology	Frequency	Responsible person
<ul style="list-style-type: none"> • Provisions of SANS 1200 Sub clause 4.1 regarding "built-up areas" apply to all areas within audible distance of residents whether in urban, peri-urban or rural areas. • Any contractors working on the site must not use sound amplification equipment on site unless for the purposes of site safety and communications and in emergency situations. • Blasting, piling or any other 'noisy' activities must take place during normal working hours (8am - 5 pm Monday to Friday). • The surrounding community must be notified 3 days prior to any planned activities that will be unusually noisy (including, but not limited to, blasting, piling, use of compressors, bulk demolitions, etc).. • All construction vehicles must be maintained in a good working order to reduce possible noise pollution. 	SKA Site Manager	During the construction phase	<ul style="list-style-type: none"> • Undertake a baseline ambient noise survey (Equivalent continuous rating levels measurement) at sensitive sites. • Measure noise levels in accordance with SANS 10103 • Record and address complaints from interested and affected parties including staff on site and surrounding landowners. 	<p>Once off prior to construction commencing</p> <p>Monthly</p> <p>When required</p>	SKA Environmental Manager

<ul style="list-style-type: none"> Equipment that is fitted with noise reduction facilities (e.g. side flaps, silencers etc.) must be used as per operating instructions and maintained properly during site operations. 					
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14. Visual impacts

<p>Management Outcome:</p> <p>Implementation of effective visual impact measures throughout the construction phase.</p>					
Impact Management Actions	Implementation		Monitoring		
	Responsible person	Timeframes	Methodology	Frequency	Responsible person
<ul style="list-style-type: none"> Measures to manage litter and dust must be in place at all times. Neatness and tidiness on site at all times must be implemented throughout the lifecycle of the project. Ensure compliance with the lighting plan established during Final Design Phase, including: Minimise night lighting and activities within requirements of safety and efficiency, and carefully select the locations of the security 	SKA Environmental Manager	During the construction phase	<p>Monitor compliance with the lighting plan.</p> <p>Site inspection for monitoring visual impacts of signage, construction activities and SKA1_MID infrastructure.</p>	Monthly	SKA Environmental Manager

<p>lights to avoid excessive influence on surrounding areas.</p> <ul style="list-style-type: none"> • Lights must be directed away from wetlands and watercourses to minimise disturbance of aquatic and semi-aquatic fauna. • Use timer switches or motion detectors (within safety requirements) to control lighting in areas that are not occupied continuously. • Limit signage to only that which is absolutely necessary. • Visual screening must be erected at strategic points around the proposed development site during construction to further minimize the visual impact to local stakeholders. • The erection of lighting must be undertaken in such a manner as to preclude the lighting from becoming intrusive. • Storage facilities, elevated tanks and other temporary structures on site must be located such that they are visually un-obtrusive to the local residents. 					
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15. Traffic Management

Management Outcome:

Effective Traffic Control is maintained throughout the construction phase. Impacts on current traffic flows in the vicinity of the site are minimised and complaints relating to traffic associated with the site's activities are minimised.

Impact Management Actions	Implementation		Monitoring		
	Responsible person	Timeframes	Methodology	Frequency	Responsible person
<ul style="list-style-type: none"> The Contractor must ensure that all construction vehicles are in a road-worthy condition. Only areas designated as parking areas must be used for parking trucks and vehicles. No loose materials must be transported onto or off the site without the load being secured. Construction vehicle movement within the construction site must be restricted to 25 km per hour. All un-surfaced roads on site must be damped down on a regular basis to reduce the levels of dust created by construction vehicles. Construction warning signs must be utilised including warning signage at the site's access and exit points. Implement mitigation measures if high rate of wildlife road 	SKA Site Manager	During the construction phase	Conduct an audit of the vehicle maintenance log book. Site inspection for parking areas, roads condition (structural damage) and enforcement of speed limits. Audit of records of wildlife collisions and road kills. Visual check of signalization at and near all construction sites.	Monthly	SKA Environmental Manager

collision is recorded/reported.					
<ul style="list-style-type: none"> Implement clear and visible signage and signals indicating movement of vehicles at all intersection to ensure safe entry and exit. 					

16.Rehabilitation of temporary construction areas

Management Outcome:					
Disturbed areas are rehabilitated to original state upon completion of construction activities in accordance with the approved Revegetation and Habitat Restoration Plan (Chapter 5 of this IEMP).					
Impact Management Actions	Implementation		Monitoring		
	Responsible person	Timeframes	Methodology	Frequency	Responsible person
<ul style="list-style-type: none"> Topsoil must be replaced in the correct order it was extracted and erosion prevention measures be put in place on areas with a steep gradient (such as geotextiles) All temporary structures, equipment, residual litter and building materials must be removed. Disturbed areas must be ripped to loosen the soil and re-vegetating the area with locally indigenous vegetation. 	SKA Environmental Manager	During the construction phase	<p>Visual site inspection to ensure that disturbed areas roads adequately rehabilitated.</p> <p>Keep photographic records of rehabilitated areas to assess the effectiveness of the rehabilitation plan.</p> <p>Check that the closure and rehabilitation plan for the</p>	As required upon completion of construction activities	SKA Environmental Manager

<ul style="list-style-type: none"> • All sloped areas (including river banks) must be appropriately stabilised and erosion controlled. • Temporary access roads no longer required for operation activities must be closed and rehabilitated. • Borrow pits and quarries no longer needed for the operation phase must be rehabilitated. 			borrow pits and quarries has been approved by DMR.		
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17. Cultural Heritage resources

Management Outcome: <ul style="list-style-type: none"> • Damages to and destruction of fossils, artefacts and materials of heritage significance are avoided. • New archaeological finds are preserved and appropriately managed should these be discovered during construction. 					
Impact Management Actions	Implementation		Monitoring		
	Responsible person	Timeframes	Methodology	Frequency	Responsible person
<ul style="list-style-type: none"> • All heritage resources encountered during construction activities must be managed in conformance to the requirements of the Heritage Resources Act 25 of 1999. • The SKA Environmental Manager must be 	SKA Environmental Manager	During the construction phase	Site inspection in case of archaeological and palaeontological materials finds.	When required	SKA Environmental Manager

<p>notified within 24 hours if any human remains, archaeological or palaeontological material are uncovered on the development site.</p> <ul style="list-style-type: none"> • SAHRA must be contacted if any heritage objects are identified during earthmoving activities and all development must cease until further notice. • No structures older than sixty years or parts thereof are allowed to be demolished altered or extended without a permit from SAHRA. • No activities are allowed within 50m of a site which contains rock art. • SAHRA must be contacted if any graves are identified during construction. 					
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18. Socio-Economic Development Initiatives and Communication Strategy

Management Outcome:

- Socio-economic development initiatives are implemented during the construction phase.
- Optimal communications technology alternatives are implemented during the construction phase.
- The stakeholder engagement framework is implemented during the construction phase as per Section X of this EMPr.
- The development programme for farm workers who would be affected by the land purchase scheme is implemented.
- National and local awareness of the SKA HC DP and educational opportunities offered by the programme is promoted and the public is informed of new opportunities and performance results of the SKA HC DP.

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Impact Management Actions	Implementation		Monitoring		
	Responsible persons	Timeframes	Methodology	Frequency	Responsible person
<ul style="list-style-type: none"> • Maintain a database of all interested and affected parties who have registered their interest in the SKA project • Ensure effective implementation of stakeholder engagement programme. • The implementation of alternative telecommunication services must be monitored through consultation with affected stakeholders. • SKA SA must review, on an ongoing basis, the telecommunication needs of the community and ongoing technology developments, to ensure appropriate technology solutions and utilisation that is relevant, affordable, and up to date, in line with the requirements of the Astronomy Geographic Advantage Act. • Implement farm worker development programme. • Review and report back on training provided to farmworkers (artisan-training and further agricultural/land management training), job opportunities provided to the farmworkers' spouses, and schooling opportunities provided to the farmworkers' children as part of the SKA Schools Programme. • Review and report back on accommodation alternative provided 	<p>SKA Stakeholder Manager & SKA Communication Manager</p>	<p>During the construction phase</p>	<p>Review and monitor the Socio-Economic Development Initiatives and associated records of consultation with interested and affected stakeholders.</p> <p>Review and monitor the Stakeholder engagement framework and associated records of consultation with interested and affected stakeholders.</p> <p>Review and monitor communications technology alternative plan and associated records of consultation with interested and affected stakeholders.</p> <p>Review and monitor the farm workers development programme and associated records of consultation with relevant stakeholders.</p>	<p>Monthly during the construction phase</p>	<p>SKA Project Manager</p>

<p>to farmworkers.</p> <ul style="list-style-type: none"> • Work with the Municipalities to maintain stakeholder engagement forums in all towns • Report back on discussions held at the stakeholders forums and identify key issues/concerns to be addressed. • Enhance collaboration with Northern Cape government to promote national and regional awareness of the HC DP and establish a long-term strategic plan to optimise and align the various HC DP investments already made by SKA and other state agencies in the Astro-Region. • Organise regular socio-economic surveys in Carnarvon, Williston and Victoria West to monitor and report on socio-economic impacts resulting of the SKA1_MID over long term. • Maintain SKA presence in the regional area to facilitate stakeholder engagement and promote regional awareness of the SKA1_MID development and associated programmes (HC DP, farm worker development programme, land management programme, alien invasive plants management programme, etc). • As part of the requirement in terms of NEMA Section 24(2)(e), the SKA Stakeholder Manager must organise public meeting(s) at least once a year in Carnarvon and/or Williston to report back on the implementation of the IEMP (including the EMPr) and the progress of the long term research and monitoring programmes conducted in the SKA telescope core. 			<p>Review and monitor the schedule for the update of the social studies</p>		
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IX. OPERATION PHASE EMPr REQUIREMENTS

1. Environmental Awareness training

Management Outcome:					
<ul style="list-style-type: none"> Environmental awareness program is implemented during operation and maintenance activities. The SKA staff and all Contractors are familiar with the EMPr requirements and have, at a minimum, a basic level of Environmental Awareness Training. 					
Impact Management Actions	Implementation		Monitoring		
	Responsible person	Timeframes	Methodology	Frequency	Responsible person
<ul style="list-style-type: none"> All staff is made aware of their individual roles and responsibilities in achieving compliance with the EMPr and any required permit or licence (e.g. Water use licence). Environmental awareness information posters must be displayed at key locations on site in all applicable languages. The Environmental Manager must undertake Environmental Awareness Induction Training prior to the start of any operation and maintenance activities on site. The induction must include as a minimum the following: How operation and maintenance activities can impact on the environment, and what measures 	SKA Environmental Manager	During the operation phase	Review and approve content of Environmental Awareness Induction Training Review records and attendance registers of all Environmental Awareness Induction Training Visual inspection to check that environmental awareness information posters are visible and maintained at key locations on site.	As required during the operation phase	SKA Environmental Manager

<p>can be taken to mitigate against these impacts;</p> <ul style="list-style-type: none"> • Awareness of emergency and response procedures; • Prevention of pollution and litter control and the minimization of disturbance to sensitive areas; • Social responsibility during operation and maintenance activities (no excessive noise (e.g. shouting/hooting), a "clean site" policy, no alcohol / drugs and no firearms permitted on site, no harvesting of fruit or firewood from the site or from areas adjacent to it); • Use of facilities provided for workers (forbidden use of alternatives such as bush as toilet facility or fires for warmth or cooking); • No trespassing on private / commercial properties bordering the site; • Environmental Awareness Induction Training material must be available and presented in all applicable languages. 					
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2. Staff behaviour onsite

Management Outcome:					
<ul style="list-style-type: none"> Contractors monitor the performance of workers to ensure compliance with good environmental practices and general conduct. Safe working environment for all staff on site through the reduction of risks of diseases, injuries, fire, spills, environmental degradation and other types of incidents 					
Impact Management Actions	Implementation		Monitoring		
	Responsible persons	Timeframes	Methodology	Frequency	Responsible person
<ul style="list-style-type: none"> The following restrictions will be placed on all staff operating on the site in general: Adherence to relevant health and safety standards and municipal by-laws; Use of appropriate Personal Protective Equipment at all times; No alcohol or illegal substance use may occur on site; No illegal disposal of rubble; No littering of the site or surrounding areas; 	SKA Environmental Manager & SKA Safety, Health and Quality Manager	During the operation phase	Visual inspections of construction areas and surroundings to ensure that there are no visible or measurable signs of littering or environmental pollution (soils, ground and surface water), wood/plants are not collected and animals not disturbed, and that workers are smoking or cooking in designated areas only. Regular audits of water systems to identify possible water leakages. Audit the complaint register and check that all complaints have been addressed.	As required during the operation and maintenance activities	SKA Environmental Manager

<ul style="list-style-type: none"> • No collection of firewood; • No interference with or damage to any fauna or flora; • No use of toilet facilities other than the dedicated ablution facilities provided on site (permanent ablution building or mobile chemical toilets); • No lighting of open fires; and • No burning of any waste on site. • Encourage the use of energy saving equipment at the site camp site (such as low voltage lights and low pressure taps), promote recycling, and minimised water use. • Ensure all gates remain closed at all times, in particular when gates on surrounding farms within the spiral arms are used by the operation/maintenance staff. 					
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3. Safety and Emergency procedures

Management Outcome:					
<ul style="list-style-type: none"> Emergency procedures are in place to enable a rapid and effective response to all types of environmental emergencies. The site, the construction camps and onsite accommodation are managed in strict accordance with the Occupational Health and Safety Act (Act No. 85 of 1993). 					
Impact Management Actions	Implementation		Monitoring		
	Responsible person	Timeframes	Methodology	Frequency	Responsible person
<ul style="list-style-type: none"> All unattended open excavations must be adequately fenced or demarcated. Ensure structures vulnerable to high winds are secured. Ensure all staff wears appropriate personal protective equipment. Contractors must maintain an incidents and complaints register in which all incidents or complaints involving employees or the public are logged. Contractors must take all reasonable and active steps to avoid increasing the risk of fire through their activities on site. Fire-fighting equipment must be made available at various appropriate locations on the construction site and in all vehicles. Fire extinguishers must be serviced and accessible. 	SKA Safety, Health and Quality Manager	During the operation phase	<p>Conduct an audit of all incidences to ensure these are reported and efficiently resolved.</p> <p>Visual inspection of open excavations to ensure these are fenced and/or demarcated</p> <p>Visual inspection of fences to check their integrity.</p> <p>Monitor compliance with the requirements of the Occupational Health and Safety Act.</p>	Monthly during the operation phase	SKA Environmental Manager

<ul style="list-style-type: none"> • Contractors must be in possession of and know how to use an emergency spill kit (including absorbent material, adequate spill containment and clean-up equipment) • A portable bioremediation kit (to remedy chemical spills) is to be held on site and used as required. • All spills of hazardous substances must be recorded, documented and reported to the SKA Environmental Manager and SKA Project Manager. • All spills over 20 litres must be reported as an environmental incident to the SKA Environmental Manager. • In the case of pollution of any surface or groundwater, the Regional Representative of the Department of Water and Sanitation (DWS) must be informed immediately. 			<p>Monitor Emergency Response</p> <p>Visual inspection of fire-fighting equipment</p> <p>Inspection of emergency spill kits.</p> <p>Site inspections and an audit of reported spills.</p>		
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4. Protection of flora and fauna

Management Outcome:

- Impacts on flora and fauna are minimised during the operation and maintenance activities.
- Poaching/hunting/intentional killing of any animal is not tolerated under any circumstances.
- Rehabilitation of disturbed areas adheres to the approved Re-vegetation and Habitat Restoration Plan.

Impact Management Actions	Implementation		Monitoring		
	Responsible person	Timeframes	Methodology	Frequency	Responsible person
<ul style="list-style-type: none"> • Undertake maintenance of rehabilitated areas in accordance with the Revegetation and Habitat restoration plan. • Access to all areas delineated as unsuitable for development (red dunes, large dolerite hills and sandstone rock sheets, populations of Aloe dichotoma, depressions and pans, seep wetlands and watercourses, and Grade II and IIIa heritage features) and sensitive environmental features (populations of Acacia erioloba and Hoodia spp, protected and listed faunal species , floodplain wetlands (river beds), valley bottom wetlands, major drainage lines, riparian zones, ridges and high lying areas, prominent and quartz outcrops, and dolerite gravel plains, Grade IIIb & IIIc rock art sites) must be restricted during the operation phase to avoid environmental incidents. • Collection of rare, endangered and endemic plants for own use or sale for their medicinal, rarity or ornamental values, is forbidden. 	SKA Environmental Manager	During the operation and maintenance activities	<p>Keep photographic records of rehabilitated areas to assess the effectiveness of the rehabilitation plan.</p> <p>Visual inspections of powerline routes to ensure that vegetation is managed appropriately.</p> <p>Review reports on number of faunal road mortalities and collisions.</p> <p>Review reports of staff patrolling powerlines to record vulnerable large birds kill due to</p>	Quarterly	SKA Environmental Manager

<ul style="list-style-type: none"> • No interference with livestock must occur without the landowner's written consent. • Poaching/hunting/killing of animals is strictly forbidden and constitute a criminal offence. • In case of a problem animal, e.g. venomous snake, encountered onsite a suitably qualified specialists must safely relocate the animal. • Ensure small animals are not trapped in open trenches. • The breeding sites of raptors and other wild birds' species must be kept intact and undisturbed during operation. • Any bats roosts discovered during operation must be kept intact and undisturbed. • Ensure that minimal soil compaction occurs and that undisturbed land is not used as thoroughfare in order to prevent reduction of soil infiltration capacity and increase in soil erosion. • Implement erosion control measures, (e.g. use of geofabric, stone gabions, re-vegetation), in case of excessive erosion, loss of soils and creation of gulleys, to reduce surface flow velocity and allow for settlement on site of silt laden surface waters. • Keep indigenous grasses that seed themselves short within the perimeter of the dish-antennas platforms to form a ground 			<p>electrocution.</p> <p>Review reports of staff patrolling powerlines to remove all bird nests.</p> <p>Monitor bat activity levels within footprint area.</p>		
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<p>cover.</p> <ul style="list-style-type: none"> Remove nests from dish-antennas to protect the infrastructure, and to prevent populations of invasive alien Cape Sparrows establishing in the operation footprint area. Ensure bird nests (in particular nests of Sociable Weavers and Crows) are removed from poles before they become large enough to cause faults (flashover risks). 					
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5. Alien invasive plant species control

<p>Management Outcome:</p> <p>Prevention of spreading of existing and new alien invasive plant species on disturbed and rehabilitated sites.</p>					
Impact Management Actions	Implementation		Monitoring		
	Responsible persons	Timeframes	Methodology	Frequency	Responsible person
<ul style="list-style-type: none"> Implement Alien invasive species control and monitoring activities specified in Chapter 5 of this IEMP. Suitably qualified specialist to monitor successful implementation of alien invasive plants eradication and management programme in compliance with the Alien and Invasive Species Regulations under the 	<p>SKA Environmental Manager & Suitably qualified specialist</p>	<p>During the operation and maintenance activities</p>	<p>Site inspection during maintenance activities to monitor any spread of new or existing alien invasive plants.</p> <p>Report on control measures performance.</p>	<p>Quarterly</p>	<p>SKA Environmental Manager</p>

<p>National Environmental Management Biodiversity Act (Act 10 of 2004).</p> <ul style="list-style-type: none"> The management of Alien Invasive Plant Species during the operational phase must follow the Working for Water Operation Standards¹³ and species-specific treatment recommendations¹⁴ including disposal of seed bearing alien invasive plants material. 					
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6. Stormwater and wastewater management

<p>Management Outcome:</p> <p>An effective system of stormwater run-off control is implemented.</p>					
Impact Management Actions	Implementation		Monitoring		
	Responsible person	Timeframes	Methodology	Frequency	Responsible person
<ul style="list-style-type: none"> Where it is required, implement an effective system of run-off control (e.g. energy dissipaters, silt fences, sand bags, brush packing with cleared vegetation, planting of vegetation, hydro seeding/hand sowing) to shed and spread water (avoid 	SKA Infrastructure Manager	During the operation phase	Undertake a periodic site inspection to verify and inspect the effectiveness and integrity of the run-off	Quaterly	SKA Environmental Manager

¹³ https://www.environment.gov.za/sites/default/files/legislations/project_operation_standards.pdf. Note: an updated version of the Operational Standards Alien Invasive Plant Species.xls is available from <https://sites.google.com/site/wfwplanning/implementation> via a Dropbox account

¹⁴ Working for Water species and herbicide list v4 (xls) Compiled by D. Sharp adapted from T. Bold and updated 2012 <https://sites.google.com/site/wfwplanning/implementation>
 Sharp, D. 2011 Terrestrial herbicides and growth forms (V3) <https://sites.google.com/site/wfwplanning/implementation>

<p>concentrating runoff) and to prevent potential down slope erosion. Use drip trays when cleaning the photovoltaic panels, to redirect water running off the panels.</p> <ul style="list-style-type: none"> • Where possible keep indigenous vegetation to form a ground cover and prevent erosion. • All erosion control mechanisms need to be regularly maintained and stormwater infrastructure regularly inspected to ensure that it is kept clear of all debris and weeds. • If water is used to clean the photovoltaic solar panels, the chemicals that are used to treat the water before washing must not contain hazardous substances that can impact negatively on groundwater. • No maintenance and cleaning of vehicles or equipment are allowed on site. 			<p>control system and to specifically record the occurrence of any erosion on site or downstream.</p>		
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7. Solid and Hazardous Waste Management

Management Outcome:					
<ul style="list-style-type: none"> • An efficient recycling of all recyclable waste generated at the site is facilitated. • The disposal to landfill of any general waste generated at the site is minimised. • The potential health, safety and environmental risks associated with the incorrect disposal of hazardous waste are minimised. • Wastes are appropriately stored, handled and safely disposed of at an appropriate licensed waste facility. 					
Impact Management Actions	Implementation		Monitoring		
	Responsible persons	Timeframes	Methodology	Frequency	Responsible person
<ul style="list-style-type: none"> • Recyclable and non-recyclable waste must be separated in clearly labelled and closed (lid-secured) bins. • Non-hazardous waste generated on site must be disposed of at a registered landfill site and waybills filed at the site office for auditing purposes. • Hazardous waste - including (but not limited to) used oil and lubricants, paint, empty tins, fuel spillages, contaminated materials, oil and grease containers, fluorescent tubes and batteries (e.g. Lead Cell, Nickel, Cadmium, etc. - must be stored in leak-proof secured storage containers/bins. • Ensure all operation and maintenance staff is aware of correct waste segregation/disposal methods. • Sufficient closed containers must be strategically located around the operation site to handle the amount of wastes generated on 	SKA Infrastructure Manager & Contractors	During the operation and maintenance activities	Visual site inspection to monitor the condition of designated area for wastes (i.e. skips and waste collection bins). Monitor waste generation (record amount of each type of waste generated). Conduct an audit of the waste manifests. Audit the chosen waste disposal site to ensure that it is functioning correctly.	During operation and maintenance activities	SKA Environmental Manager

<p>the site and must be emptied regularly (at a minimum weekly).</p> <ul style="list-style-type: none"> • Ensure that the designated area for wastes (i.e. skips and waste collection bins) is inspected on a daily basis to verify its condition and integrity, particularly after rainfall events. • Waste collection bins and skips must be covered with suitable material. • If the on-site storage of general waste or hazardous waste exceeds 100 cubic metres or 80 cubic metres respectively for more than 90 consecutive days, the National Norms and Standards for the Storage of Waste (published on 29 November 2013 under GN 926) must be adhered to. • Small amount of biodegradable waste generated during operation and maintenance activities can be buried in a pit excavated for that purpose and covered with layers of soil, incorporating a final 0,5 metre thick layer of topsoil. • The burning of waste is forbidden. • Any solids remaining in the evaporation dam after evaporation has occurred will be removed by an approved waste management Contractor as and when necessary. • Illegal dumping of waste is strictly forbidden. • Compliance with the Occupational Health and Safety Act No 85 of 1993 is monitored and the necessary permits/licences and authorisation from the relevant authorities (e.g. Flammable 			<p>Visual inspection of the hazardous substances storage area to ensure it complies with the requirements of the OHSA 85 of 1993 (restricted access, bunds, etc.).</p> <p>Conduct an audit of the Hazardous Chemical Substance control sheet and Material Safety Data Sheet to ensure it is up to date and readily available.</p> <p>Adhoc visual inspection to ensure staff wears the appropriate personal protective equipment when required.</p>		
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<p>Liquid License for diesel volumes greater than 200 litres, Environmental Authorisation for the storage of dangerous goods greater than 30 000 litres) are in place.</p> <ul style="list-style-type: none"> • Hazardous substances are handled in a safe manner and stored in suitable bunded storage areas, >100 metres away from watercourses to prevent soil and groundwater contamination and environmental degradation. • All hazardous substances (such as fuel, oil, paint, herbicide and insecticides) must be stored in suitable clearly labelled containers (indicating the contents, quantities and safety requirements) and in a locked well-ventilated area. • All storage areas/tanks must be situated on a smooth impermeable surface (concrete) with a permanent bund to contain a spill/leak from the stored containers and in a way that does not pose a danger of pollution even during times of high rainfall. The floor of the bund must be sloped, draining to an oil separator. • Maintain Alphabetical Hazardous Chemical Substance control sheet. All hazardous chemicals that will be used on site must have updated Material Safety Data Sheets. • Employees handling hazardous substances / materials must be trained in the safe use of the substance and must be aware of the potential impacts and follow appropriate safety measures. Appropriate personal protective equipment must be made available. 					
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<ul style="list-style-type: none"> • Hazardous storage areas must display the required safety signs depicting “no smoking”, No Naked lights” and “Danger”. • Adequate fire-fighting equipment must be made available at all hazardous storage areas. • No unauthorised access into the hazardous substances storage areas must be permitted. 					
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8. Cultural Heritage resources

<p>Management Outcome:</p> <ul style="list-style-type: none"> • Damages to and destruction of fossils, artefacts and materials of heritage significance are avoided. • New archaeological finds are preserved and appropriately managed should these be discovered during operation and maintenance activities. 					
Impact Management Actions	Implementation		Monitoring		
	Responsible person	Timeframes	Methodology	Frequency	Responsible person
<ul style="list-style-type: none"> • The SKA Environmental Manager must be notified within 24 hours if any human remains, archaeological or palaeontological material are uncovered on the development site. • SAHRA must be contacted if any heritage objects are identified during earthmoving activities and all development must cease until 	SKA Environmental Manager	During operation and maintenance activities.	Site inspection in case of archaeological and palaeontological materials finds.	When required	SKA Environmental Manager

<p>further notice.</p> <ul style="list-style-type: none"> No structures older than sixty years or parts thereof are allowed to be demolished altered or extended without a permit from SAHRA. No activities are allowed within 50m of a site which contains rock art. SAHRA must be contacted if any graves are identified during construction. 					
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9. Traffic Management

<p>Management Outcome:</p> <ul style="list-style-type: none"> Effective Traffic Control is maintained during the operation and maintenance activities. Impacts on current traffic flows in the vicinity of the site are minimised and complaints relating to traffic associated with the site's activities are minimised. 					
Impact Management Actions	Implementation		Monitoring		
	Responsible person	Timeframes	Methodology	Frequency	Responsible person
<ul style="list-style-type: none"> The Contractor must ensure that all operation and maintenance vehicles are in a road-worthy condition. Ensure compliance with parking areas and specified speed limits 	SKA Site Manager	During the operation and maintenance activities	Conduct an audit of the vehicle maintenance log book. Site inspection of vehicles maintenance, parking areas,	Monthly	SKA Environmental Manager

<ul style="list-style-type: none"> • No loose materials may be transported onto or off the site without the load being secured. • Ensure minimal level of dust generated by on-site vehicles during operation and maintenance activities. • Implement mitigation measures if high rate of wildlife road collision is recorded. • Implement clear and visible signage and signals indicating movement of vehicles at all intersection. 			<p>and condition (structural damage) of roads.</p> <p>Monitor speed limits and general awareness of vehicle drivers.</p> <p>Audit of records of wildlife collisions and road kills.</p>		
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10. Socio-Economic Development Initiatives and Communication Strategy

Management Outcome:

- Socio-economic development initiatives are implemented during the operation phase.
- Effective implementation of communications technology alternatives are monitored during the operation phase.
- The stakeholder engagement framework is implemented during the operation phase as per Section X of this EMPr.
- The development programme for farm workers who were affected by the land purchase scheme is implemented.
- National and local awareness of the SKA HCDP and educational opportunities offered by the programme is promoted and the public is informed of new opportunities and performance results of the SKA HCDP.

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Impact Management Actions	Implementation		Monitoring		
	Responsible persons	Timeframes	Methodology	Frequency	Responsible person
<ul style="list-style-type: none"> • Maintain a database of all interested and affected parties who have registered their interest in the SKA project • Ensure effective implementation of stakeholder engagement programme. • The implementation of alternative telecommunication services must be monitored through consultation with affected stakeholders. • SKA SA must review, on an ongoing basis, the telecommunication needs of the community and ongoing technology developments, to ensure appropriate technology solutions and utilisation that is relevant, affordable, and up to date, in line with the requirements of the Astronomy Geographic Advantage Act. • Ensure effective implementation of farm worker development programme. • Review and report back on training provided to farmworkers (artisan-training and further agricultural/land management training), job opportunities provided to the farmworkers' spouses, and schooling opportunities provided to the farmworkers 'children as part of the SKA Schools Programme. • Review and report back on accommodation alternative provided 	<p>SKA Stakeholder Manager & SKA Communication Manager</p>	<p>During the operation phase</p>	<p>Review and monitor the Socio-Economic Development Initiatives and associated records of consultation with interested and affected stakeholders.</p> <p>Review and monitor the Stakeholder engagement framework and associated records of consultation with interested and affected stakeholders.</p> <p>Review and monitor communications technology alternative plan and associated records of consultation with interested and affected stakeholders.</p> <p>Review and monitor the farm workers development programme and associated records of consultation with</p>	<p>Monthly during the operation phase</p>	<p>SKA Project Manager</p>

<p>to farmworkers.</p> <ul style="list-style-type: none"> • Work with the Municipalities to maintain stakeholder engagement forums in all towns • Report back on discussions held at the stakeholders forums and identify key issues/concerns to be addressed. • Enhance collaboration with Northern Cape government to promote national and regional awareness of the HCDP and establish a long-term strategic plan to optimise and align the various SKA Human Development Capital Programme investments already made by SKA and other state agencies in the Astro-Region. • Organise regular socio-economic surveys in the Astro-Region to monitor and report on socio-economic impacts resulting of the SKA1_MID over long term. • Maintain SKA presence in the regional area to facilitate stakeholder engagement and promote regional awareness of the SKA1_MID development and associated programmes (HCDP, farm worker development programme, land management programme, alien invasive plants management programme, etc). • SKA Stakeholder Manager must organise public meeting(s) at least once a year in Carnarvon and/or Williston to report back on the implementation of the IEMP (including the EMPr) and the progress of the long term research and monitoring programmes conducted in the SKA telescope core. 			<p>relevant stakeholders.</p> <p>Review and monitor the schedule for the update of the social studies</p>		
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X. SKA Stakeholder Engagement Programme

This section represents South African SKA Office's commitment to work effectively with its stakeholders, learn from past stakeholder engagement experiences and continue to improve its community involvement and public image. In the stakeholder engagement framework, "stakeholder" means the community members directly affected by the SKA project i.e. neighbouring farms and surrounding towns' communities, businesses, NGO's, faith based organisations, Municipalities, and other government and non-government organisations as well as the broader public.

1. Objectives

The Stakeholder Engagement Framework seeks to:

- Effectively communicate and increase public access to SKA related information that is accurate, responsible, reliable and end-user focused;
- Ensure a customised and coherent approach to stakeholder engagement across SKA stakeholders;
- Enable better planned, more informed and effective engagement activities;
- Position stakeholder engagement as one of the strategic drivers for the SKA;
- Facilitate effective collaboration and knowledge sharing;
- Communicate the South African SKA Office's commitment to and principles of stakeholder engagement to its stakeholders;
- Maintain SKA reputation and stakeholder relations while supporting the realisation of the SKA vision;
- Increase engagement (debate / discussion) on SKA related science, technology, engineering, mathematics and innovation (issues among communities / audience categories throughout South Africa and SKA African partner countries).

For these benefits to be realised, the South African SKA Office recognises that stakeholder engagement must be embedded within the culture and core functions of SKA. This commitment and integration will lead to better outcomes for the individuals and groups that are affected by, or can affect, the SKA's activities. The following 5-point strategic approach will guide all engagement activities:

- Investing in the youth;
- Supporting community upliftment programmes;
- Developing small to medium enterprises;
- Nurturing learners' talent; and
- Ensuring that communication connectivity is not compromised.

Furthermore five guiding principles will be used when engaging and implementing this stakeholder engagement strategy with the public to ensure optimal collaboration:

- **Responsive and reciprocal:** the South African SKA Office understands that engagement is a two-way process and appreciates the benefits of mutual learning (between stakeholders and SKA);
- **Inclusive:** the South African SKA Office commit to seek out and facilitate the involvement of those potentially interested or affected by SKA work, including those that are harder to reach for reasons such as language, culture, age or mobility;

- **Impartial and objective:** the South African SKA Office will make efforts to ensure information is accessible and objective and facilitate engagement with all stakeholders who have an interest;
- **Open, transparent and trusting:** the South African SKA Office will provide information so stakeholders can participate in a meaningful way and will foster a culture of sharing ideas; and
- **Respect:** the South African SKA Office will use stakeholders' input to improve its community involvement, will actively listen to and understand stakeholder needs, seeking to understand how they want to be engaged, based on their particular circumstances.

2. Levels of participation in stakeholder engagement

The Stakeholder engagement framework forms part of the broader communications framework as determined by the South African SKA Office Head of Communications and Stakeholder Engagement and is aligned to the SKA Organisation and DST strategic objectives. The South African SKA Office communications framework includes:

- Effectively communicating and increasing public access to SKA related information that is accurate, responsible, reliable and end-user focused;
- Increase engagement (debate / discussion) on SKA related science, technology, engineering, mathematics and innovation issues among communities / audience categories throughout South Africa and SKA African partner countries;
- Advancing the discipline of science communication; and
- Maintain SKA reputation and stakeholder relations while supporting the realisation of the SKA vision.

The key principles of the South African SKA Office communications framework are Inform, Consult, Involve, Collaborate, and Empower. Each of these five principles is linked to specific goals, commitments and methods of engagement (see Table 2-5 below) as determined by the South African SKA Office Head of Communications and Stakeholder Engagement.

Integrated Environmental Management Plan 2018-2023

Table 4-2: Key principles of the South African SKA Office communications framework

	Inform	Consult	Involve	Collaborate	Empower
Stakeholder engagement goals	To provide balanced, objective, accurate and consistent information to assist stakeholders to understand the Project and how they will be affected.	To obtain feedback from stakeholders on analysis, alternatives and/or outcomes	To work directly with stakeholders throughout the process to ensure that their concerns and needs are consistently understood and considered.	To partner with the stakeholder including the development of alternatives, making decisions and the identification of preferred solutions.	Stakeholders are enabled/equipped to actively contribute to the achievement of outcomes.
Promise to stakeholders	South African SKA Office will keep stakeholders informed	South African SKA Office will keep stakeholders informed, listen to and acknowledge concerns and aspirations, and provide feedback on how stakeholder input influenced the outcome	South African SKA Office will work with stakeholders to ensure that their concerns and aspirations are directly reflected in the alternatives developed and provide feedback on how stakeholder input influenced the outcome	South African SKA Office will look to stakeholders for advice and innovation in formulating solutions and incorporate stakeholders' advice and recommendations into the outcomes to the maximum extent possible.	South African SKA Office will support and complement stakeholders' actions.
Methods of Engagements	<ol style="list-style-type: none"> 1. Fact sheets 2. Site visits 3. Engagement with community structures 4. Newsletters, circulars 5. Websites, 6. Information sessions and workshops 7. School visits 8. Visitor Centre 9. Information Centre 	<ol style="list-style-type: none"> 1. Public comment 2. Online feedback 3. Focus groups 4. Surveys 5. Public meetings 6. One-on-one meetings 7. Research 	<ol style="list-style-type: none"> 1. Multi-stakeholders forums 2. Advisory panels 3. Workshops 4. Deliberative polling 5. Participatory decision making processes 6. Engagements facilitated by current community structures 	<ol style="list-style-type: none"> 1. Reference groups 2. Facilitated consensus building groups for deliberation and decision-making 3. Experimental 4. Joint projects 5. Multi-stakeholders initiatives 6. Facilitated participatory action research 	<ol style="list-style-type: none"> 1. Dialogue with different Government bodies 2. Integration of stakeholders into governance structures 3. Local governance 4. Joint planning 5. Provision of data 6. Shared projects 7. Capacity building 8. Community development

3. Stakeholder engagement Strategy

Stakeholders involved in the South African SKA Office stakeholder engagement cycle belongs to various sectors, groups and organisations including Media, Researchers (especially academics involved in the DST- National Research Foundation programmes), South African politicians, South African National Department of Science and Technology, South African National Department of Basic Education, Cooperative Governance and Traditional Affairs (CoGTA), Universities, Environmental Scientists and Environmental Assessment Practitioners, AFGRI¹⁵ Agricultural Services, Agri South Africa (AgriSA)¹⁶, local Farmers Unions, the South African San Council and other indigenous bodies; and all individuals interests in the science (at national and international levels), all South African Citizens, the Northern Cape provincial government, the local government (Hantam local municipality, Kareeberg local municipality and Karoo Hoogland local municipality; Namakwa district municipality and Pixley-ka-Seme district municipality), non-governmental organisations, educational institutions, local communities' members (including residents of the towns and settlement surrounding the proposed SKA site, farmers and farm workers affected by the SKA project and their dependents, etc), and Science Tourists/Tourists.

Different strategies must be applied to the different stakeholders groups in order to manage the various expectations and reach the best outcomes when engaging with stakeholders. Since the inception of the SKA project, the South African SKA Office has been partaking in stakeholder management on different levels through stakeholder forums, feedback sessions with the public, schools programs, media events, and community development. The strategy going forward will build on past efforts and engagements. One of the key success factors of the stakeholder management is that trust should be built with the different stakeholders.

Within SKA there are different community engagement programs including:

- Science Engagement programs (Schools outreach);
- Human Capital Development activities (Artisan program and identification of talent);
- Land acquisition (engagement with Farmers and Farm workers);
- Infrastructure (Farmers and Municipality); and
- SKA management.

All community involvement by the South African SKA Office and its service providers will be in line with the strategic objectives of the organisation, and communication to the public will be done optimally. The South African SKA Office stakeholder engagement cycle, as illustrated in Figure 2-34 below, requires several management activities including identification of relevant stakeholders, analysis of the stakeholder profile, planning and management of stakeholder engagement with review and improvement for further engagement based on feedback and results.

¹⁵ <https://www.afgri.co.za/>

¹⁶ <http://www.agrisa.co.za/>

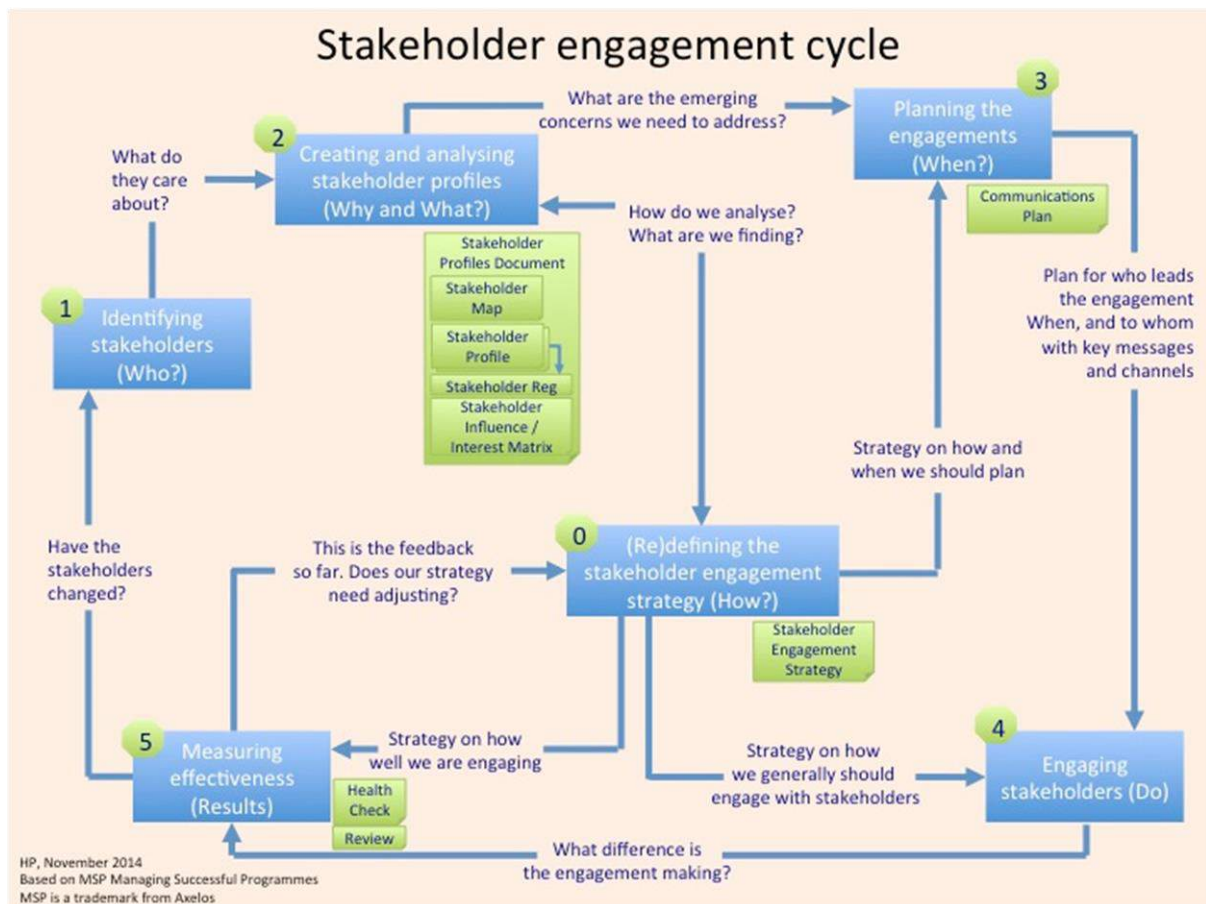


Figure 2-1: South African SKA Office stakeholder engagement cycle

The South African SKA Office stakeholder engagement cycle requires that the stakeholder engagement and management activities are continuously reviewed and improved during all project phases, with adaptation or adoption of new activities when the initial strategy is judged inefficient or inadequate. For instance, local community development forums in the local town were initially used to engage with stakeholders about the SKA project however the community recently indicated that these forums were not representative and did not work. The South African SKA Office thus decided to dissolve the forums and review the initial concept and objectives to elaborate a more efficient strategy for the engagement with stakeholders at local level.

Continuous stakeholder engagement will be done through existing structures in the different communities with close collaboration with local municipalities and provincial authorities. The various activities planned for the stakeholder engagement at national, provincial and local level include:

- National Government and Governmental departments: quarterly meetings or more frequent as required;
- Provincial Government: quarterly meetings (or more frequent as required) with representation of the Premier's office;
- Regional Government: regular meetings and involvement of CoGTA;
- Local Government (Hantam local municipality, Kareeberg local municipality and Karoo Hoogland local municipality; Namakwa district municipality and Pixley-ka-Seme district municipality): quarterly meetings with each municipality to keep the municipalities up to date

with developments and provide inputs to the Municipalities Integrated Development Plans and Spatial Development Frameworks;

- Local Communities: quarterly meetings (or more frequent as required) focused on community development to assist municipality with specific community projects, meeting and updating schools to participate in SKA activities; and
- SAN Council and other conservation agencies: meetings to collaborate on the protection of the SAN heritage as well as to document the Indigenous Knowledge Systems with regard to Cosmology.

Furthermore, a research reference group will be started aiming at combining the various research programmes currently being conducted in the towns affected by the SKA. The goal of the research reference group will be:

- To manage research activities in the area, research in the affected areas be coordinated through this body as far as possible;
- To give ethical consent for research to be conducted in the area;
- To liaise with tertiary institution on research protocols in the area;
- To develop research protocols;
- That all research conducted should include aspects of community development and upliftment; this is an ethical obligation;
- That all research and research findings should be made available to SKA; and
- That baseline studies should be conducted.

The Research Reference Group will consist of researchers from different sciences. The fields of research will include but not be limited to Human Development, Monitoring and Evaluation, Media research, Culture and Indigenous Knowledge Systems, Environmental impact on individuals, Public perceptions, Religious development, Economic Studies; and Social work. The first task for the reference research group will be to develop research protocols and establish the required baselines in the study area informed by observation and analysis of the current situation as well as a review of the last 10-15 years (in particular prior to construction of MeerKAT). As far as possible participatory action research will be encouraged and the application of research activities in these communities will be regularly monitored and reviewed for improvement.

4. Public site visits and tourism activities linked to the SKA

Local communities have requested to visit MeerKAT and the Losberg site complex. These visits will assist in demystifying the MeerKAT construction. These tours will be managed within SKA guidelines.

As the Northern Cape Province is hosting the SKA it is important to generate a branding and information presence throughout the province. It is also important that this branding and communication is done correctly reflecting official viewpoints and correct information. This presence will be negotiated with the Department of Tourism, the Northern Cape government and local governments. This presence will include but not be limited to:

- All relevant towns in the Northern Cape Province (including Carnarvon, Williston, Brandvlei, De Aar, Calvinia, Kimberly, and Upington)
- Municipal websites of the relevant Municipalities in the Northern Cape Province
- Airports in the Northern Cape Province
- Tourism brochures
- Maps for tourists
- Google Maps

Currently there is no official presence in any of the towns affected by SKA1_MID. A Visitor Science Centre is being planned by an inter-departmental task team and will be constructed by the Northern Cape Department of Tourism in Carnarvon.

In the interim the SKA South African Office will establish two temporary visitor centres late in 2016/17 or early 2017/18: one in Williston and one in Carnarvon. The buildings or office space that will be rented for the temporary visitor centres will be secured in Carnarvon and Williston.

When the Visitors Science Centre is completed the temporary visitor centre in Carnarvon will be used as offices.

5. Popularisation of Science and training

Programmes in schools and communities to popularise science will be a priority to ensure that the fields of science, engineering, technology and innovation are attractive, relevant and accessible to all interested parties in order to enhance scientific literacy and awaken interest in relevant careers.

In collaboration with the SKA HCDP team and with the support of non-governmental organisations, training programs will be identified to up skill local communities. This training will be to the benefit of the community and could include reading and writing classes, basic skills development, soft skill development, entrepreneurship courses and development and training of local business.

The SKA South African Office will organize feedback sessions every three months in collaboration with the municipality to give official feedback on the SKA project and communicate with affected communities. These feedback sessions will be optimised as an instrument to keep the communities informed.

6. Media and public relations

The SKA South African Office will create, coordinate and maintain social media campaigns on the SKA as well as manage its brand and information to stakeholders through SKA provided Internet services:

- to communicate information on the SKA project;
- to set up WiFi¹⁷ hotspots in affected area; and
- to create a similar presence at the Farmsteads, Libraries and Schools.

The SKA South African Office will participate to the organisation of community events such as Potjie Kos Competitions, Fairs, Exhibits and other competitions. At these events a strong SKA presence will be facilitated and information will be informally distributed. The main aim of these activities would be to establish trust and engrain SKA as part of the community.

7. Indicators for monitoring

The proposed indicators to measure the effectiveness and success of the SKA stakeholder engagement programme are described in Table 4-3 below.

¹⁷ wireless networking technology.

Table 4-3: proposed indicators to measure the effectiveness and success of the SKA stakeholder engagement programme

Indicator	Metric	Measurement Tool	Scale
Accessibility to decision-making process	<ol style="list-style-type: none"> 1. Timing and focus of engagement 2. Influence on decisions/processes 3. Access to decision maker 	<ol style="list-style-type: none"> 1. Number of opportunities for stakeholders to engage in early planning, to include issue identification and focus 2. Number of jointly identified alternatives/solutions discussed and adopted 	<ol style="list-style-type: none"> 1. Participants represent less than 50% of interests; public meeting/hearing formats only; meetings are inaccessible and/or conducted at inconvenient times 2. Participants represent 50-75% of interests; meeting formats foster discussion, are accessible, and held at convenient times 3. Participants represent 100% of interests; meeting formats are open, flexible, and based on participant needs; discussions are open and provide opportunities for civil debate and joint problem-solving
Clear understanding of stakeholder interests and concerns	<ol style="list-style-type: none"> 1. Comprehensive stakeholder assessment completed 2. Assessment results analyzed and categorized 3. Strategic stakeholder involvement plan developed and implemented 4. Changing/emerging interests and concerns identified and plan modified, as needed 	<ol style="list-style-type: none"> 1. Key stakeholders identified and interviewed 2. Analysis completed to identify and categorize interests and concerns 3. Methods and approaches in strategic stakeholder involvement plan reflect stakeholder needs, as identified in interviews 4. Plan contains methods for continually assessing stakeholder interests and flexibility 	<ol style="list-style-type: none"> 1. Interests neither sought nor identified; issue defined without input; no adjustments or reprioritizations based on participant interests/concerns 2. Interests of some participants identified and integrated into issue definition; alternatives reflect some, but not all interests; few or only established process adjustments 3. All participant interests identified and integrated into issue definition; alternatives reflect common interests of all participants; process continually assessed and adjustments made

<p>Diversity of views represented</p>	<p>1. Participants represent full diversity of interests 2. Engagement opportunities are convenient for all participants</p>	<p>1. Number and types of participants 2.Types and locations of meetings/discussions</p>	<p>throughout the project 1. Participants represent less than 50% of interests; public meeting/hearing formats only; meetings are inaccessible and/or conducted at inconvenient times 2. Participants represent 50-75% of interests; meeting formats foster discussion, are accessible, and held at convenient times 3. Participants represent 100% of interests; meeting formats are open, flexible, and based on participant needs; discussions are open and provide opportunities for civil debate and joint problem-solving</p>
<p>Integration of interests and concerns</p>	<p>1. Participant interests identified and integrated into issue identification; common interests identified 2. Participant interests integrated into alternative solutions 3. Participant interests result in changed actions, reprioritization, adjustments throughout the project</p>	<p>1. Number and types of interests included in issue definition 2. Number and types of alternatives reflecting common interests 3. Number and types of changed actions, adjustments, and/or reprioritizations, based on participant interests, throughout the project and integrated into final decisions</p>	<p>1. Interests neither sought nor identified; issue defined without input; no adjustments or reprioritizations based on participant interests/concerns 2. Interests of some participants identified and integrated into issue definition; alternatives reflect some, but not all interests; few or only established process adjustments 3. All participant interests identified and integrated into issue definition; alternatives reflect common interests of all participants; process continually assessed and adjustments made throughout the project</p>
<p>Information exchange</p>	<p>1. Documents from all participants are readily</p>	<p>1. Routine evaluations to gather feedback from</p>	<p>1. Written materials are highly technical and</p>

	<p>available, clearly written, understood, and translated when necessary</p> <p>2. Meetings are conducted in a manner and format conducive to open dialogue and free exchange of ideas and viewpoints</p> <p>3. Innovative approaches are utilized to share ideas and reach mutually acceptable solutions to complex issues</p>	<p>participants on availability, clarity, and understandability of written materials</p> <p>2. Routine evaluations to gather feedback from participants on openness of meetings and ability to enter into discussion on various ideas and viewpoints</p> <p>3. Types of approaches used; types of issues discussed; solutions identified; routine evaluation to gather feedback from participants on effectiveness of approach and satisfaction with identified solutions</p>	<p>available to only a minority of participants; only large, required public meetings are conducted</p> <p>2. Somewhat filtered information is provided at regular, but infrequent intervals and only at key points in the process; public meetings and limited participation workgroups are convened</p> <p>3. Written materials are clear, readily available, with flexible formats to meet needs of all participants; multiple opportunities open to all for information exchange, to include meetings, workshops, issue-specific workgroups, presentations, and additional innovative approaches</p>
Project efficiency	<p>1. Engagement and partnering are realistically integrated into overall project planning and budgeting</p> <p>2. Projects are completed on time and on budget, with engagement and partnering integral to the decision making process</p> <p>3. Partnerships leverage resources and result in general support for outcomes</p>	<p>1. Number of decisions readdressed due to lack of support</p>	<p>1. Public controversy and/or litigation results in extended time and/or additional cost to complete</p> <p>2. Project implemented in less than anticipated time and/or at less cost due to leveraging resources with partners resulting in general acceptance of solutions</p>
Decision acceptability	<p>1. Engagement and partnering relationships are established at the issue-identification stage and routinely</p>	<p>1. Number of project delays due to public protest/controversy</p> <p>2. Documentation of regulatory approval</p>	<p>1. Negative participant response; decision is rejected due to public controversy</p> <p>2. Responses mixed;</p>

	<p>utilized throughout the project</p> <p>2. Alternatives are jointly identified, discussed, and debated</p> <p>3. Decisions reflect the goals and interests of all participants</p>	<p>3. Documentation that jointly identified implementation goals are met; funding provided</p>	<p>project given low priority due to public controversy</p> <p>3. Response from majority of participants is positive; decisions are routinely implemented with general support</p>
<p>Mutual learning/respect</p>	<p>1. Participants can clearly articulate other participants' positions</p> <p>2. Participants with diverse viewpoints engage in civil dialogue and debate on issues</p> <p>3. Participants are willing to engage in joint problem-solving, compromising to reach mutually acceptable solutions</p>	<p>1. Number and types of concessions/compromises made throughout the project</p> <p>2. Documentation of routine contact among participants</p> <p>3. Meeting/engagement summaries indicating civil and productive dialogue among participants</p>	<p>1. Participants defend individual positions; not willing to compromise, remain polarized; participants don't talk to each other and/or routinely make negative/derogatory remarks</p> <p>2. Participants understand others' positions, but do not fully embrace the process; compromise is limited or one-sided; participants are civil to one another, with occasional flare-ups</p> <p>3. Participants are willing to engage in joint-problem solving to reach solutions beneficial to all; free flow of communication among participants, with positive and constructive exchange; improvements to process due to enhanced understanding and acceptance of opinions and interests among participants</p>

XI. POTENTIAL DECOMMISSIONING OF SKA1_MID

The proposed SKA project is expected to be operational for a minimum period of 50 years, after which it would either be decommissioned or alternatively upgraded. Should it be decided not to extend the operational lifespan of the project beyond 50 years, the project will be decommissioned. The decommissioning phase will entail similar, construction-type activities and associated impacts as described in Section VIII of this Chapter, as such the management and mitigation measures contained in Section VIII equally apply to the decommissioning phase.

Whether all components of the SKA project will be removed will be agreed upon with the relevant authorities and private landowners as some components may be useful for the municipality and/or for the landowner and therefore it could be decided that those remain on site. Any other supporting infrastructure no longer in use will be removed from the site and either disposed of at a registered disposal facility or recycled if possible.

Should the SKA infrastructure be decommissioned at the end of the operational phase, the development area must be rehabilitated to as close to its original (pre-development) state where feasible, following the Revegetation and Habitat Restoration programme included in Chapter 5 of this IEMP.

Prior to the commencement of the decommissioning operations, a detailed decommissioning management plan must be prepared based on Chapter 4 and Chapter 5 of this IEMP, and taking into consideration the state of the environment at the time of decommissioning (approximately 50 years in the future) as well as the results of the long term research and monitoring programme described in Chapter 5 of this IEMP.

Further, a suitably qualified specialist must be appointed to compile and oversee a detailed alien invasive plant species control and eradication programme where infrastructure has been removed for a period of 12 months after the decommissioning operation. An external audit of the development area will be undertaken by a suitably qualified specialist 5 years after the decommissioning operation to confirm that area is free of alien invasive plant species.

A final external audit of the rehabilitation of the decommissioned development area must be undertaken by an independent Environmental Control Officer 12 months after the decommissioning operation to confirm that the area is rehabilitated to an acceptable level.



CHAPTER 5: RESEARCH AND MONITORING PROGRAMMES





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This chapter of the Integrated Environmental Management Plan include:

- guidelines for the protection and rescue of plants and habitat rehabilitation for the areas disturbed and degraded during the SKA construction activities; as well as clearing and control guidelines for alien invasive plants species; and
- proposed long term research and monitoring programmes to be implemented and monitored during the construction and operation phases of the SKA mid-frequency dish array (SKA1_MID).

Table 5-1 below lists the authors and peer-reviewers of the guidelines and long term research and monitoring programmes included in this chapter.

Table 5-1: Guidelines and long term research and monitoring programmes authors and peer-reviewers

Author		Peer-reviewer	
Alien invasive plants control and management guidelines			
Dr Sue Milton	Director at RENU-KAROO Veld Restoration cc. SACNASP Professional Natural Scientist (Reg. No. 400047/08).	Dr Graham Harding	Director at Invader Plant Specialists (Pty) Ltd SACNASP Professional Natural Scientist, Pest control operator Registration No 2012/036721/07.
Protection, rescue and translocation programme			
Dr Sue Milton	Director at RENU-KAROO Veld Restoration cc. SACNASP Professional Natural Scientist (Reg. No. 400047/08).	Dr Joh Henschel	Manager at SAEON Arid Lands Node.
Re-vegetation and habitat restoration programme			
Dr Sue Milton	Director at RENU-KAROO Veld Restoration cc. SACNASP Professional Natural Scientist (Reg. No. 400047/08).	Dr Joh Henschel	Manager at SAEON Arid Lands Node.
Global change monitoring and land-use change research and monitoring programmes			
Simon Todd	Ecologist at SAEON Arid Lands Node. SACNASP Professional Natural Scientist (Reg. No. 400425/11).	Dr Joh Henschel	Manager at SAEON Arid Lands Node.
		Dr Emma Archer	Chief Researcher in Sustainable agriculture, managed ecosystems, Climate Studies, Modelling and Environmental Health at the Council for Scientific and Industrial Research.
Predator species long term research and monitoring programme			
Gabriella Duncan	Intern at the South African office of SKA. SKA SA Young Professionals Programme	Professor Justin O'Riain	Professor at the Department of Biological Sciences of the University of Cape Town. Director at the Human Wildlife Research Institute.
		Lydia Cape	Environmental Scientist at the CSIR SACNASP Professional Natural Scientist (Reg. No. 400359/13)

I. Plant Rescue and Protection

The objective of this Plant Rescue and Protection plan is to mitigate the risks associated with the permanent removal or damage of plant species of conservation concern (species listed as threatened, vulnerable or endangered in the Red Data List¹ or protected by national/Provincial legislation) during SKA construction activities, as well as prevent the further reduction of the abundance of these species.

The Northern Cape Nature Conservation Act² makes provision for restricting activities concerning "Specially Protected and Protected species" of fauna and flora. In terms of Section 49 of the Act, no person may, without a permit (a) pick; (b) import; (c) export; (d) transport; (e) possess; (f) cultivate; or (g) trade in, a specimen of a specially protected plant. All these restrictions (with the exception of possession) also apply to "protected plants" (Section 50 of the Act). There are 44 plant species classified as "Specially Protected" and 589 plant species classified as "Protected" within the Karoo Central Astronomy Advantage Area 1³. Most of the specially protected and protected species within the Karoo Central Astronomy Advantage Area 1 are trees, bulbs, succulents and herbaceous medicinal plants from the *Fabaceae* and *Apiaceae* families. A permit⁴ is required to destroy, translocate, transport or cultivate any of these plants.

The plant families with the most species of conservation concern are *Mesembryanthemaceae* (18), *Iridaceae* (13), *Amaryllidaceae* (9) and *Asphodelaceae* (8). Three plant species of conservation concern occur within the SKA core area, namely *Acacia erioloba* (declining⁵), *Aloe dichotoma* (listed as vulnerable in the Red Data List) and *Hoodia gordonii* (Data deficient, declining).

This section provides guidelines and minimum requirements to be included in the Plant Rescue and Protection Plan to be compiled by SKA.

General principles for the protection, rescue and translocation of plant species:

- The protection of plants within construction areas requires mapping of plant populations using a Global Positioning System (GPS) to record co-ordinates, and temporary demarcation of protected plant populations usually by means of hazard tape, undertaken by a suitably qualified field ecologist.
- Areas with substantial populations of plants with high conservation significance or protected plants by national or provincial regulations should be avoided. Where protection cannot be achieved by avoidance, succulent and bulb plants should be salvaged and translocated to adjacent habitat.
- Herbaceous and woody plants cannot successfully be translocated and no attempt should be made to do so. Instead, protected herbaceous plant species should be re-established from seed during the after construction re-vegetation phase and woody species replaced by nursery-grown plants where care during establishment is feasible.
- Plant translocation should ideally take place in late summer (February to April) in anticipation of rain.

¹ See IUCN Red List Categories and Criteria: <http://www.iucnredlist.org/>

² Northern Cape Nature Conservation Act 9/2009 dated 19 December 2011 (Provincial Gazette 1566)

³ Government Notice 141 dated 28 February 2014 (Government Gazette 37397)

⁴ dencpermits@ncpg.gov.za Department of Environment and Nature Conservation (D.E.N.C.), Private Bag X6120, Kimberly, 8301 Tel: +27 (0)53 807-7416/7300

⁵ Victor and Keith (2004) developed additional categories (Critically Rare, Rare and Declining) to flag taxa of conservation concern that would be classified as Least Concern (LC) according to the IUCN system (J.E. Victor, M. Keith, The Orange List: a safety net for biodiversity in South Africa, South African Journal of Science, 100 (2004), pp. 139–141).

- The translocation should occur immediately after heavy rain when the soil has been wet to a depth of 20-30 centimetres because the plants are easier to dig out, and will require less water after planting.
- Before removing the plant from the construction site, a suitable site for translocation should be identified. The translocation site should be in the same soil type and depth and outside of the demarcated construction area, i.e. if the plants were growing in hard stony soil, do not plant them in loose sand.
- A permit should be issued by the Northern Cape Department of Environment and Nature Conservation for the removal and translocation of these plants of interest.
- The following equipment will be required for the plant rescue and translocation activities:
 - ✓ Tools: spades, hand trowels, "koevoets" (i.e. heavy sharpened iron bars for digging in hard rocky ground), large screw drivers (for excavating small bulbs); sacks and canvas for carrying plants;
 - ✓ Irrigation equipment: 1000 litres water tank, watering cans,
 - ✓ Recording equipment: camera, GPS for recording the locality of the translocation site (for later monitoring and quality control), notebook or data sheet for recording the numbers of each plant species (or growth form) translocated,
 - ✓ Safety equipment: leather gloves for handling spiny plants and plants containing poisonous sap or latex; first aid officer, first aid box.

The following guidelines should be followed in order to improve transplanting success:

- Training: The manager of the translocation work should be familiar with the types of plants that can be translocated, and these guidelines. The procedure should be demonstrated to the work team before the translocation work starts;
- Before digging out plants count how many are growing in the open and how many near bushes. Dig the appropriate number of holes in the translocation sites (a) near bushes, (b) away from bushes;
- Leaf and stem succulents should be dug out saving as much of the roots as possible. Remember that the roots are the most important part of the plant for survival in an arid system;
- Bulbs and corms must be dug out complete with their roots. If the base of the bulb breaks off the plant will not survive;
- Do not shake soil off the roots – keep as much soil on the roots as possible to protect fine roots;
- Avoiding damage to the stems and leaves of succulents;
- Do not leave the salvaged plants lying in the sun;
- Do not immerse salvaged plants in buckets of water;
- Plants that grow in the shade of rocks or other "nurse" plants should be planted in a similar relative position, i.e. if the target plant was growing on the south side of a *Lycium* bush in the construction site it should be planted on the south side of a tall shrub in the translocation site;
- Do not bend or wind up the roots when planting, rather enlarge the planting hole so that roots can be spread out;
- Make sure the plant is the right way up and at the correct depth – i.e. the roots, but not the leaves, must be covered with soil;
- Bulbs and corms that were deeply buried must be deeply planted, i.e. only the green part of the leaves must show above ground;
- Press the soil down around the plant to stabilise it in the soil and if rocks are available pack these around the base of the plant to prevent it blowing or washing away;
- Water the plants well after transplanting, preferably with fresh water (i.e. with a low mineral content), to settle the soil and encourage root growth; and

- Storage of excavated plants: If there is a rush to remove plants from a site before construction, excavated succulents and bulbs can be stored in cool dry conditions for up to two weeks (e.g. in a shed or under a tree).

II. Habitat Rehabilitation

1. General guidelines

This section provides revegetation and habitat rehabilitation guidelines for construction camps, temporary access roads, trenches, dish-antennas and tower construction sites; borrow pits and alien vegetation clearing sites. These are general guidelines that may need to be adapted according to soil type and slope.

The principles governing the design and implementation of a rehabilitation plan are as follows:

- Rehabilitation is the reinstatement or improvement in the effectiveness of the driving forces that created and continue to shape and sustain the ecosystem⁶;
- The goal of rehabilitation should not be to return an ecosystem to and maintain it in a static state at some time in the past, but rather to aim to achieve a dynamic and resilient system that can respond to change and that is largely self-maintaining, requiring little human intervention over time;
- Rehabilitation should be integrated with the surrounding landscape in order to address the upstream and downstream causes of degradation;
- If a rehabilitation programme is to be effective and sustainable, there must be ownership of the project by the National Research Foundation, and their commitment to sustaining the integrity of the system must be demonstrated, and
- Rehabilitation should be well-planned with clearly stated and measurable objectives, effectively implemented, and must be continually monitored and evaluated. Rehabilitation of disturbed areas must be undertaken as soon as possible after construction.

As such, records of all areas where construction will mechanically disturb the soil below surface in any way (GPS coordinates of each area) including date and depth of topsoil stripping, and date and depth of topsoil re-spreading/rehabilitation for each of these areas must be kept. Areas should be photographed thereafter on an annual basis to record vegetation re-establishment.

The following applies to all disturbed areas requiring rehabilitation:

- All disturbed areas must be mulched to encourage vegetation re-growth. Mulch used must be free from exotic plant seed and the subsoil must be used for shaping during the reinstatement phase prior to placing the topsoil on top;
- Weeds are to be removed, if any, prior to rehabilitation, compacted areas/subsoil must be ripped (i.e. either manual or machine driven ripping) and the topsoil layers reinstated (containing seed and vegetative material) as soon as construction is complete to allow the plants to rapidly re-colonise the bare soil areas. It is important to use locally-sourced seed of indigenous grass species that were recorded on site during the pre-construction phase for the

⁶ Russell W (2009). Wetland Management Series. WET-RehabMethods: National guidelines and methods for wetland rehabilitation. WRC Report No. TT 341/09. Water Research Commission, Pretoria.

- re-seeding, supplemented with translocation of succulents and bulbs from adjacent areas where possible;
- Nursery-grown *Acacia erioloba* must be used to replace felled specimens where maintenance of the trees is feasible;
- Ripping must be done to a depth of 250 millimetres in two directions at right angles. Topsoil must be placed in the same soil zone from which it has been stripped and must be evenly spread over the entire disturbed surface so as to facilitate seeding and minimise loss of soil due to erosion; and
- Use hand-dug micro-catchments, mulch and brush packing to retain water to improve infiltration (compacted soils delay recovery).

2. Rehabilitation of construction camps sites and temporary access roads

While access roads to antennas and to some tower sites shall be maintained, there are situations where road closures will be required. These locations are usually in environmentally sensitive sites and were identified in Chapter 2 of this IEMP. Furthermore, the closure of a road may also be specifically requested by a landowner within the proposed development area.

The following programme should be followed for the re-vegetation and habitat restoration (rehabilitation) of the construction camps and temporary access roads within the proposed development area:

- Vegetation clearing. After salvage scrape remaining vegetation into windrows or remove it with the topsoil. The dead vegetation is valuable as a source of seeds, mulch and plant nutrient during rehabilitation.
- Topsoil management: remove 100 millimetres of the surface soil and store it in low berms (less than 2 metre high) adjacent to the construction area and upslope, in a position where it will not be driven on, washed away by flooding or polluted by fuel spills or building materials. Do not place any construction materials or subsoil on the topsoil storage heaps. Topsoil contains the nutrients, seeds and soil organisms required for habitat restoration after closure of the camp or temporary road.
- Preparation for re-vegetation: Remove all concrete structures and waste materials from the site and remove any soil polluted with hydraulic fluids, lubricants or fuel. Fell and poison any *Prosopis* (mesquite) on or adjacent to the site and remove any cactus and other listed Invasive Alien plants from the site (see Section III of this Chapter). Use only herbicides registered for treatment of the target species. Spread and level any heaps of building materials (sand, crushed rock) that remain on site. Build berms to close disused roads – i.e. low humps (0.2-0.3 metres) at right angles to the slope (i.e. along contours). In areas of 30 % slope and less, the fill of the road should be placed back into the roadway to restore the natural ground slope (Figure 5-1). Here it is important to use equipment that does not work outside of the road it is closing. (For example a Tractor Loader Back-hoe may be used and should operate from the cut portion of the road, working backwards and closing the road as it retreats). On steeper slopes (greater than 30 % slope), the equipment should break the road shoulder down, so that the slope nearly approximates to the original slope of the ground (Figure 5-1). The cut banks should be pushed down into the road, and a terraced side slope should be re-established with an erosion control system and re-vegetated. Rocky hills (koppies) with little soil may be steeper in places and there is no soil to replace. However soil should not be taken from another place and added to rock outcrops. Replacement of earth should

be at a slope less than the normal angle of repose (the natural angle of soil spill) for the soil type involved.

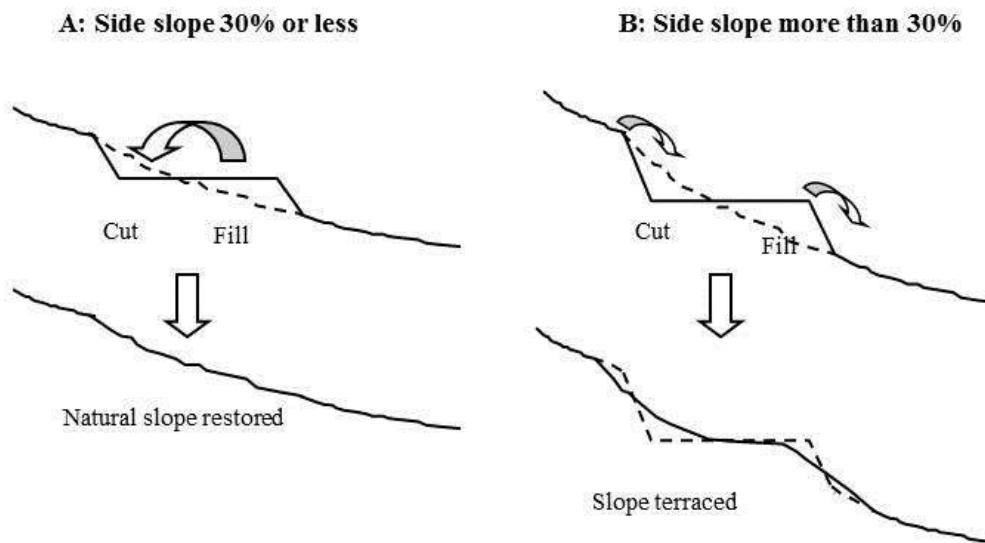


Figure 5-1: Road Closure in steep terrain

- **Top soiling.** Where topsoil has been saved as recommended, spread this over the site and top it with a mulch of the dead vegetation that was removed from the site. The final surface should be rough and chunky with scattered rocks if available. Rough surfaces capture water, seed and nutrients improving plant growth. Where access roads have crossed cultivated farmlands, the lands should be rehabilitated by ripping to a minimum depth of 600 millimetres. Rehabilitation can also be done by using Geo grids (Geotex) or Geo cells (Hyson or Multi cells) with topsoil and re-seeding, in particular under windy conditions where soil is dry and loose. Note that Hyson cells and similar grids merely contain topsoil on a temporary basis to allow the re-growth of natural vegetation, and are not suitable for carrying traffic or for use in the presence of large amounts of flowing water.
- **Erosion control and infiltration.** The risk of soil erosion increases with slope and risk is high for gradient steeper than 14 % (1:7)⁷. Erosion risks are also increased on fine-textured, deep soils where rapid runoff after rain will cause dongas if water is channelled onto bare ground. Rapid runoff will shift the topsoil off the site unless the surface is stabilised, infiltration facilitated and runoff rate managed appropriately. Where berms and drainage ditches are already in place on roads on slopes, these should be left in place to avoid build-up of water that could cause gully erosion⁸. Check all drains from berms and address gully erosion problems in the water discharge area by packing rocks to disperse runoff water⁹. On steep slopes hand dig mini catchments to trap runoff water. These can be supplemented by brush packs or windrows packed at right angles

⁷ Excellence in Environmental stewardship 14.0 Reclamation and closure. Prospectors and Developers Association of Canada <http://www.pdac.ca/docs/default-source/e3-plus---toolkits---environmental-stewardship/reclamation-and-closure.pdf?sfvrsn=4>

⁸ Keller, G. & Sherar J. 2003. Low-volume roads engineering Best Management Practices Field Guide by USDA Forest Service/USAID http://www.blm.gov/wo/st/en/prog/energy/oil_and_gas/best_management_practices/technical_information.html

⁹ Coetzee, K. 2005. Caring for natural Rangelands. University of KwaZulu-Natal Press. (order from books@ukzn.ac.za)

to the slope and pegged to the ground with stout stakes. On gentle slopes rip the ground along the contour to improve infiltration and capture water and seed (Figure 5-2).

- **Seeding.** Once drainage, infiltration, runoff control and top soiling have been completed, sow the whole area with seeds of plants that are common and indigenous in the local area (suggestions in Table 5-2). These can be harvested locally or bought from specialised suppliers of Karoo seed. Where required, re-vegetation can be enhanced using a vegetation seed, provided it is carefully selected to ensure the following:
 - a) Annual and perennial plants are chosen;
 - b) Pioneer species are included;
 - c) Species chosen must grow in the area without any problems;
 - d) Root systems must have a binding effect on the soil;
 - e) The final product should not cause an ecological imbalance in the area.
- **Translocation.** Small succulent plants from the surrounding area can successfully be translocated from surrounding natural vegetation onto the rehabilitation site (refer to Section I of this Chapter). Do not attempt to move non-succulent shrubs or grasses as they are unlikely to survive. Nursery-grown *Acacia erioloba* must be used to replace felled specimens where maintenance of the trees is feasible.
- **Site protection.** Ensure that decommissioned roads and construction sites are inaccessible for vehicles. Roads can be closed with jagged stones and no entry signs posted on closed roads and rehabilitating construction camps;
- **Record keeping.** The Environmental Manager responsible for the rehabilitation should record the position (GPS), methods used, reseeded plant species, and maintain a photographic record of the work to inform ongoing rehabilitation work in the SKA construction footprint area. It is very valuable to know what approaches work and which do not work under the harsh conditions of this area.

Table 5-2: Seeds for revegetation of bare ground in the SKA construction footprint area

Landscape position	Soil type	Grasses for seeding	Shrubs for seeding
Hillside dolerite	stony	<i>Cenchrus ciliaris, Fingerhuthia africana, Heteropogon contortus</i>	<i>Rhigozum obovatum</i>
Hillside mudstone	stony	<i>Enneapogon species, Fingerhuthia africana</i>	<i>Eriocephalis ericoides, Tripteris sinuata</i>
Foot slope	silt	<i>Stipagrostis obtusa, Fingerhuthia africana</i>	
Plain	silt	<i>Stipagrostis obtusa, Eragrostis obtusa</i>	<i>Salsola aphylla</i>
Plain	Gravel and calcrete	<i>Eragrostis lehmanniana, Stipagrostis obtusa</i>	
Plain	sand	<i>Schmidtia kalahariensis, Eragrostis lehmanniana, Stipagrostis ciliata, S. obtusa</i>	
Drainage line	silt	<i>Cenchrus ciliaris,</i>	<i>Salsola aphylla</i>
Drainage line	sand	<i>Stipagrostis ciliata</i>	



Figure 5-2: Approaches to improving infiltration and retaining seeds, water and nutrients in rehabilitations sites. A) mini catchments and ripping. B) brush fencing combined with mini-catchments. C) bulb regenerating from spread topsoil on a construction site (note rough soil surface that maximises water infiltration), and translocation of succulent plants.

3. Rehabilitation of trenched areas

The following programme should be followed for the re-vegetation and habitat restoration (rehabilitation) of the trenched areas within the proposed development area:

- Topsoil and subsoil replacement. After cable laying has been completed replace first the subsoil and then cover the subsoil with topsoil and rocks.
- Erosion control. If the trench runs up a steep hillside (1:7 or steeper), then place low berms across the trench at 10 to 20 metre intervals to divert water from the unstable soil of the trench.
- Reseeding: as per Table 5-2 above. Where required, re-vegetation can be enhanced using a vegetation seed, provided it is carefully selected to ensure the following:
 - a) Annual and perennial plants are chosen;
 - b) Pioneer species are included;
 - c) Species chosen must grow in the area without any problems;
 - d) Root systems must have a binding effect on the soil; and
 - e) The final product should not cause an ecological imbalance in the area.

4. Rehabilitation of dish-antenna sites

The following programme should be followed for the re-vegetation and habitat restoration (rehabilitation) of dish-antenna construction sites within the proposed development area:

- Drainage and erosion control. The dish-antenna footprint area is raised above the surrounding landscape, gravelled and surrounded by a compacted road to give access to service vehicles. These semi-permanent structures result in some accelerated runoff of rainwater into the surrounding vegetation. To avoid gully formation on deep soils the runoff channels should be stabilized with stones and sown with grass seed.
- Soil preparation and top soiling of damaged areas around telescope (excluding access road): Where the construction footprint for the telescope exceeded the area of the telescope infrastructure and access road, rip any compacted ground and re-spread the topsoil salvaged from the telescope site. Mulch with dead plants salvaged from the construction site.
- Seeding: Should not be required unless the bare ground area exceeds one hectare. If required, seed with grasses or shrubs appropriate for the soil type.

5. Rehabilitation of power infrastructure sites

Under normal circumstances, the majority of power infrastructure tower sites, being located on relatively even terrain, will not require extensive rehabilitation or mitigatory measures. If the top-soil is replaced in the final layer of backfill, natural ground cover vegetation will usually grow back in spite of extensive removal of surface vegetation during construction. The following programme should be followed for the re-vegetation and habitat restoration (rehabilitation) of dish-antenna construction sites within the proposed development area:

- Drainage and erosion control. Any soil removed by erosion, must be back-filled evenly and, graded to conform to the surrounding terrain. All slope areas at tower sites should be stabilized. Where towers are placed on steep slopes resulting in disturbed surfaces, or lose ground, the slopes should be rehabilitated or refurbished by one of the following methods:
 - a. Steep slopes: use retaining systems such as Gabion basket systems, retaining blocks or stone masonry.
 - b. Moderate slopes: use Geo grids (Geotex) or Geo cells (Hyson or Multi cells) with topsoil and re-seeding. Note that these may be difficult to install on rocky ground with little soil. The broken rock should be packed along contours to trap soil, organic matter and seed over the years.
- Soil preparation and top soiling of damaged areas around tower: Following foundation excavation, care must be taken to replace top-soil on the final uppermost layer of foundation backfill. Rip any compacted ground and re-spread the topsoil salvaged from the tower site. Mulch with dead plants salvaged from the construction site. Failure to replace topsoil in the final layer will leave infertile subsoil on the surface, thus impeding re-growth.
- Seeding: Should not be required unless the bare ground area exceeds one hectare. If required, seed with grasses or shrubs appropriate for the vegetation and soil type. Note that vegetation emerging from soil-stored seed is generally dominated by annual plants and grasses and it may take many years for perennial plants with animal or wind-dispersed seed to return to the site. As such seeding may therefore be best.

6. Rehabilitation of borrow pits

The following programme should be followed for the re-vegetation and habitat restoration (rehabilitation) of borrow pits sites within the proposed development area:

- Pre-closure clean up. Remove any soil contaminated by fuel or oil spills; remove all plastic bottles and other litter.
- Shaping. Shape the walls of the borrow pit at a shallow enough angle (not steeper than 1:3) to hold soil and plants. Surface topography should emulate the surrounding areas and be aligned to the general landscape character.
- Erosion control. Build a berm (approximately 30 centimetres in height) along the entire upslope edge of the borrow pit to divert water away from the borrow pit. This will prevent rill erosion cutting back upslope into rangeland and will facilitate establishment of Karoo vegetation by preventing inundation of the borrow pit depression.
- Drainage. As far as practicably possible, ensure that the borrow pit is free draining towards natural drainage lines.
- Preparation for re-vegetation. Spread any unusable material stockpile over the mined out pit. Rip any remaining hardened or scalped surfaces to facilitate water infiltration and seedling establishment. Spread the topsoil stockpile throughout the reshaped borrow pit so that all subsoil is covered by topsoil throughout the borrow pit to facilitate colonization by plant species with soil-stored seeds. Spread large chunks of hard-rock debris (if available) over the floor of the closed borrow pit to provide shelter to establishing indigenous plants. Rough surfaces capture water, seed and nutrients improving plant growth (Figure 5-2).
- Seeding. Once drainage, infiltration, runoff control and top soiling have been completed, sow the whole area with seeds of plants that are common and indigenous in the local area (suggestions in Table 5-1). These can be harvested locally or bought from specialised suppliers of Karoo seed. Where required, re-vegetation can be enhanced using a vegetation seed, provided it is carefully selected to ensure the following:
 - a) Annual and perennial plants are chosen;
 - b) Pioneer species are included;
 - c) Species chosen must grow in the area without any problems;
 - d) Root systems must have a binding effect on the soil;
 - e) The final product should not cause an ecological imbalance in the area.
- Translocation. Small succulent plants from the surrounding area can successfully be translocated from surrounding natural vegetation onto the rehabilitation site (see Section I of this Chapter). Do not attempt to move non-succulent shrubs or grasses as they are unlikely to survive. Nursery-grown *Acacia erioloba* must be used to replace felled specimens where maintenance of the trees is feasible;
- Record keeping. The Environmental Manager responsible for the rehabilitation should record the position (GPS) methods used, reseeded plant species, and maintain a photographic record of the work to inform ongoing rehabilitation work in the SKA construction footprint area. It is very valuable to know what approaches work and which do not work under the harsh conditions of the site.

7. Rehabilitation of alien vegetation clearing sites

The following programme should be followed for the re-vegetation and habitat restoration (rehabilitation) of alien vegetation clearing sites within the proposed development area:

- **Management of brushwood.** According to the Working for Water Operational Standards: methods for manual clearing (February 2015), "*felled material and other dead material (brush and logs) shall not be allowed to block or impede water courses and must be removed from all water courses, either 30 metres away from the river or out of the flood line itself*". Branches with pods should be removed from the site to a licenced waste disposal facility or burned. Felled material (thicker than 70 millimetres) shall be de-branched and cross cut in manageable logs that can be harvested for firewood.
- **Erosion control.** Brushwood can be used in various ways as part of a post-clearing erosion control and rehabilitation programme. Brushwood can be stacked along contours to reduce runoff and to control Alien Invasive Plant Species regrowth by shading. Rows should be at least 3 meter apart, no more than 3 metre wide, and no longer than 15 metre long¹⁰ with a two meter gaps between the ends of adjacent rows to allow for teams conducting follow-up clearing to move through the cleared site. Alternatively, brushwood can be used in combination with geo-textile material¹¹ to make "sausage" fences pegged to the ground for erosion control and resource (seed, water, nutrient) trapping (Figure 5-3). Brushwood can also be chipped and spread as a mulch. Ensure that mulches used for restoration must not contain seeds of Alien Invasive Plant Species.
- **Reseeding.** Sowing seeds of indigenous plants on the bare areas where *Prosopis* was cleared speeds up recovery of natural vegetation and slows down *Prosopis* regeneration from the seed bank. Seeding should take place between February and April. Sow the whole area with seeds of plants that are common and indigenous in the local area (suggestions in Table 5-2). These can be harvested locally or bought from specialised suppliers of Karoo seed.
- **Record keeping.** The Working for Water contractor must complete the latest version of the Department of Environmental Affairs "Site inspection report". The Environmental Manager in charge of revegetation in the SKA construction footprint area should record the position (GPS), methods used, reseeded plant species, and maintain a photographic record of the work to inform ongoing rehabilitation work in the SKA construction footprint area. It is very valuable to know what approaches work and which do not work under the harsh conditions of the site.

¹⁰ Working for Water Operational Standards: methods for manual clearing (Feb. 2015)

¹¹ Milton SJ 2010. Feasibility and benefits of veld rehabilitation following control of invasive *Prosopis* in the Calvinia area. Working for Water: Namaqua District Municipality. 2010.01.10



Figure 5-3: Prosopis brushwood used as pegs and filling for erosion control “sausages”, as well as mulch in hand dug mini-catchments

8. Rehabilitation of river crossings

Most of the rehabilitation of aquatic features revolves around the re-shaping and stabilisation of the bed and banks of watercourses and wetlands, in order to ensure that surface hydrology returns to pre-construction patterns and flow levels. The following programme should be followed for the re-vegetation and habitat restoration (rehabilitation) of river crossings within the proposed development area:

- **Re-shaping of river banks:** The ideal longitudinal slope to prevent erosion in a river channel is 1:7, while re-shaped bank slopes should, in general, not be steeper than 1:3¹². It is recommended that the shape of the rehabilitated river or wetland bank be fairly heterogeneous – with steeper sections and gentler sections, in order to mimic the natural shape of a river bank. Work in watercourses and wetlands shall be undertaken in such a manner so as to minimise the extent of impacts caused by such activities. Surface flow should be diverted while work is underway, in such a way that does not cause erosion of the surrounding landscape, and in order to avoid

¹² Russell W (2009). Wetland Management Series. WET-RehabMethods: National guidelines and methods for wetland rehabilitation. WRC Report No. TT 341/09. Water Research Commission, Pretoria.

mobilisation of sediments downstream. All river diversion materials must be completely removed from the river after completion of the rehabilitation works.

- **Stabilisation of banks:** It is important to consider using various stabilisation measures after the banks have been shaped, in order to prevent erosion. Stabilisation materials include: Ecologs¹³ particularly effective in areas of low gradient, such as over much of the SKA construction footprint area (see Figure 5-4 -A), biodegradable netting/matting, MacMat®¹⁴ (see Figure 5-4 -B) and mulch stabilisation.

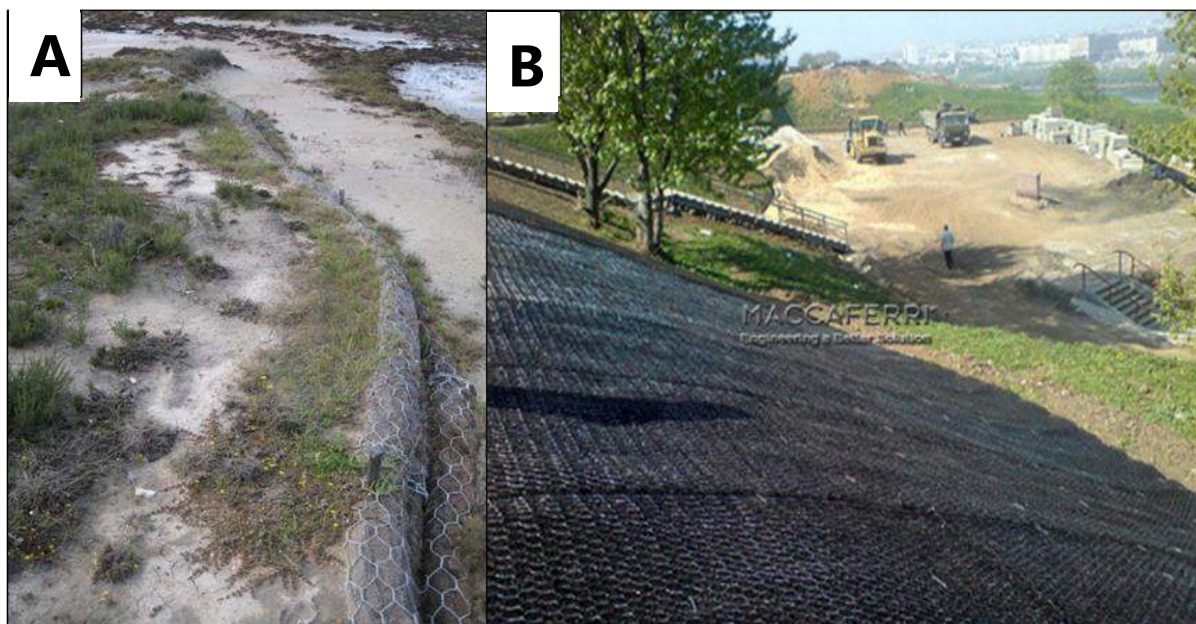


Figure 5-4: A) Ecologs installed for stabilisation. B) Maccaferri's MacMat®.

III. Alien invasive plant species in the Karoo Central Astronomy Advantage Area

This section provides a high-level description of the alien invasive plant species present within the study area of the Strategic Environmental Assessment of SKA1_MID and the wider Karoo Central Astronomy Advantage Area, as well as proposed long term research and monitoring programmes for the control and management of these alien invasive plant species. The identification of the alien invasive plant species present within the study area is based on literature review, observations made by Dr Sue Milton during the ecology specialist study fieldwork in March 2016, and personal data collected by Dr Sue Milton-Dean during other research or consulting visits to the area. It is important to note that less than one percent of the Karoo Central Astronomy Advantage Area was ground-truthed and no density data were collected within that area.

¹³ Dry woody material or sand contained in a hessian and chicken wire roll.

¹⁴ Made by Maccaferri – a non-woven geotextile matting of thick filaments designed to be secured over a vulnerable slope to prevent surface erosion.

This chapter incorporates information from the Department of Environmental Affairs (DEA) 2015 guidelines¹⁵ for alien invasive plants monitoring, control and eradication plans. The chapter aims to provide information on alien invasive plants identified within the study area and highlight the need for further research and monitoring activities within the study area. Potential control methods and approach to reducing listed alien plant invasion risks on construction sites within Strategic Environmental Assessment study area, as recommended by Dr Sue Milton and Dr Harding have been included in the draft Environmental Management Programme (Chapter 4 of this IEMP).

During the Strategic Environmental Assessment process, the South African Office of the SKA initiated a discussion with the Natural Resource Management Programme of the Department of Environmental Affairs (DEA) (contact person: Michael Braack, Deputy Director at the directorate: Operational Support and Planning) on a collaboration between the National Research Foundation and the Working for Water programme¹⁶ for alien invasive plants clearing and control activities within the SKA core area. The Department of Environmental Affairs Natural Resource Management Programmes operational Support and Planning unit is currently working on a Management Unit Control Planning (MUCP) tool which aims to quantify the extent of the alien plants invasion problem, prioritise most important areas for clearing and calculate required investment for the implementation of the alien invasive clearing and control programme, depending on the time frame and availability of funds. Department of Environmental Affairs Natural Resource Management Programmes indicated that the MUCP tool could be used for the SKA core area once invasions maps with info on species and densities, landscape management units, and a detailed history of clearing efforts in the area are available. Further research and monitoring activities are required in order to understand the densities and distributions of the different alien invasive plant species and to include detailed control and management options in the detailed alien invasive plant species Management Plan.

A list of alien invasive plant species was extracted from the South African Biodiversity Information Facility (SABIF) and the Plants of South Africa (POSA) database on South African National Biodiversity Institute (SANBI) website for all degree squares in the Karoo Central Astronomy Advantage Area 1, defined in Chapter 1- Section I-3, and additional species were added from Dr Sue Milton's field record and by referring to maps in Henderson (2001)¹⁷, Bromilow (2010)¹⁸ and Walters et al. (2011)¹⁹. As indicated in Chapter 1, the Karoo Central Astronomy Advantage Area study area covers more than 12 million hectares and lies in the Central Karoo, and mainly in the Northern Cape Province (Figure 5-5). In total 93 invasive alien invasive plant species, mostly herbaceous annuals and grasses have been recorded in the Karoo Central Astronomy Advantage Area 1. Of these, only 23 plant species are listed as category 1, 2 or 3 invaders (see Section III-7 below). These species are all illustrated and described in more detail below.

¹⁵ Department of Environmental Affairs 2015 Monitoring, Control and Eradication Plans: Guidelines for species listed as invasive in terms of Section 70 of National Environmental Management Biodiversity Act 2004 (Act No. 10 of 2004) and as required by Section 76 of this Act. Biosecurity Department of Environment Affairs Private Bag X4390, Cape Town, 8000

¹⁶ <https://www.environment.gov.za/projectsprogrammes/wfw>

¹⁷ Henderson, L. 2001. Alien weeds and invasive plants. Plant Protection Research Institute Handbook No. 12 ARC, Pretoria.

¹⁸ Bromilow, C. 2010. Problem plants and alien weeds of South Africa. Briza Publications, Pretoria.

¹⁹ Walters, M., Figueiredo, E., Crouch, N.R., Winter, P.J.D., Smith, G.F., Zimmermann, H.G. & Mashope, B.K. 2011. Naturalised and invasive succulents of southern Africa. ABC Taxa. The Belgian Development Co-operation, Belgium.

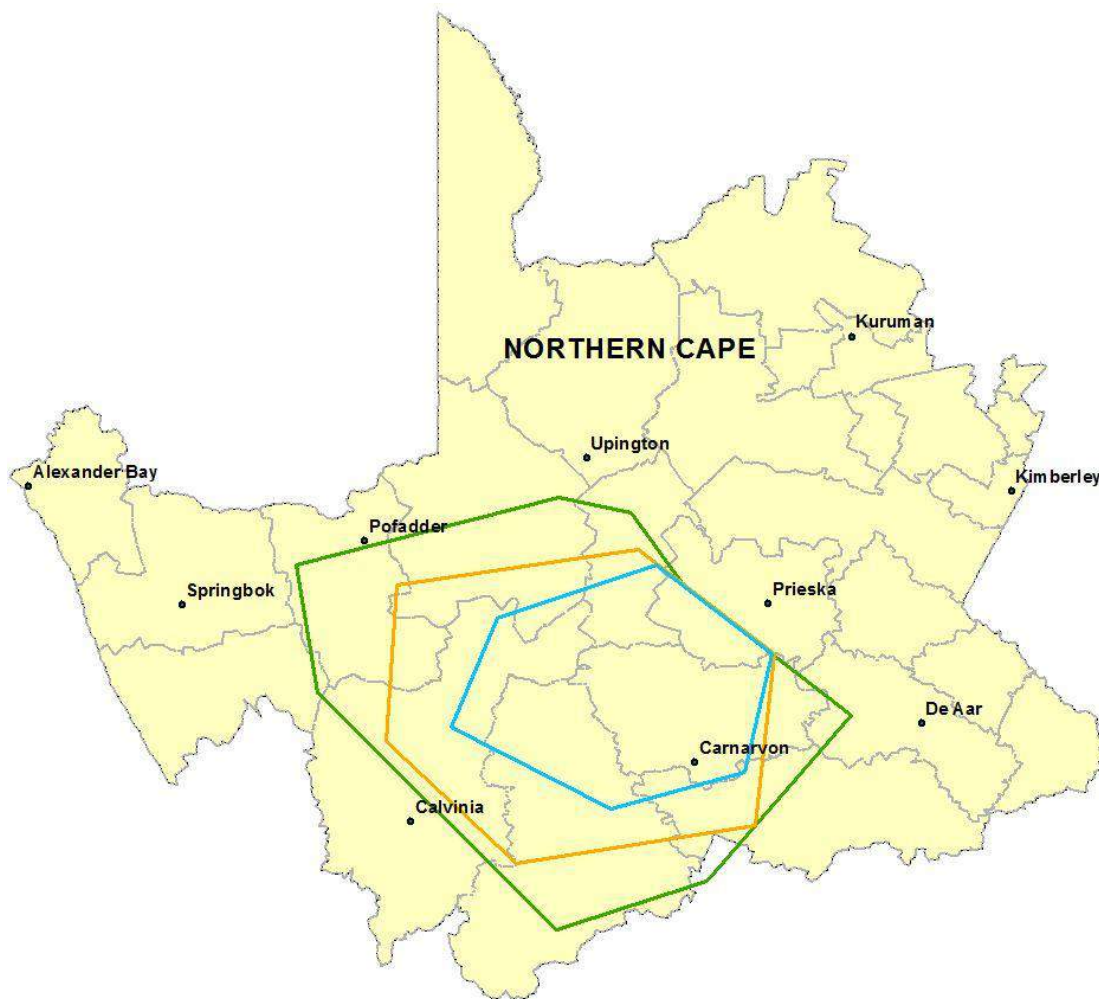


Figure 5-5: Karoo Central Astronomy Advantage Area 1 study area (green outline)

Alien invasive plant species grow among indigenous plants. It is important for any person working within the environment and especially those managing alien invasive plant species to be able to recognize alien invasive plant species amongst the indigenous ones. For example, in Figure 5-6, *Arundo donax* (giant cane), *Eucalyptus camaldulensis* (Red river gum), *Prosopis species* (mesquite) and *Tamarix ramosissima* (Pink tamarisk) are intermixed with indigenous *Acacia karoo* (Sweet thorn), *Atriplex vestita* (Vaalbrak), *Searsia lancea* (Rooi karee) and *Tamarix usneoides* (White tamarix).

Alien invasive plant species are grouped as follows:

- Trees are woody plants that when fully grown at least 3 metres high. The following sections further distinguish between “re-seeding trees” that shed large quantities of hard seeds that accumulate in the soil and germinate months or years later, and “re-sprouting trees” that increase mainly by suckering from the roots;
- Shrubs are woody plants less than 3 metres high, usually with two or more stems at ground level. As for trees, a distinction is made between re-seeding and re-sprouting shrubs;
- Succulents are plants that have non-woody swollen stems or leaves that store water;
- Herbaceous broad-leaved weeds are annual or perennial plants that do not have hard woody stems and do not store water in their stems or leaves; and
- Reeds are plants with long, narrow leaves that are herbaceous or have hollow stems.

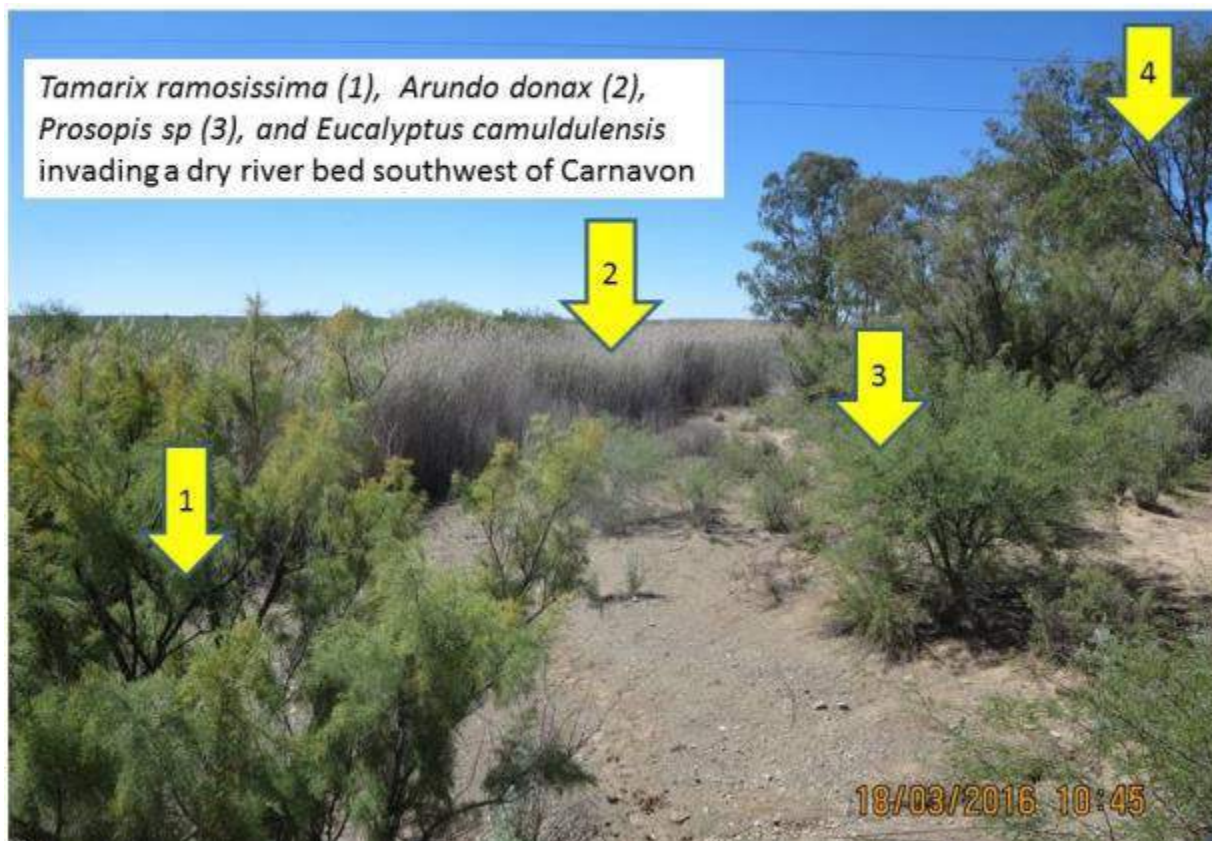


Figure 5-6: A mix of invasive alien plants in a river bed between Carnarvon and Fraserburg within the Karoo Central Astronomy Advantage Area

1. Alien invasive trees

There are six species of alien invasive trees naturalised within the study area:

1. Red River Gum (*Eucalyptus camaldulensis*) from Australia,
2. Narrow-leaved Ash (*Fraxinus angustifolia*) from Algeria,
3. Two species of Poplar, (*Populus canescens*, *P. deltoids*) from North American,
4. Weeping Willow (*Salix babylonica*) from Europe,
5. Mesquite hybrids (*Prosopis species*) from the Americas, and
6. Pink Tamarisk (*Tamarix ramosissima*) from Asia.

Of these six tree species, by far the most abundant and transforming invader is number 5: Mesquite.

Prosopis species (Mesquite)

Mesquite (*P. glandulosa* and hybrids between *P. glandulosa* and other *Prosopis*) was imported into South Africa in the early 1900s as a fodder, shade and firewood tree. All the *Prosopis* species that gave rise to the present hybrid population originate from semi-arid and arid savannas in the Americas. These may be large trees as well as multi stemmed shrubs. The shrubby form is often as a result of damage, either grazing or incomplete control operations. In the Karoo Central Astronomy Advantage Area, *Prosopis* is generally small (less than 2 metres high) and usually occurs in dense thickets. *Prosopis* bears a slight resemblance to *Acacia karroo* (sweet thorn). *Prosopis* species (Figure 5-7) is distinguished from the indigenous Sweet thorn by:

- Reddish young branches with hard thorns 10-15 millimetres in length (Sweet thorn has longer white thorns);
- Pale yellow "bottle-brush" flowers (Sweet thorn has globular dark yellow flowers);
- Yellow to straw-coloured pods containing sticky pith and brown seeds (Sweet thorn has narrow dark brown pods).

Prosopis seeds are dispersed primarily by animals in dung, but may also be spread by water and transported in mud or sand moved from site to site. Seeds normally germinate and establish after rainfall events during summer months. Seedlings establish deep roots (0.5 metres) within one year. Because many viable seeds are passed in dung, *Prosopis* trees often establish around livestock water points, stock kraals and along drainage lines where livestock and game shelter. This species commonly invades Central Karoo areas along dry river beds, old lands, around water points and in pans where the water table is shallow. As indicated in the map produced in 2007 by Working for Water (Figure 5-8), *Prosopis* is widespread in the Karoo Central Astronomy Advantage Area study area. Very dense stands occur around the pans and drainage systems of the Carnarvonsleegte and Sak drainage systems between Brandvlei Vanwyksvlei and Carnarvon. There are also dense *Prosopis* thickets in the core area. The optic fibre/power line infrastructure will pass through *Prosopis* invasions within the core as well as on all three spiral arms (Figure 5-8). Construction activities such as borrow pit excavation and channeling of water off roads or away from structures such as telescope mounts and buildings are vulnerable to mesquite invasion. Mesquite does not readily establish away from the deep alluvial soils of the drainage channels.

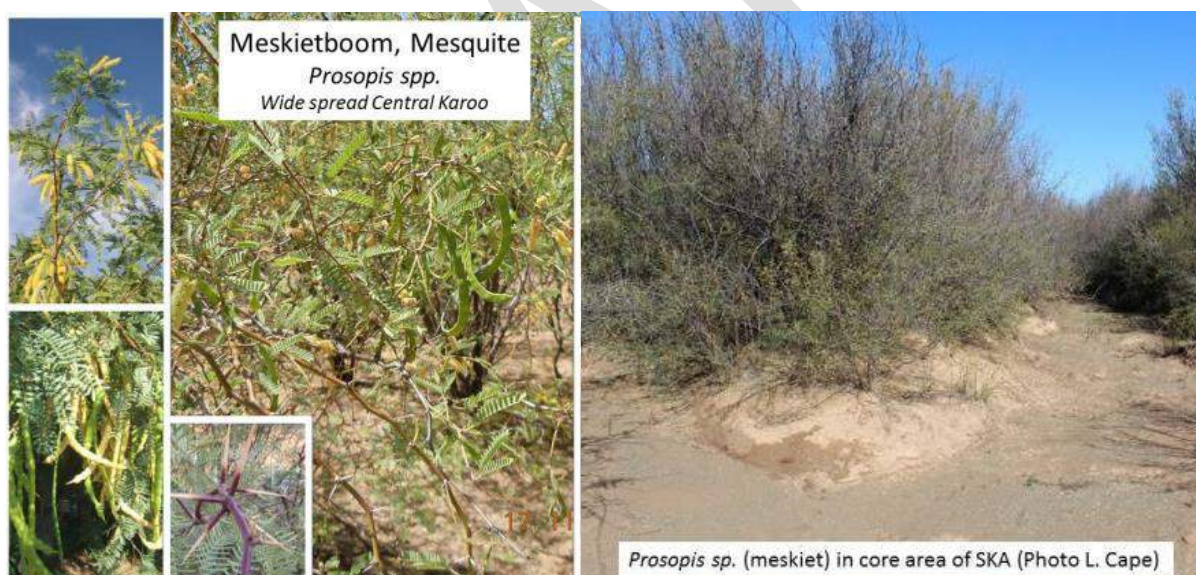


Figure 5-7: *Prosopis* species and mesquite thicket in the SKA Core area (Photo: L. Cape).

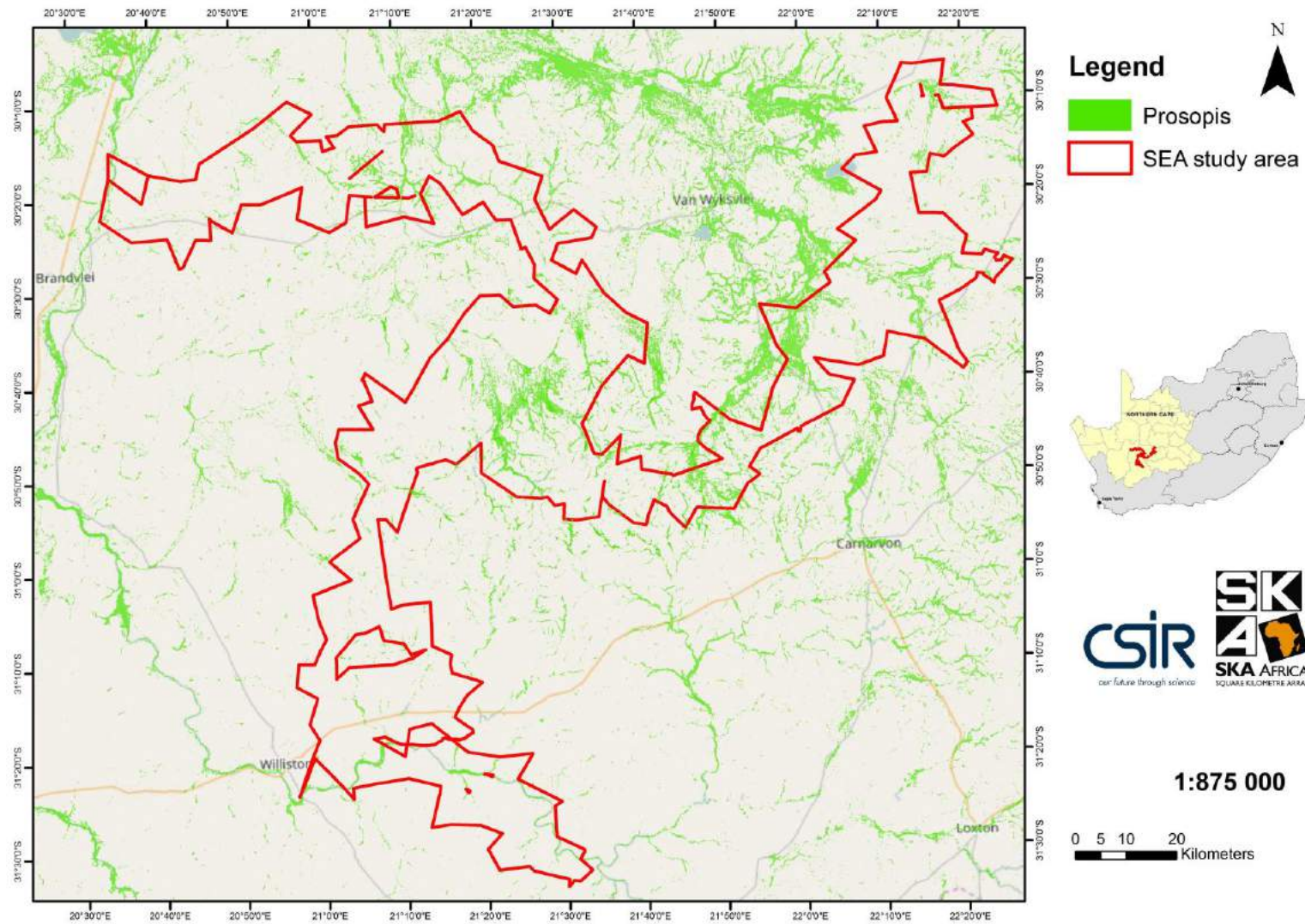


Figure 5-8: Distribution of *Prosopis* species in the Strategic Environmental Assessment study area (Data Source: SANBI (2007) and SKA SA (2016))

Eucalyptus camaldulensis (Red river gum)

The Red River Gum is often planted around farm houses for shade and firewood production. It is a large, long-lived, evergreen tree that reproduces by seeding, and recovers from felling or fire by coppicing (Figure 5-9). Although drought tolerant once established it requires damp conditions for seed germination and seedling survival. For this reason it invades along rivers and around dams and natural wetlands.



Figure 5-9: *Eucalyptus camaldulensis* (Red River Gum). Note regeneration around felled tree. Inset shows frilling used to slow-kill re-sprouting trees without felling

Populus canescens (Grey poplar) and *Populus deltoides* (Cottonwood, Matchwood poplar)

The Grey Poplar and Matchwood Poplar grow in fresh water habitats such as along perennial rivers and in springs (Figure 5-10). They were often planted near farm houses to supply wood and shade, but unfortunately they sucker strongly from the roots, forming dense thickets in springs and along the river banks. Invasive clones of these species occur in the core area and in the southern and eastern parts of the Karoo Central Astronomy Advantage Area where there are fresh water springs and rivers.



Figure 5-10: Cottonwood (*Populus deltoides*) near a water point in the SKA Core
(Photo L. Cape)

Tamarix ramosissima (pink tamarisk)

Pink Tamarix is a problem in rivers where water is saline or alkaline, and in dams that dry out. These large shrubs thrive on salty, alkaline (brak) soils in natural and modified habitats. They can easily be distinguished from indigenous *Tamarix usneoides* by small leaves that turn yellow in winter, feathery growth, supple red stems, and sprays of small bright pink flowers on the branch tips in spring (Figure 5-11). The flowers form feathery seeds that blow in the wind or drift on water. The seed is dispersed by wind and floodwater as well as being moved in building sand mined in dry river beds. When rivers, dams or borrow pits sites dry out the seeds rapidly germinate in the mud leaving behind thousands of seedlings that grow to one metre-high shrubs within a year. Dense thickets of Pink Tamarix Clog Rivers causing flooding, and by excluding light, prevent re-establishment of indigenous plants.

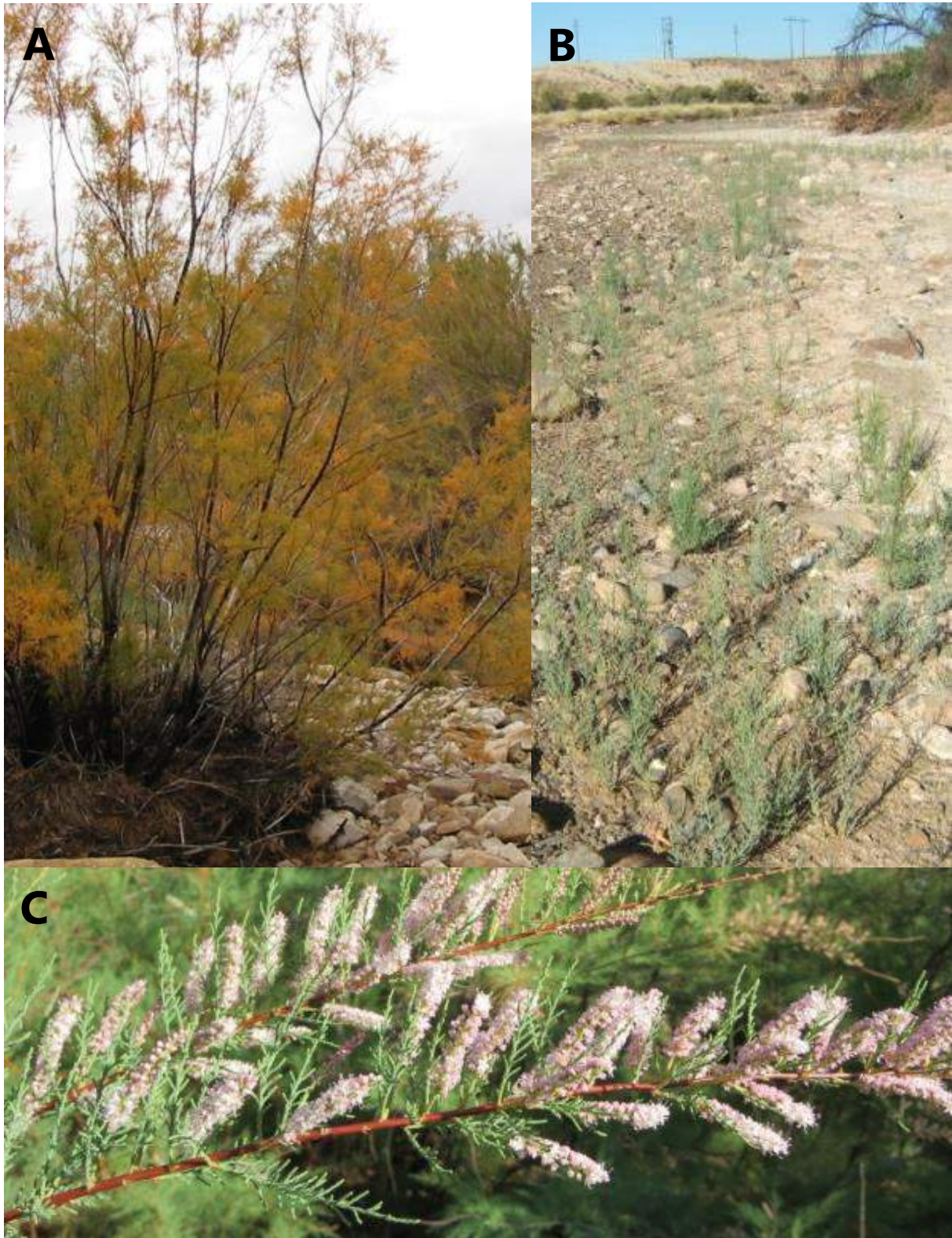


Figure 5-11: A) Pink Tamarix showing autumn and winter colours before the leaves are shed. B) numerous Pink Tamarix seedlings growing in a dry river bed downstream from a Tamarix invasion. C) flowers and feathery leaves

2. Alien invasive shrubs

There are three invasive alien shrubs in the Karoo Central Astronomy Advantage Area:

- *Nerium oleander* (Oleander, Selonsroos) is restricted to the western and southern edges of the area in freshwater rivers from mountainous watersheds;
- *Atriplex nummularia* (Oumnsoutbos) and *Nicotiana glauca* (Wild tobacco) are found throughout the area in dry river beds, on saline alluvium and floodplains.

Atriplex nummularia (Ouman soubos)

This grey salt-tolerant shrub from Western Australia was introduced to the Karoo as a drought fodder crop and planted on deep alluvial soils where it has formed dense stands (Figure 5-12), often in areas that had become too saline for crops. The seeds are dispersed in floodwaters and in the dung of livestock and wild herbivores. It can be confused with indigenous *Atriplex vestita* (Vaalbrak), a metre-high shrub that occurs naturally in similar habitats. However, Oumansoutbos reaches a height of 2 metres, is woody, and palatable, whereas the indigenous species seldom exceeds 0.5 metres, has a spreading growth habit, and is unpalatable to herbivores.

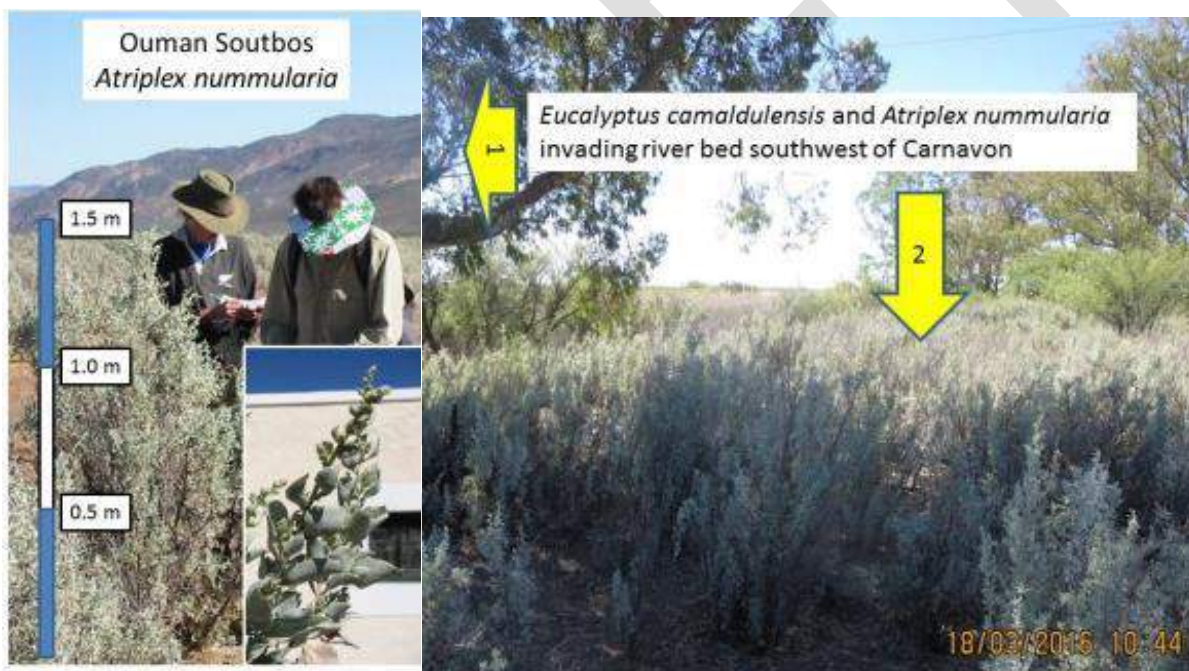


Figure 5-12: *Atriplex nummularia* (Oumansoutbos) showing height and grey colour of this shrub that forms dense stands on river banks

Nerium oleander (Oleander, Slonsroos)

Oleander are evergreen, multi-stemmed shrub with pink flowers (Figure 5-13) that invades fresh water perennial and seasonal river beds on the inland mountain slopes. Oleander leaves, green stems, dry wood and wood smoke are poisonous to people, livestock and wildlife – so the stems and wood of this plant should never be used as firewood. There are dense invasions of this species in the Hantamsrivier within the Karoo Central Astronomy Advantage Area east of Calvinia but it is absent saline or alkaline rivers in the Karoo Central Astronomy Advantage Area. The seeds are attached to silky parachutes and

drift on wind and water. However its deep roots and vigorous sprouting ability is what makes this invasive Asian plant difficult to control.



Figure 5-13: *Nerium oleander* (Oleander) showing growth habit in the Hantamsrivier area of the Karoo Central Astronomy Advantage Area east of Calvinia, multi-stemmed growth habit that captures silt in river beds. The multiple stems and mounded silt are revealed by clear felling

Nicotiana glauca (Wild Tobacco, Wildetabak)

This is a lanky shrub up to 2 metres high with blue-green leaves and tubular yellow flowers (Figure 5-14). It is poisonous to herbivores. It grows on disturbed soil subject to occasional flooding, particularly in dry river beds, on roadsides and in borrow pits. The masses of dust-like dry seeds are dispersed in wind, floodwater and sand moved to building sites.



Wildetabak, Wild Tobacco
Nicotiana glauca
 Riverbeds, borrow pits, roadsides

Figure 5-14: *Nicotiana glauca* (wild Tobacco, Wildetabak). Note large leaves and tubular flowers

3. Alien invasive succulents

Succulents are plants that store water in their leaves and stems. The succulent plant species that invade in the Karoo belong to the leaf succulent Agave family (e.g. sisal/garingboom) or to the stem succulent Cactus family (e.g. kaktus/turksvy/queen of the night). Cactus may have cylindrical or flat stems, but all are covered in thorns. Most Cactus have two kinds of thorns – long thin thorns that are barbed, and glochids or fine hair-like thorns that blow in the wind when the cactus is damaged. The best current guide to invasive succulents in South Africa is Waters et al (2011)²⁰ which should be read in conjunction with the South African Plant Invaders Atlas (SAPIA) newsletters²¹.

Agave americana (American Agave) and Agave sisalana (sisal)

Both these American aloe-like plants may be present in the Karoo Central Astronomy Advantage Area, however neither was recorded on the field trip nor present in the SABIF records for the area. The *A. Americana* has spines on the leaf point as well as along the leaf margin. The leaves have a tendency to fold onto the ground. In contrast *A. Sisalana* has rigid leaves with a single spine on the tip. They were commonly planted as fences to limit the movement of livestock into ploughed areas, as drought fodder, or planted in erosion ditches (dongas) to stop soil erosion. They produce tree-like, giant

²⁰ Walters. M., Figueiredo, E., Crouch, N.R., Winter, P.J.D., Smith, G.F., Zimmermann, H.G. & Mashope, B.K. 2011. Naturalised and invasive succulents of southern Africa. ABC Taxa Vol. 11, Belgium

²¹ <http://www.arc.agric.za/arc-ppri/Pages/Newsletters.aspx>

flowering stems (Figure 5-15). In *A. Sisalana* the seeds germinate on the flower stem and small plants fall to the ground and take root. Seedlings do not disperse far from parent plants. After flowering the old plant dies, but root suckers surrounding it give rise to two or three new plants. In this way clumps continue to increase in size over many decades or centuries. *A. Americana* produces flowers and seeds.

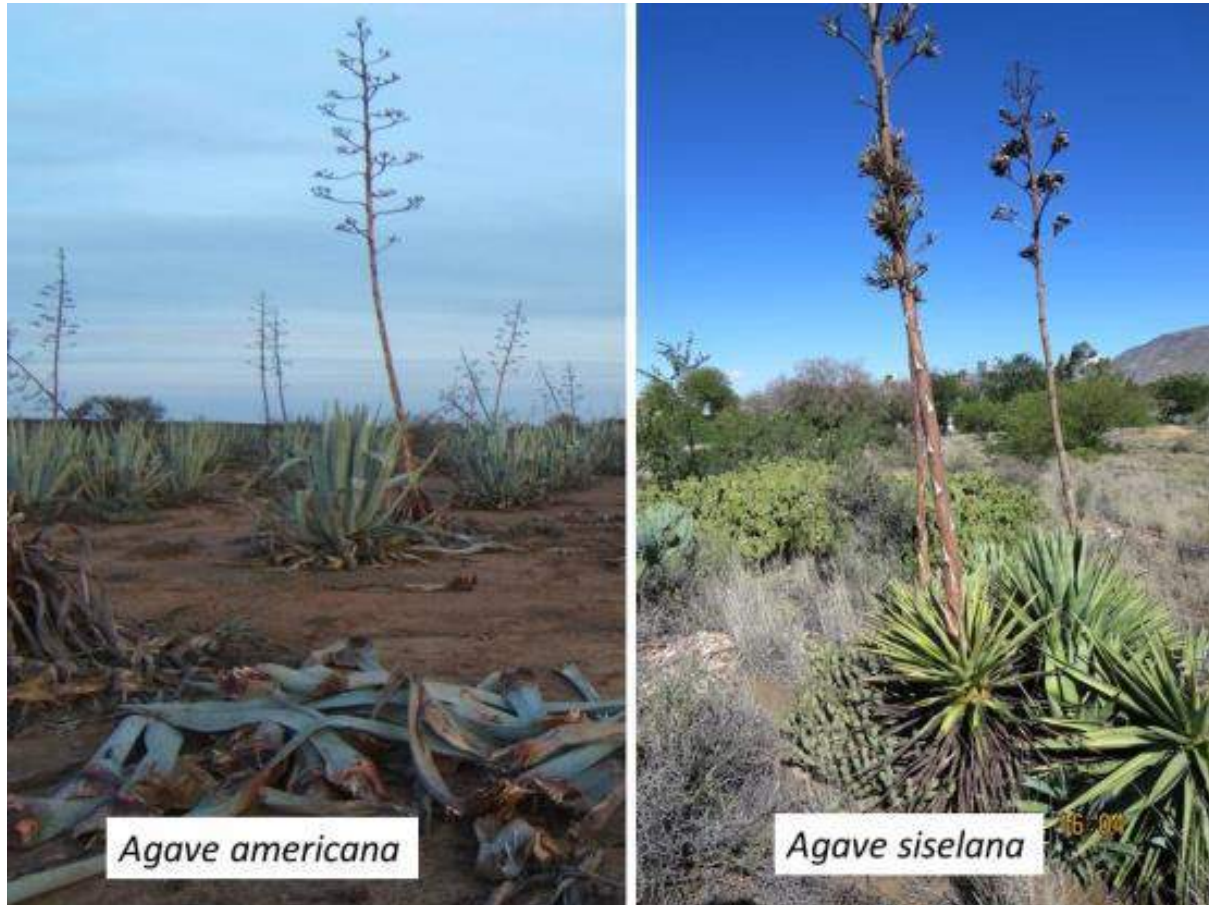


Figure 5-15: Agave and Sisal plants. Dead flower heads 3-4 metre high like trees

Cylindropuntia cactus species (*C. fulgida* var *mammilata*, *C. imbricata*, *C. pallida* and *C. spinosior*) Chain-fruit cactus, Kabel turksvy, Rosea cactus

This group of cactus species from the Americas has cylindrical stems that may be sparsely or densely covered in long white spines. They also have small fine spines (glochids) at the nodes where the longer spines are attached. Most have rose-coloured flowers and produce green to yellow fruits that hang in chains (Figure 5-16). The Boxing Glove Cactus (*C. fulgida mamillata*) has glove-shaped stems and shorter thorns. The Rosea Cactus (*C. pallida*) and some forms of *C. fulgida*, have very dense spines giving the plant a white appearance (Figure 5-16).

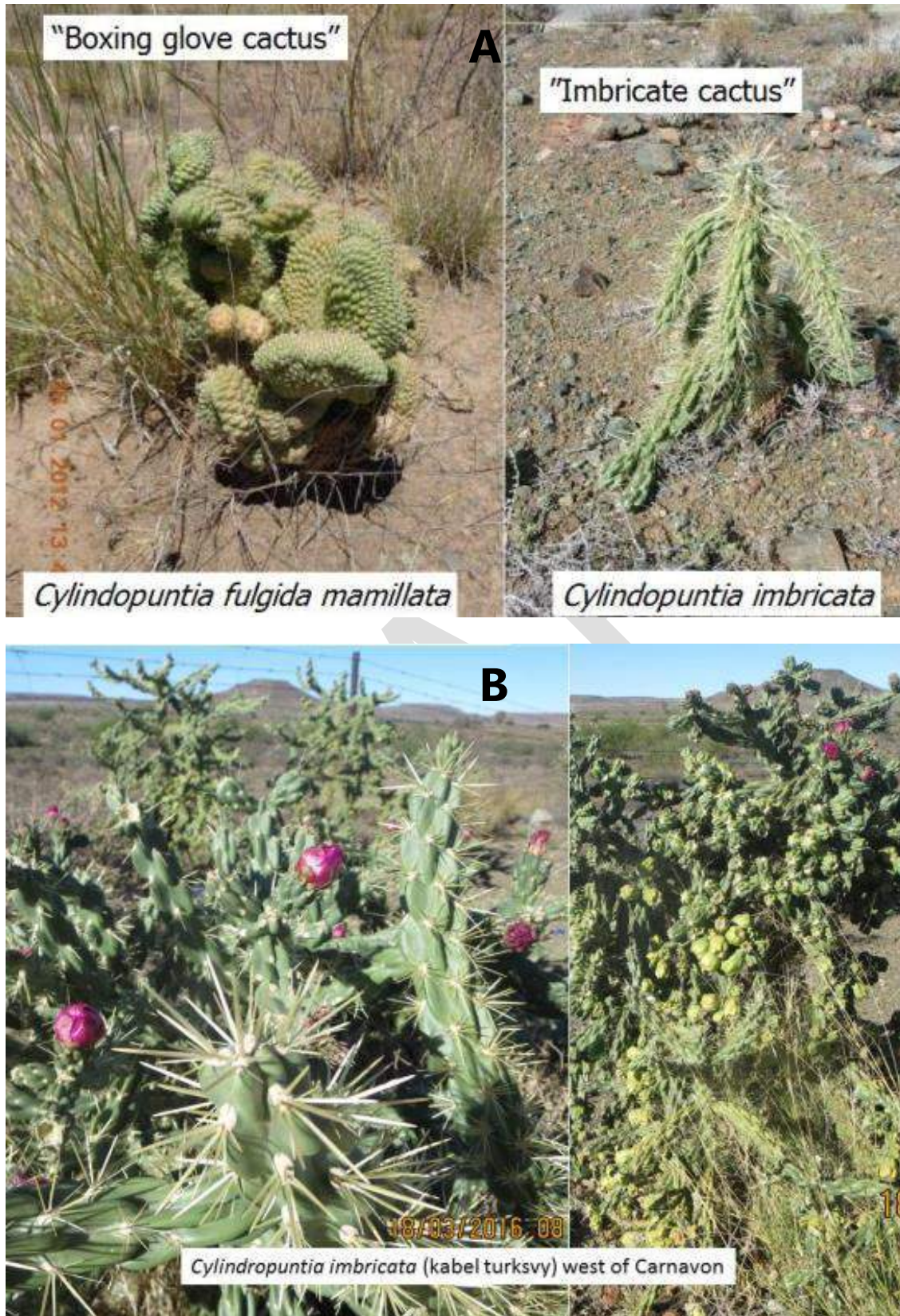


Figure 5-16: A) Boxing Glove Cactus and seedling Imbricate Cactus. B) Imbricate Cactus with rose-coloured flowers and chains of greenish-yellow fruits

All the *Cylindropuntia* Cactus species reproduce both by seeds and by shedding of stem sections that later take root. Seeds are dispersed in the fruits that are eaten by crows, monkeys and baboons, so the invasions are often associated with fences, powerlines, rock piles, koppies and other perch sites or refuges. Stem sections may be washed down rivers by floods. The very spiny forms of cylindrical cactus are also dispersed long distances when the barbed spines of small stem sections attach themselves to wildlife, shoes or vehicles (Figure 5-17). The only indigenous plant genus that could be mistaken for a cylindrical cactus is *Hoodia* (Figure 5-18). Plants in the genus *Hoodia* are all protected under national and provincial legislation and must not be removed. It is easy to tell *Hoodia* and Cactus apart – Cactus thorns are barbed and *Hoodia* thorns are short and never barbed.



Figure 5-17: *Cylindropuntia pallida* (Rosea Cactus) showing covering of white spines and a spiny cladode attached to a boot



Figure 5-18: *Hoodia gordonii* (Ghaap): protected indigenous plant

4. Alien invasive cactus

Pinecone Cactus (*Tephrocactus articulatus*) is probably one of the most widespread cactus invaders in the Central Karoo. It has escaped from farmhouse gardens via seeds dispersed by birds, and by stem sections that break off and are moved in garden refuse to dongas and dispersed further along small drainage lines during flash floods. This cactus is difficult to spot because it is grey-brown to olive green in colour and the same height as most indigenous Karoo shrubs (Figure 5-19). It occurs mainly along small washes or dry river beds and on over-grazed rangeland. It can easily be mistaken for *Hoodia* (see Figure 5-18).

Prickly Pear type Cactus (*Opuntia ficus-indica* and *Opuntia robusta*) are well known and widely planted on old lands as fodder banks and for edible fruits in the Karoo. Although Spineless Cactus is not a declared invader, the seeds dispersed by people, crows, monkey and baboons give rise to spiny plants. Plants are often seen along fence lines, under telephone poles and power pylons, and on rocky koppies where crows and baboons disperse the seeds (Figure 5-20). The plants disperse and multiply mainly by seed, but dumping of stem sections (cladodes) with other garden waste can give rise to new invasions. Torch cactus/Orrerkaktus (*Echinopsis schickendantzii*, also known as *E. spachiana* and *Trichocereus spachianus*²²) (Figure 5-21) is a tall, spiny, pole-like plant with large white flowers. It was frequently planted in gardens and as a barrier plant, but escapes into natural veld, especially among trees and rocks, via seeds dispersed by birds. It roots from cut pieces of stem and will invade wherever garden waste is dumped in the veld.

²² <http://www.arc.agric.za/arc-ppri/Newsletter%20Library/SAPIA%20NEWS%20No%2040,%20April%202016.pdf>

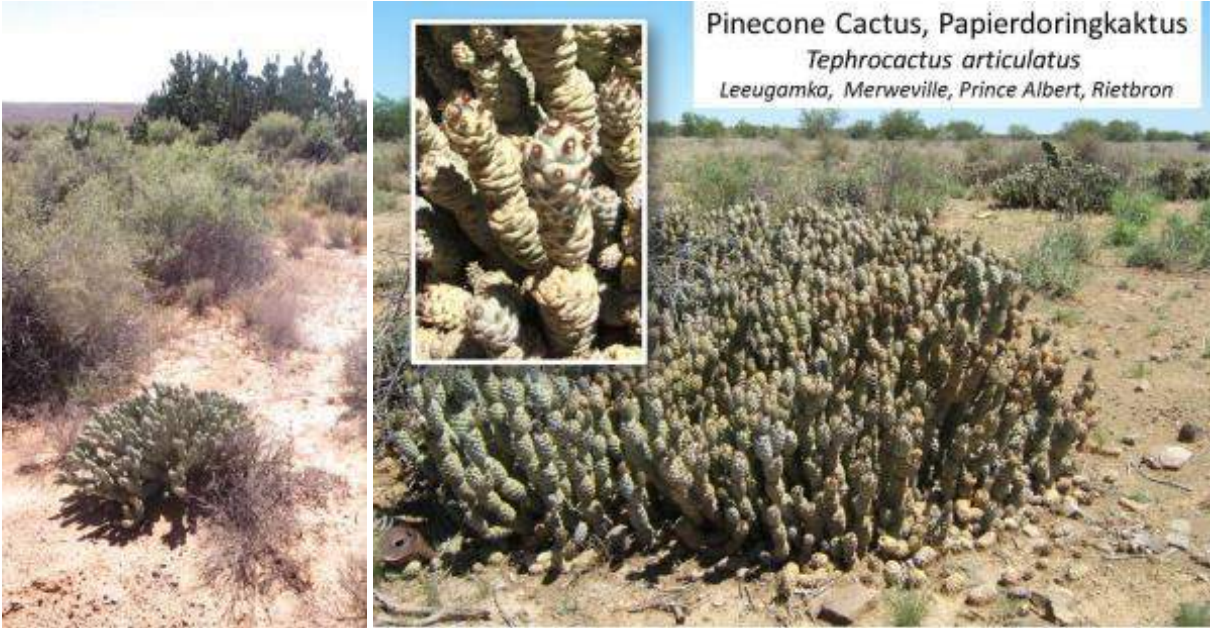


Figure 5-19: Pinecone cactus resembles indigenous Karoo shrubs in height and colour



Figure 5-20 Prickly pear (left) and Robusta Prickly Pear/Blou Turksvy

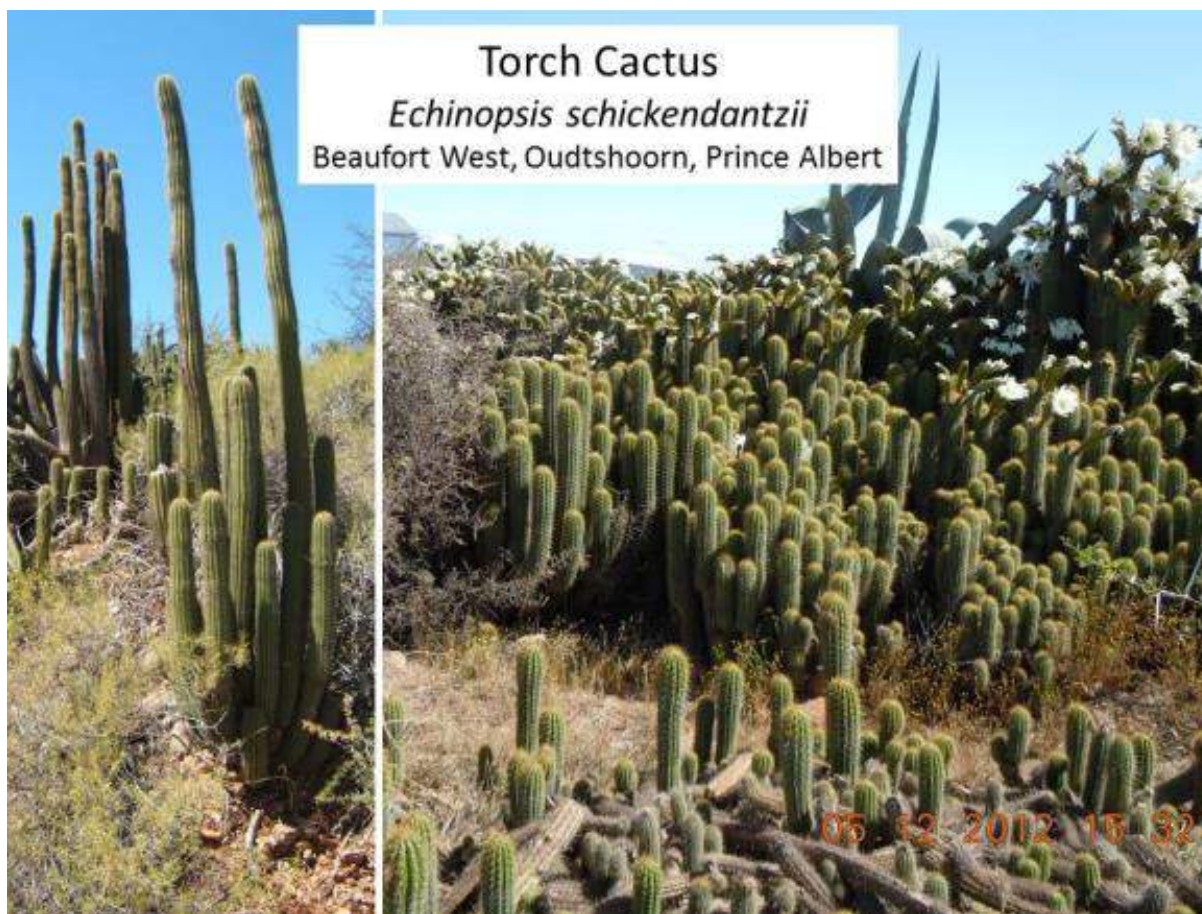


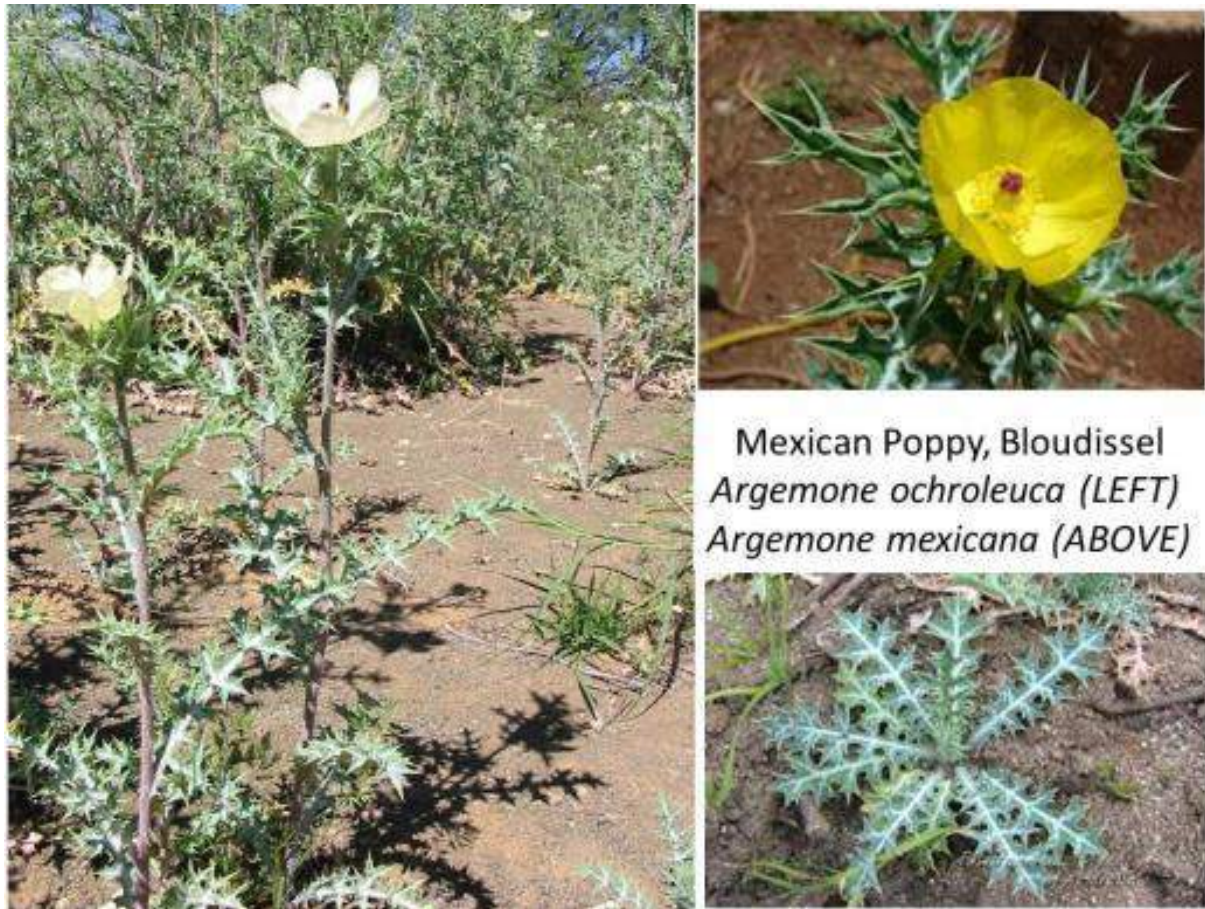
Figure 5-21 Left *Echinopsis* (orrelkactus)

5. Herbaceous broadleaved weeds (opslag)

This group of plants are typical pioneer plants in that they thrive on disturbed lands. This makes them a potentially serious threat to the construction areas of the site. While their invasion into pristine veld is generally limited, they are classified as invasive and must be managed. The exception to this is *Solanum elaeagnifolium* that is perennial and persistent. There are 7 alien invasive non-woody broad-leaved herbaceous weeds commonly found in the Karoo Central Astronomy Advantage Area on disturbed soils of roadsides, old lands and in construction sites. Most of them are opportunistic, germinating after rain and vegetation removal from seeds stored in the soil or transported on vehicles. Many are poisonous to livestock species (e.g. *Datura* species, *Solanum* species.), have burr-like seeds that tangle wool (*Xanthium* species), or are thorny and unpalatable (*Argemone*, *Salsola kali*, *Xanthium* species). They are therefore unwelcome in rangelands. All of them have abundant, long-lived seed and thrive on bare and disturbed soil where there are no indigenous plants. They are briefly described and illustrated below, in alphabetical order.

Argemone ochroleuca (Mexican Poppy, Blou Dissel)

This is a poisonous, spiny weed in the poppy family that invades dry river beds and roadsides. Leaves are a characteristic blue-green and contain an unusual bright yellow sap that stains the skin. The flowers are large and yellow (Figure 5-22). The plant starts life as a rosette, growing flat on the soil surface, and making it difficult to hand pull. Seeds are often dispersed in flood water and building sand. It is common throughout the Central Karoo.



Mexican Poppy, Bloudissel
Argemone ochroleuca (LEFT)
Argemone mexicana (ABOVE)

Figure 5-22 Left: The Mexican Poppy with the pale yellow flower is very common in Central Karoo. Lower right: The plants start off as a rosette with leaves on the ground

***Atriplex lindleyi* subspecies *inflata* (Spongefruit saltbush, Klein blasie brak)**

This saltbush imported from Western Australia a century ago has invaded saline, fine-textured soils throughout the Karoo, but particularly in areas receiving some winter rainfall. The plant is typically about 0.3 metre high, grey green, soft and spineless with characteristic sponge-filled fruits that float on water and roll along the ground in the wind (Figure 5-23). The whole plant is palatable to livestock and wild herbivores and seeds are dispersed in dung. It is particularly common in old lands, overgrazed veld and along roadsides. The plant does not re-sprout but germinates abundantly from seed stored in soil.



Figure 5-23 *Atriplex lindleyi* (Sponge Fruit Saltbush, Kleinblasiebrak) on the road verge near Carnarvon. Inset shows spongy fruits that contain seed

Datura ferox and Datura stramonium

Thorn Apple/Stinkblaar/Olieboom are large-leaved, poisonous annual plants that thrive after flooding, especially in sites enriched by manure or vegetation clearing. The plants have a characteristic oily smell, purple to white flowers and spiny fruit capsules. They are commonly found around dams and pans, livestock and wildlife watering and shelter sites and along riverbanks and roadsides. The seeds are released from the spiny fruit when the capsules dry out (Figure 5-24) and can persist in the soil for some years. The plant does not re-sprout once cut.

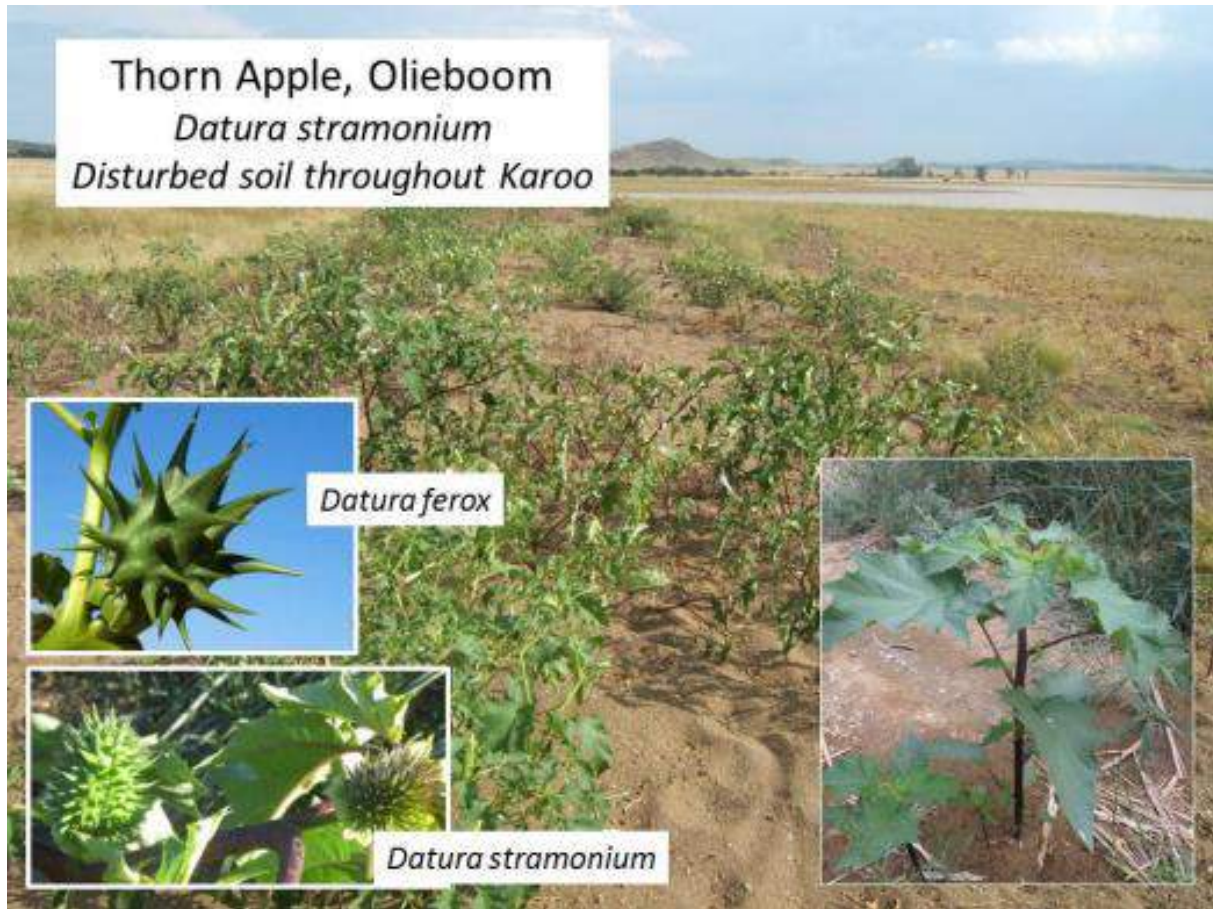


Figure 5-24 Thorn Apple/ Stinkblaar/Olieboom plants at the edge of a dam where soil is enriched by grazing antelope. Note spiny fruit capsules and large leaves (insets)

Salsola kali (Russian Tumbleweeds/Rolbos/Glasswort)

These annual plants from Asian desert areas have small leaves tipped with very sharp spines that break off in the skin. Young plants are soft and palatable to herbivores, but as the plants grow the stems and leaves harden and the plant structure thickens, eventually developing into a dry ball (Figure 5-25). When the plant dies the ball of leaves and seeds breaks loose from the roots and rolls along the ground shedding seeds – hence the common name “rolbos” and “tumbleweed”. Tumbleweed occurs throughout the Karoo Central Astronomy Advantage Area, especially on old lands and on roadsides. It does not re-sprout after clearing, but regenerates from seeds stored in the soil.

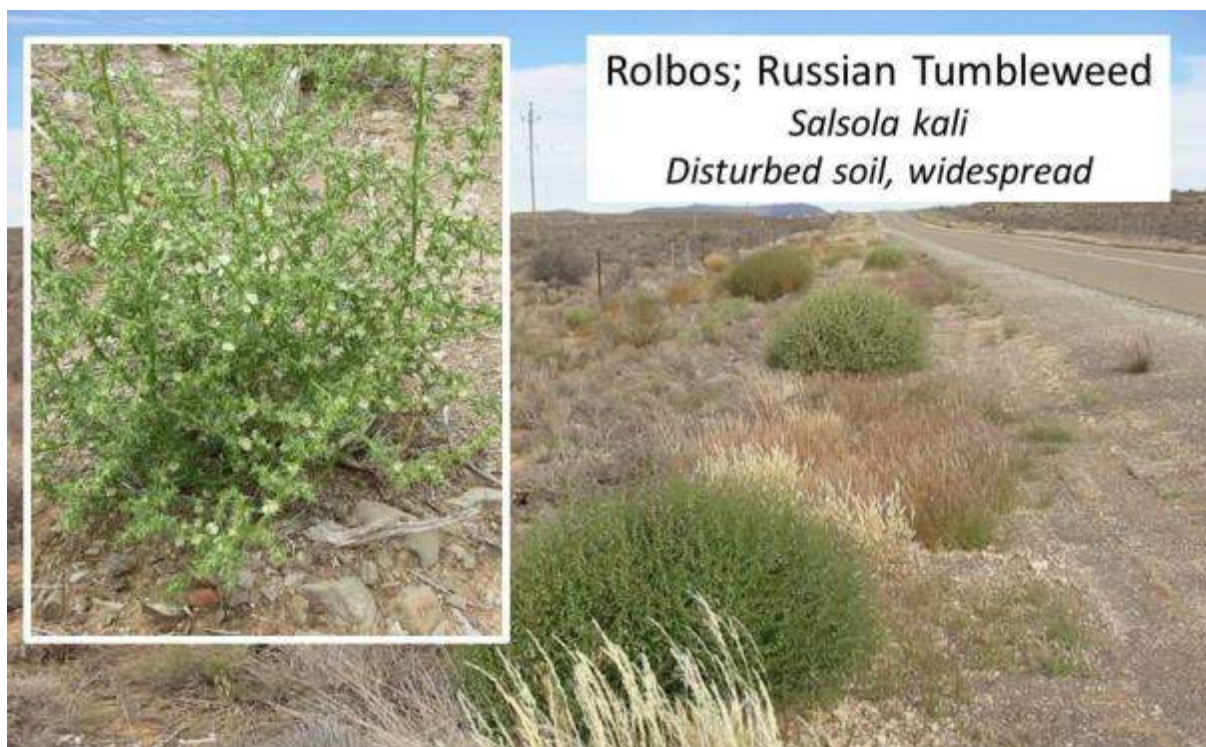


Figure 5-25 Russian Tumbleweed/Rolbos between Fraserburg and Williston

Solanum elaeagnifolium (Satan Weed)

This South American herbaceous plant with grey felty leaves and spiny stems is not annual but perennial (Figure 5-26). It has an extensive root system that enables it to re-sprout if damaged. The purple flowers develop into fruits that resemble small, yellow tomatoes and are eaten by birds and some other wildlife that disperse the seeds in their droppings. Within the Karoo Central Astronomy Advantage Area it is limited in distribution to abandoned erven in villages, and livestock kraals on farms. However, following significant rain and soil disturbance it can invade construction sites and road verges, being transported to such sites by birds perching on fences.

Xanthium spinosum (Cockleburr/Boetebos)

This burr-bearing plant is a serious threat to the wool industry and landowners who failed to eradicate it from their field and stock kraals were once fined (hence the common name "boetebos"). This large-leaved, poisonous weed with yellow sap, establishes in wet areas and on fertile soil – particularly around waterpoints, dams, rivers and roadsides. The seed case is a large burr covered in hooks (Figure 5-27) which attaches itself to the hair of animals and is dispersed in this way to places where livestock and wildlife congregate. Although the plant does not re-sprout, it regenerates from seed that can survive for years in the soil.



Figure 5-26 Satan Weed showing LEFT numerous plants linked by underground suckers, and RIGHT feltly grey leaves and purple flowers typical of the tomato family

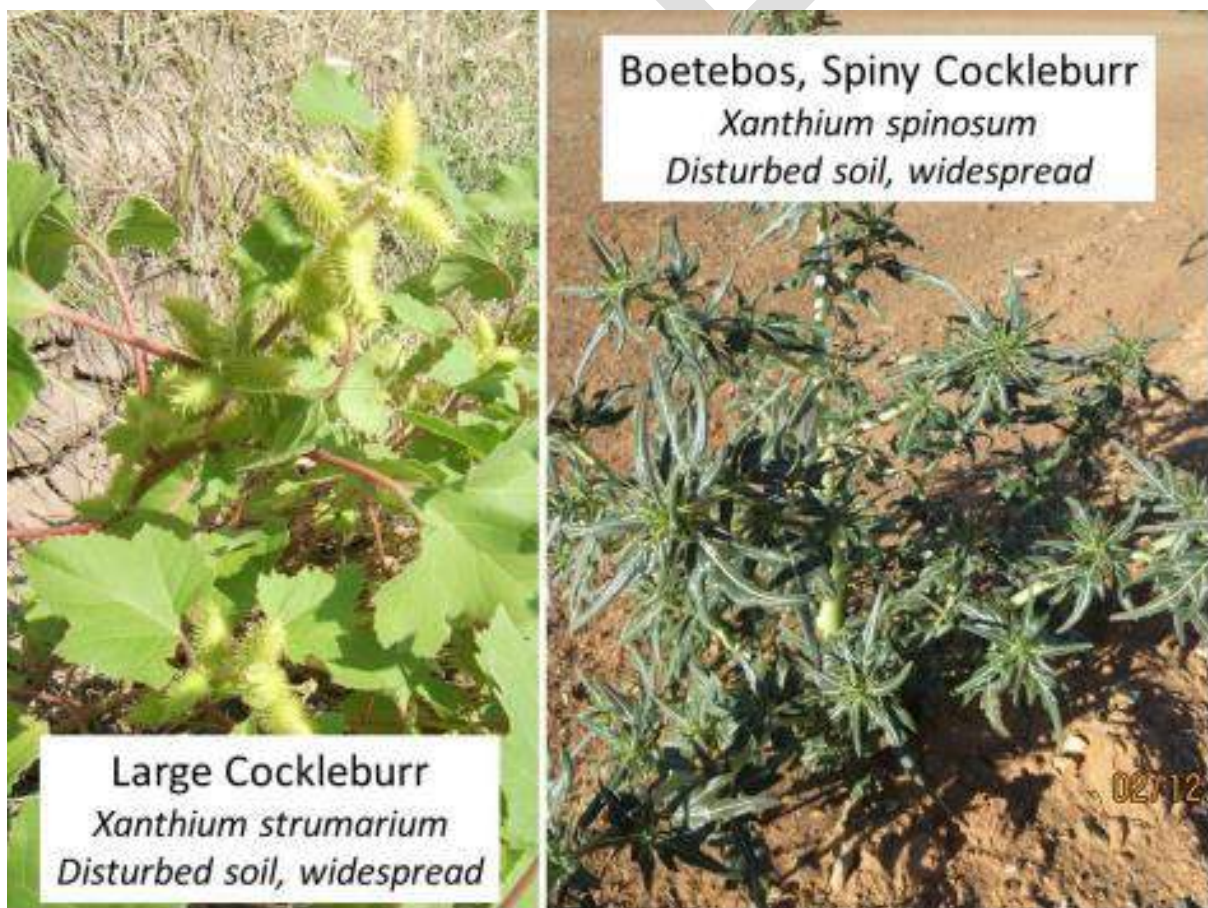


Figure 5-27 Cockle Burr/Boetebos species. Note large cylindrical burrs

6. Alien invasive Grasses and Reeds

The only troublesome invasive alien plants in this group in the Karoo Central Astronomy Advantage Area are the Fountain Grass (*Pennisetum setaceum*) from North Africa, and European Spanish Reed (*Arundo donax*).

Pennisetum setaceum (Fountain grass/Pronkgras)

Fountain Grass more commonly invades roadsides and construction sites, particularly on rocky surface or fine-textured soil (Figure 5-28). Currently it is limited to the western and southern edges of the Karoo Central Astronomy Advantage Area, but has potential to invade on rocky ground and fine-textured soils under arid conditions with winter or summer rainfall²³. It is a long-lived tussock grass with narrow leaves that have saw-toothed edges. As it is not eaten by livestock or wildlife (because of its high fibre content) the tussocks grow large and flammable because of many dead leaves. The fluffy plume-like pink flowers appear throughout the year, and the seeds are dispersed by the wind and water. It rapidly colonises bare rocky ground and small and large dry river beds. The deep-rooted tussocks are impossible to pull out by hand.



Figure 5-28 Fountain Grass as it is often seen along roadsides and in borrow pits in the Central Karoo. Note purple-pink feathery seed heads that are usually present

Arundo donax (Giant or Spanish Reed/Spaanse Riet)

This giant reed is about twice the height of the indigenous Fluitjies Riet, and colonises river banks rather than river beds (Figure 5-29). It does not set fertile seed but spreads mainly through plantings, and by movement of roots and rhizomes in flooding rivers. It re-sprouts vigorously after clearing or burning.

²³ Rahlao, S.J., Milton, S.J., Esler, K.J. & Barnard, P. 2014. Performance of invasive alien fountain grass (*Pennisetum setaceum*) along a climatic gradient through three South African biomes. *South African Journal of Botany* 91:43-48

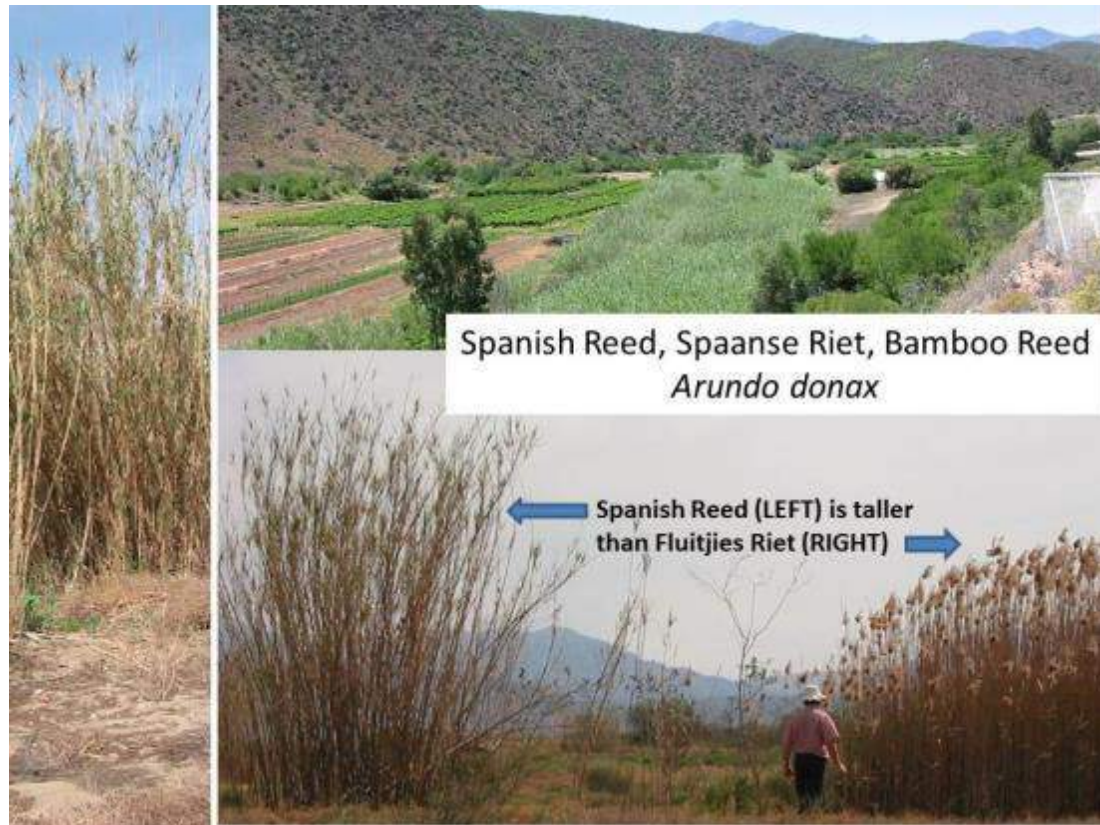


Figure 5-29: *Arundo donax* (Spanish reed) compared with the indigenous *Phragmites* (Fluitjiesriet)

7. Summary of the Invasive alien plant species recorded in Karoo Central Astronomy Advantage Area

Table 5-3 below includes the species listed as Invasive according to the National Environmental Management: Biodiversity Act (NEMBA, 2014) recorded in the Karoo Central Astronomy Advantage Area.

Table 5-3: Species listed as Invasive according to the National Environmental Management: Biodiversity Act (NEMBA, 2014) and recorded in the Karoo Central Astronomy Advantage Area

Family	Species	NEMBA listing	Data source	Number of records	Grids
AGAVACEAE	Agave. Sialana	2	Fieldwork Dr Milton		
APOCYNACEAE	Nerium oleander L	1b	Fieldwork Dr Milton	1	3119
ARUNDINACEAE	Arundo donax L.	1b	Fieldwork Dr Milton		3121
ASTERACEAE	Xanthium spinosum	1b	Fieldwork Dr Milton		
BRASSICACEAE	Nasturtium officinale R.Br.	2	POSA and SABIF	1	3122
CACTACEAE	Cylindropuntia fulgida mammilaris	1b	Fieldwork Dr Milton	2	3121 3122
CACTACEAE	Opuntia ficus-indica	1b	POSA, SABIF	4	3122
CACTACEAE	Tephrocactus articulatus	1a	Fieldwork Dr Milton	1	3121
CHENOPODIACEAE	Atriplex lindleyi Moq. subsp. inflata (F.Muell.) Paul G.Wilson	1b	POSA and SABIF, Fieldwork Dr Milton	12	3020 3021 3022 3120
CHENOPODIACEAE	Atriplex nummularia Lindl. subsp. Nummularia	2	POSA, SABIF	3	3019 3021
CHENOPODIACEAE	Salsola kali L.	1b	POSA and SABIF, Fieldwork Dr Milton	12	2919 2920
FABACEAE	Prosopis glandulosa Torr. var. and hybrids	3	POSA and SABIF	9	2919 2921
FABACEAE	Prosopis velutina Wooton	3	POSA and SABIF	7	2919
MYRTACEAE	Eucalyptus camaldulensis	1b riparian	Fieldwork Dr Milton	1	3120B
PAPAVERACEAE	Argemone ochroleuca Sweet subsp. Ochroleuca	1b	POSA and SABIF, Fieldwork Dr Milton	3	3019 3021 3022
POACEAE	Pennisetum clandestinum	1b	POSA and SABIF	1	
POACEAE	Pennisetum setaceum (Forssk.) Chiov.	1b	Fieldwork Dr Milton	1b	3121
POACEAE	Sorghum halepense (L.) Pers.	2	POSA and SABIF	1	3022
SALICACEAE	Populus x canescens (Aiton)	2	POSA and SABIF	1	3019
SOLANACEAE	Datura ferox L.	1b	POSA and SABIF	2	2920
SOLANACEAE	Datura stramonium L.	1b	POSA and SABIF	1	3121
SOLANACEAE	Nicotiana glauca Graham	1b	POSA and SABIF	2	2921 3122
SOLANACEAE	Solanum elaeagnifolium Cav.	1b	Fieldwork Dr Milton	1	3021
TAMARICACEAE	Tamarix ramosissima Ledeb.	1b	POSA and SABIF	1	3023

IV. Alien invasive plant species clearing and control

This section provides a description of control methods for woody plants, succulents, herbaceous plants, grasses and reeds. Information on methods and chemicals to be used for the control of alien invasive plant species is provided as guidelines only. Further research and monitoring activities are required in order to understand the densities and distributions of the different alien invasive plant species and to include detailed control and management options in the detailed Alien Invasive Plant Species Management Plan. Additional information species-specific herbicide application rates should be obtained from labels of registered herbicides.

1. General guidelines for the control of woody plants

Cut stump

Fell trees according to label instructions using a suitable tool (lopper, hand saw or chain saw). Label recommendations suggest that trees should be felled between 10-20 centimetres above the ground. Field conditions may dictate that trees are felled outside these parameters but this should be the exception and not the norm. A suitable and registered herbicide should then be applied as per label recommendations. When treating the cut stump of a felled tree all cut branches and stems must be treated.

Foliar applications

Foliar applications are not recommended for the SKA core area (due to the fact that development areas must be cleared for construction activities; and it is not applicable for the climate and growth characteristics of the trees in the SKA core area) but can be used for follow-up operations, treatments of suckers and any seedlings that cannot be hand pulled.

Mechanical Control

Mechanical Control is also not recommended for the SKA core area as it is not suitable for the alien plant species present within this area.

Biological control

The only tree with biological control available is *Prosopis*. The beetle is wide spread and well established already so no further action is required.

Handling of trash

Trash from felled trees should be stacked in a suitable area (to be included in the detailed Invasive Alien Species Management plan for the SKA construction footprint area). Stacking will depend on the desired and recommended actions but there is no need to remove off site.

2. Specific guidelines for the control of *Prosopis* species

This group of plants is renowned to be hard to kill. Young trees (2 metres tall) of all species can be foliar sprayed but this is difficult and has limited success due to the tree and climate. Research has

shown that the window for spraying is limited both on a daily basis and yearly. Trees cannot be sprayed during the heat of the day and should only be treated late summer to autumn. The best method to manage *Prosopis* trees is to use cut stump operations. Numerous herbicides are registered but experience has shown that not all are equally effective. Herbicides that may be used include:

- Triclopyr 480g EC with diesel;
- Triclopyr/clorpyralid (270/90) in water;
- Picloram/Triclopyr 50 50 Gel; and
- Triclopyr 360 SL in water.

Triclopyr 480 EC is not a widely used option due to the cost of the diesel but it is widely accepted as the product that is the most reliable. Follow-up treatments of felled trees will need to continue for at least 24 months. Coppice growth can be treated with one of the registered herbicides but Triclopyr/clorpyralid (270/90) is possibly the best. Use the herbicide according to the label and ensure thorough wetting of all leaves.

3. Specific guidelines for the control of Poplar species

Poplar is easy to kill but difficult to manage due to the fact that it produces root suckers. Any treatment programme must treat the parent plant and all juveniles in the area. This may involve a cut stump and foliar methods included at the same time.

Cut stump

Apply the herbicide of choice to the stems felled as discussed above. Herbicides registered for this tree include:

- Imazapyr 100;
- Picloram 240;
- Picloram/Triclopyr gel; and
- Triclopyr 360 SL.

Refer to Tables 5-3 and 5-4 below. Due to the ability of "Imazapyr 100" to translocate readily through the plant, this would be the herbicide of choice. Treatment for poplar is best conducted in late summer just before the onset of leaf fall.

Foliar treatments of suckers and seedlings

The only herbicide registered for this end use is metsulfurom-methyl (600 grams per kilogram).

4. Specific guidelines for the control of Tamarisk species

This is a problem species to manage as there are no registered herbicides currently available in South Africa. The only method of managing tamarisk legally is to use mechanical control. This however will require felling followed either by digging it out or by stump grinding.

5. Specific guidelines for the control of Sisal species

These plants are too large to remove manually. Both Sisal species can be controlled by the injection of 2 millimetres neat MSMA into pre-made holes in the stem. It may be necessary to remove some

leaves to allow access to the bole to make the holes. These plants do not re-sprout once removed and cannot regenerate from the leaves. Leaves are useful mulch if chopped and spread on site to reduce soil erosion, and provide a seed bed and protection for regenerating indigenous plants (Figure 5-30).



Figure 5-30: Leaves of cleared agave spread over bare ground to facilitate regeneration of indigenous plant species after reseeding (Photo credits: Wilderness Foundation)

6. Specific guidelines for the control of Cactus species

Manual control

Manual control should be confined to single plants or very small groups of plants because felling large plants, digging out the roots and collecting up all the fruits and “cladodes” (pieces of stem) that break off while moving the cactus not only creates disturbance but increases risk of further invasions. Pieces of stem that are left on the soil surface will take root and lead to re-invasion of the site. Moreover, Cactus spines are barbed and painful to remove, and the smaller hair-like spines (glochids) on the nodes of cactus pads spines can cause long-lasting skin irritation and eye damage. Glochids blow in the wind and embed themselves in skin and clothing when a cactus plant is cut or moved. When removing Cactus, workers need additional safety equipment including goggles, masks, boots and thick overalls.

Chemical control

Inject MSMA 720 grammes per litre into pre-made holes in the stems of the cactus. This herbicide is yellow-labeled (see Table 5-4, Table 5-5). Not all cactus plants have a stem injection registration and a few have a foliar spray registration. As indicated above, further research and monitoring activities are required in order to understand the densities and distributions of the different cactus species and to include detailed management options in the detailed Alien Invasive Plant Species Management Plan.

Table 5-4: Hazard ratings for commonly used herbicides available in South Africa²⁴

South African hazard classification for herbicides	Hazard statement	Colour band
Class Ia – Extremely hazardous	Very toxic	Red
Class Ib- highly hazardous	Toxic	Red
Class II - moderately hazardous	Harmful	Yellow
Class III - slightly hazardous	Caution	Blue
Class IV - Acute hazard unlikely in normal use	-	Green

Table 5-5: Example of chemical control (herbicides) products and associated hazard ratings

Manufacturer	Active ingredient	Concentration	Hazard class
Dow Agroscience SA (Pty) Ltd	clopyralid/triclopyr (triethylamine salts)	90/270 g/l	Class II
Dow Agroscience SA (Pty) Ltd	Glyphosate	360 g/l	Class III
Monsanto SA (Pty) Ltd	glyphosate	680 g/l	Class III
Monsanto SA (Pty) Ltd	glyphosate	540 g/l	Class III
Monsanto SA (Pty) Ltd	glyphosate	450 g/l	Class III
Arysta Life Science Pty (Ltd)	imazapyr	100 g/l	Class III
Arysta Life Science Pty (Ltd)	MSMA	720 g/l	Class II
Dow Agroscience SA (Pty) Ltd	triclopyr (butoxy ethyl ester)	480 g/l	Class II
Dow Agroscience SA (Pty) Ltd	triclopyr (Pyridyloxy Compound)	360 g/l	Class II

Biocontrol

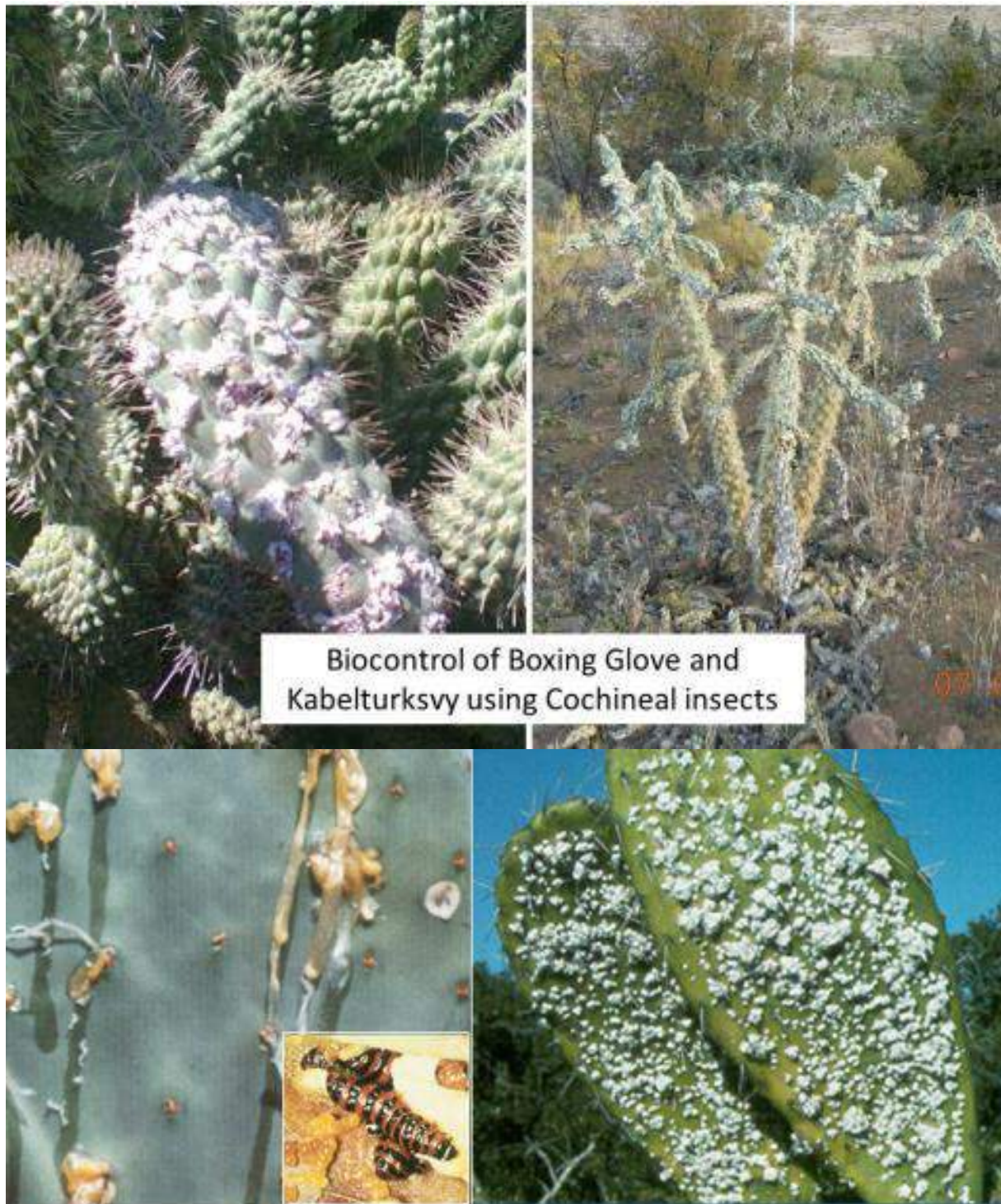
Biocontrol organisms are available for long-term control of some Cactus species (Figure 5-31). However the biological control agents appropriate for the particular cactus species must be used²⁵. Cactus species for which biocontrol is currently available are Boxing Glove and Imbricate Cactus (*Dactylopius tomentosus*, imbricata biotype, a cochineal insect), and Prickly Pear (*Cactoblastis cactorum* a stem boring caterpillar, and *Dactylopius opuntiae*, a sap sucker). Information on obtaining biocontrol agents can be obtained from the Agricultural Research Council²⁶.

²⁴ National Department of Agriculture (NDA) 2011.

http://www.nda.agric.za/doaDev/sideMenu/ActNo36_1947/AR/marketed_%20herbicides_%20active%20ingredients.pdf

²⁵ https://www.environment.gov.za/sites/default/files/docs/aip/treatment_table_biocontrol.pdf

²⁶ Agricultural Research Council information on Biocontrol Agents Tel: +27 (0)12 427 9700, Email: enquiry@arc.agric.za and see website <http://www.arc.agric.za/arc-ppri/Pages/Weeds%20Research/BrochuresFact-sheets-on-weed-biocontrol-agents-and-their-target-weeds--.aspx>



Weeds Biocontrol Leaflets series 2 ARC-Plant Protection Research Institute, Pretoria

Figure 5-31: Biocontrol of Cactus by insects

7. Control of herbaceous plants

Solanum elaeagnifolium (Satan Weed)

This herbaceous, perennial plant has a deep root system that re-sprouts after above-ground parts of the plant have been cleared. For this reason it should be controlled by foliar spraying with systemic herbicides (fluroxypyr). For chemical control to be effective the herbicide must be applied with a wetter to aid penetration and sticking on the hairy leaves. Ensure that all plants are treated and that regular follow-up treatments are made to kill any plants that were missed. Biocontrol is not a suitable method of management in construction areas but will have a role to play in large or widespread population of the plant. The leaf-feeding biocontrol Chrysomelid beetles *Leptinotarsa defecta* and *Leptinotarsa texana* are effective and can be obtained from the Agricultural Research Council (ARC)²⁷. Sites cleared of this species must be monitored and receive follow-up treatment until it is obvious that the plant has been killed.

8. Weeds of construction and disturbed areas

Broadleaved herbaceous weeds such as Mexican Poppy, Blasiebrak and Tumbleweed, and the shrub Wild Tobacco (*Nicotiana glauca*) can all be controlled in the same way. The only exception is *Solanum elaeagnifolium* (see above section) which is a re-sprouter.

Broad-leaved herbaceous weeds

When broadleaved herbaceous weeds are immature (have not yet made seed), the most effective means of control is by manual removal using a hoe or spade. Immature plants without seed can be left on site. However, if the weeds have seed heads they must be gathered up, put in garbage bags or waste drums, transported and disposed of at a licensed waste disposal facility. Alternatively broadleaved weeds that are green and actively growing can be killed by foliar spraying with herbicides such as those used to maintain road verges. Re-invasion of broadleaved weeds after cessation of construction activities is best prevented by re-seeding the area with indigenous grasses and shrubs. Indigenous plants that can colonise bare soil and are suitable for the Central Karoo include the grasses *Fingerhuthia africana*, *Cenchrus ciliaris* and *Stipagrostis* species, and the shrubs *Pentzia incana* and *Eriocephalus* species. However, the appropriate species for re-seeding will vary with soil type, altitude and drainage.

Pennisetum setaceum (Fountain Grass)

There are no registered herbicides for the control of fountain grass. However it grows as a roadside weed so a suitable grass herbicide applied as a post-emergent herbicide will control the plants (Figure 5-32). Further research and monitoring activities are required in order to provide details on *Pennisetum setaceum* and other herbaceous plant control and to include detailed management options in the detailed Alien Invasive Plant Species Management Plan. As is the case of other invaders of disturbed sites, re-invasion by Fountain Grass after construction site closure is best prevented by re-seeding the area with appropriate indigenous grasses and shrubs. Monitor construction sites from which Fountain Grass was removed after 12 months, and hand pull or spot spray any Fountain Grass seedlings that have established.

²⁷ Biocontrol agents available from the Agricultural Research Council Tel: +27 (0)12 427 9700, Email: enquiry@arc.agric.za and see website <http://www.arc.agric.za/arc-ppri/Pages/Weeds%20Research/BrochuresFact-sheets-on-weed-biocontrol-agents-and-their-target-weeds-.aspx>



Figure 5-32: Control of Fountain Grass on roadsides. Grasses are cut, allowed to re-sprout and sprayed with a herbicide containing a marker dye

9. Control of *Arundo donax* (Spanish reed)

Spanish reed is difficult to control because of its extensive underground rhizomes. Options are to completely excavate the rhizomes (roots and underground stems) using a mechanical shovel. Alternatively cut or burn and after 6-8 weeks spray the 1 metre regrowth with a systemic herbicide (glyphosate, Table 5-5), or spray standing (uncut) reeds in late summer, after flowering, but before the leaves turn brown in autumn²⁸. Dead stems should not be left standing in rivers that are subject to flash flooding because they can block waterways and bridges. The dead reeds can be used as mulch on surrounding bare soil. Reed regrowth should be monitored within six months after clearing, and follow-up treatment applied as required.

²⁸ Bell, G.P. 1997. Ecology and management of *Arundo donax*, and approaches to riparian habitat restoration in southern California. Pp 103-113 in Brock J.J, Wade, M. Pysek, P & Green, D. (eds) Plant invasion: studies from North America and Europe. Backhuys Publishers, Leiden

V. Alien invasive plants monitoring

The various SKA construction activities resulting in the reduction of vegetation cover, hydrology changes, and seeds introduction, create opportunities for invasion by alien plant species. The efficient and effective control and management of listed alien invasive plants species within the SKA construction footprint area will require a combination of invasion risk reduction on construction sites, and proactive containment of existing invasions by means of mapping, prioritization, biocontrol, systematic clearing, monitoring and follow up treatments on clearing projects²⁹. Preliminary mitigation measures, control methods and management actions compiled by Dr Sue Milton and Dr Harding for this study have been included in the SKA Environmental Management Programme (Chapter 4 of this IEMP).

It is recommended that specific alien invasive plants species management plans are developed for the various sections of the SKA construction footprint area with the services of an invader plant specialist. The alien invasive plants management plans should be prepared for:

- 1) category 1 and 3 invasive species as listed in the NEMBA: Alien and Invasive Species List³⁰ within the proposed SKA_MID development areas, and
- 2) *Prosopis glandulosa*³¹, *Prosopis velutina*⁴ or hybrids within the SKA core area.

These plans must be informed by existing *Prosopis* and SKA1_MID infrastructure maps, and include refined mapping for other alien invasive plants species of interest for the study area. These maps should be created using a grid of the management area and each grid cell numbered and prioritised for tracking and mapping of progress, methods, dates and follow-up work.

Once compiled, the specific alien invasive plants species management plans should be added to the Environmental Management Programme, prior to the construction phase of SKA1_MID, in order to ensure that the required mitigation measures, control methods and management actions are implemented, monitored and reported on at regular interval of time during the lifecycle of SKA.

The implementation of these species-specific management plans will provide opportunities for capacity building, particularly in the fields of species identification, biocontrol, environmental management, data and human resource management, communication and law enforcement. It is recommended that interns from the Department of Environmental Affairs internship programme³² provide support to the SKA Environmental Manager and Environmental Control Officer responsible for administration and monitoring of the alien invasive plants species clearing and biocontrol programmes. Long-term research and monitoring programmes including systematic clearing and follow-up observations should be based in Van Wyksvlei and Carnarvon, and should focus on low density invasions at the edges of the main invasions that appear to follow the major drainage systems.

The following activities are proposed as part of further research and monitoring activities for the SKA alien invasive plants control strategy:

- Maintain an updated map of alien invasive plants extent and density within the SKA construction footprint area;

²⁹ Department of Environmental Affairs 2014. A National Strategy for dealing with biological invasions in South Africa <https://sites.google.com/site/wfwplanning/strategy>

³⁰ National Environmental Management: Biodiversity Act 10/2004: Alien and Invasive Species List, 1 August 2014.

³¹ Listed invasive species classified as Category 1b in Western Cape and Category 3 in Northern Cape: according to NEMA it is prohibited to allow the spread of any specimen of a category 1 or 3 invasive species.

³² Department of Environmental Affairs 2014 "A National Strategy for dealing with biological invasions in South Africa" <https://www.environment.gov.za/careers/internships>

- Undertake surveys of alien invasive plants or potential alien invasive plants within the Karoo Central Astronomy Advantage Area (photograph, identify and record locations);
- Track-record and monitoring of the activities and successful eradication of alien plants in collaboration with the Expanded Public Works Programme (EPWP)³³ and Working for Water programme within the SKA construction footprint area;
- Maintain a track-record of successful clearing and control activities (e.g. percentage of new alien invasive plants-free site) with detailed information on the season during which the control measures was implemented as well as the herbicide used and the successful application method. This can be done through the creation of a grid over the study area with each grid cell numbered for tracking and mapping of progress, methods, dates and follow-up work.

Invasive alien perennials (*Prosopis glandulosa*, *Prosopis velutina* or hybrids that prefers to grow where there is moisture, and so tends to invade riparian areas, river channels, floodplains, and wetlands). According to existing models for the prioritization of alien invasive plants control operations by Working for Water in South Africa (Van Wilgen et al. 2012)³⁴, areas where alien invasive plants can be a threat to surface water (particularly water resources stressed by human demand), soil stability, and regional poverty levels; as well as areas with existing high levels of alien invasive plants invasion (especially where the invader is *Prosopis* species) should be targeted for priority control activities.

The Karoo Central Astronomy Advantage Area includes stressed surface water resources, priority wetland for conservation, erodible soils and a high river length ratio as well as high level of poverty especially in small rural towns. Within the Karoo Central Astronomy Advantage Area, the "Carnarvonleegte" drainage line between Kenhardt, Van Wyksvlei and Carnarvon is an obvious focus for biocontrol and clearing because it is heavily invaded by *Prosopis* and lies between under-resourced towns. This area should be targeted for biocontrol (seed-feeding beetle) release.

The short term Alien Invasive Plant Species management plan must be conducted in collaboration with the Working for Water Programme of the Department of Environmental Affairs (Natural Resources Management Programmes) and must follow their recommendations for initial population reduction, follow-up control and long term maintenance at all SKA sites, roads and servitudes. Existing Working for Water programmes are located outside the boundaries of the Karoo Central Astronomy Advantage Area, the nearest being at Beaufort West to the South and in Calvinia to the West. The involvement of the Working for Water operations contractors in the alien invasive clearing and control activities on the SKA core site requires that a proposal including the detailed alien invasive management plan informed by the MUCP information is submitted to Department of Environmental Affairs Natural Resource Management Programmes (NRMP) for consideration. The detailed management plan must include a biocontrol plan, a clearing plan, as well as required budgets for contractors, tools, herbicides, training, safety equipment and transport, monitoring, administration and management. This plan must be submitted to Working for Water Programme for review and annual updates according to clearing activities progress and success.

Within the Strategic Environmental Assessment study area, the *Prosopis* invasion is most concentrated within the SKA core characterised by lowland area receiving drainage from the mountains to the South. The degree of soil and vegetation and hydrological disturbance will also be greatest within the SKA

³³ The EPWP projects are funded by the Department of Environmental Affairs Natural Resource Management and Social Responsibility Programmes. The main focus of the EPWP is to provide income relief through temporary work for the unemployed to carry out socially useful activities.

³⁴ Le Maitre, D.C., Forsyth, G.C & O'Farrell, P.J. 2012. Development of generic species- and area based prioritisation models for use by Working for Water in prioritising invasive alien plant control operations in South Africa. Report number CSIR/NRE/ECO/ER/2012/0028/B for the Working for Water Programme

core area. The major steps in achieving effective control of *Prosopis* (and other alien invasive plant species) in the SKA telescope core would be financial and project planning, mapping, prioritization, appointment of contractors, clearing and rehabilitation, monitoring and follow-up control. A systematic clearing programme which aims to prioritize the lower-density edges of the invasion, very small areas of high density invasion (less than 1 hectare), and areas subject to high levels of SKA-related activity for clearing should be developed and implemented within SKA telescope core with appropriate monitoring tools for control sites (e.g. monitoring checklist in Table 5-6).

Table 5-6: Checklist for monitoring alien invasive plant species at control sites

Common name	Initial survey date	Density on site Zero, <10, 11-100, >1000	Control methods	Audit date	Density on site Zero, <10, 11-100, >1000	Follow-up treatment method
River red gum						
Grey poplar, Matchwood poplar						
Matchwood poplar						
Weeping Willow, Treurwilge						
Pink tamarisk						
American ash and Desert ash; Esseboom						
Mesquite, honey						
Oleander						
Old Man Saltbush						
Wild tobacco						
Century-plant, American aloe						
Boxing-glove cactus						
Imbricate cactus, kabelturksvy						
Torch cactus, orrelkaktus						
Rosea cactus, Rosea kaktus,; and Spiny cholla						
Blue-leaf cactus, Robusta (E), Turksvy (A)						
Mission prickly pear (E), Turksvy (A)						
Pine cone cactus, Paper- spine						
Spiny cocklebur						
Sponge-fruit saltbush, klein blasiebrak						
Tumbleweed (E), Rolbos (A)						
Mexican thistle, Bloudissel						

Large thorn apple, grootsinkblaar						
Common thorn apple, olieboom						
Silver-leaf bitter apple, satan weed						
Spanish reed						
Fountain grass						

VI. SKAEON

The Integrated Memorandum of Understanding between the SAEON and the SKA provides for the SKAEON committee to jointly manage mutual responsibilities and opportunities at the SKA site. This IMOU has been developed based on the mutual benefit provided by the presence of SAEON at SKA. The SKA has a responsibility to manage the land owned by NRF in an evidence-based manner according to best practice. However, as the SKA does not have expertise in this area, SAEON is able to address the information gaps required to manage the land, to the advantage of SKA, while at the same time furthering the goals of SAEON with respect to Global Change Research. The Arid Lands Node will develop a research and training platform based around the SKA, with the following outcomes and activities:

- Provide baseline and ongoing environmental monitoring at SKA to inform the SKA Environmental Management Programme as required by the Strategic Environmental Assessment.
- Coordinate environmental research at the SKA site. This will ensure that current and emerging issues can be addressed to inform the needs of SKA, as well as ensure that research at the site takes place in a coordinated manner to maximise science impact and output.
- SAEON Arid Lands Node will develop a sentinel research and training platform at the SKA site, which will focus on land-use impacts, climate change impacts and adaptation.

10. Short term research and monitoring programme (0 to 5 years)

The primary goals set for the 5 year period include the following:

- Fully establish the ecological monitoring programme at SKA;
- Complete installation of monitoring equipment at SKA;
- Establish a data management system specifically related to data generated at SKA;
- Establish collaborative projects with other organizations wanting to work at SKA;
- Maintain a steady stream of students working at SKA, with associated theses and publications; and
- A number of papers published in peer reviewed journals and a steady flow of papers being generated from research conducted at the site.

A summary of the activities and associated outcomes of the SAEON research platform over the coming five years is outlined in Table 5-7.

Table 5-7: SAEON five year research programme

Year	Activities	Outcomes and Outputs
Year 1	<p>Staff Recruitment – appoint Scientist, Junior Scientist and Admin Assistant.</p> <p>Recruit 1xMsc and 1xPhD for global change research at the SKA.</p> <p>Conduct gap analysis to identify gaps and priorities at the SKA and in the Upper Karoo</p> <p>Initiate Baseline Social and Environmental studies at SKA</p> <p>Establish long-term monitoring sites within SKA as well as on adjacent farmland.</p> <p>Establish SAEON-SKA Research Platform in collaboration with other partners.</p> <p>Set up and test electronic soil-water-climate monitoring equipment at SKA at selected sites.</p>	<p>Publication on the baseline conditions and conditions at SKA in regional context.</p> <p>Initiation and establishment of SAEON SKA research and training platform.</p> <p>Development of a long-term global change monitoring strategy for the site.</p>
Year 2	<p>Recruit 1xMSc student for global change research at SKA.</p> <p>Expand SAEON SKA Research Platform through collaboration with other project partners and institutions.</p> <p>Evaluate soil-water-climate monitoring equipment and supplement or adapt as required for global change research.</p> <p>Collect baseline information and develop comprehensive inventories on key bio-geophysical parameters at long-term monitoring sites.</p>	<p>First MSc completed based on research at the site.</p> <p>Development of soil-water-climate-vegetation monitoring systems at the site which will contribute significantly to global change research at national and international levels.</p> <p>Establishment of the SAEON SKA Research Platform as a key driver of research and student development in the Karoo region.</p>
Year 3	<p>On-going monitoring and evaluation of bio-geophysical monitoring with first publications being developed.</p> <p>Increased student participation and training at the site.</p> <p>Host a special session on Global Change in the Upper Karoo based on the work at SKA, at AZEF or other similar conference.</p> <p>Mid-term evaluation of SAEON Research Platform to identify gaps and implementation priorities before the operational phase of SKA commences.</p>	<p>Second MSc completed based on research at the site.</p> <p>Increased exposure and traction of SAEON-SKA Research Platform within the country, which should enable it to start leveraging additional funding or collaboration opportunities.</p> <p>Increasing amounts of bio-geophysical data accumulated for the area, which will facilitate increased opportunities for students and publications.</p>
Year 4	<p>Recruit second PhD student and another MSc student for global change research at SKA.</p> <p>Maintain bio-geophysical monitoring equipment and continue with data collection.</p> <p>Identify priority studies for research and student projects.</p>	<p>First PhD student working within the project graduates. Second PhD student comes on board.</p> <p>A variety of collaborations with different institutions has been established and increasing numbers of students are being trained at the site.</p>

	Register the site as an official ILTER site with the international ILTER network,	SAEON-SKA Research and Training Platform is able to contribute significantly to global change research in South Africa.
Year 5	Five-year review of SAEON activities and outcomes at SKA. Identification of major outcomes and contributions over the period and mapping the way forward. Maintain bio-geophysical monitoring equipment and continue with data collection. Prepare publications based on work at the SKA on global change, with reference to climate change impacts as well as land use effects.	Third MSc completed based on research at the site. First synthesis publications from the site, based on analysis of all the research that has taken place to date. SAEON SKA Research and Training Platform is fully established and is able to maintain a steady output of students and publications. SAEON SKA Research and Training Platform is a significant contributor to long-term capacity development and training in the Northern Cape and South Africa.

11. Long term research and monitoring programme

The SAEON Arid Lands Node Science Plan forms the frame for projects undertaken by the Arid Lands Node, which all have the long-term goal of contributing to the NRF Strategy 2020 strategic outcome of establishing "Leading edge research and infrastructure platforms" as well as contributing significantly towards the other four strategic outcomes through activities such as postgraduate support and research collaborations, and the development of new topical Global Change Research fields such as the nexus between water, climate, CO₂, biodiversity, energy and economics. The Arid Lands Node has responsibility for meeting SAEON's environmental monitoring and research mandate across the hyper-arid to semi-arid western half of South Africa, which has an area of approximately 555 000 km² or approximately 43% of the country. This area includes 5 different biomes: Desert, Succulent Karoo, Nama Karoo, Arid Savanna, and Grassland Biomes, as well as the Azonal vegetation types associated with the major drainage systems of the region. Since establishment, the Arid Lands Node has developed a significant and growing presence in the Arid Zone and manages a number of key long-term monitoring sites across the region.

Themes of the SAEON Arid Lands Node science plan are:

- Biome and land cover shifts due to global change
- Broad-scale infrastructural developments related to energy development
- Large infrequent events of economic and ecological significance
- Arid hydrological systems
- Degradation and ecosystem integrity in relation to land use practices

The value of the opportunities presented by the development of SKA for SAEON and terrestrial environmental research in the arid zone are summarised below:

- The opportunity of studying a change in land use across an extensive area is unique, especially from farmland to conservation-orientated land use;
- The site is representative of a large proportion of the Upper Karoo and has a wide variety of representative landforms and vegetation types present, which adds to the ecological value of the site as well as the validity and broad applicability of science carried out at the site;
- The land use at the site for the foreseeable future will be stable, which makes it highly suitable for long-term environmental science, especially as a reference site in the light of Shale Gas, Uranium mining and other developments that are happening in the rest of the Karoo;

- The site is located within an area that is predicted to undergo a high degree of climate change and represents an ideal site for investigating biome shifts and related climate-change induced impacts;
- There is very little existing data for the site or broader area, with the result that all information collected will be novel and contribute significantly to baseline knowledge in the area;
- The site has high potential as a student training platform supported by both SAEON and SKA and a large student throughput is anticipated; and
- The site will complement and enhance the Arid Lands Node's existing network of study sites, which lacks a core site at the centre of the Karoo.

A summary of the main topics identified as research and monitoring priorities in the "SAEON@SKA Research Plan" are listed below. SAEON Arid Lands Node will collaborate with other institutions and facilitate access to the site and baseline information as it emerges, to enhance the value of the site as a science and training platform.

- **Eco hydrological and Biogeochemical Cycling in relation to Vegetation Dynamics under Climate Change**

The interaction between climate change and vegetation can be observed through changes in the fluxes and availability of carbon and water in the environment at the earth-atmosphere interface. The impacts of these changes on vegetation and land cover are best understood through the examination and monitoring of ecosystem-level indicators, particularly vegetation dynamics, shifts in plant functional types, growth-form composition, productivity and diversity.

- **Ecosystem monitoring for change detection**

SAEON will establish an array of Square Kilometre environmental Observatories to monitor changes in diversity and distribution of species in response to changes in climate across habitats. This will be allied with detailed soil water and climate monitoring as detailed above.

- **Ecosystem-Level Dynamics**

The dynamics of Nama-Karoo vegetation, particularly shifts in the abundance of major functional groups such as grasses vs. shrubs is not well understood but is required to predict the impacts climate change and land use.

- **Vegetation Recovery Rates and Dynamics**

Natural recovery rates of vegetation will be recorded in areas that are currently degraded and dominated by indigenous indicators of degradation, such as *Rhigozum*, or with alien species, such as *Prosopis*.

- **Faunal Population Dynamics**

Changes in forage availability, predation, persecution and water distribution is likely to cause changes in faunal populations, such as springbok, hyrax, jackal, caracal, locusts and some birds. In addition, long-term changes in faunal community structure or abundance may be indicative of underlying changes in productivity or ecosystem-level shifts brought about by global change.

VII. Predator species monitoring

The construction and operation of SKA1_MID in South Africa will not be directly impacted by predators such as jackal and caracal however due to the lifetime of SKA1_MID (at least 50 years), it is important for SKA to take into consideration the needs and issues of the surrounding community and local stakeholders when developing the project. This chapter demonstrates that it is essential to understand the causes of livestock losses within the study area and confirm whether predation is in fact a major cause of livestock losses. The National Research Foundation together with research and monitoring partners can develop strategies to contribute to improving farming practices within the study area. Such strategies should be developed together with the local farmers and based on expert knowledge that may be presented to the local community to improve knowledge on the current situation.

1. Management strategy and long term monitoring programme for predator species

An additional 117 594 hectares of land will be acquired by the National Research Foundation in addition to the two National Research Foundation owned farms, namely "Meysdam farm and Losberg farm". Through this land acquisition programme, the National Research Foundation intends to be responsible for the management of the largest portion of open land within the Karoo region. Other large open areas occurring within a 100 kilometres radius of the SKA core include the Alkantpan military test range (see Figure 5-33) (approximately 85 900 hectares) and the Karoo National Park (approximately 76 620 hectares). Land management responsibilities include predator control and wildlife management. Predator control measures currently in use on the Alkantpan site include call-and-shoot hunting, denning, contract hunting and helicopter hunting on occasion. Despite Alkantpan actions to prevent predation, surrounding farmers are of the opinion that this problem has and continues to persist. This section provides a framework for the development of a management strategy and long term monitoring programme for predator species within the SKA core area (i.e. the area demarcated for the SKA land acquisition process).

The primary potential benefit of the establishment of a consensual predator management strategy is to prevent or minimise any potential impact of predators originating on Meysdam and Losberg Farms on surrounding sheep farmer livestock yield. The National Research Foundation will consult experts on predator control and management in the Karoo as well as the local affected stakeholders in order to better understand the current local challenges faced by farmers and foster partnerships, trust and cooperation with local stakeholders. Through this local stakeholder engagement, the National Research Foundation will be able to promote the use of alternative predator management practices more environmentally friendly and more sustainable than those currently implemented in the Karoo. This engagement will also enable the development of an integrated strategy between all local stakeholders, where set objectives can be established for predator management beyond the boundaries of Meysdam and Losberg Farms.

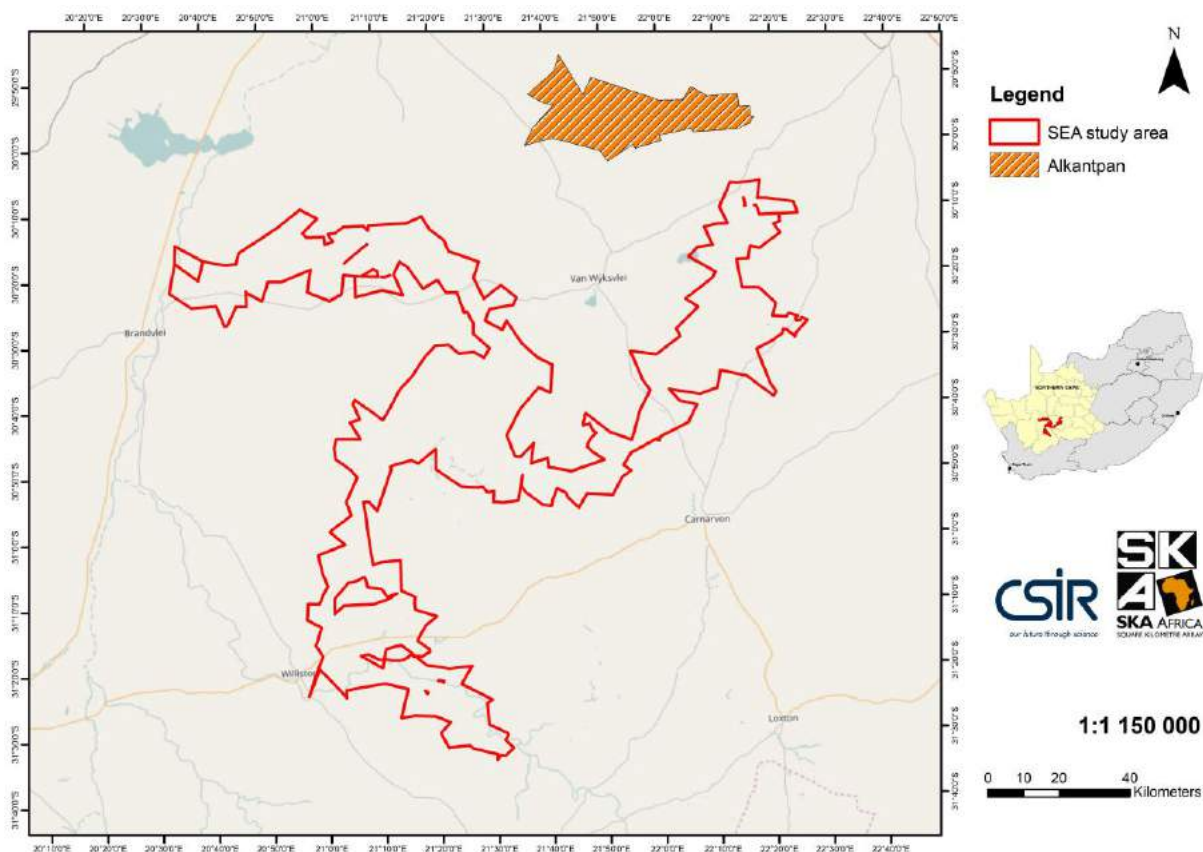


Figure 5-33: Proximity of Alkantpan from SKA1_MID

Both the fragmentation and transformation of natural land has impacted adversely on most large carnivore species which are currently experiencing global declines. Large carnivores have disappeared from areas of high human density, and the species most exposed to conflicts with people are those most prone to extinction^{35, 36}. Africa's large carnivores have declined over the last 30 years, with several species threatened according to the International Union for Conservation of Nature and Natural Resources (IUCN) red list of threatened species³⁷, including: the endangered African wild dog (*Lycaon pictus*), the vulnerable African lion (*Panthera leo*), the vulnerable cheetah (*Acinonyx jubatus*) and the near threatened brown hyaena (*Parahyaena brunnea*).

The most noticeable human-wildlife conflict impeding livestock management in South Africa is that of the predator-farmer conflict, where carnivores prey on livestock or valued wildlife resulting in financial losses and farmers respond by killing carnivores for both preventative and retaliatory reasons². There is however a lack of consensus on the relative merits, ethics and impacts of lethal versus non-lethal control methods for reducing the impacts of mesocarnivores on small livestock. The concept of human-wildlife conflict illustrated by the farmer-predator interactions in the Karoo represents a major

³⁵ Ogada, M.O., Woodroffe, R., Oguge, N.O. and Frank, L.G., 2003: Limiting depredation by African carnivores: The role of livestock husbandry, *Conservation Biology*, 17(6), 1521-1530.

³⁶ McManus, J.S., Dickman, A.J., Gaynor, D., Smuts, B.H., Macdonald, D.W., 2014: Dead or alive? Comparing costs and benefits of lethal and non-lethal human-wildlife conflict mitigation on livestock farms, *Oryx*, 49(4), 687-695.

³⁷ IUCN, 2016: The IUCN Red List of Threatened species, Accessed on the 6 May 2016: www.iucnredlist.org/search.

concern for the local farming community³⁸ and is being investigated in some details in this Section of the IEMP.

According to Bailey and Conradie³⁹, the losses of livestock to predation in South Africa are substantial making predator management one of the key economic threats to the viability of the sheep industry. Predators also indirectly contribute to farmer expenses with costs relating to predator control techniques e.g. fence installation and maintenance, contracted hunters, animal husbandry practices and animal care and disease prevention (particularly for sheep kept in enclosures or during shed lambing)⁴⁰. The predator control issue is a sensitive topic due to the current lack of regulated practices. Long term research programmes and monitoring activities are required in order to ensure a sustainable long term strategy to prevent predators from living in the SKA core area and feeding on surrounding farmland.

It would be beneficial for the National Research Foundation to participate to educating local land owners on the concept of the predator as a 'macro-parasite' and alternative methods to lethal control, e.g. implementation of guard animals, or shed lambing. The Endangered Wildlife Trust (EWT) is investigating the possibility of using Anatolian shepherd dogs on farmland to prevent lethal control on African wild dogs. If such an initiative proves to be successful it can be used as a case study for the National Research Foundation property. The following long term research and monitoring activities are recommended for the development of a long term efficient and effective predator and other wildlife management strategy land management plan:

- Scat counts: scat analysis can give insight into feeding preferences on predators however it will not identify if the predator is just moving through the SKA site or resides on the property.
- Track or foot-print detection: tracking can be used to indicate the presence of an animal in a particular area or can be used to provide an index of abundance, based on the number of tracks counted per unit distance. One of the main constraints of this technique is that it is most likely to monitor predator activity, which may vary seasonally, and may not be related to abundance. It is also time-consuming and labour intensive, affected by weather, and requires a high level of skill. Also to identify any change in activity will require a high investment in the number of plots assessed.
- Motion-sensing cameras: are an effective and efficient technique for assessing changes in both predator and prey population. Prior to the use of any such monitoring equipment the National Research Foundation will require appropriate RFI tests.

Given the current knowledge gaps on the biology and ecology of predators in the area, further targeted research will be critical to the success of the long term research and monitoring program. The following knowledge gaps have been identified (further gaps will be identified through the collaboration with local experts, academics and research institutions):

- the relative abundance of mesopredators (e.g. black-backed jackal, caracal, cape fox) and their natural prey within the region and across different land uses or landscape units;
- an estimation of the impact of each predator on livestock losses within the region;

³⁸ Natrass, N., Conradie, B. and Conradie, I., 2014: *The Koup fencing project: Community-led job creation in the Karoo*, Centre for Social Science Research.

³⁹ Bailey, A. and Conradie, B.I., 2013. The effect of predator culling on livestock losses: caracal control in Cooper Hunting Club, 1976-1981. Centre for Social Science Research.

⁴⁰ Hodkinson, C., Davies-Mostert, H.T., Komen, H. and Snow, T., 2007. Predators and farmers, *Endangered Wildlife Trust*.

- the factors that people perceive as threats to their current livelihoods in the region identified through community engagement;
- the relative effectiveness and cost-efficiency of different predator management techniques within the study area; and
- details on farming practices within the area to determine alternate reasons for livestock mortality e.g. starvation or multiple births.

Long term monitoring of wildlife on both National Research Foundation owned land and neighbouring farms is a priority land management objective and must be implemented by the SKA Organisation. The development of a long term efficient and effective strategy to manage predator population on National Research Foundation owned land must take into consideration:

- other wildlife land management activities required on the land;
- SKA RFI policy (limited electric equipment may be employed e.g. no electric fencing, limited monitoring cameras and minimal human presence on site);
- best practices in terms of public acceptance and ethical issues; and
- long-term collaboration with neighbouring land owners.

Long term research and monitoring programmes on National Research Foundation owned land require the establishment of appropriate research objectives, funding and supervision in collaboration with knowledgeable institutions. SKA should initiate this process in the near future given the importance of obtaining baseline data on the land owned by the National Research Foundation as early as possible.

Collaboration with South Africa's universities and other academic and technical tertiary institutions, with the relevant expertise and experience of working in this region, is important to ensure the independence of research on potentially sensitive issues such as livestock losses and the use of predator lethal management techniques. Furthermore it is essential to ensure that research is multi-disciplinary focusing on both the people and the wildlife within the context of the unique South African history and current socio-political standing. In this regard the following long term research and monitoring partners are recommended:

- the newly established Human Wildlife Research Institute at the University of Cape Town;
- the Centre for African Conservation Ecology at Nelson Mandela Metropolitan University;
- the African Large Predator Research Unit (ALPRU) at the University of the Free State; and
- the South African Environmental Observation Network (SAEON).

Possible local funding routes should be investigated with the National Research Foundation, the Red Meat Research and Development South Africa (RMRD SA), Cape Wools (official industry representative organisation of the South African Wool Industry) and the Endangered Wildlife Trust (EWT).

In order to establish a long term efficient and effective strategy to manage predator population, the principles of adaptive management, based on long term evaluation and monitoring, must be implemented. Adaptive management consists of altering management activities during the process of implementation based on the result of monitoring in order to alleviate, minimise or alter any undesirable impacts, results or consequences that may arise during the management process⁴². Adaptive management is a dynamic process working on a trial and error approach⁴². The adaptive management process may involve the management of other species or resources within the area that are having an impact on predator populations (e.g. rodent populations or water supply). Throughout the implementation of the predator management strategy regular, consistent and targeted monitoring (both performance and operational management) must be implemented including compliance with

the management objectives through daily operation of the implemented program. Operational monitoring estimates the proportional change in the management species population as a result of the implemented management activities. Performance monitoring assesses whether or not the objectives of the program have been achieved as a result of management activities implemented⁴¹. Populations may fluctuate due to external forcing which have not been considered or planned for in the research programme requiring revision of the research objectives and observation parameters. In addition to this, changes in predator behaviour within the area may take time, making time a crucial aspect of adaptive management⁴².

2. The concept of “predator control”

The issue of predator control on the National Research Foundation owned land was mentioned by several land owners and local stakeholders during the stakeholder engagement process as part of the Strategic Environmental Assessment (SEA) of the SKA Phase 1 in South Africa. Land owners conducting farming activities in the area have stated that predators (in particular black-backed jackal and caracal) attack the livestock for feeding purpose and that collectively these losses can have adverse economic impacts on their livelihoods and the sustainability of small livestock farming in the Karoo. The National Research Foundation is planning on initiating a long term biodiversity assessment project so that the presence and relative abundance of predators and their natural prey can be monitored within the SKA core area. These data will be used to make informed management decisions including whether the active management of any species is justifiable given that the SKA core area will be reverting to a more natural state once the SKA land acquisition process is completed. If it can be demonstrated that the rewilding of the SKA core area to a more natural state is having an adverse impact on the economic viability of livestock farms in the area only then should active management of specific damage causing wildlife on the SKA core area be considered. The efficacy of lethal management of predators at the landscape level for the specific purposes of reducing stock losses remains equivocal and hence it cannot be assumed at this stage that lethal control of predators on the SKA core area will provide a solution to livestock losses on neighbouring farms.

According to Natrass and Conradie⁴³ predators in South Africa have historically been shown to have evolved alongside indigenous pastoralists, adapting to include domestic livestock in their prey base. Black-backed jackals (*Canis mesomelas*) and caracals (*Caracal caracal*), are considered two of the major contributors to livestock losses in South Africa⁴⁴. It is further suggested that black-backed jackal and caracal, which are generalist mesopredators, are also increasingly responsible for losses in the wildlife industry and may impact ungulate populations in conservation areas as well (Du Plessis et al., 2015). These mesopredators have been subject to persecution for centuries but unlike many larger, specialist

⁴¹ Ecology Australia, 2013: Integrated predator control strategy for the southern brown bandicoot in the south-east sub-region. http://www.depi.vic.gov.au/_data/assets/pdf_file/0010/252577/Ecology-Australia-2013-Integrated-Predator-Control-Strategy_SBB_FINAL_Part-A.pdf

⁴² Luton, R., 2012: Understanding participation and integration as interlinked phenomena for Integrated Water Resources Management (IWRM) in complex systems, PhD research proposal, University of Witwatersrand, Johannesburg, South Africa.

⁴³ Natrass, N. and Conradie, B.I., 2013. *Jackal narratives and predator control in the Karoo, South Africa*. Centre for Social Science Research.

⁴⁴ Bergman, D.L., De Waal, H.O., Avenant, N.L., Bodenchuk, M., Marlow, M.C. and Nolte, D.L., 2013. The Need to Address Black-backed Jackal and Caracal Predation in South Africa.

apex predators; they are far more resilient to persecution and continue to proliferate in farming communities^{45,46}.

Over the last fifty years the international debate on optimal predator management has shifted from government supported eradication to a non-lethal control position⁴³. This has largely been driven by the acknowledgement that predators fulfil an important ecological role within rangelands in conjunction with the public perception that lethal management is unethical and causes serious welfare concerns to both target and non-target species. Consequently there has been a shift in policy, abolishing hunting clubs, gin traps and poison collars and ensuring permits are required for the removal of damage-causing species^{47,48}. Such changes make it more difficult, time consuming and more expensive for farmers to control predators, further fueling the predator-farmer conflict⁴³.

Ecological concerns surrounding predator control started arising in the early 1980's in South Africa, bringing about more environmental awareness within farming communities and cutting down on the unregulated blanket killing of predators⁴³. The shift in thinking was brought about by data showing that blanket culling may not be having the desired effect of reducing population numbers as previously thought as well as the ethical considerations surrounding mass killing of species through inhumane practices of lethal control^{43,47,49}. Small-to medium-sized predators are far more resilient to persecution and have persisted (or even flourished) despite heavy hunting pressures^{51,50}. Ecological studies have found that culling may actually cause an increase in the densities of the targeted species⁵¹. In a study by Conradie and Piesse (2014) it was found that culling of leopard (*Panthera pardus*) and caracal (*Caracal caracal*) on farms was associated with increased stock losses the following year by 27.2% and 5.7% for leopard and caracal respectively⁵². Similarly results from a study conducted by Bailey and Conradie (2013)³⁹ showed that caracal (*Caracal caracal*) culling increased subsequent livestock losses when compared to farms where fewer caracals were culled, increasing the likelihood of livestock losses in the following year by 17.5%. Furthermore ethical considerations about the unregulated nature of predator killing are based on the right to life of species and the ethical concerns of systematic persecution and eradication of a species. In nature mesopredators form an intrinsic and important part of the ecosystem and are essential for the functioning of the natural system and the maintenance of a balanced ecosystem structure, much like any other species in the

⁴⁵ Eagan, T.S., Beasley, J.C., Olson, Z.H., Rhodes Jr, O.E., 2011: Impacts of generalist mesopredators on the demography of small-mammal populations in fragmented landscapes, USDA National Wildlife Research Centre - Staff Publications, Paper 1357.

⁴⁶ Ritchie, E.G., Elmhagen, B., Glen, A.S., Letnic, M., Ludwig, G., McDonald, R.A., 2012: Ecosystem restoration with teeth: What role for predators? *Trends in Ecology and Evolution*, 27(5), 265- 271.

⁴⁷ Conradie, B., Piesse, J., Thirtle, C., Vink, N., Winter, K., 2013: Explaining declining total factor productivity in the Karoo districts of the Western Cape, 1952 to 2002, *Agricultural Economics Association of South Africa*, 52(1), 1-23.

⁴⁸ Conradie, B., 2012: Are hunting clubs the solution to small stock depredation? The case of Ceres, 1979 and 1980, *Agricultural Economics Association of South Africa*, 51(1), 96-113.

⁴⁹ Treves, A. and Naughton-Treves, L., 2005: Evaluating lethal control in the management of human-wildlife conflict, in R. Woodroffe, S. Thirgood, and A. Rabinowitz (eds.), *People and wildlife, conflict or coexistence?* Cambridge University Press, Cambridge, pp. 86–106.

⁵⁰ Knowlton, F.F., Gese, E.M., Jaeger, M.M., 1999: Coyote depredation control: An interface between biology and management, *Journal of Range Management*, 52, 446-449.

⁵¹ Minnie, L., Gaylard, A., and Kerley, G.I.H., 2015: Compensatory life-history responses of a mesopredator may undermine carnivore management efforts, *Journal of Applied Ecology*, 1-9.

⁵² Conradie, B. and Piesse, J., 2014: Productivity benchmarking of free-range sheep operations: Technical efficiency, correlates of productivity and dominant technology variants for Laingsburg, South Africa, Centre for Social Science Research, CSSR Working Paper No. 344.

ecosystem⁵³ (e.g. Black-backed jackals are important in controlling rodent populations and caracals are important in controlling Hyrax numbers on farms⁵⁴).

3. Black-backed jackals (*Canis mesomelas*) and caracals (*Caracal caracal*)

There is clearly a lack of scientific information on the ecology and management consequences for damage causing mesopredators in South Africa (black-backed jackal and caracal). A study conducted by Du Plessis et al. (2015) assessed the quantity and extent of research conducted on black-backed jackal and caracal throughout Southern Africa finding that a total of 77 studies have been conducted on these predators – 50 black-back jackal studies and 22 caracal studies. The majority of these studies were fairly old, with a median publication age of 16 years and 25 years for black-backed jackal and caracal studies respectively. More than half of the publications for both species occurred prior to 2000.

Black-backed jackals (Figure 5-34) are opportunistic, omnivorous, generalist predators, which according to Mckenzie (1993)⁵⁵ are traits that enable them to adapt to a wide range of food types and diverse habitats including those derived from human modified areas. It is generally found that jackals have a feeding preference for mammals (especially rodents and small ungulates) but they readily include reptiles, birds, human refuse, carrion, beached marine mammals, seals, fish, fruit (particularly berries) and insects in their diet⁵⁶. The black-backed jackals, being opportunistic feeders, feed on wild prey in the area but are also widely recognised for preying on farmers livestock particularly lambs and sheep⁴³. Black-backed jackal diet also changes with seasonal changes in prey abundance and with the presence of apex predators⁴⁴. Black-backed jackals are seasonal changes in habitat use, with use of closed habitat increasing through winter as prey in open areas becomes scarcer⁵⁵. Black-backed jackals are most active in the evening and early morning, however, activity patterns are markedly affected by persecution: in conservation areas there is a considerable amount of activity during daylight, while this becomes almost non-existent under persecution. In a stable social structure, black-backed jackals are strictly monogamous and each Jackal pair forms a life-long bond. Jackals become sexually mature at around 11 months of age and will typically leave their natal range in search of a mate and territory at around 1 year of age⁵¹. Those jackals that do not disperse from their natal range remain and assist their parents with raising the next litter⁵⁷. Generally one-third of sexually mature Jackals will remain as helpers⁵¹. The black-backed jackal mating season occurs during June and July and young are born between August and November after a two month gestation period^{57,55}. Jackals are territorial animals and jackal pairs will generally defend mutually exclusive territories. Generally jackal territorial ranges adjust depending on resource availability (Ferguson *et al.*, 1983). According to Bothma (2012) jackals will hunt and scavenge alone or in pairs for food but occasionally form packs to hunt larger antelopes that are old, weak, sick or injured. Within an adult pair's home range there is a core area which is intensively used. Only a small part of the total home range is used when prey is abundant, with wider-

⁵³ Roemer, G.W., Gompper, M.E., Van Valkenburgh, B., 2009: The ecological role of the mammalian mesocarnivore, *BioScience*, 59(2), 165-173.

⁵⁴ Bothma, J. 2012. Literature Review of the Ecology and Control of the Black-backed Jackal and Caracal in South Africa. Available on: <http://www.capenature.co.za/docs/2182/Literature%20Review%20of%20the%20Ecology%20and%20Control%20of%20blackbacked%20jackal%20and%20caracal%20%28Bothma%202012%29.pdf>

⁵⁵ Mckenzie, A.A., 1993: Biology of the black-backed jackal *Canis mesomelas* with reference to rabies, *Onderstepoort Journal of Veterinary Research*, 60:367-371.

⁵⁶ Skinner, J.D. and Chimimba, C.T., 2005: *The mammals of the Southern African subregion* (3rd ed), Cambridge University Press, Cambridge.

⁵⁷ Ferguson, J.W.H., Nel, J.A.J., De Wet, M.J., 1983: Social organization and movement patterns of Black-backed jackals *Canis mesomelas* in South Africa, *Journal of Zoology*, 199, 487-502.

ranging movements occurring when prey is scarce. Jackal home ranges tend to overlap particularly with immature or subordinate jackals on the fringes of a dominant pairs territory, as such the home ranges cannot be equated with true territories^{57,51}. Once persecuted, the jackal social structure is altered. Black-backed jackals, like coyotes, are highly adaptable animals and can show signs of compensator reproduction when the population is under stress^{50,51}. Minnie *et al.* (2015) compared life-history responses of black-backed jackals on farms and conservation areas to identify the impact predator control on farms have on jackal populations within the Western and Eastern Cape of South Africa. Results from the study showed that Jackals on farms compensate for increased mortality by increasing the pregnancy rate of young individuals and increasing the litter size at younger ages, thereby increasing reproductive output.



Figure 5-34: Black-backed jackals (photo source: Wikimedia Commons, free media repository)

The Caracal (Figure 5-35) is a medium-sized member of the Felidae family standing 400-450 millimetres at the shoulder – although this varies greatly for different regions with males generally heavier than females from the same region⁵⁶. Caracal colouring also varies regionally but in general is uniformly reddish tending to be paler in arid regions. Caracals have a wide habitat tolerance ranging throughout Africa except in closed forested regions and central Sahara. Outside of Africa they range across northern India, the Arabian Peninsula, Israel, Syria, Iraq, Iran and Turkestan occupying a wide variety of habitats⁵⁹. The caracal is ecologically similar to species of the Lynx genus and is characteristically agile and slender and capable of jumping more than 2m into the air^{58,59}. Caracals are generalist feeders feeding on a wide range of prey. An adult caracal requires around 1 kilogram of food per day. Generally their diet composes of rodents, hyraxes, hares, vervet monkeys, dassies, birds, reptiles and small antelope⁵⁴. Caracals weigh between 8–20 kilograms, but regularly kill prey more than twice their own mass⁵⁹. Caracals are solitary hunters, feeding mainly on fresh prey although they have been found to store fresh food in trees or under grass to return to later. Similarly to black-backed jackal, caracal can act as both hunters and scavengers depending on the presence of apex predators⁵⁴. The home range of an adult Caracal varies depending on habitat quality and the density of prey species⁵⁸ and a male home range may include the home range of several adult females. According to Bothma (2012)⁵⁴ the range of an adult male Caracal in the semi-arid Karoo can be 440 square kilometres or more. Caracals are mainly solitary, except when mating, although a female and her kittens will move around together⁵⁹. Caracals reproduce throughout the year from an age of 12 to 15 months in a male and 14 to 16 months in a female. However, caracal births tend to peak between October and February in South Africa and litters of up to six kittens are born⁵⁹. Young caracals

⁵⁸ Skinner, J.D., 1979: Feeding behaviour in Caracal *Felis caracal*, *Journal of Zoology*, 189, 523-525.

⁵⁹ Sunquist, M.E. and Sunquist, F.C., 2002: *Wild cats of the world*, University of Chicago Press, Chicago.

disperse after around 9 months of age and dispersal can take place over a distance of 65 kilometres or more from the natal site⁵⁹. Similar to black-backed jackal and other mesopredators caracals display compensatory mechanisms when under persecution^{52,39}.



Figure 5-35: Caracals (photo source: Gregory Sweeney, Africa Wild Safaris)

4. Predator control techniques

Predator control techniques used for the protection of livestock or the enhancement of game populations includes lethal control techniques and non-lethal control techniques. Lethal control techniques can be separated into non-selective and selective approaches:

- Non-selective techniques (e.g. leg-hold trap devices, snares, poisoning) are indiscriminate to the animals captured or killed and as such are ethically questionable;
- Selective techniques include livestock protection collars, call-and-shoot operations, denning and other hunting operations (on foot, in vehicles and via helicopter).

Non-lethal control techniques focus on prevention and protection (i.e. protecting and isolating livestock from predators) rather than the elimination of predators within an area, and include sheep guarding practices, fencing and shed lambing as well as behavioural modifications and animal sterilization.

An example of lethal selective predator control technique is the use of poison collars⁶⁰. The poison collar is placed around the neck of livestock and contains a toxicant stored in pouch which is released into the predator's mouth when punctured by a predator bite⁵⁰. There are legal implications associated with the use of poison collars as it may result in environmental contamination and health issues to humans^{54,61} therefore specific training and licensing is required to deploy these collars⁶⁰. An example of non-lethal alternative to poison collars are "King Collar"⁶² which is a type of 'animal armor' developed in South Africa to prevent canids from being able to grasp and kill sheep with a neck bite. Such collars are cheaper alternatives to poison collars and are more socially acceptable; however, more research needs to be focused on these collars to determine if jackal can learn to avoid them when preying livestock⁶² by attacking animals from the rear end.

⁶⁰ Mitchell, B.R., Jaeger, M.M. and Barrett, R.H., 2004: Coyote depredation management: Current methods and research needs, *Wildlife Society Bulletin (1973-2006)*, 32(4), 1209-1218.

⁶¹ Todd, S., Milton, S., Dean, R., Carrick, P.J. and Meyer, A., 2009. Ecological best-practice livestock production guidelines for the Namakwa District. *Draft (www.azef.org.za)*.

⁶² Shivak, J.A., 2004: Non-lethal alternatives for predation management, *Sheep & Goat Research Journal*, 19, 64-71.

An example of lethal non-selective predator control technique is the use of Gin trap (a type of leg-hold trap device) which is limited under the National Biodiversity Act (Act 10 of 2004) as it is a non-selective device and may trap non-targeted animals (e.g. endangered or threatened species) and causes painful injuries and death as a result of starvation or dehydration^{54,61}. Recent alterations have been made to traditional leg hold traps to attempt to make them more ethically acceptable, resulting in the development of soft hold traps. Soft hold traps cause less tissue damage when closed around the animals' limb and non-target species can be released when found in the trap. Certain soft hold traps devices can also be set for animals of a specific weight. However in the case leg-hold traps are not regularly inspected and serviced, even soft hold traps can result in significant damages to both target and non-target wildlife and domestic species⁵⁴. An example of non-lethal alternative to leg-hold trap devices is the use of jackal proof fences, which are nearly 100% effective at preventing jackals from accessing livestock if built correctly to the right specifications for anti-predator control (electric wires) and continuously maintained. Fencing is however not as effective at protecting sheep from caracals which given their felid characteristics are not easily contained by farm fences and are capable of jumping up to 2 metres in height⁵⁹. Fencing can also be problematic because it does not only limit movement of predators but also other species, particularly naturally occurring antelope, whose migration paths are cut off or whose natural range is fragmented by fencing. Large antelope also have the potential to damage fences when trying to migrate⁶³. The dispersed nature and lower grazing potential associated with the arid Karoo landscape coupled with the high cost of installing and maintaining the jackal proof fences furthermore makes fencing a less desirable technique in predation prevention⁵⁰.

Further non-lethal predator control techniques used for the protection of livestock are being researched and monitored such as sterilization of predators, behavioural modification, shed lambing and the use of guard dogs, herders and shepherds or other guarding wild animals such as llamas and donkeys. There are cases where poorly trained or unsupervised guard dogs have killed sheep and lambs, harassed or killed wild animals, and threatened people that have to work with the livestock, therefore the training and close supervision of the guard dogs is critical for the success of this method. Since the early 1980s, some sheep producers have used llamas to protect their flocks. Llamas exhibit behaviours similar to their wild predecessor, the guanaco (*Lama guanicoe*), and have been found to defend territories and family groups⁶⁴. Llamas have an inherent dislike for canines and when pastured away from other llamas, readily bond with sheep⁶⁴. According to Hulet et al. (1987)⁶⁵ guard llamas provide some advantages over guard dogs, including 1) greater longevity, 2) fewer training requirements, 3) faster acquisition of guardian status, and 4) fewer special management considerations involving food and maintenance, and 5) compatibility with other depredation control techniques.

5. Short term programme and data collection (0 to 5 years)

A baseline data on site predator population, vegetation cover and other species presence must be established prior to the implementation of predator control activities on the acquired land, in support of the development of a long term efficient and effective strategy to manage predator population and

⁶³ Linhart, S.B., Roberts, J.D., Dasch, G.J., 1982: Electric fencing reduces coyote predation on pastured sheep, *Journal of Range Management*, 35(3), 276-281.

⁶⁴ Meadows, L.E. and Knowlton, F.F., 2000: Efficacy of guard llamas to reduce canine predation on domestic sheep, *Wildlife Society Bulletin (1973-2006)*, 28(3), 614-622.

⁶⁵ Hulet, C.V., Shupe, W.L., Howard, V.W. and Jr., 1987: Coyotes, guard dogs, and electric fences, *Rangelands*, 9(3), 102-105.

livestock losses in the study area. Data on the presence and relative abundance of flora and fauna within the SKA core area as well as on neighbouring farmland is necessary to provide a robust baseline data set which can be used to 1) make informed decisions on whether to initiate management and 2) to assess the impact of SKA and neighbouring farms' land management activities on both the target and non-target species and the ecosystem more broadly. Ideally the baseline data should be collected prior to the removal of the sheep on the land in order to be able to compare the presence and relative abundance of flora and fauna within the SKA core area before and after the removal of the sheep. Baseline data should include:

- what predator management took place on the SKA land prior to the acquisition of the land;
- the current management practices on neighbouring farms;
- the current livestock losses neighbouring farmers are experiencing;
- the survival rates of livestock throughout the lifecycle of sheep including conception, lambing, weaning, birthing etc.; and
- the identification of predator dens on the SKA acquisition site.

Conservation authorities and academics (Professor O'Riain and Professor Nattrass from the University of Cape Town, Prof. Gareth Bath from Onderstepoort, and Michael Knight from SanParks) have recommended that the National Research Foundation owned land should be fenced and routinely patrolled and maintained to minimise the movement of wildlife from the SKA core to neighbouring farms. Well established and maintained fencing can be effective at keeping both predators and other damage causing animals within the SKA site. The National Research Foundation has indicated that it will employ farm workers that were previously employed within the acquisition area to take part in the land management strategy including monitoring and maintenance of the fence in the SKA core.

A research programme has been prepared by the newly established Human Wildlife Institute managed by Professor Justin O'Riain at the University of Cape Town. The institute proposed to conduct observations in the field using camera traps and scat sampling in the SKA core and surrounding farms.

Where lethal management of mesopredators has been initiated a baseline should still be established at this point in time to confirm the presence and relative abundance of predators. Data on current populations of predators and other wildlife (e.g., kudu, porcupine) is necessary to inform efficient long term control and management activities. Furthermore, the Endangered Wildlife Trust Carnivore Conservation Programme Manager Kelly Marnewick has indicated that more research is required to confirm the correlation between the removal of sheep and other agricultural activities from an area and the increase in predator distribution and abundance and livestock losses adjacent to this area.

Based on consultation with conservation agencies, existing ecological hypothesis link the removal of an abundant (and easy to catch) prey resource (i.e. sheep) and the removal of artificial watering points with an initial decrease in predator numbers and migration to neighbouring farmland. However on the long term, due to the natural recovery of the vegetation cover and increase in population and abundance of wildlife prey, predator numbers may eventually recover. This hypothesis will be confirmed or refuted during the long term research and monitoring programme to be conducted on the land acquired by the National Research Foundation.

It should be noted that any lethal predator control activities must be approved and permits must be issued by the provincial and national authorities responsible for the management of damage causing animals.

6. Long term programme of the Human Wildlife Research Institute

The establishment of the protected area in the SKA telescope core offers a unique opportunity to investigate how wildlife responds to a landscape level change in land use from small livestock farming to a nature reserve. Provided sampling commences in 2017 there is an opportunity to use a statistically powerful "Before, after and Control sites" design to monitor changes associated with the change in land use. This research will fall under the coordinating umbrella of SAEON who will also provide data on important predictor variables such as changes in plant productivity and ground cover, rainfall and temperature, all of which are predicted to have an additional effect on mammal diversity and abundance in both the short and long-term.

The Human Wildlife Research Institute proposes to record how livestock losses to wildlife vary in response to the intervention. The comparison will be between farms that border the SKA and control farms that are further away. Farmers predict that livestock losses will increase on the periphery of the protected area (edge effect) because there will be both less drinking water (artificial water points are closed) and a reduced prey biomass (livestock are removed) on land converted in the SKA telescope core. Together these changes are expected to lure wildlife that are water dependent and in particular predators, onto neighbouring farms that continue to stock the land with domestic prey species that are both catchable and palatable (i.e. sheep and goats) and provide abundant water points. The assumed net movement of predators away from the SKA telescope core and onto neighbouring farms is predicted to result in higher livestock losses and further threaten this already marginal agricultural sector.

The Human Wildlife Research Institute's goals include the annual monitoring of mammal species richness and relative abundance, predator diet and livestock losses. These variables will be recorded on:

- Treatment farms: five small livestock farms before and after they are converted to a special nature reserve,
- Edge effect farms: five small livestock farms neighbouring the SKA telescope core, before and after the formation of the SKA special nature reserve,
- Control farms: five small livestock farms that do not neighbour the SKA telescope core but are in the same district and hence experience similar climatic, social and economic impacts but are not predicted to be overtly impacted by SKA1_MID.

Together these data will be used to support or refute the short term predictions that on treatment farms there will be:

1. a reduction in the relative abundance and species richness of medium and large mammals including obligate drinking species (e.g. baboons) and predators as a result of the closure of artificial water points and the removal of catchable and palatable livestock,
2. an increase in the relative abundance and species richness of small mammal species as they will be subject to less grazing competition, disturbance by trampling and reduced predator presence and human disturbance.

While on edge effect farms there will be:

1. an increase in the relative abundance and species richness of medium and large mammal species as they move away from the special reserve and towards farms that have abundant water points and a higher biomass of palatable and catchable prey,

2. a decrease in the relative abundance and species richness of small mammal species that are subject to the normal disturbance associated with livestock and farming but which may also experience higher numbers of wildlife grazers and predators as they move away from the SKA telescope core.

Changes on control farms will reflect variation in climatic factors (e.g. rainfall) at a regional level and management factors at the level of each farm (e.g. a block hunt) with only minimal impact predicted to result from the change in land use associated with SKA1_MID.

Long-term predictions on treatment farms include:

1. an increase in the species richness and relative abundance of medium and large mammals on treatment farms as a result of the recovery of the natural vegetation reduced grazing competition with livestock and an increase in micromammals that are preferred prey for most mesopredators. In addition there is the possibility of re-introductions of select species to the SKA telescope core as part of re-wilding the special nature reserve.
2. a stabilisation of small mammal abundance with annual fluctuations in relative abundance associated with regional climatic variables. The possible increase in species richness associated with a recovery of the natural vegetation.

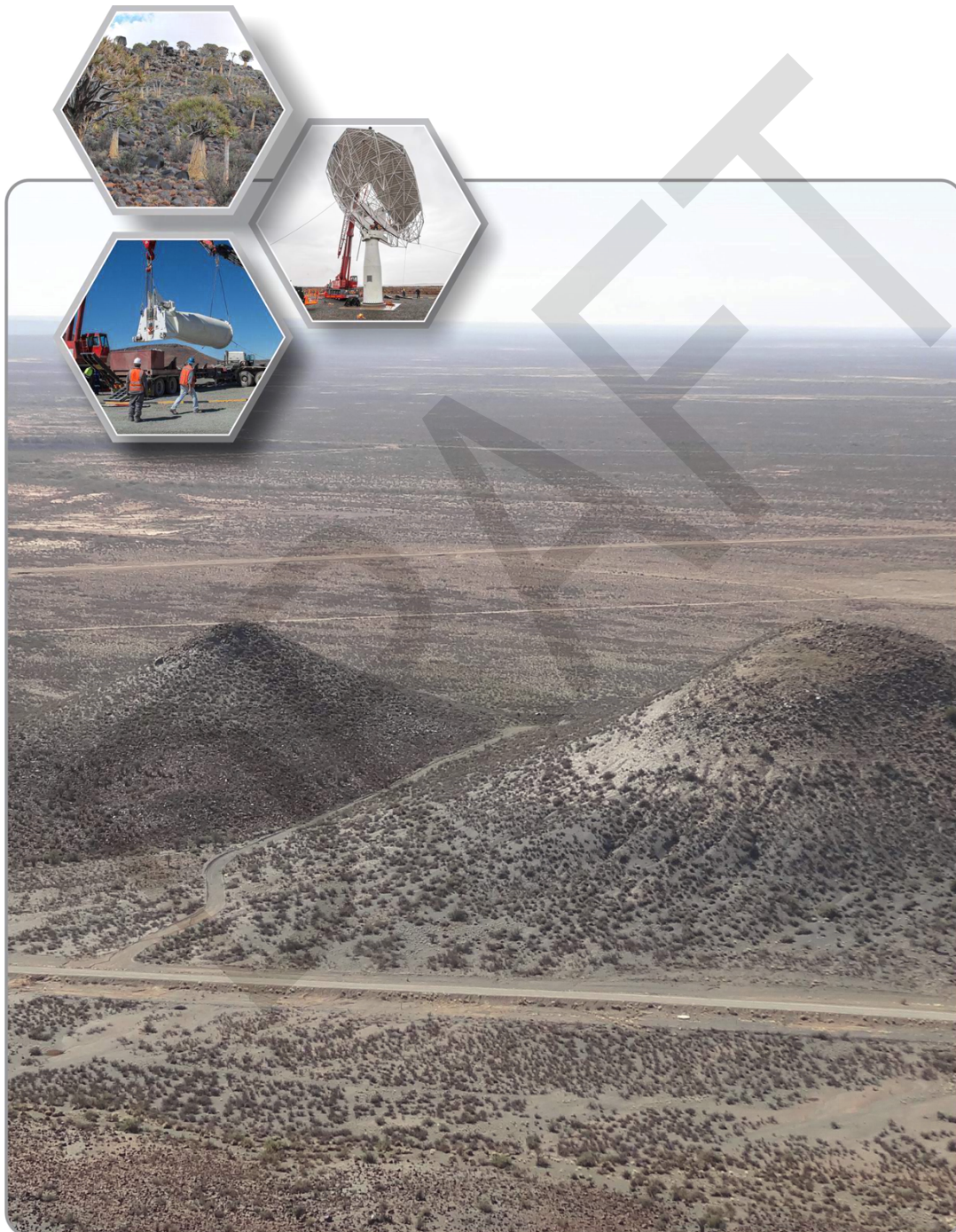
Edge effect farms are predicted to experience a gradual increase in small, medium and large mammal species as they disperse out of the special nature reserve and into surrounding farmlands. The construction of a fence between treatment and edge effect farms remains a critical but as yet undefined variable in the predictions for mammal populations on neighbouring farms. The higher the specifications and maintenance of the final fence the less dispersal there will be from the SKA telescope core onto neighbouring farms. Control farm predictions are as for short term predictions.

Species richness and relative abundance of small, medium and large mammals on different farms (intervention, edge effect and control) will be measured using both Sherman traps (small mammals) and camera traps (medium and large mammals). Sample sites within each of the farm types will be stratified (according to major habitat types: plain, riverbed and hill/mountain) and then assigned randomly with a minimum of 25 camera traps/habitat arranged in clusters of five cameras. This will result in a maximum of 75 camera trap stations per farm which with three replicates of each farm type results in a total of 675 camera stations. This will require rolling camera traps over throughout the year across different sites and hence it will not be able to control for season, but the extremes of summer and winter will be avoided.

Sherman traps will be used to sample the relative abundance and species richness of micro-mammals in each habitat type following a similar approach of stratified random sampling used for camera trapping. Each habitat type will be sampled using 240 traps in each of 5 replicates for a total of 1200 trap sites/habitat per farm type. Across all farm types (treatment, edge and control) this will amount to a maximum of 32000 trap sites.

Scats of both jackal and caracal will be collected opportunistically when sampling for small, medium and large mammals using the methods detailed above. This approach ensures a random search in each habitat type on each farm and has proven useful in identifying both the rate of occurrence of different prey (including livestock) in the diet of predators in addition to biomass estimates that are predictably biased towards small mammals. It will not be possible to use GPS clusters given the limitations on the use of radio technology in the SKA telescope core. A comprehensive hair library developed between Rhodes University and UCT will be used to identify prey remains with other hard tissues (e.g. hooves, horns and bones) being used to assist in species identification.

Lastly the Human Wildlife Research Institute will deploy camera traps along fence lines between the SKA and edge farms and on control farms. Cameras will also be placed at holes in fences and the rate and direction of movement of wildlife will be recorded. The goal of this approach will be to test the popularly held perception that wildlife and in particular predators will den in the SKA telescope core but will move across the fences at night time to feed on sheep in neighbouring farms.





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