CNNC
Rössing Uranium
Working for Namibia

Annual Environmental Management Report 2019

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ACRONYMS AND ABBREVIATIONS

µm	micrometre, 10^{-6} m
dB	decibel
cm	centimetre
CO	carbon monoxide
CO_2-e	carbon dioxide equivalent
CSIR	Council for Scientific and Industrial Research
DWA	Department of Water Affairs
EMS	Environmental Management System
FPR	Final Product Recovery plant
GHG	greenhouse gas
GIS	Geographic Information Systems
GJ	gigajoule
GJ/kt	gigajoules per kilotonne
HSE	health, safety and environment
HSE MS	Health, safety and environment management system
IUCN	International Union for Conservation of Nature
km	kilometre
L	litre
m	metre
M	mega, one million
m^3	cubic metre
mamsl	metres above mean sea level
MAWLR	Ministry of Agriculture, Water and Land Reform
mg	milligram
mg/kg	milligram per kilogram
mg/L	milligrams per litre
mg/m^3	milligram per cubic metre
mg/m^2	milligram per square metre
ML 28	Rössing Uranium Limited's Mining Licence 28
m/s	metre per second
m^3/s	cubic metres per second
MSDS	material safety data sheets
m^3/t	cubic metre per tonne
NO_x	nitrogen oxide
PM_{10}	particulate matter smaller than 10 microns in diameter
ppm	parts per million
SANS	South African National Standards
SO_2	sulphur oxide
SOP	standard operation procedure
TPH	total petroleum hydrocarbon
TPM	total particulate monitors
TSF	Tailings Storage Facility
UN	United Nations
UNSCR	United Nations Security Council Resolution
U_3O_8	uranium oxide
yellowcake	ammonium diuranate

Photograph on front cover: An Adenia pechuelii (elephant's foot) that was rescued from the mine's operations area and replanted at the off-site safety training centre.

1. INTRODUCTION

1.1 Location

Rössing Uranium Limited mines a large-scale, low-grade uranium ore body in the Namib Desert, in the sparsely populated Erongo Region of Namibia (Figure 1).

The mine is located 12 km from the town of Arandis, which lies 70 km inland from the coastal town of Swakopmund. Walvis Bay, Namibia's only deep-water harbour, is located 30 km south of Swakopmund.

The mine site encompasses a mining licence and accessory works areas of about 180 km2, of which 25 km2 is used for mining, waste disposal and processing. Rössing mine is situated about 25 km upstream of the Khan/Swakop rivers confluence.

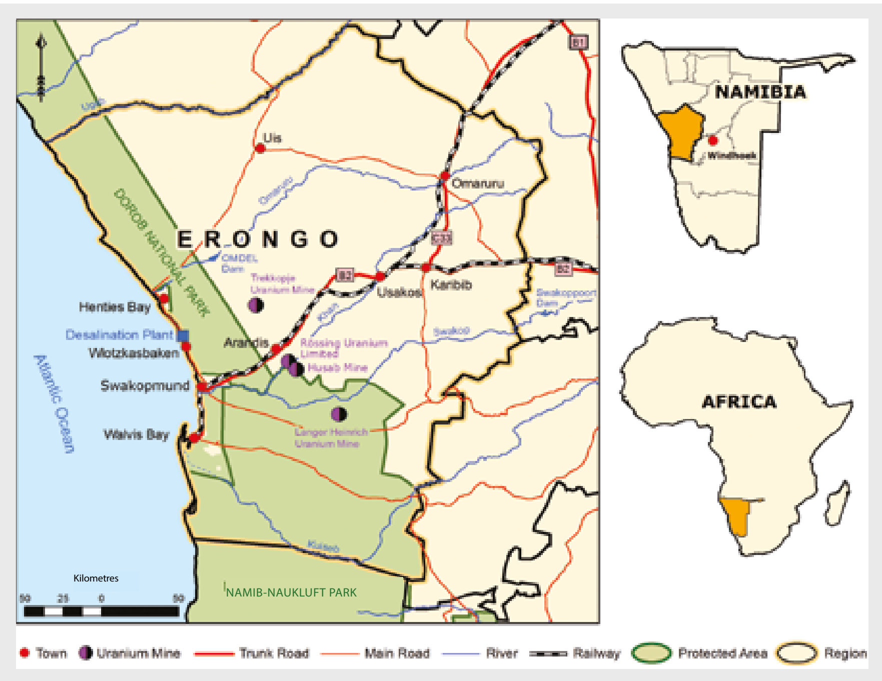


Figure 1: Location of Rössing mine.

1.2 Shareholding

On 16 July 2019, China National Uranium Corporation Limited (CNUC) became the new majority shareholder in Rössing Uranium Limited, following the sale of Rio Tinto's 68.62 per cent shareholding to CNUC.

The Namibian Government has a 3 per cent shareholding, with a majority (51 per cent) when it comes to voting on issues of national interest.

The Industrial Development Corporation of South Africa owns 10 per cent, while individual shareholders own a combined 3 per cent shareholding. The Iranian Foreign Investment Company owns 15 per cent, a stake that was acquired during the set-up of the company in the early 1970s.

1.3 Scale of operation

Rössing is the world's longest-running, open-pit uranium mine. It is a 24-hour, 365-days-a-year operation. Rössing is among the two Namibian uranium mines in operation which provides a considerable amount world uranium oxide mining output.

By the end of 2019, the production was 2,449 tonnes of uranium oxide; hence a total of 137,537 tonnes of uranium oxide supplied to the world equivalent to 3.9 per cent of world uranium in 2019.

1.4 Current life-of-mine

The life-of-mine plan currently is ending in 2026 however, there is potential for an extension of the current life-of-mine after the sale of the Rio Tinto shares to CNUC.

2. BRIEF DESCRIPTION OF THE ENVIRONMENT

2.1 Geology

The Rössing uranium deposit lies within the central part of the late-Precambrian Damara orogenic belt that occupies an area of approximately 50 km wide and extends northeast for over 100 km in west-central Namibia. The Damara lithology consists mainly of folded, steeply dipping meta-sediments (gneiss, schist, quartzite and marble) arranged in a northeast-southwest striking belt.

The geology of the mining area at Rössing is associated with a dome structure and occurs in pegmatitic granite known as alaskite, which intruded into meta-sediments. The Rössing ore body is unique in that it is the largest known deposit of uranium occurring in granite. The nature and grade of uranium ore is extremely variable and can be present as large masses or narrow inter-bands within the barren meta-sediments.

All of the primary uranium mineralisation and the majority of the secondary uranium mineralisation occur within the alaskite. However, the alaskite is not uniformly uraniferous and much of it is un-mineralised or of sub-economic grade.

Uraninite is the dominant ore mineral (55 per cent); secondary uranium minerals constitute 40 per cent, while the refractory mineral betafite makes up the remaining 5 per cent. Ore grades at the mine are very low, averaging 0.035 per cent. The uranium ore consists of 70-90 per cent alaskite and is subdivided into four ore types according to the composition of the host rock.

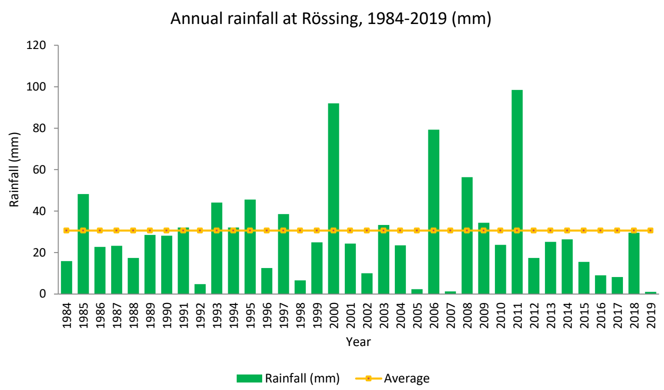


Figure 2. Variation in annual rainfall at Rössing, 1984-2019

2.2 Climate

Rössing is situated in an arid area and receive very low annual precipitation. In 2019, the total annual rainfall received on the mine was 1 mm. The annual rainfall, and the long-term rainfall average, is displayed in Figure 2.

Rössing rainfall measurements indicate an average annual rainfall of about 30 mm over the years. The average has decreased since 2014 to 2017, before a sharp increase in 2018 and drastic drop in 2019.

In terms of temperature, the variation between daily minimum

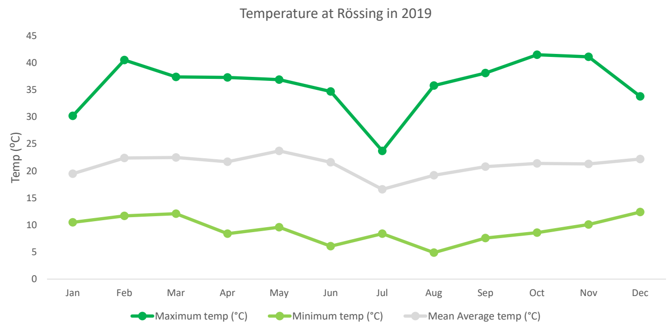


Figure 3. Temperatures measured at Rössing mine, 2019

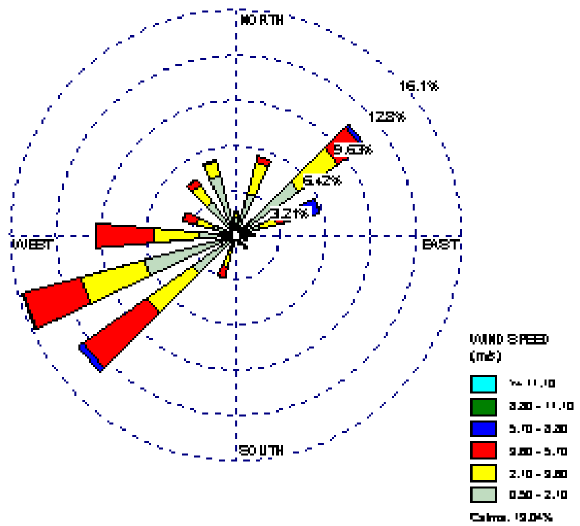


Figure 4. Wind speed and direction measured at Rössing, 2019

and maximum temperatures are wide. The lowest temperatures are recorded during September and the highest temperatures are recorded in November, as shown in Figure 3. The coldest months usually begins in April and continues to July before temperatures start picking up again during summer.

In 2019, at Rössing the predominant winds experienced were blowing from west-southwest (see Figure 4). Wind from the northeast is also experienced occasionally.

The combination of the low rainfall, high temperatures, the wide temperature ranges and prevalent winds result in high evaporation rates that vary between 6 and 15 mm per day. The potential evaporation is thus around 3,000 mm per annum.

2.3 Topography and soils

At a mean altitude of 575 m above sea level, most of the Rössing tenement in the west, north and northeast consists of broad peneplains. The flat terrain is traversed by shallow drainage lines and stormwater gullies that drains into the Khan River. Close to the Khan River, the undulating plains change to an increasingly rugged terrain, which further increases towards the Swakop River.

Soils in the vicinity of Rössing could be described as shallow (<25 cm), with a large proportion of coarse fragments and occasional concretions, characterised by high soil pH-values. Hard surface and near-surface crusts are common. The crusts reduce rainfall infiltration rates and enhance run-off.

Sand deposits of varying depth are found in sheltered areas and are a mixture of dark- to light-brown grit, quartz and feldspar fragments. Coarse material is present on the slopes of some hills. Thickness varies, but may reach a depth of up to about 1.5 m.

The deepest soil is confined to the drainage lines, comprising of mainly infertile – almost sterile – alluvium, that vary in thickness. Moreover, topsoil is shallow, poorly developed, infertile and even absent over the largest part of the hill slopes and gravel plains of the mine tenement.

2.4 Biogeography

On the gravel plains at Rössing, vegetation is dominated by sparsely-scattered dwarf shrubs and ephemeral grasslands. This is also the case for the undulating hills and mountains with sparse grass cover. A total of 21 biotopes are discernible to identify landform boundaries in association with ecosystem functions and characteristic plant species. To date, a total of 241 plants species have been identified in the mine vicinity.

Sparse riparian vegetation marks the drainage lines, in particular the Khan River. In general, vegetation relates strongly to the frequency, intensity and duration of flooding events. A few species dominate: Anaboom (Faidherbia albida, previously Acacia albida), Camel thorn tree (Vachellia erioloba, still more commonly known as Acacia erioloba), Tamarisk (genus Tamarix) and thickets of the Mustard tree (Salvadora persic). The relative more dense riparian vegetation provides food and shelter to many animal species and sustains important migration and dispersal routes as a result.

A total of 272 species of ground-living insects are recorded at Rössing; this excludes flying groups such as moths and lacewings. The rocky hillsides, in particular those located along the Khan River, are regarded as the most important habitats of invertebrates.

The Namib Desert is known for its reptile diversity, particularly of lizards and geckos. At Rössing, 33 reptile species are expected to occur. Two species, Merolis sp. Nov and Pedioplanis husabensis, are of special concern. Three species of frogs are known to occur at Rössing. From a local perspective, the Khan River has the highest bird species diversity, indicating the importance of water availability and consequent-supported plant life, as well as the diversity of cliff habitats.

Mammal diversity at Rössing is not very high, as is typical in the central Namib. Climatic variation is closely coupled with marked changes in the abundance of animal species. Many of the animal species that occur around use a wide range of habitats, or may cross a wide range in the course of migrating from one habitat to another. Common animal species include klipspringer, oryx, springbok, ostrich, kudu, Hartmann's zebra, dassie (rock hyrax), black-backed jackal, baboon and rodents (particularly gerbils).

2.5 Surface and groundwater

Open-surface water in the Namib Desert is a rarity and may occur only ephemerally during the rainy season. Flowing surface water on the mining licence area only occurs after heavy rainfall. Run-off in the drainage lines is an episodic, brief event and peaks and periods of run-off vary widely

Due to their alluvium beds, the tributaries of the Khan River contain subsurface water flow for most of the year. Permeability of the alluvium is high and the alluvium has also a high storage capacity with the water table being within 2 to 3 m of the surface.

Seasonal springs and small pools may occasionally form in the Khan River and in the gorges that drain into the Khan River. Only one natural perennial spring occurs in the Rössing area and is located in a side-arm of Panner Gorge.

Groundwater flows and rainfall seepage at Rössing is mainly along fractures and focus towards the gorges that drain into the Khan River.

Super-imposed on the natural groundwater system are sources and sinks created by mining. The open pit, more than 300 m deep, cross-cuts the hydrogeological connection between the existing Processing Plant and the Khan River receiving environment. It acts as a cut-off trench, and enables the interception and subsequent evaporation of potentially contaminated water moving downstream from the plant area.

The open pit also creates a cone of groundwater table depression that cuts off groundwater flow through bedrock and alluvial channels. Around the open pit, hydrogeological parameters of storage and permeability are very low.

The current elevation of the bottom of the open pit is substantially lower than the level of the Khan River (3 km to the south), and the regional water table (about 20 m below ground). The Khan River is also separated from the open pit by a low-permeability rock mass and the possibility of water from the Khan River entering the pit void is significantly reduced this way.

The natural groundwater quality in the vicinity of Rössing is very saline with total dissolved solids concentrations of 20 000-40 000 milligrams per litre (mg/L). The only groundwater potentially suitable for agricultural use near Rössing is found in the Khan River. This water is brackish and only suitable for livestock watering.

As a result of the high salinity of the water in the Khan River, the only beneficial uses of the water are for industrial purpose, such as dust suppression. Despite its salinity, the very hardy natural vegetation along the river depends on this water and abstraction is closely linked to monitoring of the water table.

2.6 Air quality

Atmospheric conditions at Rössing are prone to airborne dust and other impurities, a situation which is enhanced by air movements. Average daily wind speed measured at Rössing in 2019 was 2.2 metre per second (m/s) with the highest maximum wind speed over a one-hour period recorded at 8.9 m/s in September.

The recorded maximum speed is much lower in 2019 compared to 2018 which was 18.8 metres per second. These velocities usually occur during the winter and gusts of up to 34.90 m/s have been known to occur before.

Potential for the transport of dust and other impurities via atmospheric pathways towards inhabited areas is dependent on the direction of receptor points relative to wind direction. Table 1 summarises localities relevant to wind direction at Rössing.

Generally-deposited dust is not considered a health hazard, but because it is visible, it could be the cause of public complaints. In suspension, dust particles with a diameter of less than 10 micrometre (μm) can be inhaled by humans. This kind of hazard is determined by concentrations of dust and the period of exposure.

It is not only human health that can be adversely affected by dust: the fall-out of heavy metals onto soil and the foliage of plants can also result in adverse environmental impacts. Combined with the concern about nuisance dust that may end up on the land neighbouring Rössing's mining licence area ML 28, potential environmental dust deposition is monitored at several stations around the mine site.

While most of the dust generated in the open pit at Rössing is of a fugitive nature, blasting activities can be considered as a point source of particulates, from where dust is dispersed into the surroundings of the mine. Large blasts occur approximately every two weeks with smaller blasts twice or thrice a week.

The size of the blasting dust plume is unlikely to increase in size because as the pit deepens, the effects of blast dust become less. The dust plumes from the smaller blasts tend to disperse along the length of the pit and the dust settles on the benches and roads within the pit, from where it is remobilised by wind action and vehicles.

Of the eight common air impurities identified, five (SO2, CO, NOx, PM10 and dust deposition) are released at Rössing. However, only two are recognised as significant, i.e. particulate matter smaller than 10 microns in diameter (PM10) and dust deposition, which are regularly monitored. Rössing conducts annual monitoring of SO2, CO and NOx that could be emitted as a result of the yellow cake roasting at the Final Product Recovery (FPR) plant.

In addition, greenhouse gas (GHG) emissions are estimated as carbon dioxide equivalent (CO2-e) on a monthly basis, deduced from fuel consumption, electricity usage and explosives used for blasting.

Noise and vibration arise from exploration and operation activities, including mining, mineral processing, materials handling, infra-structure and on-site transport. Noise, ground vibrations and air blasts can have adverse impacts on the general living conditions of species and/or lifestyle of neighbours and are monitored to mitigate these impacts, in addition to spot-checks, specific surveys and investigations and regular risk assessments.

Table 1: Geographical position of localities relative to wind direction

Locality	Distance from mine	Direction	Relative to wind direction
Arandis Town	5 km	Northwest	Does not lie in the direction of E, NE, or SW winds
Arandis Airport	6 km	West	Lies in the direction of E wind
Swakopmund small holdings	50 km	Southwest	Lies in the direction of NE wind at a distance
Swakopmund Town	60 km	Southwest	Lies in the direction of NE wind at a distance
Walvis Bay	75 km	South-southwest	Lies in the direction of NE wind at a distance
Henties Bay	88 km	Northwest	Does not lie in the direction of E, NE, or SW winds

Air blast and ground vibration are monitored to provide information for geo-technical purposes as well, specifically to assess stability of man-made landforms.

2.7 Sites of archaeological and cultural interest

A total of 49 archaeological and historical sites are recorded at Rössing. Although there is some evidence of upper Pleistocene occupation, most of the archaeological sites date to within the last 5,000 years. A cluster of sites relates to grass-seed digging activities in well-drained soils derived from weathered granite, estimated to post-date AD 1000.

The seed-digging sites are concentrated around a number of low-lying granite outcrops associated with shallow depressions, which may contain water after rain, in between and relate to the seed-digging activities that still exist among Damara-speaking Namibians today. Historical sites relate to the narrow gauge railway that operated between Khan Mine and Arandis siding until about 1918.

The Rössing tenement is not an area of outstanding archaeological importance and does not have the dense site clusters which are characteristic of some parts of the escarpment and ephemeral river systems of the Namib Desert.

The areas of highest heritage value lie outside the main focus of mining activity and the mining area, and related high disturbance locations have a rather low heritage value. The sites also show a low vulnerability potential to disturbance. In general, the archaeological and historical sites are mainly of a low individual significance.

2.8 Land use

Apart from Arandis, there is no active land use in the proximity of Rössing's mining licence area. Water around Rössing is severely limited, meaning that agriculture is of marginal potential only, even along the ephemeral water sources of the Khan and Swakop rivers.

The closest commercial farmland is about 15 km to the east, and the border of communal land is about 15 km to the north. Along the lower Swakop River, close to the coast, commercial farming is undertaken on several smallholdings. Production aims to supply the needs of Swakopmund and Walvis Bay and includes asparagus, olive, mushroom and vegetable farming, as well as tourism- and leisure-oriented activities.

The Rössing mining license area is located within the #Gaingu Conservancy area. Not many people reside within the #Gaingu Conservancy area south of the main road.

About 720 ha of the mining licence area overlaps with the Namib-Naukluft Park on the southern bank of the Khan River.

The Dorob National Park is located about 10 km to the west of the mining licence area. Both parks fall within Category 2 of the International Union for Conservation of Nature (IUCN).

3. ENVIRON–MENTAL MANAGEMENT AT RÖSSING

3.1 The management system in effect

All operational activities at Rössing are managed to ensure that all impacts, on both the biophysical and socio-economic environment, are reduced to acceptable limits. Operations are governed through applicable national legislative and regulatory frameworks and managed through an integrated Health, Safety and Environment Management System (HSE MS). The HSE MS conforms to the international standards ISO 14001, OSHAS 18001 and ISO 9001, of which Rössing is certified to ISO 14001 since 2001.

Based on an understanding of potential health, safety and environment hazards/aspects, the HSE MS enables Rössing to identify key aspects and impacts, guide operating procedures and strive to continuous improvement in managing these. All potential impacts are listed on a business or site risk register, with related mitigating and operational controls.

The HSE MS is a tool designed to assist in achieving Rössing's goals, including its legal obligations. This systematic approach to management performance promotes the efficient use of resources and offers the prospect of financial gains to the company, generating a win-win outcome in terms of environmental and business performance.

External ISO audit evaluates the HSE MS periodically. In 2019, Rössing Uranium was successfully recertified for the ISO 14001:2015.

In addition to the HSE MS, Rössing implemented the Health, Safety and Environmental Performance Standards since 2005. The intent of the standards is to gain commitment of employees on an annual basis to improvement in impact management performance. With the new shareholder, Rössing retained similar standards for managing the various HSE aspects/risks. Rössing will continue to uphold a high level of standards and retain its existing systems for managing HSE on all its facilities. Ultimately, environmental management at Rössing aims at achieving the following:

- Assess environmental impacts of mining activities throughout the design, planning, construction, operational and decommissioning phases
- Develop, implement and manage monitoring systems to ensure maximising of avoidance, mitigation and rehabilitation of adverse environmental impacts

- Comply with all environmental regulatory and legislative frameworks during all phases of the mine's operations through approved environmental management plans
- Investigate and exploit measures to reduce usage of non-renewable resources
- Maximise positive environmental impacts
- Avoid, mitigate and rehabilitate adverse impacts
- Limit contamination through prevention measures (escapes into aquatic and atmospheric pathways), appropriate containment, recycling and removal measures
- Protect, conserve and enhance cultural, heritage and archaeological resources
- Keep communities informed and involved in decision making about mining activities
- Monitor the health and safety of employees and contractors against agreed performance criteria, and
- Support and encourage awareness, training and responsibility of environmental management.

The use of a formalised, integrative HSE MS is essential in allowing Rössing to optimise, coordinate and manage the various operations, personnel, plant and equipment and their interactions in a manner that demonstrates consistent application of best practice in environmental management.

Matters of planning, implementation and operation, checking and corrective action, and management review, are embodied in the system. This approach assists in the identification of key environmental aspects and serves to guide Rössing in continued formulation of suitable standard operating procedures (SOPs) and in attaining continual improvement objectives.

Annual HSE management reviews are conducted at Rössing by leaders of the business. The annual review is a necessary part of the continual improvement process and helps senior management focus on the effectiveness of the management system and authorise actions and/or provide resources to improve HSE performance.

The aim of the HSE management review is to ensure that the HSE MS is efficient and effective in managing HSE performance and meeting legal and other requirements.

3.2 Environmental monitoring localities

The comprehensive environmental monitoring network at Rössing includes ambient dust fallout buckets, lithops monitoring, water quality monitoring boreholes, environmental noise and vibration and weather stations for meteorological parameters (see Appendix 5).

4. ENVIRON– MENTAL PERFORMANCE IN 2019

Rössing's Environmental Management Plan contains a concise description of the management of environmental aspects and impacts at the mine, covering the various mine phases, from the designing to the decommissioning phase.

No significant environmental incidents occurred during 2019 and no deviation from the Environmental Management Plan was reportable to the respective authorities.

As a resource-intensive industry, Rössing's operations have the potential to impact on natural resources and the environment. For this reason, Rössing focuses continuously on improving environmental management programmes to maximise benefits and to minimise negative impacts. Key environmental management programmes include:

- Energy efficiency and greenhouse gas emissions
- Air quality control (including emissions of dust, other impurities, noise and vibration)
- Water management
- Waste management (both mineral and non-mineral waste)
- Chemical substance management, and
- Land-use management (including biodiversity, rehabilitation and closure).

As part of continuous improvement, there were notable improvements in the environmental monitoring space, as well as awareness on environmental aspects, such as waste management, air quality monitoring and water quality management. To mention a few:

- Rössing revived the weekly 'Wapaleka' cleaning campaign onsite, which encourages the entire workforce to voluntarily clean their working areas, and hence keeping the mine site clean on continuous basis.
- Ground water database base linked to Geographic Information Systems (GIS) for easy access and spatial display.
- Groundwater-quality monitoring schedule changed to an adaptive approach.
- Upgraded the seepage control systems for the trenches and rehabilitated monitoring boreholes.

- In terms of waste management, a training programme was tailor-made for each working area and introduced in addition to the annual HSEC training and inductions.
- The PM10 (inhalable dust) monitoring systems were installed with remote data loggers which now enables the high-peak events to be investigated immediately. The improvement also improved data availability significantly, as faulty equipments are noted and repaired/replaced immediately.
- Continuous total particulate monitors (TPM) was installed at the Final Product Recovery (FPR) to monitor dust emissions with the aim to improve scrubber efficiency and monitor effectiveness of improvements implemented by operations to keep air emissions minimal.

The performance in 2019 with regard to the environmental management programmes is discussed in the next sub-sections.

Environmental awareness and training are integral components of our environmental management system

4.1 ENVIRONMENTAL AWARENESS AND TRAINING

4.1.1 Wildlife protection

It is our role as good and corporate citizens and our duty of care over Mining License 28 land to ensure that the wildlife in our mining licence and accessory work are protected. We also have an obligation to our Environmental Management Plan (EMP) and HSSEC policy commitment of enhancing biodiversity protection.

Driving on the mine and accessory work areas is a risk to the wildlife that migrate through our operational areas. Not only do accidents seriously hurt and kill countless animals, but accidents involving wildlife also pose serious risks to the driver and passengers of the vehicle. Rössing mine is bordering the Namib Naukluft Park and various migratory routes pass through our license hence expecting various wild life to be and around our mine and accessory area.

Rössing monitor and manage wildlife mortality by vehicle incidences continuously. In 2019, only two wildlife animals (a guinea fowl and black-backed jackal) were killed on the Rössing main road by vehicles. This is lower compared with the four animals that was killed on the access road in 2018. These incidents are logged and investigated to prevent incidents in the future.

The incidents are usually followed by vigorous awareness to employee through the internal communication channels, namely by sending out a Blue Coded communication to the workforce. . The communication was sent out to all Rössing employees and contractors. It was also discussed at various platforms such as Safe Shift Starts (SSS), HSE meetings; about 86 employees and contractors were taken through the awareness training.

4.1.2 Birdwatching event

Rössing celebrated the 18th year of Rössing's annual birdwatching day. The birdwatching event is celebrated as part of the United Nation's International Day for Biological Diversity and World Environmental.

The birdwatching event aims to give participants an experience to view the unique birdlife, and to promote a long-term interest in birds linked to conserving local and wilderness biodiversity.

The local schools remained the nucleus of environmental education activities in 2019 and the programme branched out to cover other sectors of the community by involving Rössing Foundation learners. A total of 95 learners and teachers participated in the event.

Rössing worked closely with Coastal Environmental Trust of Namibia to promote coastal biodiversity conservation on the day.

Figure 5: Learners from 13 coastal school participated in the annual birdwatching event that took place in September 2019 at Walvis Bay's Lagoon area.

4.1.3 Spot-a-wild competition

Spot-a-wild competition is a good opportunity to spot wildlife by employees in areas that environment section would not have observed. This is also an opportunity to involve employees to be aware and take due regard of their environment.

In 2019, the most frequent observed wildlife was springboks, followed by klipspringers, guinea fowls and jackals. This indicates that these are the animals mostly found in this area. Most wildlife were regularly observed at the Tailings Dam and Namwater reservoir, which could be because these areas are far from operation and there is usually drinking water available. The most rare and uniquely observed wild animal was a rabbit that was observed in the Lower Pinnacle gorge.

4.1.3 In-house waste management training and 'Wapaleka' cleaning initiative

The Rössing Environmental Performance Standard requires all employees who handle hazardous material to be trained so they understand the safety, health and environmental impacts and risks associated with routine activities and the emergency actions. Area inspections are carried out on a regular basis to ensure that waste is managed accordingly as per set operational procedures.

The outcome of inspections from operations indicates that waste management is a challenge in most areas and there is a lack of basic understanding in waste sorting and segregation. This was addressed through customised training modules on waste management, in addition to the HSE trainings conducted among all employees. During 2019 the training was attended by 253 employees, including contractors.

The 'Wapaleka' cleaning campaign was re-introduced and launched in 2018. ('Wapaleka' means 'clean up' in one of the local languages, Oshiwambo). The initiative promotes waste segregation, voluntarily cleaning and improving workplace conditions in and around the mine site. In 2019, a total number of 602 refuse bags were collected voluntarily which is equivalent to 6.1 tonnes of waste, in addition to the waste managed through the integrated waste management contractor.

4.1.5 Donations to the community

To honour our corporate social responsibilities, 20 empty metal drums were donated to Erongo Regional Council to be used as garbage bins at Long Beach and Dune 7.

Figure 6: Handover of the garbage bins to Erongo Regional Council

We donated safety bibs to the Environmental Clubs of WestSide High and Namib Primary School for visibility when they are cleaning outside the school premises. A waste sorting stand was also donated to Namib Primary School to promote the 3Rs (reduse, reuse, recylce) at the school.

Figure 7: Learners and a teacher from Namib Primary School during the handover of the waste sorting stand and safety bibs.

We supported the three northern-based Community Skills Development Centres (COSDEC) by donating 6.8 tonnes of redundant pallets towards the Joinery and Cabinet Making Workshops in Otjiwarongo, Tsumeb and Ondangwa.

In addition, we supported Project Shine, availing an evaluator and a 4X4 vehicle service for the monthly evaluation sessions held in Swakopmund.

4.1.4 Snakes and scorpions

Rössing records the number of snakes and scorpions observed one the mine premises in order to understand the risk and identify the types of snakes and scorpion employees are expose to. This understanding helps the company to develop mitigation to manage these risks. It is also essential to understand the frequencies and seasons where most snakes and scorpions are observed and to be prepared for any emergencies.

In 2019, a total of 11 snakes and 14 scorpions were observed. Only three types of snakes were observed in 2019, namely the western sand snake, the puff adder and black spitting cobra. The puff adder was the most frequent snake observed in 2019. The western sand snake and the puff adder were mostly observed in juvenile stage, whilst the black spitting cobra was observed as adult in the Khan River.

The *Parabuthus* species was the most scorpion species that was observed in 2019.

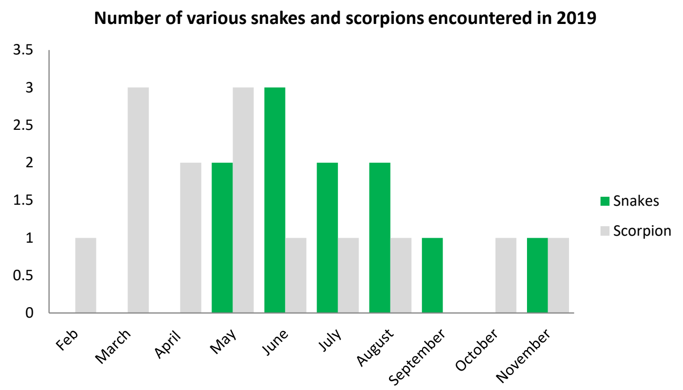


Figure 8: Number of various snakes and scorpions encountered in 2019

4.2 ENERGY EFFICIENCY AND GREENHOUSE GAS EMISSIONS

As part of the environmental commitment and priority, Rössing measures and manages its GHG emissions and energy intensities. This helps in improving energy efficiencies and reduce greenhouse gas (GHG) emissions.

Sources of GHG emissions at Rössing is electricity and fuel consumption, the transporting of reagents and of uranium, blasting (explosives), waste (sewage, rubbish disposal and landfill), and extraction and processing of ore. The intensity of emissions is reported per unit of uranium oxide produced.

Tier 2 targets are internal and calculate energy use per unit of 'work done'. 'Work done' targets are calculated for the energy used per unit and reported internally.

To calculate the greenhouse gas emissions equivalent of the amount of energy used, the total energy consumed is converted to CO_2 per tonne of U_3O_8 produced. The figures are used to drive energy efficiency and emission reductions on site, and are reported monthly and annually to CNNC.

To set targets, hauling and milling processes are measured to calculate the total amount of energy use per 'work done' at the mine's operations.

Measuring greenhouse gas emissions intensity per unit of product target and total amount of energy use per 'work done' gives an indication of energy used during the following two processes:

- Haul metric: GJ/kilotonne of material hauled, and
- Plant metric: GJ/kilotonne of ore milled.

Table 2: Tier 2 - Haul and plant metrics

Metrics	Target: 2019	Actual: 2019
Haul		
Haul metrics GJ/kt equivalent material hauled	23.49	17.68
Greenhouse gas haul metrics kg CO_2-e/t material hauled	1.93	1.41
Plant		
Plant metrics GJ/kt equivalent ore milled	55.54	45.17
GHG Plant metrics kg CO2-e/t ore milled	7.9	6.5

2.1 *Energy intensity*

In 2019, the total energy consumption of the mine was 1,297,556.63 GJ for 2,449 tonnes of uranium oxide drummed. This converts to an annual energy consumption of 530 GJ per tonne (GJ/t) of uranium oxide produced (see Figure 9).

Energy consumption shows an increase from 2018 to 2019, which could also be linked to the ore grade that has increased from 0.35kg/t in 2018 to 0.37kg/t in 2019.

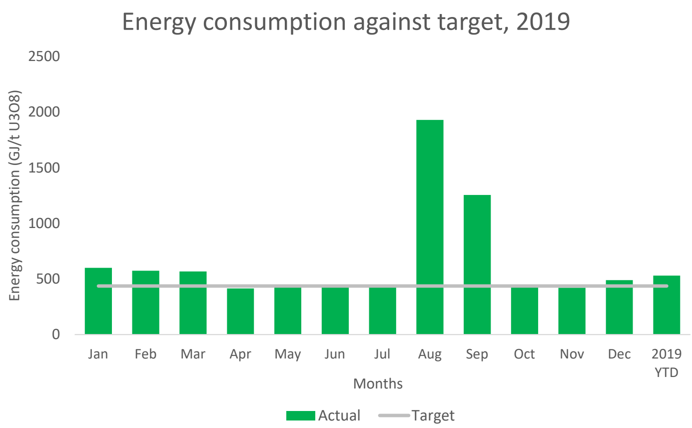


Figure 9: Total energy consumption intensity, 2019

4.2.2 *Greenhouse gas emissions*

The actual performance achieved in 2018 was 60.04 tonnes CO_2-e /t U_3O_8, which is 33 per cent below the target of 90 tonnes CO_2-e /t U_3O_8 (see Figure 10).

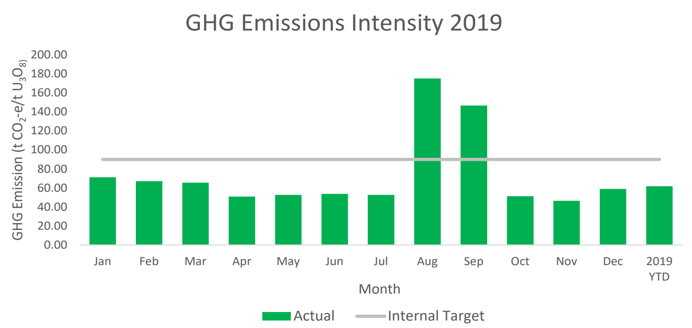


Figure 10: Total greenhouse gas emission intensity, 2019

4.2.3 In-house metrics

Rössing's performance against Tier 2 targets is displayed in Table 3. These targets were not met during 2019, mainly due to the dependency on the ore grade that has increased from 0.35kg/t in 2018 to 0.37kg/t.

4.3 AIR QUALITY MANAGEMENT

Rössing Uranium has committed to protect the environment from the harmful effects of air pollution caused by its mining activities.

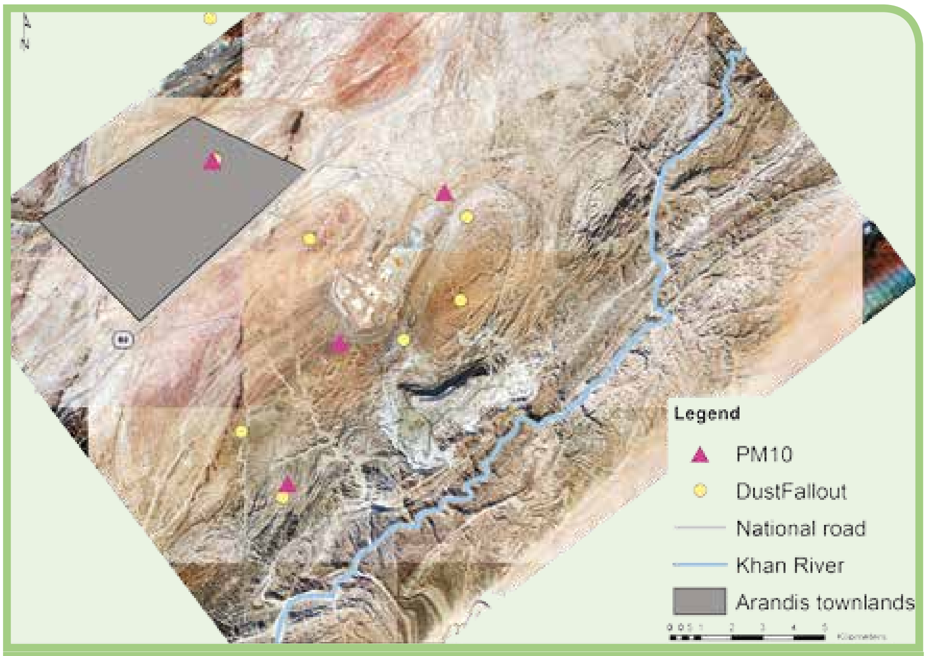


Figure 11: The map shows the PM_{10} dust monitoring network samplers and dust fall-out buckets.

Mining activities such as blasting, loading and dumping of ore and waste, crushing and conveying crushing or grinding operations and driving on dust stirred up by vehicles on roads creates dust, as well as noise and ground vibrations.

Dust particles are so small that they can get into the lungs, potentially causing serious health problems and also cause environmental effects such as:

- Reducing visibility
- Stain and damage buildings and statues
- Increase acidity in water bodies, and
- Deplete the soil and damage plants.

Therefore, dust emissions, noise and ground vibration created during mining activities requires an understanding on the impact it has on the people and the environment. Hence, an air quality monitoring programme (AQMP) is in place to measure and monitor air pollutants in the area and its surrounding and implement programmes that will help in the reduction of this impacts.

4.3.1 Environmental dust

Rössing is located in an arid environment which makes dust one of the air pollution greatest source from its mining activities. Dust emission is a public concern to the residents of Arandis and Swakopmund, especially when high-velocity winds occur during the winter months.

The AQMP in place helps in quantify dust fallout and allow mitigation when necessary. The measures are taken to ensure that exposure levels do not exceed the adopted occupational limits and that the controls efficiently detect differentiations resulting from process changes.

There are two types of dust measured:

firstly, a very fine, inhalable dust invisible to the naked eye that is comprised of particulate matter less than 10 micron (known as PM_{10}), and secondly, fallout dust, which is visible on the ground and comprised of lager particles, including PM_{10}.

The measure of PM_{10} is the weight of particles less than or equal to ten micrometres in diameter in one cubic metre of air. When inhaled, these tiny particles are not filtered out by the body and therefore reach the lungs.

We continuously monitor PM_{10} dust levels onsite at three dust monitor stations and at one PM_{10} station in the nearby town of Arandis (see Figure 11 denoted by pink triangles). As part of the best practices and Rössing standards in order to improve adaptive management and understanding of the ambient dust contributing

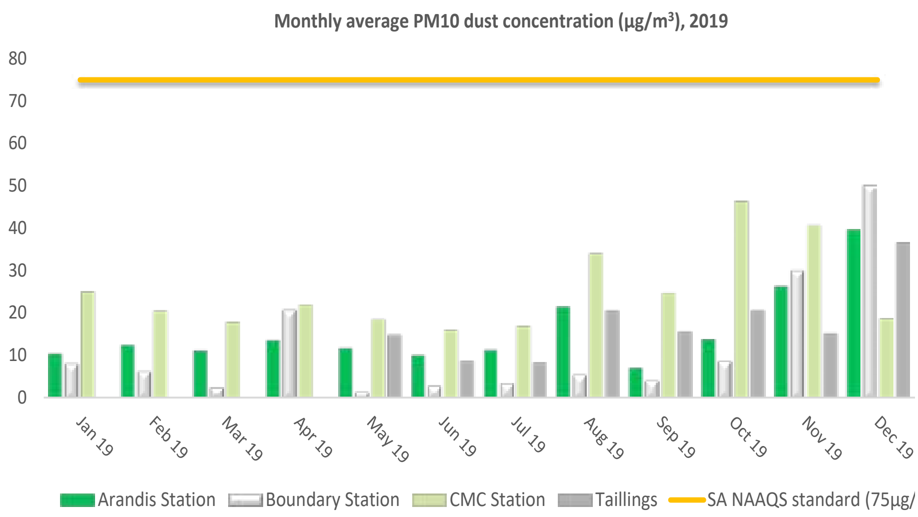


Figure 12: Monthly average PM_{10} dust concentration, 2019

activities, real time data loggers/remote communication for the PM_{10} monitoring stations were recently installed. This enable immediate investigation and observation of the current actual conditions and allow help Rössing to improve controls, as well as linking visual events to the results instantly. It also helps with the visibility on functionality of equipment for a prompt response towards maintenance, which improves data availability.

The levels measured in 2019 showed that PM_{10} dust concentrations at all stations were below the adopted World Health Organisation standard of 75µg/m³, (see Figure 12). There were no records for Tailings station for the first months of the year, as it was faulty.

4.3.2. Ambient dust fallout

Dust fallout is measured as aspect of the air quality management at Rössing as a result of our mining activity which may adversely affect the surrounding environment and residential inhabitants.

Rössing has adopted to the South African National Dust-control Regulation (SA NDCR) and World Health Organisation in the absence of Namibian legislation, the limits are 600 mg/m² per day for residential and 1,200 mg/m² per day for non-residential areas with an annual average target of 300 mg/m² per day.

Dust fallout is measured at six stations at different locations around the mine boundary. Values measured during 2019 at the six stations ranged between 5 and 104 mg/m² per day with an annual average of 17 mg/m² per day (see Figure 13).

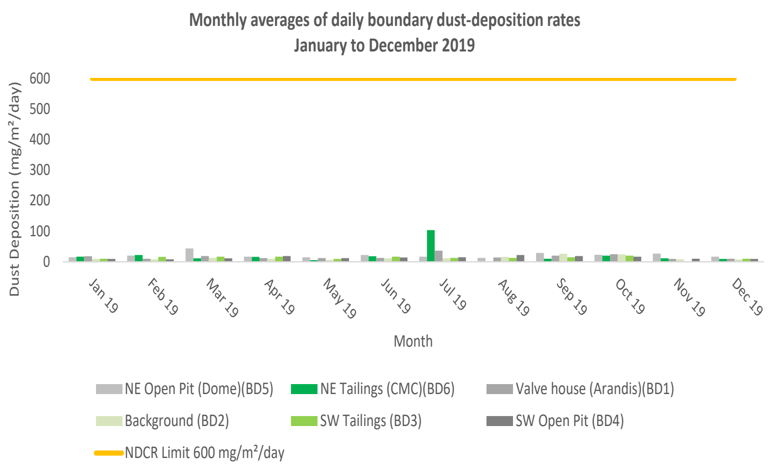


Figure 13: Monthly averages of daily boundary dust-deposition rates, 2019

All measured deposition rates were well below the selected or adopted South African dust-control regulation.

4.3.3 Environmental noise, air blast and vibration

In the absence of Namibian legislation on environmental noise and vibration, Rössing Uranium has adopted or made reference to the an acceptable standards of the United States Bureau of Mines (USBM) RI 8507 criteria for safe blasting and for operational noise the relevant South African National Standards (SANS) - Code of Practice, SANS 10103:2008 (SANS, 1992).

Noise and vibration is monitored through a network of various points and studies.

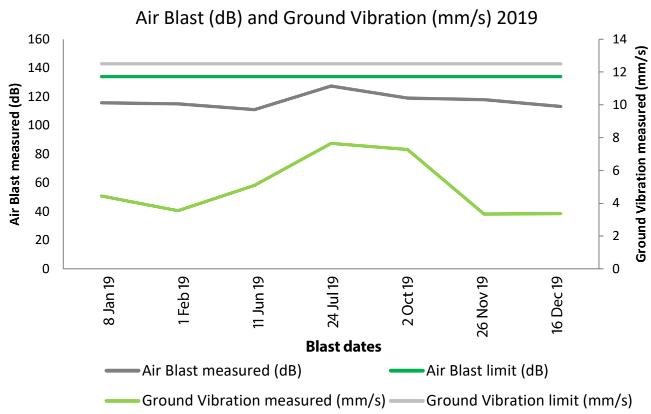


Figure 14: Air blast and vibration measurements, 2019

Environmental noise is monitored according to a specific procedure and reported on a monthly basis to minimise noise to threshold levels and identify events when these levels are exceeded.

Throughout 2019, both air-blast and ground vibration levels have been consistently below the limits of 134 dB and 12.5 mm/s respectively (Figure 14). Blasting is only carried out in the open pit, but monitored at two places on site and in Arandis.

Environmental noise is measured at six stations, namely at:

- Station 1 - Rössing Main Mine Access Road
- Station 2 - Arandis Airport Gate
- Station 3 - Khan River Valley
- Station 4 - Khan River Rock Island
- Station 5 - Khan River Bed, and
- Station 6 - Khan River Bed.

Ten noise measurement campaigns were conducted throughout 2019 (Figure 15) with no measurements in May and June due to the instrument send away for calibration. All noise measurements were below the Rössing internal noise level of 45 dBA, except in January (Station 1) and August (Station 2 and Station 3), due to strong winds and aeroplanes and cars driving to the airport, and therefore could not be associated to the mining activities.

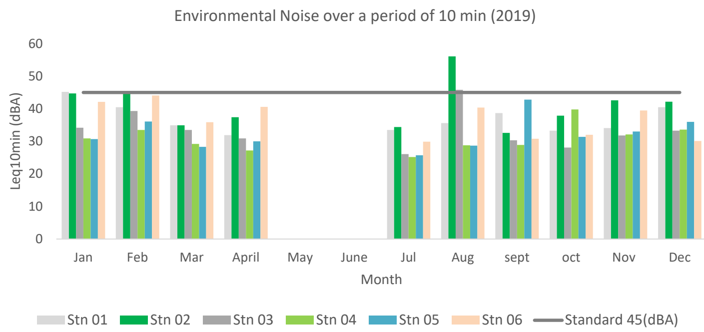


Figure 15: Environmental noise over a period of 10 minutes, 2019 (Leq 10 min (dBA))

4.4 WATER MANAGEMENT

Water management at Rössing is guided by a formal water strategy and Water Management Plan, which are developed according to our Performance Standard on "Water quality protection and water management".

Water management covers all activities connected to water abstraction, transport, storage, usage (potable and process), impounded water and groundwater. The intent of the Standard is to ensure efficient, safe and sustainable use and protection of water resources and ecosystems.

In accordance to Namibian legislation, the Water Resources Management Act of 2014, the Ministry of Agriculture, Water and Forestry (MAWF) is the custodian of all water resources in the country. Under this mandate, MAWF issued RUL with two permits

- Industrial and Domestic Effluent Disposal Exemption Permit # 674 (valid until December 2020), and
- Khan River Water Abstraction Permit # 10 200 (valid until January 2021).

4.4.1 Total water usage

The monthly fresh water usage shown in Figure 16 totals to 2.58 Mm^3 for 2019, this amount is 10.42 per cent below the planned 2.88 Mm^3 for the year. The planned fresh water annual volumes are based on planned tonnes to be milled for that year. Fresh water consumed per tonne of ore milled was 0.372 m^3/t and the ratio of fresh water to total water consumed was 0.38 m^3/t.

Monthly fresh water usage, as depicted in Figure 17, was below the planned water usage for most of the months. The graph indicates that we had to adjust our scheduled annual maintenance plans of July for August to align with maintenance schedules of the water suppliers' planned maintenance in August, which explains the switch in the planned against actual observed in the two months.

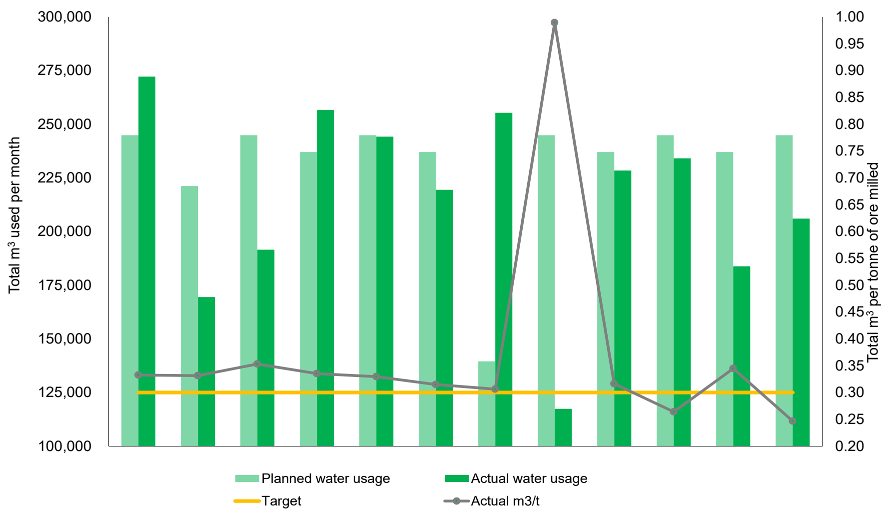


Figure 16. Water usage, 2019

4.4.2 Khan River water usage

Saline groundwater abstracted from the Khan River aquifer is used to spray on haul roads in the Open Pit to suppress dust. In 2019, a total of 141,985m^3, which is 16 per cent of the permitted 870,000 m^3 was pumped. Abstraction is maintained below 600 m^3 a day as much as reasonably possible, which is established internally to be the sustainable yield of this portion of the Khan River.

The riparian vegetation and water levels in the part of the Khan River from where we abstract the water, are monitored in order to identify potential impacts of the abstraction at an early stage. The Khan River riparian vegetation monitoring programme for the study area has been running for over 30 years. Recent monitoring indicates that trees in the study area are not affected by the abstraction from the aquifer. The river has not flooded since November 2018.

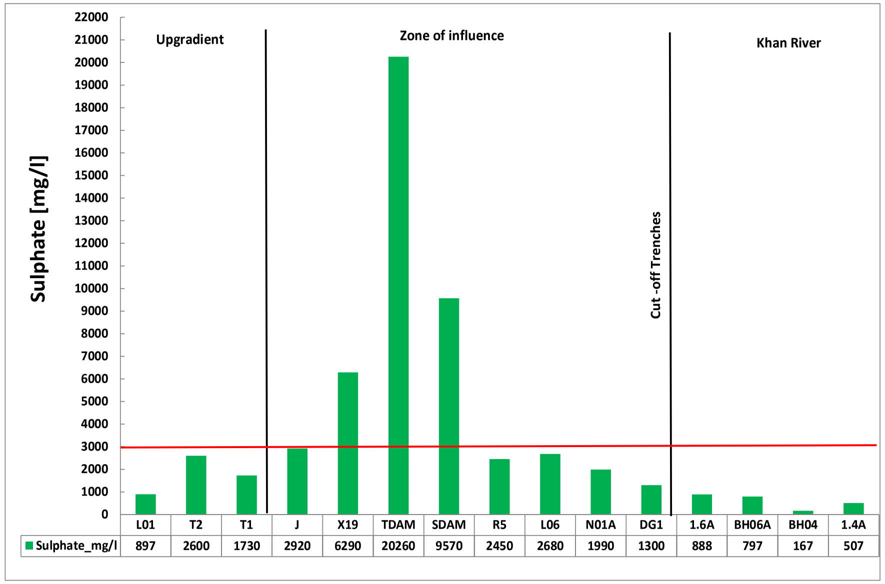
4.4.3 Groundwater quality protection

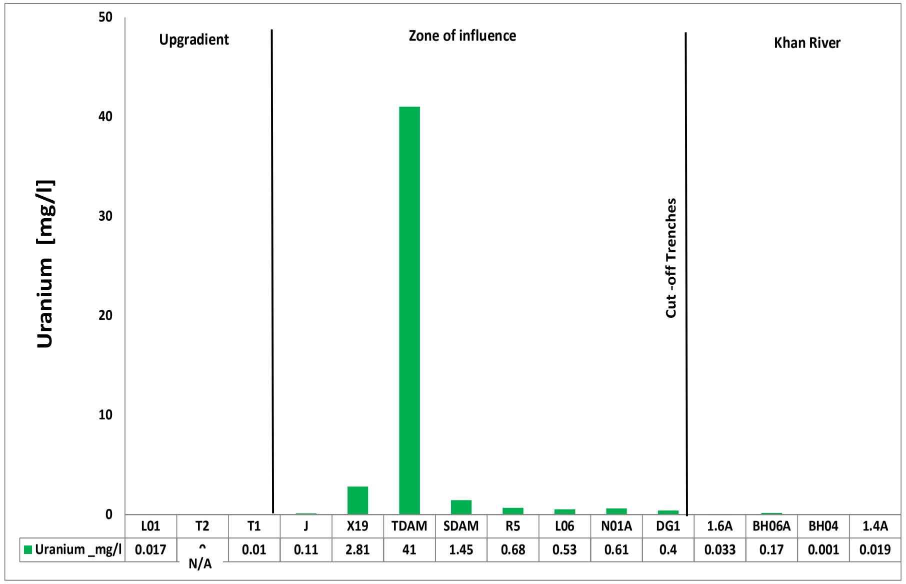
Rössing's Tailings Storage Facility (TSF) is the source of potential groundwater contamination. Contaminated tailings seepage could potentially reach downstream water users in the Swakop River via the aquatic pathways of the alluvium and rock aquifers on site and eventually the Khan River.

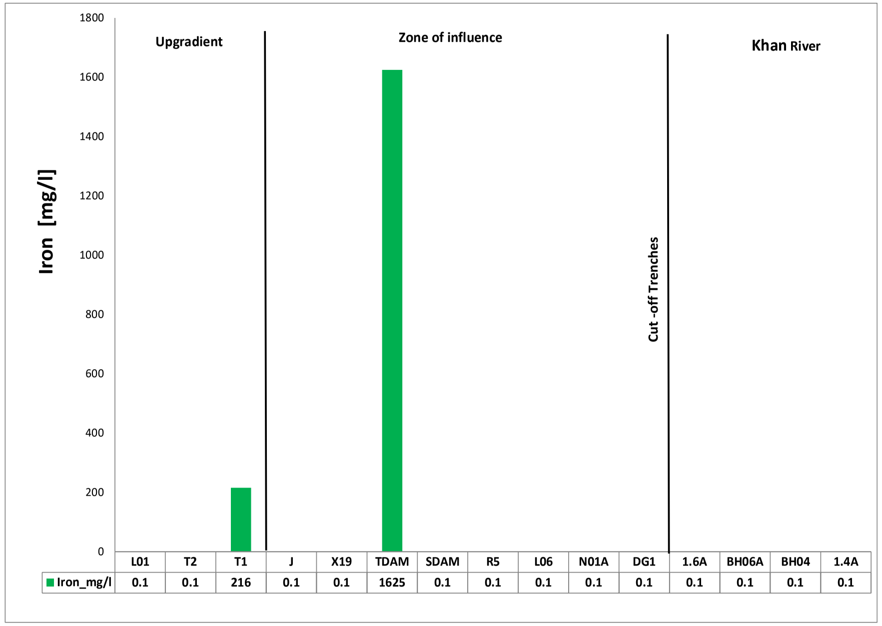
Therefore, the objective of the groundwater quality protection programme is to curb contaminated seepage from the TSF from entering the Khan River. To achieve this, a network of abstraction points, wells, sumps and trenches close to the source and in the wider environment are equipped to pump this seepage continuously. Abstracted seepage water is discharged into the overall recycle and reuse stream.

In order to ensure the effectiveness of these control systems, a groundwater level and quality monitoring network is in place. Water quality data is managed through a database and both water quality and water level data can be displayed using a geographical information system. This function allows for quick and effective spatial display of data which improves data comparison and interpretation and the management of the seepage control network.

Rössing's water quality monitoring schedule is a listed item in the "Industrial and Domestic Effluent Disposal Exemption Permit" issued by the Ministry of Agriculture, Water and Land Reform. Water samples are analysed by independent accredited laboratories, namely IAF Radioökologie GmbH (Germany) and DD Science Cc (Republic of South Africa).







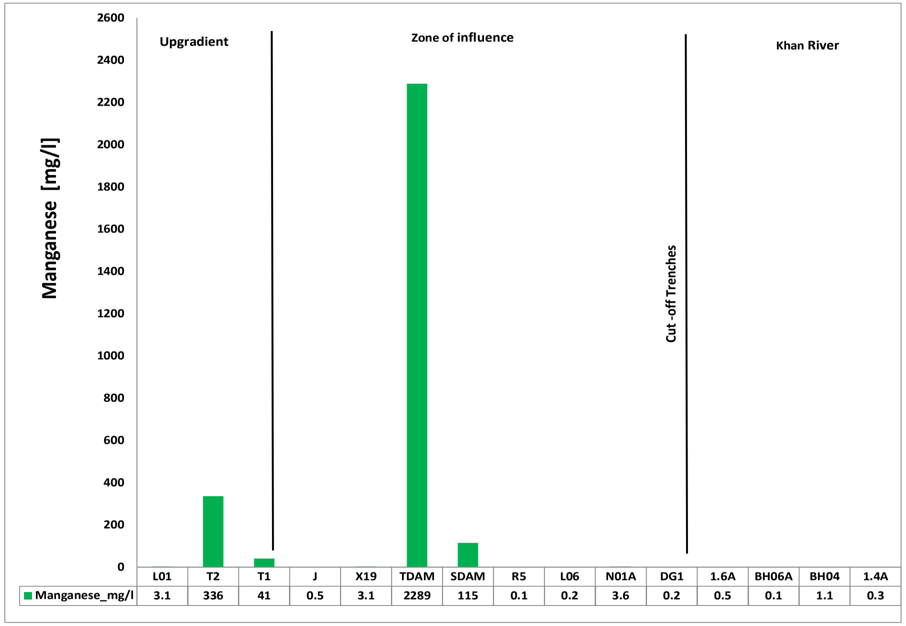


Figure 11. Water quality overview for August 2019

In the selection of graphs depicted in Figure 17, concentrations of ions from chemicals used in the Processing Plant are shown. Sampling locations are shown on the x-axis of the graphs and the graphs are grouped into upgradient background (which is the area unlikely to be influenced by seepage), zone of influence (the area within and downstream of the seepage plume, but upstream of the last seepage control systems and the cut-off trenches which is the area which is or has the potential to be contaminated) and downstream-receiving environment (Khan River) based on locations.

The sulphate concentration follows a bell-shape distribution with the highest peak observed in the TDAM (Tailings Dam) samples. This is to be expected since the TDAM sample represents water from the Processing Plant with the potential to affect the surrounding water quality.

What is evident from all the graphs, is that the concentration of elements reduces substantially as the seepage interacts with the surrounding environment, i.e. concentration of ions reduces away from the source. All four charts indicate higher concentrations within the zone of influence, particularly in the areas where the seepage plume has been delineated.

It has been suggested through various geochemical models that the decrease in concentrations of certain ions away from the source of contamination may be due to chemical precipitation of mineral phases within the tailings profile and the natural environment. A report on "Geochemistry and seepage of Rössing tailings water" by Dr. Paul Brown explains the involved chemical processes.

The water quality data in Figure 17 indicates that the seepage plume at Rössing remains confined within the zone of influence. The approximate extend of the seepage plume for 2019 is delineated in Figure 18. The outline remains unchanged, as was observed in 2017 with no new monitoring locations affected by seepage

4.4.4 Improvements in water management aspects

In 2019, Rössing refurbished 35 groundwater monitoring boreholes. Of the 35 boreholes, 22 were rehabilitated through mechanical means (brushing and plunging) and 13 were drilled, mainly as replacement boreholes for those which could not be rehabilitated.

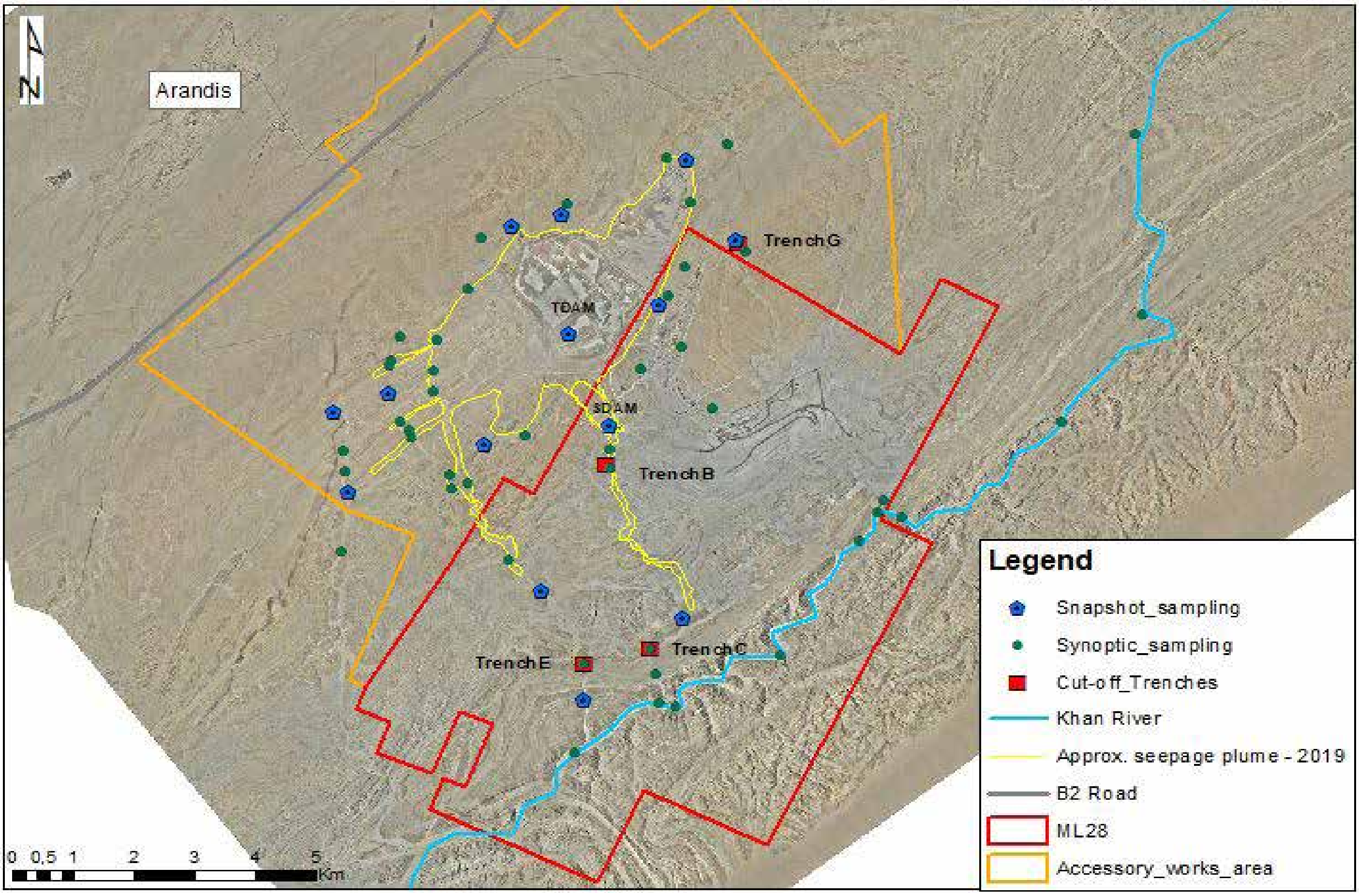


Figure 18: Location discussed for water quality

4.5 WASTE MANAGEMENT

In addition to the legislative framework for waste management in Namibia, Rössing also manages its waste in accordance with the international standards such as the ISO 14001:2004, as well as the Rössing Environmental Performance Standard E2 (Hazardous material and non-mineral waste control and minimisation) for conformances and compliance.

4.5.1 Management of non-mineral waste

Non-mineral waste at Rössing is characterised into two classes, namely 'general' and 'hazardous' waste in accordance with the risk it poses. The type of non-mineral waste generated onsite are for example scrap metal, redundant conveyor belts, used oil, domestic waste and the lubricants from maintenance activities.

Rössing developed a Non-Mineral Waste Plan (JE20/MMP/001) and a Non-mineral Waste Procedure (JE50/WMP/001) that addresses all non-mineral wastes generated through operational phase to ensure sound management through minimisation of waste generation and safe handling, treatment and disposal of waste. An integrated waste management contract was awarded to Karee Investment (a local Namibian-owned waste management contractor) since 2016 to handle and remove recyclable materials and packaging materials onsite.

During 2019, the scope of work for the waste management contract was revised to make provision for the service provider to provide its own machinery and equipment. The tender was awarded to Karee Investment once more and commenced on 1 December 2019.

Dormant landfill site

The onsite landfill site is still dormant and a total of 10.1 tonnes of garden refuge was disposed; no dry sewage waste was disposed during 2019.

Alternative disposal means are still being explored, as there is work in progress to determine the feasibility to decommission the landfill site. A consultant from PASCO Waste & Environmental Consultancy Company visited the mine site on 14–16 May 2019 to assess the site, volumes of stored waste and to propose a disposal solution. The recommended proposals and the costing of the landfill-closure design were included in the final report received for implementation.

Onsite waste disposal

Radio-active and contaminated waste is disposed in trenches at a designated site on the Tailings Storage Facility (TSF) where the quantity and the disposal location are recorded. Disposal at the contaminated waste site is restricted to Wednesdays only and access is controlled, as seen in Table 4.

In 2019, 2,538 tonnes of contaminated solid wastes were disposed of on the TSF, while 211 tonnes of oil sludge and soil was disposed at the bioremediation facility for treatment. Three of the batches of the hydrocarbon contaminated soil that were sampled and analysed in February 2019 were well within the acceptable disposal limit (TPH C10-C40 < 10 000 mg/kg) and the treated soil was transported to the Shovel Paddy to be re-use for dressing, while the contaminated soil in Cell 02 was treated further, the results of which is shown in Table 3.

Table 3: Bioremediation results for the treated soil

Sample ID	Current Results (mg/kg)	Previous Results (mg/kg)
Cell 01	9,000	12,500
Cell 02	10,300	10,400
Cell 03	8,800	15,300
Cell 04	9,300	17,000

Recyclable non-mineral waste

During 2019, a total of 1,419 tonnes of recyclable waste material (mainly used oil and scrap metal) were removed from site by the waste contractor to the verified offsite recyclers. The contractor transported the domestic waste from the mine site to the Swakopmund waste sorting facility before it is dispatched to Windhoek for recycling and re-use purposes at the contractor's refuse-derived fuel plant. The domestic materials that are non-recyclable are disposed of at the Municipal landfill site of Swakopmund.

All the medical waste generated onsite is transported from the mine site to Medixx in Arandis before it is dispatched to Walvis Bay for incineration. During 2019, a total of 0.45 tonnes of medical waste was incinerated. No chemical waste was disposed of during 2019 as the Walvis Bay hazardous landfill site has been under construction since 2018.

The hazardous waste type generated onsite includes used oils, grease, filters, redundant chemicals, batteries and other items such as fluorescent tubes and e-waste.

Hydrocarbon used oil and grease generated from the wet part of the Processing Plant are regarded as potentially radioactive contaminated and cannot be recycled offsite without due diligence. The oil is stored onsite as per permit conditions of the oil storage permit which permits a total of 100,000 litres per annum. The potential-radioactive-contaminated used oil is currently stored at the conveyor yard and the rodmill storage yard.

In 2019, Rössing initiated a project to analyse the radioactivity with the aim for removal and recycling purposes offsite. Radom oil sampling was collected and samples were analysed at NECSA for radioactivity analysis. The results of U_{238}-activity concentration indicated no traces of radioactive contamination, which means that the used oil are not classified as nuclear material and can be recycled offsite.

Rössing entered into an agreement with Oiltech to collect the potential-radioactive-contaminated used oil from site by pumping the used oil into a tanker as a mitigation measure to prevent any possibility of a contaminated drum from leaving the mine site.

In total, 91.7 tonnes of the potential-radioactive-contaminated used oil has been refined and the cash generated for Rössing from this project amounted to N$198,673. In total, 275.02 tonnes of used oil have been removed from site for recycling purposes.

In the past, Rössing used to dispose oil filters in the black contaminated luggerbin that ended up at TSF. These practices have been stopped in 2019 to prevent any possible underground water contamination and few alternative solutions were explored.

A trial was carried out with Oiltech where eight drums of 210 litre each containing metal-cast oil filters were recycled and 9.4 litre of residual oil was collected and metal was disposed with scrap metal dealers. This practise is favoured, as it reduces waste to the landfill, but it it is costly and reverted to drumming both the oil filters and oil contaminated rags in 210 litre-drums and stored at the temporally oil yard for further disposal at the Walvis Bay landfill site.

The measureable target for the reduction of non-mineral waste for recycling offsite was set at 80 per cent since 2016. This target was not achieved in 2019; offsite waste recycled disposal was only 34 per cent (see Table 4). The poor performance is related to the management of the integrated waste management contract. Therefore, Rössing identified the need to review the scope of work of the integrated waste management contract to close all the identified gaps.

4.5.2 Management of mineral waste

At Rössing mineral wastes are identified as waste rock and overburden, as well as tailings and in the future heap leach waste (ripios). While Rössing managed the disposal of these waste streams throughout the lfe-of-mine, this was not always done through a formal waste management plan. A formal management plan for mineral waste is required by the Rössing Performance Standard E4 (Chemically reactive mineral waste management). The standard sets the criteria against which Rössing is audited. It stipulates, inter alia, that waste disposal facilities should be located and designed to minimise environmental, health, safety and community impacts and risks. Facility location and design should be consistent with the long-term physical and chemical behaviour of the waste and must result in repositories that are physically and chemically safe and stable during operation and after closure.

Waste storage facilities are placed within permitted areas only. Considerations in the placement are:

- Preferentially placing waste within inactive open pits, underground workings or within existing disturbed areas
- Tying waste repositories into the surrounding topography to maintain regional drainage patterns and reduce visual impacts
- Avoiding placement on land with high biodiversity or ecosystem

Table 4: Non-mineral waste volumes (tonnes)

Year	Steel	Cardboard & paper	Wood	Plastic	e-waste	Conve-yors	Land filled	Total recycled	Total waste	% of total waste recycled
2002	1,597	10	17	-	-	-	433	1,624	2,057	78.9%
2003	1,897	23	43	-	-	-	504	1,963	2,467	79.6%
2004	1,734	36	57	-	-	-	785	1,874	2,659	70.5%
2005	1,700	39	60	-	-	-	1,016	1,885	2,901	65.0%
2006	1,411	37	42	-	-	-	548	1,500	2,048	73.2%
2007	2,290	31	45	-	-	-	445	2,374	2,819	84.2%
2008	2,254	21	39	-	-	24	410	2,339	2,750	85.1%
2009	1,715	19	29	-	4	12	679	1,779	2,458	72.4%
2010	3,128	13	45	6	3	85	672	3,380	4,052	83.4%
2011	2,314	30	91	15	-	-	746	2,517	3,254	77.1%
2012	2,930	8	45	7	-	63	415	3,055	3,470	88%
2013	908	26	115	9	-	21	165	1,182	1,347	88%
2016	315	9	49	6	-	2	0	421	916	46%
2017	1734	11	34	23	-	2	0	1,953	1,804	>100%
2018	1 188	9	73	2	-	34	1,478	1,321	2,784	47%
2019	720	14	66	8	7	107	2,766	1,419	4,185	34%

services values

- Avoiding placement in or near perennial surface water bodies or in large ephemeral drainage lines
- Avoiding placement of chemically reactive waste over important groundwater aquifers or recharge zones
- Avoiding placement in areas with significant archaeological or social value
- Avoiding placement in close proximity to local communities
- Preferentially placing chemically reactive wastes in drainage basins that already contain reactive waste (thereby avoiding placement in pristine drainages)
- Avoiding placement in areas with poor foundation conditions due to topography, underlying geology or hydrology, and
- Balancing economic considerations such as haul profiles, potential resource sterilisation, and pumping costs with environmental, social and closure considerations.

The Rössing Mineral Waste Management Plan (JE20MMP009) has been developed and prepared in accordance with the Rössing Mineral Waste Management Guidance Notes, to comply with the standard as well as Namibian regulatory requirements. The intent of the plan is to ensure sound and effective mineral waste management by the minimisation of waste generation and ensuring the safe handling, treatment and disposal of these wastes. The Mineral Waste Management Plan for Rössing was revised at the end of 2011.

The purpose of the plan is to provide a documented record of issues related to mineral waste and to manage all mineral waste produced at Rössing in such a manner that disposal facilities and sites must be physically, biologically and chemically safe. For the purpose of this document, mineral waste entails mineralised waste rock and processed waste rock (tailings), and excludes the dormant landfill site (where only non-mineral waste is disposed), commodities imported to site such as hydrocarbons and sewage farms.

Waste rock dumps are typically coarse, angular fragments of very strong rock material that is resistant to mechanical disintegration and chemical decomposition, with the exceptions of amphibole schist and biotite schist. Both these are 'minor' rocks in terms of volumes, and are furthermore mostly processed as ore. Typically therefore, the Rössing dumps are of pervious, frictional material placed on competent, but steeply sloping foundations.

The mineral composition of waste rock consists mostly of quartz, albite, microcline (both feldspars) and mica. Marbles layers add calcite or dolomite to the list, while weathered samples can contain chloritoid, kaolin or gypsum. Waste rock has higher calium oxide (CaO) and magnesium oxide (MgO) contents than ore, which is mainly due to the marble present.

Tailings material has a very similar composition with predominant quartz, albite, microcline, mica and small amounts of calcite or gypsum. Precipitates at the tailings facility are composed of chloritoid, potassium and ammonium jarosite, ammonium aluminium sulphate, ammonium manganese sulphate hydrate, quartz, feldspars and some mica. Ore and tailings are quite similar, except for the higher sulphur concentration in tailings, which can be ascribed to sulphate minerals, such as jarosite and gypsum in tailings.

An inventory of mineral waste at Rössing is kept. It reflects the tonnage per year, the cumulative tonnage, surface area, volume and the location of waste (see Table 5).

Site maps are maintained. The spatial footprint of mineral waste is also maintained and annually reported. Identification of the primary hazards posed by mineral waste was done in 2007. Primary hazards associated with mineral waste, reflecting the potential impacts, at Rössing are:

- Radioactivity from waste rock, low grade storage facilities and tailings facility (radon emanation and radionuclides in dust)
- Although there is a possibility that asbestos and asbestiform can be found in dust from the pit and crushing plant because of metamorphosed magnesium carbonate (such as marble) and the presence of serpentine, none has been found when monitoring so far
- Uranium and its decay products can be released into seepage water (from the TSF)
- Acidic drainage is possible where mineral wastes are in contact with water, and
- Residual nitrate, from the use of blasting agents, can be solubilised from waste rock and migrate to underlying groundwater.

Table 5: Mineral waste disposed in 2010-2019 (volumes in tonnes)

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Waste rock dumps	40,022,450	39,608,654	33,749,173	25,332,432	15,954,100	12,522,652	16,467,097	15,109,738	11,459,319	13,289,588
Tailings storage facility	11,594,430	10,370,362	12,152,173	11,261,619	7,040,277	6,875,719	9,194,439	8,962,923	8,851,288	8,006,059

Reshaping of the huge man-made landforms represented by the waste rock dumps and the TSF needs to be minimised at closure and to achieve this aim, dumping should progressively meet the final landform requirements. Additional work following closure (monitoring and maintenance) should be limited.

With this in mind, Rössing follows a Waste Rock Disposal Planning and Design Strategy and in the case of the TSF, an operating manual sets out the procedures to be followed in accordance with the engineering design. The following management objectives are emphasised:

- Geotechnical stability and access
- Radiation and radon emanation
- Surface drainage and rainwater leaching
- Rehabilitation and restoration requirements, and
- Visual appearance and aesthetics.

Mineral waste facilities need to be geotechnically and erosionally safe and stable, not only during operation, but also after closure. The waste rock dumps and TSF need to undergo a full geotechnical and geochemical review by an appropriately-qualified independent engineering specialist at least once every two year. Information needs to be reviewed regularly and historical trends examined in order to assess the longer-term chemical behaviour. Operation, safety and environmental aspects are periodically reviewed during an inspection by a suitably-experienced and qualified engineer.

A good understanding of geotechnical factors governing mineral waste dump stability and the potential modes of failure at Rössing exist and directives for planning, design, construction and operation of these dumps are in place. Operational manuals regulate the management of the waste rock dumps, as well as the TSF and comply with Rössing Management of Pit Slopes, Stockpiles, Spoils and Waste Dumps (Rössing Safety Standard D3). The likelihood of injury to humans and wildlife is minimised through the design, construction and access control and through ensuring (geotechnical) stable conditions. In addition, the facilities are made inaccessible for temporary and long-term use or habitation.

Inspections of the TSF are carried out annually. Design engineers from Knight Piésold Consulting Engineering undertake an annual visit to review the site operation, visual integrity and deposition plan, with specific attention to site concerns and opportunities for improvement. A report is produced to present findings, review of monitoring data and key recommendations. A third-party-independent technical review is carried out every two years.

Radiation management at Rössing is regulated by the Radiation Management Plan (JK20/MMP/001). The radiation potential from mineral waste forms an integral part of the management plan, which aims to ensure that sources of ionising radiation are identified, quantified, controlled and minimised limited, and that exposures to these sources are limited. Dust management is regulated by several operational procedures, coordinated within the Rössing's Air Quality Management Plan (JE20/MMP/004).

The main source of potential groundwater pollution at Rössing is the TSF. Due to the acid-leaching process employed at Rössing, the tailings solution is acidic and contains residual process chemicals, heavy metals and radio-nuclides. Another source of groundwater contamination is leaching of nitrate, sulphate and uranium from the waste rock deposits overlying the gorges.

To ensure that water-quality parameters remain as close as possible to the range of natural variability and to allow optimal water use after closure, implies that surface water, groundwater and the biophysical environment is protected against exposure to hazardous waterborne chemicals. The surfaces of mineral waste dump facilities are therefore inward sloped to ensure that surface drainage is not allowed outwards. Downstream cut-off trenches prevent contaminated water to enter the Khan River.

A key mineralogical hazard to be considered is acidic drainage from mineral wastes (Rössing Environmental Standard E 4). Column rainwater leach tests on samples from the various waste rock disposal areas and low-grade ore stockpiles at Rössing indicated a possibility of acid rock drainage (ARD) from certain minerals, particularly those contained in the pyritic quartzite unit. However, this rock type is mostly found within the ore material and it is processed through the plant. Therefore, there is little chance of ARD being formed at the rock waste dumps, only at the TSF.

The low sulphide content of coarser mineral wastes and the neutralisation capacity of the marble lower the potential to generate ARD in the waste rock dumps further. Finally, the potential of the Rössing waste rock dumps to generate ARD is minimal due to the arid climate (average annual rainfall around 30 mm and net evaporation potential of 2,500 mm per year).

Investigations and risk assessments were carried out to understand the stability and seepage of the TSF in terms of layout, geometry and raised embankments with and without remedial measures (i.e. buttressing). Input data was obtained from previous studies and reports, seepage modelling, piezometer readings and seismic loading criteria. Outputs from the seepage models are applied as input parameters into slope stability assessments.

The probability of major incidents (for example slope stability failure and overtopping) occurring at the TSF will be minimised as long as the procedures of the operating manual are followed. Monitoring systems are in place to give early warning of the preventable hazards. If, however, an emergency situation does arise, the emergency response plan, as described in the operating manual, is to be followed. In an event which is not covered by the established plans, the situation is to be managed by the BRRP. Although major incidents involving the waste dump storage facilities are not listed in the BRRP, this programme will be used in the event of any major incident to the rock waste dumps.

The waste rock dumps and the TSF will remain as man-made landforms at mine closure. A state that allows passive re-vegetation and integration into functioning ecosystems is the preferred option.

4.5.3 Chemical substance management

Rössing uses existing Namibian legislation, international standards such as ISO 14001:2015, as well as the Rössing Performance Standard E2 (Hazard materials and non-mineral waste control and minimisation) for conformances and compliance in terms of chemical substance management.

The aim of Rössing is to ensure that all hazardous materials are handled safely and controlled responsibly, and all risks to the environment are mitigated. For this reason, monitoring programmes are in place to prevent spillages and environmental contamination from the transport, use, storage and disposal of hazardous materials.

A Hazardous material and contamination control management plan (JE20/MMP/002), is in place at Rössing. The plan guides:

- safety and responsibility of usage and control of hazardous material handled by Rössing
- control measures to minimise the risks and the environmental impacts due to spill or other escapes, and
- properly characterise and manage cases of contamination on site.

The Rössing standard requires an inventory of all hazardous substances and locations onsite to be maintained and valid material safety data sheet (MSDS) to accompany the hazardous material during storage, handling and transportation.

The plan also entails controls to prevent or minimise spillages during the handling and storage of chemical substances, conducting of routine inspections, monitoring procedures for leaks, integrity testing for deterioration of storage tanks and pipelines, spill and leakage detection equipment and emergency response plans. Regular internal and external audits, inspections and monitoring take place.

All employees who handle hazardous material are required to attend a compulsory training on hazardous material substances on an annual basis. Stakeholders (suppliers, service providers and end-users) are engaged to provide support in purchasing of chemicals and to ensure continuous improvement. Furthermore, the plan identifies the needs for engineering controls to prevent spillages, for example by means of secondary bunds.

In 2019, the first part of the secondary containment survey was completed to ensure that any possible spills are contained and will not contaminate the environment. Even though Rössing Performance Standard requires secondary containment for all above-ground pipelines transporting hazardous material, Rössing remains exposed, due to the main supply pipelines of the hydrocarbons and the sulphuric acid that are not contained.

A project request was submitted in December 2019 by the Processing Maintenance team with the aim to repair the acid collection sump and to seal off the open trench that leads to uncontrolled spillages of sulphuric acid into the environment during maintenance operations.

During 2019, there were no major spillages or leakages of the hazardous material reported as an environmental non-conformance.

4.6 LAND-USE MANAGEMENT

Rössing's total footprint increased from 2549.011 ha in 2018 to 2552.38 ha in 2019 (see Table 6). The use of land during mining operations is unavoidable, though much can be done to limit its impact. In 2019, only the TSF expanded with 3.37 ha.

Rössing is guided by the Environmental Standard: Biodiversity, Rehabilitation and Land-use Management that requires a permit system to disturb land. The permit system allows the Environment section to conduct an environmental impact assessment prior to disturbance.

It is through the assessment that the plants species of conservation value such as *Adenia pechuelii*, *Commiphora* species and *Aloe namibensis* were rescued in 2019 and replanted at the Namib Botanical Garden in Swakopmund in collaboration with the Ministry of Agriculture, Water and Land Reform.

Table 6: Rössing Uranium's footprint, 2014-2019 (ha)		Total prior to 2014	Total in 2015	Total in 2016	Total in 2017	Total in 2018	Total in 2019
Infrastructure	Plant	195.44	195.44	195.44	195.44	195.44	195.44
	Roads	24.22	24.22	24.22	24.3	24.3	24.3
	Water	6.45	6.45	6.45	6.45	6.45	6.45
	Infrastructure rehabilitated	39.91	39.91	39.91	39.91	39.91	39.91
Non-infrastructure	Open Pit	457.5	457.5	457.5	457.5	457.5	457.5
	Waste rock dumps	747.30	747.35	747.45	747.45	747.45	747.45
	Tailings storage facility	737.05	737.24	741.70	742.22	742.22	745.59
	Explorations	7.34	7.34	7.34	7.34	7.34	7.34
	Other	275.54	275.54	275.54	275.54	275.54	275.54
	Non-infrastructure rehabilitated	52.86	52.86	52.86	52.86	52.86	52.86
Total		2,543.61	2,543.85	2,548.40	2,549.01	2,549.01	2,552.38

4.7 BIODIVERSITY MANAGEMENT

Rössing is accountable to manage impacts associated with its operations to the environment and ensure the impacts are managed in accordance with regulatory commitments. Rössing ensures that the impacts on biodiversity and natural resource features are understood, and then preferentially avoids, minimise and rehabilitate, whilst seeking opportunities to collaborate with host communities for an integrated approach to mitigation wherever possible.

In 2019, Rössing was involved in various biodiversity awareness capacity building session and surveys continued that aimed at understanding and protecting biodiversity, as well as rehabilitation. The mine continued its proud membership to the Namibia Environmental and Wildlife Society (NEWS) which give us opportunities to contribute to conservation in Namibia. Our goal on biodiversity is to create a positive impact on biodiversity and contribute to conservation in Namibia at large.

4.7.1 Powerline survey

Direct avian mortality from collisions with power transmission lines is one of the impacts-acceptance criteria on birds that need to be monitored. Three power lines are monitored on a quarterly basis since 2015. The powerline monitoring continued in 2019, and no bird mortality was observed. The outcome of the monitoring of avian mortality feeds in the national plan of monitoring and managing power-line/bird interactions. This is the incorporated bird/wildlife mitigation into the planning of future power-line networks through the NamPower-NNF strategic partnership.

4.7.2 Alien vegetation assessment

Rössing and the National Botanical Research Institute (NBRI), a subdivision of Ministry of Agriculture, Water and Land Reform, conducted an alien vegetation assessment in 2019. The assessment aimed at identifying and mapping alien vegetation of ML28 (the Rössing mining license area) and to develop a management plan that will manage the invasion of alien vegetation on the land under the management of Rössing.

The alien vegetation at Rössing was rated as moderate due to its distribution, severity and likelihood of disseminating in the area. Species with high degree of ecological impacts on the environment such as high water-utilisation requirement, invading and encroachment potential were prioritised to be managed. Species such as the *Nicotiana glauca* and *Prosopis* species that forms part of the Namibia's "nasty nine" of invader species will be managed according to the developed Rössing Alien Vegetation Management Plan.

4.7.3 Feral cats management

There has been a concern of increased population of feral cats at Rössing. The mine borders with the Namib Naukluft Park and there was a concern of inbreeding with wild cat species. There was also concern that the cats could have unknown diseases that could be a health risk to employees. In addition, they are becoming a safety hazards to the mine's operation. Rössing sought for permission from the Ministry of Environment and Tourism to implement control measures necessary to bring this problem under control. A team of OHSE representatives were trained on handling cats by Swakopmund Vet Clinic. A cat-capturing procedure was developed and approved. In 2019, 15 cats were sterilised and two were euthanised as recommended by the veterinarian.

4.8 Management of rehabilitation

Rehabilitation is a "general term referring to all measures taken to repair damaged environments, including removal of infrastructures, cleaning up pollution and revegetating" (Burke, 2007:5). Rehabilitation is part of the mitigation hierarchy of biodiversity management.

4.8.1 Progressive rehabilitation

The progressive rehabilitation work continued in 2019 in the Dome gorge. The Upper Dome gorge area has been substantially disturbed during the construction phase of the mine. A priority listing of rehabilitation focus had been developed in the rehabilitation management plan. The Upper Dome gorge has been identified as the highest priority site for testing rehabilitation techniques.

In 2019, soil samples were collected in the area and sent for geochemical analysis to determine if there is any form of pollution and to determine the level of soil fertility. Determining pollution at disturbed area is one of the rehabilitation tasks that indicates if an area requires remedial actions or the area is suitable for plants and invertebrates to recolonise the area.

The results from the analytical laboratory were compared to the total concentration threshold (TCT) limits of the National Norms and Standards for the Assessment of Waste for Landfills Disposal of the National Environmental Management: Waste Act, 2008 (Act No. 58 of 2008) of South Africa. In the absence of national and South African standards, the Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health (2007) was used for uranium. The analysis showed that the concentration of the heavy elements indicated to be below TCT1, while the leaching concentration of the anions showed to be below leaching concentration threshold (LCT1).

The presence of hydrocarbons was below the detection limit in the area. The organic content of the soil was within the range of the expected levels of desert soil and there have been annuals and perennials such as dollar bushes that were observed thriving in the gorge, indicating the ability for plants to recolonise and thrive.

Rössing has consulted experts to determine the actions required for landscaping in the Dome gorge, which will be the focus going forward. Landscaping in this context refers to is reshaping man-made landforms to blend in with the natural environment. Activities in the Dome gorge would involve developing measure for flood mitigation, slope stability and to prevent erosion.

4.9 CLOSURE PLANNING

Mine closure is an integral part of Rössing's mine planning cycle, from exploration via mine development and production, to decommissioning and after care. Therefore, closure planning has been a continuous process at Rössing since 1992.

Changes in operational circumstances, environmental conditions, legislative and regulatory frameworks, and stakeholder expectations were considered every time plans were updated over the past 26 years. Current life-of-mine plans foresee cessation of mining and processing in 2026.

Rössing's closure plan is guided by an aspirational vision for a post closure situation that is translated into objectives and targets. The vision considers to a practical extend mitigating the socio-economic impact closure would have on the employees, the neighbouring towns of the Erongo Region, as well as on the environment around the site.

Principally, the Open Pit will not be backfilled; it will remain a mining void into the future. The rock cover on TSF post closure is one of alternatives being closely studied to prevent dust and rainwater erosion.

Rössing will continue recovering tailings seepage, but instead of reusing it for mining processes, it will be allowed to evaporate. The Processing Plant and the mine's infrastructure will be demolished. Recyclable materials will be decontaminated before selling. Materials not leaving the mine site will be disposed of safely and sufficiently covered so that they cannot cause harm.

To achieve these objectives and targets, Rössing has developed implementation plans for mitigation measures and calculated the associated closure costs. The development of a detailed closure plan at pre-feasibility level, containing more technical detail and higher cost-estimation accuracy than the current plan, has started in 2018.

Rainfall statistics have been confirmed by incorporating paleo flood events into the analysis. A start has been made to confirm that the planned rock cover for the TSF will not cause slope instability due to rainwater infiltration.

Detailed engineering designs for various alternatives to transfer long-term tailings seepage to an open-pit lake for evaporative disposal have been completed, allowing an informed choice to be made. A preliminary execution plan for the rest of the prefeasibility study has been completed.

The establishment of the Rössing Environmental Rehabilitation Fund, which provides for expenditures associated with the mine's closure, complies with statutory obligations and stipulated requirements of both the Ministry of Mines and Energy and the Ministry of Environment and Tourism. Accordingly, the fund agreement states that each year Rössing will make a contribution to the fund to provide for the eventual closure of the mine.

At the end of December 2019, the fund had a cash balance of N$1.19 billion. In 2019, the total cost of closure, excluding retrenchment costs, was estimated at N$1.716 billion. The mine will make additional payments to the fund each year to provide for the eventual total cost of closure by 2026.

5. APPENDIX

Figure 19: Location of transects and production boreholes (Drawn: Sokolic, 2018)