Rio Tinto

Environmental Report 2017

Rössing Uranium
Working for Namibia

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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 1.1).

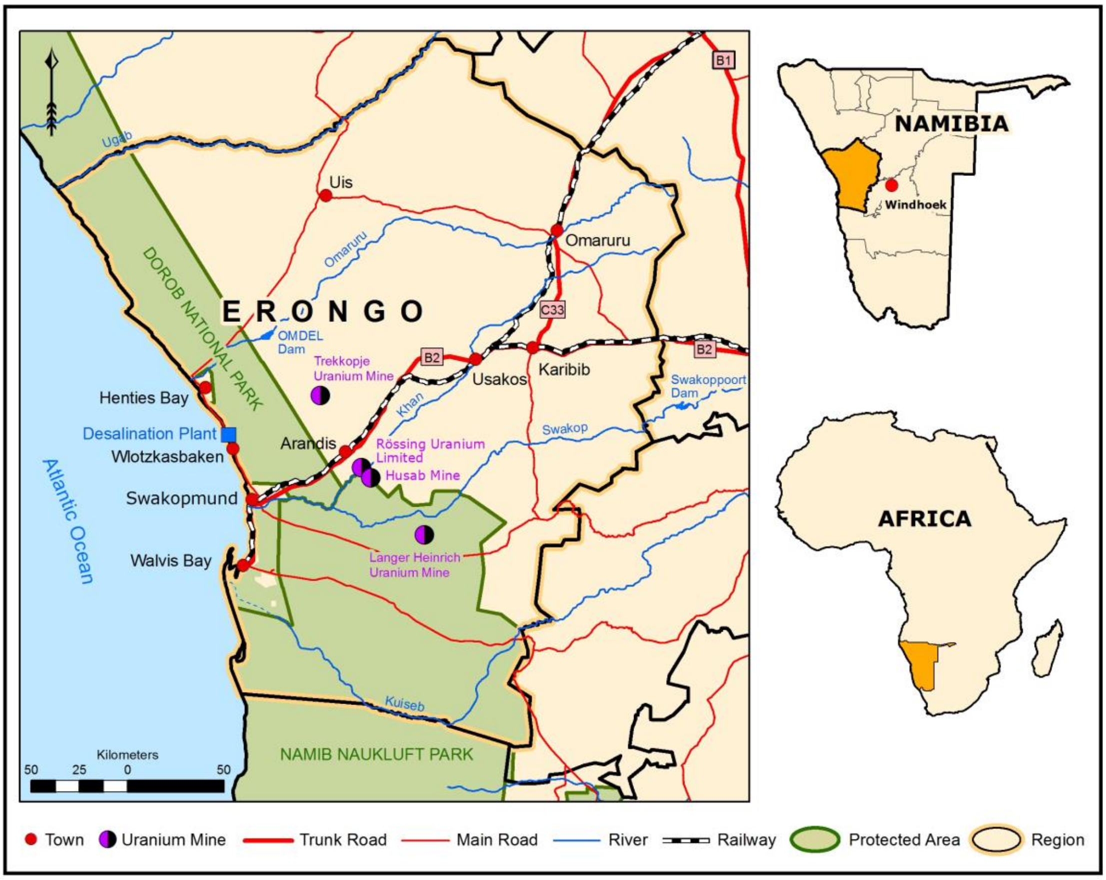


Figure 1.1: Location of Rössing Mine

Arandis is situated less than 10 km from the mine's main entrance gate. The coastal town of Swakopmund is about 70 km away and Walvis Bay is located 30 km south of Swakopmund. To the east, the nearest town to Arandis is Usakos – about 80 km away. Rössing is situated about 25 km upstream of the Khan / Swakop River confluence.

1.2 SHAREHOLDING

Rio Tinto is the majority shareholder of Rössing Uranium Limited, holding 69% of the shares. The Namibian Government has a 3% shareholding, with a majority (51%) when it comes to voting on issues of national interest. The Industrial Development Corporation of South Africa owns 10%, while individual shareholders own a combined 3% shareholding. The Iranian Foreign Investment Company owns 15%, a stake that was acquired during the set-up of the company in the early 1970s.

The minority shareholders have no uranium product off-take rights.

1.3 SCALE OF OPERATION

Rössing is the world's longest-running open pit uranium mine. It is a 24-hour operation, 365 days a year. Rössing is among the three Namibian uranium mines in operation which provides a considerable amount world uranium oxide mining output. Rössing has a nameplate capacity of 4,500 t of uranium per year and had produced 2,121.79 tonnes in 2017 which brings the total produced.

1.4 CURRENT LIFE OF MINE

The Life of Mine plan developed in 2011 foresees the end of mining activities in 2023, and closure in 2025.

At the end of mining activities in 2023, the final depth of the open pit will be reached at Bench 36, about 30 mamsl (metres above mean sea level). Processing of remaining ore stockpiles will continue for another two years, with the final uranium oxide production completed at the end of 2025.

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

2.2 CLIMATE

At Rössing rainfall measurements indicate an average annual rainfall of about 30 mm over the years. However, for the last 5 years rainfall received has been very low.
The total annual rainfall received on the mine was 8.2 mm in 2017, which is about 73% deviation from the long term average of 30.6 mm. The annual rainfall, and the long term rainfall average, is displayed in Figure 2.1.

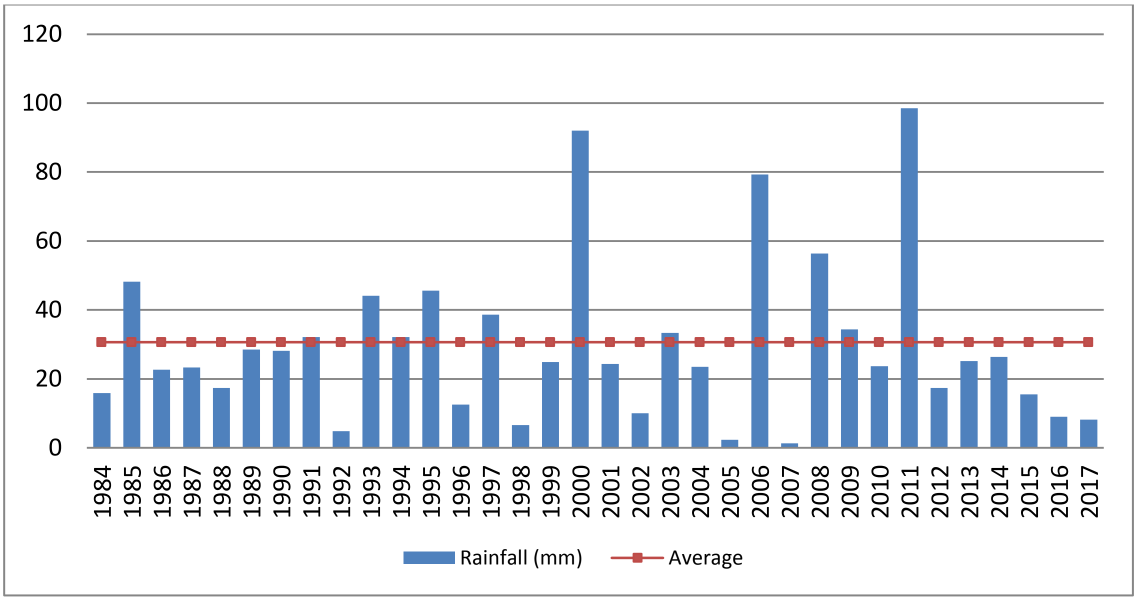
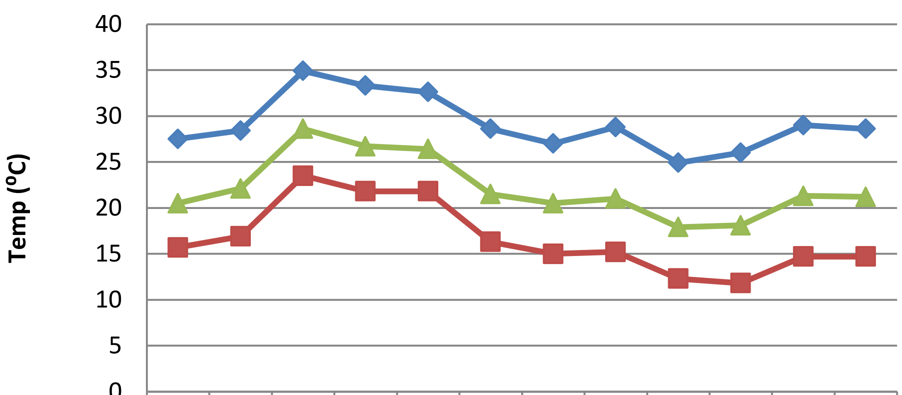


Figure 2.1: Variation in annual rainfall at Rössing

The variation between daily minimum and maximum temperatures are wide. The lowest temperatures are recorded during October and the highest temperatures are recorded in March as shown in Figure 2.2.



	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
Max	27.5	28.4	34.9	33.3	32.6	28.6	27	28.8	24.9	26	29	28.6
Min	15.7	16.9	23.5	21.8	21.8	16.3	15	15.2	12.3	11.8	14.7	14.7
Avera	20.5	22.1	28.6	26.7	26.4	21.5	20.5	21	17.9	18.1	21.3	21.2

Figure 2.2: Wind speed and direction measured at Rössing during 2017

The predominant winds experienced at Rössing are blowing from west-southwest as shown in 2017 wind rose (Figure 2.3). 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 evaporation rates that vary between 6 and 15 mm per day. The potential evaporation is thus around 3,000 mm per annum.

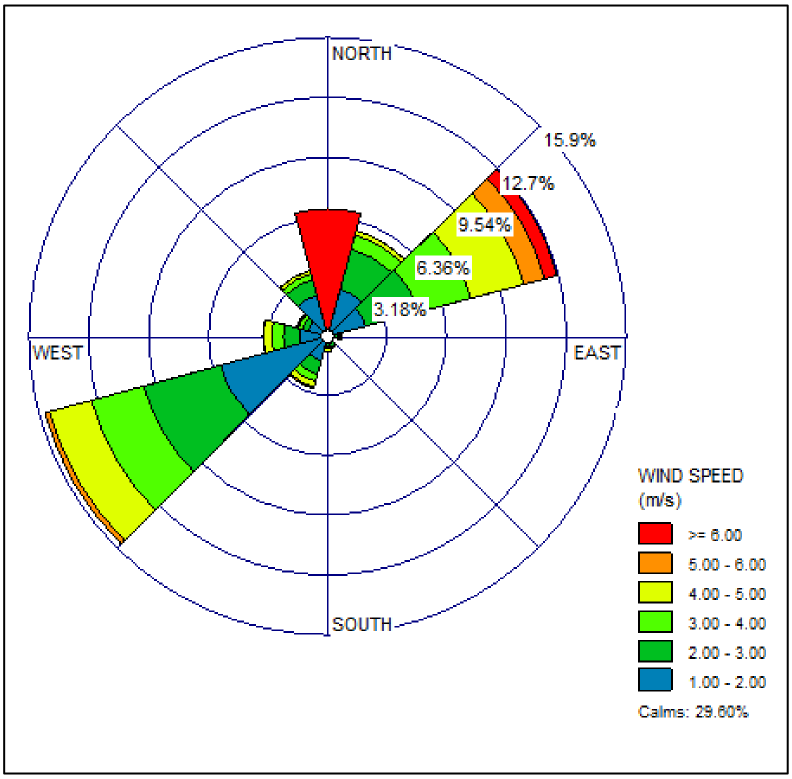


Figure 2.3. Wind speed and direction measured at Rössing during 2017

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 aim at 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, characterized 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, but grass is less. 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 at Rössing.

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 – Ana boom, Camel thorn, Tamarisk and thickets of the shrub *Salvadora persic* (Mustard tree). 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, and 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.

Superimposed 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 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 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 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 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 coupled 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 2017 was 1.2 m/s with the highest maximum wind speed over a one-hour period recorded at 18.8m/s. Though the recorded maximum speed was much lower in 2017, higher occurrences have been recorded before. These velocities usually occur during the winter and gusts of up to 34.90 m/s have been known to occur. The mean maximum gust is 26.17 m/s

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 2.1 summarizes localities relevant to wind direction at Rössing.

Table 2.1: Geographical position of localities relative to wind direction

Locality	Distance	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

Generally deposited dust is not 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 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 ML 28, potential environmental dust deposition is monitored at several stations around the mining operations.

While most of the dust generated in the 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 week with smaller blasts twice to 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 will 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, only to be remobilised again by wind action and vehicles.

Of the eight (8) common air impurities identified, five (SO_2, CO, NOx PM_{10} and dust deposition) are released at Rössing. However, only two are recognized as significant i.e. particulate matter smaller than 10 microns in diameter (PM_{10}) and dust deposition, which are regularly monitored. Rössing conducts annual monitoring of SO_2, CO and NOx that could be emitted as a result of the yellow cake roasting at the Final Product Recovery (FPR). In addition, greenhouse gas (GHG) emissions are estimated as carbon dioxide equivalent (CO_2-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, infrastructure 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. 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. 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 River. 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, about 10 km to the west of the Mining Licence area, is a near neighbour of the mine. Both parks fall within Category 2 of the International Union for Conservation of Nature (IUCN).

3. ENVIRONMENTAL 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 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. An audit evaluates the HSE MS periodically. During 2017 audits were conducted against the Rio Tinto Performance Standards and the HSEQ MS Standard (ISO 14001 surveillance), and Rössing maintained certification for ISO 14001:2004.

In addition to the HSE MS, Rössing implemented the Rio Tinto Health, Safety and Environmental Performance Standards in 2005. The intent of the standards is to gain commitment of employees on an annual basis to improvement in impact management performance. 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 maximizing 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.
- Maximize 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.

- 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 Management System is efficient and effective in managing HSE performance and meeting legal and other requirements.

4. ENVIRONMENTAL PERFORMANCE IN 2017

The Environmental Management Plan for Rössing contains a concise description of the management of environmental aspects and impacts at Rössing, from the designing to the decommissioning phase.

No significant environmental incidents occurred during 2017 and no deviation from the Environmental Management Plan is 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 maximize benefits and to minimize negative impacts. Key environmental management programmes include:

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

Performance in 2017 with regard to the environmental management programmes is discussed below.

4.1 ENERGY EFFICIENCY AND GREENHOUSE GAS EMISSIONS

Efforts to stabilise global atmospheric concentrations of greenhouse gas at lower levels is a priority to Rio Tinto and, as a result, Rössing measures these emissions too. The intensity of emissions is reported per unit of product target. Sources of greenhouse gas emissions include electricity and fuel consumption transport of reagents and uranium, blasting (explosives), waste (sewage, rubbish disposal and landfill) extraction and processing.

Greenhouse gas emissions intensity per unit of product target, the so called Tier 1 targets, is reported to Rio Tinto monthly and annually. The Tier 1 targets are shown in (Table 4.1).

Table 4.1: Tier 1 targets

Year	Emissions	Product uranium emissions target
	(tonne CO_2-e)	(t CO_2-e/tonne)
2014	**125935**	**82**
2015	**124149**	**82**
2016	**135654**	**74**
2017	**146426**	**62**
2018	**191524**	**52**
2019	**171644**	**43**
2020	**165515**	**39**

Tier 2 targets are internal and calculate energy use per unit of "work done". To calculate the greenhouse gas 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 set the Tier 2 targets, two processes are measured to calculate the total amount of energy use per work done. These two processes are hauling and milling, which are the two most energy-intensive processes of the mine's operations. Two indicators are used to measure energy use during these two processes:

- Haul metric: GJ/ kilo tonne of material hauled
- Plant metric: GJ/ kilo tonne of ore milled

4.1.1 PERFORMANCE IN 2017: TIER 1 TARGET - ENERGY EFFICIENCY

In the year 2017 production of 2 121.79 tonnes of uranium oxide drummed, the total energy consumption was 1 321 091.29 GJ. This converts to an annual energy consumption of 622.62 GJ/t uranium oxide produced, See Figure 4.1.

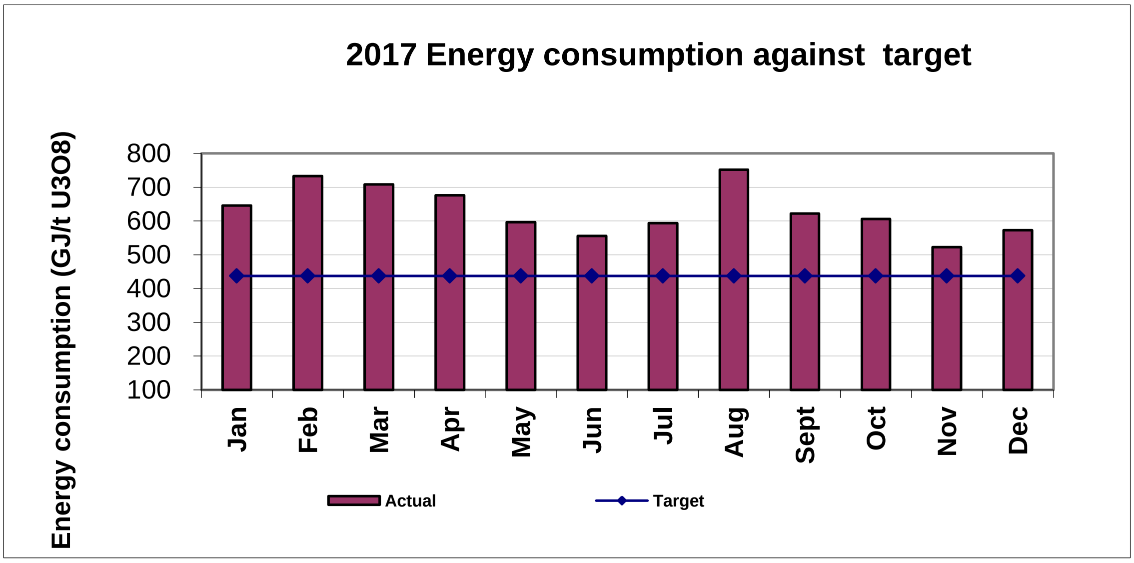


Figure 4.1: Total energy consumption intensity 2017

2.1.2 PERFORMANCE IN 2017: TIER 1 TARGET- GREENHOUSE GAS EMISSIONS

The actual performance achieved in 2017 amounted to 74.20 t CO2-e/t U_3O_8, which is 18% below the target of 90 t CO2-e/t U_3O_8 for 2017 (Figure 4.2).

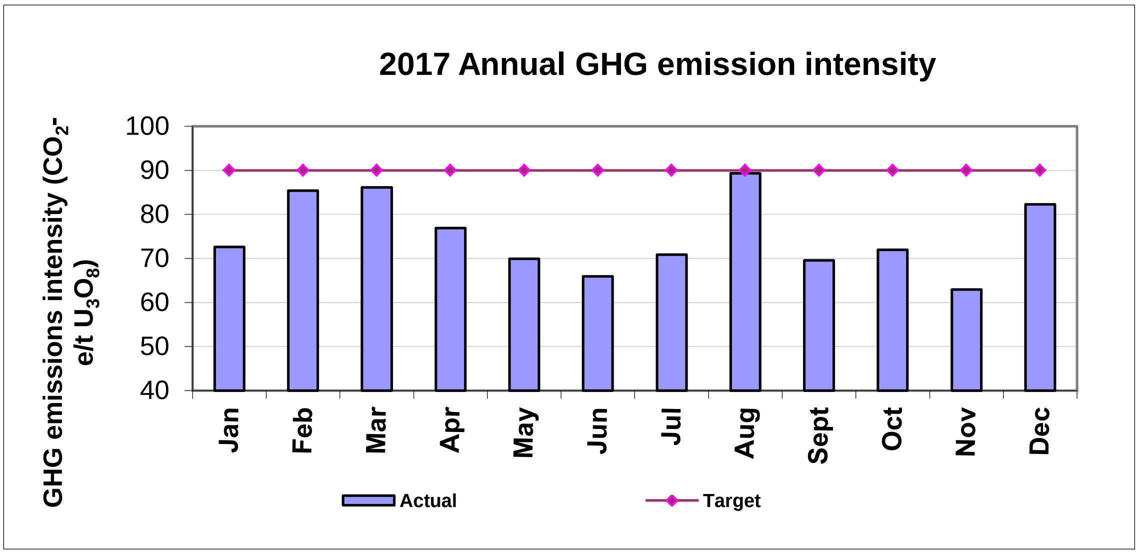


Figure 4.2: Total greenhouse gas emission intensity 2017

4.1.3 PERFORMANCE IN 2017: TIER 2 - IN-HOUSE METRICS

Rössing's performance against Tier 2 targets is displayed in Table 4.2. These targets were not met during 2017, mainly due to the unfavourable waste-ore ratio, the dependency on low-grade ore and the lower than expected production.

Table 4.2: Performance 2017: Tier 2 - Haul and plant metrics

Metrics	Target: 2017	Actual: 2017
Haul		
Haul metrics GJ/kt equivalent material hauled	17.68	21.95
Greenhouse gas haul metrics kg CO_2-e/t material hauled	1.41	1.79
Plant		
Plant metrics GJ/kt equivalent ore milled	45.17	52.64
GHG Plant metrics kg CO_2-e/t ore milled	**6.5**	**7.52**

4.1.4 CLIMATE CHANGE

As a business, Rössing participates in and influence evolving conceptual discussions and thinking on Climate Change and, where possible, attended national seminars and workshops on Climate Change policy and adaptive capacity.

4.2 AIR QUALITY CONTROL

The current Air Quality Management Plan (JE20/MMP/004) guides the management of environmental dust at Rössing. Air emissions are listed in an inventory and all air quality standards applied at Rössing are documented. In short, improvements of the air quality management practice at Rössing aims at

- a refined understanding of Rössing's dust footprint, in correlation to wind regime
- a review of the existing sources of emissions from mining operations
- characterising ambient air quality
- a better understanding of the correlation between blasting and its impacts – dust, noise and vibration
- a better comprehension of atmospheric impacts on the biosphere
- review of control measures to recommend additional measures if needed, and mitigation to manage air quality better.

4.2.1 ENVIRONMENTAL DUST

Measurements are taken in order to ensure that exposure levels to dust do not exceed prescribed occupational limits and to ensure that existing and newly introduced controls efficiently detect differentiations as a result of process changes. Informed risk-based decisions, related to the level of control, are introduced for the various exposure levels – with the objective to optimise performance in terms of emission reduction and control measures. Dust fall-out is monitored and recorded internally – monthly on site and annually to Rio Tinto – to reduce dust through innovative controls.

In 2017, the PM_{10} monitoring point at the southwest mine boundary despite several East wind events, dust concentrations recorded at this station remain below the WHO standard of 0.075 mg/m^3, even though the monitor station was mal-functioning for two months, and readings were incorrect, readings for all the other months were much lower than the standard of 0.075 mg/m3 (see Figure 4.3).

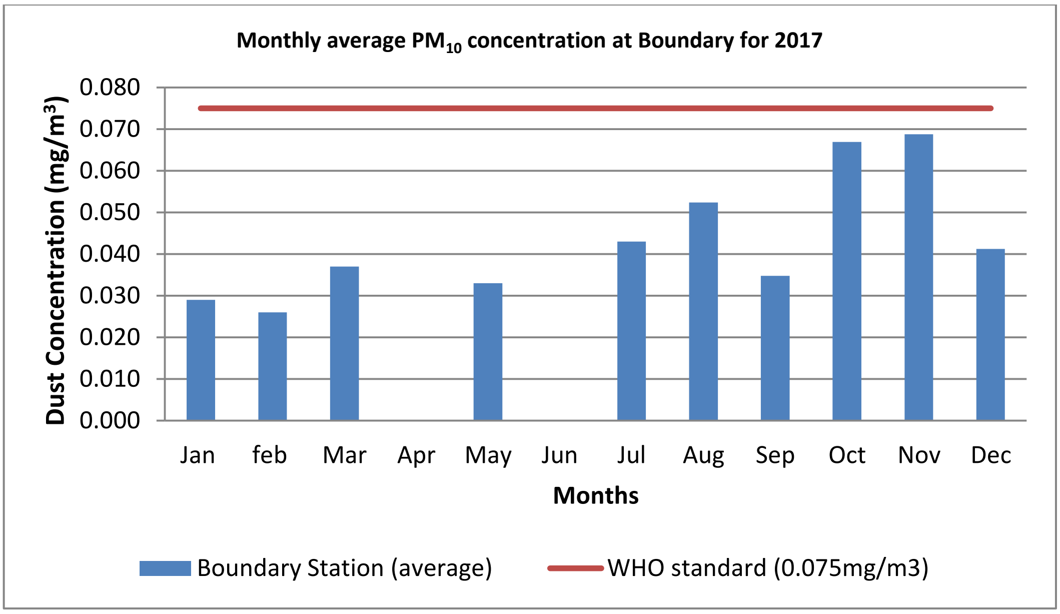


Figure 4.3: Ambient dust levels at the southwest boundary of the mine in 2017

The very low readings (average 0.075mg/m^3) indicate that PM_{10} dust dispersal from potential sources in the operational areas is limited in distance and does not cross the boundary to the southwest of the Mining License area.

PM_{10} dust levels are also monitored at Arandis; dust concentrations recorded at this station remain below the WHO standard of 0.075 mg/m^3 as can be seen in Figure 4.4.

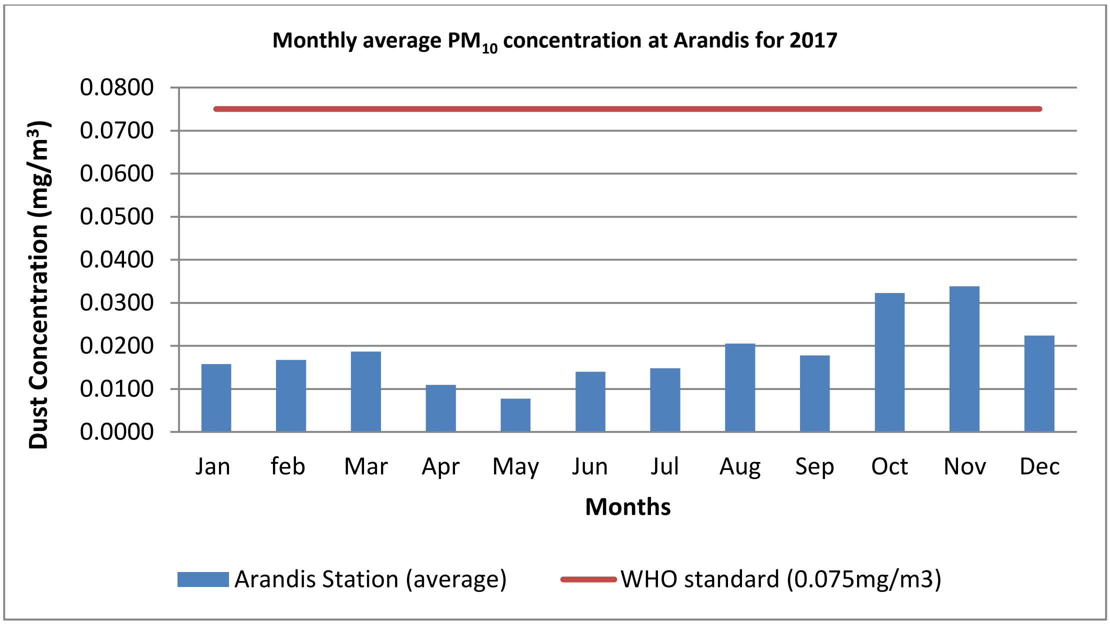


Figure 4.4: Dust concentrations measured in Arandis 2017

4.2.2 OTHER AIR EMISSIONS

The bi-annual assessment of stack emissions to evaluate the efficiency of filters, and to measure the emissions of impurities such as SOx and NOx, was conducted. Mercury emissions were monitored at the Final Product Recovery, indicating insignificant gas emissions at the time of measurement.

4.2.3 NOISE AND VIBRATION

Noise and vibration at Rössing is monitored through a network of various points and studies. Information is used to assess compliance and to address concerns, as well as feedback to the Geotechnical Section, who utilized the information in investigating the impact of blast vibrations on the stability of the pit. The management of noise and vibration is guided by the Rio Tinto Performance Standard E6 (Noise and Vibration Control) on which the management plan (JE20/MMP/008) is based. Environmental noise is monitored according to a procedure and monthly reported to minimize noise to threshold levels and to identify events when it is exceeded.

The highest air blast measured on the mine site during 2017 was 117.6 dB, in October. The lowest reading was 110.6 dB in September, as displayed in Figure 4.5. In short, the air blast levels have been consistently below the limit of 134 dB during 2017.

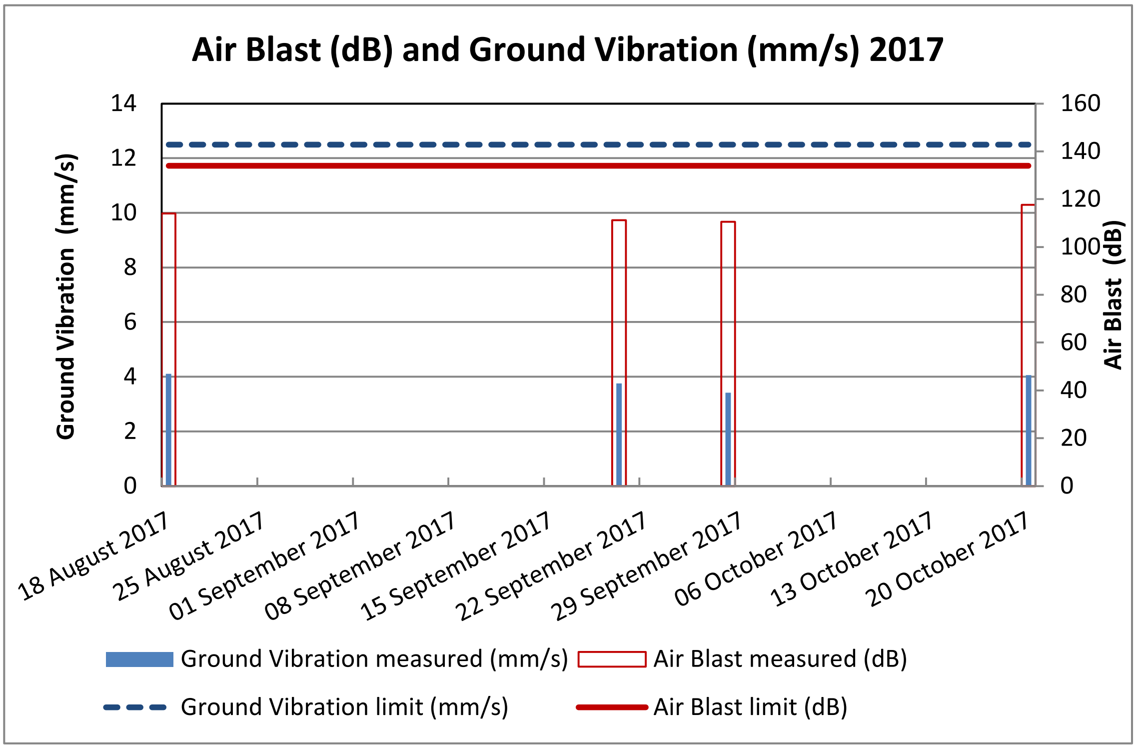


Figure 4.5: Air blast and Ground vibration levels measured during 2017

The highest resultant peak particle velocity (ground vibration) measured on the mine site for 2017, as displayed in Figure 4.5, was 4.11 mm/s in August and the lowest was 3.41 mm/s, in September. The ground vibration levels have been consistently below the limit of 12.5 mm/s throughout the year with some gaps of no detection of the vibrations.

Environmental noise is measured over snapshots of ten minutes. Figure 4.6 provides a compilation of these snapshots, related to the months of the year.

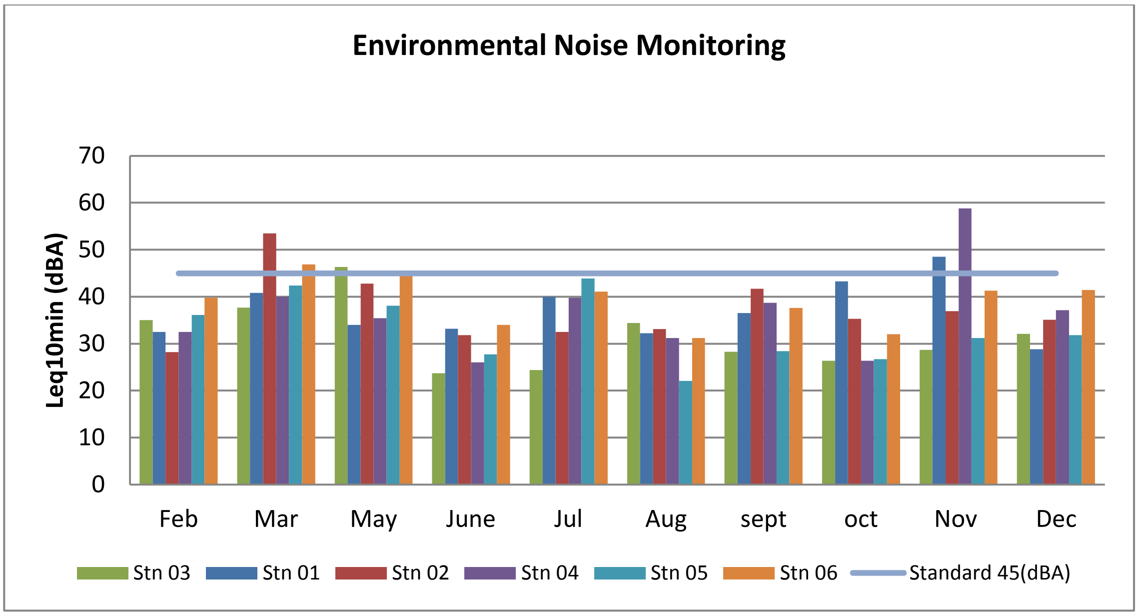


Figure 4.6: Environmental noise levels measured during 2017

There were six (6) events during which the standard was exceeded, i.e. above 45 dB(A), as recorded at the sampling points in 2017. Station 06, at the Khan riverbed, recorded two (2) such events and this is mainly due to the wind rustling foliage. The highest Leq10 recorded in 2017 was 58.8 dB(A) recorded at Station 04, in the Khan riverbed due to natural sounds of bird songs in the Khan River. The lowest Leq10 recorded in 2017 was 22.1 dB(A), recorded at Station 05 in the Khan riverbed.

In conclusion, the events during which noise levels exceeded the standard are not ascribed to the operational activities at Rössing, but can be explained as the result of natural sounds such as bird songs, wind rustling foliage and light vehicle movement in the vicinity of the sampling points.

4.3 WATER USAGE

Water management at Rössing is guided by a formal water strategy (JE05/STR/001) and Water Management Plan (JA10/MMP/001), developed according to the Rio Tinto Performance Standard “Water quality protection and water management” (E11) and supported by Rio Tinto’s Water Use and Quality Control Guidance Notes. It covers all activities connected to water abstraction, dewatering, transport, storage, usage (potable and process), and direct / indirect discharge, involving surface water (including run-off), impounded water and groundwater. The intent of the Standard is to ensure efficient, safe and sustainable use and protection of water resources and ecosystems.

Facing water usage challenges head-on, reductions aim at recycling of water, the extracting and re-use of water from the Tailings Storage Facility, minimizing high evaporative water losses, using alternative and lower-quality water sources, and creating awareness to conserve water. Water used for cleaning in the processing plant is captured and recycled. Effluent from workshops is pumped to an oil separation plant, from where the separated water is mixed with semi-purified sewage effluent and re-used in the open pit.

A groundwater flow model for the mine exists, which assists in the assessment of ongoing operations and the consequent predictions of impacts of various long-term options. Seepage of contaminants into alluvial aquifers is curbed by cut-off trenches and dewatering boreholes which are arranged in a double line on and along the western side of the tailings storage facility, in addition to the surface seepage collection dam.

The efficiency of measures to control possible contamination of the Khan River is ensured with regular borehole water monitoring. The tailings storage facility is continuously monitored over 24 hours, generally completing a circuit every 2 hours. Groundwater flows and water quality are monitored at various other points and the seepage control installations are monitored frequently. Monitoring includes checks on the available capacity at each operational open end as well as the water levels and shift log sheets are completed for evaluation. Flow meter readings are taken once per week and entered in a dedicated database to compile water balances and permit returns which is submitted to DWA on a monthly basis. By legal requirement (as per industrial and domestic effluent disposal exemption permit), 15 boreholes are required to be monitored annually. Monitoring includes an analysis of radio-nuclide concentration, in Bq/L. In 2017 a total of 28 boreholes were analysed for radio-nuclide concentrations and chemical analysis were conducted for 65 boreholes, sumps and trenches.

Water storage in the tailings facility is minimised through a seepage recovery system and cut-off trenches as well as abstraction boreholes on and around the tailings facility, which are pumped continuously to lower the water table and to reduce the advancement of groundwater contamination into the Khan aquifer. Water recovered in this way is re-used in the processing plant.

Saline groundwater abstracted from the Khan River Aquifer is used to spray on haul roads in the Open pit to suppress dust; in 2017 a total of 104,755 m3 was pumped. The abstraction permit which is valid, permits a total of 870 000 m3 per annum. Abstraction is maintained below 600 m3 a day as much as reasonably possible, which is below the safe allowable yield. In addition, the vegetation and water levels in the Khan and Swakop Rivers are monitored in order to assess the potential impacts of the abstraction.

As can be seen in Table 4.4, the total freshwater usage for 2017 was 2.986million m3, fresh water consumed per tonne ore milled was 0.335 m3 per tonne, the ratio of fresh water to total water consumed was 0.4 and the total volume of seepage water collected was 2.083 million m3.

Table 4.3: Water targets

PERFORMANCE DATA TABLE	Actual 2014	Actual 2015	Actual 2016	Target 2017	Actual 2017
Fresh water consumption (Mm^3)	2.436	2.059	2.654	2.849	2.998
Fresh water per tonne ore milled (m^3/t)	0.346	0.3	0.289	0.3	0.335
Ratio of fresh water : total water	0.43	0.36	0.38	0.37	0.4
Seepage water collected (Mm^3)	1.848	2.066	2.407	2.409	2.083

In 2017, upgrade on the seepage recovery system (for Trenches B, C, E and G) commenced and is scheduled for completion end March 2018. It is envisaged that the upgraded seepage recovery system will aid in reducing fresh water requirements by maximising seepage water collection through more reliable, robust and state of the art systems.

4.4 WASTE MANAGEMENT

In the absence of a clear legislative framework for waste management in Namibia, Rössing uses international standards such as ISO 14001:2004 as well as the Rio Tinto Environmental Performance Standard E15 (Hazardous material and non-mineral waste control and minimisation) for conformances and compliance.

4.4.1 MANAGEMENT OF NON-MINERAL WASTE

Non-mineral waste at Rössing is characterized, and an inventory and a risk register per work area are maintained. An over-arching non-mineral waste management plan is in place to ensure sound non-mineral waste management through minimization of waste generation and safe handling, treatment and disposal of waste. The plan addresses all non-mineral wastes generated at Rössing during the operational phase and will be revised for the decommissioning phase. A database for historical waste dumps is also maintained and guidance for the remediation of these sites during operations exists.

Review of the waste management plan is conducted at least every second year. In short the objectives of the plan are:

- Avoid waste generation – the use of substitutes or alternative processes reduces the volume of total wastes and hence management requirements
- Reduce waste generation – waste reduction reduces costs of further treatment and decrease the risk of pollution associated with disposal facilities
- Segregate waste – allows for different waste streams to be recycled, reused or disposed of correctly
- Re-use and recycle waste – reduces the volume of waste disposed of and has the potential to improve economic gain

Specific targets for waste management at Rössing are set annually and progress is monitored and reported annually. Effectiveness is measured against the following performance indicators:

- Number of non-conformances recorded.
- Increase in number of recycled/re-used waste.
- Reduction in waste generated.
- Incidents of pollution.

Rossing employs Integrative waste management by collection, disposal, recycling out sourced to one stop service provider. The waste management contract was awarded to Karee Investments in June 2016 to handle and remove recyclable materials such as scrap metal and packaging materials (including containers, paper and wooden pallets) on-site. The contract includes agreement on the recycling of specified waste streams and the terms for removal of waste from site against monetary targets.

Waste is weighed and a register is kept for reporting against targets. On-site landfill site is partially operational only building rubbles and garden refuse is disposed at the landfill. Records of waste generated, stored and disposed of are filed and maintained. Groundwater in the vicinity of the landfill site is monitored, according to operational procedure.

Redundant material and equipment that could potentially be contaminated is segregated according to criteria and disposed in a designated site on the tailings storage facility and the quantity and disposal location is recorded. Access to the contaminated waste disposal site is controlled.

Table 4.4: Non-mineral waste volumes (in tonnes)

Year	Steel	Cardboard & Paper	Wood	Plastic	e-waste	Conveyor	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	1,251	>100 %

There was a significant decrease in the total waste generated and disposed during 2016. This is a result of no dedicated waste management contractor appointed on-site. During 2017 a significant increase was observed in recyclable waste (mainly scrap metal, domestic waste) moved off-site by the waste management contractor. This resulted from the cumulative waste that was stored on-site during the duration when no waste contractor was appointed on-site therefore disposing off historical waste. These recyclable materials are sorted further by the waste management contractor at the Swakopmund facility for eventual dispatch to Windhoek for recycling and for use in the Refuse Derived Fuel plant. The unrecyclable materials end up at the Swakopmund landfill site.

The measureable target for the reduction of non-mineral waste destined for disposal was set at 80% for 2016. This target was not achieved with a final result of 46% (see Table 4.5). Based on a 10 year average percentage, it is recommended that the target remains at 80% to guide Rössing's current drive to increase the volume of waste recycled.

4.4.2 MANAGEMENT OF MINERAL WASTE

At Rössing mineral wastes are identified as waste rock and tailings. The Rössing Mineral Waste Management Plan (JE20MMP009) has been developed and prepared in accordance with the Rio Tinto Mineral Waste Management Guidance Notes and the Rio Tinto Performance Standard "Chemically Active Mineral waste Control" (E13), as well as Namibian regulatory requirements. The intent of the plan is to ensure sound and effective mineral waste management by ensuring the safe handling, treatment and disposal of these wastes. The Mineral Waste Management Plan for Rössing will be revised at the beginning of 2017.

The purpose of the plan is to provide a documented record of the characteristics of the mineral waste, the disposal sites used, historical and future placement, environmental impacts and projected chemical behaviour in future. Waste storage facilities are placed within permitted areas only. Considerations in the placement are:

- Preferentially placing waste within inactive portions of open pits 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 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.
- Balancing economic considerations such as haul profiles, potential resource sterilization, and pumping costs with environmental, social and closure considerations.

Waste rock consists of typically coarse, angular fragments of very strong rock material that is resistant to mechanical disintegration and chemical decomposition, with the exception of the rock type’s amphibole schist and biotite schist. Both of these rock types are occurring in minor quantities in the open pit and are generally associated with uranium grade and are mostly processed as ore. Typically thus, the Rössing dumps are of pervious, frictional material placed on competent, but steeply sloping foundations of barren country rock.

An inventory of disposed mineral waste is kept at Rössing. It reflects the tonnage per year, the cumulative tonnage, surface area, volume and the location of the waste disposal site. Site maps are maintained by the mine’s survey department. The spatial footprint of mineral waste and any changes during a specific year are annually reported.

Reshaping of the new mining and processing landforms represented by the waste rock dumps and the tailings storage facility need 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 tailings storage facility an operating manual sets out the procedures to be followed in accordance with the engineering design. The following management objectives are set:

- Maintenance of geotechnical stability and access control.
- Radiation and radon emanation is controlled.
- Management of surface drainage and rainwater leaching prevents contamination.
- Rehabilitation and restoration meets long term objectives.
- Visual appearance and aesthetics fits into the surrounding landscape.

Operational manuals regulate the management of the waste rock dumps and comply with the Rio Tinto Management of Pit Slopes, Stockpiles, Spoils and Waste Dumps (Rio Tinto Safety Standard D3). A similar standard regulates the management of the tailings facility (Rio Tinto Safety Standard D5). The likelihood of injury to humans and wildlife is minimized 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 tailings facility are carried out regularly by the Engineer of Record who is responsible for the design and implementation of changes to the facility. An Independent External Technical Review Team inspects the facility and its design every two years and reports on the findings and recommendations for improvement.

The combined surface area of the waste rock dumps and the tailings facility is currently calculated at 1376.6 ha. The surface area of the tailings storage facility was expanded with 4.5 ha during 2016, whereas the surface area of the waste rock dumps was maintained during the year.

Table 4.5: Mineral waste disposed in 2010 – 2017

	2010	2011	2012	2013	2014	2015	2016	2017
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
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

*volume in tonnes

The waste rock dumps and the tailings facility will remain as mining landforms at mine closure. Visual impacts of the final landforms are minimized in order to maintain the characteristics and attractiveness of the surrounding landscape. Deposition of mineral waste is thus scheduled in such a way that it complements the contours of the surrounding landscape. Rehabilitation actions that allow passive revegetation and integration into functioning ecosystems are the preferred option.

4.4.3 CHEMICAL SUBSTANCE MANAGEMENT

Rössing uses existing Namibian legislation, international standards such as ISO 14001:2004 as well as the Rio Tinto Environmental Performance Standard E15 (Hazard materials and non-mineral waste control and minimisation) for conformances and compliance in terms of chemical substance management.

The intent of the Rio Tinto standard is to ensure the safe and responsible use and control of all hazardous materials handled by the mine operations, commensurate with risks to the environment and prevents spillage and environmental contamination from handling, storage and processing. For this reason monitoring programs 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.
- Properly characterise and manage cases of contamination on site.

The plan requires an inventory of hazardous substances and accompanying Material Safety Data Sheets. The plan also entails controls to prevent / 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.

Awareness on the handling of chemical substances is promoted continuously. 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 (by means of secondary bunds, for example).

4.5 LAND USE MANAGEMENT

The disturbance of land is an inevitable consequence of any mining activity. It is Rössing’s objective to keep expansions of the “footprints” of the open pit, the rock disposal areas and the tailings facility to the minimum. This is achieved by following a strategy of preventing area extensions and instead developing the facilities to higher heights avoiding impacts on plant and animal life and on archaeological finds.

Table 4.6: Footprint since 2013

		Total in 2013*	Total prior to 2014*	Total in 2015*	Total in 2016*	Total in 2017*
Infrastructure	Plant	195.44	195.44	195.44	195.44	195.44
	Roads	24.22	24.22	24.22	24.21	24.3
	Water	6.45	6.45	6.45	6.45	6.45
	Infrastructure rehabilitated	39.91	39.91	39.91	39.91	39.91
Non-infrastructure	Open Pit	457.5	457.5	457.5	457.5	457.5
	Waste rock dumps	745.25	747.30	747.35	747.45	747.45
	Tailings storage facility	734.14	737.05	737.24	741.703	742.221
	Explorations	7.34	7.34	7.34	7.34	7.34
	Other	275.54	275.54	275.54	275.54	275.54
	Non-infrastructure rehabilitated	52.86	52.86	52.86	52.86	52.86
Total		**2538.65**	**2543.61**	**2543.85**	**2548.403**	**2549.011**

*totals in hectares (ha)

The total disturbed area calculated for 2017 was 0.608ha. The footprint of tailings increased by 0.5ha and about 0.09ha service track between Trench C and E contributed to the total land disturbed in 2017. To date, RUL total foot print is 2549.01 ha.

4.6 BIODIVERSITY MANAGEMENT

Rössing Uranium has committed in the HSE policy to enhance biodiversity protection by assessing and considering ecological values and land-use aspects in investment, operational and closure activities.

One of the highlights of 2017 was the continuation of the invertebrate monitoring programme by means of pitfall trapping method in the wider landscape; the focus was in the Rocky hill side that has not been sampled in the past. The results of 2017 showed that 22% of the species recorded in 2017 (48 out of 212) had not been found in 2016 and were first recorded for these sites in 2017. This shows that generally less common species than those initially found in 2016, and take them as confirmation that the increased sampling effort since 2016 is being effective in recording the uncommon species.

In the past, the invertebrate monitoring was carried out with the aim to collect information about the occurrence of 18 conservation important invertebrate species. With a particular focus on discovering the 4 spiders only found to date within the rocky hill habitat from the 1984 survey at Rössing uranium. Dr John Irish, leading Namibian ecologist analysed invertebrate monitoring data set of 2010-2015. The results revealed that none of the species concerned has been seen in the traps. However, the study also revealed that there was no change in invertebrate biodiversity since 1984.

We monitor invertebrates to obtain and add knowledge on biodiversity in the region. Monitoring of invertebrates improves understanding of invertebrate abundance and diversity in the area we operate, knowing the types of invertebrate and their conservation status, enables the mine to apply appropriate management strategies to manage impact on invertebrate. Going forward invertebrates monitoring will continue focusing on historical active but now dormant areas to see how the natural environment has re-established itself over period of time. This is essential to the mine because it will validate that natural recovery is viable when the land forms are enhanced for natural recovery in hyper arid ecosystems.

Rössing hosted the Birdwatching event on 15 September 2017 during the Biodiversity coastal week. A number of Rössing’s environmental best practices were presented to the learners by means of informative posters. The topics covered included amongst other water management, air quality, waste management and biodiversity management.

Birdwatching day is considered as a valuable Additional Conservation Action; although the Birdwatching day value cannot be quantified, the event contributes to raising Rössing’s reputation as a company striving to address its biodiversity impacts and contributing to the conservation of biodiversity and interest in Namibia. Bird watching is also reported annually to the Strategic Environmental Management Plan (SEMP) for the Central Namib.

4.6.1 MANAGEMENT OF REHABILITATION

Guidance from legislative and regulatory frameworks on rehabilitation in Namibia is limited. Rehabilitation is long term based and closely coupled to long term monitoring requirements and research, especially in arid environments. The sustainability of rehabilitation interventions in arid environments is uncertain and clarity in terms of criteria and sign-off is needed. The existence of exit plans and clarity with regard to relinquishment of land are also important prerequisites for Rössing.

Rössing’s mine is preparing for closure in 2025. In respect of ecological rehabilitation some upfront work will be carried out to allow a more focussed options analysis and choice of preferred option. This work would comprise of slope stability and rehabilitation trials, seed collecting and storage trials, confirmation of regulatory requirements, proposed completion criteria and collaboration with research institutes.

A rehabilitation strategy plan was developed to outline progressive rehabilitation activities of 10% of the footprint at Rössing, the rehabilitation activities for 90% of the footprint areas is covered in the Closure Management Plan 2012.

4.7 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, and changes in operational circumstances, environmental conditions, legislative and regulatory frameworks, and stakeholder expectations were considered every time plans were updated over the past 20 years. Current life-of-mine plans foresee cessation of mining in 2023 and processing in 2025.

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

Current mine plans foresee a cessation of production six years from now at the end of 2025. Principally, the Open pit will not be backfilled; it will remain a mining void into the future. The Tailings storage facility will be covered with waste rock to prevent dust emissions 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 them. Materials not leaving 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. A detailed closure plan at pre-feasibility level, containing more technical detail and higher cost-estimation accuracy than the current plan, will be developed in 2018.

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 the mining company will make a contribution to the fund to provide for the eventual closure of the mine.

At the end of December 2017, the Fund had a cash balance of N$718 million. In 2017 the total cost of closure, excluding retrenchment costs, was estimated at N$1.58 billion. The mine will make additional payments to the Fund each year to provide for the eventual total cost of closure by 2025.