Rio Tinto

# Implementation of Radiation Management Plan Annual Report for Rössing Uranium Limited, 2017

Rössing Uranium
Working for Namibia

Table of Contents 2

## Abbreviations

The following abbreviations are used throughout the report:

| | | |
|---|---|---|
| Bq | – | becquerels, decays per send, unit for measuring radioactivity |
| g | – | grams |
| HSEC | – | Health, Safety, Environment and Communities |
| kBq | – | kilo-becquerels, 1,000 Bq |
| LLRD | – | Long Lived Radioactive Dust |
| mBq/L | – | milli-becquerels per litre, $10^{-3}$ Bq per litre |
| mSv | – | milli-sieverts, sieverts/1,000 |
| µSv | – | mico-sieverts, sieverts/1,000,000 |
| µSv/a | – | mico-sieverts per annum |
| mSv/a | – | mSv per annum |
| mg/m$^3$ | – | milligrams per cubic metre, 1/1,000$^{th}$ of a gram per cubic metre |
| µg/m$^3$ | – | micrograms per cubic metre, 1/1,000,000$^{th}$ of a gram per cubic metre |
| µg/L | – | micrograms per litre, $10^{-6}$ grams per litre |
| NRPA | – | National Radiation Protection Authority |
| ppm | – | parts per million |
| PM10, $PM_{10}$ | – | Particulate matter with particle size below 10 microns |
| RUL | – | Rössing Uranium Limited |
| RMP | – | Radiation Management Plan |
| RPO | – | Radiation Protection Officer |
| RSO | – | Radiation safety officer (statutory role) |
| SEG | – | Similar exposure group |
| TLD | – | Thermo luminescent dosimeter |
| TEA Lab | – | Trace Element Analysis Laboratory |
| TSF | – | Tailings Storage Facility |
| NUI | – | Namibia Uranium Association Uranium Institute |
| UOC | – | Uranium oxide concentrate |
| WHO | – | World Health Organisation |
| XRF | – | X-ray fluorescence |

# 1 Introduction

## 1.1 Background

Under the Radiation Protection Regulations,[1] an annual narrative report to the National Radiation Protection Authority (NRPA) about the implementation of the site Radiation Management Plan (RMP) is a requirement.

We are hereby presenting the fifth narrative report since the implementation of this requirement. The previous reports (2013 to 2016) are publicly available on the Rössing website, http://www.rossing.com/reports-research.htm.

As required, this report is accompanied by data reported separately in the prescribed format, including:

- average exposure dose records for each similar exposure group (SEG) for the year 2017, for each of the three pathways monitored separately;
- personal dose records for the past year for each employee working at the mine in the past year;
- cumulative dose reports for all employees who have left the organisation in the past year;
- a list of sealed source on the mine with the current source activities and the location of each source;
- a list of the uranium oxide exports undertaken in 2017; and
- a summary of the radioactive waste deposited or stored, both mineral and non-mineral in origin.

# 2 Organisational arrangements

## 2.1 Organisational structure

The organisational structure relating to Radiation Safety in 2017 is shown in Figure 1.

We have made a minor change to the organisational structure after one of our officers left the team: The vacant officer position was converted into a Specialist role. This change was made to reflect the significant specialisation needed in the radiation safety team. The expertise required is better addressed by a role distribution with more senior roles.

In the meantime, Dr Bertram Schleicher has applied for and been awarded the role of Specialist, with his previous position, Advisor Radiation Safety now vacant and currently being advertised.

[1] Radiation Protection And Waste Disposal Regulations: Atomic Energy And Radiation Protection Act, 2005 (Act No. 5 Of 2005)

In order to promote on-the-job coaching and succession planning, Nelao Endjala has been registered as an understudy to Dr Bertram Schleicher, with regular coaching and training undertaken on a continuous basis.

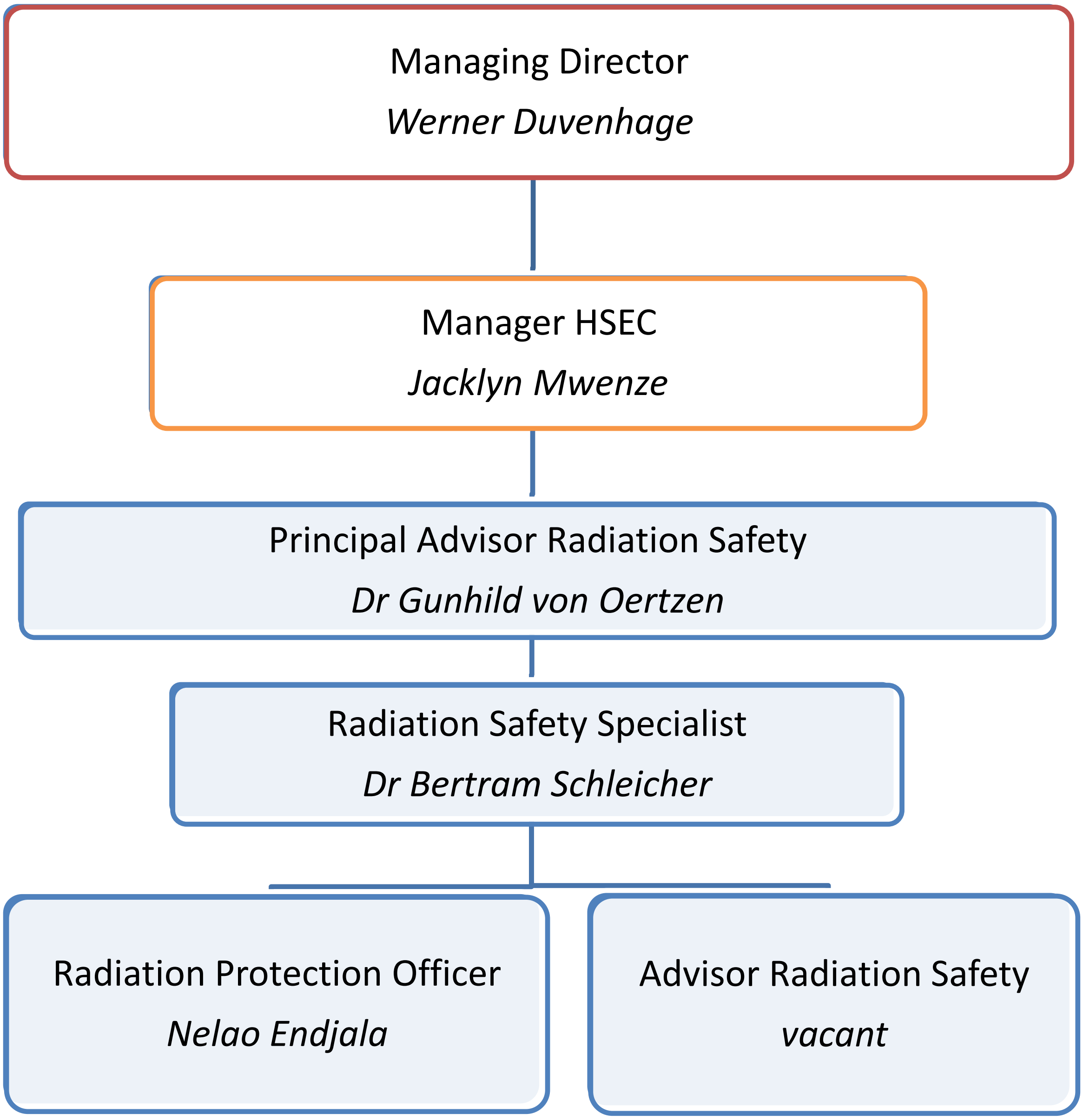


*Figure 1: Organisational structure for Radiation Safety Section, end 2017*

## 2.2 Capacity building

In 2017, two team members attended the international uranium conference held by the Southern African Institute of Mining and Metallurgy, SAIMM, in September 2017 in Swakopmund. Dr Bertram Schleicher presented a paper titled “Advanced monitoring of dust emission at Rössing”, explaining methods in use for making reliable measurements of dust inhalation dose and dust concentrations from various sources at the mine. Dr Gunhild von Oertzen presented on “Radiation exposures at Namibian uranium mines – what are the risks?”, giving an overview over best practices in radiation protection at a typical uranium mine. Both papers will be published as part of the conference proceedings.

In order to reinforce the importance of radiation protection and the skills bases needed for effective radiation protection, Rössing continues to support and contribute towards the training programme for Radiation Safety Officers (RSO) offered at the Namibian Uranium Institute (NUI). Several radiation safety training courses were offered again, including a one-week introductory RSO course, a three-day course about legal requirements, a one-day course about safety for sealed sources and the annual two-day RSO workshop aimed at bringing experts of the industry together to learn about contemporary issues in radiation safety. The annual RSO workshops highlight different themes each year; in 2017, we focused on communication about radiation safety. We used role play in several tailor-made scenarios to practise interaction between different stakeholders when radiation safety issues are at stake. As a second focal area, we revised some computational skills regularly required when working with radiation protection. In 2017, all three professionals from Rössing’s radiation safety team participated in the workshop.

Further to the training programmes offered via the NUI, Dr von Oertzen also chairs a Radiation Safety Working Group hosted by the NUI, bringing together professionals from the region to discuss and align on practices in radiation safety. In 2017, we broadened the scope of the working group to include all radiation safety professionals who have an interest in the discipline, so that maximum collaboration can be achieved with the quarterly meetings, which often cover an entire day.

Capacity building is also supported by the IAEA through various training missions to member states, focusing on distinct regulatory themes. In 2017, our staff members participated in three IAEA workshops held at the offices of the NRPA, about predisposal management of radioactive waste, management of radioactive waste and safeguards respectively.

# 3 Occupational exposure protection

## 3.1 Radiation dose monitoring results for 2017

Over the years, we have gathered a comprehensive data base of radiation exposure measurements by pathway and by similar exposure group (SEG). Although not always needed in terms of exposure risk, we continue to monitor three radiation exposure pathways for each SEG randomly every year. In 2017, we collected over six hundred personal radiation exposure samples, and many more additional samples of area dose rates. In addition to the randomly collected samples, we have a continuous record of the gamma dose for radiation workers.

This year, no worker has received a dose exceeding 5 mSv. The average dose when averaging over the entire workforce was again 1 mSv, as it has been recorded consistently for the past 5 years. Assuming a working year of 2,000 hours, the annualised and averaged dose by SEG is displayed in Figure 2. The average annual dose is shown for each SEG, broken down into contributions from gamma radiation, dust inhalation and radon inhalation. The dose value recorded in 2016 is also shown to indicate the variability of the measurements. The weighted average annual dose, 1 mSv per annum, is displayed as a dotted green line.

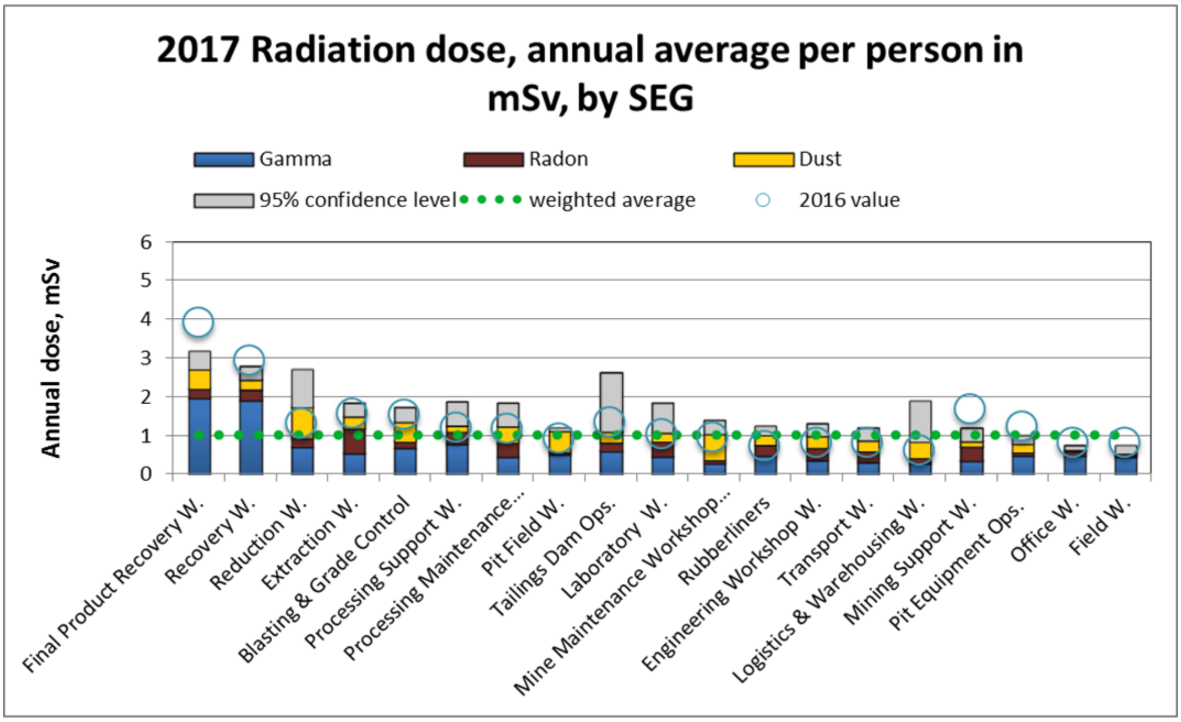


*Figure 2: Average radiation dose recorded by pathway and SEG, in 2017*

## 3.2 Radiation workers and controlled areas

The area exhibiting the highest risk in terms of radiation exposure is the Final Product Recovery (FPR) area. The area is a controlled radiation area, with access restriction, fingerprint access and contamination checks for exiting personnel. We perform regular monitoring of surface contamination, inhalation dose rate for radioactive dust and area gamma dose rate. In order to optimise on these variables, we have set a target of a maximum average surface contamination of 1 Bq/cm$^2$ for the area, and a maximum average dust inhalation dose rate of 10 µSv/h. In 2017, we have significantly improved on the controls for dust and contamination in the area and have been able to meet both of the targets, with an average surface contamination measured at 1.0 Bq/cm$^2$ exactly, and an average personal dust dose rate (without taking into consideration the protective factor offered by the use of respiratory protection) of 4 µSv/h. A summary of the average surface contamination measurements for the year is provided in Figure 3.

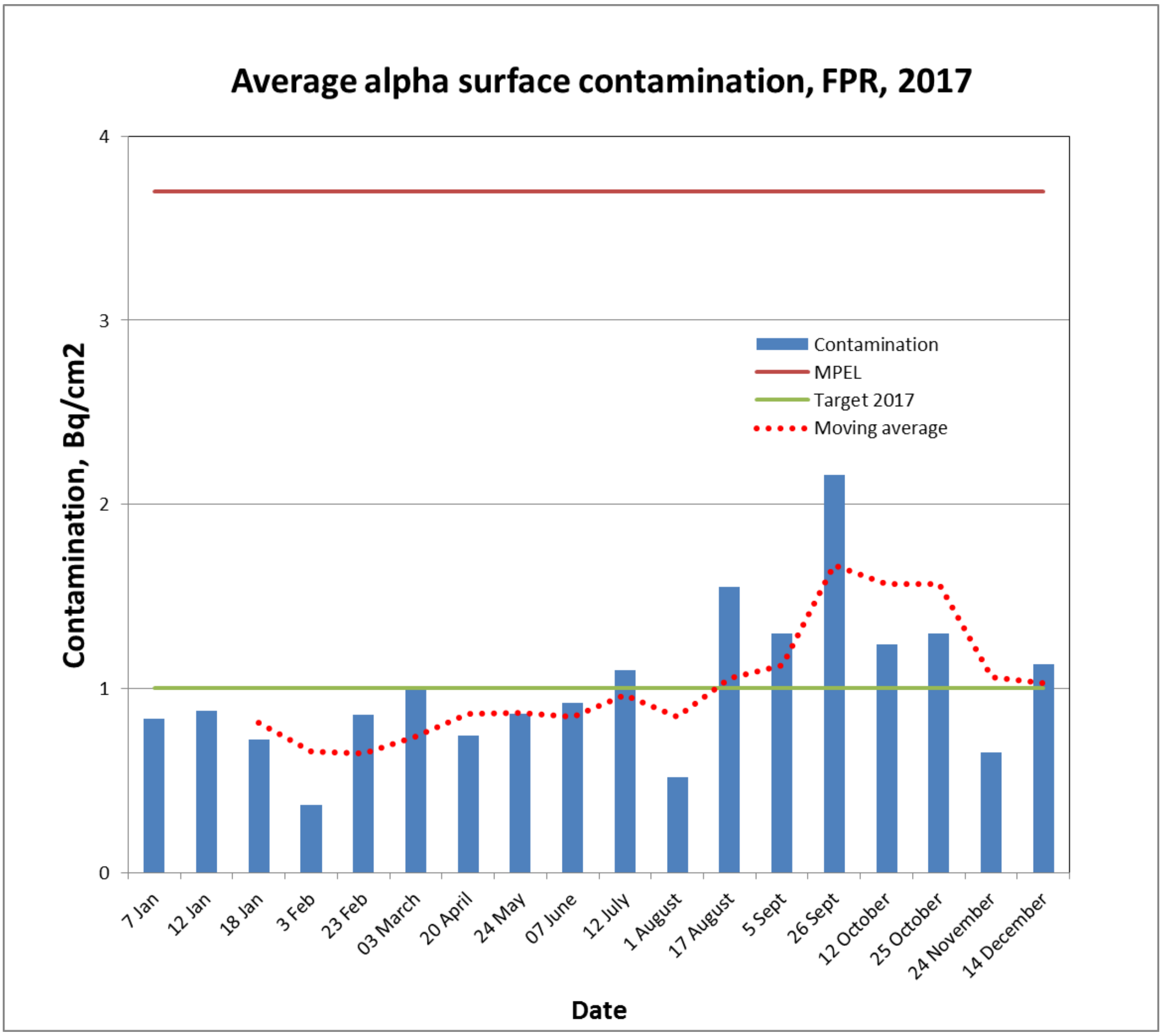


*Figure 3: Average surface contamination levels in the FPR area, 2017. The MPEL refers to the maximum permissible contamination level, as per procedures documented in the RMP.*

Those workers who are considered to be at an elevated risk of exposure to radiation exposure are termed 'radiation workers', and we consider anyone at risk of receiving a dose of 5 mSv (from all exposure pathways combined) or more to be a radiation worker. All the workers belonging to the similar exposure groups of Final Product Recovery or Recovery are classified radiation workers. Workers in these groups receive a continuous gamma monitor in the form of a thermo luminescent dosimeter (TLD), replaced at intervals of three months. They also undergo regular urine testing to check for accidental ingestion of uranium, and female radiation workers undergo monthly pregnancy testing so as the enable prompt removal of pregnant females from this working area. In 2017, we performed 800 urine samples, without any exceedances of the warning level for uranium in urine, 20 µg/L.  A summary of the results is shown in Figure 4, indicating that all individual results were below or close to the detection limit, 5 µg/L, and significantly below the warning level, 20 µg/L of U in urine.

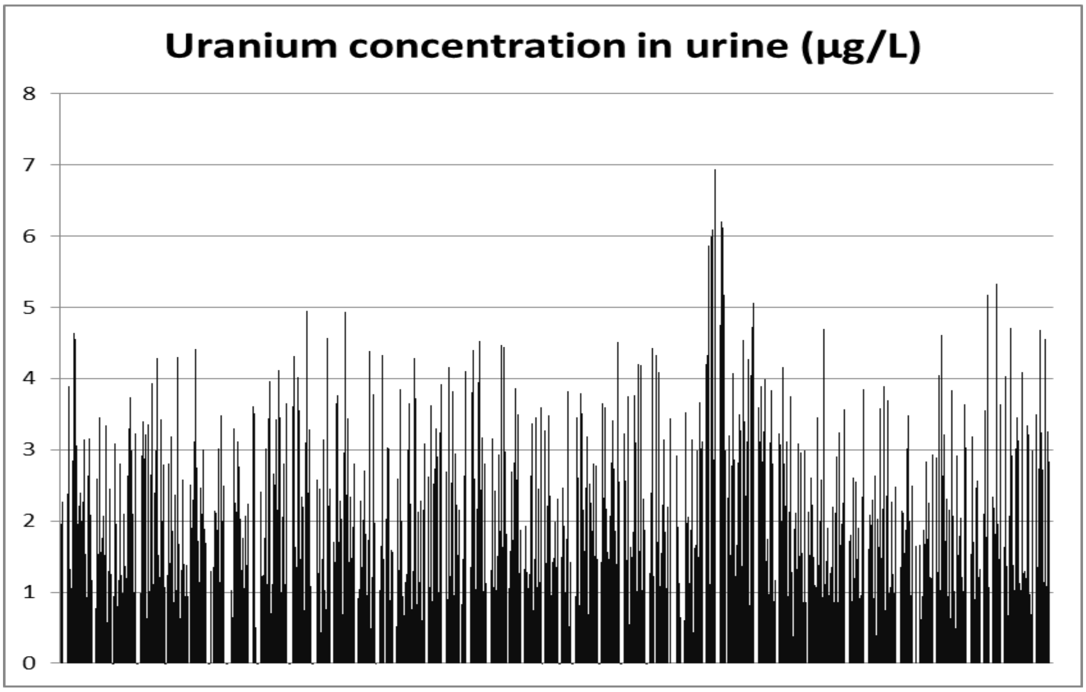


*Figure 4: Uranium-in-urine sampling results, 2017*

We also performed 37 pregnancy tests of female radiation workers, as well as 65 pregnancy tests of females not classified as radiation workers, but submitting to the testing on a voluntary basis. Seven of the tests were positive.

## 3.3 Incident

In mid-year, we discovered that one of our officers had falsified some results that had to be collected for monitoring radioactive surface contamination in the Final Product Recovery area. While this type of monitoring does not form part of our legal reporting requirements, it does represent an integral part of our site specific targets and the incident was therefore taken very seriously. The officer was suspended immediately upon discovery of the concern, and we reported this transgression to the NRPA. The disciplinary process for this employee was concluded with dismissal of the employee towards the end of the year, and the role has subsequently been re-advertised.

All monitoring results that were found to be falsified were removed from the monitoring reports. This explains the relative paucity of data for FPR surface contamination as shown in Figure 3.

## 3.4 FPR stack monitoring

The FPR area exhibits 5 stacks, three of which are low-emission venting stacks from the FPR building and two of which hail from the FPR roasters. As the latter two are fed with the exhausts from the uranium roasting process, the emissions need to be closely monitored and controlled. For the past ten years, the emissions from each stack were monitored on an annual basis by an external accredited consultant, allowing conclusions to be drawn about the efficiency of the water based stack scrubbing systems, and allowing an extrapolation to be made as to the annual emission of total particulate matter from the stacks over the year. Because of the large variability of stack flows and scrubbing operation efficiency, we have found this monitoring frequency to be unreliable in yielding representative results. Based on the extrapolated results from the past years, we have concluded that the stack scrubbing efficiency needs to be improved, and the monitoring needs to take place continuously. We have therefore embarked on an in-depth investigation of the stack scrubbing system to improve the scrubbing efficiency, and have procured equipment to transition from annual stack sampling to continuous monitoring in addition to the annual sampling.

A summary of the extrapolated stack scrubbing efficiency is provided in Figure 5, separately for each of the two FPR stacks. A new venture type scrubbing is now being installed which should increase the efficiency sustainably to the desired efficiency of 98 per cent.

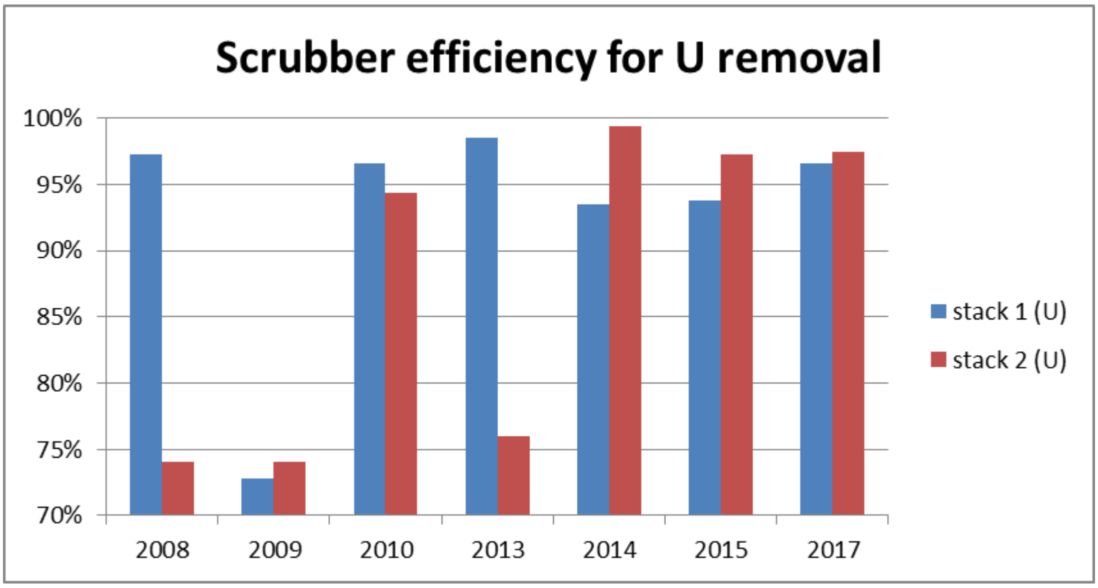


*Figure 5: FPR scrubber efficiency for uranium removal, 2008-2017*

## 3.5 Radiation awareness training

Raising awareness about radiation and maintaining appropriate perspective on the associated risks in the workplace remains one of our important focal areas. We continued providing individualised training tailor made for each work area. In order to render the workplace rules and regulations more accessible for our employees, we have also embarked on two new initiatives: we developed a ‘radiation safety calendar 2018’, which contains 26 fact sheets about radiation safety and which was distributed to all our employees and contractors (Figure 6), and we developed an online radiation safety refresher training course. The online course will be finalised and implemented in 2018, and should supplement the teaching and awareness materials which are contained in the calendar that was distributed to all mine workers.


*Figure 6: Radiation safety calendar 2018 for mineworkers*

In order to share information about our radiation protection programmes with the public, we make many of our reports, fact sheets and booklets available on the Rössing website, under the ‘Reports and Research’ tab. Apart from the RMP and RMP implementation reports, we share technical reports on environmental risk as well as fast sheets and booklets about radiation protection in uranium mining. Information in the form of fact sheets, articles and brochures is also shared via the Uranium Institute and at the mining and trade fairs.

On request of the Namibia University of Science and Technology, a public lecture about radiation safety was presented jointly with the NRPA. Mr Joseph Eiman, representing the NRPA, gave an overview of legal requirements relevant to radiation safety, and Dr von Oertzen, representing Rössing, explained how radiation protection is implemented at the mine.

## 3.6 Communication of monitoring outcomes to employees

After each week of personal radiation exposure monitoring, a group report is prepared summarising and explaining the monitoring outcome. This report is shared with the affected team during team discussions.

Urine sampling results are communicated to individuals only if an exceedance of the warning or action levels has occurred.

All personal exposure dose results and urine sampling results are available to employees via the Rössing intranet. The results displayed are only those of the person logged on to the computer, not of anyone else, hence ensuring confidentiality of the results. Most Rössing workers have access to computers in their working areas. Those with no computer access can access their dose results via the Radiation Safety Section.

## 3.7 Dust levels in FPR

Personal monitoring of the dust inhalation dose in the FPR area serves to establish the inhalation to the workers in the area. However, in order to further minimise the risk and proactively manage dust levels we also perform area dust monitoring, where we can focus specific areas of concern. For this purpose, we have established an internal target dust dose level of 10 µSv/h that (when averaged) should not be exceeded in the area. We have made significant improvements in this regard by providing a separation of the drum filling area from the remainder of the building. We have also procured a new enclosed drum filling assembly that is being installed in early 2018. With this new design, the dust levels in FPR should be significantly reduced further.

In Figure 7, we provide a summary of the measured dust dose rate levels in the area over the past few years. While the overall dust levels have decreased, the single peak in the graph in 2017 indicates that there are still high-dust events that can lead to significant inhalation risk, and hence the need for installing the drum filling assembly is relevant.

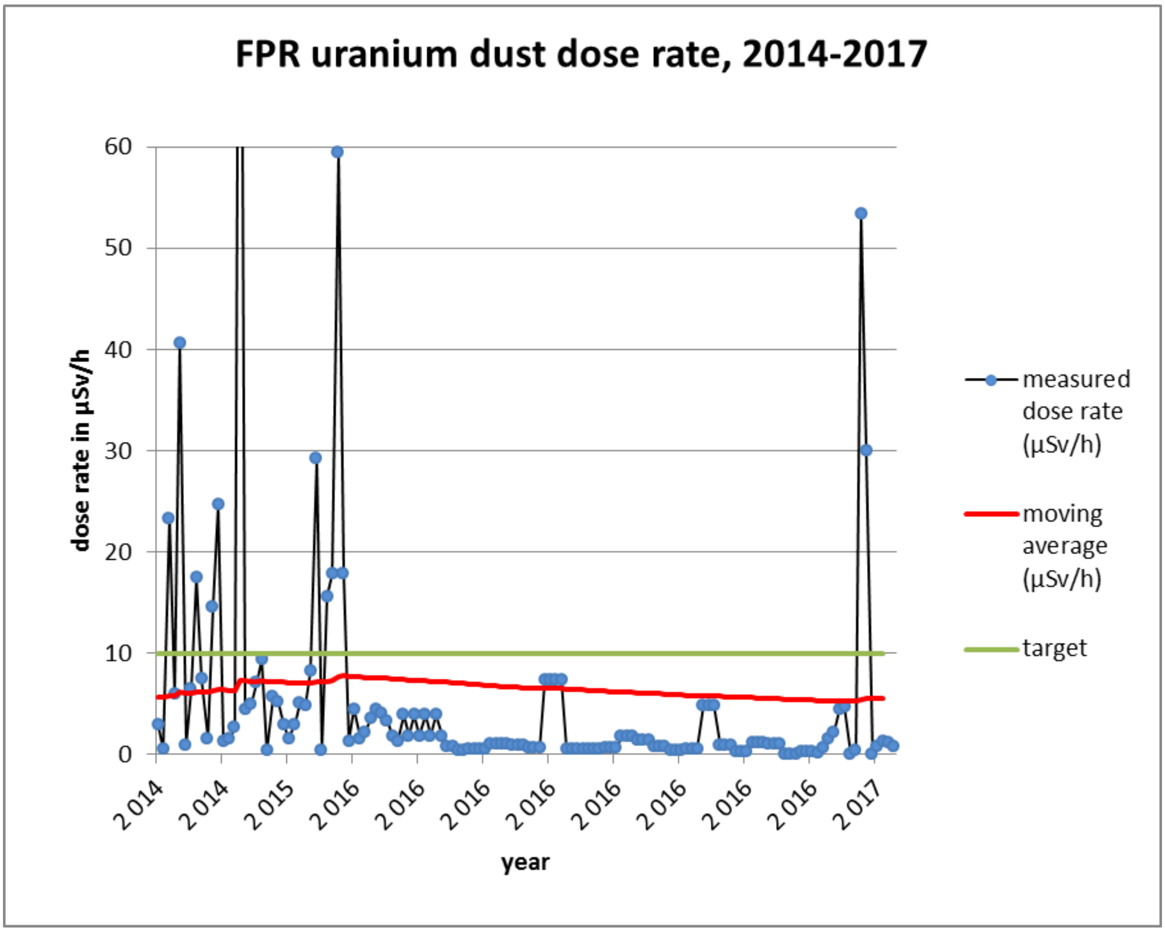


*Figure 7: Dust dose rates in FPR, 2014-2017*

# 4 Medical exposure

Not applicable

# 5 Public exposure protection

## 5.1 Background

The dose limit for public exposure resulting from mining activities at Rössing is 1 mSv per year on average. This dose limit does not include background sources, be they natural or man-made. The natural background radiation in the Erongo Region is approximately 1.8 mSv/a, while the additional dose from mining activities to critical groups in the public is generally very low to negligible. It is therefore not possible to measure the public dose [2] directly – it must be calculated from first principles, after determining the factors potentially contributing to this public dose.

At Rössing, the critical group relevant to the inhalation of radon coincides with that for the inhalation of radioactive dust and is comprised of the people of Arandis. For potential groundwater contamination, there is currently no critical group that can be affected through this pathway, as the direction of water flow from the mine is to the South, towards the Khan River. Nevertheless, groundwater contamination is well controlled with no impact on the groundwater in the immediate environment.

## 5.2 Water monitoring

Exposure through the aquatic pathway could result from the potential seepage of contaminated water from the tailings storage facility (TSF) into the Khan River aquifer.

Tailings from the processing of uranium ore at Rössing are stored in a single TSF. The tailings impoundment has an existing footprint of about 750 ha and a maximum wall height of around 100 m. The ultimate footprint for the life of mine configuration in 2025 is planned to stay about 750 ha with an increased wall height and a total storage capacity of 600 million dry tonnes. Fine tailings are pumped and coarse tailings conveyed to the facility where they are mixed and hydraulically deposited into an active paddock. Decant water from the facility is recycled back to the process plant.

Surface seepage from the tailings storage facility is captured in a down-gradient seepage collection dam (see Figure 8 for a photo of the tailings dam with surface seepage appearing at the toe of the TSF, and Figure 9 for a photo of the Processing Area with a view of the seepage dam visible in the background). This water is recycled back to the processing plant. Process water in the decant ponds on the storage facility typically has a pH of 2, contains some dissolved uranium and has a total dissolved solids concentration of about 25 g/L, reaching up to 70 g/L. Percolation towards the base of the TSF results in neutralisation and precipitation of contaminants.

[2] The additional dose to the public due to mining related activities is referred to as the “public dose”, and this explicitly excludes background related sources of radiation exposure dose.

***Figure 8: Rössing TSF with seepage appearing at the bottom toe of the dam. The view is towards the North (photo by André Terblanche)***

***Figure 9: Rössing Processing Area with seepage dam visible at the top of the image. The view is towards the South (photo by André Terblanche)***

A system of monitoring boreholes surrounds the TSF. Water quality is measured regularly and analysed as to its chemical constituents. For a selected number of boreholes, we also determine the radioactivity of the main radionuclides of the uranium and thorium chains, on an annual basis. The isotope ratio allows a determination of the origin of water resources as either naturally occurring, or resulting from seepage from the TSF.[3] The location of the boreholes from which we obtain a radionuclide analysis is strategically placed along the frontier of the seepage plume. This allows a quick judgement to determine if there has been a change in the position of the seepage plume front.

In Figure 10, the current seepage plume is indicated together with boreholes close to the edge of the plume. Boreholes close to the edge, but outside, the plume are monitored regularly; this will be sufficient to obtain information on the potential advancement of the plume. Boreholes within the plume need not be monitored, as it is already known that they are affected by seepage. In the figure, green colour indicates borehole water unaffected by contamination, and red colour indicates water contaminated by tailings. In 2017, all of the boreholes that were sampled were shown to be unaffected by contamination. This can be expected as the boreholes are immediately outside the tailings seepage plume and therefore serve as a powerful check to see if the plume is progressing.

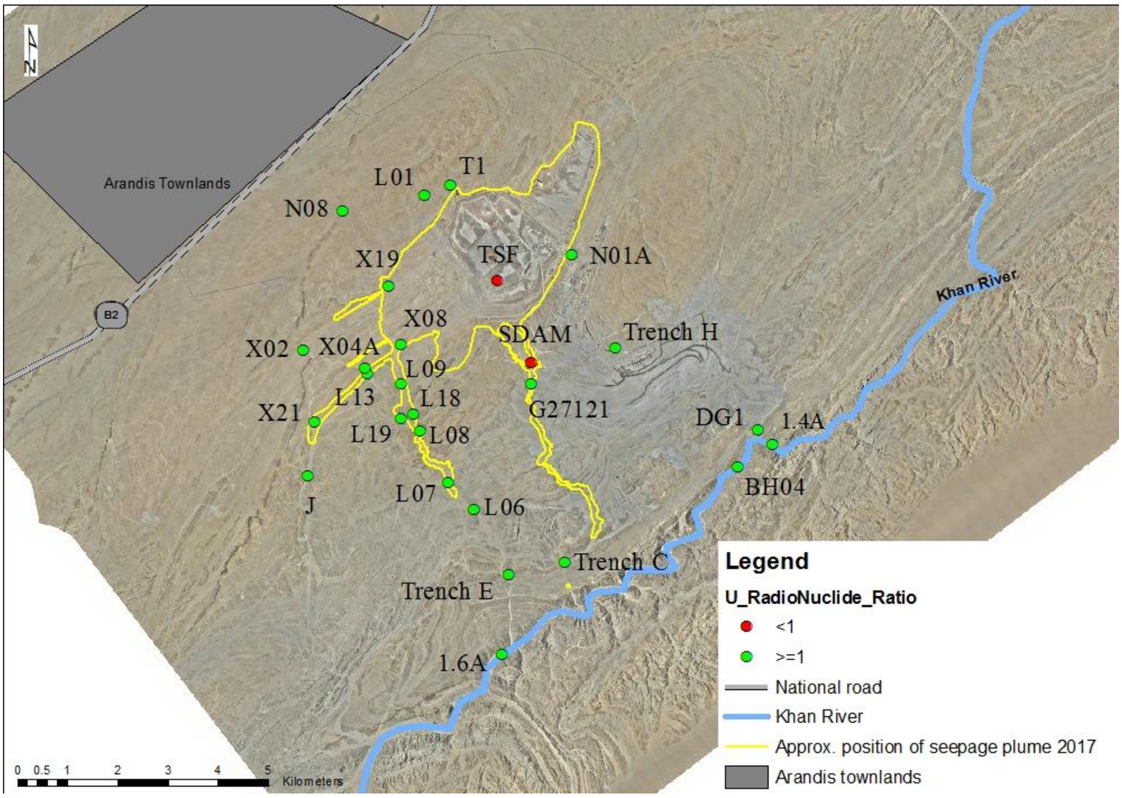


***Figure 10: Delineation of the seepage plume surrounding the tailings storage facility (yellow line). Boreholes are indicated in green or red according to the radionuclide ratio; green indicates background sources and red indicates mining related sources of uranium.***

[3] The principles behind alpha recoil and its potentials for monitoring are explained in the RMP, and in the articles 'Water quality monitoring at Rössing Uranium mine using isotope techniques', and 'Using alpha recoil as a tool for contamination control in the Khan River aquifer'. All of these are available on the Rössing website, http://www.rossing.com/reports-research2.htm .

## 5.3 Dust monitoring

The public dose from the inhalation of dust can be assessed via measurements of the concentration of dust in the air breathed. The size of particles inhaled is directly linked to their potential for causing health risks. Small particles less than 10 micrometres in diameter pose the greatest risk, because they can get deep into the lungs, and some may even get into the bloodstream.

Several dust monitoring stations are placed in strategic locations around the mine site, where the concentration of dust particles smaller than 10 microns is measured in 15-minute intervals. This dust is referred to as particulate matter smaller than 10 microns, or $PM_{10}$ in short. The locations of the $PM_{10}$ stations include amongst others one at Arandis, one at the Rössing TSF and one at the Western mine boundary.

The $PM_{10}$ sampler at Arandis provides the $PM_{10}$ dust concentration, wind speed and wind direction in intervals of 15 minutes. This allows the allocation of a dust concentration as mining related (if the wind blows from the mine) or background (when the wind is blowing in any other direction). This principle is illustrated in Figure 11.

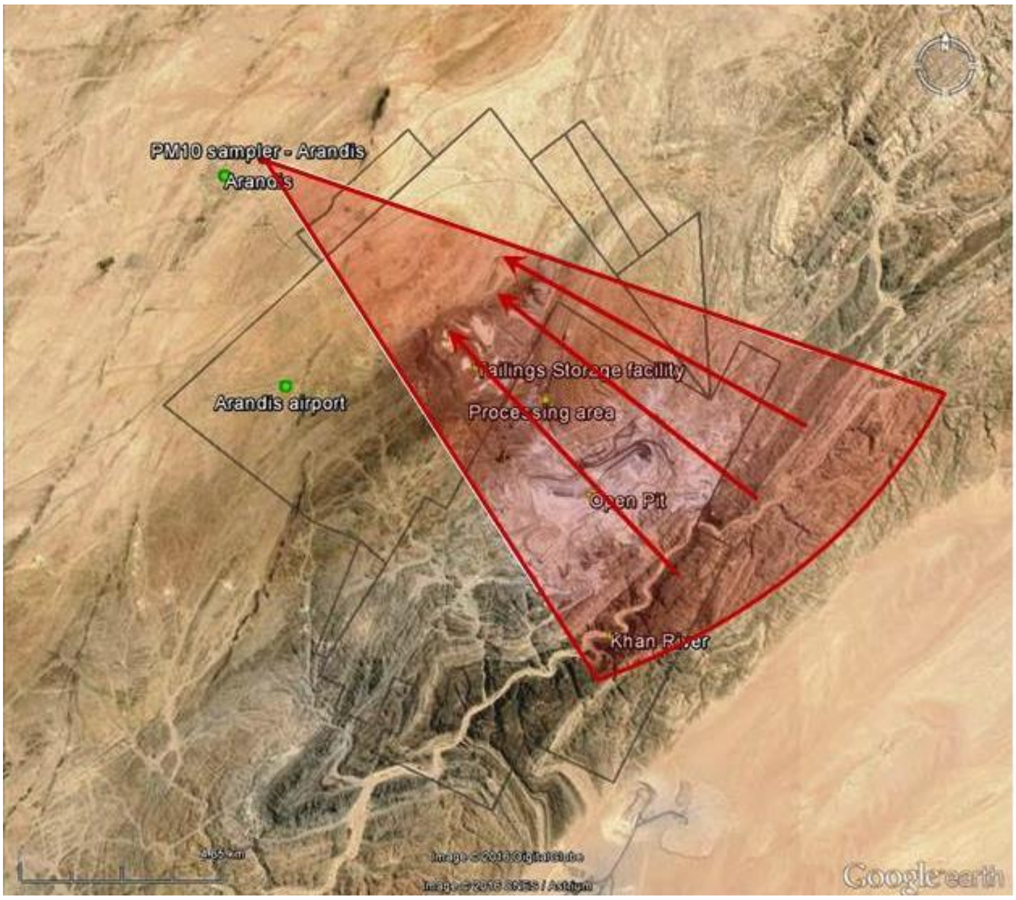


*Figure 11: A satellite image showing those wind directions at the mine that could result in dust exposure at Arandis*

In 2017, we found that the wind was blowing towards Arandis 14% of the time, and towards other directions for the remainder of the time (Figure 12). The $PM_{10}$ dust concentration measured in 15-minute intervals is summarised in Figure 13.

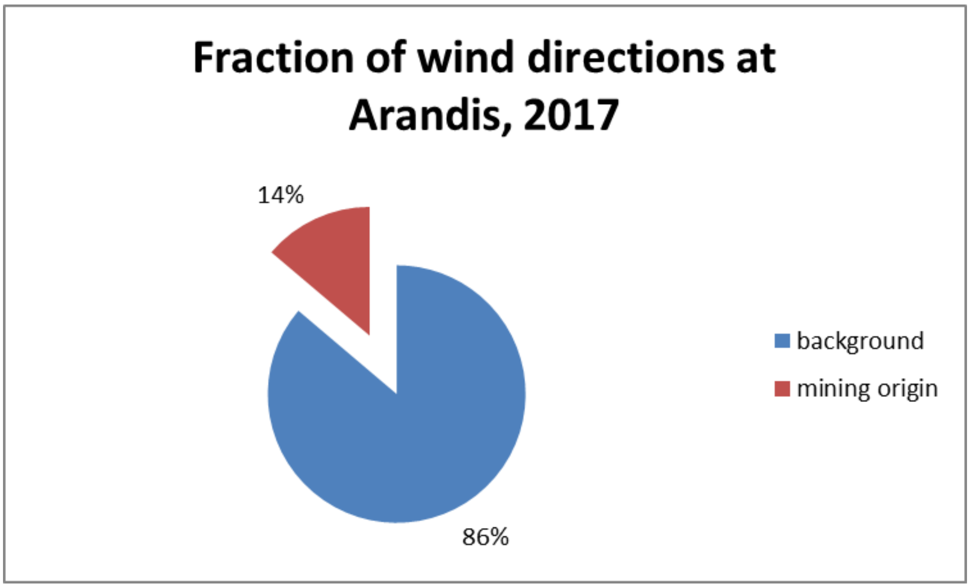


*Figure 12: Fraction of wind directions, with mining related wind directions in red*

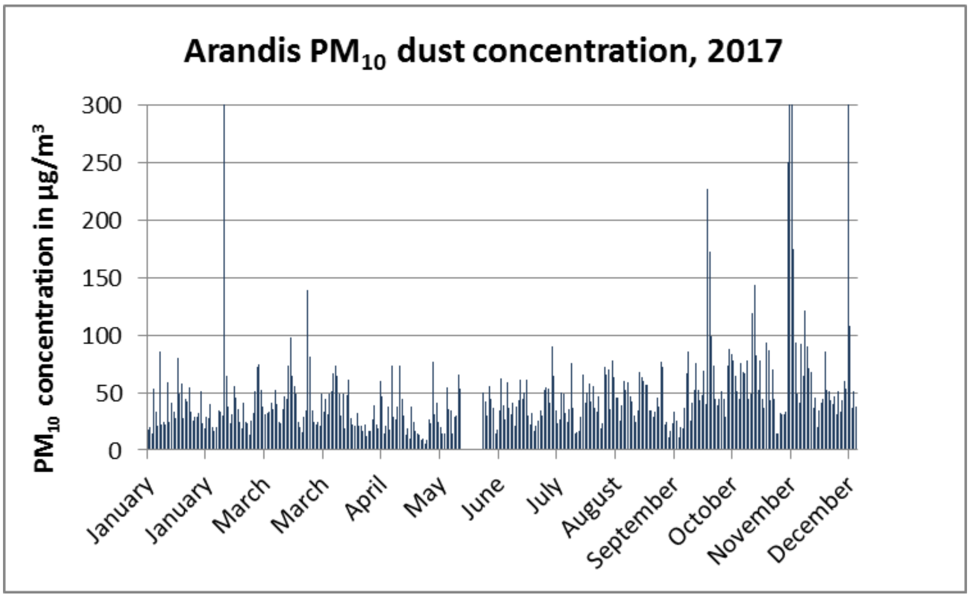


*Figure 13: $PM_{10}$ concentration at Arandis, measured in intervals of 15 minutes, 2017*

The overall average $PM_{10}$ dust concentration measured was on average 19 µg/$m^3$, which is just below the WHO guideline value for outdoor air quality of 20 µg/$m^3$ when averaged annually - see Figure 14. This is slightly higher than measured in 2016, where the average was found to be

16 µg/m$^3$. On inspection of Figure 13, it may be noted that there are some peaks in the graph corresponding to significant dust concentrations during single time intervals, which are contributing to the higher average concentrations. These peaks are not mining related and likely due to increased building activity at Arandis.

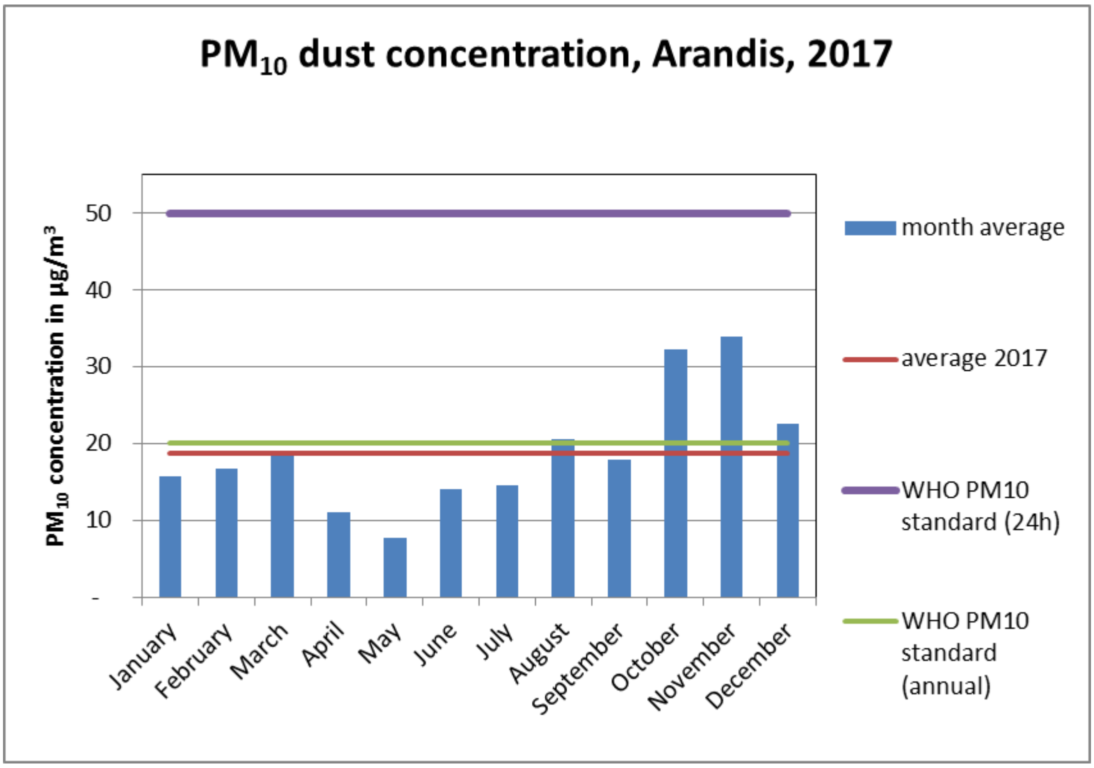


*Figure 14: Arandis $PM_{10}$ concentrations averaged per month, 2017*

The concentration measured in directions from the mine was 20 µg/m$^3$ and the average not related to mining was 18 µg/m$^3$. The mining related contribution of the dust as measured leads to a public dose of 20 µSv per annum, or 0.02 mSv per annum, significantly below the public dose limit of 1 mSv per annum. In addition, this calculation was made under the assumption that all the mining related dust arriving at Arandis is composed of ore with a uranium content of 300 ppm, which is most certainly not the case, as most dust has uranium concentrations significantly below that.

Instead, the dust concentration as measured in an Arandis dust sample can be used for the dose assessment. [4] Using this analysis and the overall average dust concentration as measured in 2017, 19 µg/m$^3$, the total inhalation dose to adult members of the public is calculated to be 19 µSv per annum, very similar to that calculated in the previous paragraph. The dose to infants is smaller and is therefore not given explicitly.

At the South-Western boundary $PM_{10}$ station, in 2017 the wind was blowing in a direction from the mine during 23 per cent of the time (Figure 15).

[4] See for example the 2015 RMP implementation report for details of this dust analysis

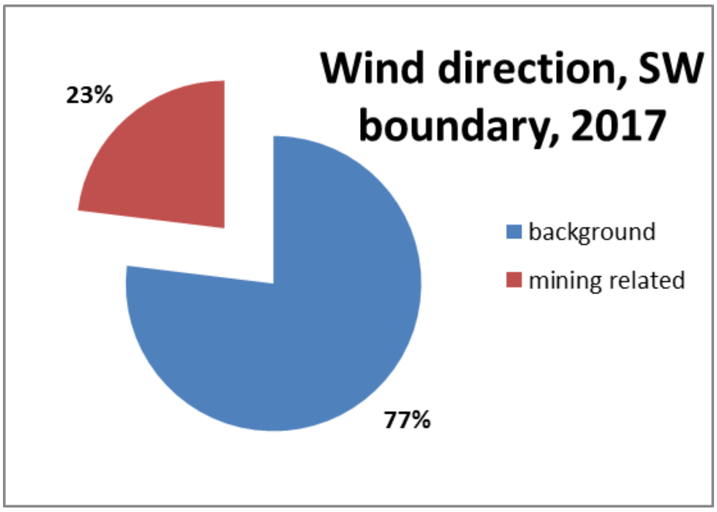


*Figure 15: Wind directions at SW boundary, 2017*

The total average $PM_{10}$ concentration at the SW boundary station was found to be 54 µg/m$^3$. The $PM_{10}$ concentrations measured down- and upwind of the mine were 47 and 80 µg/m$^3$ respectively. If one assumes as a worst case the dust downwind of the mine to be pure ore dust from the Rössing crushers, then this would result in a theoretical mining related public dose of 30 µSv/a (0.030 mSv per annum) at this location, still a very low dose even though it is larger than at Arandis.

## 5.4 Radon monitoring

As there have been no changes to the mining operations that could result in a measurable increase of the radon emitted from the site, no new radon measurement were performed in 2017. The average radon concentration at Arandis is measured at the radon station operated by the Uranium Institute and owned by the National Radiation Protection Authority. The station is located at the Arandis Namwater reservoir some 6 m above ground level. Between 2011 and 2014, the average radon concentration measured there was found to be 21 Bq/m$^3$, consistent with background radon concentrations found in the 2011 SEA report. [5]

[5] H Liebenberg-Enslin, J van Blerk, ID Kruger, Strategic Environmental Assessment (SEA) for the Central Namib 'Uranium Rush' Radiation and Air Quality Theme Report, 2010.

# 6 Safety and security of sources

## 6.1 Sealed source register

Only five sealed sources are currently being used. Four of them are used as level measuring devices in the two primary crushers. Each crusher is equipped with two sealed sources, one respectively for the bottom and the top of the rock box of each crusher.

A fifth source was purchased in 2016, with the intention of using it as a level measuring device for the drum filling process in the FPR area (license SSL/113/01/16). This source was found to be ineffective and has since been returned to the supplier. As a replacement, the source that was previously in use at FPR has been brought back to the area from the Radiation Store and was reinstalled for checking the levels in uranium drums during the drum filling process.

All other sources on site are being stored in the Radiation Source Bunker. Refer to Table 1 for a complete list of sources held at the mine. The license issued for use and operation of all our sources is SSL/113/17.

***Table 1: List of sealed sources at Rössing Uranium (radionuclide of all sources is Cs-137)***

| Serial number | Activity (GBq) | Location | Use | Comment |
|---|---|---|---|---|
| 27255 N | 38.8 | Rock Box Primary Crusher No 1 | Level | In operation |
| 004/12 | 33.1 | Rock Box Primary Crusher No 2 | Level | In operation |
| H500081140 | 39.6 | Lube Room Primary Crusher No 1 | Level | In operation |
| 005/12 | 31.6 | Lube Room Primary Crusher No 2 | Level | In operation |
| 70682 | 0.2 | FPR(ADF) | Level | In operation |
| 2771 | 13.8 | Radiation Store | Level | Not in use |
| PA 304 | 0.3 | Radiation Store | Density | Not in use |
| PA 299 | 0.3 | Radiation Store | Density | Not in use |
| PA 301 | 0.3 | Radiation Store | Density | Not in use |
| PA 302 | 0.3 | Radiation Store | Density | Not in use |
| PA 298 | 0.3 | Radiation Store | Density | Not in use |
| PA 297 | 0.3 | Radiation Store | Density | Not in use |
| 2772 | 13.8 | Radiation Store | Level | Not in use |
| 2770 | 13.8 | Radiation Store | Level | Not in use |

In addition, three low activity calibration sources are kept at the Radiation Safety Laboratory (Table 2).

*Table 2: List of calibration sources at Rössing*

| Nuclide | Type of Source | Half-life (years) | Initial activity (kBq) | Date of manufacture | Time elapsed (years) |
|---|---|---|---|---|---|
| Cs-137 | Beta | 30 | 3 | 2011/12/13 | 5 |
| Th-230 | Alpha | 75 Thousand | 1 | 2011/12/16 | 5 |
| Nat U | Alpha | 4.5 Billion | 1.4 | 2007/01/09 | 11 |

## 6.2 Sealed source checks

Leak tests of sources in operation are performed two-monthly, while sources not in use are only tested at six-monthly intervals. As these sources are stored in the Radiation Source Bunker, which is access restricted, no risk is posed by moving the leak test out to once in six months.

## 6.3 X-ray generating equipment

The Rössing chemical laboratory is making use of two analytical x-ray units, as per registration and license EPL/113/01/15, which expires in 2018.

# 7 Transport of radioactive material

## 7.1 Transport and export of UOC

Under the authorisations TRM/113/01/17/ET and TRM/113/03/17/ET, which authorise Rössing to transport uranium oxide to overseas converters, 2,124 tonnes of uranium oxide of chemical composition $U_3O_8$ (with a content of 1,801 tonnes of uranium) were exported in 2017, as summarised in Table 3.

*Table 3: List of UOC shipments from RUL in 2017*

| Date of consignment | Country of Final Destination | Total weight of UOC in shipment (kg) | Total weight of contained U element (kg) |
|---|---|---|---|
| 19 January 2017 | Canada | 90 926 | 77 106 |
| 19 January 2017 | Canada | 72 990 | 61 896 |
| 2 February 2017 | France | 162 105 | 137 465 |
| 10 February 2017 | France | 53 759 | 45 588 |
| 9 March 2017 | France | 145 377 | 123 280 |
| 18 April 2017 | Canada | 108 077 | 91 649 |

| Date of consignment | Country of Final Destination | Total weight of UOC in shipment (kg) | Total weight of contained U element (kg) |
|---|---|---|---|
| 25 April 2017 | France | 108 826 | 92 284 |
| 14 May 2017 | France | 109 156 | 92 564 |
| 11 June 2017 | USA | 163 863 | 138 956 |
| 6 August 2017 | China | 164 430 | 139 437 |
| 10 July 2017 | France | 91 652 | 77 721 |
| 21 September 2017 | Canada | 108 926 | 92 369 |
| 21 September 2017 | Canada | 72 607 | 61 571 |
| 23 October 2017 | China | 163 582 | 138 718 |
| 06 October 2017 | France | 108 958 | 92 396 |
| 30 October 2017 | France | 126 974 | 107 674 |
| 13 November 2017 | France | 108 015 | 91 597 |
| 22 December 2017 | USA | 90 926 | 77 106 |
| Total | | **2 124 777** | **1 801 811** |

# 8 Emergency preparedness and response

The Rössing emergency response to uranium spills, as outlined in the procedure *JK60/PRD/009-Uranium Oxide Spillage*, was rehearsed as a mock drill on 26 April 2017, at 17:00 (after hours).

The drill scenario was that of a train transporting containers of $U_30_8$ from the mine to Walvis Bay derailing at Arandis station, with one container damaged resulting in some $U_30_8$ drums being damaged and some uranium oxide being spilled into the environment, see Figure 16.

*Figure 16: Mock drill of a uranium oxide spillage event at Arandis Station, April 2017*

# 9 Disposal of radioactive waste

## 9.1 Disposal of contaminated non-mineral waste

Contaminated waste is deposited on the TSF, which in itself is a contaminated waste site. In 2017, a total of 1,018 tonnes of contaminated waste was deposited on the TSF. The cumulative total of the stored non mineral hazardous waste is 27,000 tonnes.

## 9.2 Mineral waste

Both tailings material and waste rocks deposited without processing are regarded as mineral waste. In 2017, we have deposited 8,962,923 tonnes of tailings onto the TSF, which now holds the cumulative amount of roughly 427 million tonnes of tailings material. We have deposited 15,109,738 tonnes of waste rock onto the Waste Rock Dumps, bringing the cumulative total of waste rock material deposited to date to roughly 954 million tonnes of material. The exposed surface area of the TSF remains unchanged at 1,377 ha.

# 10 Research

We started in 2014 to conceptualise a study to establish whether there are any potential links between workforce exposure to occupational risks, notably radiation exposure, and health effects. The Centre for Occupational and Environmental Health, Centre for Epidemiology, Institute of Population Health, Faculty of Medical and Human Sciences at The University of Manchester in the United Kingdom was selected in 2015 to perform the study based on their extensive experience and expertise in the field of epidemiological studies, in particular given the radiological risk that is being researched, and visited the mine in 2015 to kick off the study.

The protection of personal information during all stages of the study is of paramount importance; hence any information used for the study is anonymised before it is shared with the research team or other external stakeholders.

The research project has been approved by Namibia's Ministry of Health and by the Namibia National Cancer Registry. An independent External Advisory Committee consisting of delegates from the Namibian Union of Mineworkers, the Ministry of Health and Social Services, the Ministry of Mines and Energy, former Rössing workers and the Atomic Energy Board of Namibia is providing ethical oversight for the Project. Both the University of Manchester and the South African Cancer Registry have approved the project after submission to their respective Ethics Commissions. The findings from the project will be presented for publication in the internationally peer reviewed scientific literature. A final report is expected in mid-2018.

In 2017, we have continued our collaboration with the Namibia National Cancer Registry to obtain as much information as possible about all cancer cases found in the Rössing cohort. In addition, we have started collaboration with the South African Cancer Registry, so that the information about cancer cases treated or diagnosed in South Africa can be obtained. Ethics approval for the project was granted by the University of Witwatersrand Ethics Committee, and data collection was started towards the end of 2017.

The final collection of data for the project will take until about mid-2018, and the first analysis report is expected towards the end of 2018.

More information and updates on the Rössing health study are published on the Rössing website, http://www.rossing.com/reports-research2.htm. This site is also used to share more detailed information on Rössing's performance with the public. Environmental impact assessments and closure plans, environmental and biodiversity management plans and discussion of some frequently asked questions about the mine's management of health and environment are also published here. Rössing's RMP and its annual reports to the NRPA are presented here for public information.

# 11 Conclusion

Once again, the monitoring results attest to the fact that radiation exposures at Rössing Uranium are very low indeed, and our controls are therefore a successful implementation of our vision of zero harm to people and to the environment. We will continue making relevant information available to the public, in order to empower our communities with the knowledge to successfully put the risks relating to radiation safety into perspective.

Awareness about radiation risk remains a focus, and awareness sessions by suitably trained experts with all workers remain an important deliverable.

For the coming year, we have decided to focus on the following:

- Succession planning, training, and performing an understudy program for one of our team members,
- Reducing levels of uranium dust in the Final Product Recovery area further,
- Optimising FPR stack scrubbing efficiency and stack monitoring systems,
- Developing and implementing an online radiation training programme for all employees, and
- Completing the Rössing health study.