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	Report G822-R1
Swakop Uranium Husab Project	
Noise study	
For: Swakop Uranium (Pty) Ltd	Revised: 05-Oct-2010

Declaration of independence

I am a single proprietor, independent acoustic consulting engineer. I have no commercial interest in Swakop Uranium (Pty) Ltd, or the above-mentioned project.

A personal curriculum vitae in support of my qualifications, expertise and experience to undertake studies of this nature, is attached in Appendix A of this report.

Executive Summary

A noise study was carried out to determine if the proposed Swakop Uranium Husab Project will have significant noise impacts. The expected impact of the operation was determined by comparing existing ambient noise levels determined in a monitoring survey, with the expected levels of future open pit mining and processing noise determined by means of noise modelling and computer simulation.

The study finds that for the project components included in the current scope of assessment, no significant noise impacts are expected to occur in inhabited areas during any of the project phases. Mining noise and blast noise will be audible to Namib Naukluft National Park visitors on foot (outdoor conditions) should they visit areas within the 35 dBA noise footprint of the mine. This footprint will be maximum when operations take place on surface level and will reduce in size as the depth of the pits increase. There are no compelling reasons for mitigation of pit or plant noise. Blast noise can best be mitigated by adhering to a practice of blasting in the afternoon, instead of during the morning hours of the day.

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Index

1 Introduction

1.1 Location and description of the project

Swakop Uranium (Pty) Ltd (Swakop Uranium) is a wholly-owned subsidiary of Extract Resources Ltd (Extract), which is an Australian-based uranium exploration and development company. Exploration activities have been undertaken by Extract in Exclusive Prospecting License (EPL) 3138, which includes the Swakop Uranium Husab and Ida Dome deposits. This noise study forms part of an environmental impact assessment (EIA) process in which the subject is the development of a mine on the Swakop Uranium Husab deposit.

The deposit is located approximately 55 km east north east of Swakopmund, approximately 5 km directly south of the operating Rössing Uranium Mine (RUM) on the opposite side of the Khan River canyon in the northern part of the Namib Naukluft National Park (NNNP). The regional and local settings of the mine are shown in Figures 1.1 and 1.2, respectively.

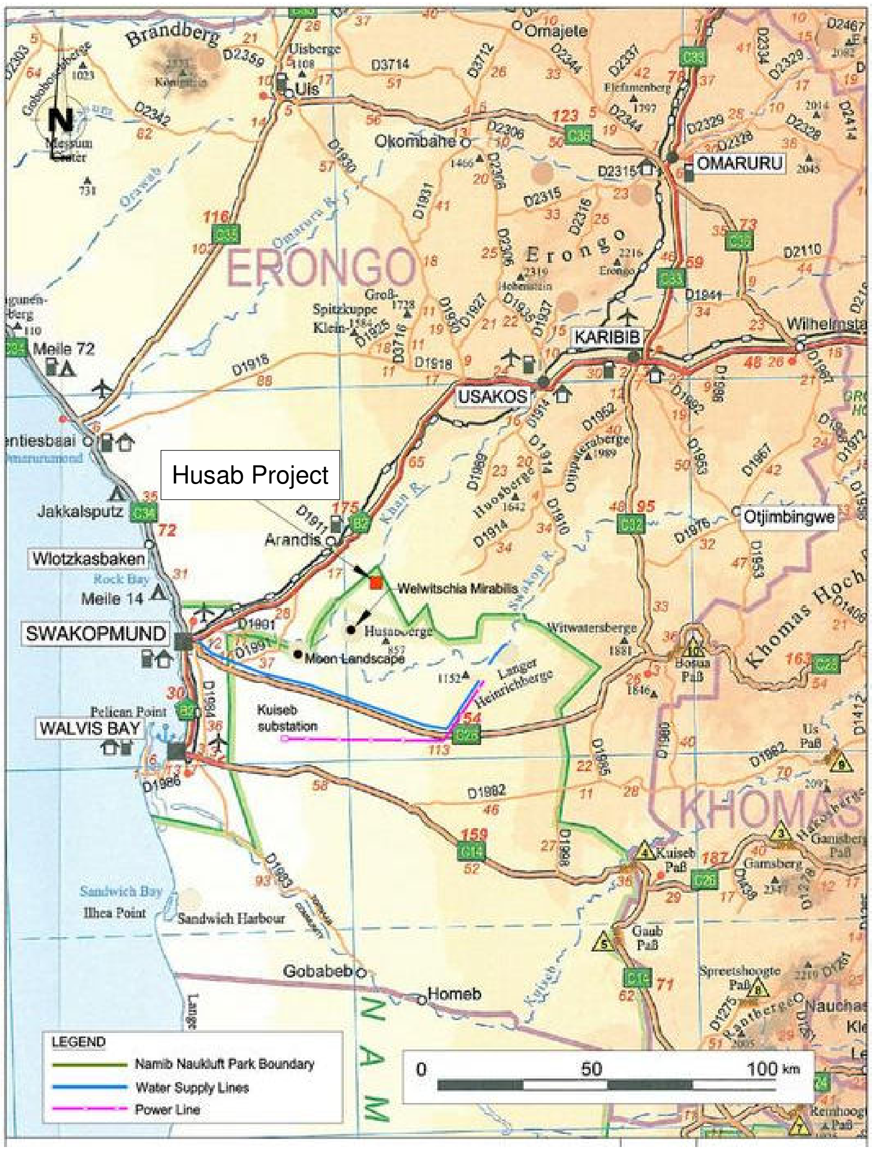


Figure 1.1

Swakop Uranium Husab Project - Regional Setting

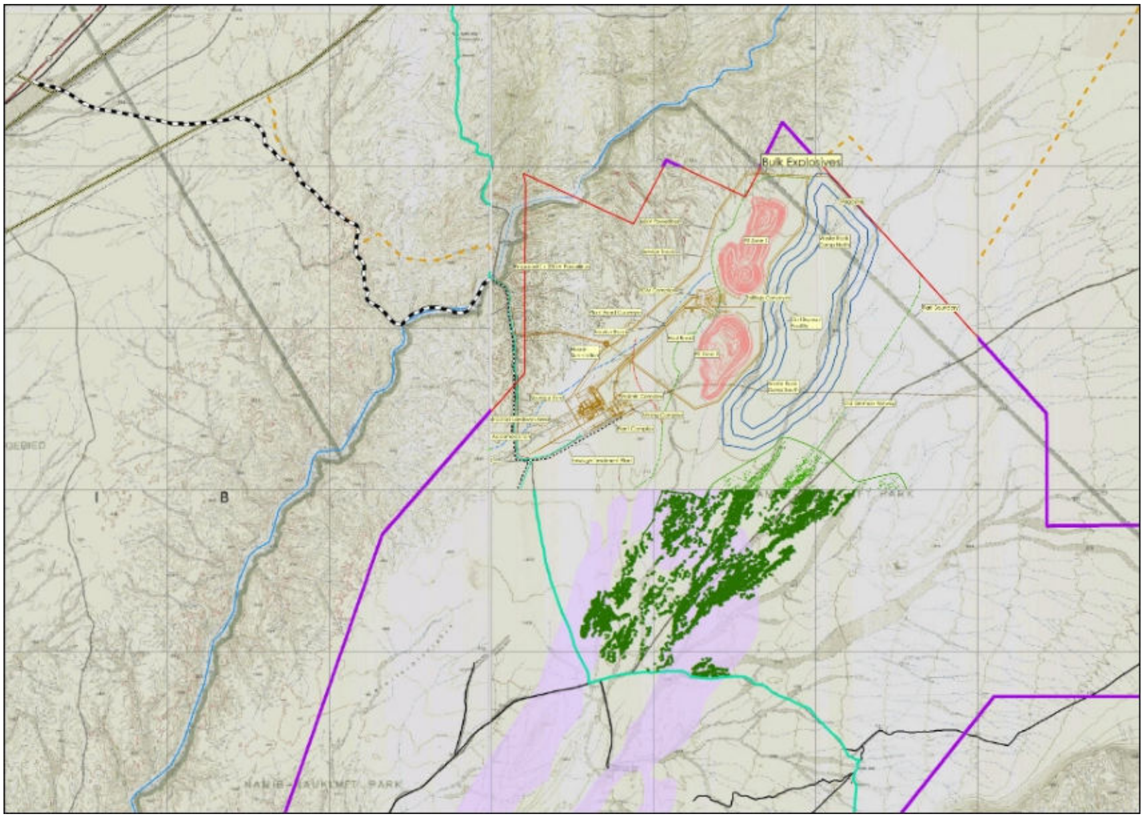


Figure 1.2

Swakop Uranium Husab Project - Local Setting

Swakop Uranium plans to develop a new uranium mine at this location with a design capacity to produce between 4 000 and 7 000 tonnes of uranium oxide per annum. The operation is planned to comprise a conventional load and haul open pit mining operation, processing plant, mine residue disposal facilities, as well as support infrastructure including road access, power supply, water supply, sulphuric acid transport and storage, fuel and lubricant storage, workshops and offices.

1.2 Terms of reference

Acusolv was tasked to carry out a noise study to assess the noise implications of the development and, to the extent applicable, the requirements and options for mitigation of excessive noise impact. This task entailed the execution of a baseline assessment and a predictive noise study, as follows:

Scoping and baseline study

Carry out a physical scoping and a measurement survey to assess the nature of the existing noise environment and to determine typical existing, i.e. predevelopment outdoor ambient sound levels in the area.

Predictive noise impact study

Carry out a study in which the expected impact of the development is quantified and assessed by means of modeling and computer simulation of the emission and atmospheric propagation of noise expected to be generated by the open pit mine, the plant and related activities.

This report presents the results of the ambient survey and the predictive noise study.

2 Methodology

2.1 General

The Swakop Uranium Husab noise study was carried out in accordance with the guidelines of Equator Bank - World Bank Group Guidelines.

2.2 Baseline Study

2.2.1 Baseline field survey

For purposes of assessing baseline conditions in the area, a scoping survey was carried out during the period 22 to 24-Feb-2010. The proposed mining site and surrounding area were visually and aurally inspected and measurements were taken to investigate existing ambient noise levels in the study area. Locations where noise was monitored are indicated on the map in Figure 2.1.

2.2.2 Test equipment

Noise measurements were carried out using the following equipment:

(a) Brüel & Kjaer Type 2260 Modular Precision Sound Analyser (Ser no. 1875497)

(b) Brüel & Kjaer Type 4189 Measurement Microphone (Ser no. 1858498)

(c) Brüel & Kjaer Type 4231 Sound Calibrator (Ser no. 2606011)

Equipment conformed to IEC 61672-1 Electro-Acoustics – Sound Level Meters – Part 1: Specifications.

Calibration: De Beer Calibration Services Certificates No's 2009-336 & 2009-337

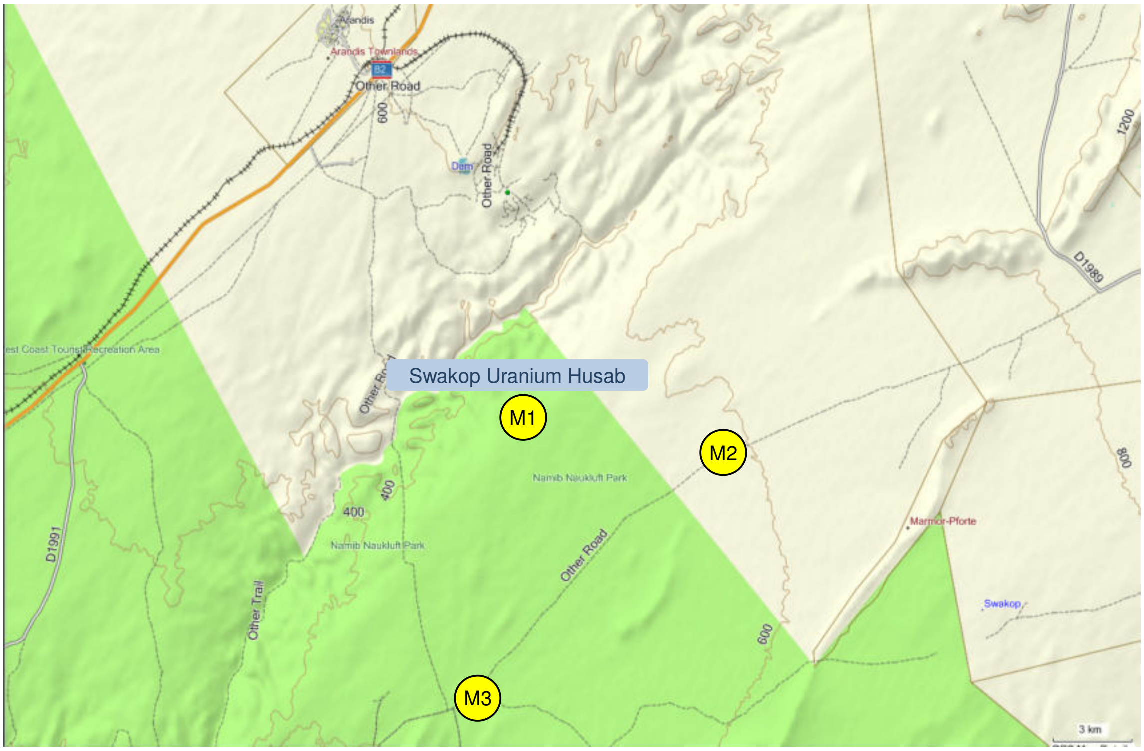


Figure 2.1

Noise monitoring locations

2.3 Noise impact study

2.3.1 Noise modelling

Estimates of future noise levels to be generated by the mine in the study area were derived with the aid of a model simulating noise emission from all major noise-generating components and activities entailed by the development. To this end, it was required to quantify the acoustic emission (sound power) levels, as well as the frequency and directional characteristics of individual or groups of sources. Calculations are based on data supplied to the noise specialist for this purpose.

2.3.2 Sources of noise

Following is an outline of operations, equipment and activities expected to be potential sources of audible noise and the main contributors to overall noise expected from the Swakop Uranium Husab Project. The findings of noise impact assessments in respect of all phases of the development, from construction to closure, are presented in Section 3.

A Construction phase

Activities in the construction phase do not constitute a constant source of noise quantifiable in the same way as noise in the operational phase of the mining operation. Hence, the assessment of noise in the construction phase is based on qualitative considerations. Activities will involve exploration drilling currently in process, infrastructure setup, road construction and stripping. Stripping will also take place concurrently with mining and is included in the modelling of operational noise. Equipment which can be expected to contribute to construction noise, are summarised in Table 2.1.

Table 2.1

Sources of noise
Construction phase

Plant Area

Construction Activity	Sources of Noise
• Power generation	Generator set engines
• Site preparation and earth-moving	Bulldozer, trucks
• Drilling	Drill rig engine and drilling
• Foundation construction	Blasting and trenching engine noise
• Building construction – Camps, stores, offices	Cutting, sawing, grinding
• Plant construction	Cutting, sawing, grinding, bolting
• Delivery – Equipment and materials	Trucks and light delivery vehicles

Pit and Other Areas

Construction Activity	Sources of Noise
• Haul road construction	Bulldozer, loaders, trucks, compactors
• Stripping, earth-moving and pit construction	Bulldozer, loaders, trucks

B Operational Phase

The project is planned to comprise a conventional load and haul open pit mining operation, processing plant, mine residue disposal facilities, as well as support infrastructure including road access, power supply, water supply, sulphuric acid transport and storage, fuel and lubricant storage, workshops and offices.

Electric and diesel rigs will drill holes 150 to 300 mm in diameter in a 4.2 x 5 m to 11 x 12 m matrix, depending on rock strength. Blasting will generally take place once per week during daytime but may occasionally be required more often. Blasted rock will be loaded by 40 - 55 m^3 bucket shovels onto 280 to 320 tonne electrical and diesel trucks which will haul and tip ore at the primary crusher for processing.

Tracked 80 tonne mobile rock breakers will roam the pit, reducing oversize material to manageable size. An additional rock breaker will be permanently fixed at the primary crusher. Eight to 10 trucks per hour will arrive at the primary crusher and approximately 60 trucks per hour at the waste dump. Dumping may take place at 4 to 5 dumping zones simultaneously.

A large wheeled loader with 20 – 25 m^3 bucket capacity will load blasted material into the primary crusher. Front-end loaders (25 m^3) will operate as back-up to shovels in the event of breakdown or during maintenance, or at the primary crusher for blending purposes.

There will be one large co-disposal facility, covering both Zone 1 and Zone 2 pits. Waste rock will be hauled and dumped onto the disposal dump. Diesel driven generator sets will provide power for lighting at tipping points. Small equipment such as tracked dozers, graders and wheeled dozers will maintain loading areas, tipping zones, dumping areas and roads.

An estimated 146 trucks per day will enter and leave the pits for ore transport and 1 242 trucks per day for waste rock transport.

Tables 2.2 and 2.3 summarise equipment and activities which will constitute sources of noise in the operational phase.

Table 2.2

Sources of noise - Operational phase
Pit operations

All sources operating 24 hours/day; 7 days/week

Equipment	Fleet Size
Electric Drill Rigs	7
Diesel Drill Rigs	3
Pre-split Rig	2
Large Electric Face Shovels	4
Smaller Diesel Face Shovels	3
Rear Dump Haul Trucks	37
Water trucks	4
Large Front End Loader	2
Utility Mass Excavator	2
Mobile Rock breakers	2
Graders	4
Wheel Dozers	9
Track Dozers	7
Power generators at dumping points	3

Table 2.3

Sources of noise - Operational phase
Plant and Mining Complex

Facility
Crusher Plant
Screening Plant
Acid Plant
Process and Beneficiation Plant
Stockpiling
Conveyor
Access road

2.4 Environmental noise assessment criteria

2.4.1 Equator Bank - World Bank Group Guidelines

World Bank Group and International Finance Corporation (IFC) performance standards and general health and safety guidelines [1] advise that pollution in general be prevented by control at source. Noise abatement measures are required to achieve either of the following:

(a) Noise levels from the development at the most sensitive point of reception should not exceed the limits specified in Table 2.4;

or

(b) Should not cause background levels to increase by more than 3 dB.

In the context of the Swakop Uranium Husab study, the background level is the ambient sound level prior to development, i.e. the baseline level. Where applicable and relevant, background levels are to be taken outside the project property boundary.

Implicit in Condition (a) is what is commonly referred to as the *acceptable level criterion*, allowing the use of a nominal table value, rather than the actual pre-development ambient level, as the baseline reference. Post-development noise is to be measured at noise receptors located outside the project property boundary and compared with the applicable baseline level derived from the table.

Condition (b) employs the so-called *noise emergence criterion*, using as baseline the actual ambient level determined by measurement at the receptor location; i.e. both pre- and post-development levels are determined by measurement.

The noise level referred to in Condition (a) is the level of the specific noise emanating from the development, i.e. not including the background ambient noise, while the level in Condition (b) is the total level, including background noise. The acceptable level criterion is an essential and practical option in cases where the actual predevelopment ambient level is unknown or if it cannot be measured at the time of the investigation - for example, where construction work has already started by the time the noise study is commissioned.

Table 2.4

World bank limits
Noise level guidelines
Maximum outdoor noise level dBA

Receptor	**Noise level** One Hour L_{Aeq} (dBA)	
(Type of district)	**Daytime** 07:00 – 22:00	**Night-time** 22:00 – 07:00
(a) Residential; institutional; educational	55	45
(b) Industrial; commercial	70	70

Levels in Table 2.4, in line with international practice, are quantified as A-weighted equivalent continuous levels, denoted as L_{Aeq} and with units in dBA. What such levels represent, are the true energy averages of the sound or noise under consideration, regardless of impulsiveness, on-off ratios, or how the level may be fluctuating. The reference period or averaging time T is usually denoted in the term as $L_{Aeq,T}$. Hence, daytime and night-time levels are commonly denoted as $L_{Aeq,d}$ and $L_{Aeq,n}$ respectively, or L_d and L_n, for short.

By specifying the One Hour L_{Aeq} in Table 2.4, World Bank guidelines implicitly require that measurement samples taken for the determination of average daytime or night-time levels should be averaged over at least an one hour period. In addition to daytime and night-time levels specified in Table 2.4, international standards commonly also employ the so-called day-night level L_{dn}, which represents a 24-hour average of the ambient noise level, with a weighting of +10 dB applied to night-time levels. With this weighting applied, the nominal 24-hour level (the table value) turns out to be numerically equal to the daytime level. L_{dn} is usually applied in the assessment of road and air traffic noise.

World Bank acceptable level criteria whereby a 55 dBA daytime level is adopted as a blanket development target, are in line with the policies and recommendations of the European Union as well as the World Health Organisation. Although 55 dBA daytime level is generally accepted as an ideal, though hard to achieve, planning target for Urban Residential development, the use of a single level without differentiation between residential districts of varying population densities, is rather simplistic. It may be too high in some scarcely populated rural districts on the one hand and unachievable and inappropriate in high-density areas on the other.

Although some national noise standards differentiate between a number of district types, typically ascending in 5 dB steps from Rural (45 dBA daytime) to Central Business Districts (70 dBA) no provision is made with respect to wilderness areas or national parks. This is because the ambient level in such remote or pristine areas, determined by a vibrant ecology (birds, insects, water flow, wind, etc.) is not necessarily lower than 45 dBA.

2.4.2 Assessment of blast noise

In the assessment of general industrial or community noise, the disturbing noise is measured and averaged over a period considered to be relevant for the source under assessment, which could be a limited period of an on-off operation, or, in the case of an on-going noise, such as road traffic, or mining noise, the relevant sub-interval of a 24-hour day, such as daytime, night-time or the day-night period.

The measurement and assessment of high-energy impulsive noise, as produced by blasting, is much more complicated. As in the assessment of general continuous noise, any test method and criteria employed in noise disturbance assessment of single-event impulsive noise, must take both amplitude and duration into account. In the lack of any test standards or criteria, the assessment of blast noise disturbance in this study is based on calculation techniques developed by the specialist in work relating to blasting at military demolition sites. These techniques adhere to accepted scientific methodology and principles. Blast magnitude is quantified by the determination of impulse energy, by time integration of the amplitude over the duration of the impulse. The equivalent continuous level of the blast impulse, calculated by spreading the energy over the span of a 12-hour day period, is used to assess the noise disturbance impact against acceptable levels for the relevant district. This principle is also adopted by international standards currently under development. In the experience of the author, at or below these levels, blast noise is normally hardly noticed by residents and not regarded as disturbing. If exceeded by 5 to 7 dB or more, it does tend to draw attention and to invoke comment.

2.4.3 Note on animal response to noise

Assessment in any scientific noise study of the impact of noise on humans, is based on well defined scientific criteria. Based on decades of statistic data, international and national standards provide consistent guidelines with respect to noise disturbance and community reaction. If the measured or predicted elevation caused by an intrusive noise, such as mining noise, exceeds certain reference levels, the response of humans to such noise can be quantified. The noise contours calculated in this study define ranges of acceptable and significant impact noise applicable to humans.

When it comes to biodiversity, however, not only are human criteria not applicable, but there simply are no national or international standards pertaining to animal response to noise - Not in terms of audibility or disturbance, let alone the effect of noise on their well-being, health, reproduction or the quality and quantity of produce yield. It should be pointed out that not even in the case of humans, (except for hearing damage) can the effect of noise on health be quantified. Hence no health-related assessment criteria are to be found in environmental noise standards.

It is completely understandable that conservationists would be concerned about the effect of general mining or blasting on biodiversity and it may very well be justifiable. But in the lack of standards or criteria, any statements made in the findings and recommendation of a noise study in that regard, would be speculative, unscientific and irresponsible. Hence in this report, we refrain to make any such unfounded statements either confirming or rejecting popular views on the matter.

3 Results and findings

3.1 Ambient noise survey

3.1.1 Existing ambient levels

In conducting the scoping survey, noise was first probed aurally and by taking spot measurements at various points over a large area to get a global picture of the ambient noise profile in the study area.

As could be expected in such a remote region practically free of human activity, with few roads and minimal road traffic, it is very quiet in most of the study area, the NNNP in particular. Moreover, because of the uniformity of the landscape, ambient levels are practically the same everywhere. The exception is the area to the north and north-west, i.e.

- A zone along the B2 main road influenced by road traffic noise;
- A zone around the existing Rössing Uranium Mine where open pit mining noise could be heard;
- And at the Swakop Uranium Husab exploration site where drill rig engine noise, as well as noise from above-mentioned RUM activity could be heard.

Based on observations made in the scoping survey, monitoring points shown on the map in Figure 3.1 were selected to give an overview of conditions at locations relevant to the study.

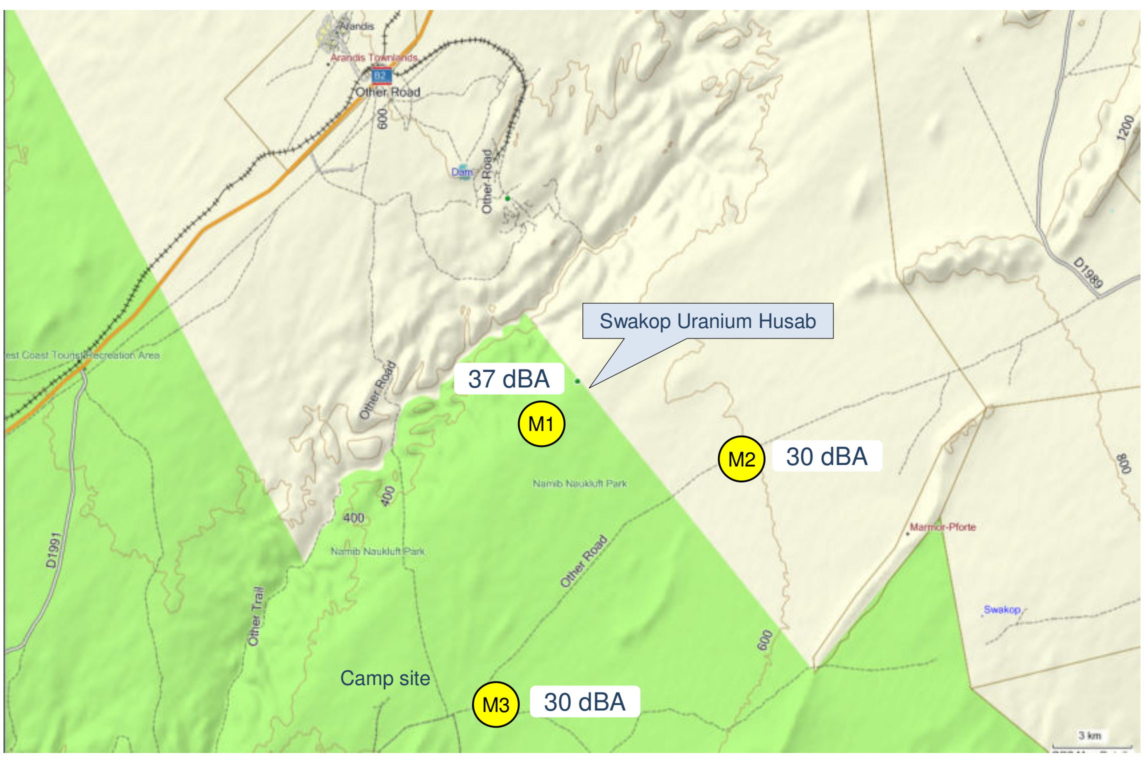


Figure 3.1

Monitoring locations and ambient levels

M1 was in the Swakop Uranium Husab exploration zone, sufficiently distant from the nearest drill rig and shielded by the sloping topography at the edge of the canyon to ensure that noise from RUM mining works was audible and the dominant source of noise. The purpose of this recording was to utilise the opportunity to measure the noise level at a known distance (5,6 km) from open pit mining operations similar to those planned for the Swakop Uranium Husab Project.

M2 was at a location where no mining, exploration or main road noise was audible. It is representative of conditions in the larger part of the study area south, east and west of the proposed development.

The measurement at M3 serves as another sample of conditions in the quiet part of the study area, confirming the reading at M2.

The nearest inhabited location relative to the proposed development is Arandis village. However, situated not far from the B2 main road and at a distance of about 18 km from the Swakop Uranium Husab development, with an existing mining operation in-between, it is estimated to be completely outside audible reach of noise originating from the proposed development. Hence no sample was taken in that area. Acceptable ambient level ratings for such a small village would be 50 dBA daytime and 40 dBA night-time, respectively.

Ambient noise levels at each location were measured over periods long enough to get good averages of daytime, night-time and day-night reference periods, defined (see Table 2.4) as:

Daytime:		from 07:00 to 22:00
Night-time:		from 22:00 to 07:00
Day-night:	(24 hours)	from 07:00 to 07:00

Averages calculated from the various samples in a manner to arrive at true energy-based averages, are defined as equivalent continuous A-weighted levels[1]. The resulting ambient noise ratings obtained in this way for daytime, night-time and day-night reference periods, respectively, are denoted L_{d}, $L_{,n}$ and L_{dn}, all expressed in dBA.

Normally, in areas where the ambient level is determined predominantly by human activity and road traffic, the night-time ambient level is typically 10 dB lower than the daytime level. This includes typical rural residential districts. The implication of this is that the environment becomes considerably more sensitive to intrusive noise at night. In wilderness areas, such as the NNNP and in most of the study area under consideration, lack of human activity and road traffic results in this 10 dB difference falling away. In fact, due to increased insect activity, night-time ambient levels are often higher than daytime levels in such areas. In this survey, daytime and night-time levels in the park were practically the same at 30 dBA, as indicated on the map in Figure 3.1.

1 *When examining results of calculated sums, differences, or averages of noise levels presented in this report, please bear in mind that averaging of sound levels is not achieved by simple arithmetic averaging of the decibel values. Instead, it involves energy-based averaging after logarithmic-to-linear conversion of decibel levels. When converted back decibels, the resulting levels represent true energy averages, defined as equivalent continuous levels.*

3.1.2 Recommended limits

As explained in Section 2.4.1, World Bank guidelines advise that

(a) Noise levels from the development at the most sensitive point of reception should not exceed the limits specified in Table 2.4;

or

(b) Should not cause background levels to increase by more than 3 dB.

These two conditions, for the study area under consideration, have completely different implications. In terms of Condition (a), the acceptable level footprint of the mine would be delineated by the 45 dBA night-time noise contour. Condition (b) is much more stringent, advising that mining noise be prevented from elevating the predevelopment ambient level, which is 30 dBA, by more than 3 dB. The latter condition is represented by the 30 dBA noise contour.[2] With this in mind, noise assessment in this study is based on the criteria summarised in Table 3.1.

Table 3.1

Noise assessment criteria applied in the Swakop Uranium Husab study area

Day-time and Night-time noise assessment criteria		
Naukluft Park (wilderness area)	Acceptable level demarcated by	30 dBA contour
	Significant (Moderate) impact by	35 dBA contour

2 *Note that the corresponding night-time level at Arandis is 40 dBA, which in conjunction with the great distance between the village and the Swakop Uranium Husab site, places it completely outside audible reach of mining noise.*

3.2 Noise impact – Construction phase

Noise disturbance

Sources of noise expected to emerge in the construction phase, are listed in Table 2.1. Noise levels generated by these sources, individually or collectively, will be much lower at source compared to levels expected from the mine when operational. Pre-mining construction noise is not expected to be audible at all at Arandis, the Rössing Uranium Mine surroundings, or at any other inhabited noise-sensitive location in the external environment.

Noise nuisance

Noise nuisance refers noises which do not necessarily register as a discernable effect on the reading of a sound level meter, yet, due to its tonal character (e.g. whistle, hum, musical tone), may be clearly audible and experienced as annoying.

A common cause of noise nuisance emanating from construction sites, are reverse alarms on trucks and earth-moving equipment, such as front-end-loaders. Reverse alarms operated in a Rural District can be audible at distances of up to 1,5 km. In the NNNP wilderness area where the ambient level is typically 30 dBA, the audibility range would be longer, up to 3 km or more. There are no residences within that range, but it may be noticed and found disturbing by visitors to the NNNP, should they be on foot or camping within such close range of the construction site.

3.3 Noise impact – Operational phase

3.3.1 Presentation of results

General noise from continuous mining operations (Excluding blast noise)

Contours of unmitigated noise levels expected from continuous mining operations are presented in Noise Maps 3.1 and 3.2. The mine is assumed to be fully operational and all continuous sources of noise are included in the model, i.e. open pit mining, co-disposal dump operations, the plant, the conveyor and road noise. These are levels of specific mining-related noise activities expected at night.

Specific noise means the noise produced by a source, in this case the entire mining operation, without the contribution of background ambient sound. To appreciate the significance of the various contour levels with respect to noise impact, it has to be noted first of all, that if the specific level of mining noise at an observation point rises to the point where it equals the background level, the ambient level will rise by 3 dB above its initial level.

Bearing this in mind, consider the 30 dBA noise contour. The 30 dBA contour of mining noise on the noise maps demarcates the range where the typical or acceptable ambient level in this particular wilderness area would rise from 30 to 33 dBA, which occurs if specific mining noise reaches a level of 30 dBA at that distance. This represents a noise impact of 3 dB, which is still acceptable in terms of World Bank guidelines. At and outside the 30 dBA contour, i.e. further away from the mine, the impact is considered to be of minor or no consequence. Inside the 30 dBA contour, moving closer to the source, the noise impact gradually becomes increasingly significant. At 35 dBA, at an excess of 5 dB, the impact will be significant (Moderate severity). It should be borne in mind, however, that such ratings are applicable to human response and would only have meaning and be of consequence if humans are living, or if visitors are camping or hiking within the significant impact footprint of the mine. The same criteria cannot be assumed to be applicable to biodiversity, birds, insects, etc. As explained in

Section 2.4.3, there are no standardized criteria for the assessment of noise impact on creatures other than humans.

Blast noise

As pointed out in Section 2.4.2, blast noise is much more difficult to predict with a high degree of accuracy. One problem is that the noise output at source is highly variable, depending on the depth of charge embedment and ore body properties. In addition, measurement and assessment of blast noise are not standardized at all. Without any World Bank guidelines or test standards, the assessment of blast noise disturbance in this assessment is based on calculation techniques developed by the specialist in studies conducted in other projects.

3.3.2 Results and findings - Unmitigated operational noise

General pit operation and haul road noise

Depending on the time of day or night and on meteorological conditions in particular, noise levels produced by industrial sources over long distances vary by a considerable margin. Noise contours in Map 3.1 were derived from calculations intended to investigate probable worst-case conditions (Night-time levels and Concawe model Meteorological Category 6). On average, typical levels are expected to be lower. “Probable worst-case”, in the context of this study, refers to levels that are higher than typical or average levels. Although less probable than typical levels, they are expected to occur from time to time during the course of the year, sometimes for several days on end. Its occurrence is not simplistically related to weather conditions and not limited to any particular season of the year.

The noise impact at any location will of course depend on wind direction. Wind roses for the area in Figure 3.2 show that the seasonal range of prevailing wind direction generally falls within the south-west to north-east sector. For purposes of assessing typical or worst-case conditions, it is fitting to consider noise levels with the wind blowing from the north.

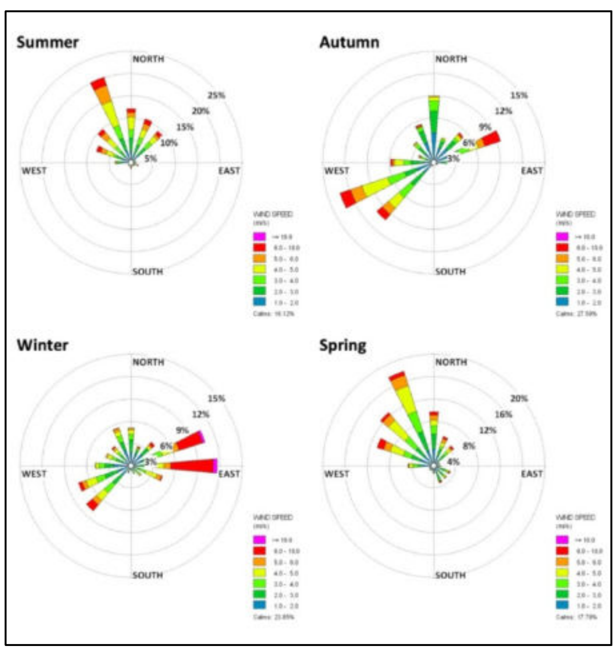


Figure 3.2

Wind profiles

Noise Map 3.1 shows contours of outdoor overall mining noise at night-time at the stage when all operations are still taking place at surface level, i.e. pit depth = 0. Noise Map 3.2 shows the levels when the pit is 50 m deep, with the relevant operations taking place inside the pit. In both cases, all other operations outside the pit, such as dump trucks on the co-disposal site trucks on the haul road and the plant, are of course assumed to be emitting noise at their respective source heights relative to ground level.

Noise Map 3.1 shows that, even when operations are taking place at surface level, the mine is not expected to have a significant impact on any inhabited noise-sensitive location in the external environment. It will not be audible at all at Arandis or in the Rössing Uranium Mine surroundings which are not only too far away to be affected, but where the background ambient levels are much higher than in the NNNP area where there are no inhabitants. As noted in respect of noise in the construction phase, mining noise may be noticed and found disturbing by visitors to the NNNP, should they be on foot or camping within the zones demarcated by the 35 dBA contours. As Noise Map 3.2 illustrates, the pit walls will act as a noise barrier with increasing efficacy as excavation progress and the pit deepens.

Confidence in the predictions, which are based on appropriately scaled data obtained in measurements on similar operations and equipment, is high. It should nevertheless be cautioned that predicted noise levels and contours are not to be taken as absolute. Although the confidence level in the acoustic model is high, predicted levels are valid for the assumptions made in respect of meteorological and other conditions. Since meteorological conditions in particular are highly variable, distant noise levels produced by a source at a constant acoustic output will vary considerably, even during the course of a single day-time or night-time period. Variance in noise level due to changes in atmospheric conditions increases with distance from the source.

Blast noise

Due to highly variable and generally unpredictable substrate and operational conditions, it is not viable to make reliable predictions of blast noise levels. What can be shown, however, is that as a result of characteristic changes in atmospheric temperature gradient profiles from morning to afternoon, there is typically a very considerable difference in noise levels at large distances for blasting during morning versus afternoon hours. Blast noise levels are generally much higher when blasting takes place during the morning than in the afternoon. This is illustrated by the contours on Noise Map 3.3 calculated for the same charge detonated during different times of the day[3].

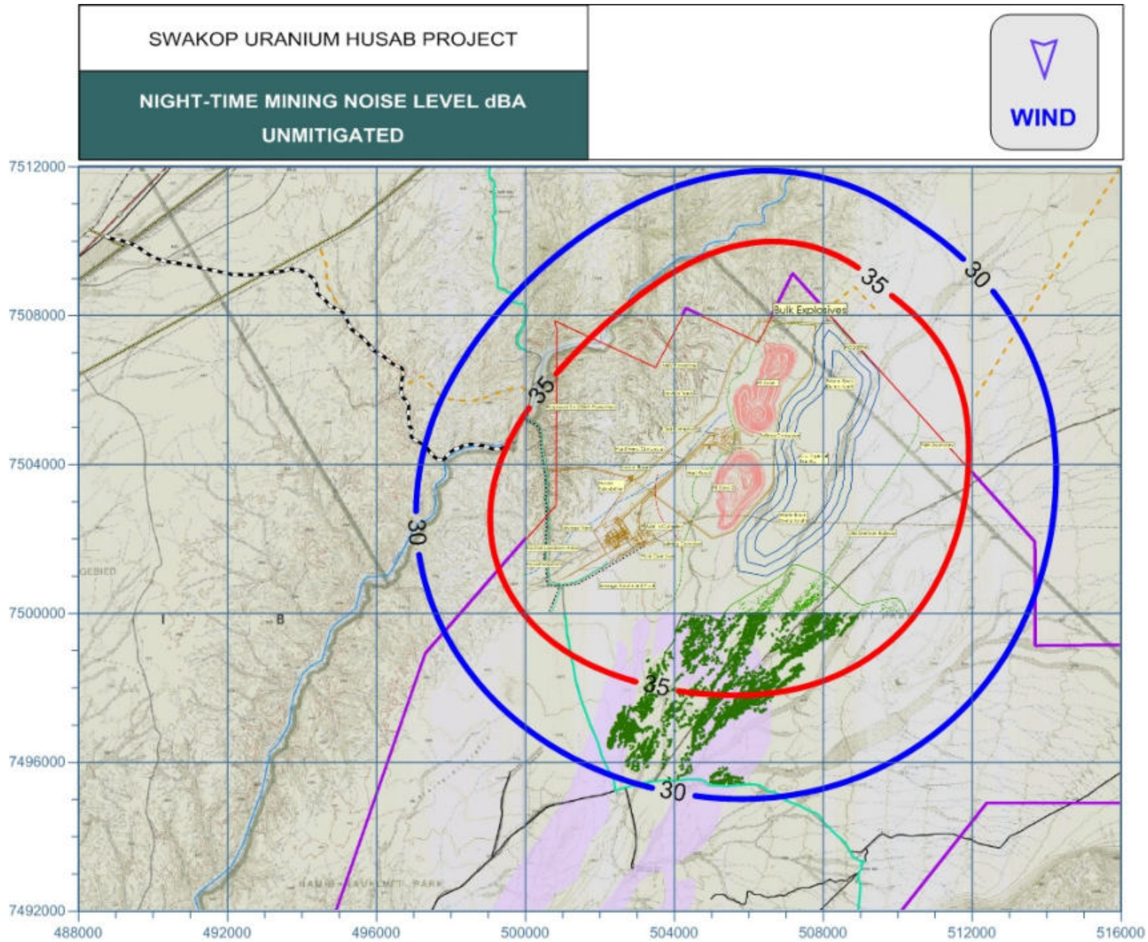
3.4 Noise impact – Decommissioning phase

Noise in the decommissioning phase will be of a similar nature to, but at a lower intensity and of shorter duration than noise in the construction phase. The noise impact will be insignificant.

3.5 Noise impact – Closure phase

No residual noise impacts will remain after decommissioning of the mine.

3 *Blast noise levels cannot be directly compared with general continuous noise levels and the criteria employed in the assessment of continuous noise are not applicable at all. The levels in these calculations are not peak blast levels, but equivalent continuous levels which take both amplitude and pulse duration (energy-based) into account and were calculated in accordance with methods developed by the specialist for blast noise disturbance assessment around military demolition ranges.*



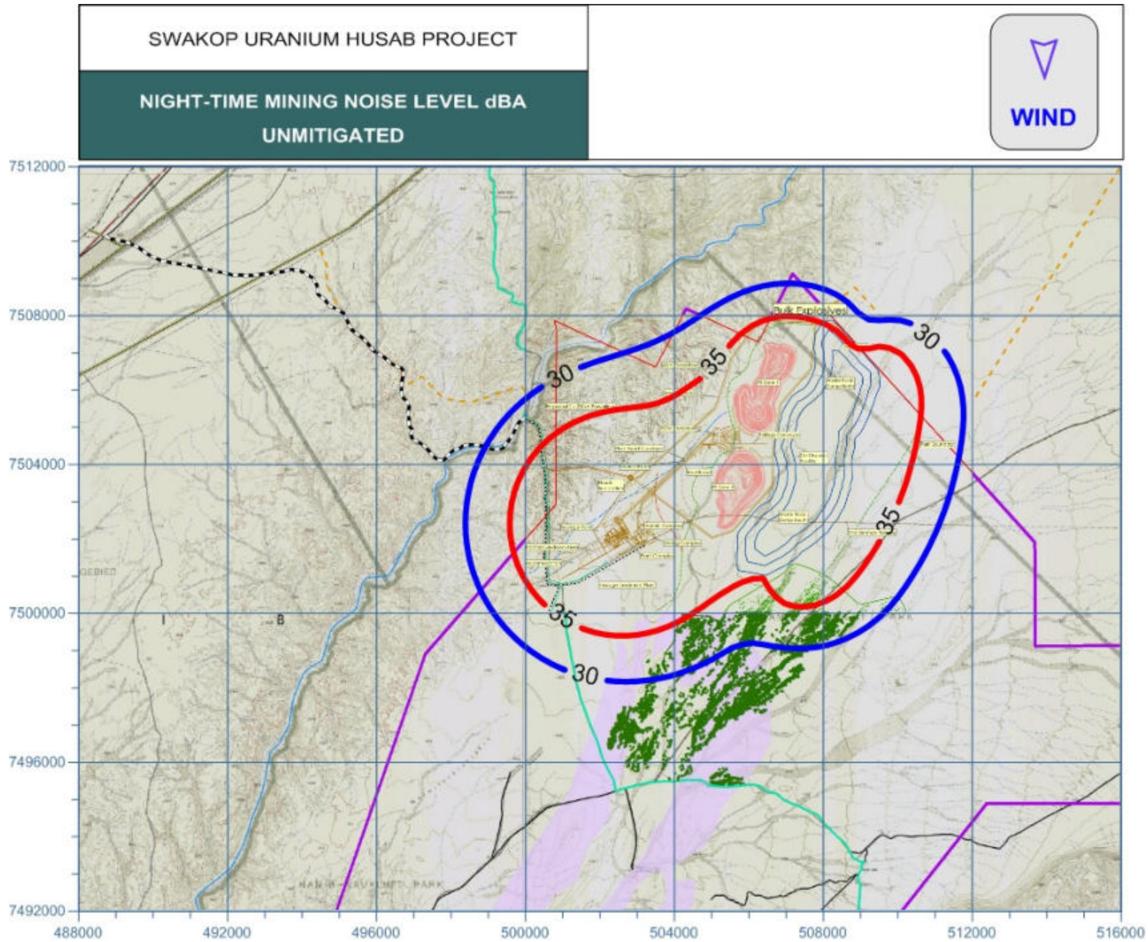
Noise Map 3.1

Swakop Uranium Husab Project

Unmitigated mining noise levels
Night-time outdoor noise level dBA
Wind blowing from the North

Pit depth = 0 (Surface operations)

Day-time and Night-time noise assessment criteria		
Naukluft Park (wilderness area)	Acceptable level demarcated by	30 dBA contour
	Significant (Moderate) impact by	35 dBA contour



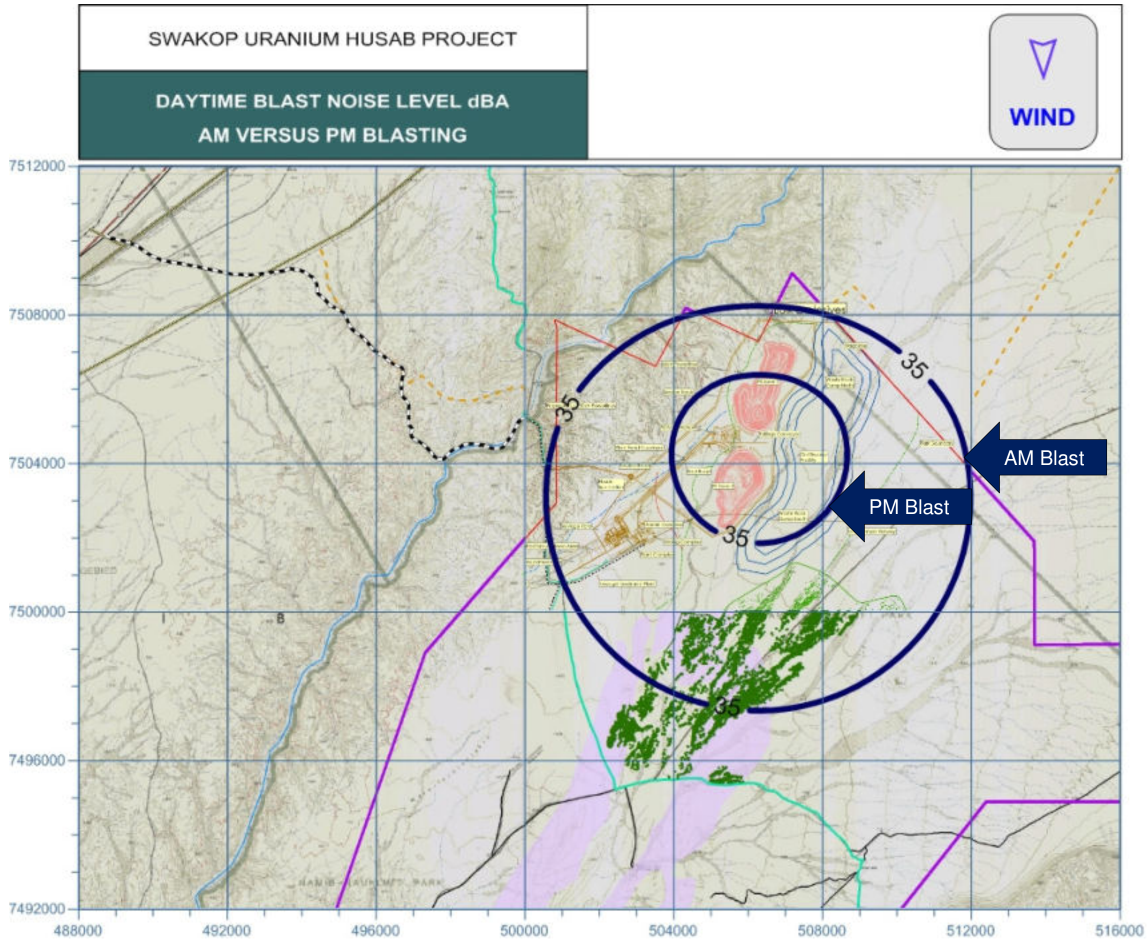
Noise Map 3.2

Swakop Uranium Husab Project

Unmitigated mining noise levels
Night-time outdoor noise level dBA
Wind blowing from the North

Pit depth = 50 m (Noise screened by pit walls)

Day-time and Night-time noise assessment criteria		
Naukluft Park (wilderness area)	Acceptable level demarcated by	30 dBA contour
	Significant (Moderate) impact by	35 dBA contour



Noise Map 3.3

Swakop Uranium Husab Project

Comparative assessment
Illustration of difference in noise levels for the same charge
Blasting in the morning (AM) versus blasting in the afternoon (PM)

Wind blowing from the North

4 Mitigation

There are no compelling reasons for mitigation of pit or plant noise. Blast noise can best be mitigated by adhering to a practice of blasting in the afternoon, instead of during the morning hours of the day.

5 Summary of noise impact implications

For the project components included in the current scope of assessment, no significant noise impacts are expected to occur in inhabited areas during any of the project phases. Mining noise and blast noise will be audible to Namib Naukluft National Park visitors on foot (outdoor conditions) should they visit areas within the 35 dBA noise footprint of the mine. This footprint will be maximum when operations take place on surface level and will reduce in size as the depth of the pits increase.

The noise impact implications of the project are summarised in Tables 5.1 and 5.2.

Table 5.1

Noise impact implications of Swakop Uranium Husab Project
General open pit operations and plant noise

Receptor	Activity	Impact	Before Mitigation						After Mitigation					
			Severity	Duration	Spatial Scale	Consequence	Probability	Significance	Severity	Duration	Spatial Scale	Consequence	Probability	Significance
Construction phase														
Inhabited areas Arandis RUM	Stripping Site & road construct	L	L	M	L	L	H	L	N/A					
Visitors NNNP	Stripping Site & road construct	L	L	L	L	L	H	L	N/A					
Operational Phase														
Inhabited areas Arandis RUM	Pit works Haul road Conveyor Plant	L	L	M	L	L	H	L	N/A					
Visitors NNNP	Pit works Haul road Conveyor Plant	L	L	L	L	L	H	L	N/A					
Decommissioning Phase														
Visitors NNNP	Vehicles Dismantling	L	L	L	L	L	H	L	N/A					
Closure Phase														
Visitors NNNP	-	L	L	L	L	L	H	L	N/A					

Table 5.2

Noise impact implications of Swakop Uranium Husab Project
Blast noise

Receptor	Activity	Impact	Before Mitigation						After Mitigation					
			Severity	Duration	Spatial Scale	Consequence	Probability	Significance	Severity	Duration	Spatial Scale	Consequence	Probability	Significance
Construction phase														
Inhabited areas Arandis RUM	Blasting	L	L	L	L	L	H	L	L	L	L	L	H	L
Visitors NNNP	Blasting	L	L	L	M	M	H	M	L	L	M	L	H	L
Operational Phase														
Inhabited areas Arandis RUM	Blasting	L	L	L	L	L	H	L	L	L	L	L	H	L
Visitors NNNP	Blasting	L	L	L	M	M	H	M	L	L	M	L	H	L
Decommissioning Phase														
Visitors NNNP	-	L	L	L	L	L	H	L	L	L	L	L	H	L
Closure Phase														
Visitors NNNP	-	L	L	L	L	L	H	L	L	L	L	L	H	L

6 Monitoring

Construction phase

General noise during the construction phase is not expected to be audible at any of the noise-sensitive locations in the study area. Blast noise will occasionally be audible in the NNNP. No noise monitoring is required.

Operational phase

(a) At this stage, within the scope of project components included in the current assessment, it is not foreseen that it will be necessary to carry out annual noise monitoring surveys, but it is recommended that an initial survey be carried out after commissioning of the plant and commencement of open pit mining.

(c) In the initial survey, measure noise levels at Arandis and carry out measurements inside the NNNP to determine the extent of the mine’s noise footprint. Use the findings to decide if subsequent annual monitoring is required and where monitoring points should be located.

Decommissioning phase

Noise during the commissioning phase is not expected to be audible at any of the noise-sensitive locations in the study area. No noise monitoring is required.

Closure phase

Noise during the closure phase is not expected to be audible at any of the noise-sensitive locations in the study area. No noise monitoring is required.

7 References

[1] World Bank Group; *"Pollution Prevention and Abatement Handbook"* - Environmental Guidelines; 1998.

Ben van Zyl PhD MSc (Eng)
Acoustical Engineer

Appendix A

Curriculum Vitae

Barend Gideon van Zyl - ID No 4605105089082
P O Box 70 596, Die Wilgers, 0041; 542 Verkenner Ave, Die Wilgers, Pretoria

Qualifications		**Institution**	**Year Completed**
(1)	BSc (Eng) Elec	University of Pretoria	1970
(2)	BSc (Eng) Hon Elec	University of Pretoria	1972
(3)	MSc (Eng) (Cum Laude)	University of Pretoria	1974
(4)	PhD	University of Natal	1986

MSc thesis: Sound intensity vector measurement
PhD thesis: Sound transmission analysis by measurement of sound intensity vector

Professional registration and membership

- Southern African Acoustics Institute Fellow (President 1994) Member since 1974

Career

CSIR
1971 – 1989

Join the Acoustics Division of the Council for Scientific and Industrial Research (CSIR) in 1971; Chief Specialist Research Engineer 1981 - 1989.

- Undertake basic and applied acoustic research & development projects;
- Pioneer technique and instrumentation for measurement of sound intensity vector, leading to sponsored research & consulting work in the Netherlands (TNO 1978) and Denmark (Brüel & Kjaer 1981).
- Acoustic consulting engineering services rendered in the fields of building acoustics, industrial noise control, acoustic materials development & environmental acoustics.

Advena
1989 – 1990

- SA Space Programme: Manager Systems Integration & Environmental Test Laboratories;
- Design and commissioning of ultra-high noise level simulation facilities for endurance testing of rocket launch vehicles, spacecraft, satellites, instrumentation and payload.

SABS
1991 – 1994

- Acoustic consulting engineering services rendered to industry
- Building acoustics, industrial noise control and environmental acoustics.

Private Practice
Since 1995

Private practice - Sole proprietor - Acoustic consulting engineering

- Noise studies; Environmental noise surveys; Blast noise measurement & assessment
- Design & problem solving: Building acoustics, Industrial & machinery noise reduction, Vehicle noise reduction (road, rail & air)
- Specialised services: Theoretical analysis & design of multi-layered acoustic panels.
- SABS Laboratory & field testing: Building systems and materials, Equipment & machinery noise

Papers and publications

- Several papers presented at international congresses and symposia.
- Several papers published in international acoustic journals, such as

  Journal of the Acoustical Society of America; Applied Acoustics; Noise Control Engineering Journal.

- Several papers published in Southern African journals.

Other

- Part-time lecturer: Architectural acoustics, Department of Architecture, University of Pretoria;
- Associate of and specialist advisor to SABS Laboratory for Sound and Vibration

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Practice Profile

Sole Proprietor: Dr Ben van Zyl

An independent sole proprietor acoustic consulting engineering practice with in-house expertise and experience in various acoustic disciplines, including building acoustics, noise impact studies, industrial noise control, test and evaluation and acoustic materials development. Based in Pretoria South Africa, specialist services have been rendered throughout the RSA, as well as in the United Kingdom, Taiwan, Pakistan, Madagascar, Mauritius and Botswana.

Equipped with state-of-the-art acoustic measuring instruments employed in noise monitoring surveys, measurement of blast noise, laboratory and field testing of systems and materials and as an aid in the investigation and solving of noise problems.

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Examples of projects

Acoustic Field: Noise studies

Project	For	Aspects
• Gauteng Waste Plant	S E Solutions	Impact study: New development application
• Swartland	Centurus	Residential and commercial development - traffic
• Mapoch II	Marlin Granite	Quarry Impact study: Blasting, open pit mining
• Delmas Extension: mining dev	Ingwe Coal Corp	Noise study – Plant, conveyors, trains, roads
• Twistdraai new access roads	Sasol Coal	Noise study – Roads, conveyors
• Bosjesspruit shaft ventilation fans	Sasol Coal	Noise study; shaft & ventilation fan noise rural area
• Hillendale new mining development	Iscor Heavy Minerals	Noise study – Plant, road transport
• Empangeni Central Mine	Iscor Heavy Minerals	Noise study – Large mine
• Rooiwater mining development	Iscor Mining	Noise study – Plants, road & rail transport
• Sigma overland conveyor	Sasol Mining	Conveyors: Investigate causes of noise generation
• Sigma overland conveyor	Sasol Mining	Noise study – Conveyors measurement survey
• Maputo steel project	Gibb Africa	Noise study peer review: trains, slurry pipe
• Pump station noise	Transvaal Suiker Bpk	Noise study & Design for noise reduction
• GPMC Environmental Resources Plan	GPMC	Noise policy & resources plan
• Damelin College Randburg	Titan Construction	Assess impact of traffic noise on college & design
• Atterbury Value Mart	Parkdev	Land use planning - City Council requirements noise
• Holmes Place HAC London	V Z de Villiers	Land use planning - City Council requirements noise
• Elmar College Pretoria	Iscor Pension Fund	Assess impact of traffic noise on college & design
• Sanae 4 Base Antarctica	Dept Public Works	Noise impact design for control - Plant rooms
• New truck fuel & service station	Bulktrans	Noise study & Design for noise control
• Country Lane	Country Lane Dev	Land use planning – Road traffic noise impact
• Randburg Water Front	Randburg City Counc	Advisor & specialist court witness
• Syferfontein overland conveyor	Sasol Coal	Noise impact as function of idler properties
• Twistdraai East mining noise	Sasol Coal	Mitigation of noise impact on neighbouring farm
• Little Loftus – The Rest Nelspruit	TAP de Beer	Sports bar - Impact study
• Blast noise	Somchem	Blast noise impact assess & design noise control
• Syferfontein overland conveyor	Sasol Coal	Noise impact as function of conveyor design
• Leeuwpan Mine Delmas district	Iscor	Noise study – Plant noise, loading
• Fairbreeze open pit mine KwaZulu	Iscor	Noise study – Open pit mining; plant, transport
• Brandspruit mine	Sasol	Noise study - Ventilation fan noise rural area
• Irene Ext 47	Irene Land Dev Corp	Noise study - Mixed development; road traffic noise
• Irene Ext 55	Irene Land Dev Corp	Noise study - Residential; road traffic noise
• Lynnwood filling station & car wash	Town Planning Hub	Noise study: Filling station & car wash in residential
• Lyttleton 190	Ferero	Noise study: Residential next to N1 highway
• Twistdraai N-East Mine shaft	Sasol Mining	Noise study; shaft & ventilation fan noise rural area

Acoustic Field: Noise studies (Continued)

Project	For	Aspects
• Wesput open pit mine	Petmin	Noise study: Blasting, excavation & transport
• Gedex open pit mine	Petmin	Noise study: Open pit excavation & transport
• Kensington college	Centurus	Noise study: Sport grounds, roads
• Spandow mine shaft	Sasol Mining	Noise study; shaft & ventilation fan noise rural area
• Twistdraai Central Mine Shaft	Sasol Mining	Noise study; shaft & ventilation fan noise rural area
• Addington Hospital	Delen Oudkerk	Equipment outdoor noise impact & mitigation
• Fourways Gardens Country Club	Fourways Gardens	Music noise impact assess & design for mitigation
• Irene Ext 29	Irene Land Dev Corp	Noise study: New township & highway noise
• Pick ‘n Pay Warehouse Meadowbrook	Pick ‘n Pay	Truck movement & loading: Assessment
• Irene Sports Academy	Centurus	Impact assessment: Sports grounds & road traffic
• Jameson substation transformer	EThekwini Municipal	Transformer noise: Assess & design mitigation
• Eugene Marais Hospital	Eugene Marais Hosp	Plantroom & outdoor equipment impact & mitigate
• Klipspruit mine wash plant	Billiton & DRA	Coal wash plant infra-sound: design for mitigation
• Eagle Quarry	Mapochs Action	Quarry new application: peer review
• Blast Test Facility Somchem	Denel	Blast noise impact: assess & design for mitigation
• Virgin Active Sandton Gym	Virgin Active	Aerobics, squash & equipment: assess & mitigate
• Conveyor noise study	Bateman	Overland conveyor noise: Causes & parameters
• Zuid Afrikaans Hospital	Z A Hospital	Chiller outdoor noise: design for mitigation
• K54 Road	Tshwane	Noise Study: Future road through residential
• PWV6 Road	Gautrans	Noise Study: Future highway noise contours
• Zandfontein mine shaft	Sasol Mining	Noise Study: Mine shaft & fan noise outdoor impact
• Pierre van Ryneveld Ext 24	Van Vuuren Dev	Noise study: New township & highway noise
• PFG Glass new float plant	PFG Glass	Noise study: Future plant noise in residential area
• Sterkfontein residential development	M&T	Noise study: road noise impact mitigation
• Sasol future Irenedale mine	Sasol	Noise study; prediction of shaft & conveyor noise
• Ammunition demolition	SA Army	Noise study: very long distance noise impact assess
• Rietvlei Ridge residential development	M&T	Noise study: road noise impact mitigation
• Mooiplaats / Hoekplaats	Chieftain	Noise study: road noise impact mitigation
• Sasol Syferfontein conveyor	Bateman	Noise study; noise complaints from farmers
• Madagascar Toliara Sands	Exxaro	Noise impact study proposed future mining
• Rooipoort Mine	Sasol Mining	Noise impact study proposed future mining
• Vlakplaats	Quantum	Noise study residential development
• Polokwane 2010 Soccer stadium	Africon	Noise impact on residential, roof design, mitigation
• New Clydesdale colliery	Exxaro	Noise study open pit mining, blasting and plant
• Grootfontein ventilation shaft	Sasol Mining	Noise study, future ventilation shaft & surface fan
• Cicada Pycna mating call study	Anglo Platinum	Cicada mating call – Mining noise interference
• Weltevreden ventilation shaft	Sasol Mining	Noise study, future ventilation shaft & surface fan
• Leandra North new colliery	Ingwe	Noise study, future mining development
• PTM new platinum mine	PTM Platinum	Noise study, future mining development
• Lyttleton X191	Pro-Direct	Noise study, new residential development
• Barking noise nuisance	Vd Merwe	Barking noise measurements, specialist report
• Doornkop new urban development	Bigen	Noise study future road and rail noise

Acoustic Field: Noise studies (Continued)

Project	For	Aspects
• Vanggatfontein	Metago	Noise study, future open pit mine
• Forfar clay mining extension	Forfar	Noise study, open pit clay mining operations
• Luhfereng Doringkop development	Bigen	Noise study, future mixed development, train noise
• K113 Road noise study	Heartland	Noise study, future road, mixed development
• Eland Mine	Metago	Noise study, new access road for product transport
• Sheraton Hotel	Pan Pacific Property	Noise study, future hotel impact on residential area
• Sishen Infrastructure Relocation	Swakop Uranium (Pty) Ltd	Noise study, railway noise simulation
• Tharisa Mine noise monitoring	Metago	Baseline noise monitoring surveys
• Sishen baseline monitoring	Swakop Uranium (Pty) Ltd	Baseline noise monitoring surveys
• Sishen Protea discard dump	Swakop Uranium (Pty) Ltd	Noise screening assessment