ANNEXURE N7:
NOISE STUDY BY
DDA ENVIRONMENTAL ENGINEERS

SOCIAL AND ENVIRONMENTAL IMPACT ASSESSMENT OF THE PROPOSED EXPANSION OF THE RÖSSING URANIUM MINE, NAMIBIA

NOISE IMPACT REPORT

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Executive Summary

1 Introduction

Rössing Uranium (RU) is undergoing a mining expansion programme for its uranium mine in the Erongo Region of Namibia. The Phase 1 Social and Environmental Impact Assessment (SEIA) for the proposed expansion was dealt with during a previous process and has been approved by the Ministry of Environment & Tourism: Directorate of Environmental Affairs (MET:DEA). The present study deals with further expansion activities not assessed during the Phase 1 SEIA, which entail:

- Extension of the current mining activities in the existing SJ open pit;
- New mining activity in the larger SK area;
- Increased waste rock disposal capacity;
- Increased tailings disposal capacity;
- Establishment of a ripios (spent ore) disposal facility; and
- Establishment of an acid heap leaching facility.

As there are no applicable Namibian National Noise Standards, the noise impact assessment and noise measurements were carried out in accordance with the South African National Standard (SABS) - Code of Practice, SANS 10103:2008, *The measurement and rating of environmental noise with respect to annoyance and to speech communication*, and as required by the regulations of the South African Department of Environmental Affairs And Tourism (DEAT), No. R154 Noise Control Regulations in Terms of Section 25 of the Environmental Conservation Act, 1989 (Act No. 73 of 1989), Govt. Gaz. No. 13717, 10 January 1992.

2 Baseline Environmental Noise Measurements

A number of noise measurements were carried out at the Rössing mining site during the Phase 1 expansion investigation and are utilised in the Phase 2 impact assessment. They are suitable to assess likely response to noise from the projected operations at the proposed mine expansion. These ambient noise measurements were made at nine positions near the property boundary, three at affected party sites, and a number within the mine site.

The ambient $L_{Aeq,I}$ and background noise measurements agree well with the adopted SANS 10103:2008 recommended values as the highest acceptable for rural districts, i.e. 45 dBA during daytime (06:00 to 22:00) and 35 dBA during night-time (22:00 to 06:00).

The only exceptions were Arandis and those areas adjacent to the B2 road, which have noise levels typical of suburban districts with little road traffic, i.e. 50 dBA and 40 dBA during daytime and night-time respectively.

3 Predicted Noise Levels

Noise modelling was utilised for the sound propagation calculations and the prediction of the sound pressure levels around the mining activities and the various plants. A modelling receptor grid was utilised for the determination of the expected noise contours as a result of the proposed operations. In addition, the noise levels were estimated at several discrete receptors placed along the RU site perimeter. The noise modelling was performed via the CADNA (Computer Aided Noise Abatement) noise model.

For the model set-up, the ground contours of the entire area, including the open pit were utilised as input. The current (2010) and the proposed expansion layout for the mining, ore loading and offloading, stockpiling, waste dumps, haul routes and processing infrastructure were set up in the model at the appropriate locations. The worst-case operational year for the proposed expansion is 2013.

The model was run initially with only the existing sources for the generation of the present situation, i.e. year 2010. The second model simulation covered the proposed expansion's noise sources, in addition to the existing ones, in order to produce the cumulative total.

One additional alternative was identified at a later stage and was included for assessment in the noise impact study. This alternative, termed Central Case, only has minor changes in the overall layout and at the locations of the heap leach, tailings disposal and ripios disposal.

3.1 Noise Modelling Results of Existing Operations

From the noise contours, it was evident that for daytime conditions, the 45 dBA contour falls well within the Rössing mine's northern, western and south-western site boundaries and did not extend beyond a 2km radius from the various noise sources. The closest distance to the Rössing site boundaries, which the 45 dBA contour reached, was approximately 2km from the south-eastern boundary.

Similarly, the night-time noise contribution of 35 dBA extended a maximum of 3 km around the various sources but did not extend beyond the mine's boundaries. The closest distance to the site boundaries, which the 35 dBA contour reached, was approximately 700 m from the south-eastern boundary.

3.2 Noise Modelling Results of Proposed Expansion

For the proposed expansion, the cumulative noise levels were calculated, i.e. taking into consideration the existing noise sources due to the current mining operations.

For the original expansion scenario, the 45 dBA contour was found to be well within the Rössing mine's northern, western and south-western site boundaries. The only exception was a small area outside the north-eastern boundary, close to the High Density Tailings Sand mining area (HDTS). However, there are no communities on the Rössing site boundary or in close proximity to that boundary.

Similarly, the night-time noise contribution of 35 dBA did not extend beyond the mine's boundaries, except for a small area outside the north-eastern boundary. The 35 dBA noise contour also reached the south-eastern boundary of the site.

3.3 Noise Modelling Results of Proposed Expansion: Central Case Alternative

Similar to the original scenario for the proposed expansion, the existing noise sources due to the current mining operations were taken into consideration for the Central Case alternative.

It was evident that for daytime conditions, the 45 dBA contour was well within the Rössing mine's boundaries, except for an area along the north-eastern side, close to the Ripios and the High Density Tailings Sand mining area (HDTS).

For night-time conditions, the 1 dBA increase above the 35 dBA contour was well within the northern and western boundaries but extended beyond the north-eastern boundary by approximately 1.4 km. At certain locations along the north-eastern boundary, the increase of the noise level above the 35 dBA guideline, was estimated to be more than 15 dB. It should be noted, however, that as the HDTS mining face moves further away from the site's boundary, this impact area outside the north-eastern boundary may be reduced. A buffer zone of approximately 1.5 km on the inside or outside of the boundary would ensure compliance with the 35 dBA rural guideline outside the mine's north-eastern boundary.

The originally proposed expansion and the Central Case alternative generated similar noise levels within and around the site. The only noteworthy difference between the two scenarios was the increase of the daytime and night-time noise levels close to the north-eastern boundary of the site. As such, for the Central Case alternative, the areas exceeding the daytime and night-time guidelines were larger than those of the original expansion scenario, primarily due to the additional conveyor belt to the Ripios.

4 Impact Assessment and Recommendations

The main conclusions of the study regarding the noise impacts of the cumulative noise levels due to the existing operations and proposed expansion were:

- The 45 dBA contour, representing the daytime rural guideline, was well contained within the Rössing mine's northern, western and south-western site boundaries.
- The only exceedance of the 45 dBA guideline outside the Rössing boundaries was a small area adjacent to the north-eastern boundary, close to the High Density Tailings Sand mining area (HDTS).
- The night-time noise levels also did not exceed the 35 dBA guideline outside the site boundaries, except for the boundary area close to the High Density Tailings Sand mining area (HDTS).
- The 35 dBA noise contour reached the south-eastern boundary of the site.
- The noise levels generated by the Central Case alternative were similar to those of the originally proposed expansion scenario in most areas, with the only exception being the north-eastern boundary.
- The Central Case alternative generated noise levels at the north-eastern boundary that exceeded the daytime and night-time guideline.

The recommended mitigation measures included the following:

- Buffer zone establishment.
- Maintenance of equipment and operational procedures.
- Placement of material stockpiles.
- Equipment noise audits.
- Environmental noise audits.

The noise impact during construction is considered to be *VERY LOW*, and with additional mitigation measures *NEGLIGIBLE*. For the operational phase, the overall noise impact is *LOW* without mitigation measures and *VERY LOW* with the additional mitigation measures. The impacts of construction and operation are summarised in the Table 1 below.

Even though the Central Case alternative generated noise levels greater than the originally proposed expansion scenario around the north-eastern boundary of the site, there are no communities in that area and no plans for any residential development. As such, the impact table presented below was considered applicable to both proposed expansion scenarios, i.e. the original one and the Central Case alternative.

Table 1. Significance of Noise Impacts for Proposed Expansion and Central Case Alternative

	Extent	Magnitude	Duration	Significance	Probability	Confidence	Reversibility
Construction Phase							
Without Mitigation	Local	Very Low	Construction period	Very low	Probable	Sure	Reversible
With Mitigation	Local	Very Low	Construction period	Negligible	Probable	Sure	Reversible
Operation Phase							
Without Mitigation	Local	Low	Long-term	Low	Probable	Sure	Reversible
With Mitigation	Local	Very Low	Long-term	Very Low	Probable	Sure	Reversible

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Glossary of Acoustic Terms

A-weighted sound level: A measure of sound pressure level designed to reflect the acuity of the human ear, which does not respond equally to all frequencies.

Ambient Noise: The distinctive acoustical characteristics of a given area consisting of all noise sources audible at that location. In many cases, the term ambient is used to describe an existing or pre-project condition.

Attenuation: The reduction of noise.

Decibel (dB): A measure of sound. It is equal to 10 times the logarithm (base 10) of the ratio of a given sound pressure to a reference sound pressure. The reference sound pressure used is 20 micropascals, which is the lowest audible sound.

dBA: Unit of sound level. The weighted sound pressure level by the use of the A metering characteristic and weighting specified in ANSI Specifications for Sound Level Meter.

Equivalent A-weighted sound level (L_{Aeq}) : Is the value of A-weighted sound pressure level in decibels of continuous steady sound that within a specified interval has the same sound pressure as a sound that varies with time. This is an average sound level that would produce the same energy equivalence as the fluctuating sound level actually occurring.

Frequency : The measure of the rapidity of alterations of a periodic acoustic signal, expressed in cycles per second or Hertz.

Hard Ground : An acoustically reflecting surface, such as concrete, most other paving materials and water. Contrasts with ‘soft ground’.

Impulsive Noise : A noise that is of short duration (typically less than one second), the sound pressure level of which is significantly higher than the background.

Integrating Averaging Sound Level Meter : A Sound Level Meter which accumulates the total sound energy over a measurement period and calculates an average.

L_{A90} : The noise level exceeded 90% of the measurement period with 'A' frequency weighting calculated by statistical analysis. It gives an indication of the underlying noise level, or the level that is almost always there in between intermittent noisy events. It is generally utilized for the determination of background noise, i.e. the noise levels without the influence of the main sources.

$L_{Aeq,I}$: Equivalent or energy-averaged sound level utilizing the 'A' frequency weighting and the ‘I’ (Impulse) dynamic response characteristic of the sound level meter.

L_{eq} : Equivalent or energy-averaged sound level.

Noise Contour : Lines plotted on maps or drawings connecting points of equal sound levels.

Noise-sensitive receptor :	Location where noise can interrupt ongoing activities and can result in community annoyance, especially in residential areas. These areas may include schools, libraries, hospitals, residences, retirement communities and nursing homes as examples of noise-sensitive receptors.
Receiver/Receptor :	A stationary far-field position at which noise levels are specified via measurement or calculated via a noise model.
Soft Ground :	Acoustically absorbent surface, such as grass, or tilled earth, which attenuates sound propagating over it, notably for points near the ground. See also 'hard ground'.
Sound Power :	The total sound energy radiated by a source per second.
Sound Pressure Level :	The amplitude of the changes in pressure level of a sound wave, measured in either pressure units (Pa) or using the decibel logarithmic reference scale.
Study Area:	Refers to the entire study area encompassing all the alternative layouts, as indicated on the study area map.

List of Abbreviations

CEN	European Committee for Standardisation
DDA	Demos Dracoulides and Associates Environmental Engineers
DEAT	Department of Environmental Affairs and Tourism
OECD	Economic Coordination and Development
HDTS	High Density Tailings Sand
I&AP	Interested and Affected Party
MET:DEA	Ministry of Environment & Tourism: Directorate of Environmental Affairs
MTPA	Million tons per annum
NIA	Noise Impact Assessment
RU	Rössing Uranium
SANS	South African National Standards
SEIA	Social and Environmental Impact Assessment
WHO	World Health Organisation

1 Introduction

Rössing Uranium (RU) has operated an open pit uranium mine in the Erongo Region of Namibia since 1976 and is undergoing a mining expansion programme. The Phase 1 Social and Environmental Impact Assessment (SEIA) for the proposed expansion was dealt with during a previous process and has been approved by the Ministry of Environment & Tourism: Directorate of Environmental Affairs (MET:DEA). The present study deals with further expansion activities not assessed during the Phase 1 SEIA, which entail:

- Extension of the current mining activities in the existing SJ open pit;
- New mining activity in the larger SK area;
- Increased waste rock disposal capacity;
- Increased tailings disposal capacity;
- Establishment of a ripios (spent ore) disposal facility; and
- Establishment of an acid heap leaching facility.

1.1 Terms of Reference

The noise study investigates the existing noise levels in the study area, as well as the future impacts on the noise environment.

The terms of reference of the noise study are:

- Utilise, where applicable, the baseline noise measurements performed at 15 locations during the Phase 1 study.
- Take into consideration the cumulative impacts of Phase 1 equipment and activities.
- Perform a site visit, in order to collect additional information and identify noise-related issues associated with Phase 2, which could not be covered by Phase 1.
- Calculate the noise levels within and around the Rössing mining site, via an internationally accepted prediction software model.
- For the noise propagation in the Rössing mine area, take into consideration the daytime and night-time wind direction patterns and frequencies.
- Using the results derived above, quantify and assess the expected noise impacts due to the construction, operation and decommissioning of the proposed project.
- Propose appropriate mitigation measures, if proven necessary.

1.2 Study Area

The proposed mining area is situated in an rural environment in the Erongo Region of Namibia, between Swakopmund and Usakos, south of Arandis (see Figure 1-1 below).

The noise levels in such remote rural areas are typically low. The noise environment is dominated by the natural sounds of rustling vegetation, wildlife, but also existing mine-influenced sounds such as traffic, as well as the current mining activity. Therefore, it is to be expected that the noise from the proposed expansion in operations, using high-powered machinery, blasting and other noisy procedures, could potentially have an impact on the surrounding area.

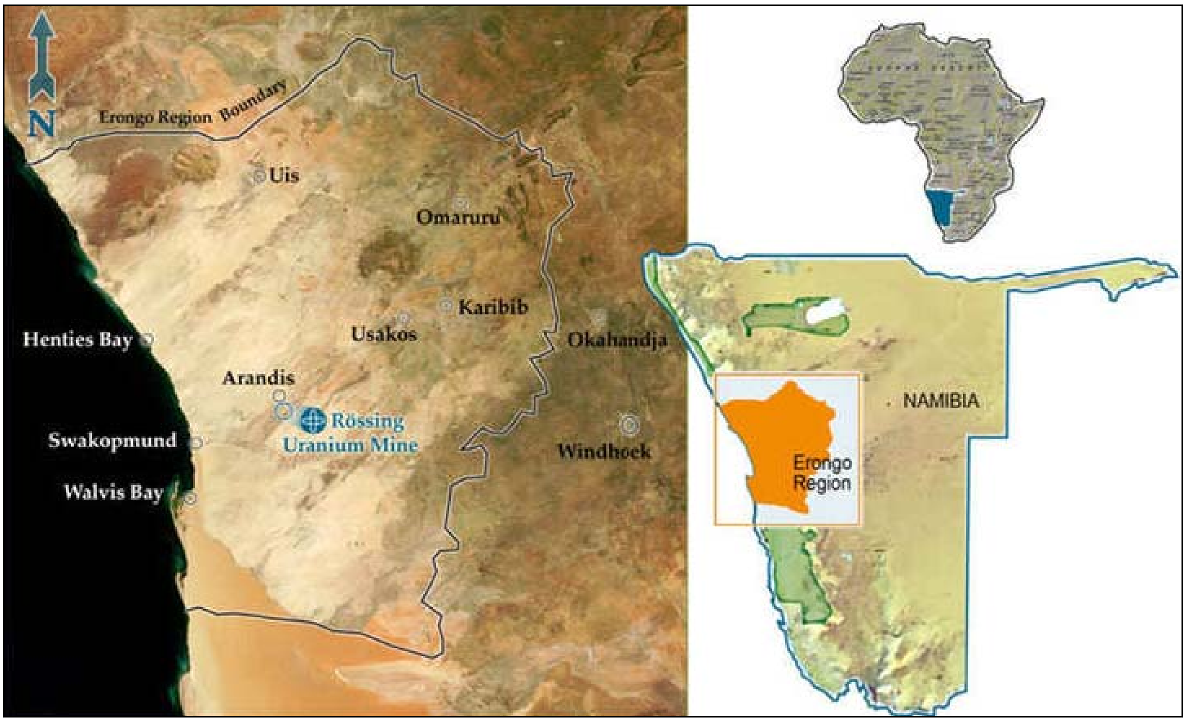

Figure 1-1. Rössing Uranium Mine Locality Map (Source RU)

2 Study Approach and Assessment Methodology

In order to be able to assess both the quantitative and geographical extent of any potential impact, it is necessary to have baseline data in the form of calculated or measured noise levels at the site and identified affected parties. This data can then be compared to the noise levels predicted to be generated by the operation of the mine expansion. The extent of community response can then be assessed according to relevant national and international standards, which take into account sociological factors, as well as the estimated change in noise climate.

There has been a recent agreement between the Namibian and South African governments through the South African Bureau of Standards (SABS) to assist the establishment of a similar Namibian organization concerned with the vetting of standards and the distribution of information regarding these. As there are no applicable Namibian

National Noise Standards, the noise impact assessment and noise measurements were carried out in accordance with the South African National Standard - Code of Practice, SANS 10103:2008, *The measurement and rating of environmental noise with respect to annoyance and to speech communication*, and as required by the regulations of the Department of Environmental Affairs And Tourism, No. R154 Noise Control Regulations in Terms of Section 25 of the Environmental Conservation Act, 1989 (Act No. 73 of 1989), Govt. Gaz. No. 13717, 10 January 1992.

2.1 Quantification and Assessment of the Noise Impact

The noise impact is quantified as the predicted increase in ambient noise level, in decibels, which can be attributed to the operation of the proposed mine expansion, appropriate to the proposed operating times and days.

Typical noise levels and human perception of common noise sources are indicated in Table 2-1 below.

Table 2-1. Typical Noise Level and Human Perception of Common Noise Sources

Noise Level (dBA)	Source	Subjective Description
160-170	Turbo-jet engine	Unbearable
130	Pneumatic chipping and riveting (operator's position)	Unbearable
120	Large diesel power generator	Unbearable
110	Circular saw Blaring radio	Very noisy
90 – 100	Vehicle on highway	Very noisy
80 – 90	Corner of a busy street Voice - shouting	Noisy
70	Voice - conversational level	Quiet
40 – 50	Average home - suburban areas	Quiet
30	Average home - rural areas Voice - soft whisper	Quiet
0	Threshold of normal hearing	Very quiet

The recommended noise levels in the various types of districts are described in Table 2-2 below (SANS 10103, 2008).

Table 2-2. Acceptable Rating Levels for Noise in Districts

Type of District	Equivalent Continuous Rating Level ($L_{Req.T}$) for Noise (dBA)					
	Outdoors			Indoors, with Open Windows		
	Day-night $L_{R,dn}$ 1)	Day-time $L_{Req,d}$ 2)	Night-time $L_{Req,n}$ 2)	Day-night $L_{R,dn}$ 1)	Day-time $L_{Req,d}$ 2)	Night-time $L_{Req,n}$ 2)
a) Rural districts	45	45	35	35	35	25
b) Suburban districts with little road traffic	50	50	40	40	40	30
c) Urban districts	55	55	45	45	45	35
d) Urban districts with one or more of the following: workshops; business premises; and main roads	60	60	50	50	50	40
e) Central business districts	65	65	55	55	55	45
f) Industrial districts	70	70	60	60	60	50

Note: Daytime: 06:00 to 22:00, Night-time: 22:00 to 06:00.
1) Equivalent continuous rating levels that include corrections for tonal character and impulsiveness of the noise and the time of day.
2) Equivalent continuous rating levels that include corrections for tonal character and impulsiveness of the noise.

The World Health Organisation (WHO), together with the Organisation for Economic Co-ordination and Development (OECD), have developed their own guidelines based on the effects of the exposure to environmental noise. These provide recommended noise levels for different area types and time periods.

The World Health Organisation has recommended that a standard guideline value for average outdoor noise levels of 55 dBA be applied during normal daytime, in order to prevent significant interference with the normal activities of local communities. The relevant night-time noise level is 45 dBA. The WHO further recommends that, during the night, the maximum level of any single event should not exceed 60 dBA. This limit is to protect against sleep disruption. In addition, ambient noise levels have been specified for various environments. These levels are presented in the following Table 2-3.

Table 2-3. WHO Guidelines for Ambient Sound Levels

Environments	Ambient Sound Level L_{Aeq} (dBA)			
	Daytime		Night-time	
	Indoor	Outdoor	Indoor	Outdoor
Dwellings	50	55	-	-
Bedrooms	-	-	30	45
Schools	35	55	-	-

The WHO specifies that an environmental noise impact analysis is required before implementing any project that would significantly increase the level of environmental noise in a community (WHO, 1999). Significant increase is considered a noise level increase of greater than 5 dB.

The expected response from the local community to the noise impact, i.e. the exceedance of the noise over the acceptable rating level for the appropriate district, is primarily based on Table 5 of SANS Code of Practice 10103 (SANS 10103, 2008), but expressed in terms of the effects of impact, on a scale of NONE to VERY HIGH (see Table 2-4 below).

Table 2-4. Response Intensity and Noise Impact for Increases of the Ambient Noise

Increase (dB)	Response Intensity	Remarks	Noise Impact
0	None	Change not discernible by a person	None
3	None to little	Change just discernible	Very low
$3 \leq 5$	Little	Change easily discernible	Low
$5 \leq 7$	Little	Sporadic complaints	Moderate
7	Little	Defined by South African National Noise Regulations as being 'disturbing'	Moderate
$7 \leq 10$	Little - medium	Sporadic complaints	High
$10 \leq 15$	Medium	Change of 10dB perceived as 'twice as loud' leading to widespread complaints	Very high
$15 \leq 20$	Strong	Threats of community/group action	Very high

In order to establish a uniform approach regarding the assessment of impacts, AURECON has issued a procedure in terms of a rating matrix for the determination of the overall noise impact due to the project. In accordance with this procedure, several aspects of the impact, such as the nature of impact, scale, duration, intensity and probability were taken into account. The detailed description of the methodology is provided in APPENDIX B.

2.2 Noise Measurements

2.2.1 Baseline Environmental Noise Measurements

A number of noise measurements were carried out at the Rössing mining site during the Phase 1 expansion investigation and are utilised in the Phase 2 impact assessment. They are suitable to assess likely response to noise from the projected operations at the proposed mine expansion. These ambient noise measurements were made at nine positions near the property boundary, three at affected party sites, and a number within the mine site. The locations can be seen in the following Figure 2-1.

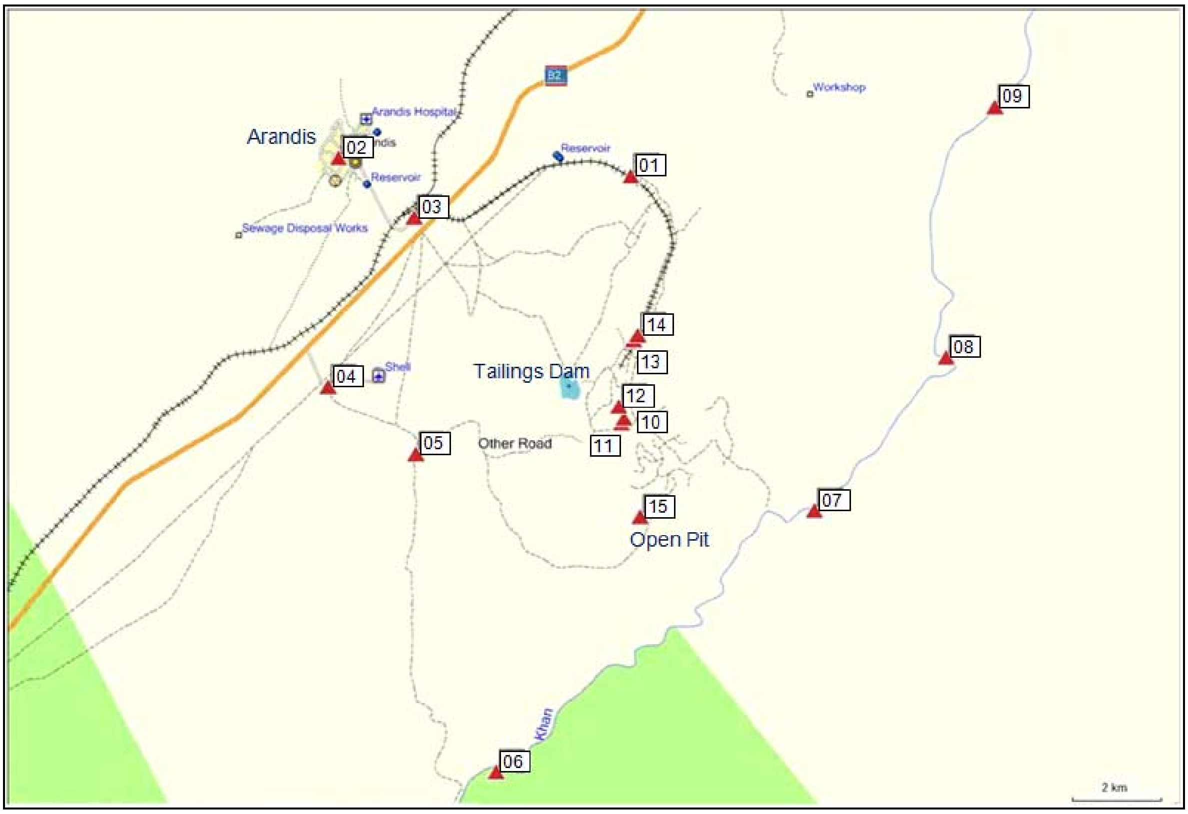

Figure 2-1. Map Showing Position of Measuring Points in the Rössing Mine Vicinity

At all measurement positions noise measurements were made of the equivalent continuous A-weighted sound pressure level, $L_{Aeq,I}$ using the 'I' (Impulse) dynamic response characteristic as recommended in SANS 10103:2008. In addition, the L_{90} was recorded, representing the background noise.

The measurement values, detailed noise environment descriptions and relevant photographs for all the points can be found in the Environmental Noise Report for Phase 1 SEIA (Hassall and Dracoulides, 2008). A summary of the baseline noise measurements can be seen in Table 2-5 below.

The ambient $L_{Aeq,I}$ and background noise measurements agree well with the SANS 10103:2008 recommended values as the highest acceptable for rural districts, i.e. 45 dBA during daytime (06:00 to 22:00) and 35 dBA during night-time (22:00 to 06:00).

The only exceptions were Arandis and those areas adjacent to the B2 road, which have noise levels typical of suburban districts with little road traffic, i.e. 50 dBA and 40 dBA during daytime and night-time respectively (points MP02 and MP03).

Table 2-5. Averaged Noise Levels at Baseline Monitoring Locations

MP	Location	$L_{Aeq,I}$	L_{A90} [a]
01	Along the main mine access road (45m from the centreline)	45	29
02	Arandis	53	45
03	Next to Arandis road intersection	50	37
04	On Arandis airport road	41	34
05	On dirt road to the Khan Mine	38	29
06	In Khan River valley	40	28
07	Along Khan River (close to open pit)	43	28
08	Along Khan River	41	25
09	Along Khan River (remote)	45	34

[a] The noise level exceeded 90% of the measurement period calculated by statistical analysis. It gives an indication of the underlying noise level and is generally utilised for the determination of background noise.

It was evident, due to the very consistent noise measurements obtained from around the RU mine lease boundary, that the noise environment was typical of a rural area. Therefore, for the noise impact assessment, the SANS 10103 recommended values for rural districts were utilised, i.e. 45 dBA during daytime (06:00 to 22:00) and 35 dBA during night-time (22:00 to 06:00).

2.2.2 Sound Measurements of Various Noise Sources

In addition to the sound measurements performed at various noise sources during the site visit for the Phase 1 assessment, another site visit was performed on 29th and 30th of July 2009, in order to conduct a second set of measurements, which focused on the crushing plant, the slimes pumps and the PADDYX pumping plant. In addition, for verification purposes, some of the Phase 1 sound measurements were repeated, such as the ore loading and offloading operations.

The approach used in this assessment was as far as possible to utilize measurements made at similar operations on the existing mine, or for operations not yet carried out on the mine, to utilize measurements from a similar plant at a different location or manufacturer's data, as has had to be done for the proposed crushing plant, ripios disposal facility and the acid heap leaching facility. This approach has the advantage that realistic noise values representing actual equipment maintenance condition and actual operating conditions are used in the predictions as far as possible. The measurements are tabulated in APPENDIX A.

All measurements were performed with a 01dB Type 1 Precision Integrating Sound Level Meter, fitted with real-time 1/1 and 1/3 octave frequency spectrum filters, serial number 10741, fitted with a 01dB Microphone Type MCE210, serial number 3857, and a windscreen. The field calibration was carried out with a 01dB Type CAL01 Sound Level Calibrator, serial number 40182. All equipment has valid calibration certificates from the testing laboratories of De Beer Calibration Services. The calibration certificates are available for viewing if required.

2.3 Prediction of Noise Levels at the Proposed Project Area

Noise modelling was utilised for the sound propagation calculations and the prediction of the sound pressure levels around the mining activities and the various plants. A modelling receptor grid was utilised for the determination of the expected noise contours as a result of the proposed operations. In addition, the noise levels were estimated at several discrete receptors placed along the RU site perimeter.

The noise modelling was performed via the CADNA (Computer Aided Noise Abatement) noise model. The latter was selected for the following reasons:

- It incorporates the ISO 9613 in conjunction with the CONCAWE noise propagation calculation methodology, in accordance with SANS 10357.
- It provides an integrated environment for noise predictions under varying scenarios of operation.
- The cumulative effects of roads, as well as point noise sources, can be determined in a three-dimensional environment.
- The ground elevations around the entire site can be entered into the model, and their screening effects taken into consideration.
- The noise propagation influences of the meteorological parameters of a specific area can also be accounted for.

The values measured in accordance with Section 2.2 above, formed the basis of calculations to predict the noise levels at specific locations of interest outside the boundaries of the proposed mine expansion. Using the point source and attenuation-by-distance model, the following assumptions were made:

1. Acoustically hard ground conditions. This assumes that no attenuation due to absorption at the ground surface takes place. This assumption represents a somewhat pessimistic evaluation of the potential noise impact.
2. Meteorological conditions. For the noise propagation in the Rössing mine area, the daytime and night-time wind direction frequencies were taken into consideration. The temperature and humidity was set for daytime to 30^{o}C and 25% respectively, and for night-time 15^{o}C and 60% respectively. The effects of frequency-dependent atmospheric absorption were taken into consideration.

3. Screening effect of temporary stockpiles, buildings and other barriers. The effect of these temporary structures on the noise climate has been ignored, representing a pessimistic evaluation of the potential noise impact. However, the ground elevations of the entire area and the mining pit were utilised in the modelling set-up.
4. Current noise control technology is assumed. No allowance is made in the noise level predictions for improvements in noise control techniques, which may be incorporated into the proposed project, representing a pessimistic evaluation of the potential noise impact.
5. Worst-case operational noise level assumption. The highest noise level of plant equipment was used as the criterion value for the noise predictions at the proposed project, representing a pessimistic evaluation of the potential noise impact.
6. Worst-case operational assumption. The year with the maximum number of simultaneously operating equipment was used for the proposed expansion. The data was supplied by Rössing.

2.3.1 Model Input

For the model set-up, the ground contours of the entire area, including the open pit were utilised as input. The current (2010) and the proposed expansion layout for the mining, ore loading and offloading, stockpiling, waste dumps and processing infrastructure were set up in the model at the appropriate locations. The worst-case operational year for the proposed expansion is 2013. The mining infrastructure layouts, haul routes, as well as the mining and waste dump locations were supplied by Rössing. These noise sources for the current and proposed operations can be seen in Figure 2-2 and Figure 2-3 respectively.

The model was run initially with only the existing sources for the generation of the present situation, i.e. year 2010. The second model simulation covered the proposed expansion's noise sources, in addition to the existing ones, in order to produce the cumulative total.

The sound power data for all the sources utilised in the modelling of the existing and expanded mining operations can be found in Table C.1 and Table C.2 of APPENDIX C, respectively.

The main noise sources of the existing operations are:

- The mining activities at the open pit, including the expansion areas.
- Auxiliary vehicle movements within the open pit areas.
- Equipment operating within the open pit areas.
- The mining activities in the other mining areas, including the Basil Read operations.
- The ore haul trucks to the primary crusher.
- The offloading of the trucks at the primary crusher.
- The primary crusher.
- The haul trucks to the waste rock dumps.

- The dumping of waste rock from the mining operations.
- The conveyor belts from the primary crusher to the stock pile and the fine crushing plant.
- The fine crushing plant.
- The slime pumps.
- The PADDYX pumping plant.
- Vehicle movements within the tailings dam area.

The main additional noise sources of the proposed expansion entail:

- The additional mining activities at the open pit.
- Other expansion mining areas.
- Additional auxiliary vehicle movements within the open pit areas.
- Additional equipment operating within the open pit areas.
- The mining activities in the other mining areas.
- The haul trucks to the waste rock dumps.
- The dumping of waste rock from the mining operations.
- The additional ore haul trucks to the primary crusher.
- The addition of a second primary crusher.
- The addition of a second fine crushing plant.
- The conveyor belts from the second primary crusher to the second stock pile and the second fine crushing plant.
- The conveyor belts from the second fine crushing plant to the heap leach circuit and the ripios pivot point.
- A stacker reclaimer at the heap leach area.
- Vehicle movements within the new high density tailings dam area.
- Vehicle movements within the old tailings dam area.
- Vehicle movements within the new high density tailings area.

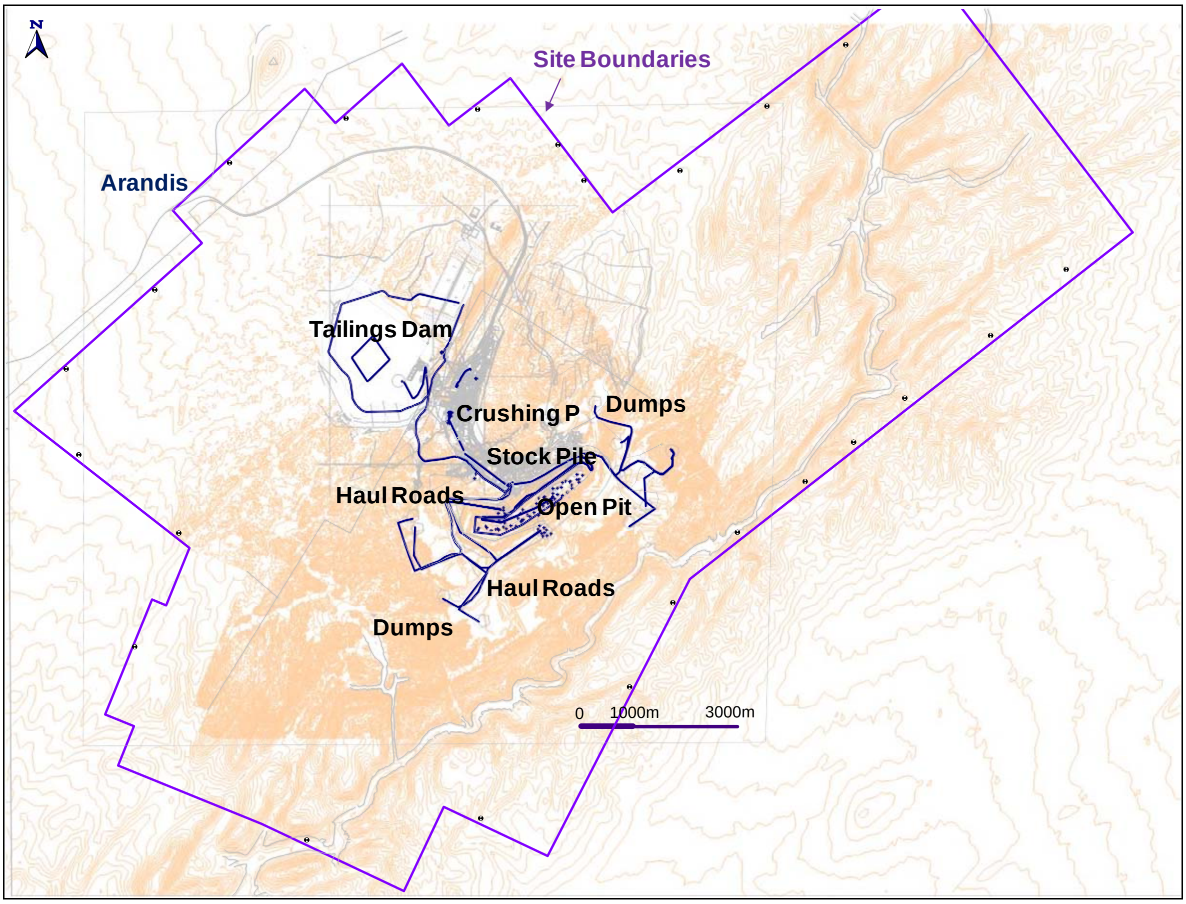

Figure 2-2. Rössing Mine Existing Main Noise Sources

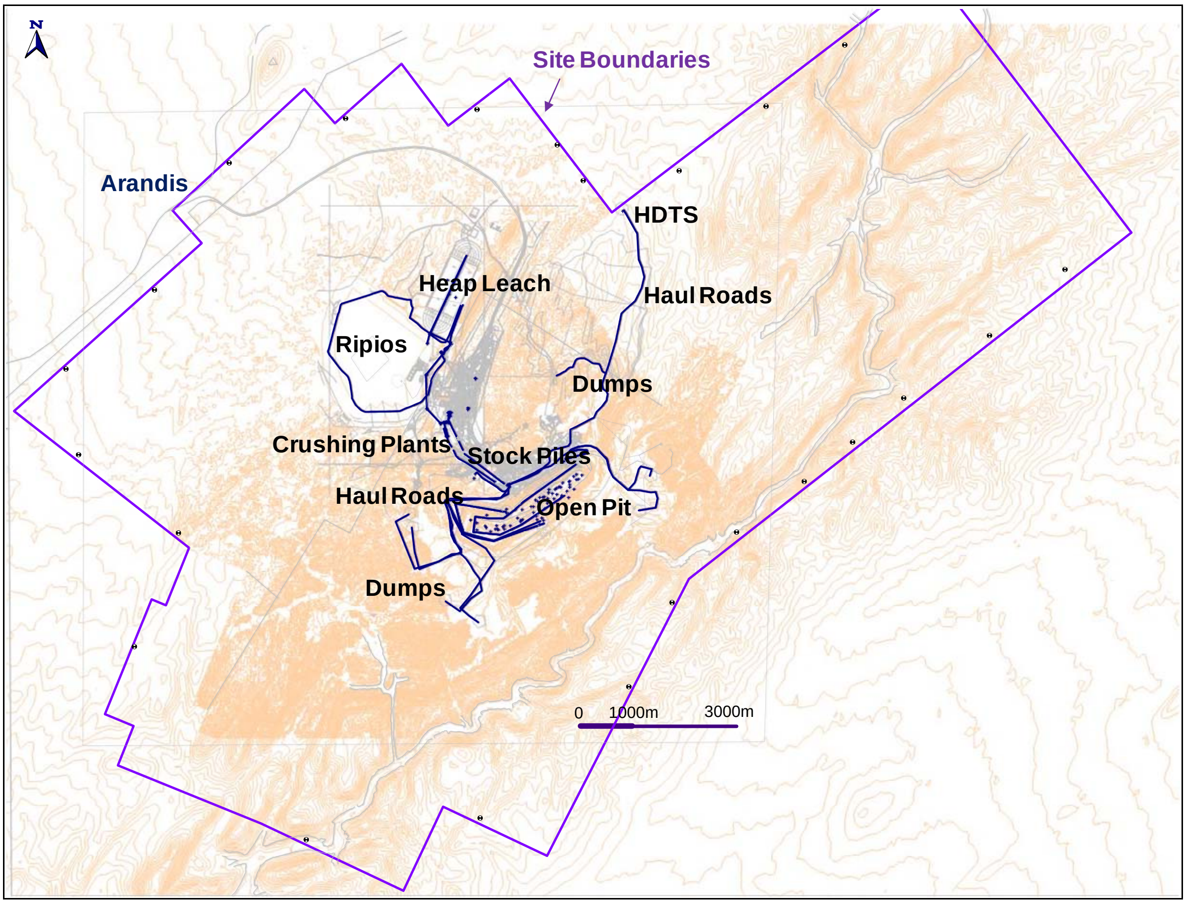

Figure 2-3. Rössing Mine Proposed Expansion Main Noise Sources

One additional alternative was identified at a later stage and was included for assessment in the noise impact study. This alternative, termed Central Case, has only minor changes in the overall layout and at the locations of the heap leach, tailings disposal and ripios disposal. The changes can be summarised as follows:

- Heap Leach: 15 million ton dynamic 60 day pad on the NE part of the current TSF.
- Ripios: Unlined disposal on the Dome transferred by rope conveyor.
- Tailings: Conventional tailings on the current TSF.

The locations of these noise sources, together with the other proposed expansion operations can be seen in Figure 2-4 below.

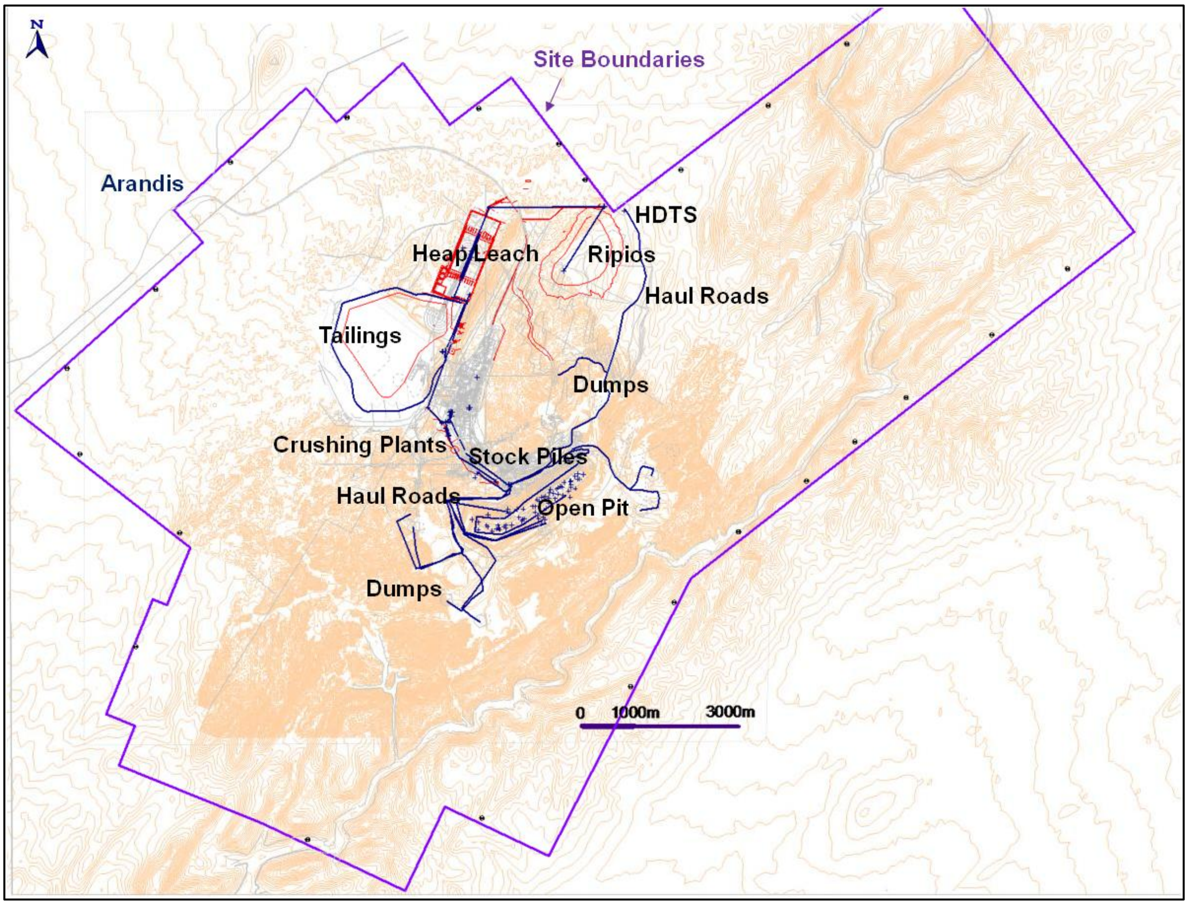

Figure 2-4. Rössing Mine Proposed Expansion Central Case Alternative Main Noise Sources

2.4 Noise Levels of Project Phases

2.4.1 Construction Phase

Construction activities associated with the new mining areas supporting infrastructure are similar to the subsequent mining activities and therefore unlikely to increase the noise level by more than that experienced for the operational phase.

2.4.2 Decommissioning Phase

No significant noise impacts are expected during the Decommissioning Phase of the proposed project. This impact is in any case likely to be of a short duration.

2.4.3 Possible Residual and Latent Impacts

With the termination of the mining and decommissioning operations, the noise levels within and around the site are expected to revert back to those existed prior to the mining activities. Therefore, no residual or latent noise impacts are expected.

2.4.4 Operational Phase

Prediction of noise levels during the operational phase of the proposed expansion is the primary purpose of the noise study, as it entails the increase of the ore quantities processed and hauled, as well as the introduction of additional processing equipment. The noise level increase and the relevant impact within and around the Rössing mining site are examined in detail in the sections below.

3 Predicted Noise Levels

Based on the noise modelling methodology and input data outlined in Section 2, the noise contours within and around the Rössing mining operations were estimated for daytime and night-time conditions. Three operational scenarios were utilised, i.e. the existing situation, the cumulative one with the originally proposed expansion and the cumulative situation with the proposed expansion and the Central Case alternative.

As there are no applicable Namibian National Noise Standards, the noise impact assessment was carried out in accordance with the South African National Standard - Code of Practice SANS 10103:2008. The noise level recommendations of 45 dBA (daytime) and 35 dBA (night-time) that were utilised for the impact assessment were taken from the above-mentioned standard for rural areas. These values are also comparable with other international practices, such as those recommended by the WHO and the OECD.

3.1 Noise Modelling Results of Existing Operations

Figure 3-1 and Figure 3-2 below show the noise contours around the Rössing mining operations due to the existing operations for the year 2010.

It can be seen that for the daytime conditions, the 45 dBA contour falls well within the Rössing mine’s northern, western and south-western site boundaries and does not extend beyond a 2km radius from the various noise sources. The closest distance to the Rössing site boundaries, that the 45 dBA contour reached, was approximately 2km from the south-eastern boundary.

Similarly, the night-time noise contribution of 35 dBA extends a maximum of 3 km around the various sources but does not extend beyond the mine’s boundaries. The closest distance to the site boundaries, that the 35 dBA contour reached, was approximately 700 m from the south-eastern boundary.

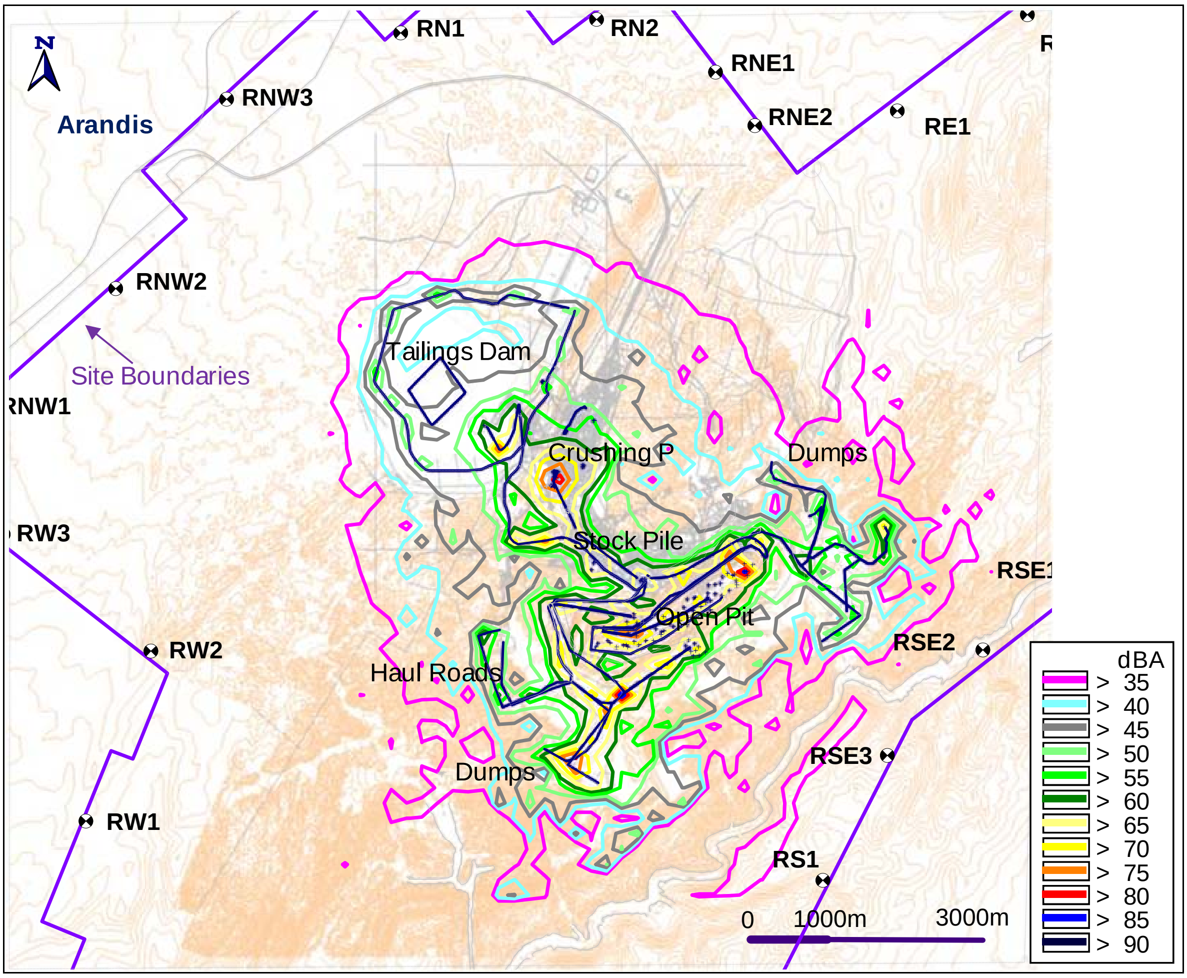

Figure 3-1. Daytime Noise Contours due to Existing Mine Operations

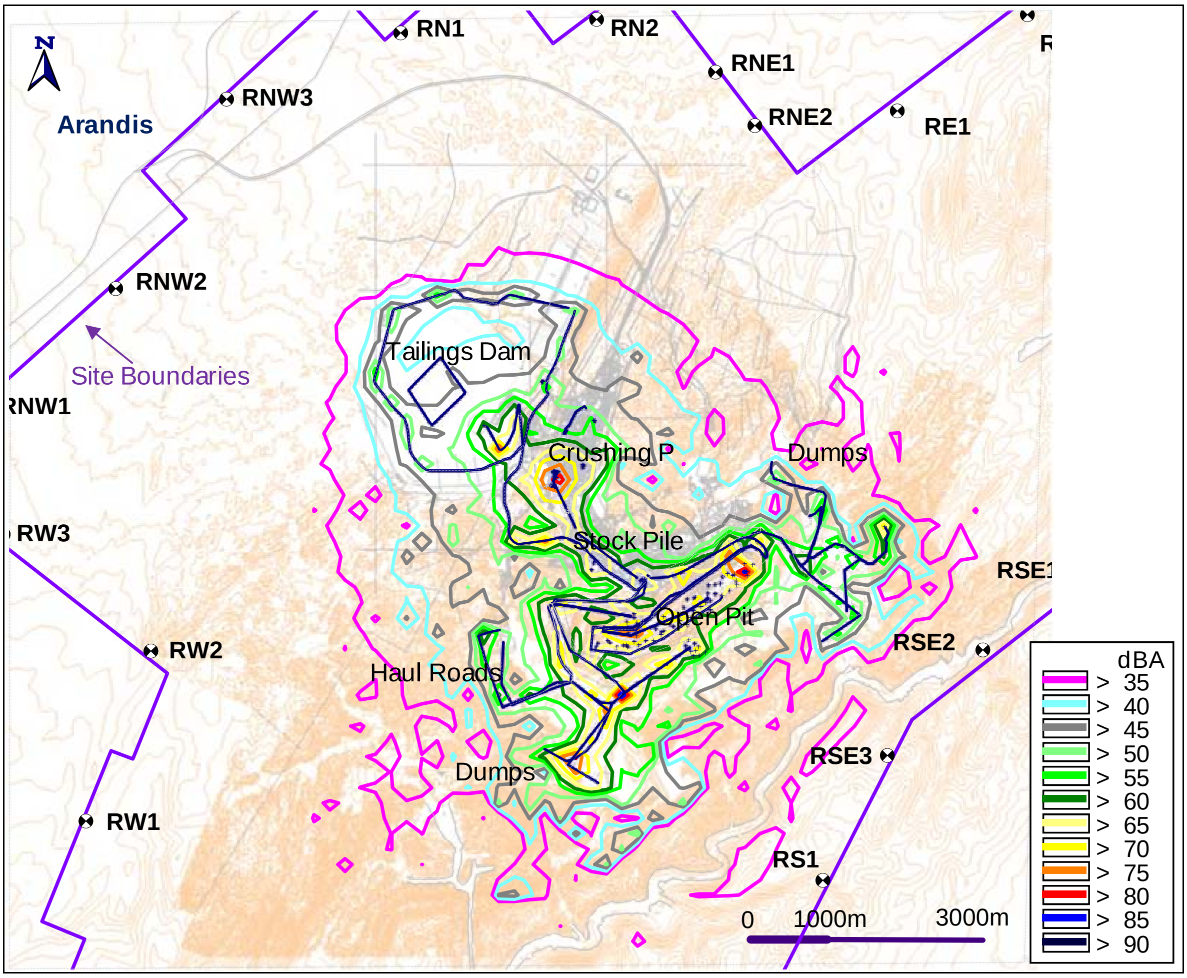

Figure 3-2. Night-time Noise Contours due to Existing Mine Operations

3.2 Noise Modelling Results of Proposed Expansion

Taking into consideration the existing noise sources due to the current mining operations in addition to the proposed expansion, the cumulative total scenario was generated. In this scenario, the cumulative noise levels were estimated for the areas within and around the site (see Figure 3-3 and Figure 3-4).

It can be seen that for the daytime conditions, the 45 dBA contour falls well within the Rössing mine's northern, western and south-western site boundaries. The only exception is a small area outside the north-eastern boundary, close to the High Density Tailings Sand mining area (HDTS).

Similarly, the night-time noise contribution of 35 dBA does not extend beyond the mine's boundaries, except for a small area outside the north-eastern boundary. The 35 dBA noise contour also reached the south-eastern boundary of the site.

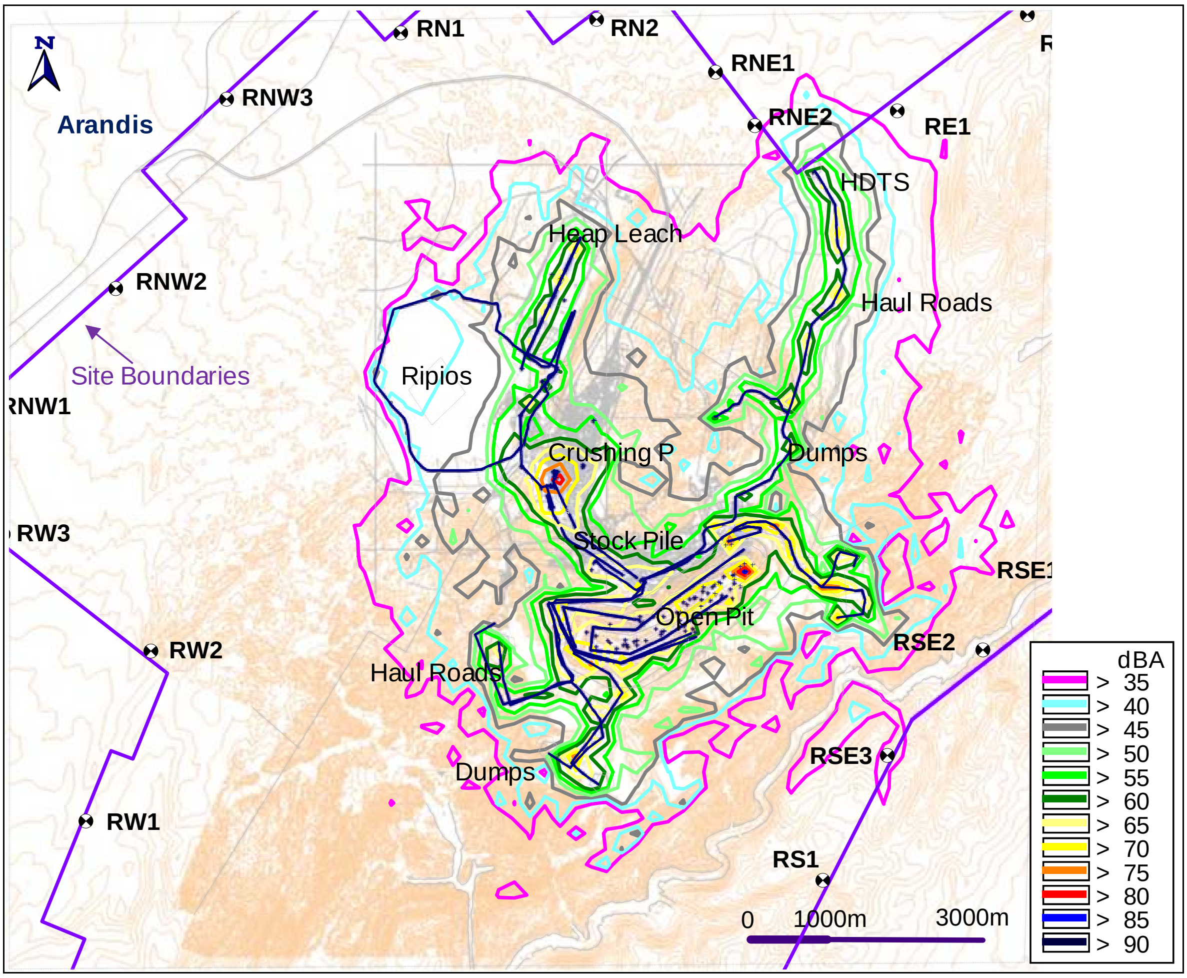

Figure 3-3. Day-time Cumulative Total due to Existing and Expansion Operations

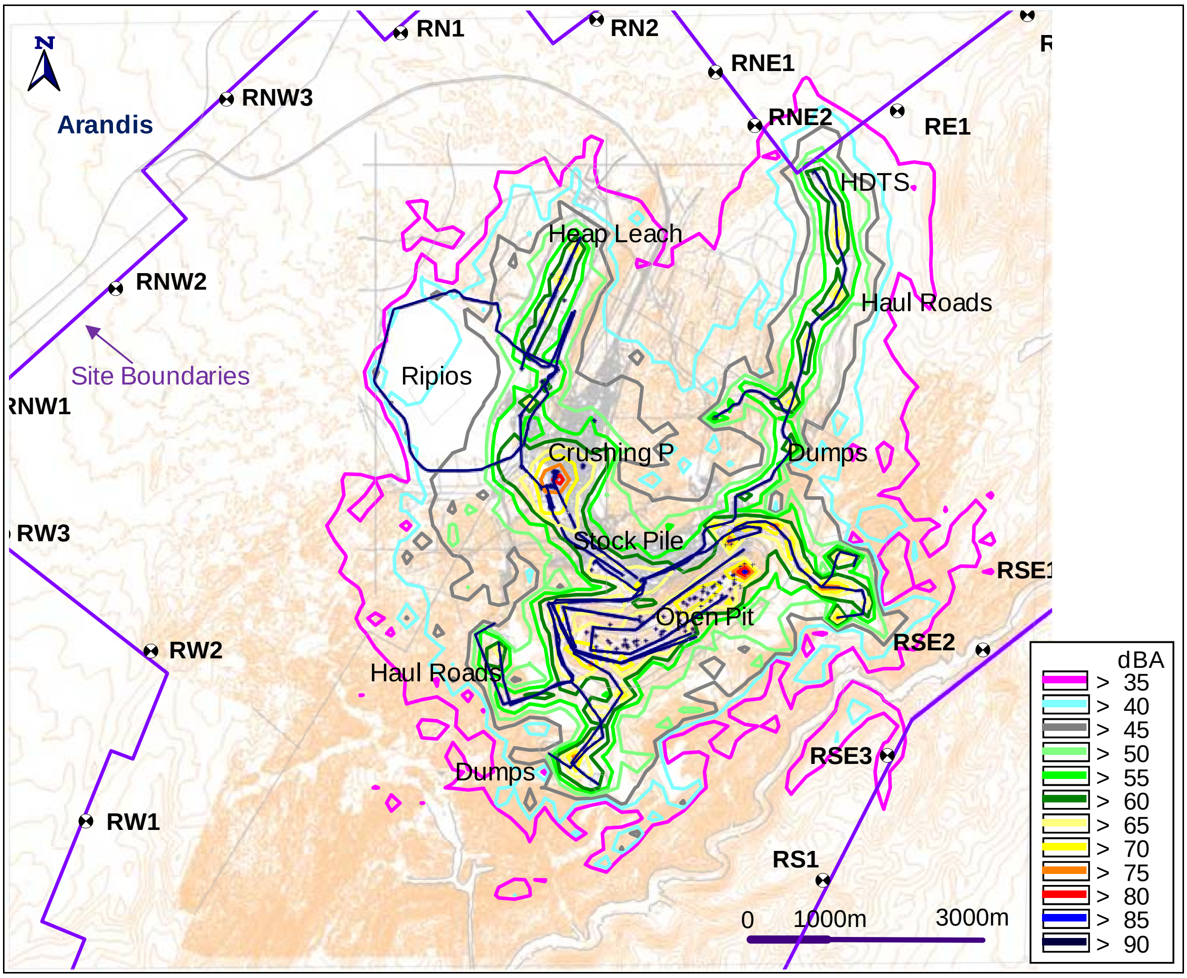

Figure 3-4. Night-time Cumulative Total due to Existing and Expansion Operations

In order to assess the cumulative noise impact of the various sources' contribution to the rural daytime and night-time noise level guidelines, the following Figure 3-5 and Figure 3-6 were generated. These show the resulting cumulative total noise level due to the current and proposed extension operations above the 45 dBA and 35 dBA guidelines for the daytime and night-time conditions respectively.

It can be seen that under daytime conditions, the noise contour that represents the 1 dBA noise level increase above the 45 dBA guideline is well contained within the mine's boundaries, apart from the small area adjacent to the north-eastern boundary (see Figure 3-5).

For night-time conditions, the 1 dBA increase above the 35 dBA contour falls well within the northern and western boundaries and extends beyond the north-eastern boundary by approximately 1 km. At a certain location along the north-eastern boundary, the increase of the noise level above the 35 dBA guideline is expected to be more than 12 dBA (see Figure 3-6). It should be noted, however, that as the HDTS mining face moves further away from the site's boundary, this impact area outside the north-eastern boundary may be eliminated. A buffer zone of approximately 1.2 km from the boundary would ensure compliance with the 35 dBA rural guideline outside the mine's north-eastern boundary.

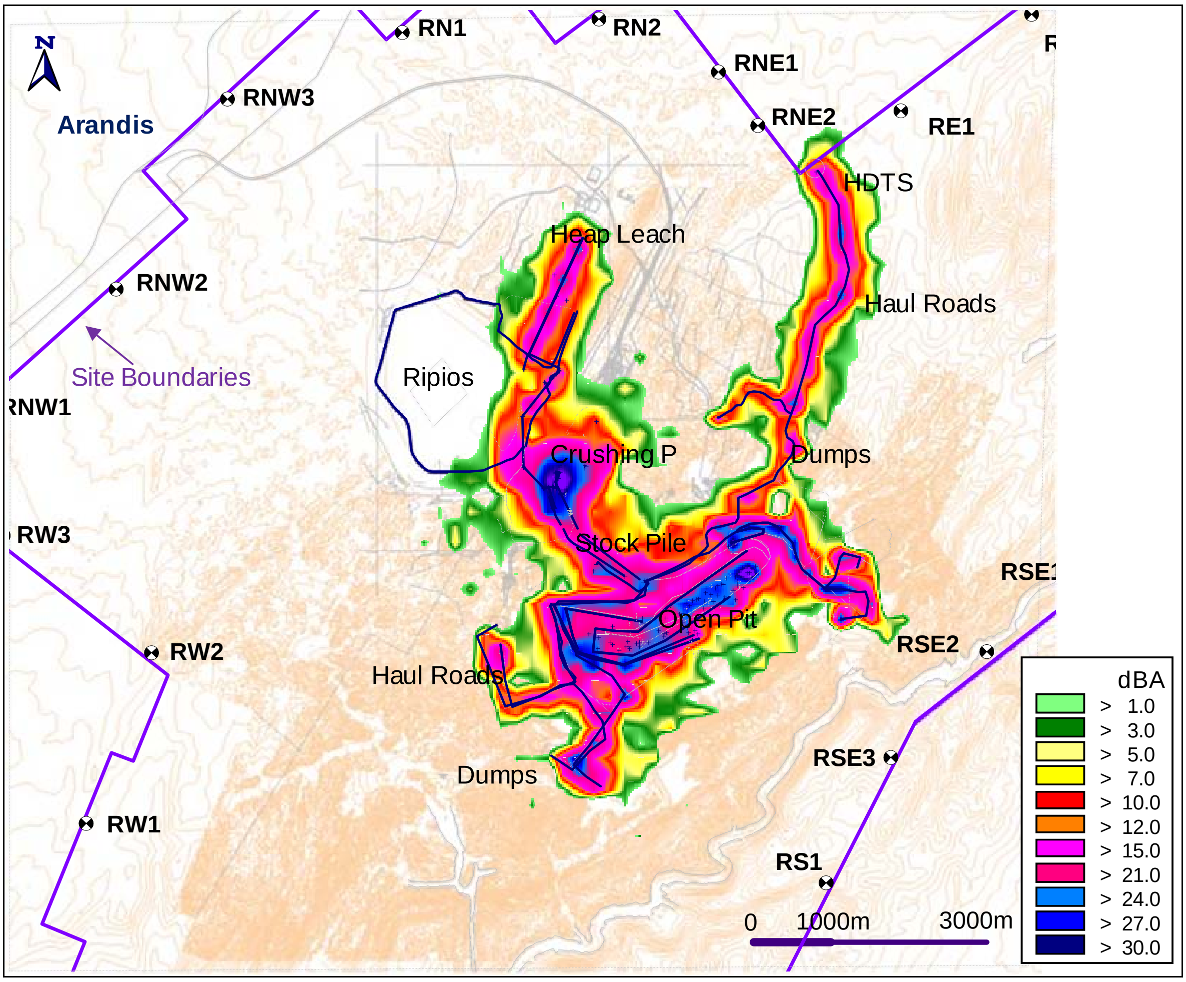

Figure 3-5. Proposed Expansion Daytime Noise Level Increase Above the 45 dBA Guideline

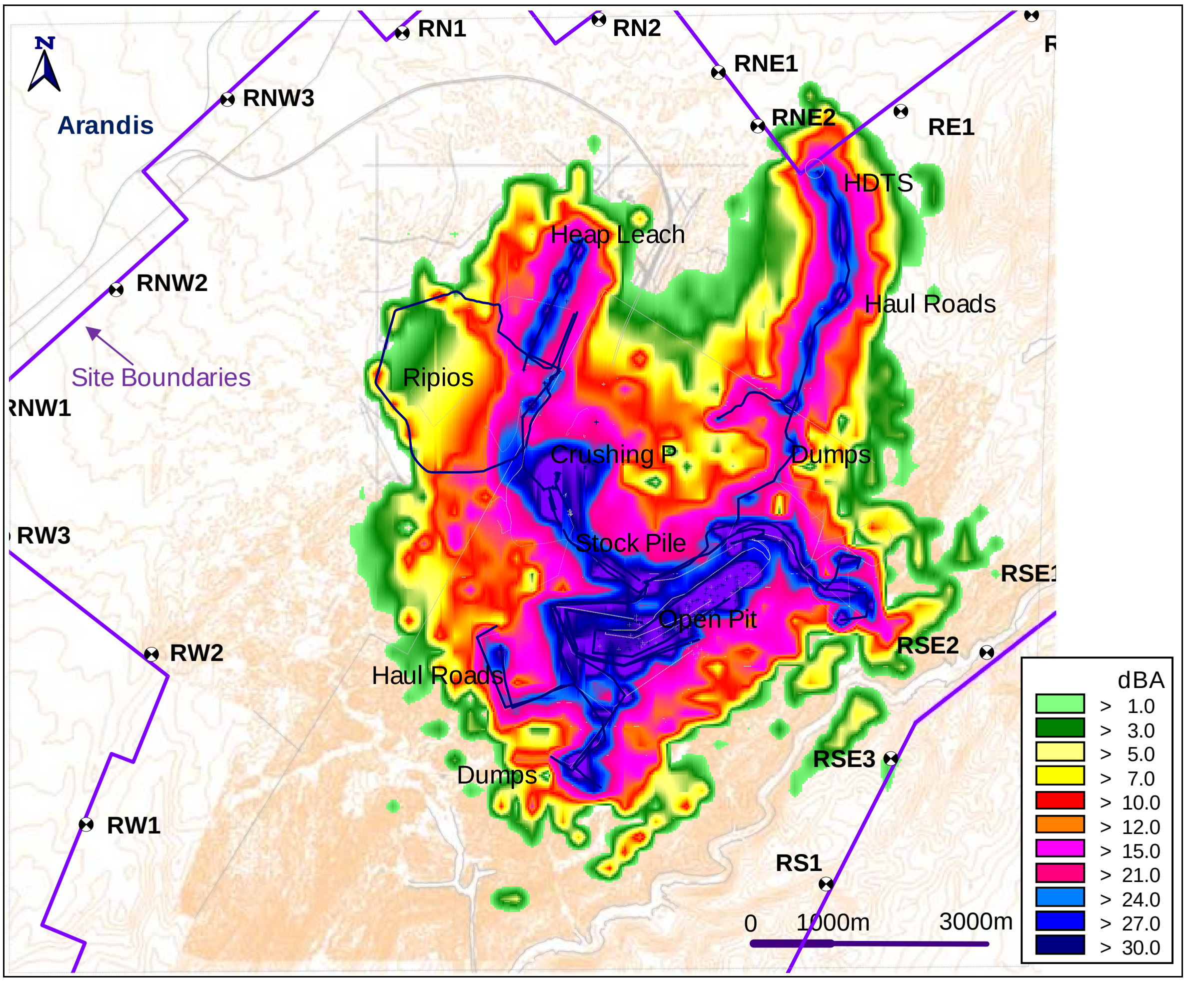

Figure 3-6. Proposed Expansion Night-time Noise Level Increase Above the 35 dBA Guideline

It should be noted that in certain remote areas around the Rössing site boundary, the noise levels can in some instances be as low as 20 dBA. In such areas and under certain atmospheric conditions, such as temperature inversions with light winds, the mining operations may be audible downwind from the mining area at great distances, i.e. more than 20 km away. A sound can be audible when it is around 3 dB above the existing noise level. As such, some of the mining activities may be audible in the above-mentioned remote areas. This however, does not constitute a disturbing noise, which is the noise level increase by 7 dB or more. The recommended guidelines for a rural area of 45 dBA during daytime and 35 dBA during night-time, are considered appropriate for the noise impact assessment in the areas around the Rössing mining site.

The noise levels at several discrete receptors along the Rössing mine boundaries were also estimated. The location of these receptors can be seen in Figure 3-7 below. The noise level contribution of the existing noise sources, as well as the cumulative total that includes the existing operations and proposed expansion, can be seen in Table 3-1 below. A noise level contribution of below 25 dBA can be considered negligible since firstly, the existing noise level there would be higher than 30 dBA, even during the night, and secondly, the guidelines for daytime and night-time conditions are 45 dBA and 35 dBA respectively.

It can be seen that at none of the boundary receptors, the noise level exceeded the daytime guideline, except for the night-time one at receptor RSE3, which was marginally exceeded. It should be noted, however, that based on the results depicted in Figure 3-6, there will be exceedance of the 35 dBA night-time and the 45 dBA daytime guidelines up to approximately 900 m and 300 m respectively outside the north-eastern boundary of the site.

The variations of the estimated daytime and night-time levels are attributed to the different wind conditions prevailing during day and night-time. The boundaries with the highest noise levels at the discrete receptors were the north-east and the south-east. However, no there are communities along the Rössing site boundary or in close proximity to the boundary.

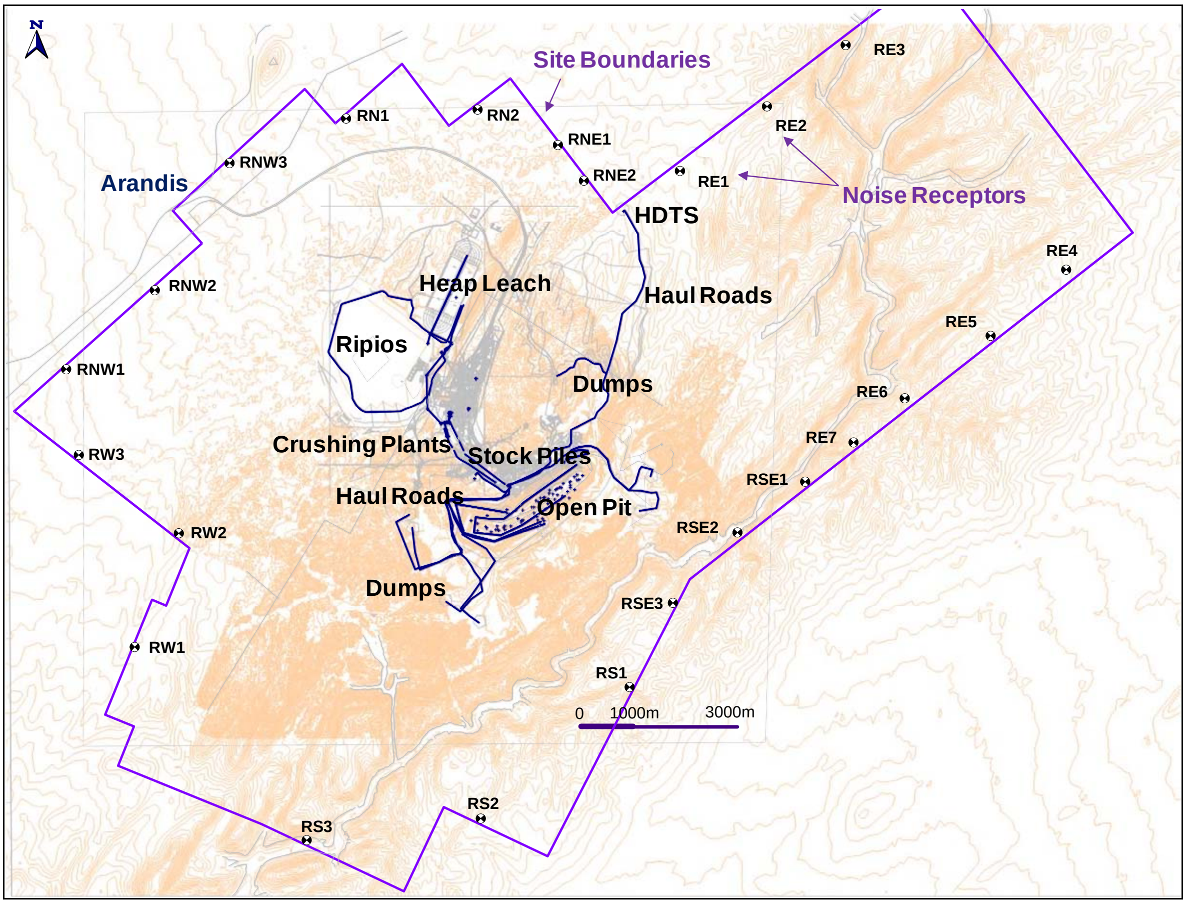

Figure 3-7. Discrete Receptor Locations Along the Rössing Mine Site Boundaries

Table 3-1. Calculated Noise Levels at Rössing Boundary Receptors

Receptor	Location	Existing Operations[1]		Proposed Expansion [2]	
ID		Daytime	Night-time	Daytime	Night-time
		(dBA)	(dBA)	(dBA)	(dBA)
RE1	East boundary	24.7	23.5	33.1	32.0
RE2	East boundary	16.7	15.5	22.1	20.9
RE3	East boundary	8.5	7.3	16.1	14.9
RE4	East boundary	4.8	3.8	13.7	12.8
RE5	East boundary	18.7	17.8	20.9	20.0
RE6	East boundary	16.8	15.9	19.8	19.0
RE7	East boundary	25.3	24.5	27.6	26.8
RN1	North boundary	22.1	21.3	24.9	24.4
RN2	North boundary	23.6	22.5	29.8	28.7
RNE1	North-east boundary	23.5	22.2	29.1	28.4
RNE2	North-east boundary	25.3	24.1	33.7	33.5
RNW1	North-west boundary	19.3	20.3	20.1	21.1
RNW2	North-west boundary	21.4	22.0	23.2	23.9
RNW3	North-west boundary	21.8	21.6	23.5	23.5
RS1	South boundary	27.9	27.8	28.3	28.4
RS2	South boundary	26.3	26.9	24.7	25.3
RS3	South boundary	13.7	14.8	14.5	15.6
RSE1	South-east boundary	27.3	26.6	29.8	29.1
RSE2	South-east boundary	27.1	26.6	28.8	28.3
RSE3	South-east boundary	32.0	31.8	36.8	37.0
RW1	West boundary	23.4	24.8	22.6	24.1
RW2	West boundary	26.5	27.9	26.9	28.3
RW3	West boundary	22.8	24.0	21.9	23.1

[1] Noise level contribution due to the existing operation noise sources, year 2010.
[2] Cumulative noise level from the current and proposed expansion's noise sources, year 2013.

3.3 Noise Modelling Results of Proposed Expansion: Central Case Alternative

Similar to the original scenario for the proposed expansion, the existing noise sources due to the current mining operations were taken into consideration for the Central Case alternative. The cumulative noise levels were estimated for the areas within and around the site for daytime and night-time conditions and are depicted in Figure 3-8 and Figure 3-9 respectively.

It is evident that for the daytime conditions, the 45 dBA contour falls well within the Rössing mine's northern, western and south-western site boundaries. The only exception is an area outside the north-eastern boundary, close to the Ripios and the High Density Tailings Sand mining area (HDTS).

Similarly, the night-time noise contribution of 35 dBA does not extend beyond the mine's boundaries, except for a small area outside the north-eastern boundary. The 35 dBA noise contour also reached the south-eastern boundary of the site.

It is evident from the results that the originally proposed expansion and the Central Case alternative will generate similar noise levels within and around the site. The only noteworthy difference between the two scenarios is the increase of the daytime and night-time noise levels close to the north-eastern boundary of the site. As such, for the Central Case alternative, the areas exceeding the daytime and night-time guidelines will be larger than those of the original expansion scenario (see Figure 3-8 and Figure 3-9).

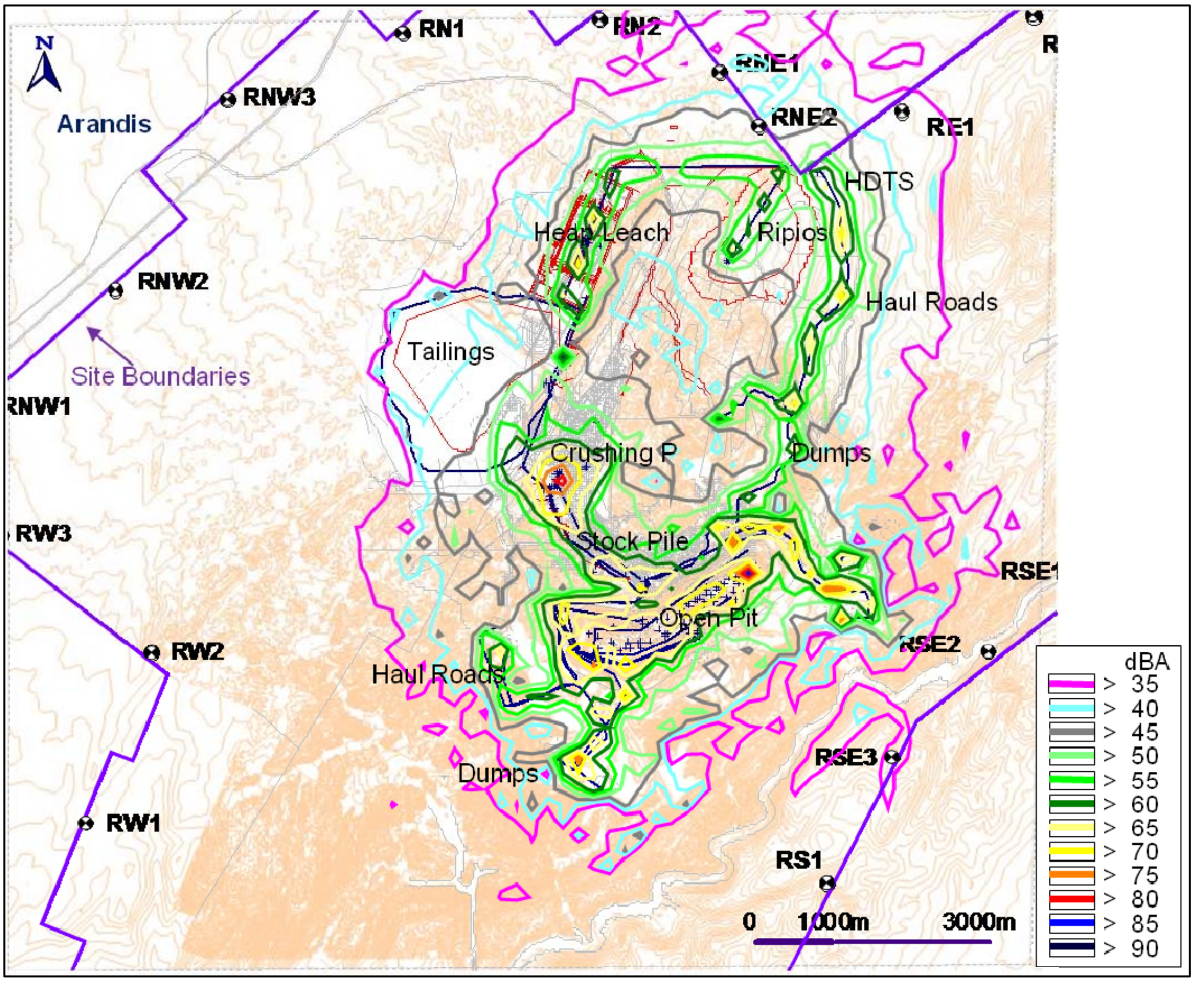

Figure 3-8. Day-time Cumulative Total due to Existing and Expansion Operations: Central Case Alternative

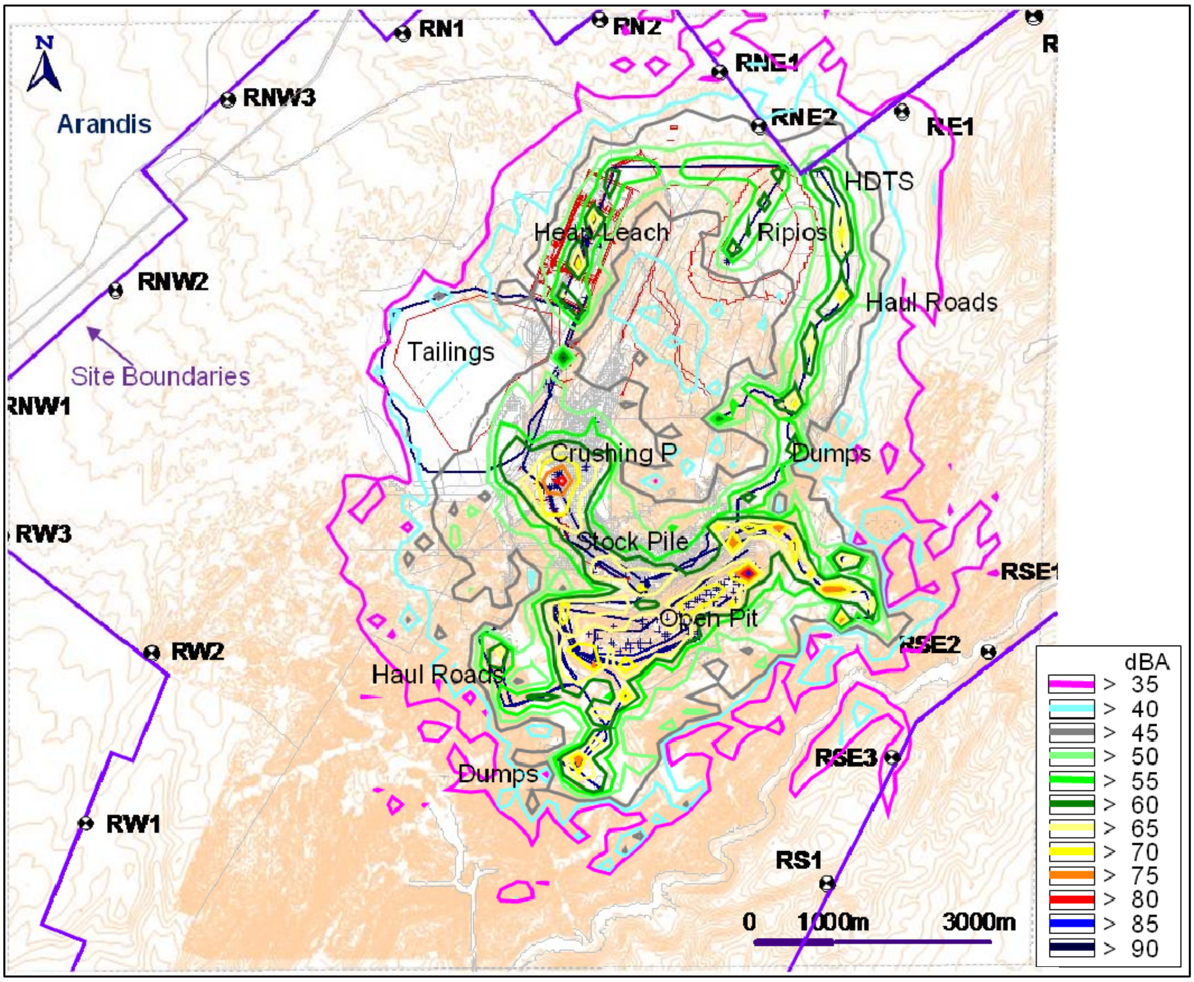

Figure 3-9. Night-time Cumulative Total due to Existing and Expansion Operations: Central Case Alternative

The following Figure 3-10 and Figure 3-11 show the resulting cumulative noise levels that are above the 45 dBA and 35 dBA guidelines for day and night-time conditions respectively. These noise levels were based on the current, as well as the proposed expansion Central Case alternative.

Similar to the results of the original proposed expansion scenario, under daytime conditions, the noise contour that represents the 1 dBA noise level increase above the 45 dBA guideline is well contained within the mine's boundaries, apart from an area adjacent to the north-eastern boundary (see Figure 3-10). This area is larger for the Central Case alternative scenario, primarily due to the additional conveyor belt to the Ripios.

For night-time conditions, the 1 dBA increase above the 35 dBA contour falls well within the northern and western boundaries but extends beyond the north-eastern boundary by approximately 1.4 km. At certain locations along the north-eastern boundary, the increase of the noise level above the 35 dBA guideline, is expected to be more than 15 dB (see Figure 3-11). It should be noted, however, that as the HDTS mining face moves further away from the site's boundary, this impact area outside the north-eastern boundary may be reduced. A buffer zone of approximately 1.5 km from the boundary would ensure compliance with the 35 dBA rural guideline outside the mine's north-eastern boundary.

This buffer zone can be established either on the inside or outside of the Rössing site boundary, since there are no sensitive receptors in that area. If this buffer is established outside the boundary, any potential residential development should be restricted within this zone. The expected noise levels, however, would allow for commercial or industrial development.

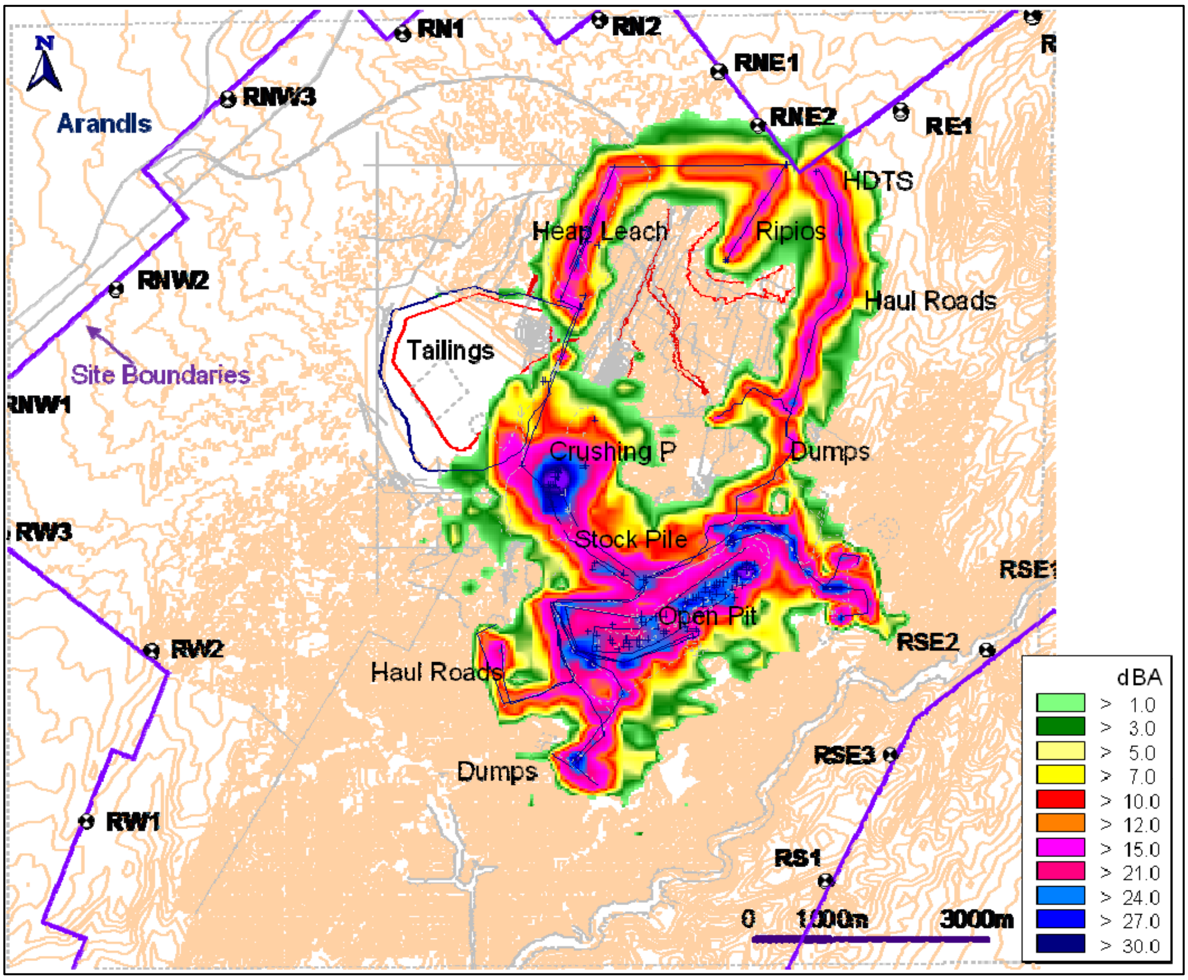

Figure 3-10. Proposed Expansion Central Case Alternative Daytime Noise Level Increase Above the 45 dBA Guideline

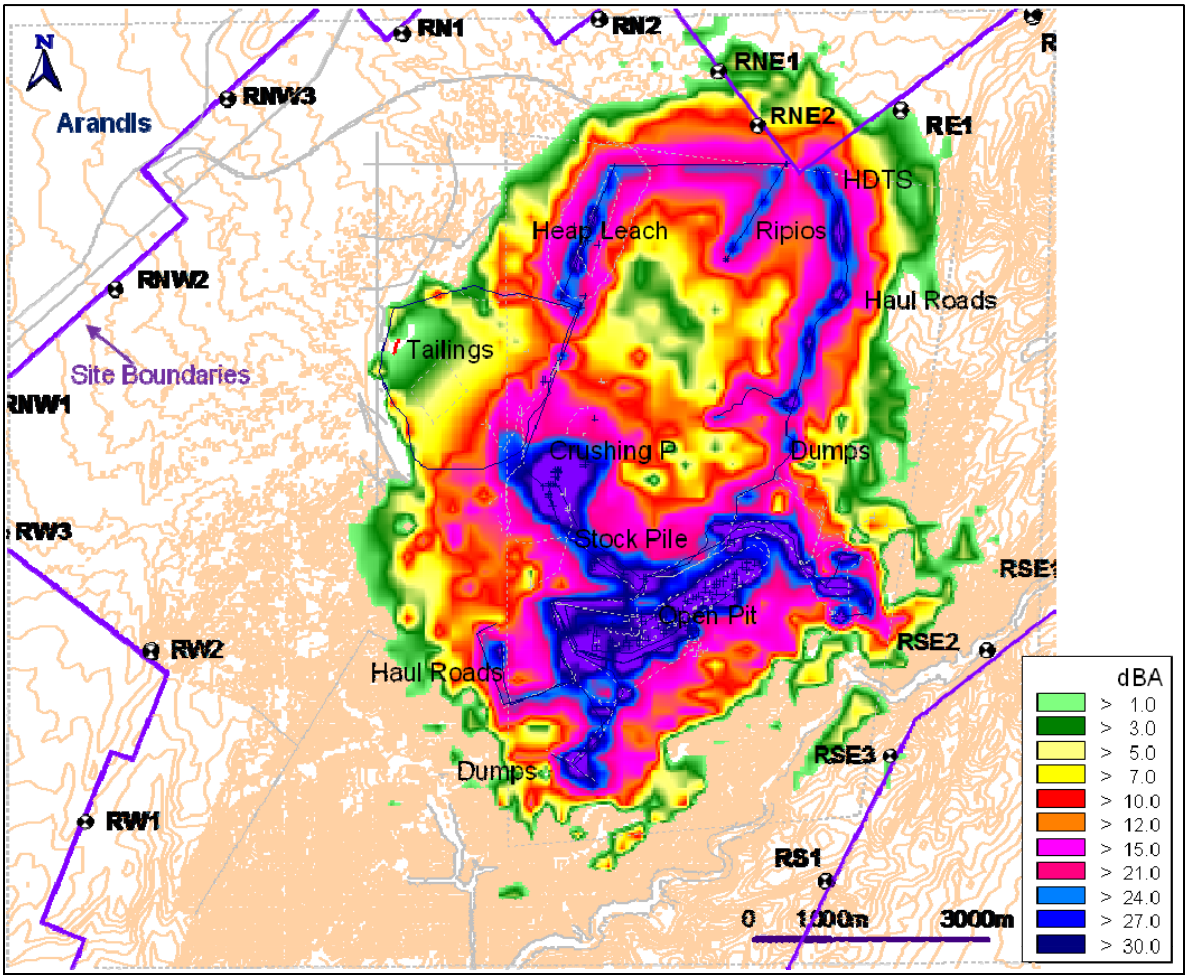

Figure 3-11. Proposed Expansion Central Case Alternative Night-time Noise Level Increase Above the 35 dBA Guideline

The noise levels at several discrete receptors (see Figure 3-7) along the Rössing mine boundaries were also estimated. The cumulative noise levels for the Central Case alternative can be seen in Table 3-2 below, together with the increase or decrease from the original expansion scenario.

The noise level at the north-eastern boundary exceeded the daytime and night-time guideline. The noise level increase at that point was around 12 dB. However, no communities or noise-sensitive receptors are situated close to the north-eastern boundary.

Table 3-2. Calculated Noise Levels at Rössing Boundary Receptors

Receptor	Location	Proposed Expansion [1] Central Case Alt.		Difference [2]	
ID		Daytime	Night-time	Daytime	Night-time
		(dBA)	(dBA)	(dB)	(dB)
RE1	East boundary	37.2	36.2	4.1	4.2
RE2	East boundary	23.7	22.6	1.6	1.7
RE3	East boundary	17.7	16.6	1.6	1.7
RE4	East boundary	14.4	13.5	0.7	0.7
RE5	East boundary	21.1	20.3	0.2	0.3
RE6	East boundary	20.2	19.5	0.4	0.5
RE7	East boundary	27.7	27.0	0.1	0.2
RN1	North boundary	25.9	25.7	1.0	1.3
RN2	North boundary	32.4	31.7	2.6	3.0
RNE1	North-east boundary	37.3	36.6	8.2	8.2
RNE2	North-east boundary	46.2	45.3	12.5	11.8
RNW1	North-west boundary	20.1	21.1	0.0	0.0
RNW2	North-west boundary	23.2	23.9	0.0	0.0
RNW3	North-west boundary	23.5	23.6	0.0	0.1
RS1	South boundary	28.3	28.4	0.0	0.0
RS2	South boundary	24.6	25.3	-0.1	0.0
RS3	South boundary	14.4	15.6	-0.1	0.0
RSE1	South-east boundary	29.9	29.2	0.1	0.1
RSE2	South-east boundary	28.9	28.4	0.1	0.1
RSE3	South-east boundary	36.9	37.1	0.1	0.1
RW1	West boundary	22.6	24.1	0.0	0.0
RW2	West boundary	26.9	28.3	0.0	0.0
RW3	West boundary	21.9	23.1	0.0	0.0

[1] Cumulative noise levels due to the current and Central Case Alternative proposed expansion's noise sources, year 2013.
[2] Difference between Central Case alternative and original proposed expansion scenario.

4 Impact Assessment and Recommendations

4.1 General

This study is an overall assessment designed to predict the collective response of a noise-exposed population and therefore the impact the operation is likely to have on them, and is based on measured and predicted equivalent continuous noise levels, according to SANS 10103:2008. It will be possible to detect and distinguish individual noise events, even if the noise impact is assessed as NONE, or VERY LOW, i.e. where a person with normal hearing will not be able to detect the predicted increase in ambient noise level attributable to operation of the relevant project component, but where an operation may nevertheless be audible to that person at some time.

In view of the very consistent noise measurements obtained from around the RU mine lease boundary, the recommended values in accordance with SANS 10103:2008, i.e. 45 dBA during daytime (06:00 to 22:00) and 35 dBA during night-time (22:00 to 06:00), were used in the assessments which follow.

4.2 Conclusions

It should be noted that under certain atmospheric conditions, such as temperature inversions with light winds, the mining operations may be marginally audible downwind from the mining area at great distances, i.e. more than 20 km away. A sound can be audible at around 3 dB above the existing noise level. This, however, does not constitute a disturbing noise. The generally acceptable noise level increase, in order to constitute a disturbing noise, is 7 dB. The rural area recommended guidelines of 45 dBA during daytime and 35 dBA for night-time are considered appropriate for the noise impact assessment around the Rössing mining site.

The main conclusions of the study regarding the noise impacts of the cumulative noise levels due to the existing operations and proposed expansion were:

- The 45 dBA contour, representing the daytime rural guideline, was well contained within the Rössing mine's northern, western and south-western site boundaries.
- The only exceedance of the 45 dBA guideline outside the Rössing boundaries was a small area adjacent to the north-eastern boundary, close to the High Density Tailings Sand mining area (HDTS).
- The night-time noise levels also did not exceed the 35 dBA guideline outside the site boundaries, except for the boundary area close to the High Density Tailings Sand mining area (HDTS).
- The 35 dBA noise contour reached the south-eastern boundary of the site.
- The noise levels generated by the Central Case alternative were similar to those of the originally proposed expansion scenario in most areas, with the only exception being the north-eastern boundary.
- The Central Case alternative generated noise levels at the north-eastern boundary that exceeded the daytime and night-time guideline.

4.3 Mitigation and Management

Mitigation measures include the following:

- Buffer zone establishment: At the HDTS mining area, a buffer zone of approximately 1.2 km from the boundary should be established, in order to ensure compliance with the 35 dBA rural guideline outside the mine's north-eastern boundary. Alternatively, consideration should be given to the restriction of the night-time operations at that location or the construction of an earth berm. For the Central Case alternative the buffer zone should extend to 1.5 km. The alignment of the conveyor belt to the Ripios should be kept as far as possible from the north-eastern boundary. It should be noted that this buffer zone can be established on either the inside or outside of the site's boundary.
- Maintenance of equipment and operational procedures: Proper design and maintenance of silencers on diesel-powered equipment, systematic maintenance of all forms of equipment, training of personnel to adhere to operational procedures that reduce the occurrence and magnitude of individual noisy events.
- Placement of material stockpiles: Where possible, material stockpiles should be placed so as to protect site boundaries from noise of individual operations. If a stockpile is constructed, it should be at a position and of such a height as to effectively act as a barrier to site noise at any sensitive area, if the line of sight calculations show this to be practicable. In particular, the erection of suitable earth berms around the permanent machinery can significantly reduce the noise by up to 15 dB. This is particularly important at the location of the High Density Tailings Sand (HDTS).
- Equipment noise audits: Standardized noise measurements should be carried out on individual equipment at the delivery to site to construct a reference data-base, and regular checks carried out to ensure that equipment is not deteriorating and to detect increases which could lead to an increase in the noise impact over time and increased complaints.
- Environmental noise audits: Environmental noise monitoring should be carried out regularly to detect deviations from predicted noise levels and enable corrective measures to be taken where warranted. A noise monitoring programme, based on the noise modelling and the baseline noise measurements was supplied as a separate document (Dracoulides and Hassall, 2010).

4.4 Impacts Significance Table

Based on the modelling results for the existing mining, as well as the proposed expansion operations, the impacts of construction and operation are summarised in the Table 4-1 below.

The noise impact during construction is considered to be *VERY LOW*, and with additional mitigation measures *NEGLIGIBLE*.

For the operational phase, the overall noise impact is *LOW* without mitigation measures and *VERY LOW* with the additional mitigation measures.

Even though the Central Case alternative generated noise levels greater than the original proposed expansion scenario around the north-eastern boundary of the site, there are no sensitive receptors in that area and no plans either for any residential development. As such, the impact table presented below is considered applicable to both proposed expansion scenarios, i.e. the original and the Central Case alternative.

Table 4-1. Significance of Noise Impacts for Proposed Expansion and Central Case Alternative

	Extent	Magnitude	Duration	Significance	Probability	Confidence	Reversibility
Construction Phase							
Without Mitigation	Local	Very Low	Construction period	Very low	Probable	Sure	Reversible
With Mitigation	Local	Very Low	Construction period	Negligible	Probable	Sure	Reversible
Operation Phase							
Without Mitigation	Local	Low	Long-term	Low	Probable	Sure	Reversible
With Mitigation	Local	Very Low	Long-term	Very Low	Probable	Sure	Reversible

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APPENDIX A

A1. Noise Measurement Locations

A1.1 Fine Crusher Plant

Position RM01

Position: Between the transfer tower and the pre-screening, along the road at a distance of 35m from RM02 (located under the conveyor belt between the tower and the pre-screen).

GPS coordinates: S22° 28.052′ E15° 02.466′, 575m ±5m

Position RM02

Position: Under the conveyor belt between the transfer tower and the pre-screening.

GPS coordinates: S22° 28.035′ E15° 02.471′, 575m ±4.7m

Position RM05

Position: Between the transfer tower and the pre-screening, along the road at a distance of 65m from RM02 (located under the conveyor belt between the tower and the pre-screen).

GPS coordinates: S22° 28.067′ E15° 02.459′, 577m ±5m

Position RM08

Position: On top of the scrubber , close to the pre-screening.

GPS coordinates: S22° 28.033′ E15° 02.461′, 580m ±5m

Position PM07

Position: On the transfer tower.

Position P12

Position: On the various levels of the pre-screen.


Position PM09

Position: On the various levels of the 1st secondary crusher.


Position PM10

Position: In front of the bag filter fan.

Position P23

Position: On the various levels of the 2nd secondary crusher.

Position P27

Position: On the various levels of the fine crusher.

Measurements Table

Octave band measurements were carried out, giving the following worst-case values of 4 sets of results, measured at various distances from the noise centres. All values are in dB re 20 microPascals.

	Measurement Position									
Freq (Hz.)	**RM01 (dB)**	**RM02 (dB)**	**RM05 (dB)**	**RM08 (dB)**	**RM07 (dB)**	**P12 (dB)**	**RM09 (dB)**	**PM10 (dB)**	**P23 (dB)**	**P27 (dB)**
31.5	92.7	85.0	87.6	90.3	92.1	99.9	82.7	90.6	84.4	85.7
63	87.3	90.8	84.1	87.3	93.9	100.3	85.2	88.1	84.9	84.1
125	84.6	94.3	80.1	86.8	92.4	93.6	86.1	88.7	87.5	91.4
250	76.3	87.7	72.8	86.0	86.1	94.1	85.7	89.0	89.6	92.1

	Measurement Position									
Freq (Hz.)	**RM01 (dB)**	**RM02 (dB)**	**RM05 (dB)**	**RM08 (dB)**	**RM07 (dB)**	**P12 (dB)**	**RM09 (dB)**	**PM10 (dB)**	**P23 (dB)**	**P27 (dB)**
500	75.8	81.6	74.8	84.2	84.5	96.2	89.6	86.3	91.0	95.6
1k	72.8	81.1	73.0	81.9	79.9	95.6	91.2	85.5	88.9	95.2
2k	69.7	81.8	69.2	81.7	75.5	92.0	84.3	80.7	84.8	92.3
4k	63.4	74.5	61.4	81.9	70.4	84.4	75.3	73.8	81.3	83.1
8k	55.3	69.6	51.9	74.1	63.7	73.9	66.2	68.9	78.2	76.3
dB(A)	78.3	87.7	77.3	88.8	86.0	99.3	93.5	89.4	93.3	98.9

A1.2 Slimes Pump Station

Position RM13, RM14, P35

Position: At three of the operating slimes pumps 2m, 1m and 1.1m away from motor centre, respectively.

GPS coordinates: S22° 27.569′ E15° 02.784′, 610m ±5m

Measurements Table

Octave band measurements were carried out, giving the following worst-case values of 3 sets of results for each pump. All values are in dB re 20 microPascals.

	Measurement Position		
Freq (Hz.)	**RM01 (dB)**	**RM02 (dB)**	**RM09 (dB)**
31.5	71.9	74.8	66.9
63	75.0	83.0	74.6
125	77.5	85.8	75.9
250	76.5	87.8	85.1
500	76.5	86.2	89.2
1k	75.3	84.3	89.3
2k	77.9	80.4	85.7

	Measurement Position		
Freq (Hz.)	**RM01 (dB)**	**RM02 (dB)**	**RM09 (dB)**
4k	76.0	76.1	76.8
8k	69.3	72.9	78.2
dB(A)	83.0	88.9	92.8

A1.3 PADDYX Pump Station

Position RM15, P37, P38

Position: At three of the operating pumps 1m, 1m and 0.8m away from motor centre, respectively.

GPS coordinates: S22° 27.284′ E15° 02.394′, 667m ±5m

Measurements Table

Octave band measurements were carried out, giving the following worst-case values of 3 sets of results for each pump. All values are in dB re 20 microPascals.

	Measurement Position		
Freq (Hz.)	**RM01 (dB)**	**RM02 (dB)**	**RM09 (dB)**
31.5	66.9	81.7	72.2
63	74.6	87.3	79.9
125	75.9	91.7	86.1
250	85.1	93.6	88.2
500	89.2	93.4	87.9
1k	89.3	90.7	82.3
2k	85.7	84.2	79.5
4k	76.8	77.5	73.0
8k	78.2	72.7	66.6
dB(A)	92.8	94.8	88.5

APPENDIX B

B1. Proposed Methodology for Assessing the Environmental Impacts

For each impact, the EXTENT (spatial scale), MAGNITUDE (size or degree scale) and DURATION (time scale) will be described. These criteria are used to ascertain the SIGNIFICANCE of the impact, firstly in the case of no mitigation and then with the most effective mitigation measure(s) in place. The tables on the following pages show the scales used to assess these variables and define each of the rating categories.

Table B-1: Assessment criteria for the evaluation of impacts

CRITERIA	CATEGORY	DESCRIPTION
Extent or spatial influence of impact	**National**	Within Namibia
	Regional	Within the Erongo Region
	Local	Mine Licence Area and Mine Accessory Works Area
Magnitude of impact (at the indicated spatial scale)	**High**	Natural and/ or social functions and/ or processes are *severely* altered
	Medium	Natural and/ or social functions and/ or processes are *notably* altered
	Low	Natural and/ or social functions and/ or processes are *slightly* altered
	Very Low	Natural and/ or social functions and/ or processes are *negligibly* altered
	Zero	Natural and/ or social functions and/ or processes remain *unaltered*
Duration of impact	**Short term** (construction period)	Up to 3 years
	Medium Term	Between 3 and 10 years
	Long Term	More than 10 years after construction

Note: where applicable, the magnitude of the impact has to be related to the relevant standard (threshold value specified and source referred).

The SIGNIFICANCE of an impact is derived by taking into account the temporal and spatial scales and magnitude. The means of arriving at the different significance ratings is explained in the following table, developed by Ninham Shand in 1995 as a means of minimising subjectivity in such evaluations, i.e. to allow for standardisation in the determination of significance.

Table B-2: Definition of significance ratings

SIGNIFICANCE RATINGS	LEVEL OF CRITERIA REQUIRED
High	• High magnitude with a regional extent and long term duration • High magnitude with either a regional extent and medium term duration or a local extent and long term duration • Medium magnitude with a regional extent and long term duration
Medium	• High magnitude with a local extent and medium term duration • High magnitude with a regional extent and construction period or a site specific extent and long term duration • High magnitude with either a local extent and construction period duration or a site specific extent and medium term duration • Medium magnitude with any combination of extent and duration except site specific and construction period or regional and long term • Low magnitude with a regional extent and long term duration
Low	• High magnitude with a site specific extent and construction period duration • Medium magnitude with a site specific extent and construction period duration • Low magnitude with any combination of extent and duration except site specific and construction period or regional and long term • Very low magnitude with a regional extent and long term duration
Very low	• Low magnitude with a site specific extent and construction period duration • Very low magnitude with any combination of extent and duration except regional and long term
Neutral	• Zero magnitude with any combination of extent and duration

Once the significance of an impact has been determined, the PROBABILITY of this impact occurring as well as the CONFIDENCE in the assessment of the impact would be determined using the rating systems outlined in the following two tables. It is important to note that the significance of an impact should always be considered in concert with the probability of that impact occurring.

Table B-3: Definition of probability ratings

PROBABILITY RATINGS	CRITERIA
Definite	Estimated greater than 95 % chance of the impact occurring.
Probable	Estimated 5 to 95 % chance of the impact occurring.
Unlikely	Estimated less than 5 % chance of the impact occurring.

Table B-4: Definition of confidence ratings

CONFIDENCE RATINGS	CRITERIA
Certain	Wealth of information on and sound understanding of the environmental factors potentially influencing the impact.
Sure	Reasonable amount of useful information on and relatively sound understanding of the environmental factors potentially influencing the impact.
Unsure	Limited useful information on and understanding of the environmental factors potentially influencing this impact.

Lastly, the REVERSIBILITY of the impact is estimated using the rating system outlined in the following table.

Table B-5: Definition of reversibility ratings

REVERSIBILITY RATINGS	CRITERIA
Irreversible	The activity will lead to an impact that is permanent.
Reversible	The impact is reversible, within a period of 10 years.

APPENDIX C

C1. Noise Model Sound Power Input Data

Table C.1: Existing Operations Sound Power Emission Levels (Year 2010)

Description	Source ID	Sound Power	Unit	Daytime Operation	Night-time Operation	Coordinates		Source Height
				(min)	(min)	(X)	(Y)	(m)
POINT SOURCES								
Primary crusher	bo_R0s_PrCr_01	98.1	dBA	960	480	5442.62	-52910.77	534.59
Offloading at primary crusher	bo_R0s_PrCr_fld_01	116	dBA	720	360	5485.65	-52895.58	537.16
Offloading at primary crusher	bo_R1s_PrCr_fld_01	116	dBA	720	360	5496.12	-52888.05	537.36
FEL at primary crusher	bo_PrCr_fel_01	109.7	dBA	960	480	5464.02	-52891.25	538.51
TDSL Excavator	BAS_TDSL loading	110.4	dBA	960	480	3406.54	-50889.73	618.93
Loading at P3L	BAS_P3L_1	107.8	dBA	720	360	6031.09	-53755.87	452.12
Loading at P3L	BAS_P3L_3	107.8	dBA	720	360	6145.56	-53724.86	467.58
Loading at P3L	BAS_P3L_2	107.8	dBA	720	360	6064.62	-53682.89	451.56
Loading at P3BRL	BAS_P3BRL_1	107.8	dBA	720	360	6157.78	-53819.65	501.2
Loading at P3BRL	BAS_P3BRL_2	107.8	dBA	720	360	6123.41	-53888.29	511.94
Loading at P3BRL	BAS_P3BRL_3	107.8	dBA	720	360	6205.39	-53879.11	541.22
Loading at P3BRL	BAS_P3BRL_4	107.8	dBA	720	360	6098.99	-53835.55	503.41
Loading at P3BRL	BAS_P3BRL_5	107.8	dBA	720	360	6285.29	-53842.1	542.27
Loading at P3BRL	BAS_P3BRL_6	107.8	dBA	720	360	6192.56	-53770.39	499.15
Loading at SK4BRL	BAS_SK4BRL_1	107.8	dBA	720	360	8609.27	-52212.5	530.59
Loding at P2L	BAS_P2L_1	107.8	dBA	720	360	5358.77	-53342.22	453.35
Loading at P2BRL	BAS_P2BRL_1	107.8	dBA	720	360	5263.31	-53450.72	386.62
Loading at P2BRL	BAS_P2BRL_2	107.8	dBA	720	360	5392.67	-53452.12	347.9
Loading at P2BRL	BAS_P2BRL_3	107.8	dBA	720	360	5359.03	-53394.58	403.23
Loading at TR10L	BAS_TR10L_1	107.8	dBA	960	480	6312.84	-53122.51	271
Loading at ROML	Bo_ROML_1	107.8	dBA	720	360	4802.92	-52766.83	555.98
Slimes pump	Bo_Slimes_Pump1	89.9	dBA	960	480	4829.75	-50825.92	576.24
Slimes pump	Bo_Slimes_Pump3	89.9	dBA	960	480	4835.62	-50831.75	575.97
Slimes pump	Bo_Slimes_Pump2	89.9	dBA	960	480	4829.87	-50830.67	576.1
Scrubber 1 stack exit	Bo_Scrub_Stkp2	106	dBA	960	480	4683.46	-51407.61	575.46
Scrubber 2 stack exit	Bo_Scrub_Stkp1	106	dBA	960	480	4698.88	-51410.05	575.24
Bag house stack exit	Bo_BagH_Stkp	106	dBA	960	480	4683.59	-51433.01	579.36
PADDYX pump	Bo_PADDYX_Pump1	95.8	dBA	960	480	4170.53	-50319.27	636.45
PADDYX pump	Bo_PADDYX_Pump2	95.8	dBA	960	480	4161.14	-50324.68	636.4

Description	Source ID	Sound Power	Unit	Daytime Operation	Night-time Operation	Coordinates		Source Height
				(min)	(min)	(X)	(Y)	(m)
PADDYX pump	Bo_PADDYX_Pump3	95.8	dBA	960	480	4167.27	-50332.82	636.33
PADDYX pump	Bo_PADDYX_Pump4	95.8	dBA	960	480	4175.42	-50327.54	636.35
Fine crushing plant points	Bo_Fine_Crush1	109	dBA	960	480	4326.19	-51487.93	565.32
Fine crushing plant points	Bo_Fine_Crush3	111.5	dBA	960	480	4351.17	-51493.68	564.07
Fine crushing plant points	Bo_Fine_Crush2	115.9	dBA	960	480	4342.71	-51492.27	564.19
Fine crushing plant points	Bo_Fine_Crush4	111.4	dBA	960	480	4366.47	-51498.34	563.77
Fine crushing plant points	Bo_Bag_Filter1	97	dBA	960	480	4325.16	-51504.78	562.49
Fine crushing plant points	Bo_Bag_Filter2	97	dBA	960	480	4339.01	-51500.79	561.85
Fine crushing plant points	Bo_2nd_Fine_Crush2	100.8	dBA	960	480	4306.76	-51495.08	566.24
Fine crushing plant points	Bo_2nd_Fine_Crush1	100.8	dBA	960	480	4305.2	-51501.65	565.99
Fine crushing plant points	Bo_2ndary_Crush1_2f	125	dBA	960	480	4311	-51561.02	567.45
Fine crushing plant points	Bo_2ndary_Crush1_t	110	dBA	960	480	4314.13	-51561.8	572.2
Fine crushing plant points	Bo_2ndary_Crush2_2f	125	dBA	960	480	4342.11	-51569.68	565.86
Fine crushing plant points	Bo_2ndary_Crush2_t	110	dBA	960	480	4338.52	-51568.71	570.92
Fine crushing plant points	Bo_Tr_Tower_t	99.1	dBA	960	480	4317.26	-51690.41	565.82
Fine crushing plant points	Bo_Tr_Tower_2f	98.8	dBA	960	480	4317.52	-51691.85	560.75
Fine crushing plant points	Bo_Tr_Tower_2f	113.7	dBA	960	480	4276.18	-51675.02	561.82
Fine crushing plant points	Bo_Tr_Tower_1f	113.7	dBA	960	480	4273.18	-51674.04	556.85
Fine crushing plant points	Bo_Tr_Tower_3f	113.7	dBA	960	480	4279.7	-51676.05	566.8
Fine crushing plant points	Bo_Tr_Tower_4f	113.7	dBA	960	480	4282.5	-51676.7	571.78
Wheeled bulldozer in open pit	Bo_W_Dozer_Pit	111	dBA	960	480	5255.55	-53741.82	257.5
Wheeled bulldozer in open pit	Bo_W_Dozer_Pit	111	dBA	960	480	6501.94	-53102.94	315.99
Wheeled bulldozer in open pit	Bo_W_Dozer_Pit	111	dBA	960	480	6790.51	-52691.47	283.05
Wheeled bulldozer in open pit	Bo_W_Dozer_Pit	111	dBA	960	480	5735.39	-53376.61	247.9
Grader in open pit	Bo_Grader_Pit	110.3	dBA	960	480	4857.85	-53770.36	339.75
Grader in open pit	Bo_Grader_Pit	110.3	dBA	960	480	6224.34	-53250.6	294.61
Grader in open pit	Bo_Grader_Pit	110.3	dBA	960	480	5954.76	-53430.74	271.23
Grader in open pit	Bo_Grader_Pit	110.3	dBA	960	480	6406.75	-52957.25	217.1
Wheeled loader in open pit	Bo_WLoader_Pit	104.7	dBA	960	480	6479.16	-52944.46	245.73
Wheeled loader in open pit	Bo_WLoader_Pit	104.7	dBA	960	480	5745.93	-53568.57	263.45
Wheeled loader in open pit	Bo_WLoader_Pit	104.7	dBA	960	480	6822.02	-52788.93	282.66
Track bulldozer in open pit	Bo_TDozer_Pit	116	dBA	960	480	6639.61	-52841.09	254.88
Track bulldozer in open pit	Bo_TDozer_Pit	116	dBA	960	480	5017.32	-53691.61	258.06
Track bulldozer in open pit	Bo_TDozer_Pit	116	dBA	960	480	5216.17	-53754.61	259.07

Description	Source ID	Sound Power	Unit	Daytime Operation	Night-time Operation	Coordinates		Source Height
				(min)	(min)	(X)	(Y)	(m)
Track bulldozer in open pit	Bo_TDozer_Pit	116	dBA	960	480	5714.28	-53577.42	258.01
Track bulldozer in open pit	Bo_TDozer_Pit	116	dBA	960	480	6159.22	-53124.6	190.52
Track bulldozer in open pit	Bo_TDozer_Pit	116	dBA	960	480	6789.24	-52793.84	278
Track bulldozer in open pit	Bo_TDozer_Pit	116	dBA	960	480	6350.2	-53165.95	304.42
Drilling in open pit	Bo_Drill_Pit_b	107.5	dBA	960	480	6320.67	-53069.47	243.44
Drilling in open pit	Bo_Drill_Pit_b	107.5	dBA	960	480	5708.37	-53610.89	272.56
Drilling in open pit	Bo_Drill_Pit_b	107.5	dBA	960	480	5269.33	-53770.36	259.82
Drilling in open pit	Bo_Drill_Pit_s	102.5	dBA	960	480	5040.95	-53721.14	257.86
Drilling in open pit	Bo_Drill_Pit_s	102.5	dBA	960	480	6137.57	-53134.44	188.49
Drilling in open pit	Bo_Drill_Pit_s	102.5	dBA	960	480	6657.33	-52825.34	257.04
BR wheeled bulldozer in open pit	BAS_BR_WDozerPit	111	dBA	960	480	6089.81	-53396.15	292.95
BR excavator in open pit	BAS_BR_ExcavPit	102.2	dBA	960	480	6003.18	-53258.33	202.02
BR excavator in open pit	BAS_BR_ExcavPit	102.2	dBA	960	480	6689.46	-52963.99	296.72
BR grader in open pit	BAS_BR_GradPit	110.3	dBA	960	480	5698.02	-53266.2	350.14
BR grader in open pit	BAS_BR_GradPit	110.3	dBA	960	480	5280.63	-53591.06	222.48
BR grader in open pit	BAS_BR_GradPit	110.3	dBA	960	480	5824.02	-53478.84	259.14
BR wheeled bulldozer in open pit	BAS_BR_DDozerPit	111	dBA	960	480	5386.94	-53632.4	224.36
BR wheeled bulldozer in open pit	BAS_BR_DDozerPit	111	dBA	960	480	6129.19	-53299.67	290.34
BR wheeled bulldozer in open pit	BAS_BR_DDozerPit	111	dBA	960	480	6349.69	-53285.89	313.45
BR truck bulldozer in open pit	BAS_BR_TDozerRit	116	dBA	960	480	6042.56	-53484.74	308.8
BR truck bulldozer in open pit	BAS_BR_TDozerRit	116	dBA	960	480	6507.2	-52856.69	197.03
BR truck bulldozer in open pit	BAS_BR_TDozerRit	116	dBA	960	480	5414.51	-53742.66	279.93
BR drilling in open pit	BAS_BR_DrillRit-s	102.5	dBA	960	480	5127.06	-53774.16	266.3
BR drilling in open pit	BAS_BR_DrillRit-s	102.5	dBA	960	480	4880.96	-53728.88	318.68
BR drilling in open pit	BAS_BR_DrillRit-s	102.5	dBA	960	480	5605.48	-53691.47	289.14
BR drilling in open pit	BAS_BR_DrillRit-s	102.5	dBA	960	480	5698.02	-53449.3	239.08
BR drilling in open pit	BAS_BR_DrillRit-s	102.5	dBA	960	480	6050.43	-53152.01	196.13
BR drilling in open pit	BAS_BR_DrillRit-s	102.5	dBA	960	480	6566.26	-52823.22	204.99
BR drilling in open pit	BAS_BR_DrillRit-s	102.5	dBA	960	480	6593.83	-53035.85	313.07
BR drilling in open pit	BAS_BR_DrillRit-s	102.5	dBA	960	480	6826.15	-52844.88	289.75
BR drilling in open pit	BAS_BR_DrillRit-b	107.5	dBA	960	480	5869.3	-53510.34	276.52
BR drilling in open pit	BAS_BR_DrillRit-b	107.5	dBA	960	480	6288.66	-53197.29	289.11
BR drilling in open pit	BAS_BR_DrillRit-b	107.5	dBA	960	480	6322.13	-52968.91	196.05
BR Ingersoll Rand in open pit	BAS_BR_INGERRit	115.4	dBA	480	240	6684.39	-52901.97	289.52

Description	Source ID	Sound Power	Unit	Daytime Operation	Night-time Operation	Coordinates		Source Height
				(min)	(min)	(X)	(Y)	(m)
Viper drill in open pit	Bo_VIPRit	115.4	dBA	480	240	5640.92	-53535.93	247.44
Viper drill in open pit	Bo_VIPRit	115.4	dBA	480	240	6404.82	-53081.13	299.94
Viper drill in open pit	Bo_VIPRit	115.4	dBA	480	240	6895.06	-52707.06	291.52
Cable reeler in open pit	Bo_CABLRit	102.2	dBA	480	240	5360.35	-53708.21	258.59
Cable reeler in open pit	Bo_CABLRit	102.2	dBA	480	240	5507.04	-53687.53	260.5
Loading at ROML	bo_ROML_2	107.8	dBA	720	360	4830.18	-52683.03	555.9
LINE SOURCES								
Conv. belt from prim crusher to st pile	bo_R0s_cvb_01	81.7	dBA/m	960	480	N/a	N/a	Var.
Conv. belt from st pile to fine crusher	bo_R0s_cvb_01	81.7	dBA/m	960	480	N/a	N/a	Var.
Manganese trucks	BASI_DO-sp-f	66	dBA/m	960	480	N/a	N/a	Var.
Haul road to crhusher	BASI_HAUL_ROADS	81.4	dBA/m	960	480	N/a	N/a	Var.
Haul road to low grade	BASI_HAUL_ROADS	76.4	dBA/m	960	480	N/a	N/a	Var.
Haul road to waste	BASI_HAUL_ROADS	90.2	dBA/m	960	480	N/a	N/a	Var.
Haul road to crhusher	BASI_HAUL_ROADS	73.8	dBA/m	960	480	N/a	N/a	Var.
Haul road to low grade	BASI_HAUL_ROADS	72.1	dBA/m	960	480	N/a	N/a	Var.
Haul road to waste	BASI_HAUL_ROADS	94.6	dBA/m	960	480	N/a	N/a	Var.
Haul road SK4 to low grade	BASI_SK4-LG	78.1	dBA/m	960	480	N/a	N/a	Var.
Haul road SK4 to ore stockpile	BASI_SK4-HG	70.8	dBA/m	960	480	N/a	N/a	Var.
Haul road SK4 to waste	BASI_SK4-W	78.1	dBA/m	960	480	N/a	N/a	Var.
Tailings road	BASI_Tailings Route	70.3	dBA/m	960	480	N/a	N/a	Var.
Tailings road	BASI_Tailings Route	62.2	dBA/m	960	480	N/a	N/a	Var.
Tailings road	BASI_Crusher to Sand Pi	83.2	dBA/m	960	480	N/a	N/a	Var.
Haul roat Trolley 10 to crusher	BASI_T10_150_ORE_E	88.2	dBA/m	960	480	N/a	N/a	Var.
Haul roat Trolley 10 to low grade	BASI_T10_150_LG_E	76.4	dBA/m	960	480	N/a	N/a	Var.
Haul roat Trolley 10 to waste	BASI_T10_150_WASTE_E	75.6	dBA/m	960	480	N/a	N/a	Var.
Conv. belt at fine crushing plant	bo_R0s_cvb_01	81.7	dBA/m	960	480	N/a	N/a	Var.
Conv. belt at fine crushing plant	bo_R0s_cvb_01	81.7	dBA/m	960	480	N/a	N/a	Var.
Conv. belt at fine crushing plant	bo_R0s_cvb_01	81.7	dBA/m	960	480	N/a	N/a	Var.
Conv. belt at fine crushing plant	bo_R0s_cvb_01	81.7	dBA/m	960	480	N/a	N/a	Var.
Conv. belt at fine crushing plant	bo_R0s_cvb_01	81.7	dBA/m	960	480	N/a	N/a	Var.
Conv. belt at fine crushing plant	bo_R0s_cvb_01	81.7	dBA/m	960	480	N/a	N/a	Var.
Haul road form ROML to prim. crusher	BAS_ROML_Crush	77.5	dBA/m	960	480	N/a	N/a	Var.
Maintenance trucks in open pit	Bo_Maint_Trucks_Pit	76	dBA/m	960	480	N/a	N/a	Var.

Table C.2: Proposed Expansion Operations Sound Power Emission Levels (Year 2013)

Noise Source Description	Source ID	Sound Power	Unit	Daytime Operation (min)	Night-time Operation (min)	Coordinates (X)	Coordinates (Y)	Source Height (m)
POINT SOURCES								
Primary crusher	bo_R0s_PrCr_01	98.1	dBA	960	480	5442.62	-52910.77	534.59
Offloading at primary crusher	bo_R0s_PrCr_fld_01	116	dBA	720	360	5485.65	-52895.58	537.16
Offloading at primary crusher	bo_R1s_PrCr_fld_01	116	dBA	720	360	5496.12	-52888.05	537.36
FEL at primary crusher	bo_PrCr_fel_01	109.7	dBA	960	480	5464.02	-52891.25	538.51
Second primary crusher	Exp_PrCr_02	98.1	dBA	960	480	5205.81	-52837.55	542.38
Offloading at primary crusher	Exp_PrCr_fld_03	116	dBA	720	360	5480.68	-52890.37	538.21
FEL at primary crusher	bo_PrCr_fel_01	109.7	dBA	960	480	5464.02	-52891.25	538.51
Loading at ROML	Bo_ROML_1	107.8	dBA	720	360	4802.92	-52766.83	555.98
Slimes pump	Bo_Slimes_Pump1	89.9	dBA	960	480	4829.75	-50825.92	576.24
Slimes pump	Bo_Slimes_Pump3	89.9	dBA	960	480	4835.62	-50831.75	575.97
Slimes pump	Bo_Slimes_Pump2	89.9	dBA	960	480	4829.87	-50830.67	576.1
Scrubber 1 stack exit	Bo_Scrub_Stkp2	106	dBA	960	480	4683.46	-51407.61	575.46
Scrubber 2 stack exit	Bo_Scrub_Stkp1	106	dBA	960	480	4698.88	-51410.05	575.24
Bag house stack exit	Bo_BagH_Stkp	106	dBA	960	480	4683.59	-51433.01	579.36
PADDYX pump	Bo_PADDYX_Pump1	95.8	dBA	960	480	4170.53	-50319.27	636.45
PADDYX pump	Bo_PADDYX_Pump2	95.8	dBA	960	480	4161.14	-50324.68	636.4
PADDYX pump	Bo_PADDYX_Pump3	95.8	dBA	960	480	4167.27	-50332.82	636.33
PADDYX pump	Bo_PADDYX_Pump4	95.8	dBA	960	480	4175.42	-50327.54	636.35
Fine crushing plant points	Bo_Fine_Crush1	109	dBA	960	480	4326.19	-51487.93	565.32
Fine crushing plant points	Bo_Fine_Crush3	111.5	dBA	960	480	4351.17	-51493.68	564.07
Fine crushing plant points	Bo_Fine_Crush2	115.9	dBA	960	480	4342.71	-51492.27	564.19
Fine crushing plant points	Bo_Fine_Crush4	111.4	dBA	960	480	4366.47	-51498.34	563.77
Fine crushing plant points	Bo_Bag_Filter1	97	dBA	960	480	4325.16	-51504.78	562.49
Fine crushing plant points	Bo_Bag_Filter2	97	dBA	960	480	4339.01	-51500.79	561.85
Fine crushing plant points	Bo_2nd_Fine_Crush2	100.8	dBA	960	480	4306.76	-51495.08	566.24
Fine crushing plant points	Bo_2nd_Fine_Crush1	100.8	dBA	960	480	4305.2	-51501.65	565.99
Fine crushing plant points	Bo_2ndary_Crush1_2f	125	dBA	960	480	4311	-51561.02	567.45
Fine crushing plant points	Bo_2ndary_Crush1_t	110	dBA	960	480	4314.13	-51561.8	572.2

Noise Source Description	Source ID	Sound Power	Unit	Daytime Operation (min)	Night-time Operation (min)	Coordinates (X)	Coordinates (Y)	Source Height (m)
Fine crushing plant points	Bo_2ndary_Crush2_2f	125	dBA	960	480	4342.11	-51569.68	565.86
Fine crushing plant points	Bo_2ndary_Crush2_t	110	dBA	960	480	4338.52	-51568.71	570.92
Fine crushing plant points	Bo_Tr_Tower_t	99.1	dBA	960	480	4317.26	-51690.41	565.82
Fine crushing plant points	Bo_Tr_Tower_2f	98.8	dBA	960	480	4317.52	-51691.85	560.75
Fine crushing plant points	Bo_Tr_Tower_2f	113.7	dBA	960	480	4276.18	-51675.02	561.82
Fine crushing plant points	Bo_Tr_Tower_1f	113.7	dBA	960	480	4273.18	-51674.04	556.85
Fine crushing plant points	Bo_Tr_Tower_3f	113.7	dBA	960	480	4279.7	-51676.05	566.8
Fine crushing plant points	Bo_Tr_Tower_4f	113.7	dBA	960	480	4282.5	-51676.7	571.78
Wheeled bulldozer in open pit	Bo_W_Dozer_Pit	111	dBA	960	480	5255.55	-53741.82	257.5
Wheeled bulldozer in open pit	Bo_W_Dozer_Pit	111	dBA	960	480	6501.94	-53102.94	315.99
Wheeled bulldozer in open pit	Bo_W_Dozer_Pit	111	dBA	960	480	6790.51	-52691.47	283.05
Wheeled bulldozer in open pit	Bo_W_Dozer_Pit	111	dBA	960	480	5735.39	-53376.61	247.9
Grader in open pit	Bo_Grader_Pit	110.3	dBA	960	480	4857.85	-53770.36	339.75
Grader in open pit	Bo_Grader_Pit	110.3	dBA	960	480	6224.34	-53250.6	294.61
Grader in open pit	Bo_Grader_Pit	110.3	dBA	960	480	5954.76	-53430.74	271.23
Grader in open pit	Bo_Grader_Pit	110.3	dBA	960	480	6406.75	-52957.25	217.1
Wheeled loader in open pit	Bo_WLoader_Pit	104.7	dBA	960	480	6479.16	-52944.46	245.73
Wheeled loader in open pit	Bo_WLoader_Pit	104.7	dBA	960	480	5745.93	-53568.57	263.45
Wheeled loader in open pit	Bo_WLoader_Pit	104.7	dBA	960	480	6822.02	-52788.93	282.66
Track bulldozer in open pit	Bo_TDozer_Pit	116	dBA	960	480	6639.61	-52841.09	254.88
Track bulldozer in open pit	Bo_TDozer_Pit	116	dBA	960	480	5017.32	-53691.61	258.06
Track bulldozer in open pit	Bo_TDozer_Pit	116	dBA	960	480	5216.17	-53754.61	259.07
Track bulldozer in open pit	Bo_TDozer_Pit	116	dBA	960	480	5714.28	-53577.42	258.01
Track bulldozer in open pit	Bo_TDozer_Pit	116	dBA	960	480	6159.22	-53124.6	190.52
Track bulldozer in open pit	Bo_TDozer_Pit	116	dBA	960	480	6789.24	-52793.84	278
Track bulldozer in open pit	Bo_TDozer_Pit	116	dBA	960	480	6350.2	-53165.95	304.42
Drilling in open pit	Bo_Drill_Pit_b	107.5	dBA	960	480	6320.67	-53069.47	243.44
Drilling in open pit	Bo_Drill_Pit_b	107.5	dBA	960	480	5708.37	-53610.89	272.56
Drilling in open pit	Bo_Drill_Pit_b	107.5	dBA	960	480	5269.33	-53770.36	259.82
Drilling in open pit	Bo_Drill_Pit_s	102.5	dBA	960	480	5040.95	-53721.14	257.86
Drilling in open pit	Bo_Drill_Pit_s	102.5	dBA	960	480	6137.57	-53134.44	188.49
Drilling in open pit	Bo_Drill_Pit_s	102.5	dBA	960	480	6657.33	-52825.34	257.04
Viper in open pit	Bo_VIPRit	115.4	dBA	480	240	5640.92	-53535.93	247.44
Viper in open pit	Bo_VIPRit	115.4	dBA	480	240	6404.82	-53081.13	299.94

Noise Source Description	Source ID	Sound Power	Unit	Daytime Operation (min)	Night-time Operation (min)	Coordinates (X)	Coordinates (Y)	Source Height (m)
Viper in open pit	Bo_VIPRit	115.4	dBA	480	240	6895.06	-52707.06	291.52
Cable reeler in open pit	Bo_CABLRit	102.2	dBA	480	240	5360.35	-53708.21	258.59
Cable reeler in open pit	Bo_CABLRit	102.2	dBA	480	240	5507.04	-53687.53	260.5
Excavator at HDTSL	EXP_HDTSL_Excv	110.4	dBA	720	360	7684.13	-47599.19	597.6
Wheeled bulldozer in open pit	EXP_W_Dozer_Pit	111	dBA	960	480	6732.43	-52732.67	253.1
Wheeled bulldozer in open pit	EXP_W_Dozer_Pit	111	dBA	960	480	6246.13	-53052.44	186.18
Wheeled bulldozer in open pit	EXP_W_Dozer_Pit	111	dBA	960	480	6657.62	-52947.93	284.47
Wheeled bulldozer in open pit	EXP_W_Dozer_Pit	111	dBA	960	480	5606.26	-53378.94	288.52
Grader in open pit	EXP_Grader_Pit	110.3	dBA	480	240	6177.09	-53358.72	303.59
Grader in open pit	EXP_Grader_Pit	110.3	dBA	480	240	5476.18	-53453.06	301.2
Grader in open pit	EXP_Grader_Pit	110.3	dBA	480	240	5956.58	-53315.08	209.17
Grader in open pit	EXP_Grader_Pit	110.3	dBA	480	240	6257.81	-52992.03	197.27
Wheeled loader in open pit	EXP_WLoader_Pit	104.7	dBA	960	480	6523.46	-52857.67	204.05
Wheeled loader in open pit	EXP_WLoader_Pit	104.7	dBA	960	480	5129.52	-53798.61	293.59
Wheeled loader in open pit	EXP_WLoader_Pit	104.7	dBA	960	480	6657.34	-52895.74	287.9
Wheeled bulldozer in open pit	EXP_TDozer_Pit	116	dBA	960	480	4858.83	-53628.45	251.44
Wheeled bulldozer in open pit	EXP_TDozer_Pit	116	dBA	960	480	6010.6	-53500.31	286.66
Wheeled bulldozer in open pit	EXP_TDozer_Pit	116	dBA	960	480	6637.68	-53139.85	393.74
Wheeled bulldozer in open pit	EXP_TDozer_Pit	116	dBA	960	480	4738.73	-53579.72	393.69
Wheeled bulldozer in open pit	EXP_TDozer_Pit	116	dBA	960	480	5993.87	-53185.79	244.19
Wheeled bulldozer in open pit	EXP_TDozer_Pit	116	dBA	960	480	5047.84	-53486.86	345.26
Wheeled bulldozer in open pit	EXP_TDozer_Pit	116	dBA	960	480	5239.8	-53684.57	236.06
Drilling in open pit	EXP_Drill_Pit_b	107.5	dBA	960	480	6739.05	-52980.71	295.05
Drilling in open pit	EXP_Drill_Pit_b	107.5	dBA	960	480	6146.43	-53584.98	437.76
Drilling in open pit	EXP_Drill_Pit_b	107.5	dBA	960	480	6378.75	-52986.29	222.09
Drilling in open pit	EXP_Drill_Pit_s	102.5	dBA	960	480	6608.12	-53018.12	309.94
Drilling in open pit	EXP_Drill_Pit_s	102.5	dBA	960	480	5392.36	-53686.38	252.47
Drilling in open pit	EXP_Drill_Pit_s	102.5	dBA	960	480	6079.49	-53145.77	191.31
Viper drill in open pit	EXP_VIPRit	115.4	dBA	480	240	6042.56	-53219.77	200.66
Viper drill in open pit	EXP_VIPRit	115.4	dBA	480	240	5391.86	-53752.18	282.65
Viper drill in open pit	EXP_VIPRit	115.4	dBA	480	240	6229.6	-53157.43	256.7
Cable reeler in open pit	EXP_CABLRit	102.2	dBA	480	240	5913.59	-53322.16	216.34
Cable reeler in open pit	EXP_CABLRit	102.2	dBA	480	240	6452.07	-52937.09	227.44
Loading at P2L	EXP_P2L_1	107.8	dBA	720	360	5432.26	-53374.42	392.82

Noise Source Description	Source ID	Sound Power	Unit	Daytime Operation (min)	Night-time Operation (min)	Coordinates (X)	Coordinates (Y)	Source Height (m)
Loading at P2L	EXP_P2L_1	107.8	dBA	720	360	5437.84	-53456.35	303.03
Loading at P2L	EXP_P3L_1	107.8	dBA	720	360	6115.12	-53537.64	392.58
Loading at P2L	EXP_P3L_1	107.8	dBA	720	360	6082.25	-53662.66	451.78
Loading at P2L	EXP_P3L_1	107.8	dBA	720	360	6028.61	-53567.85	362.02
Loading at P2L	EXP_P4L_1	107.8	dBA	720	360	6545.76	-52446.43	466.44
Loading at P2L	EXP_P4L_1	107.8	dBA	720	360	6623.51	-52439.87	452.42
Loading at P2L	EXP_P4L_1	107.8	dBA	720	360	6582.1	-52391.5	483.01
Loading at ROML	bo_ROML_2	107.8	dBA	720	360	4830.18	-52683.03	555.9
Second fine crushing plant source	EXP_Fine_Crush1	109	dBA	960	480	4295.45	-51963.1	555
Second fine crushing plant source	EXP_2nd_Fine_Crush2	100.8	dBA	960	480	4233.4	-51810.39	555
Second fine crushing plant source	EXP_Tr_Tower_1f	113.7	dBA	960	480	4268.01	-51957.96	555
Second fine crushing plant source	EXP_Bag_Filter1	97	dBA	960	480	4234.58	-51815.91	553
Second fine crushing plant source	EXP_Tr_Tower_2f	113.7	dBA	960	480	4272.63	-51956.55	560
Second fine crushing plant source	EXP_Tr_Tower_3f	113.7	dBA	960	480	4270.41	-51952.49	565
Second fine crushing plant source	EXP_Fine_Crush1	109	dBA	960	480	4293.91	-51957.45	555
Second fine crushing plant source	EXP_Fine_Crush1	109	dBA	960	480	4292.06	-51951.24	555
Second fine crushing plant source	EXP_Fine_Crush1	109	dBA	960	480	4290.34	-51945.71	555
Second fine crushing plant source	EXP_2nd_Fine_Crush2	100.8	dBA	960	480	4231.35	-51804.51	555
Conveyor belt motors	EXP_vb_motor	87.7	dBA	960	480	4347.3	-50137.62	632.72
Conveyor belt motors	EXP_vb_motor	87.7	dBA	960	480	4345.99	-50140.44	632.62
Conveyor belt motors	EXP_vb_motor	87.7	dBA	960	480	4344	-50136.81	632.74
Conveyor belt motors	EXP_vb_motor	87.7	dBA	960	480	4342.11	-50139.16	632.65
Conveyor belt motors	EXP_vb_motor	87.7	dBA	960	480	3962.02	-49965.94	629.6
Conveyor belt motors	EXP_vb_motor	87.7	dBA	960	480	3959.19	-49964.69	630.07
Conveyor belt motors	EXP_vb_motor	87.7	dBA	960	480	3962.22	-49961.52	627.77
Conveyor belt motors	EXP_vb_motor	87.7	dBA	960	480	3963.48	-49958.52	627.44
Conveyor belt motors	EXP_vb_motor	87.7	dBA	960	480	3947.1	-49983.5	633.39
Conveyor belt motors	EXP_vb_motor	87.7	dBA	960	480	3944.33	-49982.25	633.48
Conveyor belt motors	EXP_vb_motor	87.7	dBA	960	480	3897.08	-50153.18	680.93
Conveyor belt motors	EXP_vb_motor	87.7	dBA	960	480	3899.98	-50153.9	680.54
Conveyor belt motors	EXP_vb_motor	87.7	dBA	960	480	4349.1	-50167.43	631.84
Conveyor belt motors	EXP_vb_motor	87.7	dBA	960	480	4350.56	-50168.65	631.81
Conveyor belt motors	EXP_vb_motor	87.7	dBA	960	480	4357.04	-50173.87	631.72
Conveyor belt motors	EXP_vb_motor	87.7	dBA	960	480	4358.48	-50175	631.7

Noise Source Description	Source ID	Sound Power	Unit	Daytime Operation (min)	Night-time Operation (min)	Coordinates (X)	(Y)	Source Height (m)
Conveyor belt motors	EXP_vb_motor	87.7	dBA	960	480	4285.27	-50254.66	629.17
Conveyor belt motors	EXP_vb_motor	87.7	dBA	960	480	4286.81	-50255.81	629.18
Conveyor belt motors	EXP_vb_motor	87.7	dBA	960	480	3877.03	-50766.75	632.73
Conveyor belt motors	EXP_vb_motor	87.7	dBA	960	480	3875.61	-50765.55	632.92
Conveyor belt motors	EXP_vb_motor	87.7	dBA	960	480	3876.95	-50764.81	632.76
Conveyor belt motors	EXP_vb_motor	87.7	dBA	960	480	3878.93	-50764.64	632.51
Conveyor belt motors	EXP_vb_motor	87.7	dBA	960	480	3891.27	-51423.96	579.83
Conveyor belt motors	EXP_vb_motor	87.7	dBA	960	480	3893.05	-51423.97	579.65
Conveyor belt motors	EXP_vb_motor	87.7	dBA	960	480	3891.88	-51423.1	579.83
Conveyor belt motors	EXP_vb_motor	87.7	dBA	960	480	3893.16	-51421.82	580.03
Conveyor belt motors	EXP_vb_motor	87.7	dBA	960	480	4156.37	-51704.66	554
Conveyor belt motors	EXP_vb_motor	87.7	dBA	960	480	4157.94	-51703.37	554
Conveyor belt motors	EXP_vb_motor	87.7	dBA	960	480	4155.04	-51702.14	554
Conveyor belt motors	EXP_vb_motor	87.7	dBA	960	480	4154.38	-51700.23	554
Conveyor belt motors	EXP_vb_motor	87.7	dBA	960	480	4224.3	-51681.3	555.04
Conveyor belt motors	EXP_vb_motor	87.7	dBA	960	480	4225.22	-51683.41	554.93
Conveyor belt motors	EXP_vb_motor	87.7	dBA	960	480	4222.72	-51685.45	554.79
Conveyor belt motors	EXP_vb_motor	87.7	dBA	960	480	4225.18	-51684.77	554.85
Conveyor belt motors	EXP_vb_motor	87.7	dBA	960	480	4222.89	-51686.05	554.76
Conveyor belt motors	EXP_vb_motor	87.7	dBA	960	480	4223.47	-51688.09	554.65
Conveyor belt motors	EXP_vb_motor	87.7	dBA	960	480	4265.09	-51674.29	555.77
Conveyor belt motors	EXP_vb_motor	87.7	dBA	960	480	4265.96	-51676.9	555.63
Staker reclaimer operation	EXP_Stak_drop	81.7	dBA	960	480	4287.7	-48931.86	615.52
Staker reclaimer motor	EXP_Stak_motor	87.7	dBA	960	480	4398.97	-48985.04	618.91
Staker reclaimer motor	EXP_Stak_motor	87.7	dBA	960	480	4321.67	-49208.52	619.26
Staker reclaimer operation	EXP_Stak_drop	81.7	dBA	960	480	4449.19	-49262.62	623.2
LINE SOURCES								
Conv. belt from prim crusher to st pile	bo_R0s_cvb_01	81.7	dBA/m	960	480	N/a	N/a	Var.
Conv. belt from st pile to fine crusher	bo_R0s_cvb_01	81.7	dBA/m	960	480	N/a	N/a	Var.
Conv. belt from 2nd prim. crusher to 2nd st pile	Exp_Conv_B1	81.7	dBA/m	960	480	N/a	N/a	Var.
Conv. belt from 2nd pile to 2nd fine crusher	Exp_Conv_B2	81.7	dBA/m	960	480	N/a	N/a	Var.
Conv. belt at 2nd fine crushing plant	Exp_Conv_B2	81.7	dBA/m	960	480	N/a	N/a	Var.
Conv. belt at 2nd fine crushing plant	Exp_Conv_B2	81.7	dBA/m	960	480	N/a	N/a	Var.

Noise Source Description	Source ID	Sound Power	Unit	Daytime Operation (min)	Night-time Operation (min)	Coordinates (X)	Coordinates (Y)	Source Height (m)
Conv. belt at 2nd fine crushing plant	Exp_Conv_B2	81.7	dBA/m	960	480	N/a	N/a	Var.
Conv. belt at 2nd fine crushing plant	Exp_Conv_B2	81.7	dBA/m	960	480	N/a	N/a	Var.
Conv. belt at 2nd fine crushing plant	Exp_Conv_B2	81.7	dBA/m	960	480	N/a	N/a	Var.
Conv. belt to ripios and heap leach	Exp_Conv_B2	81.7	dBA/m	960	480	N/a	N/a	Var.
Conv. belt to ripios and heap leach	Exp_Conv_B2	81.7	dBA/m	960	480	N/a	N/a	Var.
Conv. belt to ripios and heap leach	Exp_Conv_B2	81.7	dBA/m	960	480	N/a	N/a	Var.
Conv. belt to ripios and heap leach	Exp_Conv_B2	81.7	dBA/m	960	480	N/a	N/a	Var.
Conv. belt to ripios and heap leach	Exp_Conv_B2	81.7	dBA/m	960	480	N/a	N/a	Var.
Conv. belt to ripios and heap leach	Exp_Conv_B2	81.7	dBA/m	960	480	N/a	N/a	Var.
Conv. belt to ripios and heap leach	Exp_Conv_B2	81.7	dBA/m	960	480	N/a	N/a	Var.
Conv. belt to ripios and heap leach	Exp_Conv_B2	81.7	dBA/m	960	480	N/a	N/a	Var.
Conv. belt to ripios and heap leach	Exp_Conv_B2	81.7	dBA/m	960	480	N/a	N/a	Var.
Conv. belt to ripios and heap leach	Exp_Conv_B2	81.7	dBA/m	960	480	N/a	N/a	Var.
Conv. belt at stacker reclaimer	Exp_Conv_B2	81.7	dBA/m	960	480	N/a	N/a	Var.
Conv. belt to ripios	Exp_Conv_B2	81.7	dBA/m	960	480	N/a	N/a	Var.
Conv. belt to ripios	Exp_Conv_B2	81.7	dBA/m	960	480	N/a	N/a	Var.
Conv. belt at 2nd fine crushing plant	Exp_Conv_B2	81.7	dBA/m	960	480	N/a	N/a	Var.
Haul road high denstity tailings sand	EXPl_Tailings_Route	84.8	dBA/m	960	480	N/a	N/a	Var.
Haul road high denstity tailings sand	EXPl_Tailings_Route	84.2	dBA/m	960	480	N/a	N/a	Var.
Haul road tailings to heap leach	EXPl_Tailings_Route	60.3	dBA/m	960	480	N/a	N/a	Var.
Haul road to low grade	EXPI_HAUL_ROADS	80.3	dBA/m	960	480	N/a	N/a	Var.
Haul road to ore	EXPI_HAUL_ROADS	88.4	dBA/m	960	480	N/a	N/a	Var.
Haul road to low waste	EXPI_HAUL_ROADS	84.5	dBA/m	960	480	N/a	N/a	Var.
Haul road to low grade	EXPI_HAUL_ROADS	82.1	dBA/m	960	480	N/a	N/a	Var.
Haul road to ore	EXPI_HAUL_ROADS	85.2	dBA/m	960	480	N/a	N/a	Var.
Haul road to low waste	EXPI_HAUL_ROADS	90.5	dBA/m	960	480	N/a	N/a	Var.
Haul road to low grade	EXPI_HAUL_ROADS	81.8	dBA/m	960	480	N/a	N/a	Var.
Haul road to low waste	EXPI_HAUL_ROADS	90.6	dBA/m	960	480	N/a	N/a	Var.
Haul road to ore	EXPI_HAUL_ROADS	83.4	dBA/m	960	480	N/a	N/a	Var.
Conv. belt at fine crushing plant	bo_R0s_cvb_01	81.7	dBA/m	960	480	N/a	N/a	Var.
Conv. belt at fine crushing plant	bo_R0s_cvb_01	81.7	dBA/m	960	480	N/a	N/a	Var.
Conv. belt at fine crushing plant	bo_R0s_cvb_01	81.7	dBA/m	960	480	N/a	N/a	Var.
Conv. belt at fine crushing plant	bo_R0s_cvb_01	81.7	dBA/m	960	480	N/a	N/a	Var.
Conv. belt at fine crushing plant	bo_R0s_cvb_01	81.7	dBA/m	960	480	N/a	N/a	Var.

Noise Source Description	Source ID	Sound Power	Unit	Daytime Operation (min)	Night-time Operation (min)	Coordinates (X)	Coordinates (Y)	Source Height (m)
Conv. belt at fine crushing plant	bo_R0s_cvb_01	81.7	dBA/m	960	480	N/a	N/a	Var.
Haul road from ROML to crusher	EXP_ROML_Crush	86.6	dBA/m	960	480	N/a	N/a	Var.
Maintenance trucks in open pit	Bo_Maint_Trucks_Pit	76	dBA/m	960	480	N/a	N/a	Var.
Maintenance trucks in open pit	EXP_Maint_Trucks_Pit	75.8	dBA/m	960	480	N/a	N/a	Var.

SOCIAL AND ENVIRONMENTAL IMPACT ASSESSMENT OF THE PROPOSED EXPANSION OF THE RÖSSING URANIUM MINE, NAMIBIA

NOISE MONITORING PLAN

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Glossary of Terms

A-weighted sound level:	A measure of sound pressure level designed to reflect the acuity of the human ear, which does not respond equally to all frequencies.
dBA:	Unit of sound level. The weighted sound pressure level by the use of the A metering characteristic and weighting specified in ANSI, IEC and ISO Specifications for Sound Level Meter.
Equivalent A-weighted Sound Level (L_{Aeq}):	Is the value of A-weighted sound pressure level in decibels of continuous steady sound that within a specified time interval has the same sound pressure as a measured sound that varies with time.
L_{A90}	The noise level which is exceeded 90% of the measurement time period.

1 Introduction

Rössing Uranium (RU) has operated an open pit uranium mine in the Erongo Region of Namibia since 1976 and is undergoing a mining expansion programme. The Phase 1 Social and Environmental Impact Assessment (SEIA) for the proposed expansion was dealt with during a previous process and has been approved by the Ministry of Environment & Tourism: Directorate of Environmental Affairs (MET:DEA).

The envisaged further expansion would entail, in summary, an increase in size of the current mining pit, the opening of new mining areas, new disposal areas for waste rock, new processing plants, additional tailings dam capacity, and an increase in staff numbers and facilities.

The present report delineates the requirements of a noise monitoring programme applicable for the Rössing mining expansion and provides advice, in order to ensure that noise emissions from the site are appropriately managed.

2 Monitoring Overview

There has been a recent agreement between the Namibian and South African governments through the South African Bureau of Standards (SABS) to assist the establishment of a similar Namibian organization concerned with the vetting of standards and the distribution of information regarding these. As there are no applicable Namibian National Noise Standards, the noise monitoring programme and the recommended noise measurements should comply with the South African National Standard - Code of Practice, SANS 10103:2008, *The measurement and rating of environmental noise with respect to annoyance and to speech communication*, and the regulations of the Department of Environmental Affairs And Tourism (DEAT), No. R154 Noise Control Regulations in Terms of Section 25 of the Environmental Conservation Act, 1989 (Act No. 73 of 1989), Govt. Gaz. No. 13717, 10 January 1992.

Noise monitoring is to be carried out within and around the site, in order to ensure that noise levels resulting from the mining operations comply with the above-mentioned standard and regulations, as well as are consistent with the calculated noise levels and requirements outlined in the Noise Impact Report for the proposed expansion of the Rössing mine (Dracoulides, 2010).

3 Noise Monitoring Plan

3.1 Noise Measurement Locations

A number of noise measurements were carried out at the Rössing mining site during the Phase 1 expansion investigation. These ambient noise measurements were made at nine positions near the property boundary, three at affected party sites, and a number within the mine site. The locations can be seen in the following Figure 1. They are suitable to assess likely response to noise from the projected operations at the proposed mine expansion and are utilised in the selection of the measurement locations for the current monitoring programme.

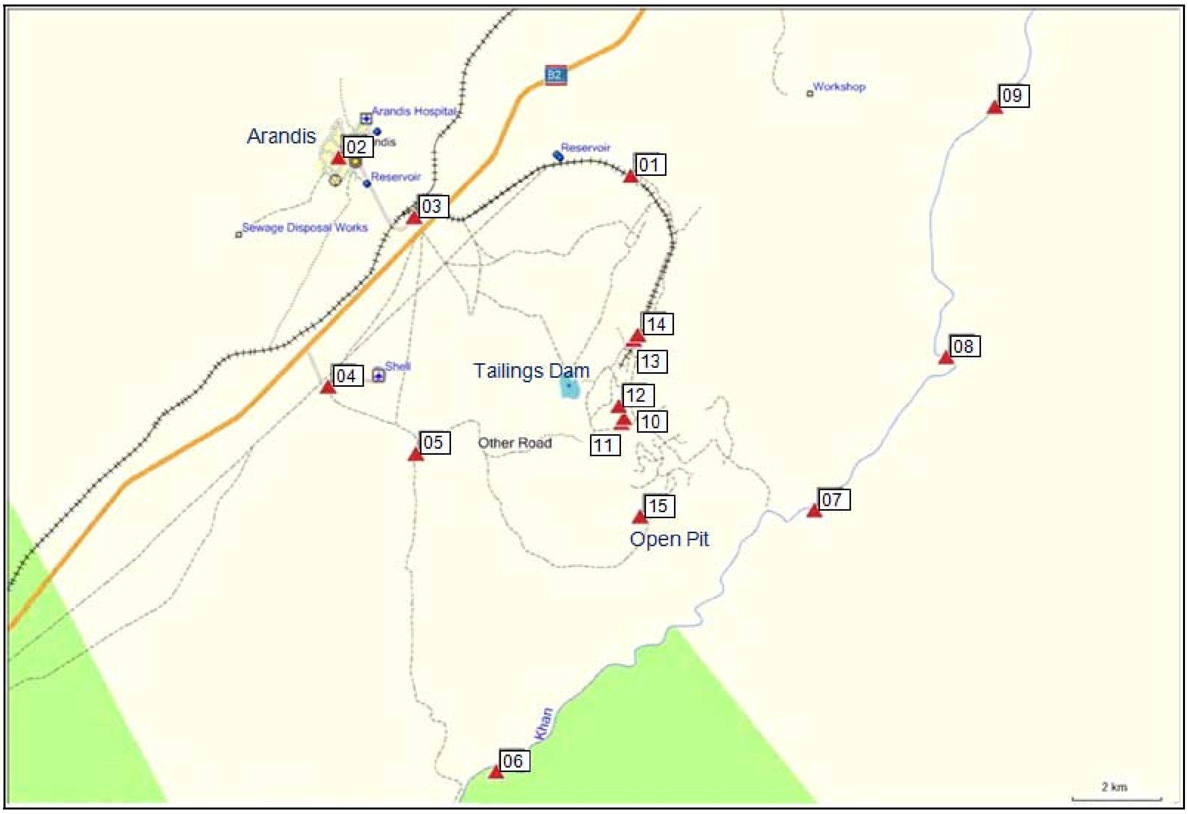

Figure 1. Map Showing Position of Noise Measuring Points for Phase 1

Based on the proposed activities and the noise impact assessment of the proposed expansion, a total of five locations were selected as noise monitoring points. These locations are described in the following Table 3.1 and can be seen in Figure 2.

Table 3.1: Description of Noise Monitoring Locations

Point	Location	Description
01	S22° 25.331′ E15° 02.723′	Point 45m from the centreline of the main mine access road at the position near the only tree and isolated boulder in the area marked by a cairn.
02	S22° 25.110′ E14° 58.421′	Point inside the Rössing foundation gardens in Arandis near the fire assembly point.
03	S22° 25.830′ E14° 59.538′	Point behind the welcome sign to Arandis at the road intersection.
10	S22° 28.311′ E15° 02.582′	Point between the primary reclaim area and the main plant, at the edge of the dirt road.
13	S22° 27.311′ E15° 02.762′	Point close to the office area and main entrance, at the pipeline valve chest.

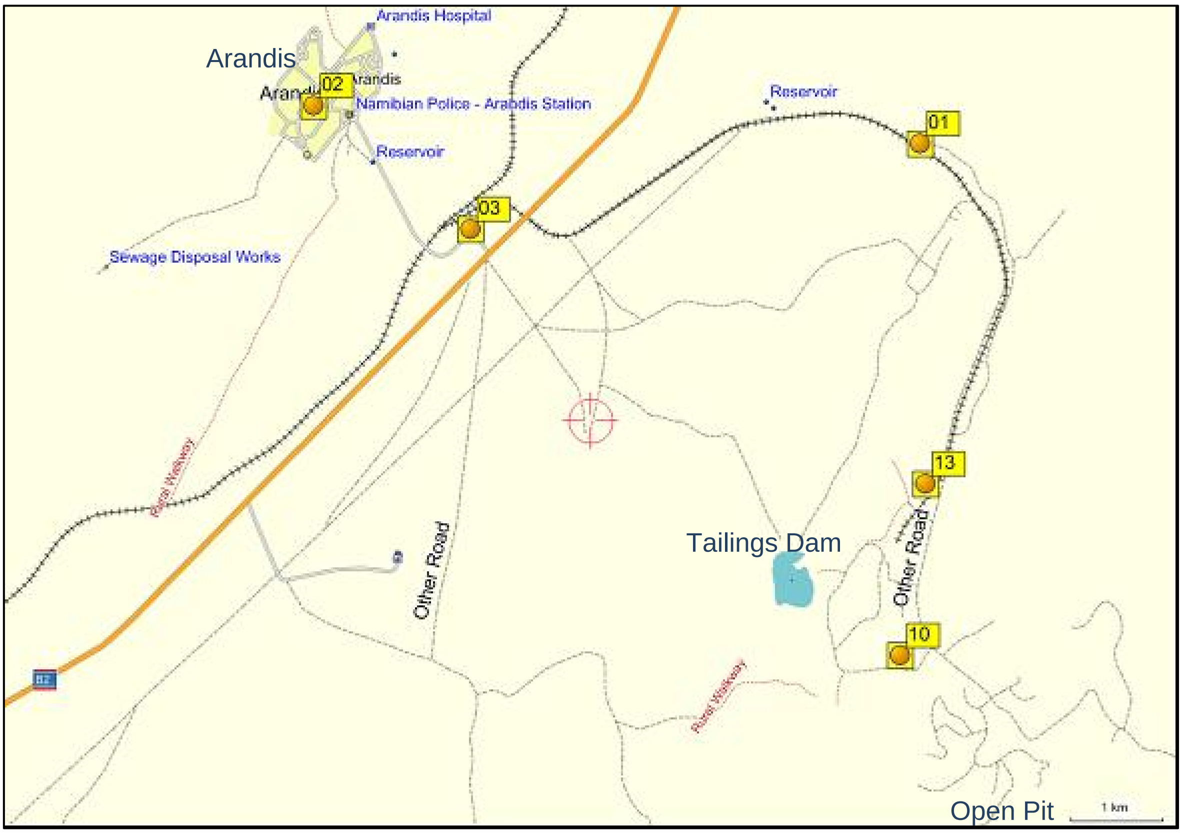

Figure 2. Rössing Noise Monitoring Programme Measurement Locations

3.2 Noise Measurement Methodology

3.2.1 Noise Measurement Procedure

As indicated previously, since there are no applicable Namibian National Noise Standards, the measurements should be performed in accordance with procedures stipulated in the South African National Standards (SANS) Code of Practice: SANS 10103:2008, as well as the requirements of the South African Department of Environmental Affairs And Tourism (DEAT) Noise Control Regulations in Terms of Section 25 of the Environmental Conservation Act 73 of 1989. These requirement are outlined below.

The monitoring programme approach should incorporate ambient noise measurements at the five specified points (see Figure 2) during day and night-time. The point locations can be altered or additional points introduced in subsequent years, depending on the previous years' recommendations.

A Type 1 precision impulse integrating sound level meter (SLM) should be used for all the noise measurements. The SLM should be calibrated immediately before and after each series of sound level measurements and the results discarded if the two checks do not coincide to within 1.0 dB.

At each select measuring point the microphone of the sound level meter should be placed at a height of between 1.2 m and 1.5 m and at least 3.5 m away from walls, buildings and other large, flat vertical surfaces.

The noise measurements should cover at least a twenty-four hour period and be categorised in terms of daytime (06:00 22:00) and night-time (22:00-06:00), in order to generate results comparable to legislation and the applicable SANS Codes. These periods should be broken down into 4 day-time sub-periods (06:00 – 10:00, 10:00 – 14:00, 14:00 – 18:00, 18:00 – 22:00) and 2 night-time sub-periods (22:00 – 00:00, 00:00 – 06:00), in order to cover the noise level variations during the 24-hour period.

In each period two continuous A-weighted equivalent sound pressure level (L_{Aeq}) measurements of at least a 10- minute duration should be performed. Two sets of measurements over two different days should be collected. For simplification purposes, the night-time measurement period can also be considered one time segment, therefore reducing the segments to five.

In addition, the occurring maximum (L_{max}) and minimum levels (L_{min}) during the measurement period, as well as the L_{10}, L_{50} and L_{90} should also be recorded.

The measured equivalent continuous A-weighted sound pressure level ($L_{\mathrm{Aeq,T}}$) during the specified time interval should be adjusted for tonal character and impulsiveness of the sound in accordance with the following equation:

$$L_{\mathrm{r}} = L_{\mathrm{Aeq,T}} + C_{\mathrm{i}} + C_{\mathrm{t}}$$

where

L_r is the equivalent continuous rating level;

$L_{\mathrm{Aeq,T}}$ is the equivalent continuous A-weighted sound pressure level in decibels;

C_{i} is the impulse correction (if any);

C_{t} is the correction for tonal character (if any).

Abnormal disturbances, such as loud noise generation in close proximity or sudden noise bursts that affect the measurement, should be discarded.

The wind speed should be checked at each location with a portable wind speed meter capable of measuring the average wind speed and wind gusts in meters per second.

All the noise measurements should be in compliance with appropriate weather condition requirements, i.e. measurements should not be performed in the presence of fog, rain, wind with a steady speed exceeding 5 ms^{-1} or wind with gusts exceeding 10 ms^{-1}.

3.2.2 Monitoring Equipment

The utilised sound level meter should comply with the accuracy requirements for a Type 1 instrumentation and calibrator specified in the IEC Publication 651, IEC 804 and IEC 942. A windscreen should be fitted and the correction for the free field measurements should be applied in accordance with the specific windscreen type during the calibration. In line with the SANS 10103 Code, a calibration should be performed before and after the series of sound measurements. All equipment should be accompanied with valid calibration certificates from an accredited testing laboratory.

It is recommended to utilise two portable data-logging precision impulse integrating sound level meters, in order to minimise the required monitoring time and cover the five locations simultaneously for each time period. One portable instrument, however, could also be adequate due to the close proximity of the points.

A permanent monitoring base station with satellite stations, in order to cover all points can also be utilised. Such a system consists of a set of stations connected over a network that transfers in real time several types of information and data. Stations allow for real-time listening of their noise context and can be associated with video or weather systems. The monitoring information can be stored in one database and the post-processing can be automated.

The localised weather parameters should be ascertained during the noise measurements at each point location or globally. These parameters should be noted on the point data sheet and include: wind speed, temperature, relative humidity, atmospheric pressure and cloud cover.

For the identification of the current or future new point coordinates a GPS instrument should be used.

3.3 Monitoring Frequency, Record Keeping and Reporting

The noise monitoring programme should commence immediately, in order to collect noise data of the noise levels due to the existing operations and be repeated at a 6-month intervals. With the commencement of the proposed expansion operations, a new cycle of 6-montly monitoring intervals should be introduced.

Information relating to the noise monitoring should be collated on separate sheets per location and kept in a file for future reference and interpretation of past results.

The data should include a GPS location of each point, the meteorological conditions at the time of the measurement, photographs of the location, as well as notes on relevant noise influencing events.

A noise monitoring report should be produced with the completion of each cycle of measurements. The submitted report should include the following sections and information:

- A locality map with the monitoring points.
- The GPS locations and photos of the monitoring points.
- A description of the monitoring equipment and methodology.
- A description of the noise climate at monitoring points.
- Parameters such as wind speed, temperature, relative humidity, atmospheric pressure and cloud cover should be noted.

- A section with the detailed noise measurements, including the field datasheets in an appendix.
- A section with the analysis of the results and comparisons against local and international guidelines.
- A section with conclusions and recommendations for possible mitigation actions, as well as recommendations to be adopted during the following monitoring programme.

Valid calibration records of the sound level meter and its portable field calibrator should also accompany each noise monitoring report. The calibration of the sound level meter should be performed biannually and the field calibrator on an annual basis.

In the event of community or individual complaints, records should be kept in order to provide an appropriate complaint response and establish resolution procedures. A specially assigned person from the directorate should take note of the complaint. Depending on its severity, it should be referred to the noise monitoring specialist, in order to conduct an on-site investigation, or alternatively, it should be taken into consideration during the subsequent monitoring.

REFERENCES

DEAT, 1992. Noise Control Regulations (Section 25). Environmental Conservation Act 73 of 1989. Gov. Gaz. No. 13717, 10 January 1992.

Dracoulides D. A., 2010. Noise Impact Report. Social and Environmental Impact Assessment of the Proposed Expansion of the Rössing Uranium Mine, Namibia.

SANS 10103:2008 'The measurement and rating of environmental noise with respect to land use, health, annoyance and to speech communication'.