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Sierra Rutile Project Area 1 – Environmental, Social and Health Impact Assessment: Specialist noise study.	
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For: Sierra Rutile Limited	

Executive Summary

Scope

A noise study comprising a noise baseline and a noise impact assessment was carried out in support of an Environmental Social and Health Impact Assessment (ESHIA) undertaken by SRK Consulting (South Africa) (Pty) Ltd for Sierra Rutile Limited (SRL) Area 1 concession (SR Area 1). The objective of the study was to establish and assess current baseline conditions and to assess the noise implications for people living in the area resulting from changes proposed for operations in SR Area 1. Data obtained in field surveys was used with noise modelling to compose a map describing the current ambient noise profile in SR Area 1. This enabled derivation of reference ratings used in modelling and assessment of current and future SR Area 1 noise impacts.

Existing State of the Environment

Observations made in a field survey, samples taken throughout SR Area 1 and the results of 24-hour surveys confirm that ambient noise in SR Area 1 has evolved in character and level from a former rural district to what is now characteristic of a mining district interspersed with rural villages. The results of the 2017 baseline survey show that ambient noise levels in the villages vary around 55 dBA during the day and around 45 dBA at night.

Apart from truck noise in villages intercepted by haul roads, current daytime and night-time noise accrues predominantly from natural sounds and community activity noises. Sources of natural sounds include rain, wind, birds, insects and amphibia. Community activities creating noise include local traffic,

trade, work, living, leisure, speech communication, children having fun and the sounds of radios and music being played. Local traffic comprises predominantly of motor cycles used for private and public (taxi) transport. Although noisy, the traffic volumes of motor cycles in villages are generally low and mostly confined to a single road running through the centre of a village.

When taking readings of noise levels during surveys, attention was paid to listen to the content of ambient noise. This was to detect the presence and assess the prominence of audible mining activity noises, especially during night-time. In villages not intersected by haul roads, little evidence of audible plant or any other SR Area 1 activity noises could be detected during the course of the 2017 survey. It is possible and likely, however, that audibility would vary over time with natural variances in atmospheric propagation conditions (see Section 3.2.4). Truck noise was clearly audible in villages intersected by haul roads.

Noise Impacts of Current SR Area 1 Operations

Observations and results of field measurements conducted in the 2017 survey, supported by noise modelling investigations, indicate that noise from current plant, dredging, Nitti Port operations and excavation operations within SR Area 1 do not have significant impacts on the nearest villages. Significant impacts are however caused by haul roads. In villages intersected by haul roads, the first rows of houses next to the road are experiencing high levels of truck noise amounting to impacts of well over 5 dB. Such impacts caused by noise of a transient nature occurring every 20 to 40 minutes, are bound to cause sleep interference at night.

New activities and increases in throughput required in terms of the proposed changes in SR Area 1 operations are not expected to change the current status of plant, port and excavation impacts; they will remain insignificant. Haul road noise impacts will remain significant and will increase by 3 dB for the first rows of houses in villages intersected by haul roads.

Mitigation

No significant impacts are currently experienced or are expected to arise from noise produced by the Mineral Separation Plant (MSP), the Lanti and Gangama Dry Plants, Nitti Port, or by noise produced at the excavation (mining) sites. No mitigation is required for any of these operations and activities.

Mitigation of haul road noise on existing routes passing through villages such as Foya Nitti and Lungi will be difficult to accomplish without major costs and practical consequences. Principles and options of mitigating measures that should be considered, are explained. Options include restriction of operating hours, realignment of roads, relocation and construction of noise barriers.

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Definitions and Acronyms

Acoustic Terminology

Term	Label	Unit	Definition
Noise			Unwanted sound
A-weighting			Frequency-dependent weighting applied to band-filtered or spectral sound levels, corresponding to the frequency characteristics of human hearing
A-weighted level	L_A	dBA	A-weighted sound pressure or sound power level
dBA			A-weighted unit of magnitude on a logarithmic scale
Decibel		dB	Unit of sound magnitude on a logarithmic scale defined as 10 log ($f\{W\}/W_o$) $f\{W\}$ is proportional to the acoustic power or intensity of the sound or noise W_o is a power or intensity reference
Sound or Noise Level	L, LP	dB	Pressure Level representing the magnitude of the sound or noise on the decibel scale
Sound Power Level	LW	dB	Sound Power Level [dB] defined as 10 log (W/W_0) where W is the sound power [W], P_0 = 10 pW, the international standard reference of sound power
Sound Pressure Level	LP	dB	Magnitude of sound or noise [dB] defined as 10 log (P^2/P_0^2) where P is the sound pressure [Pa], P_0 = 20 μPa, the international standard reference of sound pressure
Equivalent continuous level	$L_{eq,T}$	dB	The average level of a sound or noise determined by integrating and averaging the acoustic energy over a measurement period T The level of a sound with constant amplitude which would have the same average over time T
A-weighted equivalent continuous sound level	L_{Aeq}	dBA	Average level of a sound or noise determined by integrating and averaging the A-weighted acoustic energy over a measurement period T

1 Introduction

1.1 Project Description

Sierra Rutile Limited (SRL) is an existing mining operation located in the Bonthe and Moyamba Districts of the Southern Province of Sierra Leone (Figure 1-1). The mine has been in operation for over 50 years and produces rutile, ilmenite and zircon rich concentrate. SRL currently holds seven mining leases covering 559 km^2 with a total of 16 deposits identified. SRL's Area 1 Mine Lease Area (SR Area 1) covers an area of approximately 290 km^2.

SRL has an existing Environmental Licence (reference number EPA-SL030) for their SR Area 1 operations and has undertaken two previous Environmental and Social Impact Assessment (ESIA) studies in 2001 and an update in 2012 respectively. When these studies where undertaken, the primary mining process was dredge mining (referred to as wet mining) with some secondary dry mining operations. During 2013 SRL commenced a distinct open cast dry mining operation as an auxiliary method of ore extraction in conjunction with wet mining. In 2016 a second dry mining operation was commissioned. It is anticipated that, over time, dredge mining will cease, and dry mining would be the primary mining method employed.

In 2015 the Environmental Protection Agency of Sierra Leone (EPA-SL) issued a notification to SRL (reference number EPA-SUHA.96/214/a/HNRM), instructing them to undertake an integrated Environmental, Social and Health Impact Assessment (ESHIA) and develop an Environmental, Social and Health Management Plan (ESHMP) for their current and proposed dry and wet mining activities, including the proposed expansion areas. This included the Gangama and Lanti deposits, as well as other deposits within SRL's current operating concession in SR Area 1.

The purpose of the ESHIA is to update the previous ESIA and associated management plans to incorporate the dry mining process and associated activities and include social and community health aspects.

1.2 Project Location

SR Area 1 ("SR Project" or "the Project") is located in the Moyamba and Bonthe District in the Southern Province of Sierra Leone. It is situated 30 km inland from the Atlantic Ocean and 135 km south east (geodesic distance) of Freetown. The regional setting of is shown in Figure 1-1.

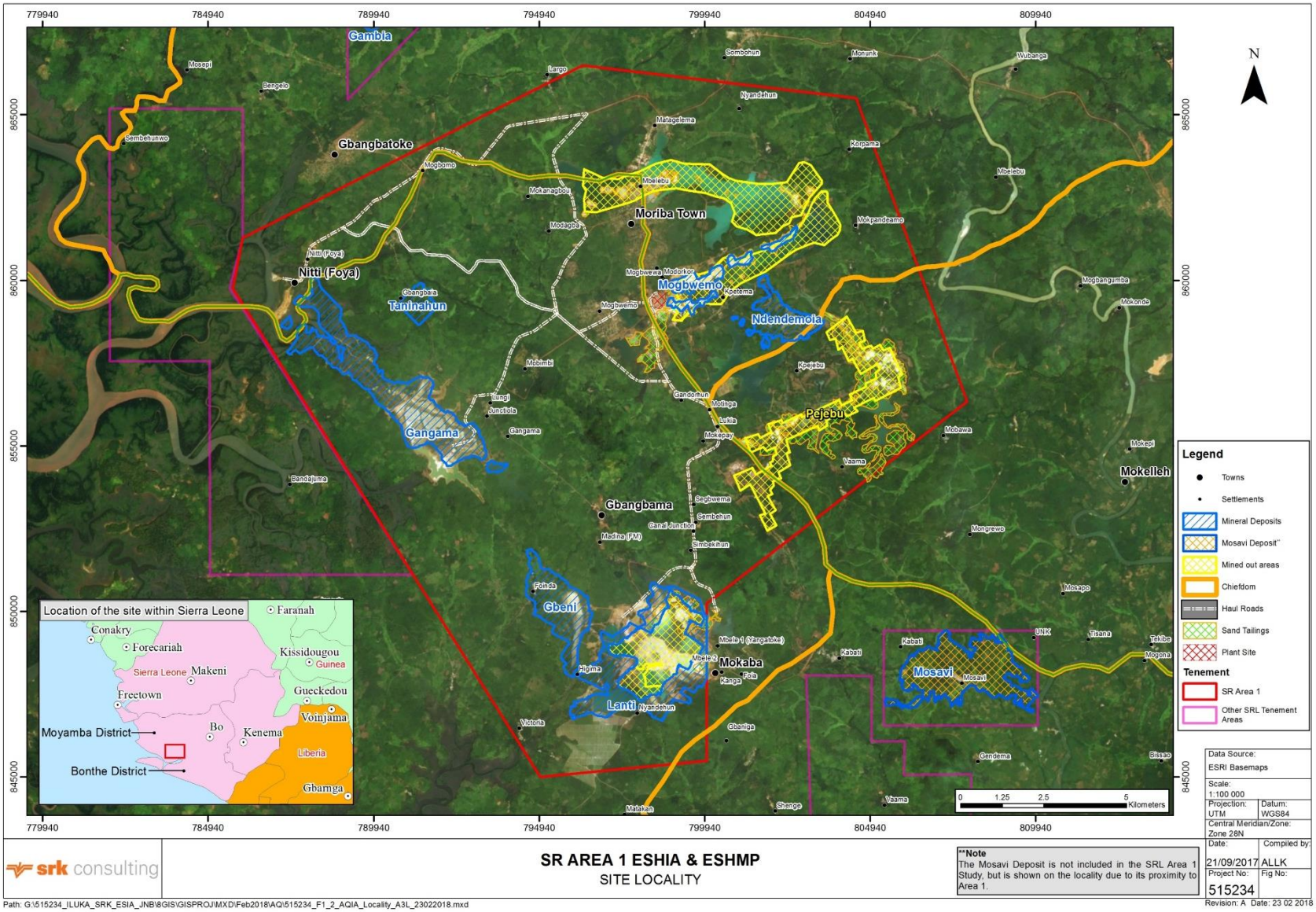

Figure 1-1
Regional setting of SR Area 1

1.3 ESHIA by SRK

SRK Consulting (South Africa) (Pty) Ltd (SRK) was appointed by SRL in 2017 to undertake a ESHIA to meet the Sierra Leonean legal requirements and in accordance with SRL corporate policies, which are aligned with Good International Industry Practice (GIIP). A scoping report prepared by SRK in 2017 and submitted to the EPA-SL forms part of the first phase of the 2017 ESHIA. This noise specialist study will provide input into the 2017 ESHIA and ESHMP.

2 Noise Study Overview

2.1 Noise Specialist

2.1.1 Terms of Reference

Noise generated by the current and proposed future mining operations within SR Area 1 may affect some residents in towns, villages and settlements in the surroundings. Acusolv has been appointed to undertake a noise study to investigate the noise implications of SR Area 1 and to consider the requirements and options for mitigation.

2.1.2 Specialist Details

Details of the specialist who carried out the noise study and compiled this report, are summarised in Table 2-1.

Table 2-1

Details of noise specialist

Name of practitioner:	Ben van Zyl Acoustical Engineer PhD
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2.1.3 Qualifications

Ben van Zyl is a noise specialist in private practice based in Pretoria, South Africa. He holds Masters and PhD degrees in acoustical engineering and has more than 30 years' experience in environmental acoustics, including baseline, annual and diagnostic noise monitoring; noise impact assessment, noise problem solving and design for noise reduction in the mining and other industries. A personal curriculum vitae in support of qualifications, expertise and experience to undertake studies of this nature, is attached in Appendix B.

2.1.4 Declaration of Independence

As a single proprietor and independent noise specialist, Ben van Zyl has no commercial interest in SR Area 1 or Sierra Rutile Limited, other than fair payment for consulting services rendered as part of the ESHIA process.

2.2 Scope of Work

Noise generated by operations within SR Area 1 is likely to elevate ambient noise levels in an area which can be described as a mining district interspersed with rural villages and roads. This noise study investigates the environmental noise implications for people living in the area.

The scope of work required in support of the ESHIA involves the following tasks:

A Scoping and Baseline Assessment

A site visit was carried out during which a scoping assessment was conducted and during which surveys were carried out. The purpose was to sample, monitor and establish ratings for existing day and night-time ambient noise levels in the external surroundings of plants, excavations and associated infrastructure within SR Area 1. The results were employed as reference ambient levels in the modelling and prediction of Project noise impacts.

B Predictive Noise Impact Study

The predictive study quantifies and assesses the expected noise impact of SR Area 1. Estimation of noise levels and of noise impacts is based on modelling of the emission and atmospheric propagation of noise generated by the main SR Area 1 components and activities. Incremental impacts are referenced to existing ambient noise ratings derived in the baseline study.

This report describes the methodology and presents the results and findings of the noise study.

2.3 Noise Study Area

The focus in this noise study is on SR Area 1 shown on the map in Figure 1-1. Limits defining the study area for purposes of noise mapping were adjusted to extend well beyond potential worst-case noise footprints and beyond all known noise receptors potentially located within estimated reach of audible SR Area 1 core activity noises.

3 Methodology

3.1 Noise Study Guideline Standard

The SR Area 1 environmental noise study was carried out in accordance with World Bank Group and International Finance Corporation (IFC) performance standards (World Bank Group International Finance Corporation, 2012) [1] and general health and safety guidelines (World Bank Group International Finance Corporation, 2007) [2]. The regulatory framework is described in Section 6. World Bank limits are stipulated in Table 6-1.

Measurement of environmental noise levels in the baseline surveys complied with standards ISO 1996-1 (International Standards Organisation) [3] and ISO 1996-2 (International Standards Organisation) [4]. ISO 1996 gives guidelines in respect of basic quantities and procedures (Part 1); acquisition of data pertinent to land use (Part 2) and the principles of application to noise limits (Part 3). ISO 1996 does not define or prescribe any limits. No environmental noise limits are prescribed in terms of Sierra Leonean legislation.

3.2 Baseline Assessment Methodology

3.2.1 Objective

The objective of the noise baseline study was to ascertain ambient noise levels in SR Area 1 under current conditions, with SRL and other mining operations running. Data obtained from field scoping and measurement surveys, in conjunction with noise modelling, was used to map ambient noise. This enabled derivation of reference ratings used in modelling and assessment of the noise impacts resulting from existing and future SR Area 1 operations.

3.2.2 Sources of Baseline Data

A comprehensive overview of ambient noise in the area was obtained from the following sources of information:

(a) A visual and aural scoping survey was carried out to identify the apparent sources of audible noise and to observe the nature of these sources in the SR Area 1.

(b) Long duration 24-hour surveys were carried out at Mobimbi[1].

(c) Ambient noise was sampled by means of short duration measurements of ambient noise levels at various locations throughout SR Area 1 (Figure 3-1). Measurements were taken in the absence of any prominently audible noise from nearby approaching, passing or receding vehicles.

(d) Noise modelling, accounting for the contributions of traffic noise from public roads and noise from existing mining activities, was used in conjunction with field measurement data to generate a baseline ambient noise map depicting the ambient noise profile of the entire SR Area 1.

Using the composite ambient noise profile as reference, SR Area 1 noise impact footprints were computed by modelling of existing and future mining noise emissions in the predictive impact assessment. Noise contour maps derived in this way facilitate the assessment of the mines impact on any town, village or settlements in SR Area 1.

[1] *The intent to conduct similar long duration surveys in villages did not materialise. Leaving sophisticated equipment exposed to the elements was ruled out by heavy rains as well as advice by the mine against leaving such equipment unattended.*

3.2.3 Selection of Baseline Monitoring Locations

Principles and good practice considerations applied in the selection of suitable locations for sampling and detailed monitoring of ambient noise levels, include the following:

- **Worst-case impact:** Focus on areas where maximum noise impact is expected. This usually includes receptor locations nearest to the primary sources of noise.
- **Suitability for future surveys:** As far as possible, select locations likely to be accessible in future surveys.
- **Avoid interference:** As far as practically possible, stay clear of and avoid interference by proximity sources of noise which may distort the data. Examples are power distribution boxes, barking dogs, speech interference and insects.

3.2.4 Meteorological Considerations

General

In the following, this section presents an overview of principles and factors which influence the direction of travel and the levels of noise in long distance propagation of sound through the atmosphere[2]. It does not deal with the specifics of the 2017 SR Area 1 survey (for the latter, see Section 3.2.5). It is intended to explain the scientific footing for some findings and statements made in this study and to shed light on uncertainties and questions that might arise.

The characteristic fluctuating nature of noise

Of particular relevance is that environmental noise levels, i.e. the levels measured in any survey, are subject to considerable variances and fluctuations over time. This applies to current SRL ambient noise levels measured in the 2017 survey, as well as future levels after implementation of proposed changes in SRL operations.

Fluctuations in ambient noise levels are not, as often mistakenly assumed, caused by climatic conditions on the ground. In other words, it is of no use measuring or knowing the temperature, humidity or atmospheric pressure at the location where the noise measurement was taken. It is irrelevant whether it is a hot or a cold day or night. Fluctuations in ambient levels are caused by meteorological conditions prevailing in the lower atmosphere. The conditions referred to, are temperature gradients and wind speed gradients (differentials with height) causing diffraction in sound. Depending on how these temperature and wind profiles vary over time and distance, refraction causes variable degrees of bending (skyward or earthbound), scattering, weakening, or intensification (focusing) of sound energy.

The end result, the level of noise arriving at and measured at a receptor location depends on the changes that occurred along the entire transmission path over the full distance travelled by the sound between source and receiver.

It should be noted that, although the mechanisms are well understood, the specific conditions which prevailed in the atmosphere during the course of any particular survey are generally unknown. We can however in noise modelling make valid assumptions on a scale of meteorological categories for prediction of typical or worst-case noise levels.

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[2] *Long distance propagation becomes relevant if the distance between a source (such as an opencast operation, a plant or a road) and a receiver (such as the residents of a village) is more than roughly 500 m. The longer the distance, the greater the potential effect of atmospheric conditions on noise levels.*

Relevance of Weather and Atmospheric Conditions

Rain, drizzle or fog may generate noise on the microphone and affect the conductivity of measurement microphones, resulting in faulty readings. Although measurement often has to be performed in the presence of wind, care was taken to verify that wind turbulence noise on the microphone capsule is negligible compared to the sound level under investigation. There is no fixed upper limit for permissible wind speed; it all depends on the level being measured. Another weather phenomenon which may cause interference and distort measurement data, is thunder.

Due to its influence on atmospheric propagation of sound, meteorological conditions also affect the acoustic environment and sound levels without causing interference or measurement error. Normal fluctuations in atmospheric conditions may cause substantial variations in noise level which are unpredictable. These random fluctuations constitute the natural variance in both background and intrusive noise levels. They cannot and need not be avoided in the planning and execution of noise monitoring surveys.

Noise levels at a distance from large sources are highly dependent on atmospheric propagation conditions. In fact, the difference in characteristic day and night meteorological patterns is one reason why 24-hour mining or industrial operations invariably have much higher noise impacts at night[3].

Relevance of season

Although season may influence noise impact, the potential effects are generally smaller than those resulting from random fluctuations in long distance noise levels caused by variances in atmospheric propagation parameters that are unrelated to season.

Season may affect noise impact through changes in the density of vegetation (trees, undergrowth and ground cover). Vegetation, or ground cover, acts to absorb the component of the sound wave travelling parallel to the ground. The resulting attenuation is quantified in noise modelling in terms of what is called % Acoustic Soft Ground.

In tropical regions, such as SR Area 1, overgrown by evergreen vegetation, vegetation density and the resulting % Acoustic Soft Ground remains more or less constant throughout the year. In regions covered with deciduous vegetation, a decline in vegetation density during the dry season will result in a reduction in the % Acoustic Soft Ground and consequently in a reduction in the level of the ground component of the sound intensity vector. This reduction, however, does not apply to the component of noise emitted skywards and subsequently refracting back to earth over distance. Neither does it have any bearing on the residual background noise level created by local sources of natural sound, such as birds, insects and wind. Overall, with all other factors kept constant, the noise impact of large mining and industrial sources surrounded by areas largely covered with deciduous vegetation, will tend to increase during the winter season.

Much more significant than seasonal effects, are wide-ranging, random, short-term fluctuations in ambient levels as a result of regular variations in weather and atmospheric conditions. These short-term fluctuations will also reflect in ambient levels measured in consecutive surveys conducted in different seasons and are often mistaken for and ascribed to seasonal variances.

Variances in long distance propagation and dispersion of noise and the resulting noise levels do not depend on temperature *per se*; but on vertical temperature gradient profiles in the atmosphere (changes in temperature as a function of height). Moreover, the end result is not determined by conditions at either the source, nor the receptor or monitoring point. It is

[3] *The other main reason is the increased community sensitivity at night due to a natural decline in road traffic and human activity noise.*

determined by the variable profile in the lower atmosphere along the entire propagation path between source and receiver. In other words, noise levels at large distances from a source are determined by spatial atmospheric patterns along the propagation path; not by conditions at the receptor only, and not by the absolute day or night temperature or the season of the year. The same principle applies to wind: noise levels are influenced by wind direction and wind gradient with height above the ground, along the propagation path, rather than wind speed measured at any particular point on the ground.

For the reasons explained above, the monitoring of meteorological conditions, such as temperature, wind and humidity on the ground can at best only serve to avoid errors and distortion of measurement data. Knowledge of cloud cover, temperature, humidity and wind which prevailed during the course of a noise survey has little if any value in the post-processing and interpretation of data. To the contrary, noise modelling and computations made in the prediction of impacts should clearly state the assumptions made with regard to meteorological conditions for which the predictions would be valid.

3.2.5 SRL 2017 Ambient Noise Survey

Baseline scoping and ambient noise surveys were carried out at the start of the rainy season during the period 23 to 30 June 2017[4]. An assessment was made of habitation, the physical landscape, topography and vegetation. Torrential rain made long duration surveys almost impossible. In an attempt to obtain useable data for determination of typical day and night averages, two 24-hour surveys were carried out at monitoring location M1 (Figure 3-1). Selecting data from brief intervals when rain subsided, these surveys contributed to the determination of the typical 24-hour ambient noise profile and of typical day and night-time averages of the ambient level. Detailed renderings of the noise profile and of the variation in noise level with time was obtained by logging and analysing noise in sequences of 10-minute intervals.

In addition to the abovementioned detailed long duration surveys, ambient noise was probed by short duration sampling of daytime and night-time ambient levels in the area. The map in Figure 3-1 shows location M1 at Mobimbi where the 24-hour surveys were carried out, as well as sampling locations “S”.

Care was taken at all times to avoid undue influence by rain, wind and thunder on readings. As explained in Section 3.2.4, the results obtained in the current survey are samples valid for the atmospheric conditions which prevailed at the time. Those conditions in the lower atmosphere cannot be quantified. They are unknown and must be accepted as given. Since changes in atmospheric conditions will cause the levels to fluctuate randomly over time, the same measurements repeated in the future should not be expected to yield identical results.

3.2.6 Test Equipment

Measurement data obtained in the detailed surveys was processed to obtain time-variable profiles of ambient noise levels. Using audio recordings made during the survey, it was possible to listen to the actual noises which occurred at any time, to identify sources of noise, to correlate audible noise events with data and to filter out distorted data.

[4] *As explained in Section 3.2.4, the season during which a noise survey is undertaken, is not expected to have a significant influence on the residual background noise level created by local sources of natural sound. Seasonal changes may occur in the levels of intrusive noise propagating over large distances in vegetated areas. Much larger fluctuations in ambient noise are caused by short-term day-night and day-to-day fluctuations in atmospheric temperature and wind profiles, rather than seasonal fluctuations.*

Noise Level Measurements

Field measurements were carried out using the following equipment:

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

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

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

Equipment conformed to IEC 61673-1 Electro-Acoustics – Sound Level Meters – Part 1: Specifications.

Calibration:

National Metrology Institute of SA Certificate No AV\AS-4251-R

National Metrology Institute of SA Certificate No AV\AS-0008

Data Logging Equipment

(a) RS5 Acoustic Data Logger (Serial no. 200109647)

(b) RS6 Acoustic Data Logger (Serial no. 200108967)

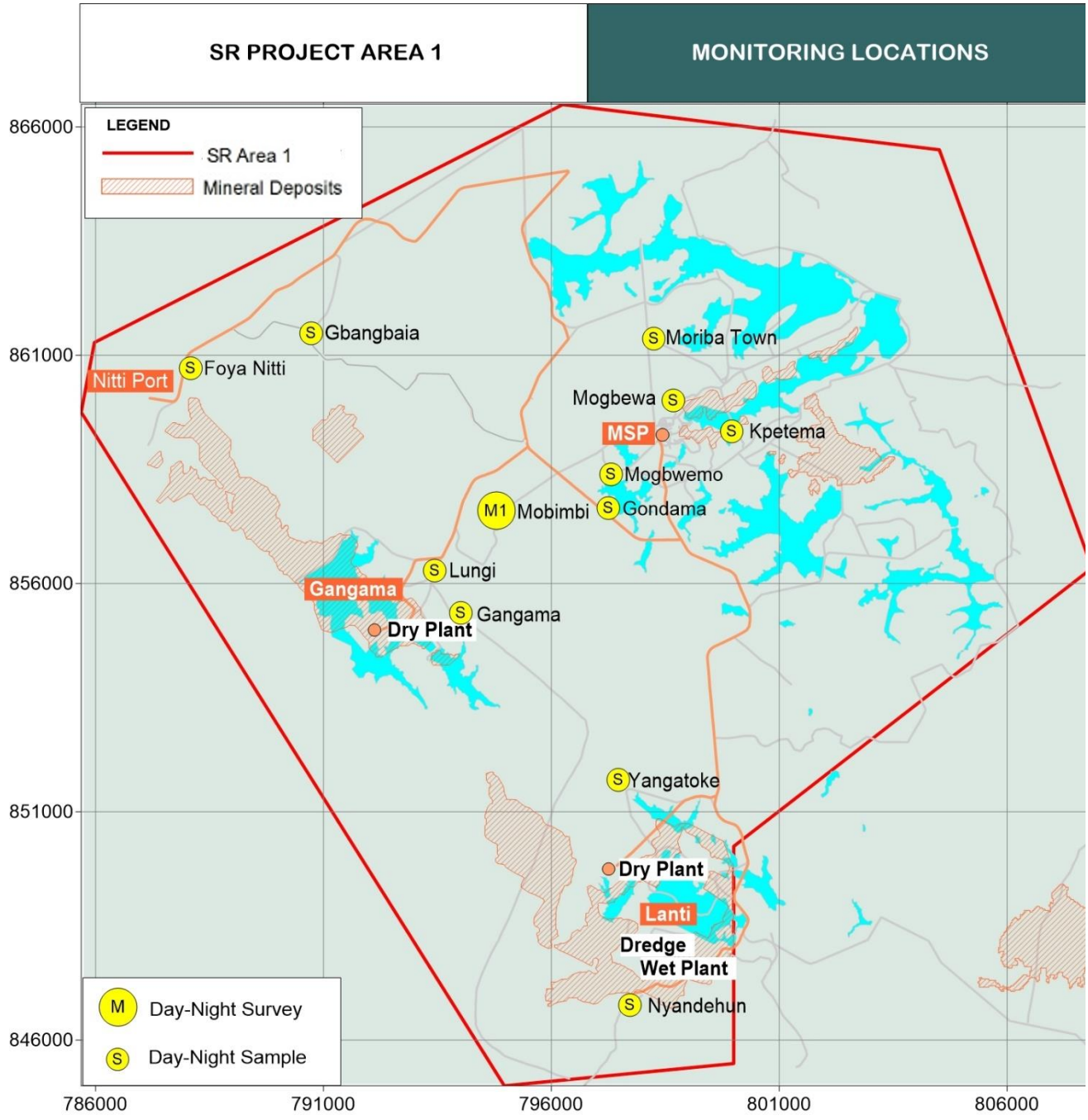


Figure 3-1

2017 SR Area 1 baseline ambient noise survey and sampling locations
Surveys at M1: Continuous logging over 24-hour day-night cycle
Samples (s): Samples taken during daytime and night-time periods

3.2.7 Baseline Assessment

Although measurements covered daytime periods as well, when considering the noise implications of any 24-hour operation, it is the night-time results that matter the most. Daytime noise disturbances are important, but night-time, when people are normally sleeping, is when the environment is most sensitive to intrusive noise and when maximum impact is experienced. The acceptable outdoor daytime background level for a school, for example, is 55 dBA, compared to typically 45 dBA at night in a residential area. The same source of intrusive noise potentially has a 10 dB higher impact risk for the latter. Hence, in the assessment of noise produced by 24-hour operations and in the determination of the amount of noise reduction required, the focus is on night-time conditions (see Section 7.3 as well).

3.3 Predictive Noise Impact Assessment Methodology

Calculation of noise propagation and dispersion in the SR Area 1 study is based on the principles of the CONCAWE method. CONCAWE (Conservation of Clear Air and Water in Europe) is an organisation established by a group of oil companies in 1963. A noise propagation model developed by CONCAWE (Concawe Report 4/81, Manning et al,1981) [5] has been validated and adopted to become one of the most widely used methods for the simulation of small and large sources of noise and in the prediction of noise for purposes of environmental noise impact assessment (International Standards Organisation) [6], [7].

Caution

Noise predictions and noise maps derived from acoustic modelling should be interpreted with caution. Even if the accuracy of an acoustic model is good, predicted levels are valid for the specific assumptions made in respect of meteorological and other conditions. Since meteorological conditions are highly variable, noise levels produced at a distance by a source at a constant acoustic output will vary considerably, even during the course of a single day-time or night-time period. Variance in noise level due to changes in atmospheric conditions increases with distance from the source. It should also be borne in mind that noise propagation is not only affected by distance and wind direction, but by temperature gradients in the atmosphere as well. Noise contours calculated for the SR Area 1 represent best estimates of continuous operation noise levels averaged over a relatively long duration, in this case the nominal daytime and night-time periods of 15 hours and 9 hours, respectively.

4 Project Description

4.1 Existing and Planned Operations

4.1.1 Existing SRL Operations

Currently, SRL's primary operations within SR Area 1 (Figure 1-1) comprise of the following main components and activities, some of which have potential noise implications which were investigated and assessed in this noise study:

- Lanti mining operations (both dredge and dry mining), processing operations (floating and land-based concentrators);
- Gangama dry mining operations (dry mining and land-based concentrator);
- Mineral Separation Plant (MSP);
- Transport and export of product through the Nitti Port facilities. This includes transport of mined product on haul roads from the Lanti and Gangama concentrator stockpiles to the MSP and of the final product from the MSP to Nitti Port.
- In addition, the mine maintains an extensive network of ponds and has power generation facilities, accommodation, offices, clinic and roads.

Mining, scrubbing and screening is undertaken on board the Lanti dredge, with mineral concentrate produced on board the floating concentrator. The dry mines produce run of mine ore for their respective concentrators, where de-sliming and primary heavy mineral concentration takes place. The separation of mineral concentrate into the various products takes place at the MSP.

4.1.2 Planned Changes in SRL Operations

SRL intends to amend their current SR Area 1 operations by implementing a more cost-effective mining method as well as by doubling the throughput of Lanti and Gangama dry mining operations and increasing the throughput capacity of the MSP.

Table 4-1 summarises current and proposed future changes in SR Area 1 operations. Table 4-2 summarises timeframes for current and proposed future SR Area 1 operations and processes.

Table 4-1

Current and proposed future SRL Activities

Stage	Activities
Current (operational)	• Site clearing • Dredging • Dam construction • Ore extraction (earth moving) • Primary mineral processing • Secondary mineral processing • Tailings management • Transporting and storage of ore and product • Port handling and shipping • Access road building and maintenance • Waste management • Power generation facility and transmission of power • Potable water services • Mine offices, workshops storage, accommodation and associated facilities • Rehabilitation
Planned (construction and operational)	• Site clearing • Ore extraction (earth moving) • Access road building and maintenance • Primary mineral processing • Tailings management • Transporting of ore • Waste management • Power transmission services • Potable water services • Mine offices, workshops and storage • Rehabilitation

Table 4-2

Summary of timeframes for the current and proposed mining operations and processes

Life of Mine (LOM)	4 plus years
Deposit groups (current and planned)	Lanti Wet Lanti Dry (including Gbeni) Mogbwemo Pejebu Gangama
Current mining operations (LOM)	Lanti Wet (18 months) Lanti Dry (including Gbeni) (4 years) Gangama (4 years)
Existing and current operations	Lanti Wet processing plant Lanti Dry processing plant Gangama processing plant Mineral Separation Plant (MSP) Nitti Port
Construction of additional infrastructure at	Gangama Lanti Dry
Closure and decommissioning (timeframes to be determined during a mine closure study and process)	Lanti Wet (TBC) Lanti Dry (including Gbeni) (TBC) Gangama (TBC)

4.2 Project Operation and Activity Changes

Following, are descriptions of changes in SR Area 1 components and activities which have potential noise implications to be investigated and assessed in this noise study.

4.2.1 Lanti Dry Mine

SRL proposes to modify the current excavation and haul mining method by constructing an in-pit mining unit, followed by an ex-pit scrubber, before ore is pumped to the current concentrator. Lanti Dry Mine currently has a nameplate capacity of 500 tonnes per hour (tph) and intends to increase throughput to 1 000 tph.

4.2.2 Gangama Dry Mine

Construction of the Gangama Dry Mine commenced in April 2015 after the manmade dredge pond was drained. Construction activities focused on a dry mining concentrator plant and associated infrastructure such as roads. The plant was commissioned in May 2016. Similar to Lanti Dry Mine, the intention is to modify the mining method and increase the current throughput from 500 tph to 1 000 tph.

4.2.3 Mogbwemo Tailings

Mogbwemo dry mine operates on the fringes of the Pejebu Deposit that was historically wet mined. The process will be similar to the other two dry mining operations, with the exception that ore would be transferred to an existing concentrator.

4.2.4 Mineral Separation Plant

The MSP consists of a feed preparation plant and a dry plant. Flotation (a small part of the circuit) and completion of heavy mineral concentration will continue to be carried out in the feed preparation plant. The dry plant will be rebuilt to modern health and safety standards. Throughput will be increased from the current nominal 165 - 175 kilo tonne (kt) to 250 – 275 kt of rutile per annum. Figure 4-1 provides a simplified process flow of the current SRL mining operations and processes.

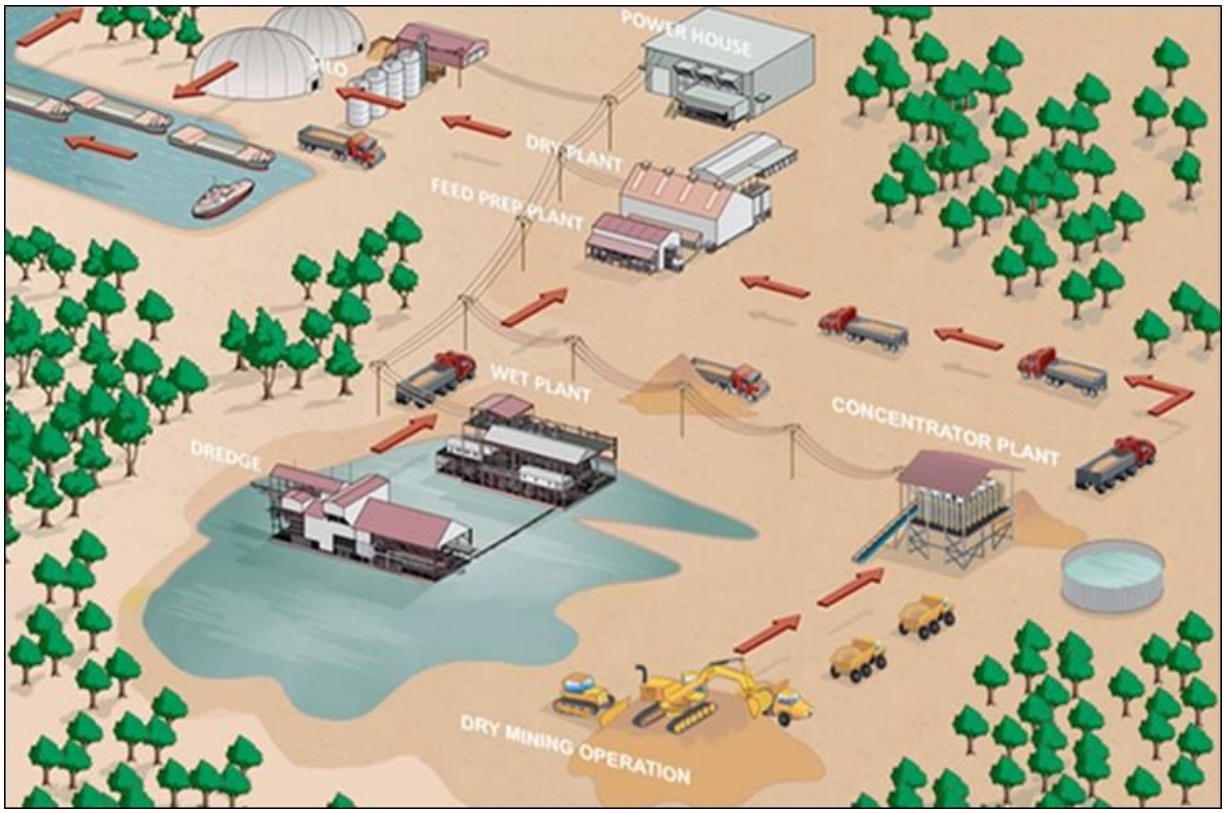


Figure 4-1 Simplified process flow of the current SR Area 1 operations and processes.

5 SR Area 1 Sources of Noise

5.1 Construction Sources of Noise

5.1.1 Current Noise-generating Construction Activities

Current noise-generating construction activities (Table 5-1) take place concurrently with, though intermittently and at a much smaller scale than operation activities. Swamped by operation noise, noise modelling and computation of current SR Area 1 noise footprints in this assessment account for existing construction activities as an integral part of the existing operation.

Table 5-1

Current SR Area 1 noise-generating construction activities

Construction Activity	Sources of Noise
Site clearing	Bulldozers, trucks
Dam construction	Excavation, bulldozers and trucks
Road construction and maintenance	Mostly graders. Other include trucks and compactors

5.1.2 Future Noise-generating Construction Activities

Future noise-generating construction activities and equipment operations are summarised in Table 5-2. These activities will not differ in nature or magnitude from current construction activities; the only variable is that they will change location over deposit areas as mining progresses. Future activities will largely be a continuation of existing activities and will also take place concurrently with operation activities.

Site clearing will not involve changes in quantities or volumes, but merely changes over time in location due to the progression or migration of mining activities. In the modelling of both current and future operations, ongoing construction activities are accounted for by considering it as an integral part of operation activities and sources.

Table 5-2

Future noise-generating construction activities following SR Area 1 changes

Construction Activity	Sources of Noise
Site clearing (see above)	Bulldozers, trucks
Road construction and maintenance	Mostly graders

5.2 Operation Sources of Noise

5.2.1 Current Noise-generating Operation Activities

Current noise-generating operation activities and equipment are summarised in Table 5-3.

Table 5-3

Current SR Area 1 noise-generating operation activities and equipment

Operation Activity	Sources of Noise
Dredging	On-board scrubbing and screening
Wet Plant operation	Mineral product processing
Ore extraction	Excavation, dozing, loading and truck movements
Primary Mineral Processing	Scrubber, screens, spirals and conveyor operations
Secondary Mineral Processing	MSP Plant operation
Tailings Management	Pumps, dozing and truck movements
Transporting of ore and product	Haul truck engine and road noises
Port handling and shipping	Material handling, barge engine noise, truck noise
Power generation	Generator and engine noise

5.2.2 Proposed Future Noise-generating Project Activities

Changes and new noise-generating activities and equipment operations to be introduced in terms of the proposed SR Area 1, are summarised in Table-5-4.

Table 5-4

Additional noise-generating operation activities to be introduced by SR Area 1 changes

Operation Activity	Sources of Noise
Ore extraction	Additional excavation, dozing, loading, truck movements
Transporting of ore and product	Additional haul truck engine and road noises
Port handling and shipping	Additional material handling, barge engine noise and truck noise

5.2.3 Operation Capacities and Equipment

SRL intends to amend their current operations by implementing a more cost-effective mining method as well as by doubling the throughput of Lanti and Gangama dry mining operations and increasing the throughput capacity of the MSP.

5.3 Noise Source Characteristics

5.3.1 Noise Source Tests Conducted during the 2017 Survey

In addition to baseline ambient noise surveys, noise tests at source were carried out to obtain noise emission (sound power) data. This was used in noise modelling to quantify primary sources of noise in current and future SR Area 1 operations. Figures 5-1 to 5-6 in the following sections show characteristic noise emission spectra for some of the primary SRL plants and operations. These are extracts of more comprehensive data derived from tests conducted within the proximity, but in the acoustic far-fields of the various sources.

Similar information used in the simulation of various other sources of noise embodied by SR Area 1 activities, such as excavators, dozers, trucks and power generators, were obtained from noise emission data archives built from numerous measurements previously conducted by Acusolv for similar equipment and activities.

5.3.2 MSP Dry Plant

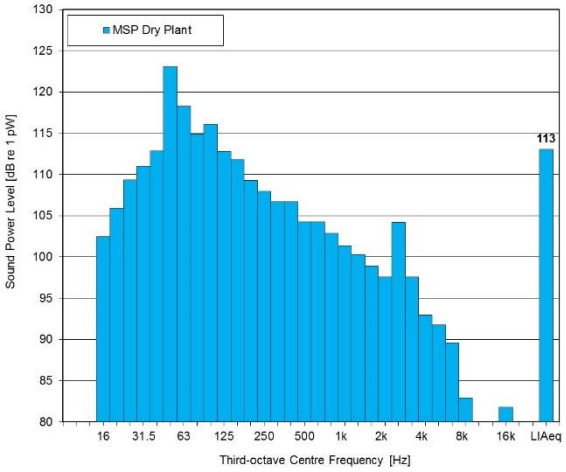
	
MSP Dry Plant	Characteristic third-octave noise emission spectrum

Figure 5-1 MSP Dry Plant noise emission characteristics

5.3.3 Lanti Wet Mining Dredge

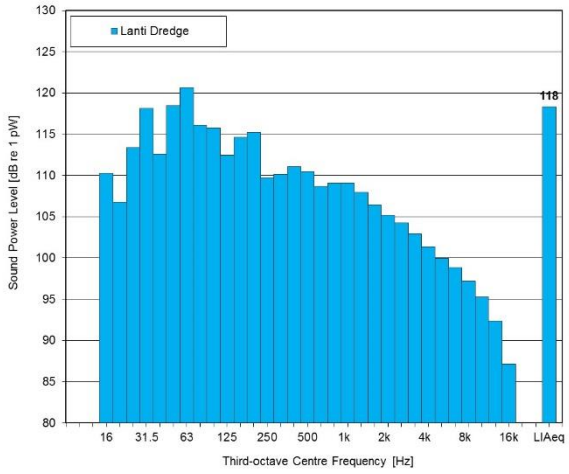
	
Lanti Dredge	Characteristic third-octave noise emission spectrum

Figure 5-2 Lanti Dredge noise emission characteristics

5.3.4 Lanti Wet Mining Concentrator

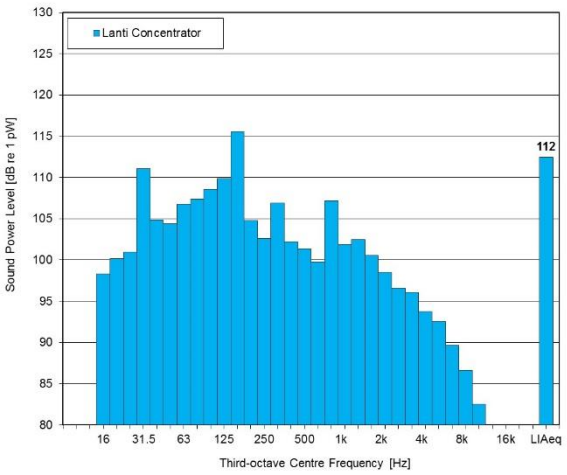
	
Lanti Floating Concentrator	Characteristic third-octave noise emission spectrum

Figure 5-3 Lanti Floating Concentrator noise emission characteristics

5.3.5 Lanti Dry Mining Feed Preparation Plant

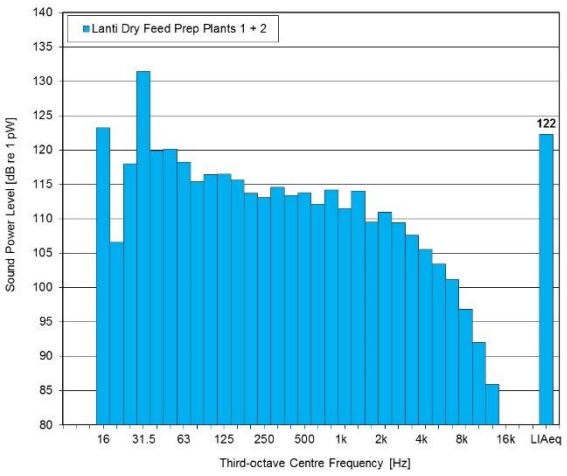
	
Lanti Feed Preparation Plant (one of two)	Characteristic third-octave noise emission spectrum

Figure 5-4 Lanti dry mining Feed Preparation Plant noise emission characteristics

5.3.6 Lanti Dry Mining Spiral Plant

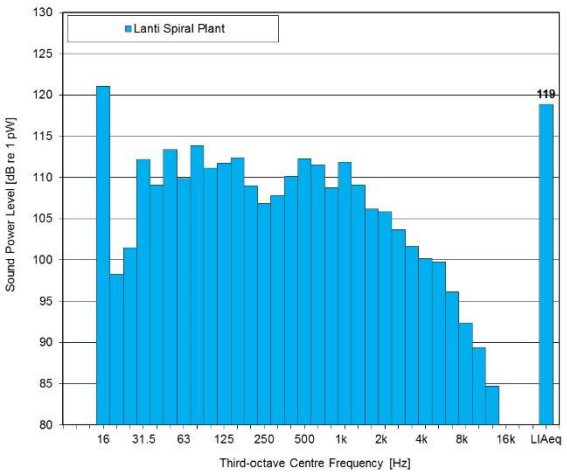
	
Lanti dry mining Spiral Plant	Characteristic third-octave noise emission spectrum

Figure 5-5 Lanti dry mining Spiral Plant noise emission characteristics

5.3.7 Gangama Dry Mining Feed Preparation Plant

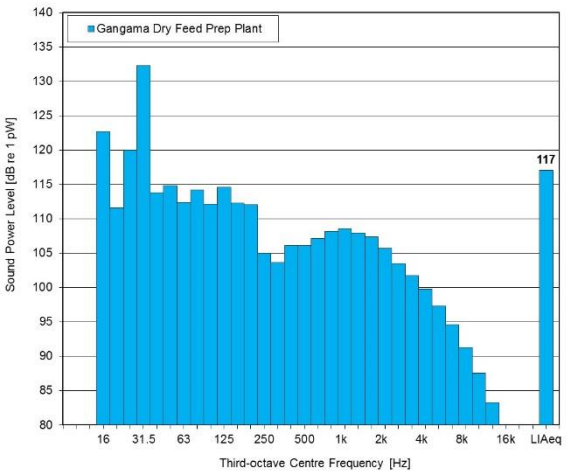
	
Gangama dry mining Feed Preparation Plant	Characteristic third-octave noise emission spectrum

Figure 5-6 Gangama dry mining Feed Preparation Plant noise emission characteristics

6 Legal Framework

6.1 Equator Principles - World Bank Group Guidelines

World Bank Group and International Finance Corporation (IFC) Performance Standards [1] in conjunction with Environmental Health and Safety Guidelines [2] advise that pollution in general be prevented by control at source. Environmental noise abatement measures are required to meet either Condition (a), or Condition (b) below.

Condition (a) Noise levels from the development at the most sensitive point of reception should not exceed the limits specified in Table 6-1;

or

Condition (b) Noise levels from the development at the most sensitive point of reception should not cause background levels to increase by more than 3 dB.

Measurements are to be taken outside the project property boundary and noise levels are to be measured on the A scale (dBA).

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

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

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

Table 6-1

World Bank limits
Noise level guidelines
Maximum outdoor noise level dBA

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

In line with international standard practice, levels in Table 6-1 are quantified as A-weighted equivalent continuous levels, denoted as L_{Aeq} with units in dBA. Such levels represent the true energy averages of the sound under consideration, regardless of impulsiveness, on-off ratios, or how the level may be fluctuating. The reference period or averaging time T is usually denoted in the level term as $L_{Aeq,T}$. Hence, daytime and night-time levels are commonly denoted as $L_{Aeq,d}$ and $L_{Aeq,n}$ respectively, or L_d and L_n, for short.

By specifying the One Hour L_{Aeq} in Table 6-1, World Bank guidelines implicitly require that measurement samples taken for the determination of average daytime or night-time levels be averaged over at least an one hour period. In addition to daytime and night-time levels specified in Table 6-1, international standards commonly also employ the so-called day-night level L_{dn}, which represents a 24-hour average of the ambient noise level, with a weighting of +10 dB applied to night-time levels. With this weighting applied, the nominal 24-hour level (the table value) turns out to be numerically equal to the daytime level. L_{dn} is usually applied in the assessment of road and air traffic noise.

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

It is for this reason that most national noise standards, such as Australian Standards (Australian Standard AS 1055.3, 1997) [8], differentiate between various district types, typically ascending in 5 dB steps from areas with negligible road traffic, or Rural Districts (the lowest noise category) with a typical daytime level of 45 dBA, to areas with high density of transportation and commerce, or Central Business Districts (CBD areas) at 65 dBA and industrial districts at 70 dBA. In all these categories, the corresponding night-time level is typically 10 dB lower than the daytime level.

7 Results and Findings – Existing Ambient Levels

7.1 Existing State of the Environment

Results of the 2017 SR Area 1 baseline survey are presented on the map in Figure 7-1. Charts of ambient levels averaged in sequences of 10 minute intervals in two surveys conducted over 24 hour periods at Mobimbi (M1), are presented in Appendix B.

Observations and ambient noise surveys confirm that ambient noise in SR Area 1 has evolved in character and level from a former rural district to what is now characteristic of a mining district interspersed with rural villages. In assessing this scenario, the following should be borne in mind:

(a) The location of a village amidst mining developments does not necessarily imply that mining noise should impact significantly or audibly on ambient levels in the village. The influence of mining related noise on any particular receptor area will depend on several factors. This includes the levels of residual and domestic activity background noises. It also depends on the noise outputs of the nearest mining activities (e.g. extraction, plants and roads) and the distances between each noise generating activity and the receptor area.

(b) Even without any influence from external mining activities, a rural village by virtue of its own activities, entails a degree of urbanisation. Urbanisation results in a gradual increase in ambient levels above that of a purely rural district. With population growth, ambient levels tend to rise towards typically 55 dBA during the day and 45 dBA at night, which are the ratings designated to residential districts in accordance with World Bank criteria (Table 6-1).

(c) When evaluating the results of the current or any future SR Area 1 survey, it should be realised that ambient noise levels, whether purely residual, or elevated by intrusive noise, are bound to fluctuate perpetually. Although specific ratings have to be assigned for purposes of assessment, the actual level in any area will never be constant. Hence, in an area rated at 45 dBA for example, the actual level will from one day to the next, characteristically vary by several decibels around this value, even during the course of a single night.

The relevance of conditions (a) and (b) in SR Area 1 are substantiated by the results of the 2017 baseline survey depicted in Figure 7-1. The map shows that ambient levels in the villages vary around 55 dBA during daytime and 45 dBA at night.

Except for the intrusion of truck noise in a few villages intersected by haul roads, daytime and night-time background noise in villages surveyed otherwise accrues predominantly from the following:

- Natural sounds (rain, wind, birds, insects and amphibia);
- Noises produced by community activities, such as minimal local traffic, trade, work, living, leisure, speech communication, children having fun and the sounds of radios and music being played;
- Local traffic, comprising predominantly of motor cycles used for private and public (taxi) transport. Although noisy, the traffic volumes of motor cycles in villages are generally very low and mostly confined to a single road running through the centre of a village.

When taking readings of noise levels during surveys, particular attention was paid to listen to the content of ambient noise and to detect the presence and prominence of audible mining activity noises, especially during night-time. In villages not intersected by haul roads, very little evidence of such audible plant or any other SR Area 1 activity noises could be detected during

the course of the 2017 survey. It is possible and likely, however, that the audibility would vary over time with natural variances in atmospheric propagation conditions (Section 3.2.4).

One location where evidence of audible SR Project noise was found, was Mogbewa village where, on the edge of the village in a clearing with line-of-sight view of the MSP, plant noise was audibly discernible during the quiet hours of the night. The effect on the measured ambient noise reading was relatively small (in the order of 2 dB), elevating the recorded night-time level to 47 dBA. Similar observations of audible MSP noise were made in Kpetema village. In this case, the effect was smaller, with a recorded night-time level of 43 dBA.

Lungi was another location where SR Project noise could be detected. In this case it was coming from the Gangama dry mining Feed Preparation Plant. Apparently, (see Figure 7-1), the night-time ambient level at 44 dBA is not significantly affected by this noise.

Prompted for comment, residents of Nyandehun noted that they had previously experienced significant night-time noise disturbance from Lanti wet mining operations at a stage when dredging took place to the south in close proximity of the village. In the meantime, the operation has moved away, and the disturbance has ceased. Neither the wet plant and dredge, nor the Lanti dry plant could be heard above community background noise during the course of the 2017 survey.

Due to higher volumes of motor cycle traffic, as well as higher levels of trade activities, average background noise levels in towns such as Moriba are considerably higher than corresponding levels in villages. In the town centre daytime levels surged to 72 dBA during the day. Daytime and night-time levels of 49 dBA and 48 dBA, respectively, mapped in Figure 7-1, were obtained from samples taken at residences located away from the busy Moriba town centre. Although elevated above typical levels in villages, this is due entirely to community activities. SR Area 1 operations have no effect on ambient noise levels in this area.

The effect of haul road noise on current ambient levels in villages intersected by haul roads constitutes a component of the current noise impact of SR Area 1 operations. Its effect on levels captured during the 2017 survey was not very noticeable, but it does, for example, reflect in the somewhat elevated levels measured in Foya Nitti. The significance of haul road noise and of noise produced by other SR Area 1 activities, such as plants, is assessed in Chapter 8.

Results of Field Survey and Noise Modelling

The results of the baseline field survey shown on the map in Figure 7-1 were used in conjunction with noise modelling to create a global map of the current ambient noise profile of SR Area 1 shown in Figure 7-2. The map shows estimated contours of existing night-time ambient noise levels. The model accounts for all primary sources of noise; i.e. excavation, plant and haul road activities. Daytime and night-time periods are as defined in terms of World Bank criteria (Table 6-1).

7.2 Baseline Reference Ambient Levels

7.2.1 Baseline Reference for Current Operations

When defining reference ambient levels for purposes of noise impact assessment, World Bank guidelines and provisions (Chapter 6) should be borne in mind. In the context of the SR Area 1 study, the background level in the assessment of the existing overall impact of current operations would be the ambient sound level in the absence of Project operations; or the levels which theoretically prevailed prior to commencement of any mining activities. Without any records of useable measurement data dating back that far and because it cannot be determined by measurement at this stage anymore, Condition (a) of World Bank guidelines, i.e. employment of a nominal table rating (Section 6.1), is applicable. Hence the assessment of

current SR Area 1 noise impacts is made by modelling and estimation of the elevation in ambient noise levels relative to 55 dBA daytime and 45 dBA night-time baseline ratings.

7.2.2 Baseline Reference for Proposed Future Operations

The best estimate and representation of existing conditions in SR Area 1 is the ambient noise profile depicted in Figure 7-2. This map was derived from the 2017 baseline survey, supplemented by noise modelling. The profile is produced by energy-based summation of the background ambient noise and noise from existing SR Area 1 operations; i.e. noise produced by excavation, plant and haul road activities. Background noise is the nominal night-time rating of 45 dBA in accordance with World Bank guidelines, which was also confirmed by the levels recorded in the 2017 baseline survey.

Total noise levels and the expected incremental impact due to new activities arising from the proposed changes in SR Area 1 operations are computed relative to the contours shown on the map (Figure 7-2).

7.3 Recommended Limits

7.3.1 24-hour Operation Noise - Maximum Impact Occurs at Night

Daytime intrusive noise levels created by distant industrial noise sources, such entailed by the SR Area 1 Project operation, are as a general rule substantially lower than the levels created by the same sources at night. The reason is that typical daytime meteorological conditions result in skyward refraction of sound propagation, in contrast with downward diffraction caused by typical night-time temperature profiles (vertical gradients). During the day, most of the noise emitted by a large source does not reach the ground, while at night, both direct sound and a portion of the energy radiated skywards are diffracted and focussed downwards to earth.

It follows that for continuous noise generated in a 24-hour operation, as is taking place in SR Area 1, maximum impact will occur at night. For all practical purposes, provided the night-time impact is limited to acceptable levels, the daytime impact would also be contained.

7.3.2 Significant Impact Criterion

According to decibel arithmetic, if intrusive SR Area 1 noise at any location rises to the point where it equals the background ambient level in that area, the total ambient level will be elevated by 3 dB, amounting to a Project noise impact of 3 dB. In line with World Bank guidelines, an impact of 3 dB or less is insignificant. It becomes notable if intrusive noise elevates the ambient level by more than 3 dB. In this assessment the magnitude of impact is rated as significant with Moderate magnitude, if it reaches a level of 5 dB or more.

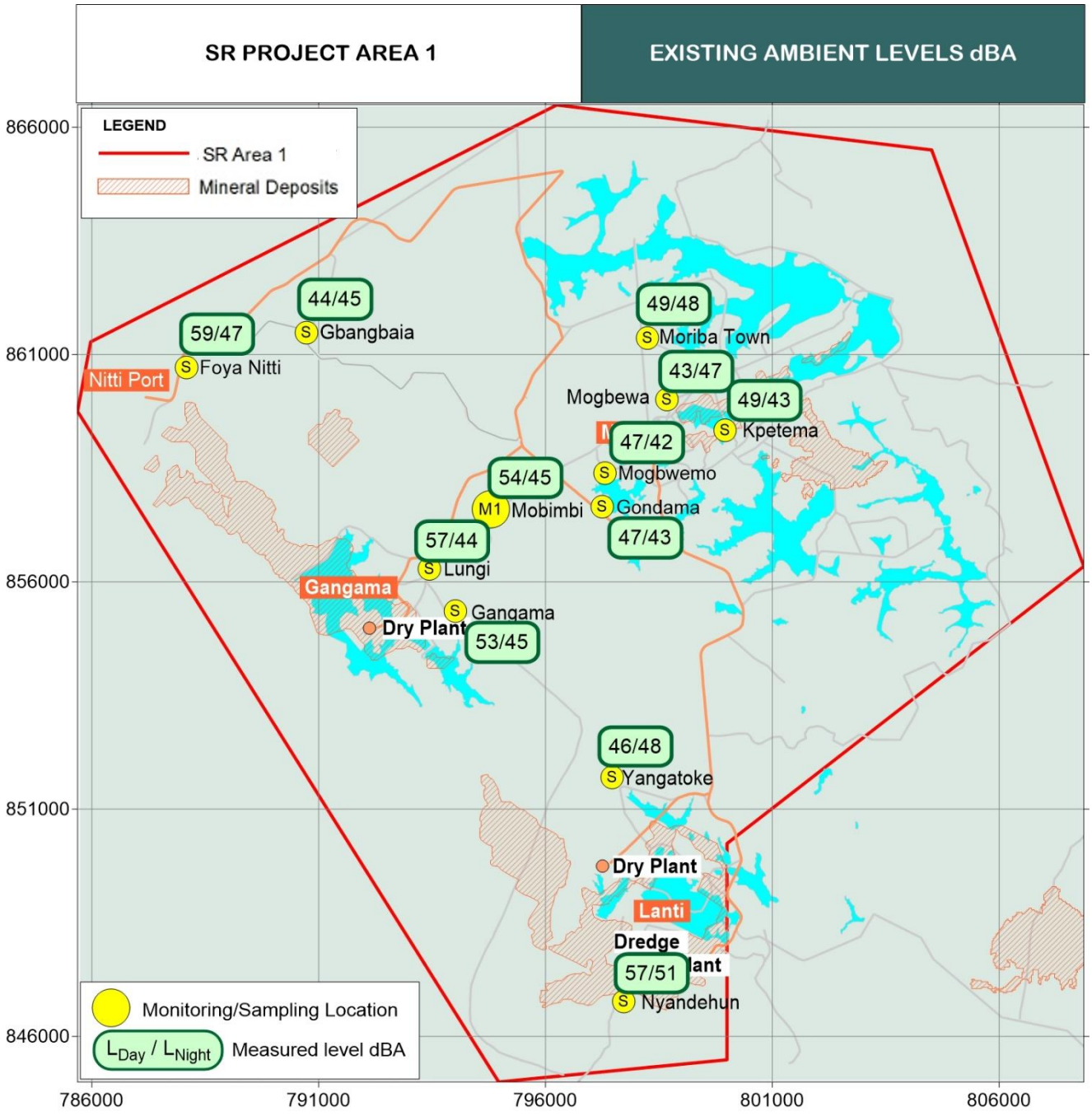


Figure 7-1

Existing ambient noise levels measured in the 2017 SR Area 1 survey

Paired values L_{Day} / L_{Night} dBA are daytime and night-time levels

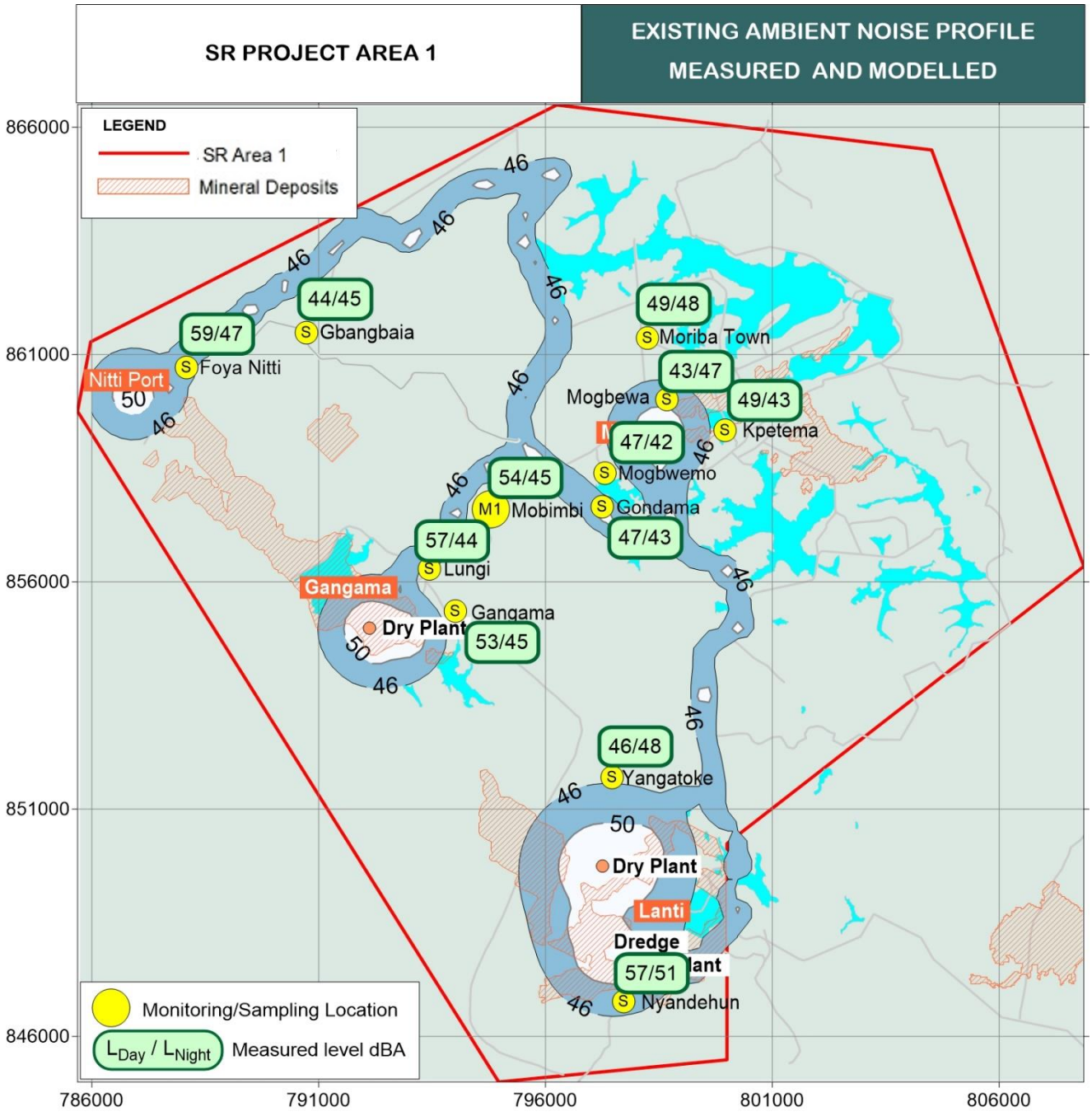


Figure 7-2

Existing ambient noise profile for SR Area 1
Day and Night levels from 24 hour surveys and samples taken in the 2017 baseline survey
Noise contours show typical night-time levels determined by modelling

8 Results and Findings – Noise Impact Assessment

8.1 Construction Phase Noise

Potential noise-generating activities during the SR Area 1 construction phase (see Section 5.1) are:

Current Construction Activities

- Vegetation clearing, soil stripping & stockpiling;
- Dam construction;
- Haul road construction: clearing of vegetation, bulldozing, loading and truck movements.

Future Noise-generating Construction Activities ensuing from Proposed Changes

- Vegetation clearing, soil stripping & stockpiling;
- Construction of access and internal roads;
- Digging of foundations and trenches.

As in current operations, future noise-generating construction activities will take place concurrently with operation activities. They will however be intermittent and of much smaller scale. The dominant audible source of noise will be diesel engines (trucks, dozers, loaders and other earth-moving equipment). Compared to operation noise, construction noise will be of similar character but of a much lower intensity. It will seldom be audible above operation and general background noise. Moreover, considering that most construction activities will occur during daytime, it is not expected to have a discernible impact on the nearest noise receptors.

8.2 Operation Phase Noise

8.2.1 Assessment Criteria and Baseline References

8.2.1.1 Significant Impact Criterion

In terms of World Bank guidelines, an impact of 3 dB or less is regarded as insignificant. In this assessment, noise impact is deemed to become significant if intrusive noise elevates the ambient level by 5 dB or more. SRK's impact assessment methodology applicable to this ESHIA, rates impact magnitude on a scale from Minor, to Moderate to Major. To this end, noise impact in decibels (dB) is rated as follows:

- Below and up to 3 dB an impact is rated as insignificant and negligible. The magnitude (severity) is rated from Zero, up to Minor.
- Above 3 dB the impact becomes notable. Between 3 dB and 5 dB the magnitude is rated from Minor, up to Moderate.
- At and above 5 dB the impact becomes significant. Between 5 dB and 10 dB the magnitude of impact is rated from Moderate, up to Major.
- At or above 10 dB the magnitude of impact is rated as Very High; likely to invoke vigorous community action.

8.2.1.2 Definition of Impacts and Baseline References

Noise impact refers to a change in ambient level caused by intrusive noise. Quantitatively, it is defined as the increase in ambient level from a predefined reference or baseline level. The reference level will vary, depending on the progressive rank (order) of impact (incremental or cumulative) under consideration. This noise study considers the existing impacts of current SR Area 1 operations, the incremental impacts of new activities expected to arise from the proposed changes in operations, as well as the cumulative impacts of current and proposed new operations. The rationale followed and the formulation of baselines for various orders of impact, were explained in Section 7.2.

Noise Impact of Current SRL Operations

The noise impact of current SR Area 1 operations is defined as the elevation in the ambient noise level as a result of current Project operations and activities; i.e. the difference in the ambient level before and after introduction of the proposed changes in operations.

As explained in Section 7.2.1, the assessment of current SR Area 1 noise impact is made by modelling and estimation of the elevation in ambient noise levels relative to 55 dBA daytime and 45 dBA night-time baseline ratings.

Incremental Impact of Activities arising from proposed changes in SR Area 1 Operations

The incremental impact of noise generated by activities to be introduced in terms of the proposed changes in SR Area 1 operations (Section 7.2.2), is the expected elevation in ambient level relative to the ambient levels prior to introduction of the proposed changes, i.e. the ambient levels which prevailed at the time of the 2017 SR Area 1 baseline survey. The baseline employed in this assessment, is the ambient noise profile depicted in Figure 7-2 (Section 7.2.2).

Cumulative impact of Current and Proposed New SRL Operations

The cumulative impact of SR Area 1 operations is defined as the expected elevation in the ambient level resulting from all those current operations that will be continued, plus all new activities expected to arise in terms of the proposed changes. As in the case of current operations, the reference levels used for computation of cumulative impacts are also taken as 55 dBA daytime and 45 dBA nominal night-time ratings in terms of World Bank guidelines (Table 6-1).

8.2.2 Assumptions and Limitations

8.2.2.1 Assumptions

Probable Worst-case Conditions

Noise impacts resulting from SR Area 1 operations were investigated for probable worst-case meteorological and operating conditions as outlined in the following.

On average, typical noise levels produced by the SR Area 1 operations are expected to be lower than the estimates derived for the worst-case conditions. “Probable worst-case” in the context of this study refers to levels that are higher than typical levels. Although less probable than typical levels, they will inevitably occur from time to time over the course of a year, sometimes possibly for several days on end. Occurrence of worst-case atmospheric propagation conditions is unpredictable; it is not simplistically related to weather conditions and not limited to any particular season of the year. In practice, it cannot be predicted when worst-case meteorological conditions will occur and for how long it will prevail, but it can be safely assumed that, occasionally, from time to time, it will occur.

Time of Day

Noise levels were computed for night-time conditions when the levels of operation noise at large distances will be elevated by atmospheric conditions.

Meteorological Conditions

Depending on the time of day or night and on meteorological conditions in particular, noise levels produced by mining and industrial sources over long distances fluctuate by a considerable margin. This is in response to variable atmospheric absorption (losses) and refraction (bending) caused by ever-changing wind and temperature gradients as a function of altitude. For purposes of acoustic modelling, meteorological conditions are divided into six categories, with Meteorological Category 1 resulting in the lowest noise levels (skyward refraction and maximum atmospheric losses) and Category 6 resulting in the highest noise levels (downward refraction and minimum atmospheric losses). Category 4 represents so-called “Neutral Conditions”. Noise contours in this assessment were computed for worst-case Category 6 conditions.

Vegetation and Season

Vegetative ground cover, i.e. savannah, shrubs and trees, does not affect the local ambient level in villages produced by natural sounds, but it does afford a degree of sound absorption adding to atmospheric absorption losses encountered in long distance propagation of noise from plants and mining operations (see Section 3.2.4). Although the incremental attenuation (dB/m) of ground cover is minimal, it does add up to significant reductions over long distances. Ground cover absorption is quantified in terms of “% Soft Ground”. The higher the % Soft Ground, the faster the decline in noise level with distance. Conversely, the lower the % Soft Ground, the longer the distance travelled by noise before dropping to a specified level and the higher the impact at a specified distance.

Except for dams, ponds and areas cleared for mining, SR Area 1 is covered with dense, lush evergreen vegetation, effectively constituting close to 100 % Soft Ground. Although the state of ground cover has little effect on the level of internal background ambient noise generated by local activities in villages, high density vegetation does act as a powerful mitigating factor by affording strong attenuation of noise propagated from distant SR Area 1 operations. Because of the evergreen nature of vegetation, this effect in SR Area 1 will be largely independent of season.

The mitigating advantage of high density vegetation does not apply to the impact of haul truck noise on the first rows of houses in villages intersected by haul roads. Impact assessment in this report accounts for this, as well as for the lack of vegetation at and around SR Area 1 excavation and plant sites.

Operation Parameters

- Computations assume that all operations are running simultaneously and continuously throughout the night.

- Excavation pit walls act as noise barriers between sources of noise operating on the pit floor and receptors in the external surroundings some distance away from the mine; the deeper the pit, the stronger the screening effect. While pits may reach deeper depths, noise contours were calculated for a pit depth of only 10 m. The mitigating advantage of pit wall noise screening obviously has no bearing on noise generated in surface operations around the pits, or noise generated by trucks on haul roads.

Adherence to Good Practice Protocols

No special design measures specifically aimed at noise reduction and control of the mine's environmental impact are presumed in the modelling and assessment of unmitigated noise impact. Adherence to the following protocols is not regarded as mitigation, but as obligatory, minimum good practice requirements.

- Vehicles and other equipment are fitted out as standard in accordance with Original Equipment Manufacturer (OEM) Manuals;

- Vehicles and earth-moving equipment are properly serviced and maintained as per manufacturer's specifications and operated within design operating limits. For example:

  - Trucks and earthmoving equipment are serviced regularly with attention given to the condition of noise controlling components such as exhaust silencers;

  - Machine and vehicle noise hoods, screens and covers are replaced after routine service. Drivers of trucks are instructed to use hooters in a disciplined manner for purposes of safety only, not for casual signalling or any other purpose. The mine strictly enforces this rule and verifies compliance.

8.2.2.2 Assumptions, Limitations and Uncertainties

The SR Area 1 noise assessment is valid for the latest Project layout and for the operation and equipment data provided by SRL. Since excavations will be roaming operations, traversing relatively large areas over time, their noise footprints will change with time. Noise contours on the noise maps serve as examples of scenarios computed for selected reserve areas near villages, assuming a spread of excavation activities and truck movements over the entire area. In reality, the noise footprints around excavation activities will for most of the time be smaller in extent than the footprints on the noise maps. Computation of future noise levels assumes that wet mining has been discontinued.

To the extent that the layouts, equipment and operating data assumed in the current assessment are valid, the noise model and predictions derived from it are considered to be reliable and accurate.

8.2.3 Presentation of Results

The unmitigated noise footprints of SR Area 1 operations are presented with the aid of noise contour maps showing 3 dB and 5 dB noise impact footprints, delineating the distances at which SR Area 1 operations elevate the ambient level by 3 dB (Minor impact; recommended planning limit) and 5 dB (Significant, Moderate impact), respectively. On maps where the 3 and/or the 5 dB impact footprints are too small in extent, or where the contours are too closely grouped to be clearly differentiated on the scale of the map, the 1 dB contour is also plotted.

A 1 dB impact is totally insignificant. An impact of 3 dB (see Section 7.3) is still acceptable in terms of World Bank criteria. Inside the 3 dB footprint, moving towards the centre of noise generating activities, the impact gradually becomes more significant. The 5 dB contour delineates the extent of what in this assessment, is considered a significant impact of Moderate magnitude[5].

8.2.4 Findings – SR Area 1 Operation Noise Impacts

8.2.4.1 Noise Impact of Current SR Area 1 Operations

Noise Map 8-1 depicts the magnitude and physical extent of the noise impacts arising from current SR Area 1 operations. As explained in Section 8.2.1, this is the increase in ambient noise level relative to conditions presumed to have prevailed prior to commencement of mining in the district. The baseline reference used in the computation of current impacts is a nominal night-time ambient level of 45 dBA for urban districts.

A significant impact of Moderate to Major magnitude occurs inside the 5 dB footprint. The zone between the 3 dB and 5 dB contours is where a significant impact of Minor to Moderate magnitude will occur. Outside the 3 dB contour (further away from the SR Area 1 activity under consideration) the noise impact in terms of World Bank criteria will be negligible. This is not to say that SR Area 1 noise will never be heard outside of the 3 dB footprint; depending on wind and atmospheric conditions, SR Area 1 noise may at times become audible at distances beyond the 3 dB range, but the impact on average will remain insignificant. Audibility by itself, does not equate to a significant impact; the latter is defined in terms of a measurable or quantifiable excess over specified acceptable limits.

As confirmed by the observations and results of field measurements conducted in the 2017 survey, the noise maps indicate that noises from current SRL plant, dredging Nitti Port and excavation operations do not have significant impacts on the nearest villages.

The same cannot be said of haul road activities. Viewed on a large scale and compared to mining and plant noise footprints, the haul road noise footprints appear to be relatively small in extent. Not so evident from this picture, however, are the consequences where haul roads run through the centres of villages, such as Foya Nitti and Lungi. Despite the mitigating effect of Soft Ground attenuation afforded by dense, evergreen vegetation in the larger area, the first rows of houses next to the haul road are exposed to direct noise from passing trucks. During each truck passing, houses next to the road are exposed to short duration peak levels (as measured on a sound level meter set to Slow response) in the order of 65 to 70 dBA. Averaged over longer time periods, the corresponding equivalent continuous levels (dBA) are numerically lower, but still amount to Major impacts of well over 5 dB. Moreover, the recurring short duration transients and the peak levels are what actually tends to interrupt sleep at night.

[5] *World Bank guidelines do not differentiate between degrees of impact, and do not provide guidelines to rate the degree or magnitude of impact as Minor, Moderate, Major, etc.*

8.2.4.2 Incremental Noise Impact arising from Proposed SR Area 1 changes

Noise Map 8-2 depicts the incremental noise impact expected to occur as a result of new activities ensuing from the proposed changes in SR Area 1 operations; i.e. the amount by which the existing impact will increase. As explained in Section 8.2.1, this is the expected elevation in ambient level relative to the ambient levels prior to introduction of the proposed changes, i.e. the ambient levels which prevailed at the time when the 2017 baseline survey was conducted.

Doubling in throughput of the Lanti and Gangama Plants, of Nitti Port and doubling in haul road trips, are expected to result in increases in the order of 40 % in the physical extent (range) of the corresponding noise footprints[6]. Noise footprints also change as a result of roaming operations, as well as the planned discontinuation of wet plant operations. The map shows that the proposed increases in throughputs and the corresponding increases in footprint ranges will not have a significant effect on the existing impacts of plants and excavations on the nearest villages.

As in the case of existing impacts, the large-scale map does not reflect wat happens at houses a few meters away from the haul road, where an incremental impact of 3 dB will occur. Although such a change on its own may appear to be small, the current baseline and existing impacts on houses next to haul roads are already high and the cumulative impacts should be considered.

8.2.4.3 Cumulative Noise Impact of Current and Future SR Area 1 Operations

Noise Map 8-3 depicts the cumulative noise impact expected to occur as a result of those current operations that will be continued, plus the proposed new activities collectively. Confirming the comments made above in respect of current and incremental impacts, the map shows that the proposed increases in throughputs and the corresponding increases in footprint ranges will not have a significant effect on the impacts of plants and excavations on the nearest villages. The cumulative impact of truck noise in villages intersected by haul roads is significant and Major in magnitude.

8.3 Decommissioning Phase Impacts

Noise in the decommissioning phase will be of a similar nature, but of a lower intensity and of shorter duration than noise in the construction phase. Decommissioning noise will not be audible at the nearest receptors and the noise impact will be negligible.

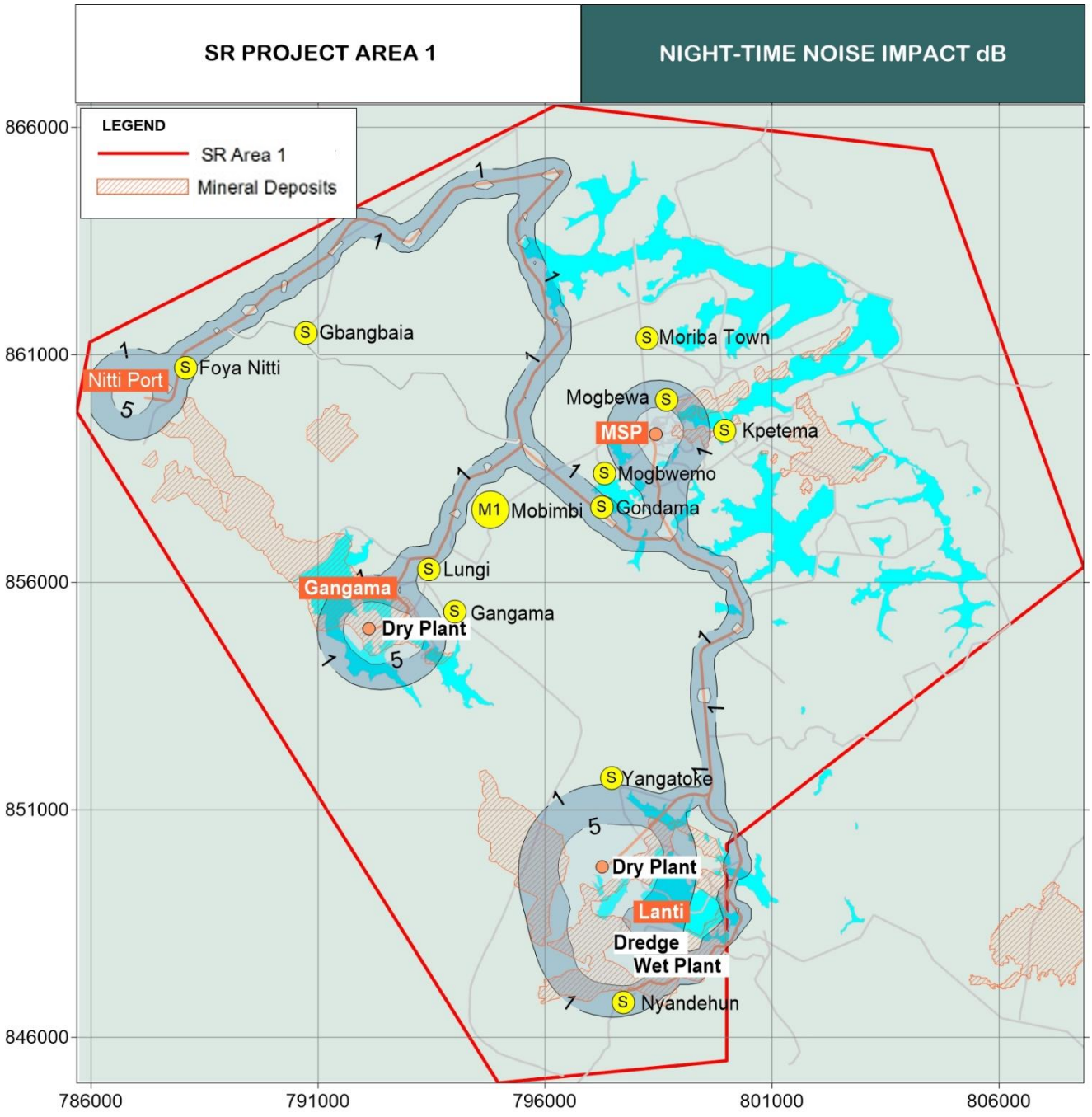
8.4 Closure Phase Impacts

No residual noise impacts will remain after decommissioning of SR Area 1 operations.

[6] *VIMETCO shares the Nitti haul road for a significant portion and will be shipping approximately 1.5 million tons compared with circa 0.3 million tons by SRL in the current year.*

Noise Maps

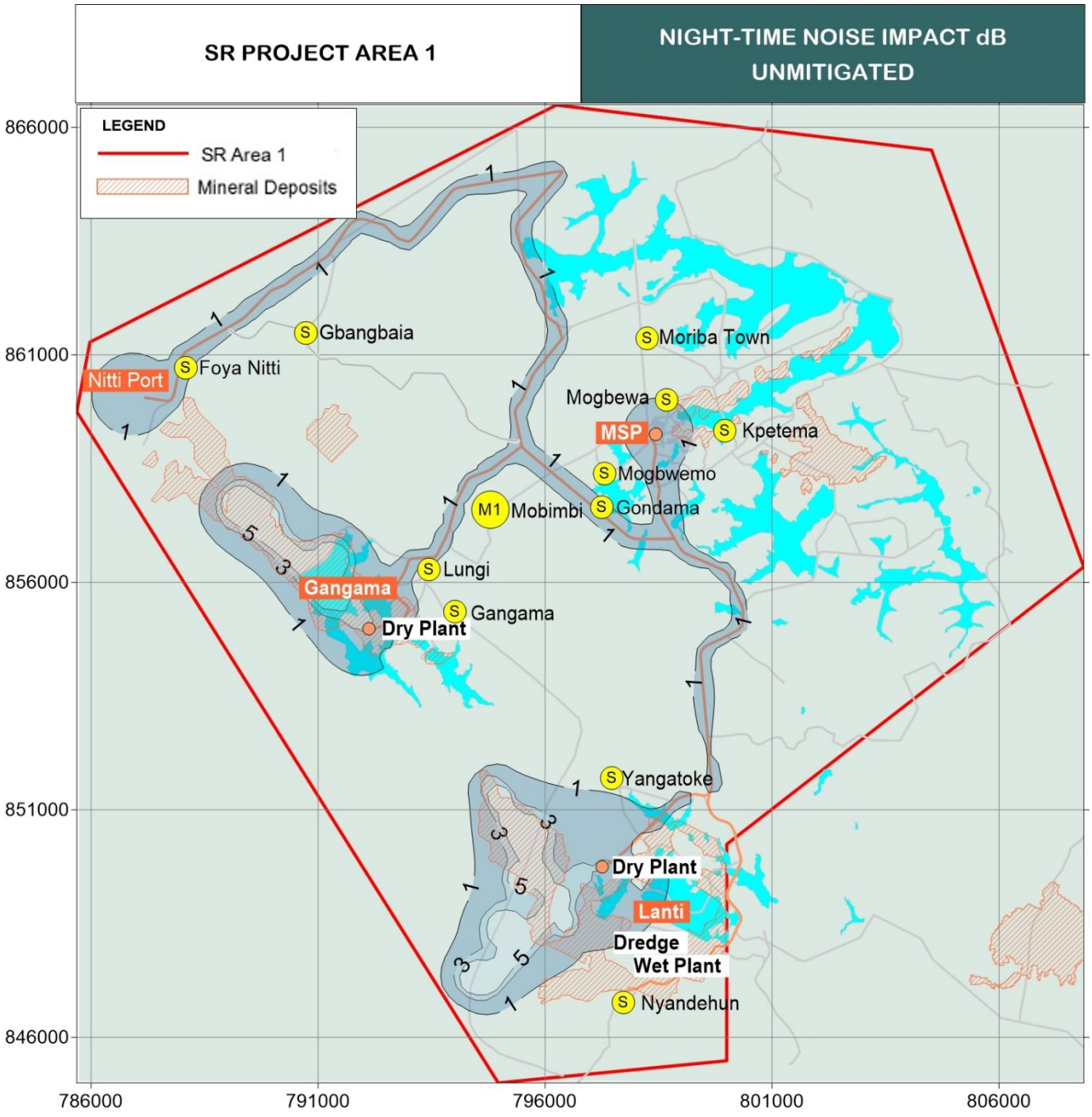
Unmitigated SR Area 1 Noise Impacts



Noise Map 8-1

Night-time impact of current SR Area 1 operations
The baseline reference is a night-time ambient level of 45 dBA

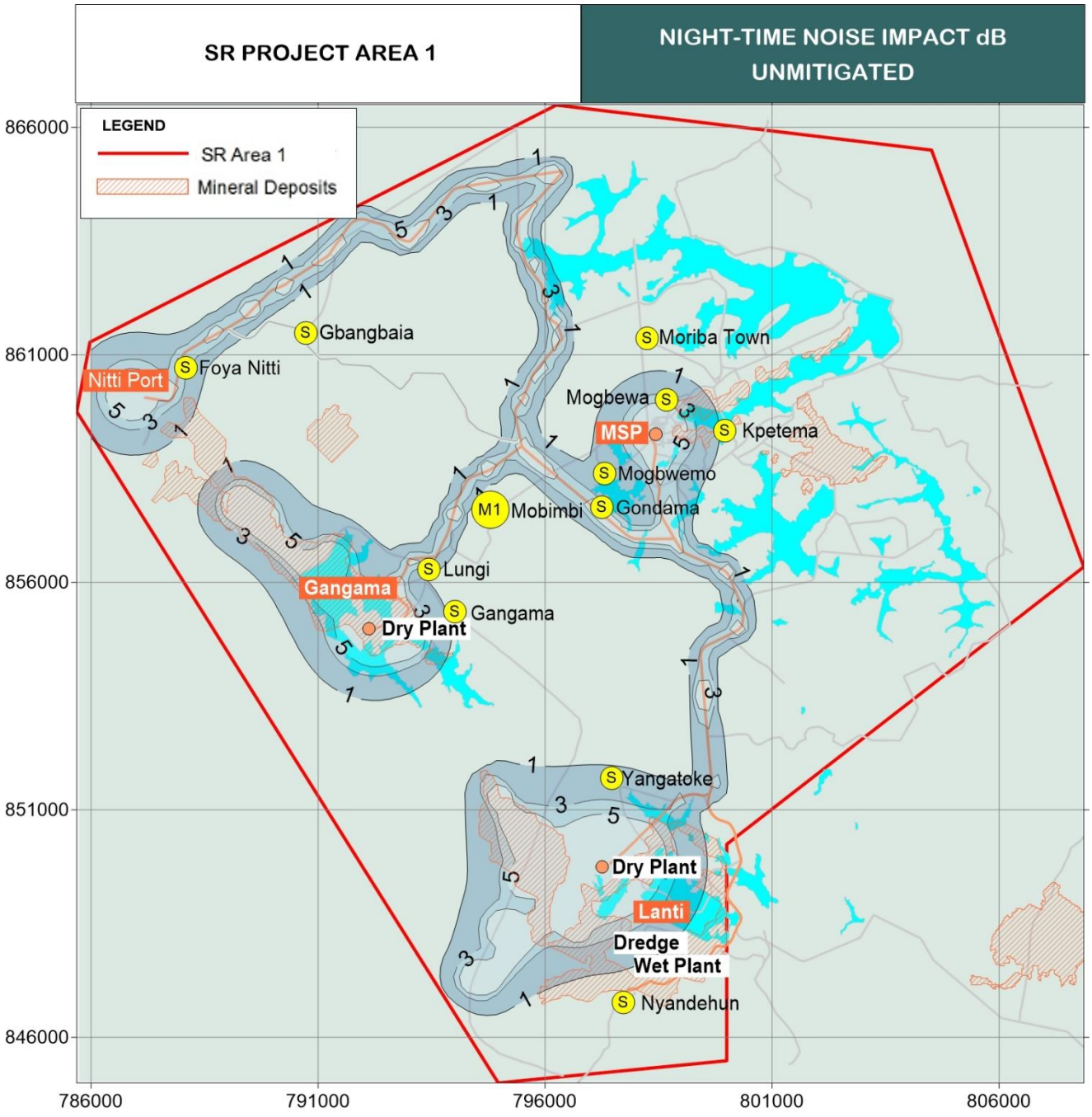
The 3 dB contour delineates a Minor impact and the 5 dB contour a Moderate impact



Noise Map 8-2

Incremental night-time impact of proposed changes in SR Area 1 operations
Unmitigated
The baseline reference is the ambient noise profile depicted in Fig 7-2

The 3 dB contour delineates a Minor impact and the 5 dB contour a Moderate impact



Noise Map 8-3

Cumulative night-time impact of current and proposed new SR Area 1 operations
Unmitigated
The baseline reference is a night-time level of 45 dBA

The 3 dB contour delineates a Minor impact and the 5 dB contour a Moderate impact

9 Mitigation

9.1 Construction Noise

Since the intensity of general construction noise will be relatively low, construction is not expected to have any noise implications in the external surroundings during day or night-time. No mitigation is required.

9.2 Operation noise

9.2.1 Primary Sources of Noise

It has been shown that noise produced by current SR Area 1 plant and excavation operations does not have significant impacts on the nearest villages and that the proposed changes in Project operations are not expected to have a significant additional impact.

Haul roads and truck noise in particular, are the primary sources of current and expected future impacts experienced in villages intersected by haul roads.

9.2.2 Mitigation

9.2.2.1 Plants and Excavations

No significant impacts are currently experienced or are expected to arise from noise produced by operation of the MSP, the Lanti and Gangama Dry Plants, or by noise produced at the excavation sites. No mitigation is required for any of these operations and activities.

Note however (see Section 8.2.2.1) that adherence to good practice protocols in respect of equipment and vehicle maintenance is not regarded as mitigation, but as obligatory.

9.2.2.2 Mitigation of Haul Road Noise

Unlike in the planning of new haul roads, mitigation of haul road noise on existing routes passing through villages such as Foya Nitti and Lungi will be difficult to accomplish without major costs and implications. In principle, not taking cost and practical feasibility into account, the options available for consideration are as follows:

Restriction of Operating Hours

Although the levels of truck noise at short distances from the road will remain constant over a 24-hour period for a given number of trucks/hour, the effective noise impact will be reduced by 10 dB if haul road operation is restricted to daytime hours 07:00 to 22:00. This is because daytime background ambient levels (See Table 6-1) are typically 10 dB higher than the corresponding night-time levels, effectively rendering the daytime the environment 10 dB less sensitive to the same level of intrusive noise.

Realignment of Haul Roads

When considering the possible realignment of haul roads, it should borne in mind that haul roads in SR Area 1 serve dual purposes in that, in addition to its primary function to facilitate product transport by the mine, it also provides conveniently located, well maintained roads used for private and public transport by the community. Relocating of a haul road to completely bypass a village may therefore not necessarily be viewed by the affected community as progress or a desirable solution.

The purpose of haul road realignment would be to create a buffer zone between the road and

the nearest houses in a village. To mitigate or avoid a significant transient noise impact in a village at night, a haul road should be located such that the normal (shortest) distance between the nearest row of houses and the road, is at least 150 m.

Relocation of Houses

Relocation of houses would be an alternative way of creating a buffer zone between a haul road and the nearest houses; subject to the same considerations applicable to road relocation outlined above.

Construction of Noise Barriers

In the planning stage of new roads, or in the case of existing roads with sufficient space available for construction, noise barriers can be very effective to screen off and mitigate the impact of road noise on adjacent areas. In the case of the villages and roads under consideration in SR Area 1, with many houses located at less than 5 m from the road, there is no space at all for the construction of any form of barrier (berm, wall or screen).

The decision whether it is viable to employ noise barriers, whether proactively on new roads, or for remedial purposes on existing routes, will depend on various considerations and rests with SRL. Notwithstanding, for future consideration, it is advised that the following broad principles and guidelines be followed in the planning, costing and construction of haul road noise barriers.

Guidelines for the construction of noise barriers and screens

The effective noise screening height of a noise berm may comprise of any or a combination of three components:

- A road cutting;
- A berm, comprising of an earthen mound or landscaping;
- A noise screen, comprising of a solid wall.

The principle of noise barrier construction is illustrated in Figure 9-1, which shows a barrier with an effective screening height relative to the road surface, comprising of a combination of all three of the above-mentioned elements. The barrier may comprise of only one or any combination of aforementioned three components, as long as the total height as specified, is achieved.

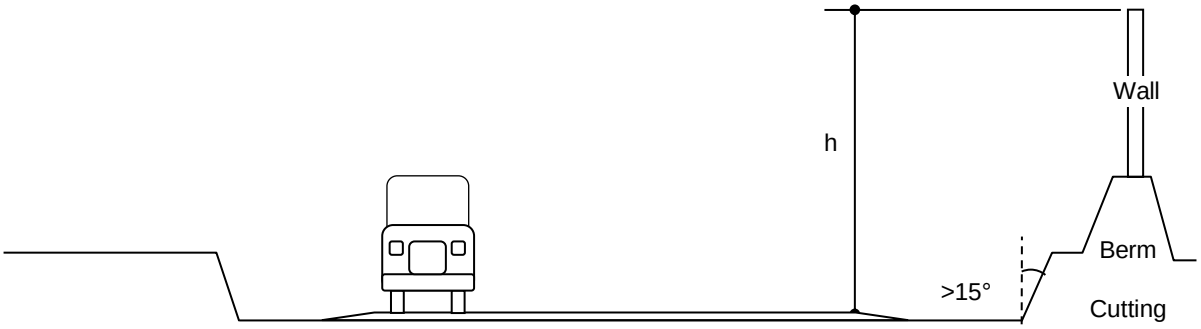


Figure 9-1 Principle of noise barrier construction

In designing and constructing noise barriers and screens, the following rules and guidelines should be observed:

- For a barrier to act as an effective noise screen, it must be high enough to at least obstruct the line-of-sight between:

  (a) A point 2.5 m (exhaust height) above any point on the road surface;

  And

  (b) The rooftop of the house to be protected against haul road noise.

- An earthen berm is the most effective and desirable construction to employ as a noise screen. The reason is that, in its natural form, the surface properties and mound shape of a berm present a slope which partly absorbs sound, whilst reflecting the remainder of the sound in a preferred direction, i.e. skywards, rather than parallel with the ground.

- Similar arguments apply to a cutting.

- Except for entrances and road junctions, the barrier must be continuous, with no openings.

- Grass or other lush ground cover constitutes acoustic soft ground providing a small additional amount of reduction, which only becomes significant over large distances. Over small distances, it has practically no advantage. For example, over a distance of 50 m, lush ground cover would at best only yield about 1.5 dB additional reduction.

Cautionary Note: *Trees do not act as a noise barrier*

It should be cautioned that the planting of trees or vegetation has practically no value in noise screening or any other scheme for noise reduction. A row of trees provides virtually no noise screening and the planting of vegetation (grass and shrubs) on a noise berm will only have a minor effect on the noise screening performance of the berm. Vegetation does provide a small degree of sound absorption adding to propagation losses, but this only becomes significant if such vegetation covers large landscapes extending over long distances between source and receiver. A single row of trees does not provide any measurable screening or reduction of noise.

9.3 Decommissioning phase

No mitigation will be required during decommissioning.

9.4 Closure phase

No mitigation will be required after decommissioning.

10 Conclusion and Rating of Noise Impacts

10.1 Conclusion

Observations made in the field survey, samples taken throughout the area and the results of the 24-hour surveys all confirm that ambient noise in SR Area 1 has evolved in character and level from a former rural district to what is now characteristic of a mining district interspersed with rural villages and roads. The results of the 2017 baseline survey show that ambient noise levels in the villages vary around 55 dBA during the day and around 45 dBA at night. In villages not intersected by haul roads, little or no evidence of audible plant or any other SR Area 1 activity noises could be detected during the course of the 2017 survey.

The study finds that noise from current SR plant, dredging and excavation operations and activities do not have a significant impact on the nearest villages. Truck noise on haul roads running through the centres of villages, such as Foya Nitti and Lungi have a significant impact on the first rows of houses next to the haul road.

The net effect of the proposed doubling in throughput of the dry mining plant operations and of a doubling in haul road trips, is an expected increase in the order of 40 % in the extent of the corresponding noise footprints. Noise footprints will also change in shape and extent as a result of roaming operations and new roads, as well as the discontinuation of wet plant operations. Predictions based on noise modelling show that the proposed increases in throughputs and the corresponding increases in footprint ranges will not have a significant effect on the impacts of plants and excavations on the nearest villages.

Doubling of haul road traffic will result in a further increase of 3 dB in the already significant current impact on houses a few meters away from the haul road.

The study concludes that although the proposed changes in SR Area 1 operations will result in an increase in noise footprint ranges, the net impact of plant and excavation operations on the nearest villages will remain insignificant. The impact of truck noise on the first rows of houses in villages intersected by haul roads will remain significant and is expected to increase by 3 dB.

Mitigation of haul road noise on existing routes passing through villages such as Foya Nitti and Lungi will be difficult to accomplish without major costs and consequences. Options of mitigating measures that should be considered, include restriction of operating hours, realignment of roads, relocation and the construction of noise barriers.

10.2 Noise Impact Ratings

The noise impacts of current and future SR Area 1 operations for the various life cycle phases are rated in Tables 10-1 and 10-2.

Table 10-1: Noise Impact in the Construction Phase

Activities	• Site clearance; • Dam construction; • Access road construction and maintenance.					
Impacts	• Noise disturbance impacts on residents of villages in SR Area 1.					
Impact Significance Rating						
Status	**Magnitude**	**Duration**	**Spatial Scale**	**Consequence**	**Probability**	**Significance**
Unmitigated	Minor -	Medium Term	Local	Low	Unlikely	Low
	Mitigation/Management Measures • No mitigation required • If complaints are received, restrict construction activities to daytime hours 06h00 to 18h00					
Mitigated	Minor -	Medium Term	Local	Low	Unlikely	Low

Table 10-2: Noise Impact of Current and Future SR Area 1 Operations

Activities	• Dredging; • Ore extraction (earth moving); • Primary mineral processing; • Secondary mineral processing; • Tailings management; • Port handling and shipping; • Waste management; • Power generation and distribution; • Water services.					
Impacts	• Noise disturbance impacts on residents of villages in SR Area 1					
Impact Significance Rating						
Status	**Magnitude**	**Duration**	**Spatial Scale**	**Consequence**	**Probability**	**Significance**
Unmitigated	Minor -	Long Term	Local	Medium	Unlikely	Low
	Mitigation/Management Measures • No mitigation required; • If complaints are received, investigate and identify activities/source of noise and options for mitigation.					
Mitigated	Minor -	Long Term	Local	Medium	Unlikely	Low

Activities	• Transport and haul road operations.					
Impacts	• Noise disturbance impacts on residents within 150 m of haul road in villages intersected by SRL haul roads.					
Impact Significance Rating						
Status	**Magnitude**	**Duration**	**Spatial Scale**	**Consequence**	**Probability**	**Significance**
Unmitigated	Major -	Long Term	Local	High	Definite	High
	Mitigation/Management Measures Mitigation options for consideration: • Restriction of operating hours to daytime period 07:00 – 22:00; • Realignment of haul roads; • Relocation of affected residents; • Construction of noise berms.					
Mitigated	Moderate -	Long Term	Local	Medium	Definite	Medium

10.3 Community Concerns

Comments from Interested and Affected Parties

Comments received from Interested and Affected Parties are summarised below

Comments, issues, suggestions raised by stakeholders	Stakeholder Name	Organisation or Village or Chiefdom	Date	Source of comment: (meeting or written)
He is concerned that noise from machinery and mining activities etc. will increase as the mine expands.	Paramount Chief Alie Badara Sheriff III	Jong	19 June 2017	Community meeting: Jong-Kabati
Since SRL has started operations, the noise levels have increased, resulting in wild animals moving away from the area. Hence, malnutrition is a major problem in the project area due to the shortage of bush meat.	Jacob Villa	Mbelleh, Imperri	16 June 2017	Community meeting: Imperri-Gbangbama
Villages around the Lanti area are disturbed by the noise from the dredge.	Simeon Amara	Chiefdom Speaker, Imperri	16 June 2017	Community meeting: Imperri-Gbangbama
There is lots of noise from the mine.	Brutus Jebboh	Gbangbama, Imperri	June 2017	Written comment (Comment form)
Use of haulage trucks and light vehicles, dredge and wet plant operations, power generator and construction activities have resulted in increased noise levels around the clock in SR Area 1. SRL is in complete violation of Mines and Minerals Act, 2009, Sect. 32 (1b) (ii). For example, the distances between the dredge, wet plant, dry plants and the villages of Nyandehun, Higima, Foinda and Gangama/Junctuela respectively. The local residents there are restless because of the constant and heavy noise always produced by those plants. No greenbelt zones are created to reduce the noise. If greenbelts are created, they will not only absorb air and water pollutants but also help in controlling noise and erosion. This is very important. On the other hand, how can that be when an effective and proper reclamation is not carried out in the area?	Thomas B M Sabbah	Moriba Town, Imperri	23 June 2017	Written comment (Email)
The noise from the dredge mining is a problem. People cannot sleep at night because of it.	Joseph Kaiyenge	Town Chief Nyandehun	20 June 2017	Social team introductory visit
Dry mining causes noise.	Augustine Songo	Moriba Town, Imperri	June 2017	Written comment (Comment form)

Response to Comments from Interested and Affected Parties

Community concerns about noise from SR Area 1 activities are valid, at least for some of the issues mentioned in the comments. Although not highlighted as a specific or major concern in the Interested and Affected Parties (I&AP) comments, the 2017 survey found that significant noise impacts are caused by truck noise where haul roads run through the centres of villages, such as Foya Nitti and Lungi. Houses next to haul roads are exposed to high levels of truck noise amounting to impacts of well over 5 dB. Such impacts caused by noise of a transient nature occurring every 30 minutes are bound to cause sleep interference at night.

Evidence of significant noise impacts from plant and mining operations, however, did not transpire during the course of the 2017 survey. In carrying out the tests and investigations, attention was paid to discern the content of ambient noise and to detect the presence and prominence of audible mining activity noises, especially during night-time. Evidence of audible SR Area 1 operation noise was found in some villages, such as Mogbewa and Lungi. Audibility in itself, however, does not equate to or imply a significant impact. Based on measurement, the impact, i.e. the excess over the background ambient level, was not excessive.

I&AP comments mention Dredge noise as a specific concern. Prompted for comment, residents of Nyandehun noted that they had previously experienced significant night-time noise disturbance from Lanti wet mining operations at a stage when dredging took place to the south in close proximity of the village. In the meantime, the operation has moved away, and the disturbance has ceased to occur. Neither the wet plant and dredge, nor the Lanti dry plant could be heard above community background noise during the course of the 2017 survey. In any event, in terms of the proposed changes in SR Area 1 operations, wet mining will be discontinued, after which the occurrence of dredging noise will stop.

Findings in respect of plant and mining noise impacts are based on what transpired during the course of the current 2017 survey. The range of the audible footprint of SR Area 1 operations is bound to vary over time with natural variances in atmospheric propagation conditions. It is possible that noise from plants or mining operations may (for example during the dry season) become clearly audible in areas where it could not be detected in the 2017 survey conducted in the presence of daily bouts of heavy showers and very wet conditions.

Community concerns raised in the social engagement survey should be followed up. A noise complaint register should be kept. In addition to routine monitoring, SRL should respond to noise complaints by investigating and taking measurements of night-time ambient levels in specific areas where disturbance by plant and mining operation noise is reported to occur. Noise should also be monitored, and the consequences investigated in villages affected by haul road noise.

11 EMP Noise Monitoring and Management

11.1 Standards and Guidelines

As depicted on Noise Maps 8-1 and 8-2, this study finds that haul road noise is currently having and in future expected to continue having a significant impact on residents of villages intersected by SR Area 1 haul roads. It is therefore imperative for mine's ESHMP to include a noise monitoring programme. Although plant and excavation operations are not expected to cause noise disturbance, this should be verified by regular checks.

Future noise monitoring procedures and assessment will be subject to the provisions of World Bank guidelines.

11.2 Monitoring Localities and Procedures

11.2.1 Selection of Noise Monitoring Localities

As a first priority, noise monitoring should be carried out in villages intersected by SRL haul roads to establish the extent of noise disturbance caused by haul roads. The focus should be on night-time conditions with monitoring conducted at locations representative of the worst affected areas.

In addition, routine noise monitoring should be conducted in the nearest villages around the MSP, the Lanti and Gangama Dry Mining Feed Preparation Plants, the excavation sites and Nitti Port.

In subsequent annual noise surveys, the monitoring plan must be revised on an on-going basis prior to and after each monitoring exercise to assess the need for changes or for the inclusion of additional monitoring locations. Revision will be based on factors such as changes in the locations of excavation, responses and complaints from residents in the area and on the results of previous monitoring exercises.

11.2.2 Operation Status and other Considerations

Revision and updating of the monitoring plan should take the following factors into account:

- **State of Progress:** The status of implementation of operation changes at the time when monitoring takes place and for which the results of the survey will be valid.

- **Operating Conditions:** Verify and document operating conditions before and after the survey. If the survey is intended to obtain data for a specific state of operation, verify that operating conditions will be in accordance with the purpose of the survey.

- **Shut-down Opportunities:** Information on background ambient noise levels and the state of the environment in the absence of SR Area 1 operation noise can at any phase in the life of the mine be of great value. It is generally not possible for a mining operation or a plant to shut down only for the purpose of noise monitoring, but opportunities do arise during scheduled maintenance shut-downs. Look out for and utilise opportunities for conducting night-time ambient surveys before, during and after shut-down.

- **Community concerns:** In selecting locations for noise monitoring, concerns raised by communities should be taken into account.

- **Worst-case impact:** Focus on areas where maximum noise impact is expected.

12 References

[1] World Bank Group International Finance Corporation, Performance Standards on Social and Environmental Sustainability (2012).

[2] World Bank Group International Finance Corporation, Environmental Health and Safety Guidelines (April 2007).

[3] International Standards Organisation, ISO 1996-1: Description, measurement and assessment of environmental noise – Part 1: Basic quantities and assessment.

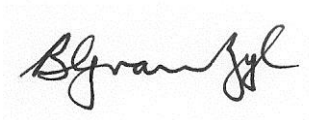
[4] International Standards Organisation, ISO 1996-2: Description, measurement and assessment of environmental noise – Part 2: Determination of environmental noise levels.

[5] Concawe Report 4/81, Manning et al (1981), The propagation of noise from petroleum and petrochemical complexes to neighbouring communities, Den Haag, May 1981.

[6] International Standards Organisation, ISO 9613-1: Attenuation of sound during propagation outdoors – Part 1: Calculation of the absorption of sound by the atmosphere.

[7] International Standards Organisation, ISO 9613-2: Attenuation of sound during propagation outdoors – Part 2: General method of calculation.

[8] Australian Standard AS 1055.3-1997. Description and measurement of environmental noise, Part 3: Acquisition of data pertinent to land use.



Ben van Zyl MSc (Eng) PhD
Acoustical Engineer

Appendix A

Noise Survey Detailed Analyses

Figure A-1 Monitoring Point M1 Mobimbi Survey 1 25-Jun-2017

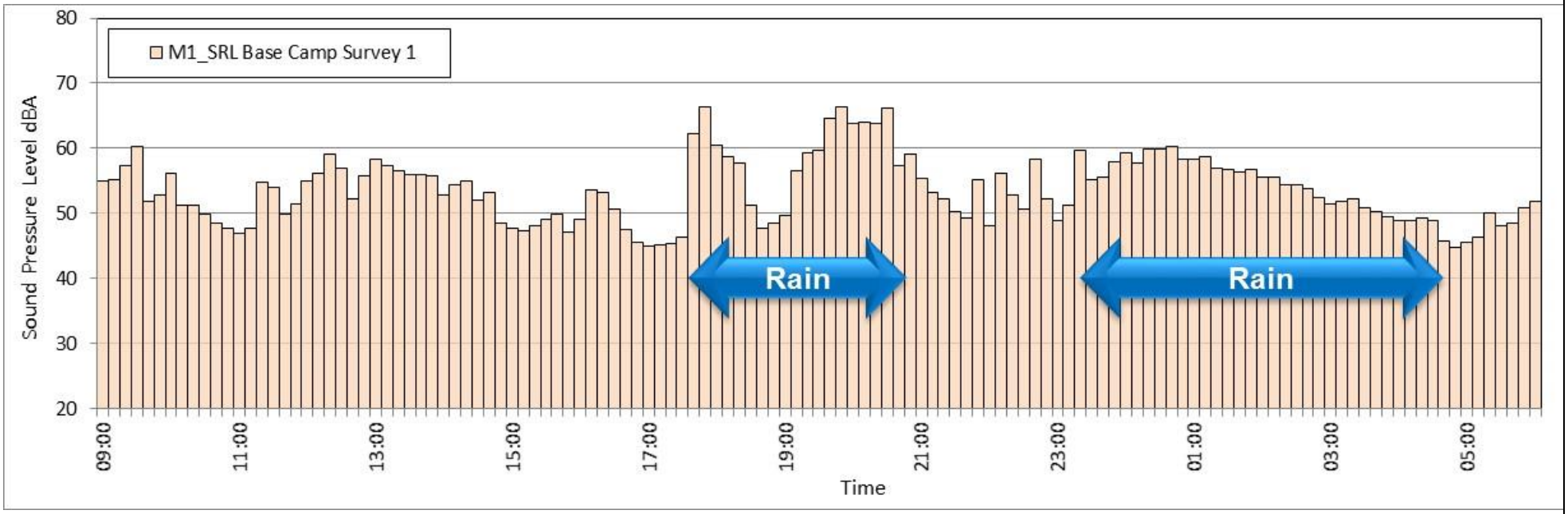
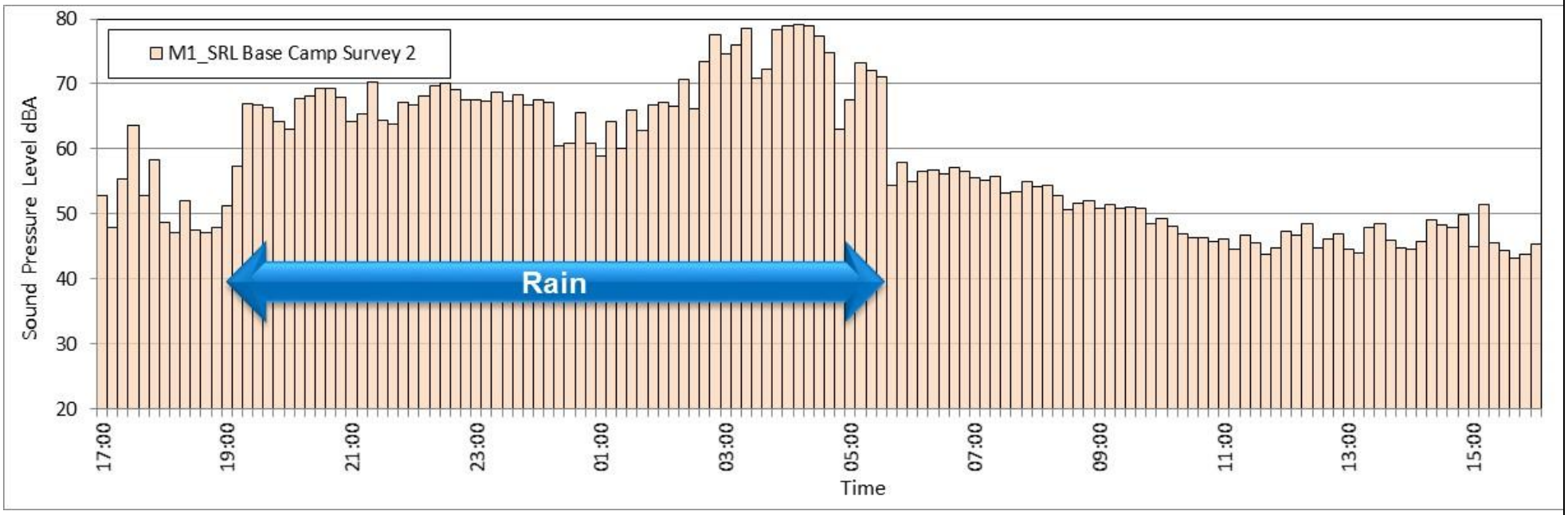


Figure A-2 Monitoring Point M1 Mobimbi Survey 2 27-Jun-2017



Appendix B

Curriculum Vitae

ABOUT THE AUTHOR

Dr B G van Zyl

Ben van Zyl is an acoustic consulting engineer in private practice based in Pretoria, South Africa. After graduating with a Batchelor's degree in electronic engineering from the University of Pretoria in 1970, he worked as Chief Research Engineer in the Acoustics Division of the CSIR. Apart from applied research and consulting in various fields of acoustics, he pioneered the principle and developed practical instrumentation for the measurement of sound intensity, a vector quantity fundamental in the formulation of sound power and various other acoustic parameters and properties. This work formed the subject of an MSc (Eng) (Cum Laude), followed by a PhD and sponsorship to develop and assess industrial applications of sound intensity in the Netherlands (Dutch Ministry of the Environment) and Denmark (Brüel & Kjaer). In 1998 he joined Denel where he worked in the SA Space Programme as Manager of Systems Integration and Environmental Test Laboratories. He also worked in the Acoustics Division of the SABS, before venturing into private practice in 1995.

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Curriculum Vitae

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

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

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

Professional registration and membership

- Southern African Acoustics Institute (Fellow) Member since 1974

Career

CSIR
1971 – 1989

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

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

Advena
1989 – 1990

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

SABS
1991 – 1994

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

Acusolv
Private Practice
Since 1995

Private practice - Sole proprietor - Acoustic consulting engineering

- EIA noise surveys; Blast noise measurement & assessment
- Acoustical engineering design & problem solving: Industrial & Machinery noise, Vehicle noise (road, rail & air)
- Theatre Acoustics, Building Acoustics
- Specialised services: Theoretical analysis & design of multi-layered acoustic panels.
- SABS Laboratory & Field testing: Building systems and materials, Equipment & machinery noise

---

Papers and publications

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

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

- Several papers published in Southern African journals.

Other

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

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Practice Profile

Sole Proprietor: Dr Ben van Zyl

Practicing since 1995.

Based in Pretoria South Africa, Ben van Zyl T/A Acusolv is an independent sole proprietor acoustic consulting engineering practice with in-house expertise and experience in various acoustic disciplines, including:

- Building acoustics: Theatre design, offices, Green Star Rating design and assessment
- Environmental noise: EIA studies; noise modelling, noise monitoring surveys
- Blast noise monitoring and assessment
- Industrial noise: Testing, problem investigation and problem solving
- Engineering design for noise reduction
- Test and evaluation
- Acoustic materials development.

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

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Examples of projects

Acoustic Field: Environmental Noise & EIA

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

Acoustic Field: Environmental Noise & EIA (Continued)

Project	For	Aspects
• Wesput open cast mine	Petmin	Noise EIA: Blasting, excavation & transport
• Gedex open cast mine	Petmin	Noise EIA: Open cast excavation & transport
• Kensington college	Centurus	Noise EIA: Sport grounds, roads
• Spandow mine shaft	Sasol Mining	Noise EIA; shaft & ventilation fan noise rural area
• Twistdraai Central Mine Shaft	Sasol Mining	Noise EIA; shaft & ventilation fan noise rural area
• Addington Hospital	Delen Oudkerk	Equipment outdoor noise impact & mitigation
• Fourways Gardens Country Club	Fourways Gardens	Music noise impact assess & design for mitigation
• Irene Ext 29	Irene Land Dev Corp	Noise EIA: New township & highway noise
• Pick 'n Pay Warehouse Meadowbrook	Pick 'n Pay	Truck movement & loading: Assessment
• Irene Sports Academy	Centurus	Impact assessment: Sports grounds & road traffic
• Jameson substation transformer	EThekwini Municipal	Transformer noise: Assess & design mitigation
• Eugene Marais Hospital	Eugene Marais Hosp	Plantroom & outdoor equipment impact & mitigate
• Klipspruit mine wash plant	Billiton & DRA	Coal wash plant infra-sound: design for mitigation
• Eagle Quarry	Mapochs Action	Quarry new application: peer review
• Blast Test Facility Somchem	Denel	Blast noise impact: assess & design for mitigation
• Virgin Active Sandton Gym	Virgin Active	Aerobics, squash & equipment: assess & mitigate
• Conveyor noise study	Bateman	Overland conveyor noise: Causes & parameters
• Zuid Afrikaans Hospital	Z A Hospital	Chiller outdoor noise: design for mitigation
• K54 Road	Tshwane	Noise Study: Future road through residential
• PWV6 Road	Gautrans	Noise Study: Future highway noise contours
• Zandfontein mine shaft	Sasol Mining	Noise Study: Mine shaft & fan noise outdoor impact
• Pierre van Ryneveld Ext 24	Van Vuuren Dev	Noise EIA: New township & highway noise
• PFG Glass new float plant	PFG Glass	Noise EIA: Future plant noise in residential area
• Sterkfontein residential development	M&T	Noise EIA: Road noise impact mitigation
• Sasol future Irenedale mine	Sasol	Noise EIA: Prediction of shaft & conveyor noise
• Ammunition demolition	SA Army	Noise EIA: Long distance noise impact assess
• Rietvlei Ridge residential development	M&T	Noise EIA: Road noise impact mitigation
• Mooiplaats / Hoekplaats	Chieftain	Noise EIA: Road noise impact mitigation
• Sasol Syferfontein conveyor	Bateman	Noise EIA: Noise complaints from farmers
• Madagascar Toliara Sands	Exxaro	Noise EIA: Future mining, plant, transport
• Rooipoort Mine	Sasol Mining	Noise EIA: Mining and conveyor noise
• Vlakplaats	Quantum	Noise EIA: Residential development
• Polokwane 2010 Soccer stadium	Africon	Noise EIA: Stadium noise in residential area
• New Clydesdale colliery	Exxaro	Noise EIA: Open cast mining, blasting and plant
• Grootfontein ventilation shaft	Sasol Mining	Noise EIA: Ventilation shaft & surface fan
• Cicada Pycna mating call study	Anglo Platinum	Cicada mating call – Mining noise interference
• Weltevreden ventilation shaft	Sasol Mining	Noise EIA: Ventilation shaft & surface fan
• Leandra North new colliery	Ingwe	Noise EIA: Mining development
• PTM new platinum mine	PTM Platinum	Noise EIA: Mining development
• Lyttleton X191	Pro-Direct	Noise EIA, new residential development
• Barking noise nuisance	Vd Merwe	Barking noise measurements, specialist report

Acoustic Field: Environmental Noise & EIA (Continued)

Project	For	Aspects
• Vanggatfontein	Exxaro/Metago	Noise EIA: Open-cast mine
• Forfar clay mining extension	Forfar/Zimbiwe	Noise EIA: Open-cast clay mining operations
• Luhfereng Doringkop development	Bigen	Noise EIA: Mixed development, train noise
• K113 Road noise study	Heartland/Bokamoso	Noise EIA: Road, mixed development
• Eland Mine	Exstrata/Metago	Noise EIA: New access road for product transport
• Sheraton Hotel	Pan Pacific Property	Noise EIA: Hotel impact on residential area
• Sishen Infrastructure Relocation	Kumba/Synergistics	Noise EIA: Railway route options evaluation
• Tharisa Mine noise monitoring	Tharisa/Metago	Baseline noise monitoring surveys
• Sishen Mine baseline monitoring	Kumba/Synergistics	Baseline noise monitoring surveys
• Sishen Mine Protea discard dump	Kumba/Synergistics	Discard dump location - Noise screening assess
• Eastplats	Barplats/Metago	Noise EIA: New vertical shaft
• Inyanda Mine noise disturbance	Exxaro	Noise surveys: Noise complaints investigation
• Irenedale Mine commissioning	Sasol Mining	Noise Monitoring: New shaft operational phase
• Honey Ridge indoor shooting range	Insul-Coustic	Design for noise reduction
• Sishen Mine expansion project 2	Kumba/Synergistics	Noise EIA: New processing plant Sishen mine
• Sishen Mine noise monitoring	Kumba Iron Ore	Peer review: Baseline survey
• Sishen Mine new 10 MTon plant	Kumba/AGES	Noise EIA: New 10 MTon processing plant
• Khameni Kalkfontein/Tamboti Mine	Khameni/Metago	Noise EIA: New opencast mine and plant
• Exxaro Kalbasfontein rail load-out	Exxaro	Noise survey: Assess impact of railway loud-out
• Sishen Mine Lylyveld development	Kumba/EGES	Noise EIA: New opencast mine & transport
• Haasfontein new opencast mine	Exxaro/Synergistics	Noise EIA: New underground mine + conveyor
• Westlake mixed development	Heartland/SEF	Noise EIA: New urban mixed development
• Marlboro road M60	Heartland/SEF	Noise EIA: New road traffic noise modelling
• Driefontein Mine	Goldfields	Noise scoping assessment and recommendations
• Bokfontein Chrome Mine	Hernic/Metago	Noise EIA: New furnaces and beneficiation plant
• Eland opencast mine extensions	Exstrata/Metago	Noise EIA: Opencast mine extensions
• Tharisa Mine EMP noise monitoring	Tharisa/Metago	EMP noise monitoring survey 1
• Dragline noise reduction Kriel	Anglo Coal	Dragline noise – Design for noise reduction
• Ivory Coast noise studies	Metago	Peer review
• Eskom Grootvlei Power Station	Insul-Coustic	Design for noise reduction - internal
• Inyanda Mine	Exxaro	Design for plant noise reduction - enviromental
• Swakkop Uranium Husab Project	Swakkop Uranium	Noise EIA: New open-cast operation & plant
• Sasol Shondoni Shaft	Sasol Mining	Noise EIA: New shaft and overland conveyor
• Vanggatfontein EMP	Keaton	EMP annual noise surveys
• Doornpoort Plaza Service Station	Petroland	Noise EIA: New service station on N4 highway
• Hawerklip railway load facility	Exxaro	Noise EIA: New railway coal loading facility
• Lusthof Coal Mine	Black Gold	Noise EIA: New open-cast coal mine
• Conveyor noise parameters	Melco	Research investigation: Conveyor noise
• Sishen discard dumps	Kumba	Noise EIA: New discard dumps at Sishen
• Impala Shafts 18 & 19	Impala Platinum	Noise EIA: New shafts & infrastructure
• Tharisa noise complaint investigation	Tharisa Minerals	Noise complaint investigation, survey & assessment
• Moonlight Iron Ore Project	Turquoise Moon	Noise EIA: New Open-cast mine and plant
• New Largo	Anglo Coal	Noise EIA: New Open-cast mine

Acoustic Field: Environmental Noise & EIA (Continued)

Project	For	Aspects
• Phola-Kusile conveyor	Anglo Coal	Noise EIA: New conveyor to Kusile Power Station
• Leeuw Colliery	Leeuw Mine	Noise EIA: Leeuw Utrecht Colliery
• Letaba Crushers	F Kruger	Noise complaint investigation, survey & assessment
• Sasol Shondoni Conveyor	Sasol	Design measures for conveyor noise reduction
• Aquarius Everest Mine	SLR Metago	Noise EIA: New shafts and infrastructure
• Anglo Kriel Beneficiation Plant	SRK	Noise EIA: New coal beneficiation plant
• Tharisa Mine expansions	SLR Metago	Noise EIA: Plant and opencast mine expansion
• NN Metals processing plant	Bokamoso	Noise EIA and certification Tshwane
• Magazynskraal Mine	SLR Metago	Noise EIA: Future opencast mine
• Anglo Kriel Block F	AACT	Noise EIA: Future underground mine & shafts
• Wallmannsthal Fluor Spar	AGES	Noise EIA: Future Opencast mine & Plant
• Thubelisha Conveyor	Sasol Mining	Conveyor noise tests & impact assessment
• SANDF Bethlehem Demolition Range	Rheinmetall	Blast noise: Tests & impact assessment
• SANDF Kroonstad Demolition Range	Rheinmetall	Blast noise: Tests & impact assessment
• Tharisa West Mine	Tharisa Minerals	Noise monitoring & assessment
• Impala Platinum Shaft 18	SLR Metago	Noise EIA: Future Shaft development
• Kitumba Copper Mine Zambia	AGES	Noise EIA: Future mine and Plant
• Anglo New Denmark Destoning Plant	SRK	Noise EIA: New Destoning Plant
• Nyumba Gold & Copper Mine (DRC)	SRK	Noise EIA: Cement Plant and Quarry
• Kamoto (DRC)	SRK	Noise EIA: Copper opencast mine and plant
• Exxaro Inyanda Mine	Exxaro	Noise complaints investigation, monitoring
• Exxaro Inyanda Mine	Exxaro	Develop Plant Noise Reduction Strategy
• Frontier Saldanha Plant	AGES	Noise EIA: Separation Plant
• Sedex REE Mine Zandkopsdrift	AGES	Noise EIA: Mine and Processing Plant
• Anglo SRL Project	Synergistics	Noise EIA: New coal mine with conveyors
• TFM DRC Acid Plant	SRK	Noise EIA Acid Plant extension DRC
• TFM DRC Haul Road	SRK	Noise EIA New Haul Roads DRC
• Anglo noise reduction programme	Anglo	Noise reduction design – Underground vehicles
• PPC Barnett DRC	SRK	Noise EIA new cement mine and plant DRC
• A-Cap Lethlakane Botswana	SLR	Noise EIA new Uranium mine Botswana
• FNB Faerie Glen	ARUP	Data Centre Plant noise study & NR design
• FNB Randburg	ARUP	Data Centre Plant noise study & NR design
• Mkhombi Cascade Mining Project	Ethical Exchange	Noise EIA screening assessment
• Eldoraigne Cricket Building	Eldoraigne School	Noise assessment and design for noise control
• Glen Douglas Mine expansion	Warburton	EIA peer review
• Southern Implants Generator	Southern Implants	Generator noise compliance certification
• Tharisa Mine Annual noise survey	Tharisa Minerals	EMPR 2015 Annual noise survey
• Eastway Centre Plants & machines	City Property	Tshwane noise compliance tests & certification
• PwC Building Waterfall Midrand	Atterbury	Construction noise monitor
• Sishen Far South Project	Kumba Iron Ore	Baseline surveys + EIA noise study
• Sishen Mine	Kumba Iron Ore	2015 Annual noise survey
• Waterfall Mall of Africa	Attacq	Power Substation noise impact assessment
• Tharisa Mine Buffelspoort	Tharisa Minerals	2016 Annual Noise Monitoring
• Bidvest Protea Coin Shooting Range	Bidvest	Shooting Range impact assessment

Acoustic Field: Environmental Noise & EIA (Continued)

Project	For	Aspects
• Eskom Substation Riverside	Lebohang	Noise EIA: New electrical substation
• Glen Douglas Mine	Afrimat	4 -Day noise survey
• Black Mountain Chrome Mine	Umnotho	Noise EIA: Chrome mine extensions
• Sishen Expansion Project	Kumba Iron Ore	Noise EIA: Mine expansion programme
• Glen Douglas Mine	Afrimat	Diagnostic surveys, noise source identification
• Glen Douglas Mine	Afrimat	Sinter Plant noise reduction design
• Eskom Substation Riverside View	Lebohang	Substation: Design for noise reduction

Acoustic Field: Industrial, machinery & equipment noise control

Project	For	Aspects
• Iscor New Compressor House	Voest Alpine	Design for noise reduction, inspection & testing
• Botswana TV centre Air-con system	Atlantic Tech	Design for control of plantroom & ducted noise
• Granulation plant	DOW Plastics	Design for noise reduction, inspection & testing
• CS2 Xantate plant	DOW Chemicals	Design for noise reduction, inspection & testing
• Alkylate chemical plant	DOW Chemicals	Design for noise reduction, inspection & testing
• SAP 4 Acid plant	Sasol Agri Palaborwa	Design for noise reduction, inspection & testing
• Motor pump enclosures	Sulzer	Design of noise hoods for large motor-pump units
• Rite Value Refrigeration Plant	Rite Value	Problem solving & design for noise reduction
• Sugar mills pump station	TSB	Design for noise reduction – noise impact control
• Pferd factory noise reduction	Pferd SA	Problem solving & design factory noise reduction
• Alusaf Bayside compressor plant	Alusaf	Problem solving & design for noise reduction
• Alusaf Bayside blower plant	Alusaf	Problem solving & design for noise reduction
• Alusaf Bayside cold rolling mill	Alusaf	Problem solving & design for noise reduction
• Sinter plant Van der Bijl Park	Iscor	Noise reduction strategy & requirements
• Blast furnace fan noise	Universal Fans	Design for fan noise reduction
• Aircraft Engine test facility	Kentron	Design for noise control – environmental impact
• Sulphuric acid plant noise	Fedmis	Design for noise reduction, inspection & testing
• Automotive assembly line	Nissan	Design & commissioning noise reduction canopies
• Scrubber fan noise	RBM	Design for noise reduction
• Ship unloader machine room noise	Algroup Alusuisse	Design for noise reduction
• Paint plant noise	Daimler Chrysler	Design for noise reduction on skid cleaner
• Mail sorting centre plantroom noise	Telkom Sapos	Design for plantroom noise control
• Scrubber system and fan noise	Aquachlor	Design for noise reduction
• Power station turbine hall noise	Eskom	Design for noise reduction
• Mill noise	PPC	Design for noise reduction in control rooms & offices
• Plantroom noise	Vodacom	Design for noise control in offices
• G6 armoured veh power plant noise	SME	Design enclosure for noise control
• Carltonville hospital boiler plant noise	Gauteng Health Dept	Design for noise reduction
• Refinery noise	Rand Refineries	Diagnostic investigation & strategy for noise reduct
• Engine test facility ultra-high noise	Sasol	Design for sound proofing engine test facility
• Chiller plant noise	Dep Public Works	Design for noise reduction
• New Chipper Plant	Sappi Tugela	Plant building design for external noise control
• Transformers	Hawker Siddeley	Acoustic test and evaluation
• Sappi Enstra Paper Mill	Sappi SA	Noise reduction programme and design
• Blast noise	Somchem	Blast noise eval; test facility design for noise control
• Mill noise	Anglo Platinum	Bond mill & sieve shaker design for noise reduction
• Vibration screen infra-sound problem	Billiton	Problem analysis and design for infra-sound control
• Bucket repair workshop	S A Coal Estates	Design enclosures & screens for noise reduction
• LoadHallDump vehicle noise reduction	Anglo-Coal	Design ventilated hood for noise reduction
• PMR Precious metal refinery	Anglo Platinum	Excessive ventilation noise: design to reduce
• Pebble bed ball impact test facility	Necsa	Noise control booth design

Acoustic Field: Industrial, machinery & equipment noise control (Continued)

Project	For	Aspects
• Sasol Syferfontein conveyor	Sasol Mining	Design: Overland conveyor noise reduction
• SARS Alberton new building	SARS	Plantroom design for noise impact control
• Sulzer large flow bend	Insul-Coustic	Design bend treatment for flow noise control
• BMW wax & seal test facility	Insul-Coustic	Test facility soundproofing design - Metal cutting
• Kumba induction panel test facility	Kumba	Test facility soundproofing
• KZN P Maritz B new legislative offices	KZN Dept P Works	Plantrooms and machinery design for noise control
• Alstom 32 MVA Power transformer	Alstom	Power transformer noise output tests
• Waterfall Boven	Nkalanga Municipal	New water purification design for noise control
• Conveyor noise study	Bateman	Overland conveyor noise: Causes & parameters
• Harvest House Pretoria	Desmo Eng	Chiller & cooler plant design noise screening meas
• Ventilation fan noise problem	Anglo Coal	Surface ventilation fan - Design noise reduction
• Sasol Syferfontein conveyor	Sasol Mining	Diagnostic analysis: noise generating mechanisms
• Sasol Syferfontein conveyor	Sasol Mining	Design: Overland conveyor noise reduction
• Metal press noise	TRW	Design enclosures & screens for noise reduction
• Stone Duster Vehicle	Bird Machines	New vehicle – Design & achieve noise spec
• Gautrain	Insul-Coustic	Construction sites – Design noise enclosures
• Exxaro High-frequency generator	Insul-Coustic	Noise enclosure and soundproofing design
• Unisa new registration building	Unisa	Plantroom noise predictions and design inputs
• Columbus Steel	Insul-Coustic	Control room and pulpit soundproofing design
• Sesane TV studios	Insul-Coustic	Plantroom and machinery noise reduction design
• Safour air plant noise reduction	Insul-Coustic	Compressor enclosure and soundproofing design
• Rustenburg Mine Laboratories	Rustenburg Mine	Design for machine noise reduction
• Anglo Research Lab Mills	Anglo American	Research lab mills, design for noise reduction
• Safripol Blowers	Safripol	Blower noise, design for noise reduction
• Eskom Grootvlei Power Station	Insul-Coustic	Design NR, boardrooms, offices
• Exxaro Inyanda Mine	Exxaro	Noise Reduction Strategy
• Locomotive air-conditioning system	Booyco	Design to meet Alstom noise spec
• Gecko Rapid Deployment Vehicle	LMT	Noise Reduction – Strategy and Design
• Sasol Wright 356 & Toro 350 LHD	Sasol Mining	LHD Vehicles design for noise reduction
• Denel B43 Chiller Plant	Denel	Chiller Plant design for noise reduction
• Eskom substation Fourways	Insul-Coustic	Design for noise reduction
• Grain Building Chiller Plant	Grain Building	Design for noise reduction
• In-Shere Shopping Centre Plant	Golden Properties	Design for noise reduction

Acoustic Field: Specialised services

Project	For	Aspects
• Specialist advisor to SABS LVA	SABS	Specialist advisor for SABS Acoustics Laboratory
• Pakistan Airforce: Missile assessment	Dep Trade & Industry	Assessments non-proliferation treaty
• Taiwan push-pull loco bullet train	Union Carriage	Driver's cabin speech intelligibility & noise control
• NRZ rail coaches	Union Carriage	Acoustic design for noise reduction
• Locomotive Class 9E Electrical Sishen	Alstom	Design upgrade - Noise reduction for hearing safety
• Theoretical analysis sound insulation	CSIR & several other	Predict/analyse acoustical properties of materials
• Overland coal conveyor noise	Sasol	Diagnostic analysis: noise generating mechanisms
• G6 artillery vehicle – Gun shot noise	LIW	Acoustic measurements & assessment hearing risk
• Locomotive Class 11E Electrical	Spoornet	Design upgrade - Noise reduction for hearing safety
• Dakota aircraft upgrade	Aerosud	Design for noise reduction
• Hearing damage gunshot noise	SA Police	Hearing conservation programme
• New drywall product development	BPB Gypsum	Theoretical analysis of acoustical properties
• Power generators outside broadcast	Ontrack	Noise reduction and field tests
• Ermelo – Richards Bay Locomotive	Transwerk	Design upgrade speech intelligibility & noise control
• Indoor artillery test facility	Somchem	Design for environmental noise control
• MUF building systems	Chipboard Industries	System acoustic evaluation and development
• Locomotive Class 34GM Diesel-elec	Spoornet	Design upgrade - Noise reduction for hearing safety
• Locomotive Class 35GM Diesel-elec	Spoornet	Design upgrade - Noise reduction for hearing safety
• Locomotive Class 36GM Diesel-elec	Spoornet	Design upgrade - Noise reduction for hearing safety
• Locomotive Class 37GM Diesel-elec	Spoornet	Design upgrade - Noise reduction for hearing safety
• Locomotive Class 34GE Diesel-elec	Spoornet	Design upgrade - Noise reduction for hearing safety
• Locomotive Class 35GE Diesel-elec	Spoornet	Design upgrade - Noise reduction for hearing safety
• Locomotive Class 36GE Diesel-elec	Spoornet	Design upgrade - Noise reduction for hearing safety
• SABS acoustic test lab validation	SABS	Assess & validate SABS test laboratory & method
• Mobile partitioning system	L J Doors	Design input to improve insulation performance
• Locomotive Class 7E Elec	Spoornet	Design upgrade - Noise reduction for hearing safety
• Weapons and ammunition demolition	SA Navy	Measurement of hi-explosives detonation noise
• Locomotive Class 19E Elec	UCW	New Coal-link locomotive – Low noise design
• Locomotive Class 15E Elec	UCW	New Sishen iron ore loco - Low noise design
• Soshalowa power car	Transnet	Train set power car sound-proofing design
• Locomotive hooters	Transnet	Study hooter audibility at level crossings
• Aluglass building systems	Aluglass	Acoustic panel theoretical evaluation