Basic Noise Impact Assessment for the proposed Letsoai Concentrated Solar Power (CSP) Project (Site 1) near Aggenys, Northern Cape Province

Project done for **WSP | Parsons Brinckerhoff, Environment & Energy, Africa**

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Report Details

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Document Record

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Glossary and Abbreviations

ASG	Atmospheric Studies Group
dB	Descriptor that is used to indicate 10 times a logarithmic ratio of quantities that have the same units, in this case sound pressure.
dBA	Descriptor that is used to indicate 10 times a logarithmic ratio of quantities that have the same units, in this case sound pressure that has been A-weighted to simulate human hearing.
CSP	Concentrated Solar Power
EHS	Environmental, Health, and Safety (IFC)
Hz	Frequency in Hertz
IEC	International Electro Technical Commission
IFC	International Finance Corporation
ISO	International Standards Organisation
L_{Aeq} (T)	The A-weighted equivalent sound pressure level, where T indicates the time over which the noise is averaged (calculated or measured) (in dBA)
L_{AIeq} (T)	The impulse corrected A-weighted equivalent sound pressure level, where T indicates the time over which the noise is averaged (calculated or measured) (in dBA)
$L_{Req,d}$	The L_{Aeq} rated for impulsive sound and tonality in accordance with SANS 10103 for the day-time period, i.e. from 06:00 to 22:00.
$L_{Req,n}$	The L_{Aeq} rated for impulsive sound and tonality in accordance with SANS 10103 for the night-time period, i.e. from 22:00 to 06:00.
$L_{R,dn}$	The L_{Aeq} rated for impulsive sound and tonality in accordance with SANS 10103 for the period of a day and night, i.e. 24 hours, and wherein the $L_{Req,n}$ has been weighted with 10dB in order to account for the additional disturbance caused by noise during the night.
L_{A90}	The A-weighted 90% statistical noise level, i.e. the noise level that is exceeded during 90% of the measurement period. It is a very useful descriptor which provides an indication of what the L_{Aeq} could have been in the absence of noisy single events and is considered representative of background noise levels (L_{A90}) (in dBA)
L_{AFmax}	The A-weighted maximum sound pressure level recorded during the measurement period
L_{AFmin}	The A-weighted minimum sound pressure level recorded during the measurement period
L_P	Sound pressure level (in dB)
L_{PA}	A-weighted sound pressure level (in dBA)
L_{PZ}	Un-weighted sound pressure level (in dB)
L_W	Sound Power Level (in dB)
MW	Power in mega Watt
NEMAQA	National Environment Management Air Quality Act
p	Pressure in Pa
p_{ref}	Reference pressure, 20 μPa
rpm	Rotational speed in revolutions per minute
SABS	South African Bureau of Standards
SANS	South African National Standards
SLM	Sound Level Meter
SoW	Scope of Work
USGS	United States Geological Survey
WHO	World Health Organisation

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1 INTRODUCTION

BioTherm Energy (Pty) Ltd proposes the development of a Concentrated Solar Power (CSP) plant near Aggenys in the Northern Cape Province. One of two sites are being considered for the Letsoai CSP plant. Airshed Planning Professionals (Pty) Ltd (Airshed) was commissioned by WSP / Parsons Brinckerhoff, Environment & Energy, Africa, to prepare a basic noise impact assessment report for Site 1. The main objective of the basic noise assessment was to determine the potential impact on the acoustic climate and receivers given activities proposed as part of the project.

1.1 Scope of Work

To meet the project objective, the following tasks were included in the Scope of Work (SoW):

1. A review of the project description and available technical project information (Section 1.2) to identify likely sources of noise.
2. A review of the legal requirements and applicable environmental noise guidelines (Section 2).
3. A study of the receiving (baseline) acoustic environment (Section 3), including:
    a. The identification of potentially sensitive receptors from available maps and satellite imagery;
    b. A study of environmental noise attenuation potential by referring to available weather records, land use and topography data sources; and
    c. Determining representative baseline noise levels through the analysis of sampled environmental noise levels obtained from a survey conducted in December 2016.
4. A basic impact assessment (Section 4), including:
    a. The development of a high-level source inventory for the project;
    b. Basic noise propagation calculations to determine environmental noise levels; and
    c. The screening of noise levels against environmental noise criteria.
5. The identification and recommendation of suitable mitigation measures and monitoring requirements (Section 5).
6. A specialist basic noise impact assessment report.

1.2 Brief Project Description

The Letsoai CSP plant will produce 150 mega Watt (MW) of electrical power. An on-site substation will connect the facility's power island to the national grid. The power island will consist of a steam turbine-generator and transformer.

The CSP technology entails the use of an array of sun tracking mirrors/lenses (heliostats) to focus sunlight onto a receiver at the top of a central concrete tower, 200 to 250 m high. The receiver consists of tubes filled with circulating Heat Transfer Fluid (HTF) which is typically an oil or molten salt. The focussed solar energy heats up the HTF which in turn is used to generate the steam that drives a turbine-generator unit. After passing through the turbine, the steam is condensed and HTF recirculated to the receiver. The HTF can be stored in thermal energy storage tanks.

The construction plan of the above includes the following:

- Establishment of an access road to the site.
- Establishment of internal access roads.
- Site preparation including the clearance of vegetation and any bulk earthworks that may be required.
- Transport of components and equipment to site including all construction material, machinery and equipment (i.e. graders, excavators, trucks, cement mixers, lifting equipment and cranes etc.).
- Establishment of 5 ha laydown and assembly area on site.

- Construction of the central tower and power island.
- Construction of substation, inverters and internal powerlines.
- Establishment of ancillary infrastructure including a water abstraction point and supply pipeline, water treatment plant and water storage facilities (including both raw water dams and evaporation ponds for wastewater from the generation process), heliostat assembly plant, storage areas, control room, office buildings, chemical storage area, security gate and buildings, and critical staff accommodation.

From the above it is clear that noise will mostly be generated during the construction phase by diesel mobile earth moving and construction equipment. The delivery of construction materials to site may increase road traffic noise. Reverse warning signals and hooters of such equipment are often heard over long distances. During the operational phase the power island is expected to be the most notable source of noise.

1.3 Site Description

The proposed CSP plant (site 1) is located approximately 15 km south of the town of Aggeneys (Figure 1). Other towns in the region include: Pofadder (65 km to the east) and Springbok (114 km to the west). The study region is sparsely populated, with the only significant population concentration being the mining town of Aggeneys. The main road is the N14.

The economic activities around Aggeneys are dominated by the Black Mountain Mine and farming of livestock. The mine is an underground base-metal operation, producing zinc, lead; copper and silver. A new opencast zinc mine, called Gamsberg Mine, is currently being developed at the top of the Inselberg.

The vegetation cover of the study area is representative of the Namaqualand Broken Veld category. Grasses are generally sparse in the Gamsberg but are more common on the surrounding plains. Heavy grazing by domestic livestock coupled with periodic drought is believed to have led to reduced vegetation cover resulting in what is regarded as "poor" veld condition. Ten "Red Data" plant species and species of rare occurrence have been recorded in the region of the Gamsberg (Scorgie, Annegarn, & Burger, 1999).

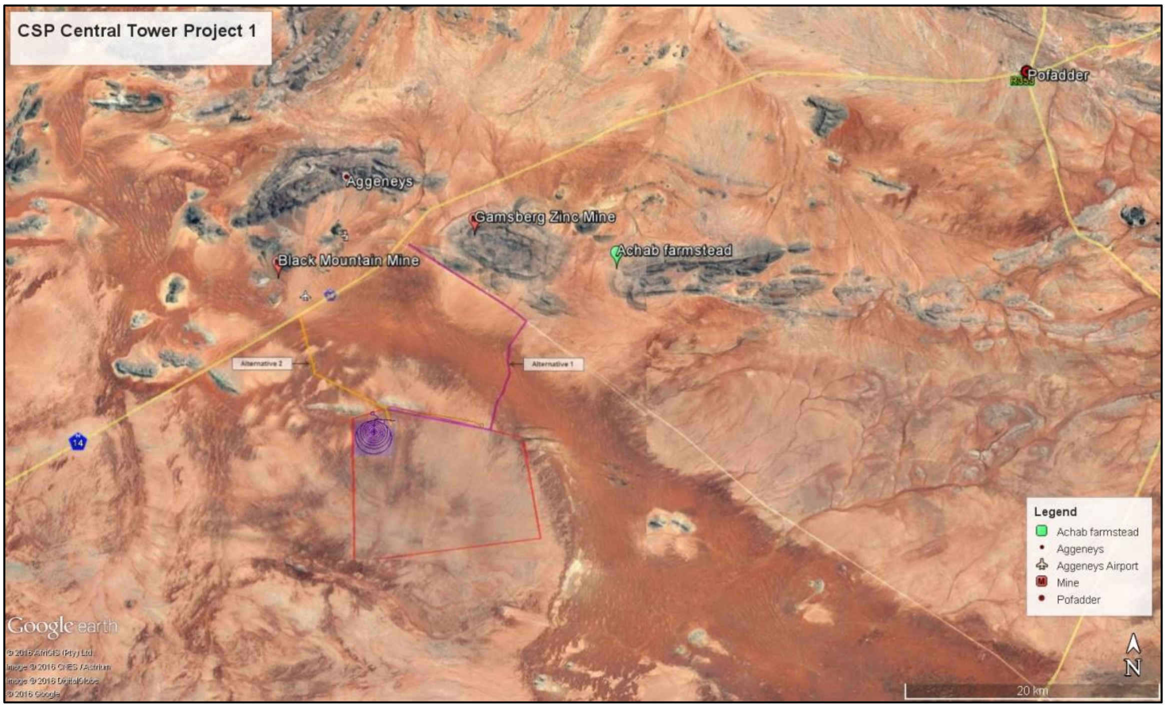


Figure 1: Location of the proposed CSP plant (site 1) near Aggeneys, in relation to other sources and receptors

1.4 Background to Environmental Noise and the Assessment Thereof

Before more details regarding the approach and methodology adopted in the assessment is given, the reader is provided with some background, definitions and conventions used in the measurement, calculation, and assessment of environmental noise.

Noise is generally defined as unwanted sound transmitted through a compressible medium such as air. Sound in turn, is defined as any pressure variation that the ear can detect. Human response to noise is complex and highly variable as it is subjective rather than objective.

Noise is reported in decibels (dB). "dB" is the descriptor that is used to indicate 10 times a logarithmic ratio of quantities that have the same units, in this case sound pressure. The relationship between sound pressure and sound pressure level is illustrated in this equation.

$$L_p = 20 \cdot \log_{10}\left(\frac{p}{p_{ref}}\right)$$

Where:

L_p is the sound pressure level in dB;
p is the actual sound pressure in Pa; and
p_{ref} is the reference sound pressure (p_{ref} in air is 20 µPa)

1.4.1 Perception of Sound

Sound has already been defined as any pressure variation that can be detected by the human ear. The number of pressure variations per second is referred to as the frequency of sound and is measured in hertz (Hz). The hearing of a young, healthy person ranges between 20 Hz and 20 000 Hz.

In terms of L_P, audible sound ranges from the threshold of hearing at 0 dB to the pain threshold of 130 dB and above. Even though an increase in sound pressure level of 6 dB represents a doubling in sound pressure, an increase of 8 to 10 dB is required before the sound subjectively appears to be significantly louder. Similarly, the smallest perceptible change is about 1 dB (Brüel & Kjær Sound & Vibration Measurement A/S, 2000).

1.4.2 Frequency Weighting

Since human hearing is not equally sensitive to all frequencies, a ‘filter’ has been developed to simulate human hearing. The ‘A-weighting’ filter simulates the human hearing characteristic, which is less sensitive to sounds at low frequencies than at high frequencies (Figure 2). “dBA” is the descriptor that is used to indicate 10 times a logarithmic ratio of quantities that have the same units (in this case sound pressure) that has been A-weighted.

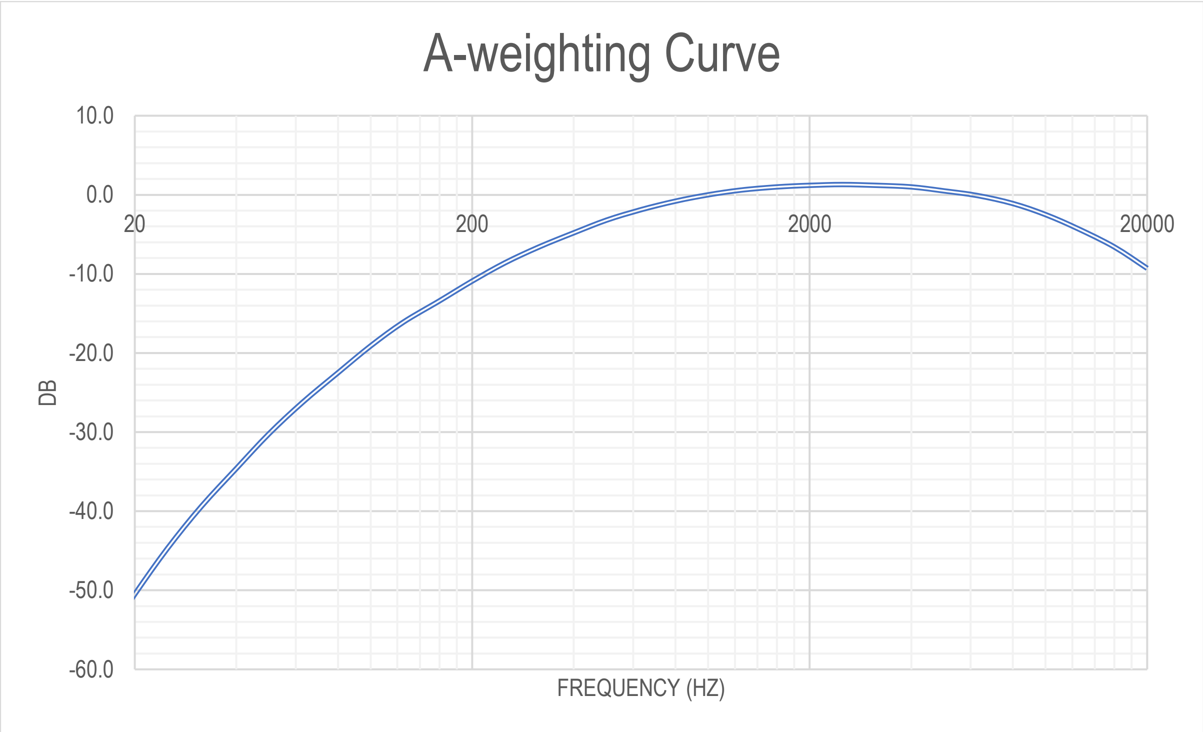


Figure 2: A-weighting curve

1.4.3 Adding Sound Pressure Levels

Since sound pressure levels are logarithmic values, the sound pressure levels as a result of two or more sources cannot just simply be added together. To obtain the combined sound pressure level of a combination of sources such as those at an industrial plant, individual sound pressure levels must be converted to their linear values and added using:

$$L_{p\_combined} = 10 \cdot \log\left(10^{\frac{L_{p1}}{10}} + 10^{\frac{L_{p2}}{10}} + 10^{\frac{L_{p3}}{10}} + \cdots 10^{\frac{L_{pi}}{10}}\right)$$

This implies that if the difference between the sound pressure levels of two sources is nil the combined sound pressure level is 3 dB more than the sound pressure level of one source alone. Similarly, if the difference between the sound pressure levels of two sources is more than 10 dB, the contribution of the quietest source can be disregarded (Brüel & Kjær Sound & Vibration Measurement A/S, 2000).

1.4.4 Environmental Noise Propagation

Many factors affect the propagation of noise from source to receiver. The most important of these are:

- The type of source and its sound power (L_W);
- The distance between the source and the receiver;
- Atmospheric conditions (wind speed and direction, temperature and temperature gradient, humidity etc.);
- Obstacles such as barriers or buildings between the source and receiver;
- Ground absorption; and
- Reflections.

To arrive at a representative result from either measurement or calculation, all these factors must be taken into account (Brüel & Kjær Sound & Vibration Measurement A/S, 2000).

1.4.5 Environmental Noise Indices

In assessing environmental noise either by measurement or calculation, reference is generally made to the following indices:

- **L_{Aeq} (T)** – The A-weighted equivalent sound pressure level, where T indicates the time over which the noise is averaged (calculated or measured). The International Finance Corporation (IFC) provides guidance with respect to L_{Aeq} (1 hour), the A-weighted equivalent sound pressure level, averaged over 1 hour.
- **L_{AIeq} (T)** – The impulse corrected A-weighted equivalent sound pressure level, where T indicates the time over which the noise is averaged (calculated or measured). In the South African Bureau of Standards' (SABS) South African National Standard (SANS) 10103 of 2008 for 'The measurement and rating of environmental noise with respect to annoyance and to speech communication' prescribes the sampling of L_{AIeq} (T).
- **$L_{Req,d}$** – The L_{Aeq} rated for impulsive sound (**L_{AIeq}**) and tonality in accordance with SANS 10103 for the day-time period, i.e. from 06:00 to 22:00.
- **$L_{Req,n}$** – The L_{Aeq} rated for impulsive sound (**L_{AIeq}**) and tonality in accordance with SANS 10103 for the night-time period, i.e. from 22:00 to 06:00.
- **$L_{R,dn}$** – The L_{Aeq} rated for impulsive sound (L_{AIeq}) and tonality in accordance with SANS 10103 for the period of a day and night, i.e. 24 hours, and wherein the $L_{Req,n}$ has been weighted with 10 dB in order to account for the additional disturbance caused by noise during the night
- **L_{A90}** – The A-weighted 90% statistical noise level, i.e. the noise level that is exceeded during 90% of the measurement period. It is a very useful descriptor which provides an indication of what the L_{Aeq} could have been in the absence of noisy single events and is considered representative of background noise levels.
- **L_{AFmax}** – The maximum A-weighted noise level measured with the fast time weighting. It's the highest level of noise that occurred during a sampling period.
- **L_{AFmin}** – The minimum A-weighted noise level measured with the fast time weighting. It's the lowest level of noise that occurred during a sampling period.

1.5 Approach and Methodology

The assessment included a study of the legal requirements pertaining to noise impacts, a study of the physical environment of the area surrounding the project and the analyses of existing noise levels in the area. The impact assessment focused on the estimation of sound power levels (L_W's) (noise 'emissions') and sound pressure levels (L_P's) (noise impacts) associated with both the construction and operational phases. The findings of the assessment components informed recommendations of management measures, including mitigation and monitoring. Individual aspects of the basic noise impact assessment methodology are discussed in more detail below.

1.5.1 Review of Assessment Criteria

In South Africa, provision is made for the regulation of noise under the National Environmental Management Air Quality Act (NEMAQA) (Act. 39 of 2004) but environmental noise limits have yet to be set. It is believed that when published, national criteria will make extensive reference to South African National Standard (SANS) 10103 of 2008 '*The measurement and rating of environmental noise with respect to annoyance and to speech communication'*. These guidelines, which are in line with those published by the International Finance Corporation (IFC) and World Health Organisation (WHO), were considered in the assessment.

1.5.2 Study of the Receiving Environment

Receivers generally include private residences, community buildings such as schools, hospitals and any publicly accessible areas outside the industrial facility or mine property. Receivers included in the assessment were identified from available maps and satellite imagery.

The ability of the environment to attenuate noise as it travels through the air was studied by considering local meteorology, land use and terrain. Black Mountain Mining owns and operates a weather station at their Gamsberg operations (currently in the construction phase). They have made the data set for July 2016 to January 2017 available for consideration in this basic assessment.

The extent of noise impacts as a result of an intruding noise depends largely on existing noise levels in an area. Higher ambient noise levels will result in less noticeable noise impacts and a smaller impact area. The opposite also holds true. Increases in noise will be more noticeable in areas with low ambient noise levels. Data from a baseline noise survey conducted in the area by Airshed from 23 December 2016 to 1 January 2017 as part of a study for Black Mountain Mining was, with their consent, studied to determine representative baseline noise levels for use in the assessment of cumulative impacts.

1.5.3 Source Inventory

The source noise inventory was informed by:

- Equipment specific sound power (L_W) predictive equations as published by Crocker (1998).
- Process specific L_W's from similar operations as contained in the database of François Malherbe Acoustic Consulting.
- Trip generation and transport information.
- Area wide general L_W for industrial and commercial areas.

1.5.4 Noise Propagation Simulations

The propagation of noise from proposed activities was simulated with the DataKustic CadnaA software. Use was made of the International Organisation for Standardization's (ISO) 9613 module for outdoor noise propagation from industrial noise sources and road traffic RSL-90 module.

ISO 9613 specifies an engineering method for calculating the attenuation of sound during propagation outdoors in order to predict the levels of environmental noise at a distance from a variety of sources. The method predicts the equivalent continuous A-weighted sound pressure level under meteorological conditions favourable to propagation from sources of known sound emission. These conditions are for downwind propagation or, equivalently, propagation under a well-developed moderate ground based temperature inversion, such as commonly occurs at night.

The method also predicts an average A-weighted sound pressure level. The average A-weighted sound pressure level encompasses levels for a wide variety of meteorological conditions. The method specified in ISO 9613 consists specifically of octave-band algorithms (with nominal midband frequencies from 63 Hz to 8 kHz) for calculating the attenuation of sound which originates from a point sound source, or an assembly of point sources. The source (or sources) may be moving or stationary. Specific terms are provided in the algorithms for the following physical effects; geometrical divergence, atmospheric absorption, ground surface effects, reflection and obstacles. A basic representation of the model is given in the equation below:

$$L_P = L_W - \sum [K_1, K_2, K_3, K_4, K_5, K_6]$$

Where;

L_P *is the sound pressure level at the receiver*
L_W *is the sound power level of the source*
K_1 *is the correction for geometrical divergence*
K_2 *is the correction for atmospheric absorption*
K_3 *is the correction for the effect of ground surface*
K_4 *is the correction for reflection from surfaces*
K_5 *is the correction for screening by obstacles*

This method is applicable in practice to a great variety of noise sources and environments. It is applicable, directly or indirectly, to most situations concerning road or rail traffic, industrial noise sources, construction activities, and many other ground-based noise sources. It does however not apply to blast waves from mining.

To apply the method of ISO 9613, several parameters need to be known with respect to the geometry of the source and of the environment, the ground surface characteristics, and the source strength in terms of octave-band sound power levels for directions relevant to the propagation.

If the dimensions of a noise source are small compared with the distance to the listener, it is called a point source. All sources were quantified as point sources or areas represented by point sources. The sound energy from a point source spreads out spherically, so that the sound pressure level is the same for all points at the same distance from the source, and decreases by 6 dB per doubling of distance. This holds true until ground and air attenuation noticeably affect the level. The impact of an intruding industrial/mining noise on the environment will therefore rarely extend over more than 5 km from the source and is therefore always considered "local" in extent.

1.5.5 Presentation of Results

Construction activities will be limited to day-time hours (06:00 to 18:00) and the results thereof are therefore presented as:

- The equivalent continuous day-time rating level ($L_{Req,d}$)as function of distance from the construction site; and
- The effective increase ambient day-time noise levels over estimated baseline $L_{Req,d}$ as a function of distance.

It is assumed that, during the operational phase, the power island will be running continuously since the HTF can store energy. Results are therefore presented as:

- $L_{Req,d}$ and $L_{Req,n}$ as function of distance from the source; and
- The effective increase ambient day and night-time noise levels over estimated baseline $L_{Req,d}$ and $L_{Req,n}$ as a function of distance.

Simulated noise levels were assessed according to guidelines published in SANS 10103 and by the IFC. To assess annoyance at nearby places of residence, reference was made to guidelines published in SANS 10103.

1.5.6 Recommendations of Management and Mitigation

The findings of the noise specialist study informed the recommendation of suitable noise management and mitigation measures.

2 Legal Requirements and Noise Level Guidelines

2.1 SANS 10103 (2008)

SANS 10103 (2008) successfully addresses the way environmental noise measurements are to be taken and assessed in South Africa, and is fully aligned with the WHO guidelines for Community Noise (WHO, 1999). The values given in Table 1 are typical rating levels that should not be exceeded outdoors in the different districts specified. Outdoor ambient noise exceeding these levels will be annoying to the community.

Table 1: Typical rating levels for outdoor noise, SANS 10103 (2008)

Type of district	Equivalent Continuous Rating Level ($L_{Req,T}$) for Outdoor Noise		
	Day/night $L_{R,dn}$[c] (dBA)	Day-time $L_{Req,d}$[a] (dBA)	Night-time $L_{Req,n}$[b] (dBA)
Rural districts	45	45	35
Suburban districts with little road traffic	50	50	40
Urban districts	55	55	45
Urban districts with one or more of the following; business premises; and main roads	60	60	50
Central business districts	65	65	55
Industrial districts	70	70	60

Notes

(a) $L_{Req,d}$ =The L_{Aeq}[1] rated for impulsive sound and tonality in accordance with SANS 10103 for the day-time period, i.e. from 06:00 to 22:00.

(b) $L_{Req,n}$ =The L_{Aeq} rated for impulsive sound and tonality in accordance with SANS 10103 for the night-time period, i.e. from 22:00 to 06:00.

(c) $L_{R,dn}$ =The L_{Aeq} rated for impulsive sound and tonality in accordance with SANS 10103 for the period of a day and night, i.e. 24 hours, and wherein the $L_{Req,n}$ has been weighted with 10dB in order to account for the additional disturbance caused by noise during the night.

SANS 10103 also provides a useful guideline for estimating community response to an increase in the general ambient noise level caused by intruding noise. The categories of community response overlap because the response of a community does not occur as a stepwise function, but rather as a gradual change. If Δ is the increase in noise level, the following criteria are of relevance:

- "$\Delta \leq 0$ dB: There will be no community reaction;
- 5 dB < $\Delta \leq$ 15 dB: There will be a 'medium' reaction with 'widespread complaints'. Δ = 10 dB is subjectively perceived as a doubling in the loudness of the noise;
- 10 dB < $\Delta \leq$ 20 dB: There will be a 'strong' reaction with 'threats of community action'; and
- 15 dB < Δ: There will be a 'very strong' reaction with 'vigorous community action'.

[1] $L_{Aeq,\ T}$ is the A-weighted equivalent sound pressure level, where T indicates the time over which the noise is averaged (calculated or measured).

2.2 IFC Guidelines on Environmental Noise

The IFC General Environmental Health and Safety Guidelines on noise address impacts of noise beyond the property boundary of the facility under consideration and provides noise level guidelines.

The IFC states that noise impacts **should not exceed the levels presented in Table 2**, or result in a maximum **increase above background levels of 3 dBA** at the nearest receptor location off-site (IFC, 2007). For a person with average hearing acuity an increase of less than 3 dBA in the general ambient noise level is not detectable. Δ = 3 dBA is, therefore, a useful significance indicator for a noise impact.

It is further important to note that the IFC noise level guidelines for residential, institutional, and educational receptors correspond with the SANS 10103 guidelines for urban districts.

Table 2: IFC noise level guidelines

Area	One Hour L_{Aeq} (dBA) 07:00 to 22:00	One Hour L_{Aeq} (dBA) 22:00 to 07:00
Industrial receptors	70	70
Residential, institutional, and educational receptors	55	45

2.3 Criteria Applied in this Assessment

Reference is made to the IFC guideline for residential, institutional, and educational receptors (55 dBA during the day) since it is -

(a) applicable to nearby receivers which include farmsteads; and
(b) in-line with SANS 10103 guidelines for urban districts.

IFC's 3 dBA increase criterion is used to determine the potential for noise impact.

3 DESCRIPTION OF THE RECEIVING ACOUSTIC ENVIRONMENT

This chapter provides details of the receiving acoustic environment which is described in terms of:

- Local receivers;
- The local environmental noise propagation and attenuation potential; and
- Sampled baseline or pre-development noise levels.

3.1 Noise Receivers

Noise receivers generally include places of residence and areas where members of the public may be affected by noise generated by industrial/mining activities. No farmsteads or residences could however be identified within a 5 km radius of the CSP plant (site 1).

3.2 Environmental Noise Propagation and Attenuation potential

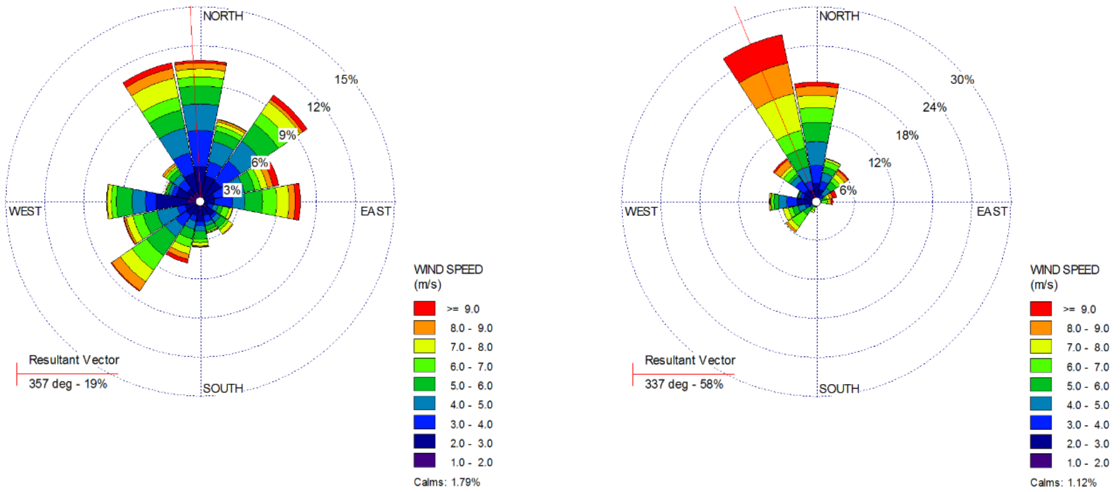
3.2.1 Atmospheric Absorption and Meteorology

Atmospheric absorption and meteorological conditions have already been mentioned with regards to their role in the propagation on noise from a source to receiver (Section 1.4.4). The main meteorological parameters affecting the propagation of noise include wind speed, wind direction, temperature, and relative humidity. These along with other parameters such as relative humidity, air pressure, solar radiation and cloud cover affect the stability of the atmosphere and the ability of the atmosphere to absorb sound energy. Reference is made to data recorded by Black Mountain Mining at their Gamsberg mine (15 km to 20 km north-east of the CSP site 1) for the period June 2016 to January 2017.

Wind speed increases with altitude. This results in the 'bending' of the path of sound to 'focus' it on the downwind side and creating a 'shadow' on the upwind side of the source. Depending on the wind speed, the downwind level may increase by a few dB but the upwind level can drop by more than 20 dB (Brüel & Kjær Sound & Vibration Measurement A/S, 2000). It should be noted that at wind speeds of more than 5 m/s ambient noise levels are mostly dominated by wind generated noise.

The diurnal wind field is presented in Figure 3. Wind roses represent wind frequencies for the 16 cardinal wind directions. Frequencies are indicated by the length of the shaft when compared to the circles drawn to represent a frequency of occurrence. Wind speed classes are assigned to illustrate the frequencies with high and low winds occurring for each wind vector. The frequencies of calms, defined as periods for which wind speeds are below 1m/s, are also indicated. On average, noise impacts are expected to be most notable to the south-southeast of the project area.

Temperature gradients in the atmosphere create effects that are uniform in all directions from a source. On a sunny day with no wind, temperature decreases with altitude and creates a 'shadowing' effect for sounds. On a clear night, temperatures may increase with altitude thereby 'focusing' sound on the ground surface. Noise impacts are therefore generally more notable during the night. During the day, an average temperature of 20.9°C and a humidity of 32% were recorded. During the night the average temperature was 16.7 °C and humidity 45%.



(a) Day-time wind field (06:00 to 22:00) **(b) Night-time wind field (22:00 to 06:00)**

Figure 3: Wind roses (Black Mountain Mining's Gamsberg data, July 2016 to January 2017)

3.2.2 Terrain, Ground Absorption, and Reflection

Noise reduction caused by a barrier (i.e. natural terrain, installed acoustic barrier, building) feature depends on two factors namely the path difference of the sound waves as it travels over the barrier compared with direct transmission to the receiver and the frequency content of the noise (Brüel & Kjær Sound & Vibration Measurement A/S, 2000). Ridges to the north of the CSP site 1 may act as acoustic barriers.

Sound reflected by the ground interferes with the directly propagated sound. The effect of the ground is different for acoustically hard (e.g., concrete or water), soft (e.g., grass, trees, or vegetation) and mixed surfaces. Ground attenuation is often calculated in frequency bands to consider the frequency content of the noise source and the type of ground between the source and the receiver (Brüel & Kjær Sound & Vibration Measurement A/S, 2000). Based on observations, ground cover was found to be acoustically hard (not conducive to noise attenuation).

3.3 Sampled Baseline and Representative Pre-Development Noise Levels

Airshed conducted an unattended baseline noise survey for Black Mountain Mining on the farm Achab, approximately 23 km north-west of the project area, from 21 December 2016 to 1 January 2017. The survey methodology, which closely followed guidance provided by the IFC General EHS Guidelines (IFC, 2007) and SANS 10103 (2008), is summarised below:

- The survey was designed by a trained specialist. Equipment was installed by a local landowner.
- Sampling was carried out using a Type 1 sound level meter (SLM) that meets all appropriate International Electrotechnical Commission (IEC) standards and is subject to annual calibration by an accredited laboratory. Equipment details are included in Table 3.
- The acoustic sensitivity of SLM was tested with a portable acoustic calibrator before and after the 11 day continuous sampling campaign.
- One unattended sample, 286 hours in duration, representative and sufficient for statistical analysis was taken with the use of the portable SLM capable of logging data continuously over the time period.
- As generally recommended, L_{AIeq} (T), L_{Aeq} (T); L_{AFmax}; L_{AFmin}; L_{90} and 3rd octave frequency spectra were recoded.
- The SLM was located approximately 1.5 m above the ground and 10 m to reflecting surfaces.

- The land-owner kept a record of farm activities and weather conditions on some days during the measurements period.

Table 3: SLM details

Equipment	Serial Number	Purpose	Last Calibration Date
SVANTEK SV977 Class 1 SLM	S/N 36183	Unattended continuous measurement.	26 January 2016
SVANTEK 7052E ½" Pre-polarized microphone.	S/N 56665	Unattended continuous measurement	26 January 2016
SVANTEK SV33 Class 1 Acoustic Calibrator	S/N 57649	Testing of the acoustic sensitivity before and after measurement.	14 June 2016

A summary of broadband results for the full measurement period is provided in Table 4. Logged L_{Aeq} (1s) and statistics of logged L_{Aeq} (1s) are graphically presented in Figure 4 and Figure 5 respectively. 3rd octave frequency spectra are presented in Figure 6.

An L_{Aeq} of 42.1 dBA was recorded between 21-Dec-16 and 1-Jan-17. As per the definitions of SANS 10103, overall noise levels are similar those typically found in rural areas (35 dBA to 45 dBA). The small differences between day and night-time noise levels are indicative of the area's rural nature. It is typical of areas away from communities and infrastructure.

90% of all logged values were above 20.7 dBA (L_{A90}) which is at the lower range of the SLM's range. The large difference between recorded L_{Aeq} and L_{A90} generally indicates the frequent occurrence of noisy incidents (refer to peaks in Figure 4). During the specialist's time, on-site, it was observed that wind generated noise contributed notably to ambient levels. From the record kept by the landowner on certain days during the measurement, other such incidents may include;

- the arrival and departure of private vehicles;
- farm activities (animals, vehicles, implements);
- birds and insects; and
- air conditioning units during their start-up, operational or shutdown cycles.

3rd octave frequency spectra indicate the presence of tones at 6.3 kHz (Figure 6). The source of acoustic energy within the 6.3 kHz frequency band could not be determined. It was however found that peaks at 6.3 kHz occurred daily but only during day-time hours. Without the contribution of the acoustic energy contained in the peaks at 6.3 kHz, the overall L_{Aeq} reduces from 42.1 dBA to approximately 41.7 dBA. The difference is considered immaterial.

Table 4: Summary of logged broadband results

Period	21-Dec-16 to 1-Jan-17		
	Overall	**Day-time**	**Night-time**
$L_{Aeq\ (T)}$	42.1	41.8	42.7
L_{A90}	20.7	20.4	28.4
L_{AFmin}	15.5		
L_{AFmax}	81.1		

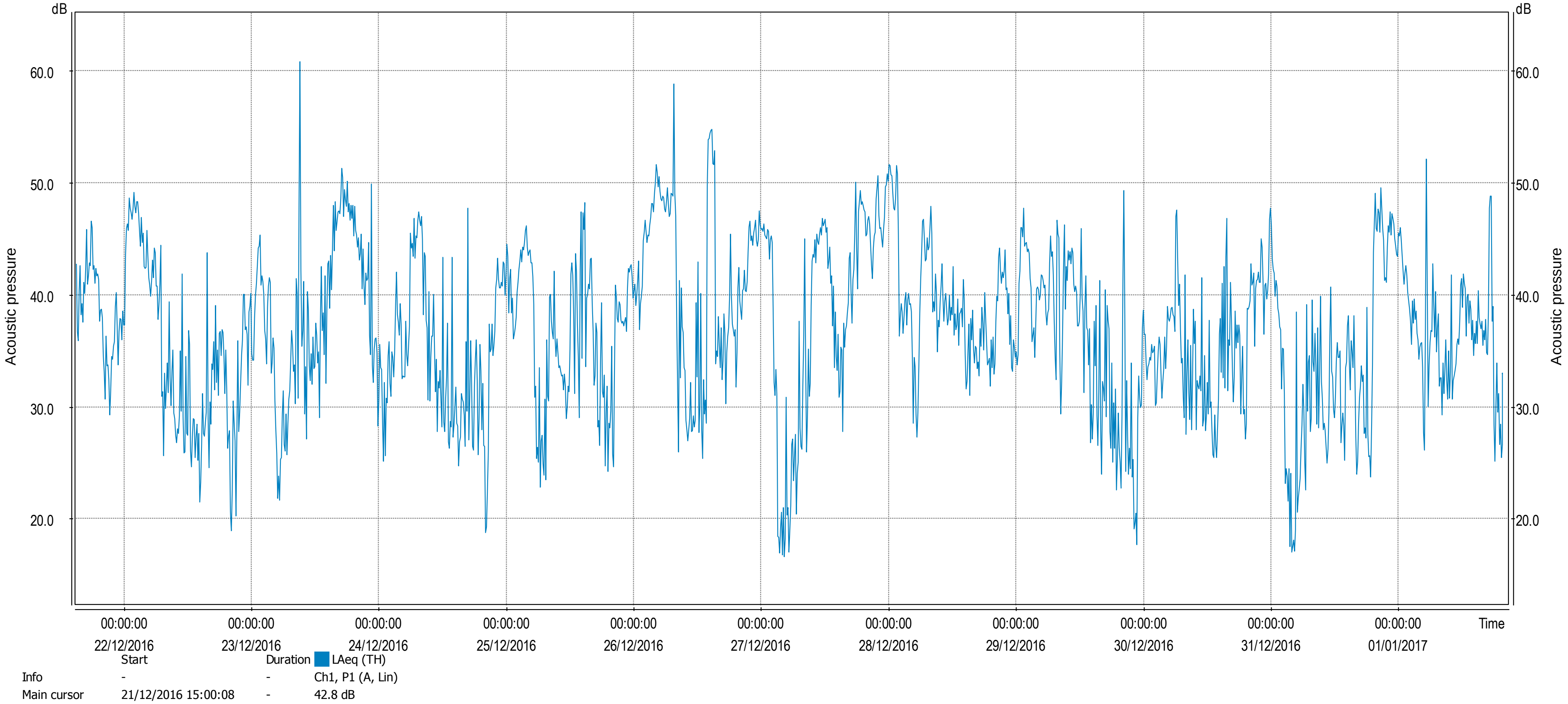


Figure 4: Logger data, L_{Aeq} (1 sec), 21-Dec-16 to 1-Jan-17

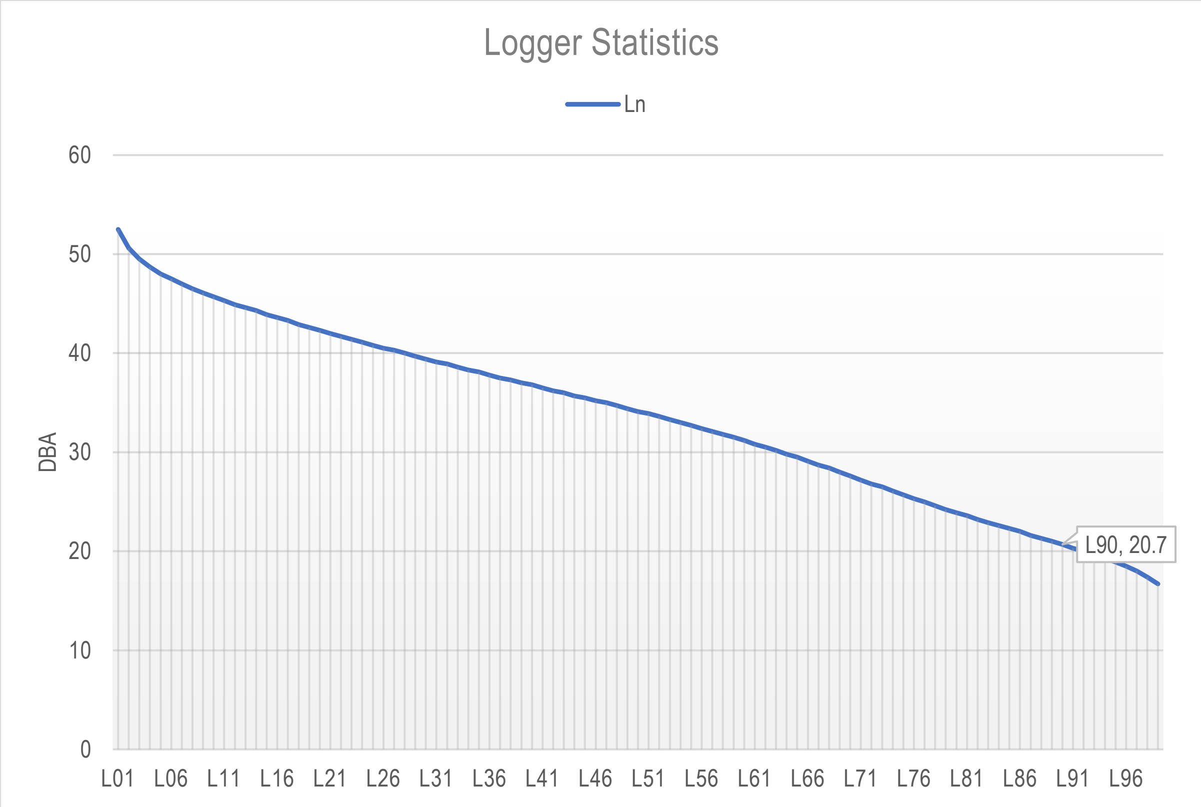


Figure 5: Logger statistics L_{Aeq}, 21-Dec-16 to 1-Jan-17, L_{A90} 20.7 dBA

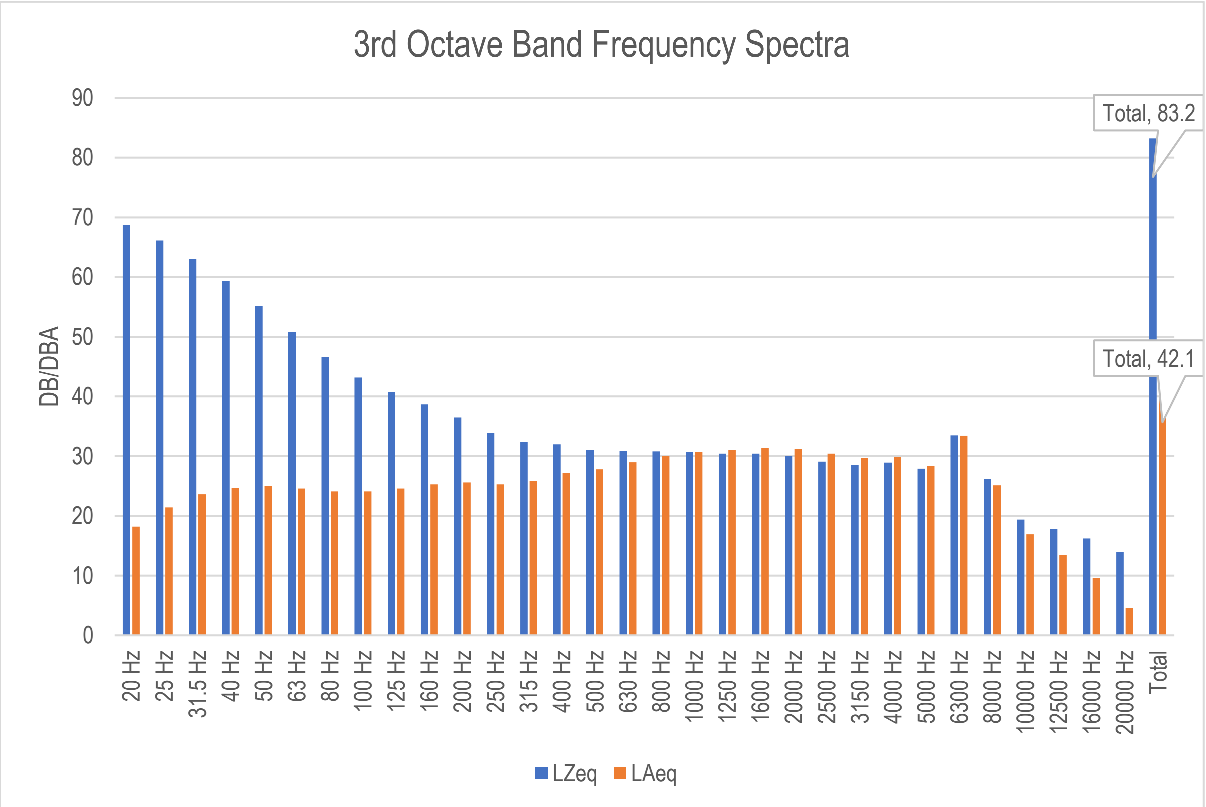


Figure 6: 3rd octave band frequency spectra, L_{Zeq}, 21-Dec-16 to 1-Jan-17

4 Impact Assessment

The noise source inventory, noise propagation calculation and results for activities associated with the construction and operational phases of the CSP plant at site 1 are discussed in in this section.

4.1 Construction Phase

Given the nature of a typical screening level assessment construction phase noise emissions were estimated by applying the recommended factors as proposed for use by the European Commissions (EC) Working Group on the Assessment of Environmental Noise (WG-AEN).

The WG-*AEN "Good Practice Guide for Strategic Noise Mapping and the Production of Associated Data on Noise Exposure"*, provides default sound power levels, L_W's, for different types of industry, to be used when sufficient information for a detailed noise emissions inventory is not available. For the construction phase, the default L_{WA} of 65 dBA/m^2 for heavy industrial areas was applied to the CSP plant site 1 infrastructure footprint area. This factor was applied to take into account all on site vehicle movement, materials handling, feed hoppers, conveyors, electrical motors, motor driven pumps and fans, pumping and compressed air noise, cement batching, assembly, etc. The construction laydown area is 5 ha (50 000 m^2). The total noise emission over the 5 ha area was estimated at 112 dBA.

Noise from construction phase traffic along access routes need also be considered. The 2017 traffic assessment by WSP | Parsons Brinckerhoff indicated that traffic will be generated by construction workforce, the delivery of heliostats and bulk construction materials. They estimated 74 trips during AM and PM peak hours for workforce transport (32% heavy vehicles), 22 trips per day for the delivery of bulk construction materials, and 12 trips per day for the delivery of the heliostats. A typical AM or PM peak traffic hour would therefore include ~76 vehicle trips (35% heavy vehicles) and a typical day-time traffic hour ~3 vehicle trips (100% heavy vehicles). It was assumed that these vehicles will travel at an average speed of 60 km/h on unsurfaced roads and 100 km/hour on the N14.

The construction phase's noise impact profiles are presented in Figure 7 and Figure 8. Whereas Figure 7 shows $L_{Req,d}$ as a function of distance from the source, the increase above the baseline is shown in Figure 8.

Simulations indicate that activities within the construction laydown area may result in noise levels exceeding 55 dBA up to 190 m from construction activities, with the 3 dBA increase impact criteria exceeded over a distance of 625 m. Road traffic along unsurfaced roads and along the N14 may result in noise levels of over 55 dBA up to 25 m and 12 m from the road's centreline respectively. An increase of more than 3 dBA may be expected up to 325 m and 175 m from the unsurfaced road and N14 respectively.

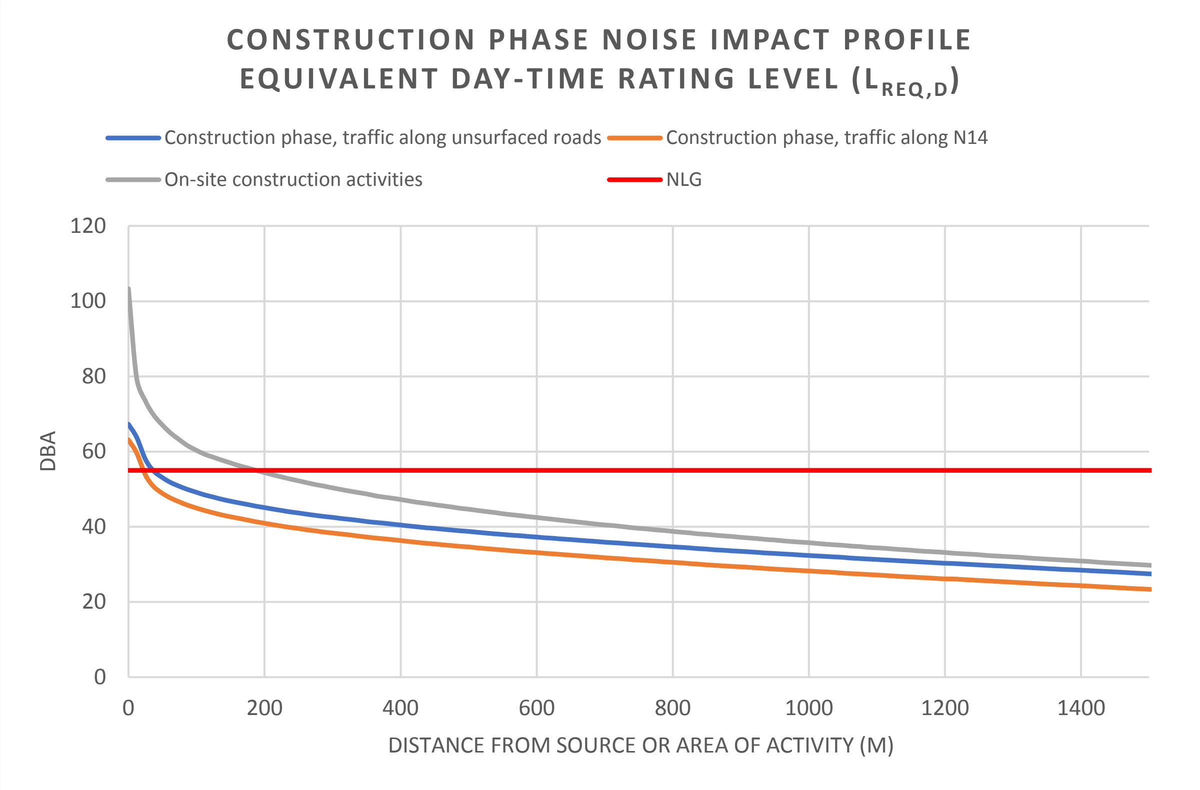


Figure 7: Construction phase noise impact profile, equivalent day-time rating level ($L_{Req,d}$)

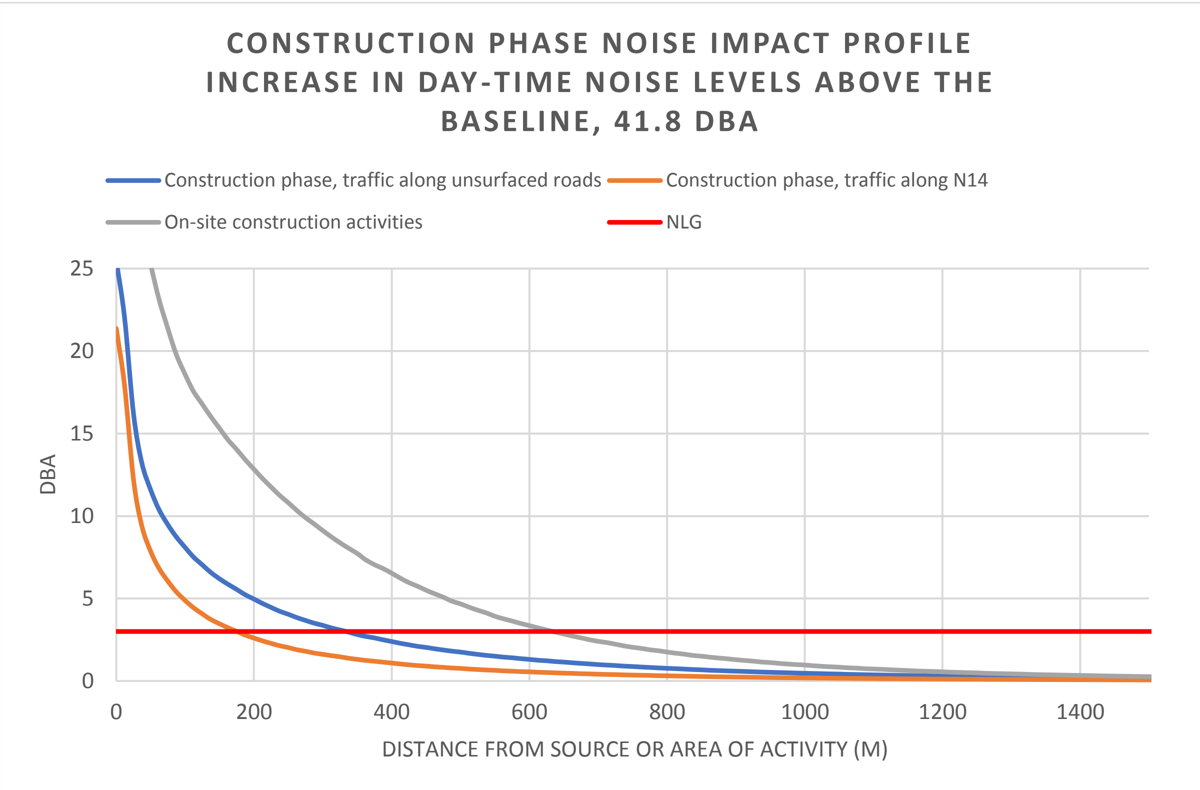


Figure 8: Construction phase noise impact profile, increase in day-time noise levels

4.2 Operational Phase

The power island is expected to be the most notable source of noise during the operational phase. Whereas the power island will consist of many noise generating activities, sufficiently detailed information was not available to determine source specific noise emissions. The operational phase source inventory therefore consists of the noise emissions typically associated with a 150 MW_e turbine generator unit as calculated using the method stipulated by Crocker (1998) and general noise quantified over an area wide basis by applying the EC WG-EAN factor of 60 dBA/m² for light industries. A steam turbine-generator L_{WA} of 110.2 dBA was calculated. The power island footprint area is approximately 3 ha with the L_{WA} of other operational phase sources therefore at 104.8 dBA.

Note that operational phase traffic is considered negligible from a noise impact perspective.

The operational phase's noise impact profiles are presented in Figure 9 and Figure 10. Figure 9 shows noise levels as a function of distance from the source. The increase above the baseline is shown in Figure 10. Note, there is no difference in the impact profiles of day- and night-time noise

Simulations indicate that operational phase activities may result in noise levels exceeding the day-time noise level guideline of 55 dBA up to 250 m and the night-time noise level guideline of 45 dBA up to 750 m. A 3 dBA increase in nose levels can be expected up to 1 km from the power island.

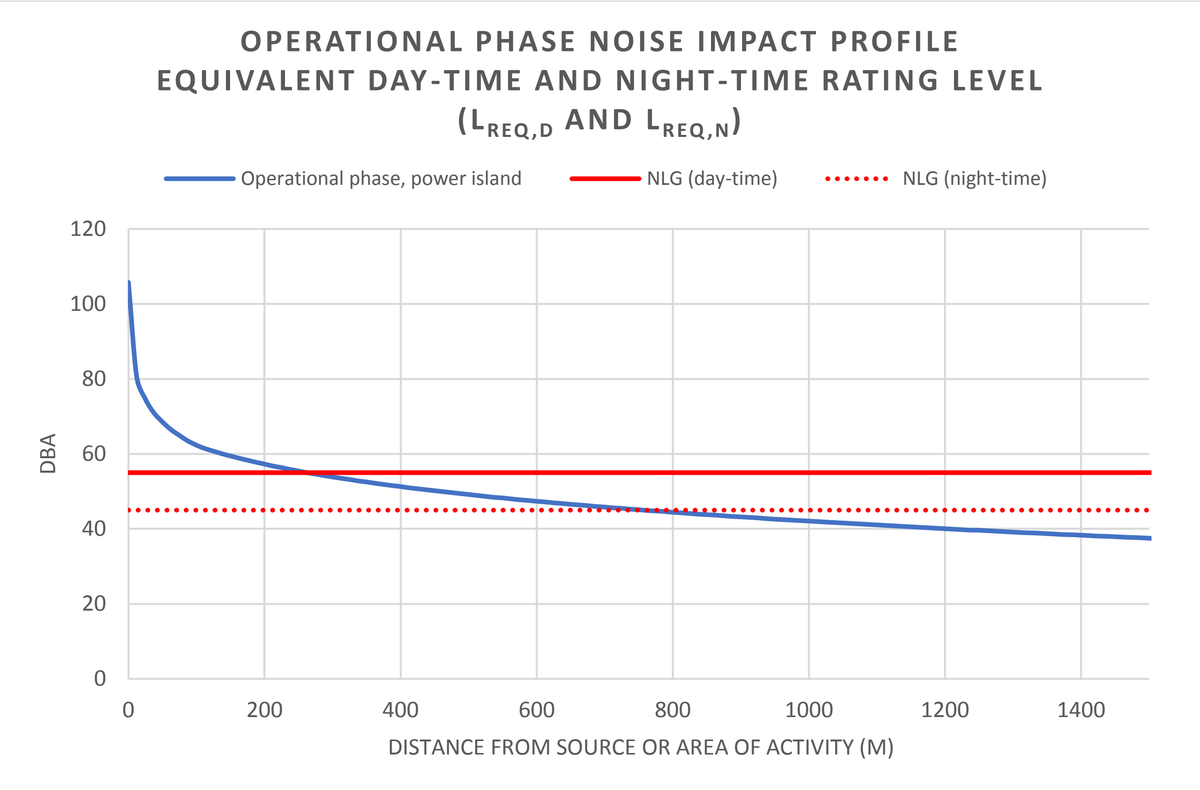


Figure 9: Operational phase noise impact profile, equivalent day-time and night-time rating level ($L_{Req,d}$ and $L_{Req,n}$)

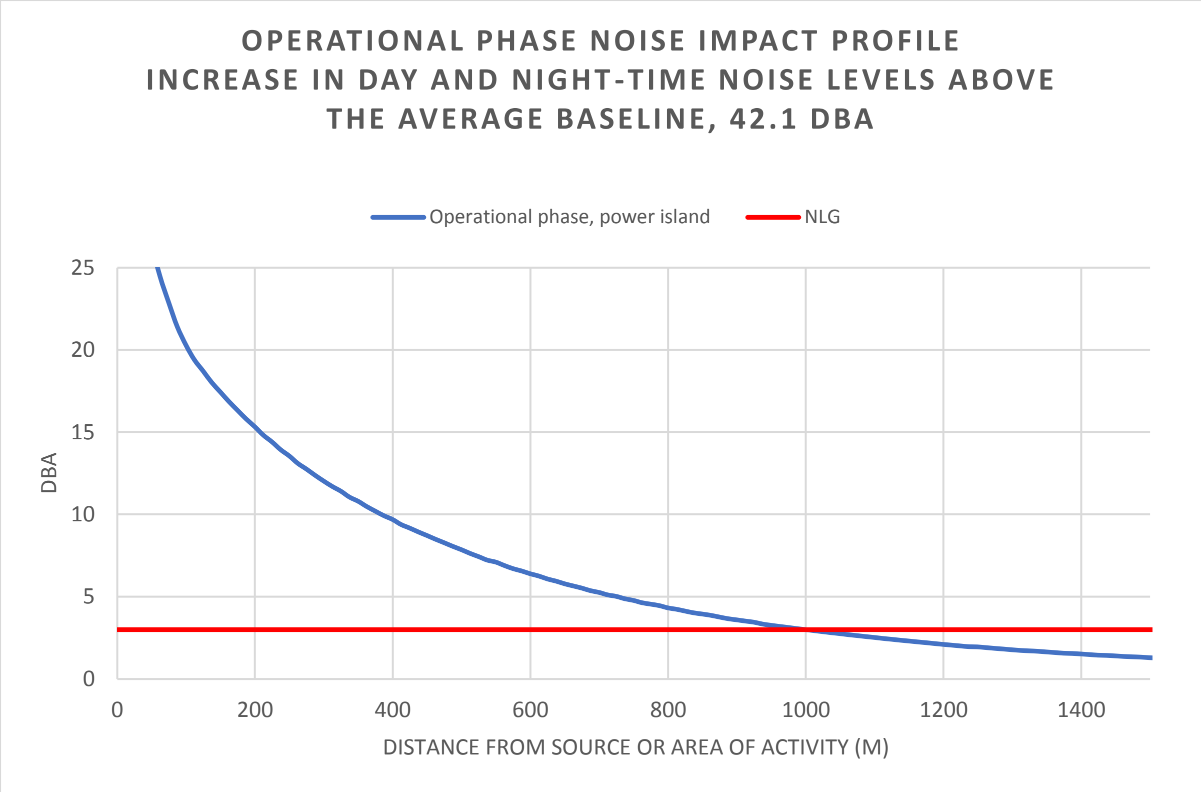


Figure 10: Operational phase noise impact profile, increase in day-time and night-time noise levels

5 MANAGEMENT, MITIGATION, AND RECOMMENDATIONS

In the quantification of noise emissions and screening simulations of noise levels because of the proposed CSP plant at site 1, it was calculated that ambient noise evaluation criteria for human receptors will only be exceeded within approximately 625 m from areas of activity during the construction phase and 1 km during the operational phase. To the author's knowledge there are no permanent human receptors within 1 km of the site and impacts are therefore unlike. The site does however fall within an area of very low noise levels and efforts should be made minimise the impact on the acoustic environment.

From a noise perspective, the project may proceed if best practice management and mitigation measures listed below are implemented as part of the conditions of environmental authorisation to ensure minimal impacts on the surrounding environment.

5.1 Good Engineering and Operational Practices

For general activities, the following good engineering practice **should** be applied:

- All diesel-powered equipment and plant vehicles should be kept at a high level of maintenance. This should particularly include the regular inspection and, if necessary, replacement of intake and exhaust silencers. Any change in the noise emission characteristics of equipment should serve as trigger for withdrawing it for maintenance.
- To minimise noise generation, vendors should be required to guarantee optimised equipment design noise levels.
- A mechanism to monitor noise levels, record and respond to complaints and mitigate impacts should be developed.

5.2 Traffic

The measures described here are considered good practice in reducing traffic related noise. In general, road traffic noise is the combination of noise from individual vehicles in a traffic stream. The following general factors are considered the most significant with respect to road traffic noise generation:

- Traffic volumes i.e. average daily traffic.
- Average speed of traffic.
- Traffic composition i.e. percentage heavy vehicles.
- Road gradient.
- Road surface type and condition.
- Individual vehicle noise including engine noise, transmission noise, contact noise (the interaction of tyres and the road surface, body, tray and load vibration and aerodynamic noise).

In managing noise specifically related to traffic, efforts **should** be directed at:

- Minimizing individual vehicle engine, transmission, and body noise/vibration. This is achieved through the implementation of an equipment maintenance program.
- Minimize slopes by managing and planning road gradients to avoid the need for excessive acceleration/deceleration.
- Maintain road surface regularly to avoid corrugations, potholes etc.
- Avoid unnecessary idling times.

- Minimizing the need for trucks/equipment to reverse. This will reduce the frequency at which disturbing but necessary reverse warnings will occur. Alternatives to the traditional reverse 'beeper' alarm such as a 'self-adjusting' or 'smart' alarm could be considered. These alarms include a mechanism to detect the local noise level and automatically adjust the output of the alarm is so that it is 5 to 10 dB above the noise level near the moving equipment. The promotional material for some smart alarms does state that the ability to adjust the level of the alarm is of advantage to those sites 'with low ambient noise level' (Burgess & McCarty, 2009).

5.3 Operational Hours

Noise generating activities should be limited to day-time hours as far as possible.

5.4 Monitoring

If noise related complaints are received short term (24-hour) ambient noise measurements should be conducted as part of investigating the complaints. The results of the measurements should be used to inform any follow-up interventions.

It is further recommended that at least one survey be included during the construction phase and one at the commencement activities to confirm simulation results.

The following procedure should be adopted for all noise surveys:

- Any surveys should be designed and conducted by a trained specialist.
- Sampling should be carried out using a Type 1 sound level meter (SLM) that meets all appropriate International Electrotechnical Commission (IEC) standards and is subject to annual calibration by an accredited laboratory.
- The acoustic sensitivity of the SLM should be tested with a portable acoustic calibrator before and after each sampling session.
- Samples of at least 24 hours in duration and sufficient for statistical analysis should be taken with the use of portable SLM's capable of logging data continuously over the time period. Samples representative of the day- and night-time acoustic climate should be taken.
- The following acoustic indices should be recoded and reported:
    - L_{Aeq} (T)
    - L_{AIeq} (T)
    - Statistical noise level L_{A90}
    - L_{Amin} and L_{Amax}
    - Octave band or 3rd octave band frequency spectra.
- The SLM should be located approximately 1.5m above the ground and no closer than 3m to any reflecting surface.
- Efforts should be made to ensure that measurements are not affected by residual noise and extraneous influences, e.g. wind, electrical interference and any other non-acoustic interference, and that the instrument is operated under the conditions specified by the manufacturer. It is good practice to avoid conducting measurements when the wind speed is more than 5 m/s, while it is raining or when the ground is wet.
- A detailed log and record should be kept. Records should include site details, weather conditions during sampling and observations made regarding the acoustic climate of each site.

5.5 Access Route Alternatives

From an acoustic perspective, there is no preference to the access route alignment.

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7 ANNEX A – SPECIALIST'S CURRICULUM VITAE