ENVIRONMENTAL ACOUSTIC IMPACT ASSESSMENT

PROPOSED HIGH-SPEED PROVING GROUND

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WSP | PARSONS BRINCKERHOFF

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PROPOSED HIGH-SPEED PROVING GROUND

Mercedes-Benz SA Ltd

Report (version 1)

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GLOSSARY OF TERMS

Sound	Sound is small fluctuations in air pressure, measured in Newtons per square meter (N/m^2) or Pascals (Pa) that are transmitted as vibrational energy via a medium (air) from the source to the receiver. The human ear is a pressure transducer, which converts these small fluctuations in air pressure into electrical signals, which the brain then interprets as sound.
Noise	Noise is generally defined as unwanted sound.
Sound or noise level	A sound or noise level is a sound measurement that is expressed in Decibels (dB or dB(A)).
dB or dB(A)	The human ear is a sensitive instrument that can detect fluctuations in air pressure over a wide range of amplitudes. This limits the usefulness of sound quantities in absolute terms. For this reason a sound measurement is expressed as ten times the logarithm of the ratio of the sound measurement to a reference value, 20 micro (millionth) Pa. This process converts a scale of constant increases to a scale of constant ratios and considerably simplifies the handling of sound measurement quantities. The attached 'A' indicates that the sound measurement has been A-weighted.
dB(Z)	Historically sound levels were read off a hand held meter and the noise levels were noted in dB, after the development of different weighting curves sound levels were noted as Z-weighting or dB(Z) to reduce the confusion with different type of weighting applied noise levels. dB(Z) refers to linear noise levels.
A-weighting	The human ear is not equally sensitive to sound of all frequencies, i.e. it is less sensitive to low pitched (or 'bass') than high pitched (or 'treble') sounds. In order to compensate when making sound measurements, the measured value is passed through a filter that simulates the human hearing characteristic. Internationally this is an accepted procedure when working with measurements that relate to human responses to sound/noise.
Ambient sound level	Ambient noise will be defined as the totally encompassing sound in a given situation at a given time, and is usually composed of sound from many sources, both near and far.
Annoyance	General negative reaction of the community or person to a condition creating displeasure or interference with specific activities**.**
Sound pressure	Sound pressure is the force of sound exerted on a surface area perpendicular to the direction of the sound and is measured in N/m^2 or Pa. The human ear perceives sound pressure as loudness and can also be expressed as the number of air pressure fluctuations that a noise source creates.
Sound pressure level	The sound pressure level is a relative quantity as it is a ratio between the actual sound pressure and a fixed reference pressure. The reference pressure is usually the threshold of hearing, namely 20 microPascals (µPa).

Sound power Sound power is the rate of sound energy transferred from a noise source per unit of time in Joules per second (J/s) or Watts (W).

Sound power level The sound power level is a relative quantity as it relates the sound power of a source to the threshold of human hearing (10^{-12} W). Sound power levels are expressed in dB (A), as they are referenced to sound detected by the human ear (A-weighted).

Noise nuisance Noise nuisance means any sound which disturbs or impairs or may disturb or impair the convenience or peace of any person.

Octave bands The octave bands refer to the frequency groups that make a sound. The sound is generally divided in to nine groups (octave bands) ranging from 32 Hertz (Hz) to 8,000 Hz. The lower frequency ranges of a sound have a vibrating character where the higher frequency of sound has the character of high pitched sound. In viewing the total octave bands scale from 32 Hz to 8000 Hz the character of the sound can be described.

ACRONYMS AND ABBREVIATIONS

dB	Decibel
dB(A)	A-weighted sound measurement
dB(Z)	Z-weighted sound measurement
ECA	Environmental Conservation Act 73 of 1989
Hz	Hertz
L_{Aeq}	Equivalent continuous sound pressure level
$L_{R,dn}$	Equivalent continuous day/night rating level
$L_{Req,d}$	Equivalent continuous rating level for day-time
$L_{Req,n}$	Equivalent continuous rating level for night-time
$L_{Req,T}$	Typical noise rating levels
MBSA	Mercedes-Benz South Africa
NEMA	National Environmental Management Act
NEMAQA	National Environmental Management: Air Quality Act 39 of 2004
S&EIR	Scoping and Environmental Impact Reporting
SABS	South African Bureau of Standards
SANS	South African National Standards
WHO	World Health Organisation

EXECUTIVE SUMMARY

Mercedes-Benz South Africa (Pty) Ltd (MBSA) proposes to develop a High-Speed Proving Ground for vehicle testing for the Mercedes-Benz Research and Development Team, in the Northern Cape Province of South Africa. WSP Environmental (Pty) Ltd has been appointed by MBSA to conduct the Scoping and Environmental Impact Reporting (S&EIR) process for the project. As part of this process an Environmental Acoustic Impact Assessment is not required, but at the Client's request, such a study has been included. This report details the findings of the environmental acoustic impact assessment.

This assessment investigated noise impacts associated with the construction and operation of the Proposed High-Speed Proving Ground. Due to the remoteness of the proposed site, no baseline acoustic monitoring was performed but rather the SANS guideline rating level for noise in rural districts was considered to be a reasonable representation of the current noise climate in the area.

Acoustic model results confirmed that noise levels at all nearby farm house receptor locations will be low, with no changes in the existing noise levels predicted during both the construction and operational phases. The highest noise levels during the construction phase are predicted around the quarry and borrow pit areas as well as at locations scattered along the high-speed oval, dependant on where specific construction equipment will be located at a given time. The highest noise levels during the operational phase are predicted along the high-speed oval, multifunctional area and handling track.

The acoustic impacts of the Proposed High-Speed Proving Ground were evaluated using a risk matric which assessed the severity, extent, duration, probability and confidence of potentially significant impacts. Based on this rating system, it was calculated that the acoustic impacts of the proposed project are expected to be "Low".

ENVIRONMENTAL ACOUSTIC CONSULTANT

Kirsten Collett is an air quality and acoustic consultant with a Master of Science (Atmospheric Sciences) degree obtained from the University of the Witwatersrand. She is currently employed by WSP and has worked on environmental acoustic impact assessments, monitoring and modelling for a variety clients over the past three years. She has provided acoustic consulting support to various client industries including petrochemical, mining and production industries.

DECLARATION OF INDEPENDENCE

I hereby declare that I am fully aware of my responsibilities in terms of the National Environmental Management Act 2006 Environmental Impact Assessment Regulations and that I have no financial or other interest in the undertaking of the proposed activity other than the imbursement of consultants fees.

Name: Kirsten Collett

Company: WSP Environmental (Pty) Ltd

Signature:

1 INTRODUCTION

Mercedes-Benz South Africa (Pty) Ltd (MBSA) proposes to develop a High-Speed Proving Ground for vehicle testing for the Mercedes-Benz Research and Development Team, in the Northern Cape Province of South Africa. WSP Environmental (Pty) Ltd (WSP) has been appointed by MBSA to conduct the Scoping and Environmental Impact Reporting (S&EIR) process for the project. As part of this process an Environmental Acoustic Impact Assessment is not required, but at the Client's request, such a study has been included.

This report details the findings of the environmental acoustic impact assessment conducted by WSP. Included in this report is background to the project; fundamentals and principles of environmental noise; an overview of the legal framework for environmental noise; discussions on the acoustic inventory development and identification of key noise sources at the facility; identification of sensitive receptors (noise receivers); and acoustic modelling outputs and results.

1.1 SCOPE OF WORK

Below is a summary of the scope of work performed by WSP in fulfilment of the requirements of the environmental acoustic specialist study:

- Description of the receiving environment, specifically relating to sensitive receptors (noise receivers);
- Development of a comprehensive acoustic inventory detailing sound power levels of all proposed noise sources at the facility during both the construction and operational phases;
- Evaluation of the proposed noise climate during the construction and operational phase as well as the noise propagation potential using the CadnaA acoustic modelling software;
- An assessment of the acoustic impacts of the construction and operation of the proposed facility on the surrounding communities; and
- Compilation of an environmental acoustic impact assessment report, inclusive of all information listed above.

1.2 RATIONALE FOR THE STUDY

An Environmental Acoustic Impact Assessment for the Proposed High-Speed Proving Ground is not required in terms of the S&EIR process. However, based on previous experience with High-Speed Proving Grounds in other parts of the world, the Client is concerned that acoustic issues may arise and as such have commissioned this Environmental Acoustic Impact Assessment study.

Such a project has the potential to produce significant noise levels and thus such a study is warranted in this case.

2 PROJECT BACKGROUND

2.1 LOCALITY AND STUDY AREA

The Proposed High-Speed Proving Ground is located on property Steenkamps Pan, Farm 419/06 in the //Khara Hais Municipality, approximately 38 km northeast of Upington in the Northern Cape Province (**Figure 1**). The surrounding land use is limited to extensive and low-intensity livestock grazing with scattered agricultural smallholdings.

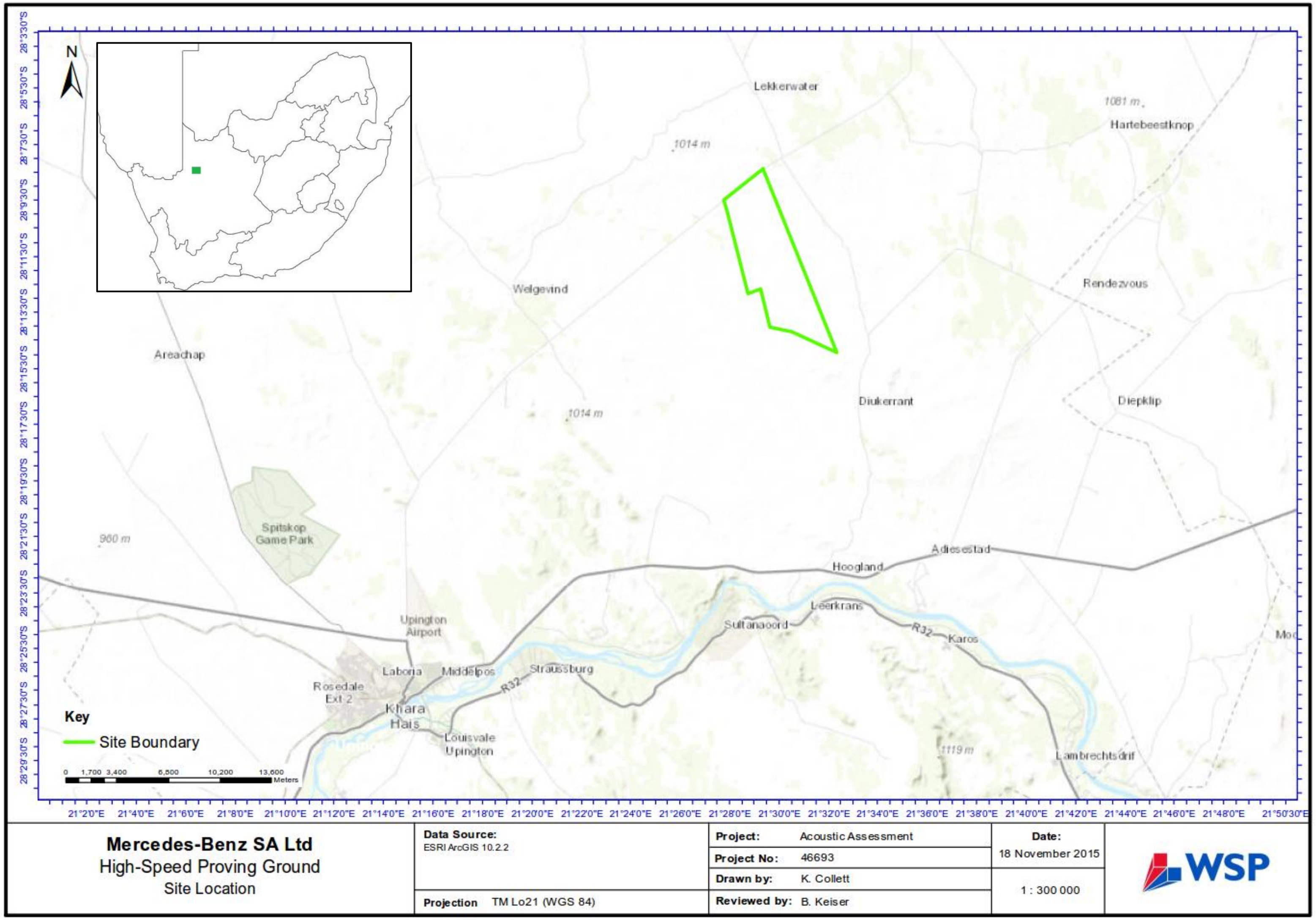

Figure 1: Location of the Proposed High-Speed Proving Ground in the Northern Cape Province

2.2 PROJECT DESCRIPTION

CONSTRUCTION PHASE

The construction phase of the Proposed High-Speed Proving Ground will take place over a two year period, with construction occurring in two phases. Phase one will include construction of the oval, lay-bys, bridge, slope hill, access roads (outside the oval) and buildings and is envisaged to have a duration of fourteen months. Phase two will commence after phase 1 and will endure for eight months. This phase will include the construction of the handling track, multi-functional area, bad roads and access roads inside the oval.

A third "mining" phase may be introduced in order to abstract the material required for the construction and development of the High-Speed Proving Ground by means of one borrow pit (calcrete) and one quarry (granite) located within the boundary of Steenkamps Pan, Farm 419/06. Granite material may be mined from the quarry located west of the proving ground while calcrete material may be mined from the borrow pit located southeast of the proving ground (**Figure 2**).

The construction phases (mining included) will be operational from 07:00 – 17:00 (Monday to Friday) and 07:00 – 14:00 (Saturdays).

OPERATIONAL PHASE

The operation of the Proposed High-Speed Proving Ground and associated infrastructure will enable Mercedes Benz to undertake testing of vehicles under hot climate conditions in parallel to the European winter season under specified technical conditions in terms of testing modules.

The test modules that will be designed and operated at the site include:

- High-Speed Oval – A 17 km long loop for performing acceleration tests (50 – 250 km/h);
- Handling Track – A 5.8 km long module designed for testing the handling characteristics of the test vehicles (50 – 230 km/h);
- Multi-Functional Area – A 0.8 km long module for testing the steering characteristics of the test vehicles (up to 120 km/h);
- DPF Road – A 0.8 km long module for testing the diesel particle filter applications of the test vehicles (10 – 30 km/h);
- Bad Roads – A 10 km long off-road module designed to conduct comfort and corrosion testing (40 – 80km/h); and
- Access Roads (outside oval) – A 2.5 km test module designed for performing acceleration tests (0 – 100 km/h).

The test modules will be operational from 08:00 – 20:00 (Monday to Saturday) for six months of the year (October to April). The six month period will coincide with the European winter season testing. Ad hoc testing may be conducted at the site during the remainder of the year.

2.3 EXISTING NOISE CLIMATE

The existing noise climate in the area surrounding the Proposed High-Speed Proving Ground is typically rural with limited anthropogenic influences. Current sources of noise include livestock, birds, insects and motor vehicles travelling along nearby roads.

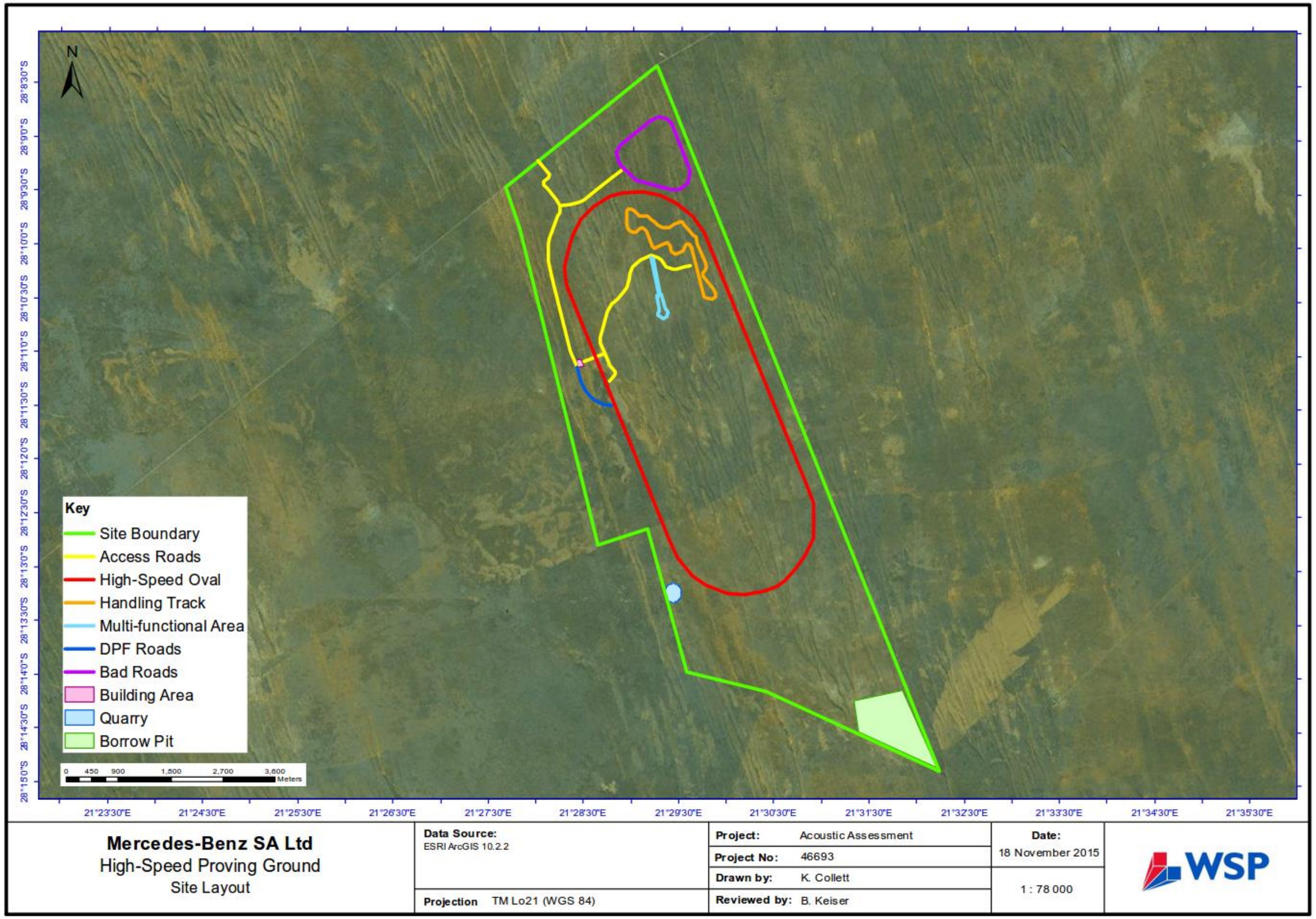

Figure 2: Site layout of the Proposed High-Speed Proving Ground

3 ACOUSTIC FUNDAMENTALS

3.1 PRINCIPLES

Sound is defined as any pressure variation (in air, water or other medium) that the human ear can detect. Noise is defined as “unwanted sound”. Noise can lead to health impacts and can negatively affect people’s quality of life. Hearing impairment is typically defined as a decrease in the threshold of hearing. Severe hearing deficits may be accompanied by tinnitus (ringing in the ears). Noise-induced hearing impairment occurs predominantly in the higher frequency range of 3,000 to 6,000 Hertz (Hz), with the largest effect at 4,000 Hz. With increasing $L_{Aeq,8h}$ and increasing exposure time, noise-induced hearing impairment occurs even at frequencies as low as 2,000 Hz. However, hearing impairment is not expected to occur at $L_{Aeq,8h}$ levels of 75 dB(A) or below, even for prolonged occupational noise exposure.

Speech intelligibility is adversely affected by noise. Most of the acoustical energy of speech is in the frequency range of 100 to 6,000 Hz, with the most important cue-bearing energy being between 300 and 3,000 Hz. Speech interference is basically a masking process in which simultaneous interfering noise renders speech incapable of being understood. Environmental noise may also mask other acoustical signals that are important for daily life such as doorbells, telephone signals, alarm clocks, music, fire alarms and other warning signals.

Sleep disturbance is a major effect of environmental noise. It may cause primary effects during sleep and secondary effects that can be assessed the day after night-time noise exposure. Uninterrupted sleep is a prerequisite for good physiological and mental functioning and the primary effects of sleep disturbance are: (a) difficulty in falling asleep; and (b) awakenings and alterations of sleep stages or depth. The difference between the sound levels of a noise event and background sound levels, rather than the absolute noise level, may determine the reaction probability.

The annoyance due to a given noise source is subjective from person to person, and is also dependent upon many non-acoustic factors such as the prominence of the source, its importance to the listener’s economy (wellbeing), and his or her personal opinion of the source. The result of increased exposure to noise on individuals can have negative effects, both physiological (influence on communication, productivity and even impaired hearing) and psychological effects (stress, frustration and disturbed sleep). As such, noise impacts need to be understood to mean one or a combination of negative physical, physiological or psychological responses experienced by individuals, whether consciously or unconsciously, caused by exposure to noise.

More technically, noise impacts are defined as the capacity of noise to induce annoyance depending upon its physical characteristics including the sound pressure level, spectral characteristics and variations of these properties with time. During day-time, individuals may be annoyed at L_{Aeq} levels below 55 dB(A), while very few individuals are moderately annoyed at L_{Aeq} levels below 50 dB(A). Sound levels during the evening and night should be 5 to 10 dB(A) lower than during the day (World Health Organisation, 1999).

Table 1: Typical noise levels

Sound Pressure Level (dB(A))	Typical Source	Subjective Evaluation
130	threshold of pain	intolerable
120 **110**	heavy rock concert grinding on steel	extremely noisy
100 **90**	loud car horn at 3m construction site with pneumatic hammering	very noisy
80 **70**	kerbside of busy street loud radio or television	loud
60 **50**	department store general office	moderate to quiet
40 **30**	inside private office inside bedroom	quiet to very quiet
20	unoccupied recording studio	almost silent

3.2 NOISE PROPAGATION

Sound is a pressure wave that diminishes with distance from source. Depending on the nature of the noise source, sound propagates at different rates. The three most common categories of noise are point sources (specified single point of noise generation) line sources (multiple linear noise generating points, such as a road) and area sources (specified single area of noise generation). The most important factors affecting noise propagation are:

- → The type of source (point, line or area);
- → Obstacles such as barriers and buildings;
- → Distance from source;
- → Atmospheric absorption;
- → Ground absorption; and
- → Reflections.

Research has shown that doubling the distance from a noise source results in a proportional decline in noise level. Sound propagation in air can be compared to ripples on a pond. The ripples spread out uniformly in all directions, decreasing in amplitude as they move further from the source. An acoustically hard site exists where sound travels away from the source over a generally flat, hard surface such as water, concrete, or hard-packed soil. These are examples of reflective ground, where the ground cover provides little or no attenuation. The standard attenuation rate for hard site conditions is 6 dB(A) per doubling of distance for point sources. Thus, if you are at a position one meter from the source and move one meter further away from the source, the sound pressure level will drop by 6 dB(A), moving to 4 meters, the drop will be a further 6 dB(A), and so on. When ground cover or normal unpacked earth (i.e. a soft site) exists between the source and receptor, the ground becomes absorptive to sound energy. Absorptive ground results in an additional noise reduction of approximately 1.5 dB(A) per doubling of distance.

This methodology is only applicable when there are no reflecting or screening objects in the sound path. When an obstacle is in the sound path, part of the sound may be reflected and part absorbed and the remainder may be transmitted through the object. How much sound is reflected, absorbed and/or transmitted depends on many factors, including the properties of the object. When receptor locations are not in the line of sight of the noise source, there may be up to 20 dB(A) attenuation for broadband noise, with a further 10 to 15 dB(A) attenuation when inside the average residence and the windows are open.

3.3 CHARACTERISTICS OF NOISE

The human ear simultaneously receives sound (normal un-weighted sound or Z-weighting dB(Z)) at many frequencies (octave bands) at different amplitudes. The ear then adjusts its sensitivity based on the amplitude of the sound observed. This focuses the sound and makes it audible by adjusting the amplitude of the low, middle and high frequencies. To measure how a person experiences sound, an electronic weighting adjusted to the Z-weighted sound was developed, including three different weighting curves, namely:

- **A-weighting** - This measurement is often noted as dB(A) and this weighting curve attempts to make the noise level meter respond closely to the characteristics of a human ear. It adjusts the frequencies at low and high frequencies. Various national and international standards relate to measurements recorded in the A-weighting of sound pressure levels;
- **B-weighting** - is similar to A-weighting but with less attenuation. The B-weighting is very seldom, if ever, used. The B-weighting follows the C-weighted trend;
- **C-weighting** - is intended to represent how the ear perceives sound at high decibel levels. C-weighted measurements are reported as dB(C); and
- **Z-weighting** - this refers to linear, un-weighted noise levels.

The weighting is employed by arithmetically adding a table of values **(Table 2)**, listed by octave bands, to the measured linear sound pressure levels for each specific octave band. The resulting octave band measurements are logarithmically added to provide a single weighted value describing the sound, based on the applied weighting curve (**Figure 3**). Thus, if the A-weighted curve was applied to the sound, the noise level is noted as dB(A).

Table 2: Frequency weighting table for the different weighting curves.

Frequency (Hz)	32 Hz	63 Hz	125 Hz	250 Hz	500 Hz	1k Hz	2k Hz	4k Hz	8k Hz
A-weighting	-39.4	-26.2	-16.1	-8.6	-3.2	0	1.2	1	1.1
B-weighting	-17.1	-9.3	-4.2	-1.3	-0.3	0	-0.1	-0.7	-2.9
C-weighting	-3	-0.8	-0.2	0	0	0	-0.2	-0.8	-3
Z-weighting	0	0	0	0	0	0	0	0	0

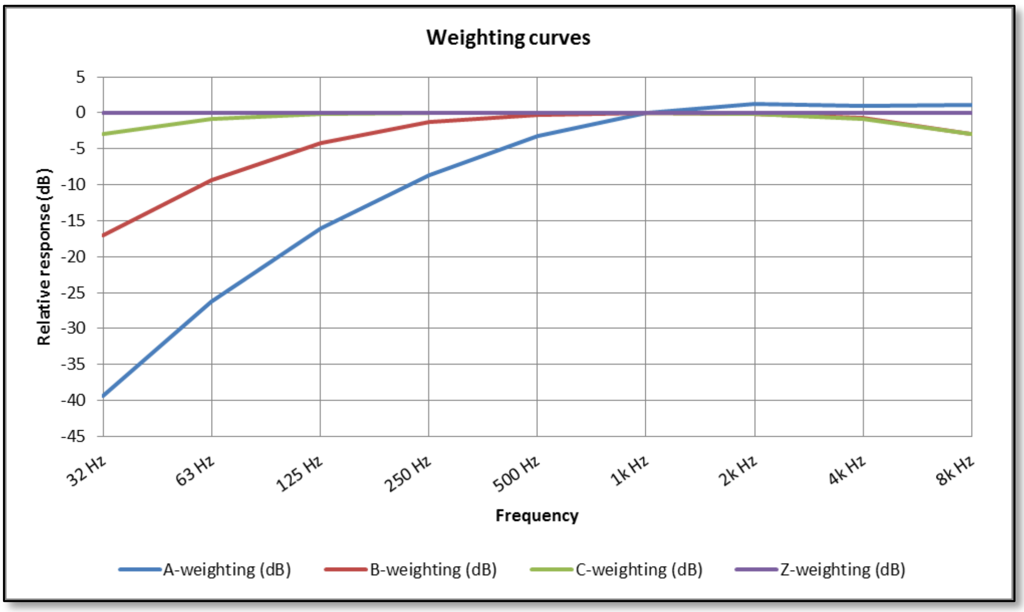

Figure 3: Weighting curves

4 ENVIRONMENTAL NOISE STANDARDS AND GUIDELINES

4.1 SOUTH AFRICAN NOISE CONTROL REGULATIONS

In South Africa, environmental noise control has been in place for three decades, beginning in the 1980s with codes of practice issued by the South African National Standards (then the South African Bureau of Standards, SABS) to address noise pollution in various sectors of the country. Under the previous generation of environmental legislation, specifically the Environmental Conservation Act 73 of 1989 (ECA), provisions were made to control noise in different districts from a national level. In later years, the ECA was replaced by the National Environmental Management Act 107 of 1998 (NEMA) as amended. The National Environmental Management: Air Quality Act 39 of 2004 (NEMAQA) was published in line with NEMA and contains noise control provisions under Section 34:

> *"(1) The minister may prescribe essential national standards –*
> *(a) for the control of noise, either in general or by specific machinery or activities or in specified places or areas; or*
> *(b) for determining –*
> *(i) a definition of noise; and*
> *(ii) the maximum levels of noise.*
> *(2) When controlling noise the provincial and local spheres of government are bound by any prescribed national standards."*

Under NEMAQA, the noise control regulations were updated and are to be applied to all provinces in South Africa. The noise control regulations give all the responsibilities of enforcement to the local provincial authority, where location specific by-laws can be created and applied to the locations with approval of provincial government. Furthermore, NEMAQA prescribes that the Minister must publish maximum allowable noise levels for different districts and national noise standards. These have not yet been accomplished and as a result all monitoring and assessments are done in accordance with the SANS 10103:2008 and 10328:2008 as described below.

4.2 SOUTH AFRICAN NATIONAL STANDARDS (SANS)

The SANS 10328:2008 *Methods for environmental noise impact assessments* presently inform environmental acoustic impact assessment in South Africa. The SANS 10103:2008 - Typical Rating Levels ($L_{Req,T}$) for noise are presented in **Table 3**.

Table 3: Typical Rating Levels for Noise in Districts (adapted from SANS 10103:2008)

Type of District	Classification	Equivalent Continuous Rating level for Noise ($L_{Req,T}$) (dB(A)) Outdoors	
		Day-time ($L_{Req,d}$)	Night-time ($L_{Req,n}$)
a) Rural	A	45	35
b) Suburban (with little road traffic)	B	50	40
c) Urban	C	55	45
d) Urban (with one or more of the following: workshops, business premises and main roads)	D	60	50
e) Central Business Districts	E	65	55
f) Industrial District	F	70	60
Guidelines in red are applicable to this acoustic impact assessment			

As stipulated by the SANS 10103:2008, noise can pose as an annoyance to a community if the increase in average noise levels exceeds the rating level of the residual noise. These noise rating levels together with estimated group responses are presented in **Table 4**.

Table 4: Categories of Community/Group Response (Adapted from SANS 10103:2008)

Excess ($\Delta L_{Req,T}$)[a] dB(A)	Estimated Community or Group Response	
0 – 10 5 – 15 10 – 20 >15	Little Medium Strong Very Strong	Sporadic Complaints Widespread Complaints Threats of community/group action Vigorous community/group action

Overlapping ranges for the excess values are given because a spread in the community reaction might be anticipated.
[a] $\Delta L_{Req,T}$ should be calculated from the appropriate of the following:
1) $L_{Req,T}$ = $L_{Req,T}$ of ambient noise under investigation MINUS $L_{Req,T}$ of the residual noise (determined in the absence of the specific noise under investigation);
2) $L_{Req,T}$ = $L_{Req,T}$ of ambient noise under investigation MINUS the maximum rating level of the ambient noise given in Table 1 of the code;
3) $L_{Req,T}$ = $L_{Req,T}$ of ambient noise under investigation MINUS the typical rating level for the applicable district as determined from Table 2 of the code; or
4) $L_{Req,T}$ = Expected increase in $L_{Req,T}$ of ambient noise in the area because of the proposed development under investigation.

4.3 WORLD HEALTH ORGANISATION GUIDELINES FOR COMMUNITY NOISE

The World Health Organisation (WHO) together with the Organisation for Economic Co-operation and Development (OECD) are the main international bodies that have collected data and developed assessments on the effects of exposure to environmental noise. This has provided the following summary of thresholds for noise nuisance in terms of outdoor daytime L_{Aeq} in residential districts:

- At 55 - 60 dB(A) noise creates annoyance.
- At 60 - 65 dB(A) annoyance increases considerably.
- Above 65 dB(A) constrained behaviour patterns, symptomatic of serious damage caused by noise

The World Health Organisation recommends a maximum outdoor daytime L_{Aeq} of 55 dB(A) in residential areas and schools in order to prevent significant interference with normal activities. It further recommends a maximum night-time L_{Aeq} of 45 dB(A) outside dwellings. No distinction is made as to whether the noise originates from road traffic, from industry, or any other noise source.

The WHO also lists that the guideline for industrial noise is set to 70 dB(A) over a period of 24 hours. This would cause hearing impairment, where the peak noise level of 110 dB(A) is allowable on a fast response measurement.

5 STUDY METHODOLOGY

5.1 BASELINE ASSESSMENT

Due to the remoteness of the proposed site and the limited number of existing noise sources, an ambient acoustic monitoring campaign was not conducted at the site or at any nearby sensitive receptor locations. In order to quantify the existing noise climate for this assessment, a worst-case rural noise level of 45 dB(A) during the day and 35 dB(A) at night (the SANS guideline rating level for rural districts as presented in **Table 3**) is assumed to be a good representation of the current noise levels in the region.

5.2 ENVIRONMENTAL ACOUSTIC MODELLING

CADNA ACOUSTIC MODELLING SOFTWARE

Acoustic modelling was used to calculate noise contours indicating the spatial extent of projected sound levels from the Proposed High-Speed Proving Ground within a specified grid area (15 km x 15 km) as well as the noise levels at specific receivers (sensitive receptors). The acoustic modelling software used in this study is the internationally recognised package, CadnaA (Computer Aided Noise Abatement). The CadnaA software provides an integrated environment for noise predictions under varying scenarios and calculates the cumulative effects of various sources. The model uses ground elevations in the calculation of the noise levels in a grid and uses standard meteorological parameters that have an effect on the propagation of noise. CadnaA has been utilised in many countries across the globe for the modelling of environmental noise and town planning. It is comprehensive software for three-dimensional calculations, presentation, assessment and prediction of environmental noise emitted from industrial plants, parking lots, roads, railway schemes or entire towns and urbanized areas.

ACOUSTIC INVENTORY

A detailed inventory of all noise sources during both the construction and operational phases was compiled using sound level data from the BSI British Standards (BS 5228-1:2009) (BSI, 2009), Noise Navigator™ sound level database (Berger *et al.*, 2010) as well as relevant applicable literature (Noise Advisory Council, 1978; BHP Billiton, 2010; Bobcat 2010).

The sound pressure levels (SPL) for each source were then converted to sound power levels (PWL), using **Equation 1** for input to the acoustic model. **Equation 1** calculates PWLs based on the hemispherical propagation of sound under free field conditions (i.e. it is assumed that the noise source is located in the vicinity of hard, reflecting surfaces). The 'r' value represents the distance from the source that the SPL was recorded.

$$PWL = SPL - 10 \log \frac{2}{4\pi r^2} \tag{1}$$

Full descriptions of the noise sources and relevant sound power levels of each source during both construction and operational phases are presented below.

CONSTRUCTION PHASE

The noise sources identified during the construction phase of the Proposed High-Speed Proving Ground are presented in **Table 5**, together with the location, number, operational length, source type and sound power levels that were utilised in the acoustic model. Due to uncertainties with the specific operational timeframes related to each piece of equipment, for a worst-case assessment it was assumed that all sources will operate simultaneously onsite. It must be noted that the construction phase noise sources are based on estimated quantities provided by the WSP Engineers and it is essentially the site contractors' responsibility to provide an accurate programme for construction when the phase is initiated.

All sources will operate within the construction footprint or at the mining areas (as specified in **Table 5**). For a worst case assessment, noisy equipment was positioned in closest proximity to the nearest sensitive receptors.

Table 5: Construction phase noise sources and noise levels used in the acoustic model

Source	Location	Length of Operation (months)	Number in Operation	Sound Power Level (dB(A))	Source Type
GENERAL CONSTRUCTION					
Grader	Oval, building area, access roads (outer) and slope hill	14	6	112.0	Point Source
Water cart	Oval, building area, access roads (outer), slope hill and for dust control on haul roads	14	7	109.0	Point Source
Small water cart	Oval, building area, access roads (outer), slope hill and mining areas. Dust control on haul roads/access roads.	14	4	109.0	Point Source
Articulated Dump Truck	Hauling material to the entire site from oval cut to fill	14	20	109.0	Point Source
Crane Truck	Bridge, building area	As and when needed	1	104.0	Point Source
Payloader	On oval for cut and fill	14	5	108.0	Point Source
Excavator	On oval for cut and fill	14	5	112.0	Point Source
4 Ton Truck	Oval, building area, access roads (outer) and slope hill (for small works)	14	3	102.0	Point Source
15 Ton Tipper	Oval, building area, access roads (outer), and slope hill	14	10	104.0	Point Source
30 Ton Tipper	Only for asphalt - Oval, paved access roads, building area and slope hill	14	15	108.0	Point Source

Padfoot Roller	Mostly on oval, also building area, access roads (outer), and slope hill	14	6	101.0	Point Source
Smooth Drum Roller	Oval, building area, access roads (outer), and slope hill	14	6	101.0	Point Source
Pneumatic Roller	Oval, building area, access roads (outer), and slope hill	14	6	101.0	Point Source
Grid Roller	mostly on Oval, also building area, access roads (outer), and slope hill	14	2	101.0	Point Source
Asphalt Batching Plant	Near quarry	5	1	106.0	Point Source
Asphalt paver	Only for asphalt - Oval, paved access roads, building area and slope hill	3	3	105.0	Point Source
Diesel Bowser	Oval, building area, access roads (outer), and slope hill	14	4	117.0	Point Source
Tractor-Loader-Backhoe (TLB)	Oval, building area, access roads (outer), and slope hill	14	10	96.0	Point Source
Service truck	Oval, building area, access roads (outer), and slope hill	14	3	72.0	Point Source
Bobcat	Oval, building area, access roads (outer), and slope hill	14	10	102.0	Point Source
Bulldozer	Oval, building area, access roads (outer), and slope hill	14	6	111.0	Point Source
Mechanical broom	Oval, building area, access roads (outer), and slope hill	14	3	101.0	Point Source
Recycler	Oval, building area, access roads (outer), and slope hill	14	4	75.0	Point Source
Concrete Batching Plant	Near the Quarry	8	1	106.0	Point Source

Readymix trucks	From quarry concrete batch plant to building area/bridge and concrete drains around oval	14	5	103.0	Point Source
Mobile crushing and screening plant	On oval for cut to fill operations	7	2	118.0	Point Source
Generator	At main site office - near building area	14	1	102.0	Point Source
Blasting	Oval - cut to fill	Once a week	1	128.0	Point Source
MINING					
Blasting	Borrow pit and quarry	6 months borrow pit 12 months quarry	1	128.0	Point Source
Front End Loaders (FELs)	3 at borrow pit and 3 at quarry		6	112.0	Point Source
Tipper Trucks	10 at borrow pit and 10 at quarry		20	108.0	Point Source
Water bowsers	1 at borrow pit and 1 at quarry		2	109.0	Point Source
Excavators	1 at borrow pit and 1 at quarry		2	112.0	Point Source
Bulldozers	Will alternate from quarry to borrow pit (only used to clear site in beginning), will mostly stay at borrow pit for pushing material		1	111.0	Point Source
Crushing and screening plant	1 at borrow pit and 1 at quarry		2	104.0	Point Source
Generator	1 at borrow pit and 1 at quarry area near site offices		2	102.0	Point Source

OPERATIONAL PHASE

Table 6 through **Table 9** presents the noise sources identified during the operational phase of the Proposed High-Speed Proving Ground together with the location, number, operational speeds and sound power levels that were utilised in the acoustic model. The number of trucks and employee vehicles operational at the site was obtained from the specialist Traffic Impact Assessment (WSP, 2015) compiled for the project.

Table 6: Acoustic model inputs for the various vehicle test modules

TEST MODULES	Test Description	Operational Speed (km/h)	Module length (km)	Average vehicle numbers per hour	Sound Power Level (dB(A))
High-Speed Oval	Acceleration tests	50 - 250	17	31	118.5
Access Roads (onsite)	Acceleration tests	0 - 100	2.5	25	99.9
DPF Road	Constant driving	10 - 30	0.8	25	84.2
Handling Track	Vehicle handling (acceleration/breaking)	50 - 230	5.8	11	118.5
Multi-Functional Area	Steering tests	up to 120	0.8	150	105.2
Bad Roads	Comfort and corrosion tests	40 - 80	10	6	97.0

Table 7: Acoustic model inputs for heavy vehicles on site

HEAVY VEHICLES	Location	Operational Speed (km/h)	Number to and from site/month	Sound Power Level (dB(A))
Test car delivery trucks	External Access Road	80	4	103.0
Test equipment deliveries	External Access Road	80	2	103.0
Fuel tankers	External Access Road	80	6	104.0
Waste trucks	External Access Road	80	1	107.0
Sewerage trucks	External Access Road	80	2	107.0
Hazardous waste trucks	External Access Road	80	1	107.0
Used tyre trucks	External Access Road	80	1	113.0
Technical service providers	External Access Road	80	4	103.0

Table 8: Acoustic model inputs for employee vehicles

EMPLOYEE VEHICLES	Location	Operational Speed (km/h)	Number to and from site/day	Sound Power Level (dB(A))
Mini-bus	External Access Road	80	2	82.0
Test cars	External Access Road	80	20	97.0
Other light vehicles	External Access Road	80	8	96.5

Table 9: Acoustic model inputs for other sources on site

OTHER SOURCES	Location	Number	Sound Power Level (dB(A))
Generators	Building Area	2	95

MODELLING SCENARIOS

To effectively assess the impact of the Proposed High-Speed Proving Ground on ambient noise levels, the following scenarios have been developed and are assessed in the acoustic model:

- → Scenario 1 – Construction Phase;
- → Scenario 2 – Construction Phase during a blasting event; and
- → Scenario 3 – Operational Phase.

NOISE RECEIVERS

In order to assess the impact of the construction and operation of the Proposed High-Speed Proving Ground on the existing noise climate in the region, the baseline and predicted (modelled) noise levels at certain identified receptor locations (noise receivers) were compared to assess changes in noise levels with the introduction of the Proposed High-Speed Proving Ground. Such noise levels were also compared with the SANS rating levels to determine compliance (**Table 3**) as well as the SANS categories of community response (**Table 4**) to assess the impacts of any increases in noise levels.

The noise receivers identified in the region surrounding the Proposed High-Speed Proving Ground include the town of Upington, as well as various neighbouring smallholdings (farm houses (FH)) (**Figure 4** and **Table 10**). It must be noted that the majority of these receivers are located too far from the proposed site to be impacted on and as such not all receivers were included in the acoustic model.

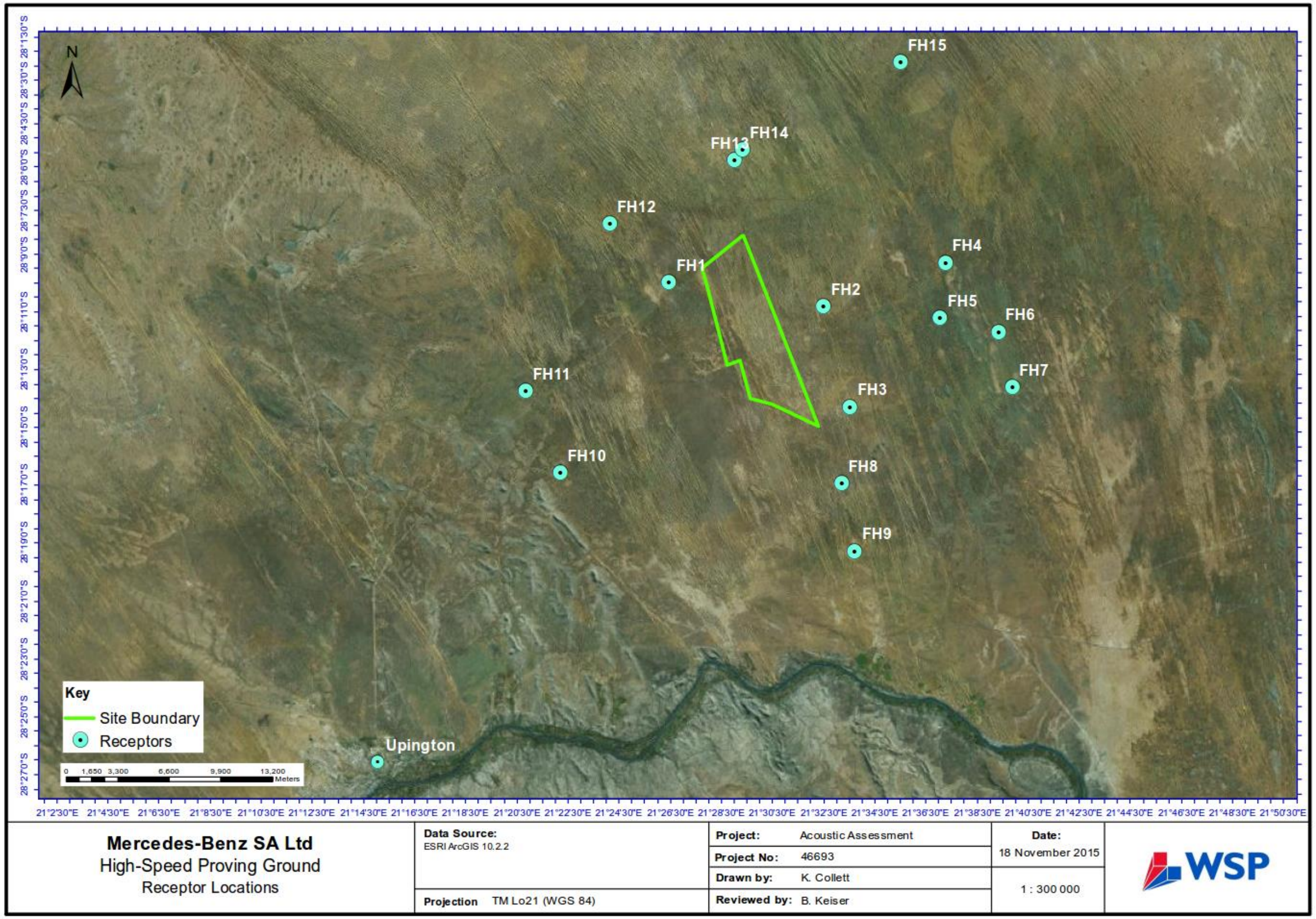

Figure 4: Location of noise receivers surrounding the Proposed High-Speed Proving Ground

Table 10: Locations and distances of the noise receivers surrounding the Proposed High-Speed Proving Ground

Receiver	Distance from Nearest Site Boundary (m)	Latitude (°S)	Longitude (°E)
FH1	2,400	28.1657	21.4392
FH2	3,200	28.1791	21.5397
FH3	2,400	28.2369	21.5574
FH4	11,400	28.1535	21.6189
FH5	9,800	28.1856	21.6157
FH6	12,700	28.1930	21.6536
FH7	12,500	28.2249	21.6629
FH8	3,700	28.2811	21.5520
FH9	8,100	28.3199	21.5607
FH10	13,000	28.2751	21.3686
FH11	13,000	28.2283	21.3463
FH12	6,600	28.1316	21.4004
FH13	5,000	28.0945	21.4813
FH14	5,600	28.0887	21.4867
FH15	15,000	28.0381	21.5891
Upington	31,600	28.4249	21.2573

6 ASSUMPTIONS

In this environmental acoustic impact assessment, various assumptions were made that may impact on the results obtained. These assumptions include:

- The information provided regarding the construction and operational activities is assumed to be representative of what will occur in reality;
- It is assumed that all proposed noise sources for the Proposed High-Speed Proving Ground have been included in this assessment;
- During the construction phase, all equipment will be operational simultaneously;
- The highest sound power levels for equipment without provided specifications were selected;
- All mining and general construction equipment will be operational during the construction phase;
- Sources with the highest sound levels are placed in closest proximity to the nearest receptors (farm houses);
- Light duty vehicles were not included during the construction phase, as when compared to other noise sources (machinery) on site, such noise will be negligible;
- As a worst case, all test modules will operate simultaneously for twelve hours a day;
- As a worst case, the maximum operational speed for each test module was used in the acoustic model;
- The operational speed of the off-site roads was based on the speed limit (80 km/h) of these roads;
- Generators will be operational 24 hours a day;
- Light duty vehicles operating around the building area during the operational phase are excluded from this assessment as noise from this source will be negligible; and
- As a worst case, all heavy duty vehicles associated with the operational phase will operate on the off-site access road on the same day.

7 RESULTS AND DISCUSSION

Predicted noise levels from the Proposed High-Speed Proving Ground during both the construction and operational phases are presented here. Construction activities will only occur during daytime hours, so no night-time modelled results are presented for the construction phase. During the operational phase, test modules and general vehicle movement will be operational during daytime hours (08:00 – 20:00), while the only source of noise at night will be the on-site generators.

It must be noted that the visual outputs presented here are for the Proposed High-Speed Proving Ground operations only and are not cumulative (i.e. taking the existing background noise levels into account). For each receiver point, the current sound levels are evaluated against the predicted noise levels (modelled) to assess the change in sound levels as a result of the Proposed High-Speed Proving Ground. Cumulative sound levels (current and predicted together) are also presented for each receiver, however, it must be noted that since sound levels are represented in logarithmic units, simple addition cannot be applied to obtain the cumulative sound levels, but rather logarithmic addition.

7.1 CONSTRUCTION PHASE

Table 11 presents the predicted daytime sound levels at the three nearest receiver locations (farm houses) during the construction phase of the Proposed High-Speed Proving Ground. Predicted noise levels are compared with the existing baseline noise levels as well as the SANS rural guideline level to evaluate compliance. A graphical output of the modelled results for the construction phase is presented in **Figure 5**.

Predicted daytime noise levels at the nearest farm house receptors are low, with no changes in the existing noise levels predicted. Noise levels within the boundary of the High-Speed Proving Ground will be elevated, but due to the distance of the receivers away from the proposed site, noise generated during the construction phase will not negatively impact on the existing noise climate at these receivers. The highest noise levels are predicted around the quarry and borrow pit areas as well as at locations scattered along the high-speed oval, dependant on where specific construction equipment will be located at a given time.

During a blasting event, the same noise levels at the nearest farm houses as those predicted in the construction scenario are noted (**Table 11**). Higher noise levels are predicted around the specific blasting sites (**Figure 6**), however, blasting associated noise is very localised and does not propagate to any of the farm house locations. Although the noise impacts of the blasts may not be sensed at the receiver locations, it must be noted that in addition to the noise impacts of a blasting event, air over pressure and ground-borne vibration impacts may also be noted. Such impacts were beyond the scope of this environmental acoustic impact assessment and as such were not assessed.

Table 11: Daytime acoustic model results during the construction phase of the Proposed High-Speed Proving Ground

Receiver	Predicted Noise Level (dB(A))	Existing Daytime Noise Level (dB(A))	Cumulative Noise Level (dB(A))	Change (dB(A))	SANS Guideline (dB(A))	Compliant
FH1	0	45	45	0	45	Yes
FH2	0	45	45	0	45	Yes
FH3	0	45	45	0	45	Yes

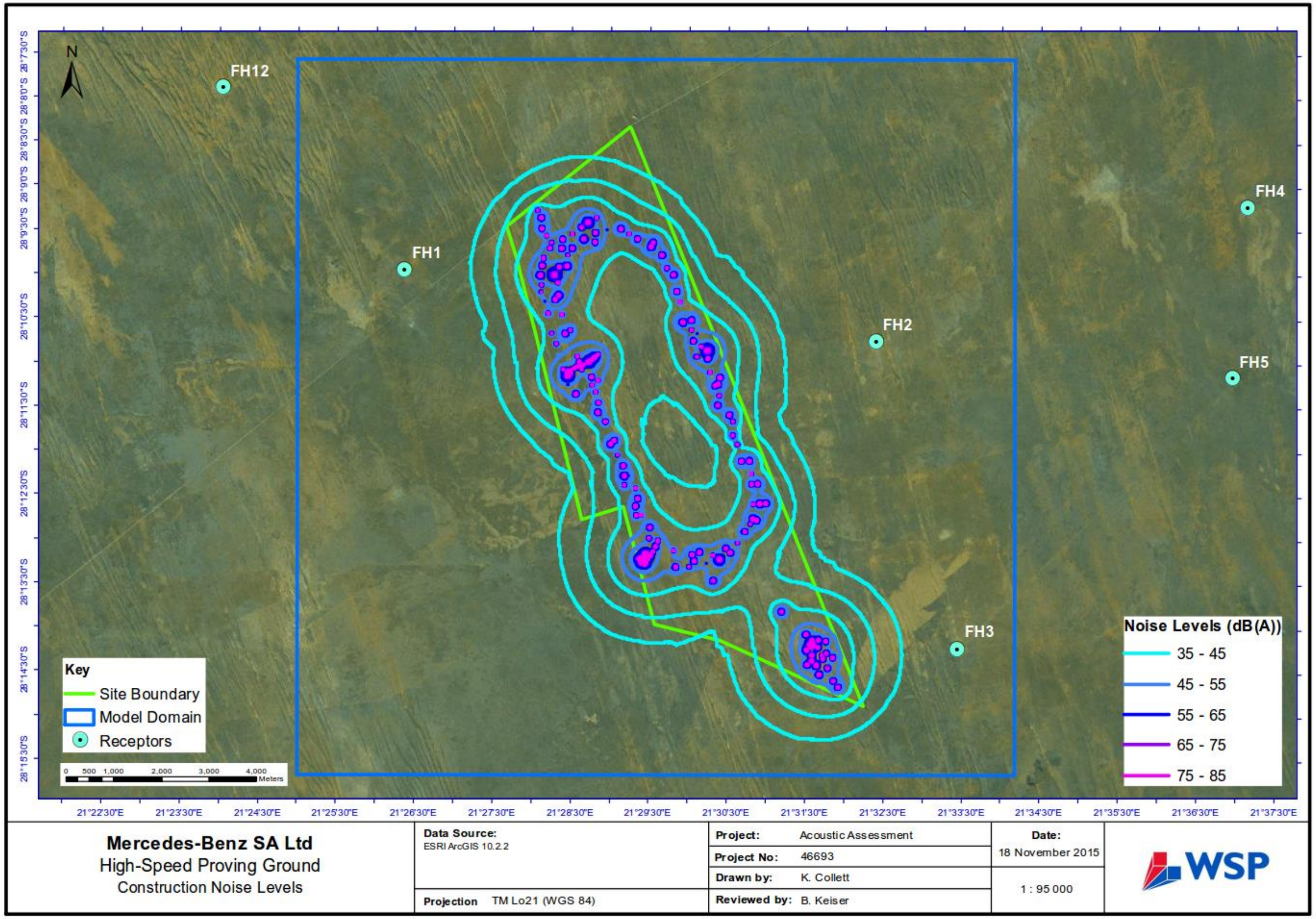

Figure 5: Predicted daytime noise levels during the construction phase of the Proposed High-Speed Proving Ground

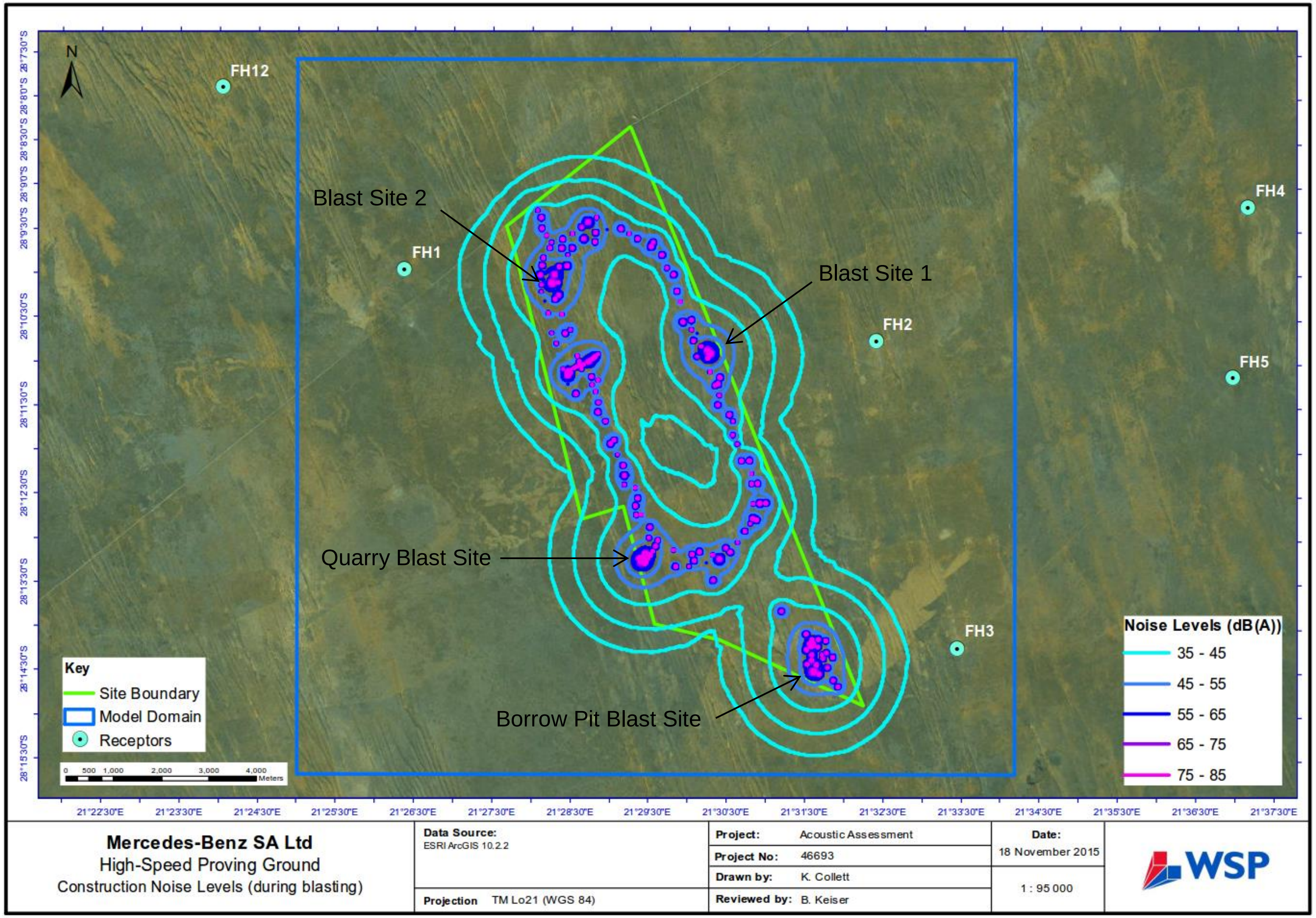

Figure 6: Predicted daytime noise levels during the construction phase (during blasting) of the Proposed High-Speed Proving Ground

7.2 OPERATIONAL PHASE

Table 12 and **Table 13** present the predicted daytime and night-time noise levels at the three nearest receiver locations during the operational phase of the Proposed High-Speed Proving Ground. Predicted noise levels are compared with the existing baseline noise levels as well as the SANS rural guideline to evaluate compliance. A graphical output of the modelled results for the operational phase is presented in **Figure 7**.

Predicted daytime noise levels at all receiver locations are low with noise associated with the operation of the High-Speed Proving Ground only perceived at one receiver location (FH1). This farm house is located approximately 650 m from the off-site access road. Noise from test vehicles and heavy duty vehicles travelling along this road may be detected at this location, but not to such an extent as to increase noise levels above the existing levels experienced at this location. The highest noise levels are predicted along the high-speed oval, multifunctional area and handling track.

At night, predicted noise levels are very low, with the on-site generators being the only noise sources. No increases in noise levels at any of the receiver locations are predicted. Due to the very localised nature of the noise impacts from the generators, no night-time output plots are presented for the operational phase.

Table 12: Daytime acoustic model results during the operational phase of the Proposed High-Speed Proving Ground

Receiver	Predicted Noise Level (dB(A))	Existing Daytime Noise Level (dB(A))	Cumulative Noise Level (dB(A))	Change (dB(A))	SANS Guideline (dB(A))	Compliant
FH1	23	45	45	0	45	Yes
FH2	0	45	45	0	45	Yes
FH3	0	45	45	0	45	Yes

Table 13: Night-time acoustic model results during the operational phase of the Proposed High-Speed Proving Ground

Receiver	Predicted Noise Level (dB(A))	Existing Daytime Noise Level (dB(A))	Cumulative Noise Level (dB(A))	Change (dB(A))	SANS Guideline (dB(A))	Compliant
FH1	0	35	35	0	35	Yes
FH2	0	35	35	0	35	Yes
FH3	0	35	35	0	35	Yes

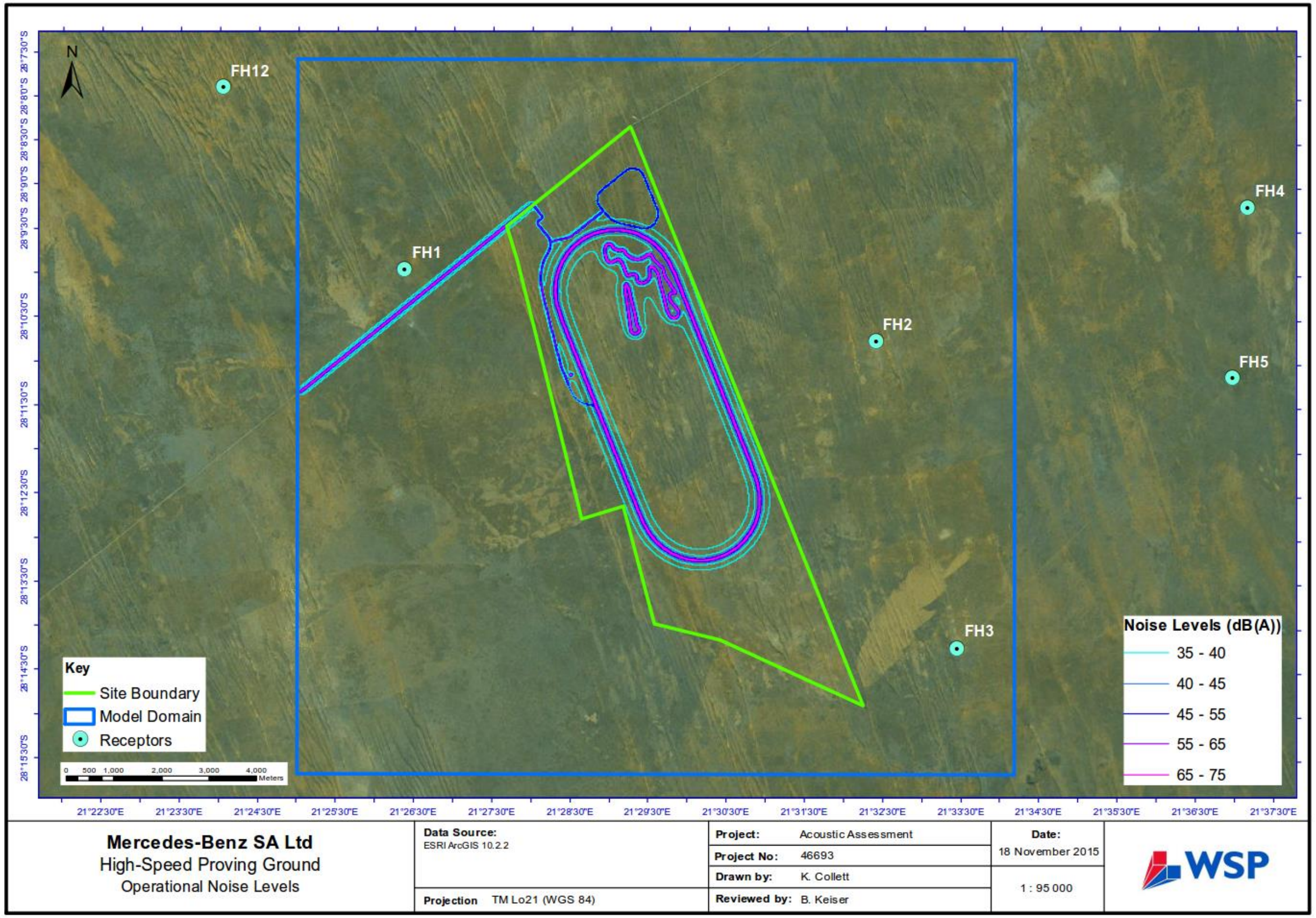

Figure 7: Predicted daytime noise levels during the operational phase of the Proposed High-Speed Proving Ground

7.3 MITIGATION RECOMMENDATIONS

Since noise associated with the construction and operation of the Proposed High-Speed Proving Ground will not impact on any surrounding receptors, no specific noise mitigation interventions are recommended. Should MBSA want to decrease construction noise even further, the following mitigation options can be employed:

- Installation of mufflers on exhausts of construction vehicles;
- Selection of construction equipment with lower sound power levels; and
- The use of ear protection equipment for personnel working onsite in close proximity to noise sources.

Although noise associated with blasting activities will not impact on the noise climate at any of the receiver locations, adequate blasting management techniques should be employed. This includes:

- Informing nearby residents as to when blasting will occur on a certain day at a given time;
- Not blasting after daytime hours; and
- Consideration for livestock that currently graze on the land and timeously moving them off site when a blast is to occur.

8 IMPACT ASSESSMENT

The purpose of this environmental acoustic impact assessment is to identify the potential impacts of the construction and operation of the Proposed High-Speed Proving Ground on the noise climate of the area. The outcomes of the impact assessment provide a basis to make informed decisions to ensure that there is not unacceptable social or environmental impact of the proposed facility.

The impact assessment was evaluated using the Hackings risk matrix, which is a semi-quantitative risk assessment methodology. This system derives an environmental impact level on the basis of the severity, extent, duration, probability and confidence of potentially significant impacts. The overall risk level is determined using professional judgement based on a clear understanding of the nature of the impact, potential mitigatory measures that can be implemented and changes in risk profile as a result of implementation of these mitigatory measures. A full description of the risk rating methodology is presented in **Appendix A**.

Outcomes of the acoustic impact assessment are presented in **Table 14** outlining the impact of each parameter and the resulting risk level during the construction and operational phases. Based on the distance of the residential receptors from the proposed site, the acoustic impacts during both the construction and operational phases of the Proposed High-Speed Proving Ground are deemed “Low”.

Table 14: Impact Assessment of Acoustic Risks Associated with the Proposed High-Speed Proving Ground

Description	Without Mitigation						With Mitigation					
	Severity	Duration	Extent	Consequence	Probability	**Risk Level**	Extent	Duration	Potential Intensity	Probability	Significance Weighting	**Risk Level**
Acoustic impacts on residential receptors (construction)	L	L	L	L	L	Low	L	L	L	L	L	Low
Acoustic impacts on residential receptors (operations)	L	L	L	L	L	Low	L	L	L	L	L	Low

9 CONCLUSIONS

This environmental acoustic impact assessment investigated noise associated with the construction and operation of the Proposed High-Speed Proving Ground near Upington in the Northern Cape. Due to the remoteness of the proposed site, no baseline acoustic monitoring was performed but rather the SANS guideline rating level for noise in rural districts was considered to be a reasonable representation of the current noise climate in the area.

Acoustic model results confirmed that noise levels at all nearby farm house receptor locations will be low, with no changes in the existing noise levels predicted during both the construction and operational phases. The highest noise levels during the construction phase are predicted around the quarry and borrow pit areas as well as at locations scattered along the high-speed oval, dependant on where specific construction equipment will be located at a given time. The highest noise levels during the operational phase are predicted along the high-speed oval, multifunctional area and handling track.

The acoustic impacts of the Proposed High-Speed Proving Ground were evaluated using a risk matric which assessed the severity, extent, duration, probability and confidence of potentially significant impacts. Based on this rating system, it was calculated that the acoustic impacts of the proposed project are expected to be “Low”.

10 REFERENCES

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Appendix A

IMPACT RATING METHODOLOGY

In accordance with GNR 982, promulgated in terms of Section 24(J) of the National Environmental Management Act, 1998 (Act 107 of 1998), the significance of potential impacts are assessed in terms of the following criteria:

- Cumulative impacts;
- The nature, significance and consequences of the impact and risk;
- The extent and duration of the impact and risk;
- The probability of the impact and risk occurring;
- The degree to which the impact and risk can be reversed;
- The degree to which the impact and risk may cause irreplaceable loss of resources; and
- The degree to which the impact and risk can be mitigated.

The significance of environmental aspects can be determined and ranked by considering the criteria presented in **Table 15**. In some cases it may be necessary to undertake the impact assessment to determine whether a particular aspect is significant. Therefore, a fair degree of iteration is unavoidable during the assessment process.

Table 15: Criteria Used to Determine the Significance of Environmental Aspects

Significance Ranking	Negative Aspects	Positive Aspects
H (High)	Will always/often exceed legislation or standards. Have characteristics that could cause significant negative impacts.	Compliance with all legislation and standards. Have characteristics that could cause significant positive impacts.
M (Moderate)	Have characteristics that could cause negative impacts.	Have characteristics that could cause positive impacts.
L (Low)	Will never exceed legislation or standards. Unlikely to cause significant negative impacts.	Will always comply with all legislation and standards. Unlikely to cause significant positive impacts.

Where significant environmental aspects are present ("high" or "moderate"), significant environmental impacts may result. The significance of the impacts associated with the significant aspects can be determined by considering the risk:

- Significance of Environmental Impact (Risk) = Probability x Consequence
- The consequence of impacts can be described by considering the severity, spatial extent and duration of the impact.

SEVERITY OF IMPACTS

Table 16 presents the ranking criteria that can be used to determine the severity of impacts on the bio-physical and socio-economic environment. **Table 17** provides additional ranking criteria for determining the severity of negative impacts on the bio-physical environment.

Table 16: Criteria for Ranking the Severity of Environmental Impacts

	Negative			Positive		
Criteria	High-	Medium-	Low-	Low+	Medium+	High+
Qualitative	Substantial deterioration. Death, illness or injury.	Moderate deterioration. Discomfort.	Minor deterioration. Nuisance or minor irritation.	Minor improvement.	Moderate improvement.	Substantial improvement.
Quantitative	Measurable deterioration.		Change not measurable i.e. will remain within current range.		Measurable improvement.	

	Recommended level will often be violated.	Recommended level will occasionally be violated.	Recommended level will never be violated.	Will be within or better than recommended level.	
Community Response	Vigorous community action.	Widespread complaints.	Sporadic complaints.	No observed reaction.	Favourable publicity

Table 17: Criteria for Ranking the Severity of Negative Impacts on the Bio-physical Environment

Ranking Criteria			
	Low (L-)	**Medium (M-)**	**High (H-)**
Soils and land capability	Minor deterioration in land capability. Soil alteration resulting in a low negative impact on one of the other environments (e.g. ecology).	Partial loss of land capability. Soil alteration resulting in a moderate negative impact on one of the other environments (e.g. ecology).	Complete loss of land capability. Soil alteration resulting in a high negative impact on one of the other environments (e.g. ecology).
Ecology (Plant and animal life)	Disturbance of areas that are degraded, have little conservation value or are unimportant to humans as a resource. Minor change in species variety or prevalence.	Disturbance of areas that have some conservation value or are of some potential use to humans. Complete change in species variety or prevalence.	Disturbance of areas that are pristine, have conservation value or are an important resource to humans. Destruction of rare or endangered species.
Surface and Groundwater	Quality deterioration resulting in a low negative impact on one of the other environments (ecology, community health etc.)	Quality deterioration resulting in a moderate negative impact on one of the other environments (ecology, community health etc.).	Quality deterioration resulting in a high negative impact on one of the other environments (ecology, community health etc.).

SPATIAL EXTENT AND DURATION OF IMPACTS

The duration and spatial scale of impacts can be ranked using the criteria in **Table 18**:

Table 18: Ranking the Duration and Spatial Scale of Impacts

Ranking Criteria			
	Low (L-)	**Medium (M-)**	**High (H-)**
Duration	Quickly reversible (less than the project life - Short-Term)	Reversible over time (within life of the project - Medium-Term)	Permanent (beyond closure - Long-Term)
Spatial Scale	Localised (within site boundary - Site)	Fairly widespread (beyond site boundary – Local)	Widespread (far beyond site boundary – Regional / National)

Where the severity of an impact varies with distance, the severity should be determined at the point of compliance or the point at which sensitive receptors will be encountered. This position corresponds to the spatial extent of the impact.

CONSEQUENCE OF IMPACTS

Having ranked the severity, duration and spatial extent, the overall consequence of impacts can be determined using the following qualitative guidelines:

Table 19: Ranking the Consequence of an Impact

Severity = L

DURATION	Long Term	**H**	**Medium**	**Medium**	**Medium**
	Medium Term	**M**	**Low**	**Low**	**Medium**
	Short Term	**L**	**Low**	**Low**	**Medium**

Severity = M

DURATION	Long Term	**H**	**Medium**	**High**	**High**
	Medium Term	**M**	**Medium**	**Medium**	**High**
	Short Term	**L**	**Low**	**Medium**	**Medium**

Severity = H

DURATION	Long Term	**H**	**High**	**High**	**High**
	Medium Term	**M**	**Medium**	**Medium**	**High**
	Short Term	**L**	**Medium**	**Medium**	**High**
			Low	**Medium**	**High**
			Localised - within site boundary (Site)	Fairly widespread - beyond site boundary (Local)	Widespread - Far beyond site boundary (Regional/National)
			SPATIAL SCALE		

To use **Table 19**, firstly go to one of the three "layers" based on the severity ranking obtained from **Table 16** and/ or **Table 17**. Thereafter determine the consequence ranking by locating the intersection of the appropriate duration and spatial scale rankings.

OVERALL SIGNIFICANCE OF IMPACTS

Combining the consequence of the impact and the probability of occurrence, as shown by **Table 20**, provides the overall significance (risk) of impacts.

Table 20: Ranking the Overall Significance of Impacts

Probability	Definite Continuous	H	Medium	Medium	High
	Possible Frequent	M	Medium	Medium	High
	Unlikely Seldom	L	Low	Low	Medium
			Low	Medium	High
			CONSEQUENCE (from Table 19)		

The overall significance ranking of the negative environmental impacts provides the following guidelines for decision making (**Table 21**):

Table 21: Guidelines for decision-making

	Nature of Impact	Decision Guideline
High	Unacceptable impacts	Likely to be a fatal flaw.
Moderate	Noticeable impact	These are unavoidable consequence, which will need to be accepted if the project is allowed to proceed.
Low	Minor impacts	These impacts are not likely to affect the project decision.