Blast Management & Consulting

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Report: Blast Impact Assessment Environmental Authorisation for the proposed Exxaro Dorstfontein Mine extension of Pit 1 Project	
Date:	17 May 2017
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ii. Study Team Qualifications and Background

The study team comprises J D Zeeman (as the member of Blast Management & Consulting) and Blast Management & Consulting employees. Blast Management & Consulting's main areas of concern are pre-blast consultation and monitoring, insitu monitoring, post-blast monitoring and consulting as well as specialised projects. Blast Management & Consulting has been active in the mining industry since 1997 and work has been done at various levels for mining companies in South Africa, Botswana, Namibia, Mozambique, Democratic Republic of Congo, Sierra Leone and Côte d'Ivoire.

J D Zeeman holds the following qualifications:

1985 - 1987	Diploma: Explosives Technology, Technikon Pretoria
1990 - 1992	BA Degree, University of Pretoria
1994	National Higher Diploma: Explosives Technology, Technikon Pretoria
1997	Project Management Certificate, Damelin College
2000	Advanced Certificate in Blasting, Technikon SA

Member: International Society of Explosive Engineers

iii. Independence Declaration

Blast Management & Consulting is an independent company. The work done for the report was performed in an objective manner and according to national and international standards, which means that the results and findings may not all be positive for the client. Blast Management & Consulting has the required expertise to conduct such an investigation and draft the specialist report relevant to the study. Blast Management & Consulting did not engage in any behaviour that could be result in a conflict of interest in undertaking this study.

iv. Legal Requirements

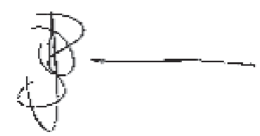
In terms of the NEMA 2014 EIA Regulations contained in GN R982 of 04 December 2014 all specialist studies must comply with Appendix 6 of the NEMA 2014 EIA Regulations (GN R982 of 04 December 2014). Table 1 show the requirements as indicated above.

Table 1: Legal Requirements for All Specialist Studies Conducted

Legal Requirement		**Relevant Section in Specialist study**
(1)	A specialist report prepared in terms of these Regulations must contain-	
(a)	details of-	
	(i) the specialist who prepared the report; and	i
	(ii) the expertise of that specialist to compile a specialist report including a curriculum vitae	Section ii and 21
(b)	a declaration that the specialist is independent in a form as may be specified by the competent authority;	Section iii
(c)	an indication of the scope of, and the purpose for which, the report was prepared;	Section 4
(d)	the date and season of the site investigation and the relevance of the season to the outcome of the assessment;	Section 7
(e)	a description of the methodology adopted in preparing the report or carrying out the specialised process	Section 6
(f)	the specific identified sensitivity of the site related to the activity and its associated structures and infrastructure;	Section 10
(g)	an identification of any areas to be avoided, including buffers;	Section 10
(h)	a map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers;	Section 13 & 15
(i)	a description of any assumptions made and any uncertainties or gaps in knowledge;	Section 8
(j)	a description of the findings and potential implications of such findings on the impact of the proposed activity, including identified alternatives on the environment;	Section 15
(k)	any mitigation measures for inclusion in the EMPr;	Section 15.13
(l)	any conditions/aspects for inclusion in the environmental authorisation;	Section 18
(m)	any monitoring requirements for inclusion in the EMPr or environmental authorisation;	Section 18.10
(n)	a reasoned opinion (Environmental Impact Statement)-	Section 20

Legal Requirement		**Relevant Section in Specialist study**
	as to whether the proposed activity or portions thereof should be authorised; and	Section 20
	if the opinion is that the proposed activity or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the EMPr, and where applicable, the closure plan;	Section 20
(o)	a description of any consultation process that was undertaken during the course of preparing the specialist report;	Section 11
(p)	a summary and copies of any comments received during any consultation process and where applicable all responses thereto; and	None
(q)	any other information requested by the competent authority.	None

v. Document Control:

Name & Company	Responsibility	Action	Date	Signature
C Zeeman Blast Management & Consulting	Document Preparation	Report Prepared	17/05/2017	
JD Zeeman Blast Management & Consulting	Consultant	Report Finalise	17/05/2017	

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List of Acronyms used in this Report

a and b	Site Constant
ANFO	Ammonium nitrate fuel oil
APP	Air Pressure Pulse
B	Burden (m)
BH	Blast Hole
BM&C	Blast Management & Consulting
Bs	Scaled Burden ($m^{3/2}kg^{-1/2}$)
D	Distance (m)
D	Duration (s)
E	East
E	Explosive Mass (kg)
EIA	Environmental Impact Assessment
Freq.	Frequency
GRP	Gas Release Pulse
I&AP	Interested and Affected Parties
k	Factor value
L	Maximum Throw (m)
Lat/Lon hddd°mm'ss.s"	Latitude/Longitude Hours/degrees/minutes/seconds
M	Charge Height
m (SH)	Stemming height
M/S	Magnitude/Severity
Mc	Charge mass per metre column
N	North
NE	North East
NO	Nitrogen Monoxide
NO_2	Nitrogen Dioxide
NOx	Nitrogen Oxide
NOx's	Noxious Fumes
NW	North West
P	Probability
POI	Points of Interest
PPD	Peak particle displacement
PPV	Peak Particle Velocity
PVS	Peak vector sum
RPP	Rock Pressure Pulse
S	Scale
S	South
SE	South East
SH	Stemming height (m)

SW	South West
T	Blasted Tonnage
TNT	Explosives (Trinitrotoluene)
USBM	United States Bureau of Mine
W	West
WGS 84	Coordinates (South African)
WM	With Mitigation Measures
WOM	Without Mitigation Measures

List of Units used in this Report

%	percentage
cm	centimetre
dB	decibel
dBL	linear decibel
g	acceleration
g/cm^3	gram per cubic centimetre
Hz	frequency
kg	kilogram
kg/m^3	kilogram per cubic metre
kg/t	kilogram per tonne
km	kilometre
kPa	kilopascal
m	metre
m^2	metre squared
MJ	Mega Joules
MJ/m^3	Mega Joules per cubic meter
MJ/t	Mega Joules per tonne
mm/s	millimetres per second
mm/s^2	millimetres per second square
ms	milliseconds
Pa	Pascal
ppm	parts per million
psi	pounds per square inch
θ	theta or angle

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1 Executive Summary

Blast Management & Consulting (BM&C) was contracted as part of the Environmental Impact Assessment (EIA) to perform review of possible impacts with regards to blasting operations on the proposed extension of Pit 1 of the Dorstfontein East Mine Project located in the Mpumalanga Province of South Africa. Ground vibration, air blast, fly rock and fumes are some of the aspects resulting from blasting operations. The report concentrates on the possible influences of ground vibration, air blast and fly rock. It intends to provide information, calculations, predictions, possible influences and mitigation of blasting operations for the project.

The evaluation of effects yielded by blasting operations was evaluated over an area as wide as a 3500 m radius from where blasting will take place. The range of structures observed and considered in this evaluation ranged between rural buildings, farm buildings, industrial buildings, power lines and provincial roads.

The project area does have houses and communities at very close distance to the project area. The nearest house or buildings is found 293 m away. There are various farmsteads and small settlements in the area. Specific attention will be required for adjustments in the blasting operations to ensure expected levels of ground vibration and air blast are within the required limits. Consideration will need to be given to relocation of households in close proximity to the pit area. A recommended distance should at least be all within 500 m from area. There are also regulations that will need to be followed for permission to conduct blasting operations as these installations area within 500 m from the blast operations. Ground vibration at structures and installations other than the identified problematic structures is well below any specific concern for inducing damage. The ground vibration levels predicted for all installations evaluated surrounding the pit area ranged between 0.9 mm/s and very high. Ground vibration levels at the nearest buildings where people may be present is 28.7 mm/s.

Air blast predicted for the maximum charge ranges between 105 and 143 dB for all the POI's considered. Air blast observed and predicted showed greater concern than ground vibration. In view of the predicted levels the probability of damages exist if blasting operations does not take careful planning of stemming length and material into consideration. Damages are only expected to occur at levels greater than 134dB. On prediction it is expected that air blast will be greater than 134 dB at a distance of 500 m and closer to the pit boundary. Various private installation is within 500 m from the pit boundary. Air blast that could lead to complaints is expected to reach distances of 1250 m from the pit area. The levels at other private houses or settlements are expected to be within limits and not damaging.

An exclusion zone for safe blasting was also calculated. The exclusion zone was established to be at least 297 m. Normal practice observed in mines is a 500 m exclusion zone. The minimum distance recommended is 297 m. This distance may be greater but not less.

Recommendations were made that should be considered, specifically for review of blast designs, monitoring of ground vibration and air blast, safe blasting zones, safe ground vibration and air blast limits, blast designs, blasting times and relocations of infrastructure to be considered.

Providing opinion if the project may continue it can be indicated that only with recommended mitigations and careful planning of blasting operations it is possible. The pit is located such that free blasting will not be possible and will require detail planning and considerations of the recommendations. Considering this there is no reason to believe that this operation cannot continue.

This concludes this investigation for the extension of Pit 1 of the Dorstfontein East Mine Project.

2 Introduction

Exxaro Coal plan to undertake the necessary Environmental Authorisation (EA) process for the extension of Pit 1, the pipeline from Dorstfontein West to Dorstfontein East and the disposal of discard into the opencast pit. This supplementary footprint does not fall within the existing EMP, thus authorization will be sought for the proposed infrastructure in terms of the National Environmental Management Act (Act No 107 of 1998) [NEMA]. National Water Act (Act No. 38 of 1996) [NWA], and the Minerals and Petroleum Resources Development Act (Act No. 28 of 2002) [MPRDA]. This would also include the amendment of the EMP.

The existing Total Coal South Africa Dorstfontein Coal Mine is located immediately to the north east of the town of Ga-Nala (Kriel) in the Mpumalanga Province, South Africa at coordinates (Lat/Lon WGS84) 26°11'39.21"S 29°19'46.76"E.

The proposed Dorstfontein Coal Mine expansion, which includes two new opencast pits, a discard dump, a rail link, a water pipeline, as well as a future mining area which was also included in this study, will take place within the existing mining right area on the farms adjacent to Dorstfontein Mine.

As part of Environmental Impact Assessment (EIA), Blast Management & Consulting (BM&C) was contracted to perform a review of possible impacts from blasting operations for the proposed new open pit coal mining operation. Ground vibration, air blast and fly rock are some of the aspects that result from blasting operations and this study considers the possible influences that blasting may have on the surrounding area in this respect. The report concentrates on ground vibration and air blast and intends to provide information, calculations, predictions, possible influences and mitigating aspects of blasting operations for the project.

3 Objectives

The objectives of this document are to outline the expected environmental effects that blasting operations at the Dorstfontein Mine Project could have on the surrounding environment and to propose specific mitigation measures if required. This study investigates the related influences of expected ground vibration, air blast and fly rock. These effects are investigated in relation to the blast site area and surrounds and the possible influence on nearby private installations, houses and the owners or occupants.

The objectives were dealt with whilst taking specific protocols into consideration. The protocols applied in this document are based on the author’s experience, guidelines taken from literature research, project applicant requirements and general indicators in the various appropriate pieces of South African legislation. There is no direct reference in the following acts regarding requirements and limits on the effect of ground vibration and air blast and some of the aspects addressed in this report:

- National Environmental Management Act, 1998 (Act No. 107 of 1998) (NEMA)
- Mine Health and Safety Act, 1996 (Act No. 29 of 1996)
- Mineral and Petroleum Resources Development Act, 2002 (Act No. 28 of 2002) (MPRDA)
- Explosives Act, 2003 (Act No. 15 of 2003)

The guidelines and safe blasting criteria are based on internationally accepted standards and specifically criteria for safe blasting for ground vibration and recommendations on air blast published by the United States Bureau of Mines (USBM). There are no specific South African standards and the USBM is well accepted as a standard for South Africa. Additional restrictions are also considered where necessary. Specifically, where a structure of lesser integrity is observed i.e. traditional built structures.

4 Scope of Blast Impact Study

The scope of the study is determined by the terms of reference to achieve the objectives. The terms of reference can be summarised according to the following steps taken as part of the EIA study with regards to ground vibration, air blast and fly rock due to blasting operations.

- Site specific evaluation of blasting operations according to the following:
    - Evaluation of expected ground vibration levels from blasting operations at specific distances and on structures in surrounding areas
    - Evaluation of expected ground vibration influence on neighbouring communities
    - Evaluation of expected blasting influence on national and provincial roads surrounding the blasting operations, if present
    - Evaluation of expected ground vibration levels on water boreholes if present within 500 m from blasting operations
    - Evaluation of expected air blast levels at specific distances from the operations and possible influence on structures
    - Evaluation of fly rock unsafe zone
    - Discussion on the occurrence of noxious fumes and dangers of fumes
    - Evaluation of the location of blasting operations in relation to surrounding areas according to the regulations from the applicable Acts

- Undertake an impact assessment and identify suitable mitigation measures

5 Study Area

The existing Total Coal South Africa Dorstfontein Coal Mine is located immediately to the north east of the town of Ga-Nala (Kriel) in the Mpumalanga Province, South Africa at coordinates (Lat/Lon WGS84) 26°11'39.21"S 29°19'46.76"E.

Figure 1 shows a Regional Map of the proposed Project area. Figure 2 shows the Proposed Layout Plan.

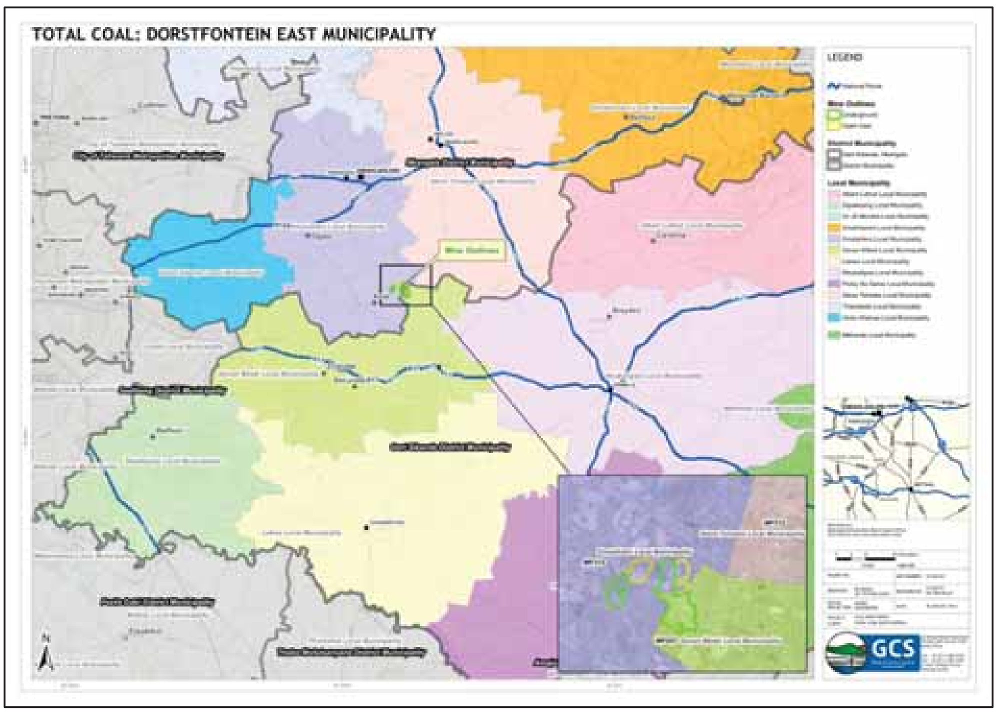


Figure 1: Regional Map of the proposed Project area

Figure 2: Proposed Pit 1 Extension Plan

6 Methodology

The detailed plan of study consists of the following sections:

- Baseline influence: The Dorstfontein Mine is active and ground vibration and air blast recorded for the mine is used as base line.
- Identifying surface structures/ installations that are found within reason from the project site. A list of Point of Interests (POI's) were created that will be used for the evaluation.
- Site evaluation: This entails an evaluation of the expected levels of ground vibration and air blast from blasting operations. Various accepted mathematical equations were applied to determine the attenuation of ground vibration, air blast and fly rock. These values were then calculated over the distance investigated from the site and shown as amplitude level contours. Overlaying these contours on the location of the various receptors gave an indication of the possible impacts and the expected results of potential impacts. Evaluation of each receptor according to the predicted levels further gave an indication of the possible mitigation measures to be applied. The possible

environmental or social impacts were addressed in the detailed EIA phase investigation.

7 Site Investigation

The site was visited and structure identification was done on various days including the 22nd August 2016, 09th & 12th September 2016 and 19th May 2017. This site visit was done specifically to get an understanding of the location of the open pit for the project and identifying the structures and installations surrounding the proposed open pit area.

The investigation and evaluation is not season specific. The operations are not season specific.

8 Assumptions and Limitations

The following assumptions have been made:

- The anticipated levels of influence estimated in this report are calculated using standard accepted methodology according to international and local regulations.
- The assumption is made that the predictions are a good estimate with significant safety factors to ensure that expected levels are based on worst case scenarios. These will have to be confirmed with actual measurements once the operation is active.
- The work done is based on the author's knowledge and information provided by the project applicant.

9 Legal Requirements

The protocols applied in this document are based on the author's experience, guidelines elicited by the literature research, project applicant requirements and general indicators provided in the various applicable South African Acts. There is no direct reference in the consulted acts specifically with regard to limiting levels for ground vibration and air blast. There is however specific requirements and regulations with regard to blasting operations and the effect of ground vibration and air blast and some of the aspects addressed in this report. The acts consulted are:

- National Environmental Management Act, 1998 (Act No. 107 of 1998) (NEMA)
- Mine Health and Safety Act, 1996 (Act No. 29 of 1996)
- Mineral and Petroleum Resources Development Act, 2002 (Act No. 28 of 2002) (MPRDA)
- Explosives Act, 2003 (Act No. 15 of 2003)

There are no specific South African standards providing limiting levels regarding ground vibration and air blast. The guidelines and safe blasting criteria applied in this study are as per internationally accepted standards, and specifically the United States Bureau of Mines (USBM) criteria for safe blasting for ground vibration and the recommendations on air blast. The USBM is well accepted as a standard for South Africa. Additional criteria required by various institutions in South Africa were also taken into consideration, i.e. Eskom, Telkom, Transnet, Rand Water Board, etc. as well as specific limitations regarding traditional built structures where applicable.

In view of the acts consulted the following guidelines and regulations are noted. Only parts of the acts were extracted:

- **Mine Health and Safety Act, 1996 (Act No. 29 of 1996)**

(Gazette No.17242, Notice No. 967 dated 14 June 1996. Commencement date: 15 January 1997 for all sections with the exception of sections 86(2) and (3), which came into operation on 15 January 1998, [Proc.No.4, Gazette No. 17725])

Mine Health and Safety Regulations

Precautionary measures before initiating explosive charges

4.7 The employer must take reasonable measures to ensure that when blasting takes place, air and ground vibrations, shock waves and fly material are limited to such an extent and at such a distance from any building, public thoroughfare, railway, power line or any place where persons congregate to ensure that there is no significant risk to the health or safety of persons.

General precautions

4.16 The employer must take reasonable measures to ensure that:

4.16(1) in any mine other than a coal mine, no explosive charges are initiated during the shift unless –

(a) such explosive charges are necessary for the purpose of secondary blasting or reinitiating the misfired holes in development faces;

(b) written permission for such initiation has been granted by a person authorised to do so by the employer; and

(c) reasonable precautions have been taken to prevent, as far as possible, any person from being exposed to smoke or fumes from such initiation of explosive charges;

4.16(2) no blasting operations are carried out within a horizontal distance of 500 metres of any public building, public thoroughfare, railway line, power line, any place where people congregate or any other structure, which it may be necessary to protect in order to prevent any significant risk, unless:

(a) a risk assessment has identified a lesser safe distance and any restrictions and conditions to be complied with;

(b) a copy of the risk assessment, restrictions and conditions contemplated, in paragraph (a) have been provided for approval to the Principal Inspector of Mines;

(c) shot holes written permission has been granted by the Principal Inspector of Mines; and

(d) any restrictions and conditions determined by the Principal inspector of Mines are complied with.

- **Mineral and Petroleum Resources Development Act, 2002 (Act No. 28 of 2002)**

(Gazette No. 23922, Notice No. 1273 dated 10 October 2002. Commencement date: 1 May 2004 [Proc. No. R25, Gazette No. 26264])

Mineral and Petroleum Resources Development Regulations

67. Blasting, vibration and shock management and control

(1) A holder of a right or permit in terms of the Act must comply with the provisions of the Mine Health and Safety Act, 1996, (Act No. 29 of 1996), as well as other applicable law regarding blasting, vibration and shock management and control.

(2) An assessment of impacts relating to blasting, vibration and shock management and control, where applicable, must form part of the environmental impact assessment report and environmental management programme or the environmental management plan, as the case may be.

10 Sensitivity of the Project

A review of the project and the surrounding areas is done before any specific analysis is undertaken and sensitivity mapping is undertaken based on typical areas and distance from the proposed pit area. This sensitivity map uses distances at which possible influences may occur and where influence is expected to be very low or none. Three different areas were identified in this regard:

- A highly sensitive area of 500 m around the mining area. Normally, this 500 m area is considered an area that should be cleared of all people and animals prior to blasting. Levels of ground vibration and air blast are also expected to be higher closer to the decline shaft area.
- An area 500 m to 1500 m around the shaft area can be considered as being a medium sensitive area. In this area, the possibility of impact is still expected, but is lower. The expected level of influence may be low, but there may still be reason for concern, as levels could be low enough not to cause structural damage but still result in a reaction by surrounding landowners/occupiers.

- An area greater than 1500 m is considered a low sensitivity area. In this area it is relatively certain that influences will be low with low possibility of damages or a reaction by surrounding landowners/occupiers.

Figure 3 shows the sensitivity mapping with the identified POI in the surrounding areas for the Open Pit for the proposed Dorstfontein Mine Project.

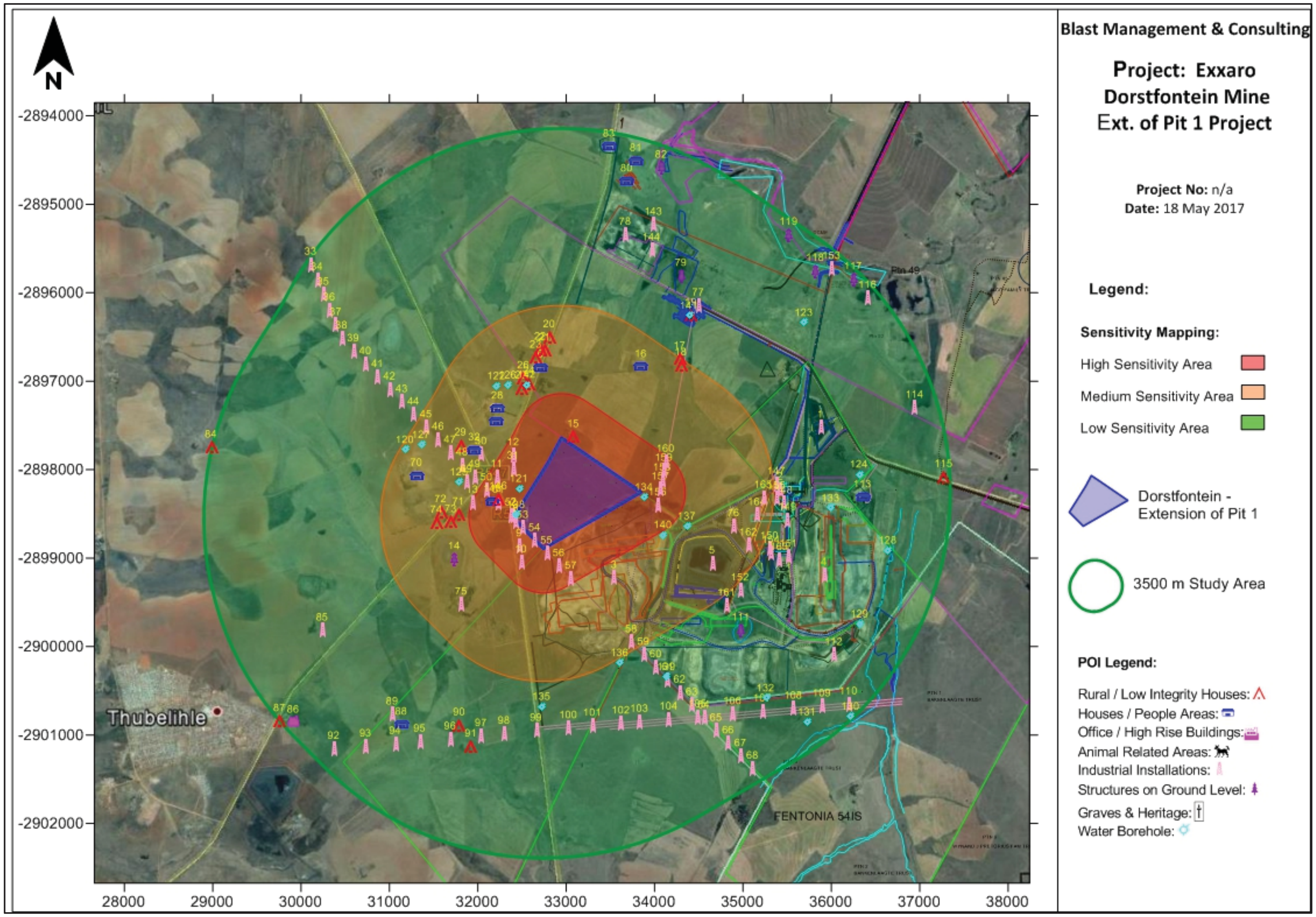


Figure 3: Identified sensitive areas

11 Consultation Process

SRK Consulting the lead consultant is responsible for the consultation process throughout the EIA. No specific consultation was done by the author with any external parties as part of the study.

12 Influence from Blasting Operations

Blasting operations are required to break rock for excavation to access the targeted ore material. Explosives in blast holes provide the required energy to conduct the work. Ground vibration, air blast and fly rock result from the blasting process. Based on the regulations of the different acts consulted and international accepted standards these effects are required to be within certain limits. The following sections provide guidelines on these limits. As indicated there are no specific South African ground vibration and air blast limit standards.

12.1 Ground Vibration Limitations on Structures

Ground vibration is measured in velocity with units of millimetres per second (mm/s). Ground vibration can also be reported in units of acceleration or displacement if required. Different types of structures have different tolerances to ground vibration. A steel structure or a concrete structure will have a higher resistance to vibrations than a well-built brick and mortar house. A brick and mortar house will be more resistant to vibrations than a poorly constructed or a traditional built mud house. Different limits are then applicable to the different types of structures. Limitations on ground vibration take the form of maximum allowable levels or intensity for different installations or structures. Ground vibration limits are also dependent on the frequency of the ground vibration. Frequency is the rate at which the vibration oscillates. Faster oscillation is synonymous with a higher frequency and lower oscillation is synonymous with a lower frequency. Lower frequencies are less acceptable than higher frequencies because structures have a low natural frequency. Significant ground vibration at low frequencies could cause increased structure vibrations due to the natural low frequency of the structure and this may lead to crack formation or damages to occur.

Currently, the USBM criteria for safe blasting are applied as the industry standard where private structures are of concern. Ground vibration amplitude and frequency is recorded and analysed. The data is then evaluated accordingly. The USBM graph is used for plotting of data and evaluating the data. Figure 4 below provides a graphic representation of the USBM analysis for safe ground vibration levels. The USBM graph is divided mainly into two parts. The red lines in the figure are the USBM criteria:

- Analysed data displayed in the bottom half of the graph shows safe ground vibration levels; and
- Analysed data displayed in the top half of the graph shows potentially unsafe ground vibration levels.

Added to the USBM graph is a blue line and green dotted line that represents 6 mm/s and 12.5 mm/s which are additional criteria that are used by BM&C. 6 mm/s is used for traditional built rural structures and 12.5 mm/s is used for structures that are considered being of lesser structural integrity than brick and mortar structures built according to building regulations.

Figure 4: USBM Analysis Graph

Additional limitations that should be considered were determined through research and prescribed by the various institutions; these are as follows:

- National roads/tar roads: 150 mm/s
- Steel pipelines: 50 mm/s (Rand Water Board)
- Electrical lines: 75 mm/s (Eskom)
- Sasol Pipe Lines: 25 mms/s (Sasol)
- Railways: 150 mm/s
- Concrete less than 3 days old: 5 mm/s

- Concrete after 10 days: 200 mm/s
- Sensitive plant equipment: 12 mm/s or 25 mm/s, depending on type. (Some switches could trip at levels of less than 25 mm/s.)
- Water wells: 50 mm/s

Considering the above limitations, BM&C work is based on the following:

- USBM criteria for safe blasting.
- The additional limits provided above.
- Consideration of private structures in the area of influence.
- Should structures be in poor condition the basic limit of 25 mm/s is halved to 12.5 mm/s or when structures are in very poor condition limits will be restricted to 6 mm/s. It is a standard accepted method to reduce the limit allowed with poorer condition of structures.
- Traditional built mud houses are limited to 6 mm/s. The 6 mm/s limit is used due to unknowns on how these structures will react to blasting. There is also no specific scientific data available that would indicate otherwise.
- Input from other consultants in the field locally and internationally.

12.2 Ground Vibration Limitations and Human Perceptions

A further aspect of ground vibration and frequency of vibration that must be considered is human perceptions. It should be realized that the legal limit set for structures is significantly greater than the comfort zone of human beings. Humans and animals are sensitive to ground vibration and the vibration of structures. Research has shown that humans will respond to different levels of ground vibration at different frequencies.

Ground vibration is experienced at different levels; BM&C considers only the levels that are experienced as “Perceptible”, “Unpleasant” and “Intolerable”. This is indicative of the human being’s perceptions of ground vibration and clearly indicates that humans are sensitive to ground vibration and humans perceive ground vibration levels of 4.5 mm/s as unpleasant (See Figure 5). This guideline helps with managing ground vibration and the complaints that could be received due to blast induced ground vibration.

Indicated on Figure 5 is a blue solid line that indicates a ground vibration level of 12.5 mm/s and a green dotted line that indicates a ground vibration level of 6 mm/s. These are levels that are used in evaluation.

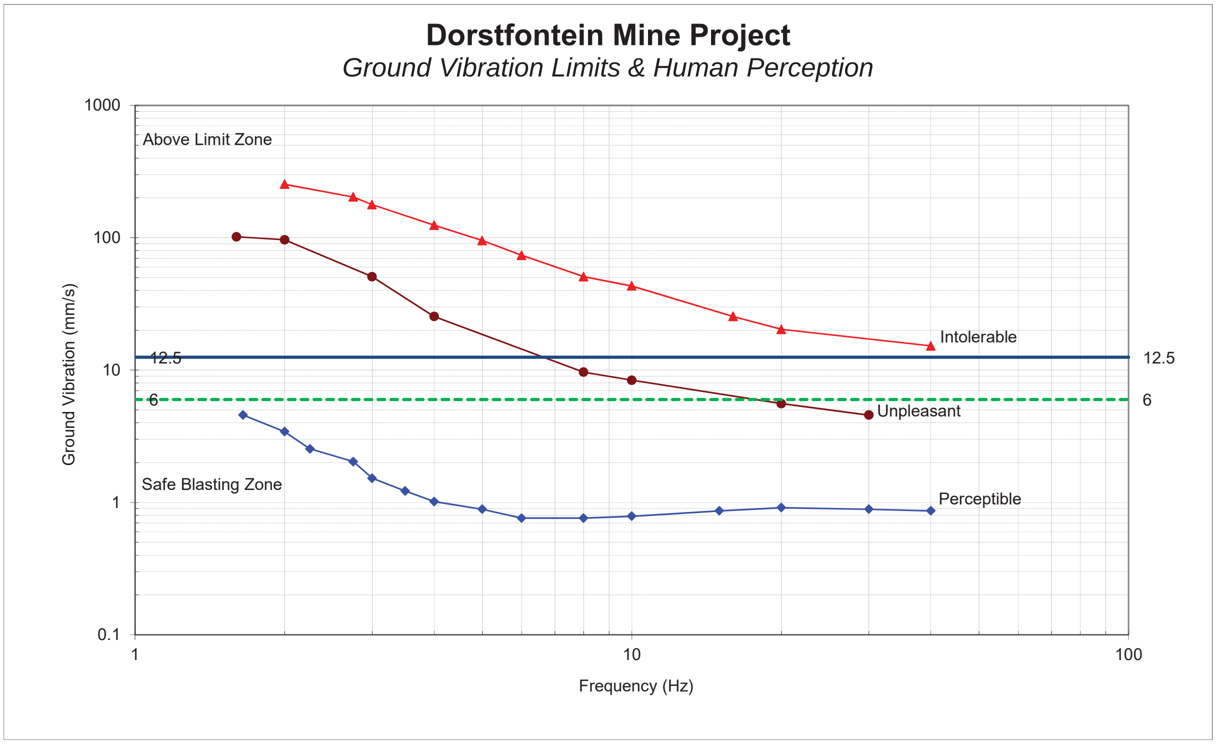


Figure 5: USBM Analysis with Human Perception

12.3 Air Blast Limitations on Structures

Air blast or air-overpressure is a pressure wave generated from the blasting process. Air blast is measured as a pressure in pascal (Pa) and reported as a decibel value (dBL). Air blast is normally associated with frequency levels less than 20 Hz, which is at the threshold for hearing. Air blast can be influenced by meteorological conditions, the final blast layout, timing, stemming, accessories used, blast covered by a layer of soil or not etc. Air blast should not be confused with sound that is within the audible range (detected by the human ear). A blast does generate sound as well but for the purpose of possible damage capability we are only concerned with air blast in this report. The three main causes of air blasts can be observed as:

- Direct rock displacement at the blast; the air pressure pulse (APP).
- Vibrating ground some distance away from the blast; rock pressure pulse (RPP).
- Venting of blast holes or blowouts; the gas release pulse (GRP).

The general recommended limit for air blast currently applied in South Africa is 134 dBL. This is based on work done by the USBM. The USBM also indicates that the level is reduced to 128 dB in proximity of hospitals, schools and sensitive areas where people congregate. Based on work carried out by Siskind *et al.* (1980), monitored air blast amplitudes up to 135 dB are safe for structures, provided the monitoring instrument is sensitive to low frequencies. Persson *et al.* (1994) have published estimates of damage thresholds based on empirical data (Table 2). Levels given in Table 2 are at the point of measurement. The weakest points on a structure are the windows and ceilings.

Table 2: Damage Limits for Air Blast

Level	Description
>130 dB	Resonant response of large surfaces (roofs, ceilings). Complaints start.
150 dB	Some windows break
170 dB	Most windows break
180 dB	Structural Damage

All attempts should be made to keep air blast levels from blasting operations well below 120dB where the public is of concern.

12.4 Air Blast Limitations and Human Perceptions

Considering human perceptions and the misunderstanding about ground vibration and air blast, BM&C generally recommends that blasting be done in such a way that air blast levels are kept below 120dB. This will ensure fewer complaints regarding blasting operations. The effect on structures that startle people will also be reduced, which reduces the reasons for complaints. It is the effect on structures (like rattling windows, doors or a large roof surface) that startles people. These effects are sometimes erroneously identified as ground vibration and considered to be damaging to the structure.

In this report initial limits for evaluating conditions have been set at 120 dB, 120 dB to 134 dB and greater than 134 dBL. The USBM limits recommended limit is 134 dBL.

12.5 Fly Rock

Blasting practices require some movement of rock to facilitate the excavation process. The extent of movement is dependent on the scale and type of operation. For example, blasting activities at large coal mines are designed to cast the blasted material over a greater distance than in quarries or hard rock operations or a decline shaft as in this project. The movement should be in the direction of the free face. The orientation of the blast and expected movement direction is important. Material or elements travelling outside of a planned or expected range would be considered fly rock. Figure 6 shows a schematic representation of the following fly rock definitions.

Fly rock can be categorised as follows:

- Throw - the planned forward movement of rock fragments that form the muck pile within the blast zone.
- Fly rock - the undesired propulsion of rock fragments through the air or along the ground beyond the blast zone by the force of the explosion that is contained within the blast clearance (exclusion) zone. When using this definition, fly rock, while undesirable, is only a safety hazard if a breach of the blast clearance (exclusion) zone occurs.
- Wild fly rock - the unexpected propulsion of rock fragments that travels beyond the blast clearance (exclusion) zone when there is some abnormality in a blast or a rock mass.

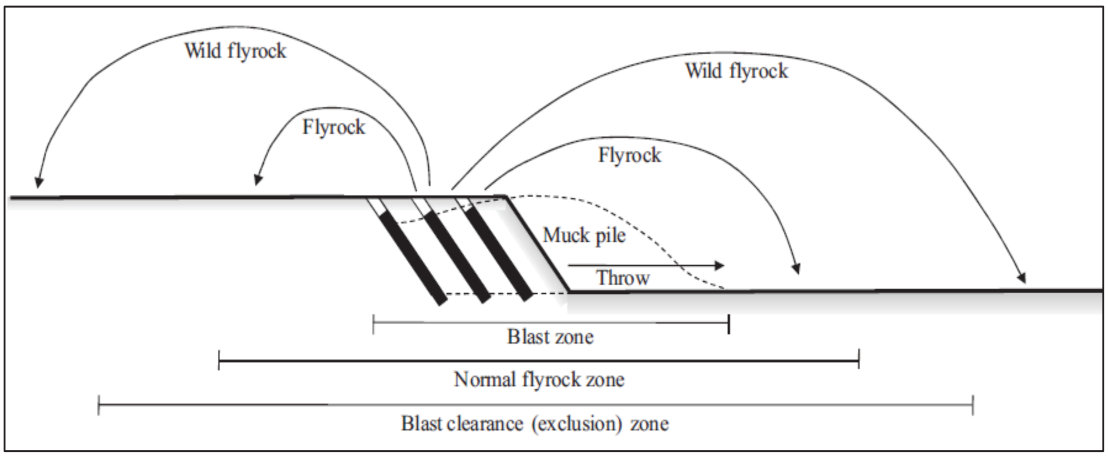


Figure 6: Schematic of fly rock terminology

Fly rock from blasting can result under the following conditions:

- When burdens are too small, rock elements can be propelled out of the free face area of the blast.
- When burdens are too large and movement of blast material is restricted and stemming length is not correct, rock elements can be forced upwards creating a crater forming fly rock.
- If the stemming material is of poor quality or too little stemming material is applied, the stemming is ejected out of the blast hole, which can result in fly rock.

Stemming of correct type and length is required to ensure that explosive energy is efficiently used to its maximum and to control fly rock.

The occurrence of fly rock in any form will have impact if found to travel outside the safe boundary. If a road or structure or people or animals are within the safe boundary of a blast, irrespective of the possibility of fly rock or not, precautions should be taken to stop the traffic, remove people or animals for the period of the blast. The fact is that fly rock will cause damage to the road, vehicles or even death to people or animals. This safe boundary is determined by the appointed blaster or as per mine code of practice. BM&C uses a prediction calculation defined by the International Society of Explosives Engineers (ISEE) to assist with determining minimum distance.

12.6 Noxious Fumes

Explosives used in the mining environment are required to be oxygen balanced. Oxygen balance refers to the stoichiometry of the chemical reaction and the nature of gases produced from the detonation of the explosives. The creation of poisonous fumes such as nitrous oxides and carbon monoxide are particularly undesirable. These fumes present themselves as red brown cloud after the blast has detonated. It has been reported that 10 ppm to 20 ppm can be mildly irritating. Exposure to 150 ppm or more (no time period given) has been reported to cause death from pulmonary edema. It has been predicted that there is a 50 % chance of death following exposure to 174 ppm for 1 hour. Anybody exposed must be taken to hospital for proper treatment.

Factors contributing to undesirable fumes are typically: poor quality control on explosive manufacture, damage to explosive, lack of confinement, insufficient charge diameter, excessive sleep time, water in blast holes incorrect product used or product not loaded properly and specific types of rock/geology can also contribute to fumes.

12.7 Vibration impact on provincial and national roads

The influence of ground vibration on tarred roads are expected when levels is in the order of 150 mm/s and greater. Or when there is actual movement of ground when blasting is done to close to the road or subsidence is caused due to blasting operations. Normally 100 blast hole diameters are considered the minimum radius from a blast hole where cracks may be expected. Crack forming can also occur due to improper timing arrangements where excessive back break is caused and cracks extend further than expected. Fact remain that blasting must be controlled in the vicinity of roads. Air blast from blasting does not have influence on road surfaces. There is no record of influence on gravel roads due to ground vibration. The only time damage can be induced is when blasting is done next to the road and there is movement of ground. Fly rock will have greater influence on the road as damage from falling debris may impact on the road surface if no control on fly rock is considered.

12.8 Vibration will upset adjacent communities

The effects of ground vibration and air blast will have influence on people. These effects tend to create noises on structures in various forms and people react to these occurrences even at low levels. As with human perception given above – people will experience ground vibration at very low levels. These levels are well below damage capability for most structures.
Much work has also been done in the field of public relations in the mining industry. Most probably one aspect that stands out is “Promote good neighbour ship”. This is achieved through thorough communication with the neighbours. Consider their concerns and address in a proper manner.

The first level of good practice is to avoid unnecessary problems. One problem that can be reduced is the public's reaction to blasting. Concern for a person's home, particularly where they own it, could be reduced by a scheme of precautionary, compensatory and other measures which offer guaranteed remedies without undue argument or excuse.

In general it is also in an operator's financial interests not to blast where there is a viable alternative. Where there is a possibility of avoiding blasting, perhaps through new technology, this should be carefully considered in the light of environmental pressures. Historical precedent may not be a helpful guide to an appropriate decision.

Independent structural surveys are one way of ensuring good neighbour ship. There is a part of inherent difficulty in using surveys as the interpretation of changes in crack patterns that occur may be misunderstood. Cracks open and close with the seasonal changes of temperature, humidity and drainage, and numbers increase as buildings age. Additional actions need to be done in order to supplement the surveys as well.

The means of controlling ground vibration, overpressure and fly rock have many features in common and are used by the better operators. It is said that many of the practices also aid cost-effective production. Together these introduce a tighter regime which should reduce the incidence of fly rock and unusually high levels of ground vibration and overpressure. The measures include the need for the following:

- Correct blast design is essential and should include a survey of the face profile prior to design, ensuring appropriate burden to avoid over-confinement of charges which may increase vibration by a factor of two,

- The setting-out and drilling of blasts should be as accurate as possible and the drilled holes should be surveyed for deviation along their lengths and, if necessary, the blast design adjusted,
- Correct charging is obviously vital, and if free poured bulk explosive is used, its rise during loading should be checked. This is especially important in fragmented ground to avoid accidental overcharging,
- Correct stemming will help control air blast and fly rock and will also aid the control of ground vibration. Controlling the length of the stemming column is important; too short and premature ejection occurs, too long and there can be excessive confinement and poor fragmentation. The length of the stemming column will depend on the diameter of the hole and the type of material being used,
- Monitoring of blasting and re-optimising the blasting design in the light of results, changing conditions and experience should be carried out as standard.

12.9 Cracking of houses and consequent devaluation

Houses in general have cracks. It is reported that a house could develop up to 15 cracks a year. Ground vibration will be mostly responsible for cracks in structures if high enough and at continued high levels. The influences of environmental forces such as temperature, water, wind etc. are more reason for cracks that have developed. Visual results of actual damage due to blasting operations are limited. There are cases where it did occur and a result is shown in Figure 7 below. A typical X crack formation is observed.

Figure 7: Example of blast induced damage.

Observing cracks of this form on a structure will certainly influence the value as structural damage has occurred. The presence of general vertical cracks or horizontal cracks that are found in all structures does not need to indicate devaluation due to blasting operations but rather devaluation due to construction, building material, age, standards of building applied. Proper building standards are not always applied or else stated was not always applied in the country side when houses were built. Thus damage in the form of cracks will be present. Exact costing of devaluation for normal cracks observed is difficult to estimate. A property valuator will be required for this and I do believe that property value will include the total property and not just the house alone. Mining operations may not have influence to change the status quo of any property.

13 Baseline Results

Baseline work for this report normally consists of two parts. The first part is monitoring of blasting operations if the mine is operational and obtaining blast related information from the mine. The second part of baseline work done is familiarising oneself with the surroundings and the typical structures that are found in the area of the project. The information for this is presented below.

13.1 Baseline influence

The Dorstfontein East mine is an operational mine. Blasts were specifically monitored and data obtained from the mine. Data obtained from the mine is provided in figures Figure 8, Figure 9 and Figure 10.

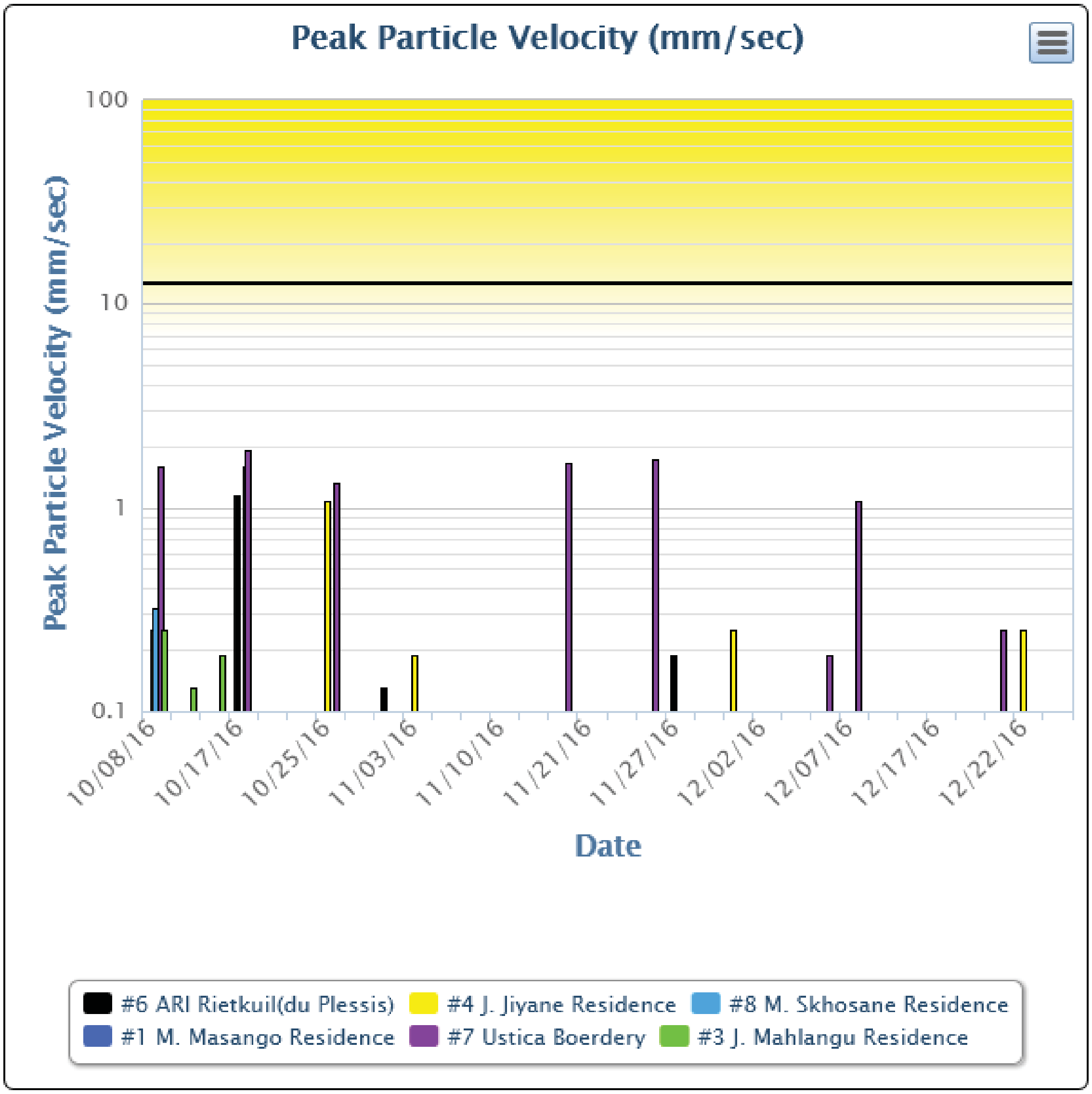


Figure 8: Mine monitor program ground vibration summary for October to December 2016

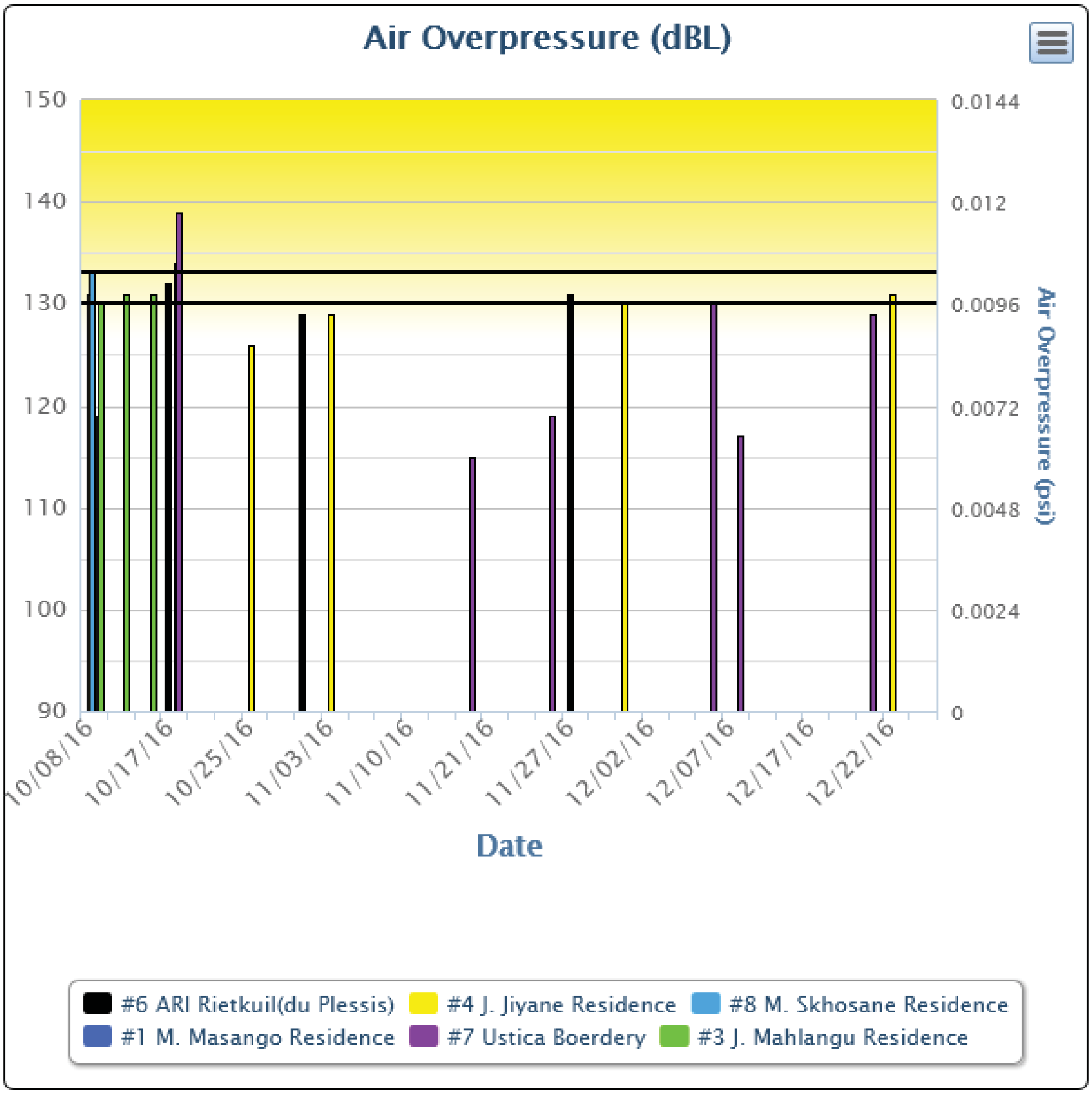


Figure 9: Mine monitor program air blast summary for October to December 2016

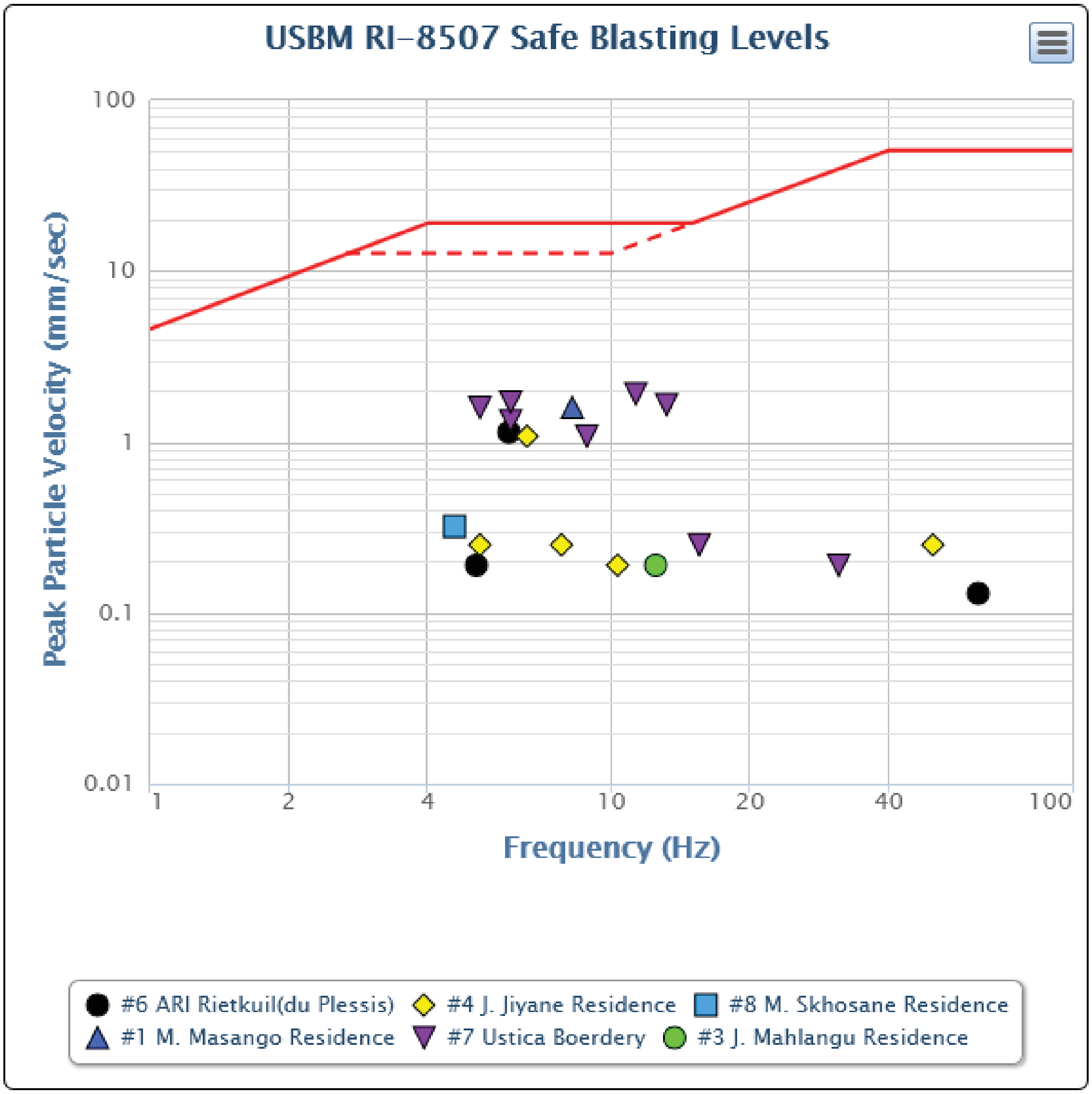


Figure 10: Mine monitor program USBM analyses for October to December 2016

Data recorded from this project is presented as baseline data for comparison. Figure 11 below shows monitoring points used during blasting operations. Table 3 below summary data from monitoring done.

Figure 11: BM&C Monitor point locations

Table 3: BM&C Recorded data

Date	Time	Seismograph Location	L-PPV	T- PPV	V-PPV	L-Freq	T-Freq	V-Freq	Resultant PPV (mm/s)	Air Blast (dB)
2016/08/22	16:37:06	DFPoint 01	61.72	100.60	23.88	5.33	6.24	9.48	108.80	144.8
2016/08/22	16:37:05	DFPoint 02	6.35	5.97	2.92	10.45	4.38	16.00	6.45	120.8
2016/08/22	16:37:07	DFPoint 03	10.03	6.35	3.43	5.39	5.22	16.00	10.83	130.3
2016/08/22	16:37:06	DFPoint 04	4.95	7.11	1.78	5.75	5.69	5.89	7.19	121.5
2016/08/22	16:37:06	DFPoint 05	9.02	5.59	2.54	5.51	4.97	5.69	9.22	130.3
2016/08/22	16:37:06	DFPoint 06	3.30	4.83	1.91	6.17	6.40	5.82	4.87	122.1
2016/09/09	16:26:48	DFPoint 01	2.41	2.41	1.91	19.69	42.67	51.20	2.61	141.3
2016/09/12	12:29:22	DFPoint 05	2.45	1.22	0.74	5.94	5.03	6.42	2.78	109.2
2016/09/12	12:29:22	DFPoint 06	0.87	1.98	0.83	11.13	8.64	6.85	2.04	106.1

Data recorded were then applied to obtain indicators of ground vibration attenuation over distance. The results from the outcome is presented in Figure 12 and Figure 13 below. The attenuation constants obtained from the analyses were applied in prediction of ground vibration and air blast in the EIA operational evaluation.

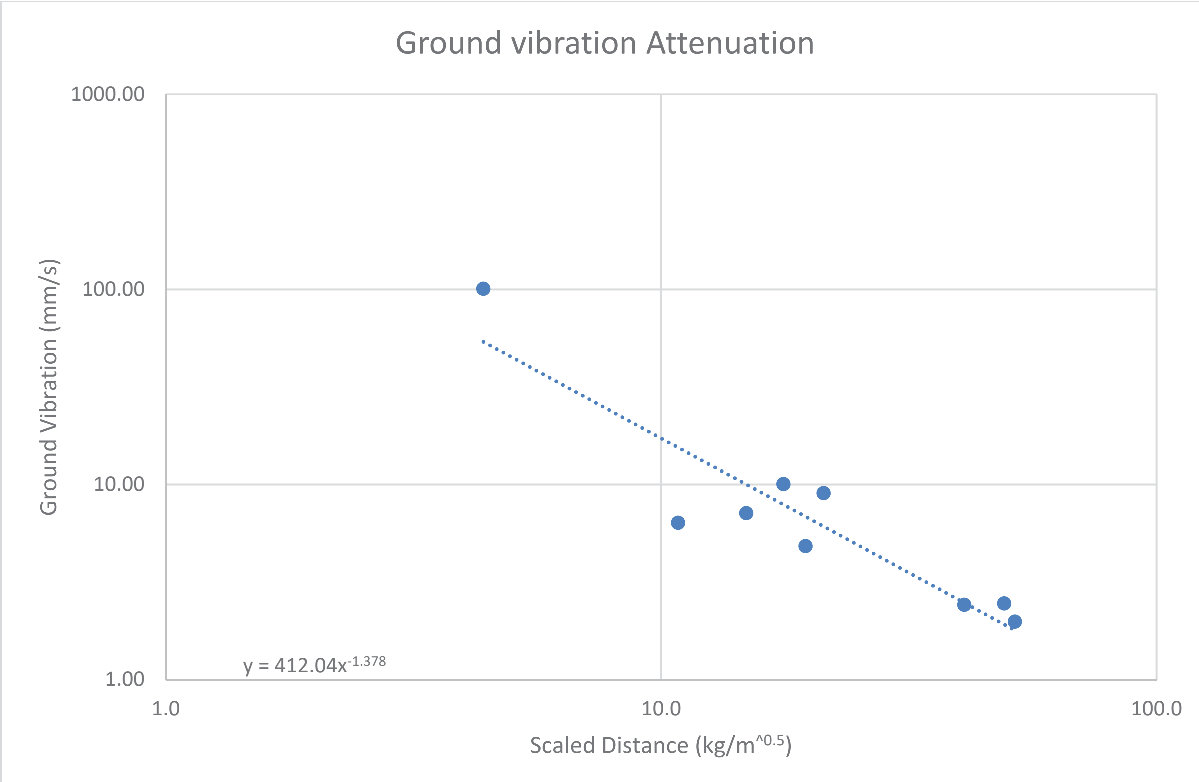


Figure 12: Ground vibration attenuation

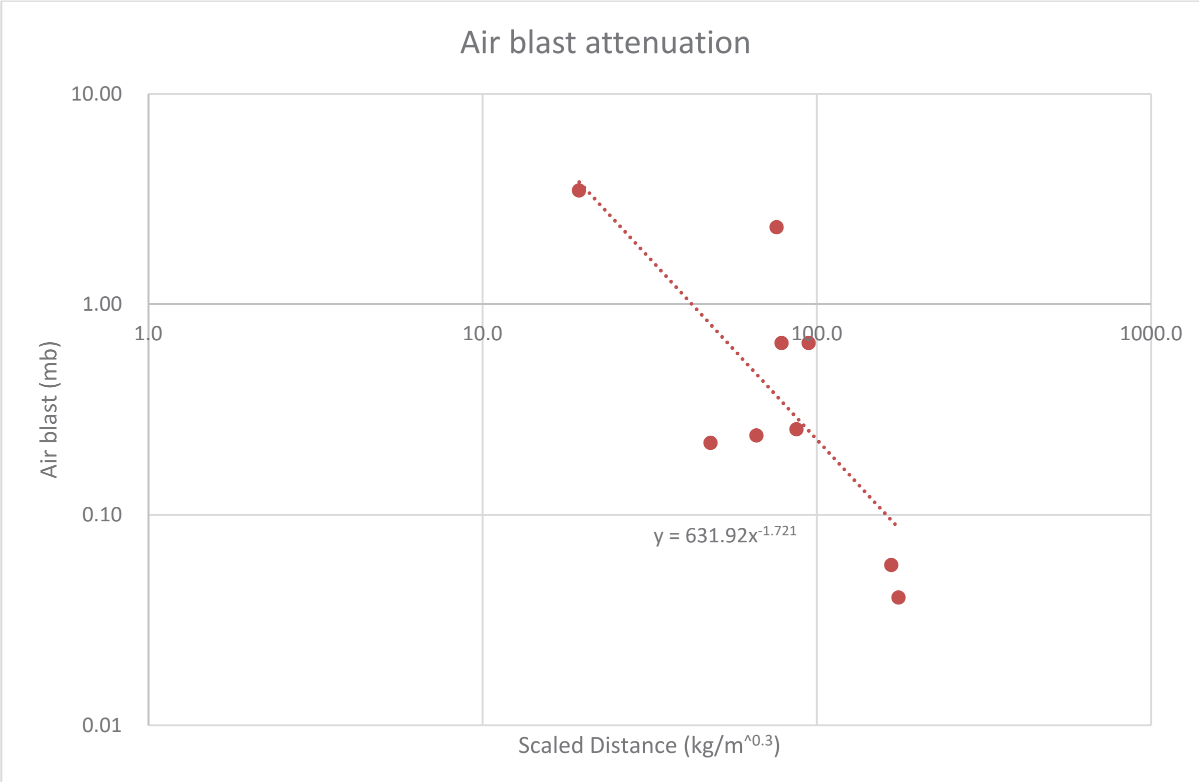


Figure 13: Air blast attenuation

13.2 Structure Profile

As part of the baseline, all possible structures in a possible influence area are identified. The site was reviewed using Google Earth imagery. Information sought during the review was to identify surface structures present in a 3500 m radius from the proposed open pit area, which will require consideration during modelling of blasting operations, e.g. houses, general structures, power lines, pipelines, reservoirs, mining activity, roads, shops, schools, gathering places, possible historical sites, etc. A list was prepared of all structures in the vicinity of the open pit area. The list includes structures and POI within the 3500 m boundary – see Table 4 below. A list of structure locations was required to determine the allowable ground vibration limits and air blast limits. Figure 14 shows an aerial view of the open pit area and surroundings with POIs. The type of POIs identified is grouped into different classes. These classes are indicated as "Classification" in Table 5. The classification used is a BM&C classification and does not relate to any standard or national or international code or practice. Table 4 shows the descriptions for the classifications used.

Table 4: POI Classification used

Class	Description
1	Rural Building and structures of poor construction
2	Private Houses and people sensitive areas
3	Office and High rise buildings
4	Animal related installations and animal sensitive areas
5	Industrial buildings and installations
6	Earth like structures – no surface structure
7	Graves & Heritage
8	Water Borehole

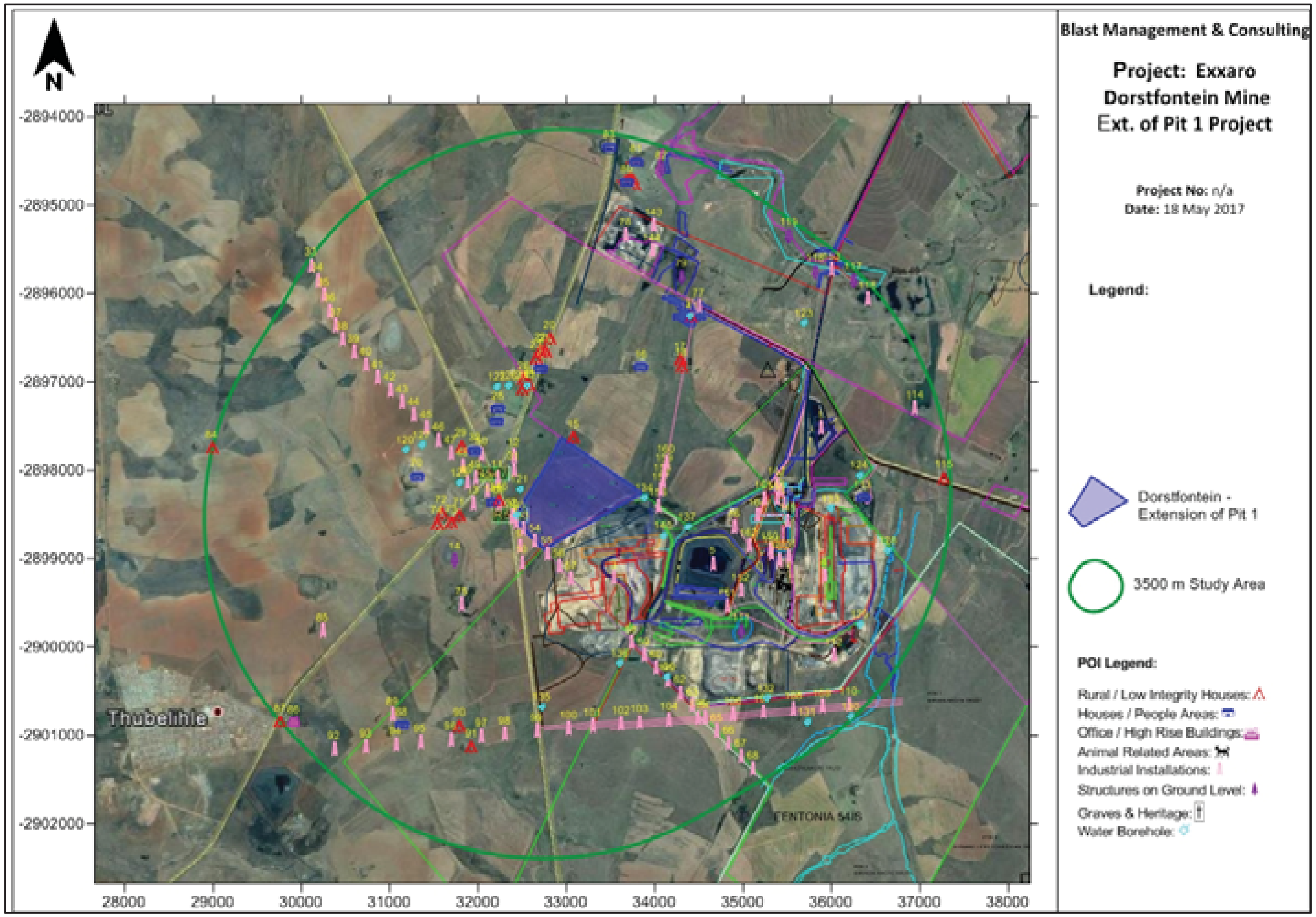


Figure 14: Aerial view and surface plan of the proposed mining area with points of interest identified

Table 5: List of POIs identified (WGS – LO 29°)

Tag	Description	Classification	Y	X
1	PCD's	5	-35881.52	2897523.40
2	Plant Area	5	-35423.01	2898225.75
3	Pit 1	5	-33545.26	2899226.46
4	Pit 2	5	-35923.75	2899192.72
5	Co-disposal facility	5	-34657.33	2899058.61
6	Impilo Primary School	2	-32712.93	2896841.82
7	R544 Road	5	-32411.34	2898516.23
8	R544 Road	5	-32430.57	2898586.93
9	R544 Road	5	-32471.36	2898864.71
10	R544 Road	5	-32494.64	2899047.76
11	R547 and R544 Road Intersection	5	-32218.20	2898080.94
12	R544 Road	5	-32406.95	2897838.43
13	R547 Road	5	-31943.92	2898375.85
14	Pan	6	-31737.97	2899010.04
15	Ruins	1	-33084.41	2897629.65
16	Buildings/Structures	2	-33848.79	2896839.11
17	Informal Housing	1	-34288.36	2896745.80
18	Ruins	1	-34302.37	2896819.32
19	Informal Housing	1	-34416.62	2896254.92
20	Informal Housing	1	-32812.43	2896503.49
21	Informal Housing	1	-32760.19	2896650.95
22	Informal Housing	1	-32711.65	2896641.32
23	Informal Housing	1	-32660.01	2896732.14
24	Informal Housing	1	-32583.56	2897031.00
25	Informal Housing	1	-32497.05	2897079.17
26	Informal Housing	1	-32518.54	2896968.50
27	Farm Buildings/Structures	2	-32213.19	2897452.24
28	Farm Buildings/Structures	2	-32225.60	2897308.85
29	Informal Housing	1	-31809.18	2897725.58
30	Dam	5	-32042.52	2897823.99
31	Cement Dam	5	-32402.71	2897990.66
32	Building/Structure	2	-31964.94	2897780.13
33	Power Lines/Pylons (no electrical lines)	5	-30114.00	2895684.13
34	Power Lines/Pylons (no electrical lines)	5	-30187.41	2895852.89
35	Power Lines/Pylons (no electrical lines)	5	-30257.31	2896022.96
36	Power Lines/Pylons (no electrical lines)	5	-30324.93	2896195.73
37	Power Lines/Pylons (no electrical lines)	5	-30396.28	2896363.75
38	Power Lines/Pylons (no electrical lines)	5	-30463.17	2896516.35
39	Power Lines/Pylons (no electrical lines)	5	-30595.49	2896661.45
40	Power Lines/Pylons (no electrical lines)	5	-30733.19	2896806.92
41	Power Lines/Pylons (no electrical lines)	5	-30869.93	2896951.14
42	Power Lines/Pylons (no electrical lines)	5	-31007.53	2897092.60
43	Power Lines/Pylons (no electrical lines)	5	-31144.55	2897235.97
44	Power Lines/Pylons (no electrical lines)	5	-31278.74	2897377.47
45	Power Lines/Pylons (no electrical lines)	5	-31417.50	2897521.84
46	Power Lines/Pylons (no electrical lines)	5	-31556.48	2897660.66
47	Power Lines/Pylons (no electrical lines)	5	-31691.97	2897807.48
48	Power Lines/Pylons (no electrical lines)	5	-31826.18	2897950.35
49	Power Lines/Pylons (no electrical lines)	5	-31968.70	2898085.95
50	Power Lines/Pylons (no electrical lines)	5	-32104.08	2898231.53
51	Power Lines/Pylons (no electrical lines)	5	-32239.56	2898372.81
52	Power Lines/Pylons (no electrical lines)	5	-32379.09	2898516.87
53	Power Lines/Pylons (no electrical lines)	5	-32512.41	2898659.42

Tag	Description	Classification	Y	X
54	Power Lines/Pylons (no electrical lines)	5	-32648.89	2898803.65
55	Power Lines/Pylons (no electrical lines)	5	-32783.12	2898949.30
56	Power Lines/Pylons (no electrical lines)	5	-32921.80	2899089.90
57	Power Lines/Pylons (no electrical lines)	5	-33058.83	2899232.90
58	Power Lines/Pylons (no electrical lines)	5	-33741.93	2899949.56
59	Power Lines/Pylons (no electrical lines)	5	-33880.33	2900092.76
60	Power Lines/Pylons (no electrical lines)	5	-34017.41	2900233.89
61	Power Lines/Pylons (no electrical lines)	5	-34153.38	2900377.48
62	Power Lines/Pylons (no electrical lines)	5	-34289.55	2900518.72
63	Power Lines/Pylons (no electrical lines)	5	-34426.07	2900663.04
64	Power Lines/Pylons (no electrical lines)	5	-34562.71	2900807.29
65	Power Lines/Pylons (no electrical lines)	5	-34700.21	2900952.83
66	Power Lines/Pylons (no electrical lines)	5	-34837.52	2901093.13
67	Power Lines/Pylons (no electrical lines)	5	-34976.51	2901236.80
68	Power Lines/Pylons (no electrical lines)	5	-35112.49	2901379.62
69	Dam	5	-31876.54	2898142.33
70	Farm Buildings/Structures	2	-31310.53	2898068.18
71	Informal Housing	1	-31786.25	2898507.93
72	Informal Housing	1	-31583.96	2898479.66
73	Informal Housing	1	-31698.03	2898592.36
74	Informal Housing	1	-31537.16	2898597.66
75	Cement Dam	5	-31818.19	2899523.98
76	Mine Activity	5	-34900.36	2898638.68
77	Road	5	-34499.75	2896144.82
78	Dam	5	-33673.55	2895343.86
79	Pan	6	-34303.68	2895807.92
80	Farm Buildings/Structures	2	-33688.00	2894741.07
81	Farm Buildings/Structures	2	-33794.08	2894509.76
82	Pan	6	-34082.01	2894584.01
83	Farm Buildings/Structures	2	-33489.86	2894348.94
84	Informal Housing	1	-28988.00	2897747.29
85	Reservoir	5	-30244.21	2899819.66
86	Hospital/Clinic - Thubelihle	3	-29917.15	2900839.46
87	Thubelihle Village Houses	1	-29761.59	2900842.89
88	Farm Buildings/Structures	2	-31137.52	2900883.59
89	Cement Dam	5	-31036.23	2900767.42
90	Informal Housing	1	-31793.41	2900888.62
91	Informal Housing	1	-31925.34	2901130.22
92	Power Lines/Pylons	5	-30373.09	2901157.21
93	Power Lines/Pylons	5	-30735.13	2901130.41
94	Power Lines/Pylons	5	-31070.07	2901100.31
95	Power Lines/Pylons	5	-31346.58	2901073.73
96	Power Lines/Pylons	5	-31693.35	2901046.96
97	Power Lines/Pylons	5	-32040.57	2901011.45
98	Power Lines/Pylons	5	-32302.42	2900984.16
99	Power Lines/Pylons	5	-32664.36	2900953.26
100	Power Lines/Pylons	5	-33029.61	2900922.53
101	Power Lines/Pylons	5	-33301.30	2900894.42
102	Power Lines/Pylons	5	-33624.74	2900868.31
103	Power Lines/Pylons	5	-33833.13	2900850.37
104	Power Lines/Pylons	5	-34166.05	2900821.85
105	Power Lines/Pylons	5	-34490.53	2900795.65
106	Power Lines/Pylons	5	-34886.16	2900765.39

Tag	Description	Classification	Y	X
107	Power Lines/Pylons	5	-35226.79	2900731.33
108	Power Lines/Pylons	5	-35574.09	2900700.76
109	Power Lines/Pylons	5	-35898.76	2900675.17
110	Power Lines/Pylons	5	-36199.72	2900651.57
111	Pan	6	-34982.13	2899819.40
112	Dam	5	-36031.49	2900093.31
113	Farm Buildings/Structures	2	-36358.66	2898311.23
114	Dam	5	-36947.36	2897299.51
115	Informal Housing	1	-37275.98	2898081.35
116	Dam	5	-36415.92	2896056.86
117	Olifants River	6	-36252.70	2895847.87
118	Olifants River	6	-35822.49	2895751.97
119	Olifants River	6	-35523.59	2895342.52
120	Hydrocensus Borehole (NBH24 - Livestock and crop watering)	8	-31179.38	2897776.18
121	Monitoring Borehole (DFTNM11)	8	-32471.32	2898215.65
122	Hydrocensus Borehole (NBH22 - Livestock watering)	8	-32215.12	2897055.46
123	Monitoring Borehole (NBH5)	8	-35694.29	2896338.30
124	Hydrocensus Borehole (NBH6 - Dormant)	8	-36318.39	2898054.45
125	Hydrocensus Borehole (NBH20 - Drinking water)	8	-31792.81	2898142.73
126	Hydrocensus Borehole (NBH21 - Drinking water)	8	-32341.19	2897046.13
127	Hydrocensus Borehole (NBH23 - Drinking water)	8	-31363.23	2897719.02
128	Monitoring Borehole (DFTNM1)	8	-36643.31	2898912.39
129	Monitoring Borehole (DFTNM2)	8	-36325.12	2899747.99
130	Monitoring Borehole (DFTNM3)	8	-36222.26	2900792.48
131	Monitoring Borehole (DFTNM4)	8	-35729.40	2900854.27
132	Monitoring Borehole (DFTNM5)	8	-35261.45	2900582.65
133	Monitoring Borehole (DFTNM6)	8	-35997.95	2898434.18
134	Monitoring Borehole (DFTNM7)	8	-33884.24	2898313.26
135	Monitoring Borehole (DFTNM8)	8	-32725.79	2900677.93
136	Monitoring Borehole (DFTNM9)	8	-33609.51	2900186.05
137	Monitoring Borehole (DFTNM10)	8	-34369.15	2898640.27
138	Monitoring Borehole (DFTNM12)	8	-32438.40	2898512.31
139	Monitoring Borehole (DFTNM13)	8	-34138.78	2900342.55
140	Monitoring Borehole (DFTNH1)	8	-34099.02	2898739.27
141	Monitoring Borehole (DFBH)	8	-34396.45	2896259.40
142	Emalayinini Community Borehole (ECBH)	8	-32558.04	2897039.07
143	Dam	5	-33992.02	2895232.19
144	Dam	5	-33969.40	2895520.41
145	Farm Buildings/Structures	2	-32170.87	2898361.12
146	Informal Housing	1	-32236.60	2898332.07
147	Mine Buildings(Workshop)	5	-35384.70	2898164.59
148	Sub Station	5	-35467.28	2898381.43
149	Sub Station	5	-35509.91	2898568.78
150	Sub Station	5	-35306.00	2898894.57
151	Water Tank	5	-35521.63	2898984.17
152	Mine Buildings/Structures	5	-34972.74	2899365.73
153	Bridge	5	-36007.34	2895727.34
154	Conveyor	5	-35322.79	2898940.92
155	Mine Buildings/Structures	5	-35385.06	2898325.65
156	Power Lines/Pylons	5	-34040.40	2898401.29
157	Power Lines/Pylons	5	-34072.76	2898222.94

Tag	Description	Classification	Y	X
158	Power Lines/Pylons	5	-34091.12	2898122.59
159	Power Lines/Pylons	5	-34110.19	2898013.25
160	Power Lines/Pylons	5	-34130.45	2897909.83
161	Power Lines/Pylons	5	-34820.45	2899538.80
162	Power Lines/Pylons	5	-35066.74	2898856.64
163	Power Lines/Pylons	5	-35416.21	2899019.09
164	Power Lines/Pylons	5	-35164.44	2898513.15
165	Power Lines/Pylons	5	-35234.82	2898317.22

During the site visit, the structures were observed and the initial POI list ground-truthed and finalised as represented. Structures ranged from well-built structures to informal building styles.

Table 6 shows photos of the structures found in the area.

Table 6: Structure Profile

Structure Photo	**Description**
	House - rural building style

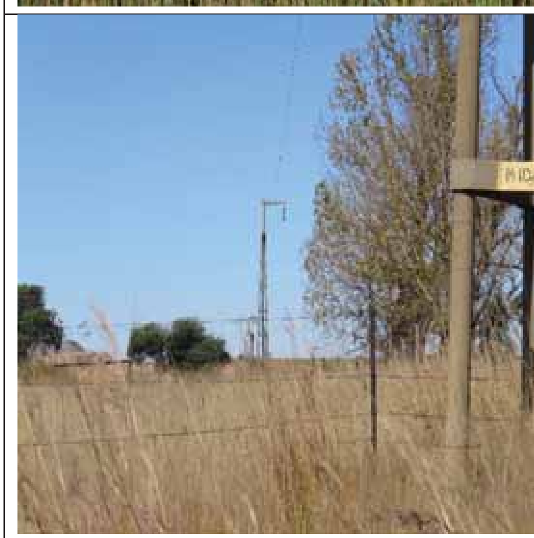
	Partially built cement brick house
	House – rural built
	Farm house

	Farm house
	Ruins of old buildings north of mine
	Ruins of old buildings north of mine

	Ruins of old buildings north of mine
	Farmstead
	Farmstead

	Farmstead
	Corrugated Iron house
	Thubelihle Village

	Thubelihle Village road intersection
	Reservoir
	Corrugated iron house

	Farmstead
	Farm houses
	Old powerline – no electrical lines

	Powerline
	Structure
	Farmstead

	Ruins – old farmhouse
	School
	Settlement houses

14 Construction Phase: Blast and Vibration Assessment

The mine is operational. The application considers only extension of existing operations. No specific evaluation is required as part of the construction phase.

15 Operational Phase: Impact Assessment and Mitigation Measures

The area surrounding the proposed mining areas was reviewed for structures, traffic, roads, human interface, animals interface etc. Various installations and structures were observed. These are listed in Table 5. This section concentrates on the outcome of modelling the possible effects of ground vibration, air blast and fly rock specifically to these points of interest or possible interfaces.

15.1 Ground Vibration and Air Blast Predictions

Explosives are used to break rock through the shock waves and gasses yielded from the explosion. Ground vibration and air blast is a result from blasting activities. Factors influencing ground vibration are the charge mass per delay, distance from the blast, the delay period and the geometry of the blast. These factors are controlled by planned design and proper blast preparation.

An aspect that is not normally considered as pre-operation definable is the effect of air blast. This is mainly due to the fact that air blast is an aspect that can be controlled to a great degree by applying basic rules. Air blast is the direct result from the blast process, although influenced by meteorological conditions, the final blast layout, timing, stemming length, stemming material, accessories used, covered blast or not covered blast etc. all has an influence on the outcome of the result.

The opencast bench mining technique will be employed. The following activities will take place during the operation: Topsoil stripping, Softs stripping, Hards drill and blast, load and haul blasted hards, Drill and blast coal, Load and haul coal.

In order to evaluate the possible influence, two charge masses that will span the range of possible charge mass per delay were selected. Considering the option of standard shock tube initiation products to be used for overburden blasts a minimum charge and maximum charge is calculated. Minimum consists of a single blasthole charge and maximum charge consists of the approximately six blastholes detonating simultaneously due to the shock tube initiation system. The selected charge masses selected for evaluation consist of a single blasthole at 300 kg and maximum charge of 1800 kg. This range of minimum and maximum charge will span various alternatives can may be possible. These charge masses were used for baseline modelling in this report. Applying the above charge masses, various ground vibration calculations were done and considered in this report. Attention is given to limit levels of 6 mm/s, 12.5 mm/s and 25 mm/s.

When predicting ground vibration and possible decay, a standard accepted mathematical process of scaled distance is used. The equation applied (Equation 1) uses the charge mass and distance with two site constants. In the absence of testing or monitoring standard constants are applied. These constants are applied in equation 1 below.

Equation 1:

$$PPV = a\left(\frac{D}{\sqrt{E}}\right)^{-b}$$

Where:
PPV = Predicted ground vibration (mm/s)
a = Site constant
b = Site constant
D = Distance (m)
E = Explosive Mass (kg)
General factors applied for the constants a & b are:
a = 1143 and
b = -1.65.

Utilizing the abovementioned equation and the given factors, allowable levels for specific limits and expected ground vibration levels can then be calculated for various distances.

Predicting the outcome of air blast is considered difficult in most circumstances. There are many variables that have influence on the outcome of air blast. In most cases mainly an indication of typical levels can be obtained. A standard cube root scaling prediction formula is applied for air blast predictions. The following Equation 2 was used to calculate possible air blast values in millibar. This equation does not take temperature or any weather conditions into account.

Equation 2:

$$\mathrm{P} = \mathrm{A} \times \left(\frac{\mathrm{D}}{\mathrm{E}^{\frac{1}{3}}}\right)^{-B}$$

Where:
P = Air blast level (mB)
D = Distance from source (m)

E = Maximum charge mass per delay (kg)
A = Constant
-B = Constant

The constants for A and B were then selected according to the information as provided in Figure 13 above. In this report the data from baseline was applied in the prediction or air blast – constants of 631.92 (A) and -1.721 (B) was applied.

The air pressure calculated in Equation 2 is converted to decibels in Equation 3. The reporting of air blast in the decibel scale is more readily accepted in the mining industry.

Equation 3:

$$p_s = 20 \text{ x} \log \frac{P}{P_o}$$

Where:

p_s = Air blast level (dB)
P = Air blast level (Pa (mB x 100))
P_o = Reference Pressure (2 x 10^{-5} Pa)

Although the above equation was applied for prediction of air blast levels, additional measures are also recommended to ensure that air blast and associated fly-rock possibilities are minimized as best possible.

Based on the designs presented on expected drilling and charging design,
Table 7 shows expected ground vibration levels (PPV) for various distances calculated at the two different charge masses. A low charge mass and a maximum charge mass as worst case scenario. The charge masses are 300 kg and 1800 kg.

Table 7: Expected Ground Vibration at Various Distances from Charges Applied in this Study

No.	Distance (m)	Expected PPV (mm/s) for 300 kg Charge	Expected PPV (mm/s) for 1800 kg Charge
1	50.0	95.4	328.4
2	75.0	54.5	187.7
3	150.0	20.9	72.1
4	200.0	14.1	48.5
5	250.0	10.4	35.6
6	300.0	8.0	27.7
7	400.0	5.4	18.6
8	500.0	4.0	13.7
9	600.0	3.1	10.6

10	700.0	2.5	8.6
11	800.0	2.1	7.2
12	900.0	1.8	6.1
13	1000.0	1.5	5.3
14	1250.0	1.1	3.9
15	1500.0	0.9	3.0
16	1750.0	0.7	2.4
17	2000.0	0.6	2.0
18	2500.0	0.4	1.5
19	3000.0	0.3	1.2
20	3500.0	0.3	0.9

Although above equations 2 & 3 was applied for prediction of air blast levels, additional measures are also recommended to ensure that air blast and associated fly-rock possibilities are minimised as best as possible. As discussed earlier the prediction of air blast is very subjective. Following in Table 8 below is a summary of values predicted according to Equation 2 and Equation 3.

Table 8: Air Blast Predicted Values

No.	**Distance (m)**	**Air blast (dB) for 300 kg Charge**	**Air blast (dB) for 1800 kg Charge**
1	50.0	159.9	168.9
2	100.0	153.9	162.8
3	150.0	143.5	152.4
4	200.0	139.2	148.1
5	250.0	135.9	144.8
6	300.0	133.2	142.1
7	400.0	128.9	137.8
8	500.0	125.5	134.4
9	600.0	122.8	131.7
10	700.0	120.5	129.4
11	800.0	118.5	127.4
12	900.0	116.8	125.7
13	1000.0	115.2	124.1
14	1250.0	111.8	120.7
15	1500.0	109.1	118.1
16	1750.0	106.8	115.8
17	2000.0	104.9	113.8
18	2500.0	101.6	110.5
19	3000.0	99.1	107.8
20	3500.0	96.9	105.6

15.2 Review of Expected Ground Vibration

Ground vibration and air blast was calculated from the edge of the pit outline and modelled accordingly. Blasting further away from the pit edge will certainly have lesser influence on the surroundings. A worst case is then applicable with calculation from pit edge. As explained previously reference is only made to some structures and these references covers the extent of all structures surrounding the mine.

The following aspects with comments are addressed for each of the evaluations done:

- Ground Vibration Modelling Results
- Ground Vibration and human perception
- Vibration impact on national and provincial road
- Vibration will upset adjacent communities
- Cracking of houses and consequent devaluation
- Air blast Modelling Results
- Impact of fly rock
- Noxious fumes Influence Results

Please note that this analysis does not take geology, topography or actual final drill and blast pattern into account. The data is based on good practise applied internationally and considered very good estimates based on the information provided and supplied in this document.

Presented herewith are the expected ground vibration level contours and discussion of relevant influences. Expected ground vibration levels were calculated for each POI identified surrounding the mining area and evaluated with regards to possible structural concerns and human perception. Tables are provided for each of the different charge models done with regards to:

- "Tag" No. is the number corresponding to the POI figures.
- "Description" indicates the type of the structure.
- "Distance" is the distance between the structure and edge of the open pit area.
- "Specific Limit" is the maximum limit for ground vibration at the specific structure or installation.
- "Predicted PPV (mm/s)" is the calculated ground vibration at the structure.
- The "Structure Response @ 10Hz and Human Tolerance @ 30Hz" indicates the possible concern and if there is any concern for structural damage or potential negative human perception respectively. Indicators used are "perceptible", "unpleasant", "intolerable" which stems from the human perception information given and indicators such as "high" or "low" is given for the possibility of damage to a structure. Levels below 0.76 mm/s could be considered to have low or negligible possibility of influence.

In evaluation the two different charge mass scenarios are considered with regards to ground vibration and air blast. Review of the charge per blast hole and the possible timing of a blast the two different charge mass of 300 and 1800 kg were selected to ensure proper source coverage.

Ground vibration is calculated and modelled for the open pit area at the minimum and maximum charge mass at specific distances from the open pit area. The charge masses applied are according to blast designs discussed in Section 15.1. These levels are then plotted and overlaid with current mining plans to observe possible influences at structures identified. Structures or POI's for consideration are also plotted in this model. Ground vibration predictions were done considering distances ranging from 50 m to 3500 m around the open pit mining area.

The simulation provided shows ground vibration contours only for a limited number of levels. The levels used are considered the basic limits that will applicable for the type of structures observed surrounding the open pit area. These levels are: 6 mm/s, 12.5 mm/s, 25 mm/s and 50 mm/s. This enables immediate review of possible concerns that may be applicable to any of the privately-owned structures, social gathering areas or sensitive installations.
Data is provided as follows: Vibration contours; a table with predicted ground vibration values and evaluation for each POI. Additional colour codes used in the tables are as follows:

Structure Evaluations:
Vibration levels higher than proposed limit applicable to Structures / Installations is coloured "Red"
People's Perception Evaluation:
Vibration levels indicated as Intolerable on human perception scale is coloured "Red"
Vibration levels indicated as Unpleasant on human perception scale is coloured "Mustard"
Vibration levels indicated as Perceptible on human perception scale is coloured "Light Green"

Simulations for expected ground vibration levels from minimum and maximum charge mass are presented.

- ***Minimum charge mass per delay – 300 kg***

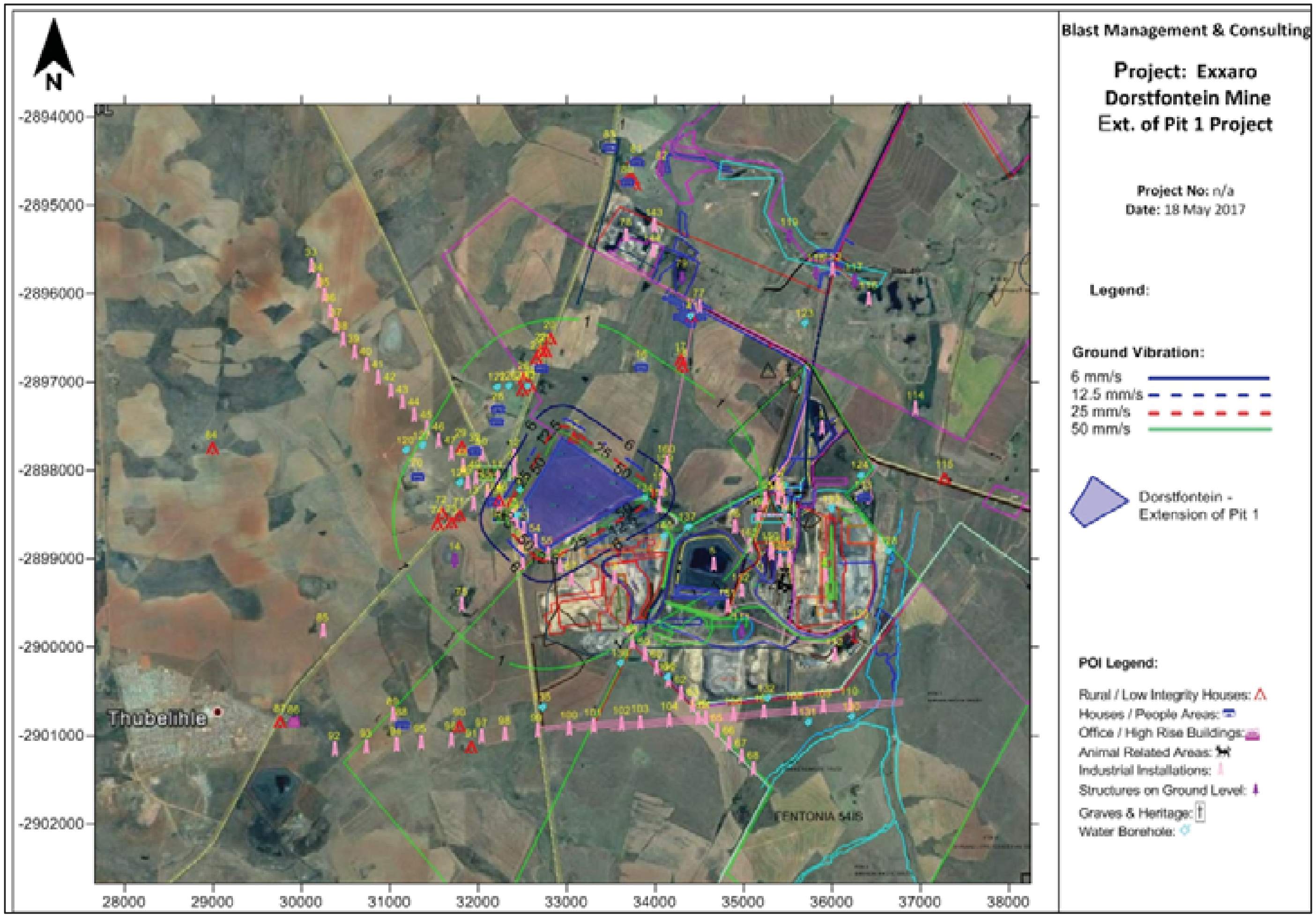


Figure 15: Ground vibration influence from minimum charge for Pit Area

Table 9: Ground vibration evaluation for minimum charge for Pit Area

Tag	Description	Distance (m)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
1	PCD's	2172	0.5	Acceptable	N/A
2	Plant Area	1586	0.8	Acceptable	N/A
3	Pit 1	691	2.5	Acceptable	N/A
4	Pit 2	2285	0.5	Acceptable	N/A
5	Co-disposal facility	1144	1.3	Acceptable	N/A
6	Impilo Primary School	833	2.0	Acceptable	Perceptible
7	R544 Road	11	729.5	Problematic	N/A
8	R544 Road	6	1888.0	Problematic	N/A
9	R544 Road	173	17.2	Acceptable	N/A
10	R544 Road	285	8.6	Acceptable	N/A
11	R547 and R544 Road Intersection	402	5.4	Acceptable	N/A
12	R544 Road	372	6.0	Acceptable	N/A
13	R547 Road	488	4.1	Acceptable	N/A
14	Pan	807	2.1	Acceptable	N/A
15	Ruins	87	44.2	Problematic	Intolerable
16	Buildings/Structures	1170	1.2	Acceptable	Perceptible
17	Informal Housing	1495	0.9	Acceptable	Perceptible
18	Ruins	1443	0.9	Acceptable	Perceptible
19	Informal Housing	1973	0.6	Acceptable	Too Low
20	Informal Housing	1146	1.3	Acceptable	Perceptible
21	Informal Housing	1008	1.5	Acceptable	Perceptible
22	Informal Housing	1027	1.5	Acceptable	Perceptible
23	Informal Housing	953	1.6	Acceptable	Perceptible
24	Informal Housing	710	2.5	Acceptable	Perceptible
25	Informal Housing	719	2.4	Acceptable	Perceptible
26	Informal Housing	797	2.1	Acceptable	Perceptible
27	Farm Buildings/Structures	734	2.3	Acceptable	Perceptible
28	Farm Buildings/Structures	791	2.1	Acceptable	Perceptible
29	Informal Housing	937	1.7	Acceptable	Perceptible
30	Dam	687	2.6	Acceptable	N/A
31	Cement Dam	294	8.3	Acceptable	N/A
32	Building/Structure	776	2.2	Acceptable	Perceptible
33	Power Lines/Pylons (no electrical lines)	3442	0.3	Acceptable	N/A
34	Power Lines/Pylons (no electrical lines)	3287	0.3	Acceptable	N/A
35	Power Lines/Pylons (no electrical lines)	3137	0.3	Acceptable	N/A
36	Power Lines/Pylons (no electrical lines)	2992	0.3	Acceptable	N/A
37	Power Lines/Pylons (no electrical lines)	2850	0.4	Acceptable	N/A
38	Power Lines/Pylons (no electrical lines)	2719	0.4	Acceptable	N/A
39	Power Lines/Pylons (no electrical lines)	2532	0.4	Acceptable	N/A
40	Power Lines/Pylons (no electrical lines)	2337	0.5	Acceptable	N/A
41	Power Lines/Pylons (no electrical lines)	2145	0.5	Acceptable	N/A
42	Power Lines/Pylons (no electrical lines)	1953	0.6	Acceptable	N/A
43	Power Lines/Pylons (no electrical lines)	1761	0.7	Acceptable	N/A
44	Power Lines/Pylons (no electrical lines)	1572	0.8	Acceptable	N/A
45	Power Lines/Pylons (no electrical lines)	1377	1.0	Acceptable	N/A
46	Power Lines/Pylons (no electrical lines)	1186	1.2	Acceptable	N/A
47	Power Lines/Pylons (no electrical lines)	993	1.5	Acceptable	N/A
48	Power Lines/Pylons (no electrical lines)	803	2.1	Acceptable	N/A
49	Power Lines/Pylons (no electrical lines)	610	3.0	Acceptable	N/A
50	Power Lines/Pylons (no electrical lines)	418	5.1	Acceptable	N/A
51	Power Lines/Pylons (no electrical lines)	228	11.7	Acceptable	N/A

Tag	Description	Distance (m)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
52	Power Lines/Pylons (no electrical lines)	34	161.8	Problematic	N/A
53	Power Lines/Pylons (no electrical lines)	8	1239.8	Problematic	N/A
54	Power Lines/Pylons (no electrical lines)	7	1357.9	Problematic	N/A
55	Power Lines/Pylons (no electrical lines)	70	60.5	Acceptable	N/A
56	Power Lines/Pylons (no electrical lines)	260	9.8	Acceptable	N/A
57	Power Lines/Pylons (no electrical lines)	453	4.6	Acceptable	N/A
58	Power Lines/Pylons (no electrical lines)	1415	0.9	Acceptable	N/A
59	Power Lines/Pylons (no electrical lines)	1608	0.8	Acceptable	N/A
60	Power Lines/Pylons (no electrical lines)	1799	0.7	Acceptable	N/A
61	Power Lines/Pylons (no electrical lines)	1991	0.6	Acceptable	N/A
62	Power Lines/Pylons (no electrical lines)	2182	0.5	Acceptable	N/A
63	Power Lines/Pylons (no electrical lines)	2375	0.5	Acceptable	N/A
64	Power Lines/Pylons (no electrical lines)	2568	0.4	Acceptable	N/A
65	Power Lines/Pylons (no electrical lines)	2763	0.4	Acceptable	N/A
66	Power Lines/Pylons (no electrical lines)	2953	0.3	Acceptable	N/A
67	Power Lines/Pylons (no electrical lines)	3147	0.3	Acceptable	N/A
68	Power Lines/Pylons (no electrical lines)	3339	0.3	Acceptable	N/A
69	Dam	658	2.7	Acceptable	N/A
70	Farm Buildings/Structures	1191	1.2	Acceptable	Perceptible
71	Informal Housing	615	3.0	Acceptable	Perceptible
72	Informal Housing	819	2.0	Acceptable	Perceptible
73	Informal Housing	704	2.5	Acceptable	Perceptible
74	Informal Housing	864	1.9	Acceptable	Perceptible
75	Cement Dam	1101	1.3	Acceptable	N/A
76	Mine Activity	1128	1.3	Acceptable	N/A
77	Road	2111	0.5	Acceptable	N/A
78	Dam	2411	0.5	Acceptable	N/A
79	Pan	2279	0.5	Acceptable	N/A
80	Farm Buildings/Structures	2994	0.3	Acceptable	Too Low
81	Farm Buildings/Structures	3245	0.3	Acceptable	Too Low
82	Pan	3262	0.3	Acceptable	N/A
83	Farm Buildings/Structures	3338	0.3	Acceptable	Too Low
84	Informal Housing	3505	0.3	Acceptable	Too Low
85	Reservoir	2503	0.4	Acceptable	N/A
86	Hospital/Clinic - Thubelihle	3378	0.3	Acceptable	Too Low
87	Thubelihle Village Houses	3497	0.3	Acceptable	Too Low
88	Farm Buildings/Structures	2559	0.4	Acceptable	Too Low
89	Cement Dam	2536	0.4	Acceptable	N/A
90	Informal Housing	2214	0.5	Acceptable	Too Low
91	Informal Housing	2387	0.5	Acceptable	Too Low
92	Power Lines/Pylons	3277	0.3	Acceptable	N/A
93	Power Lines/Pylons	3007	0.3	Acceptable	N/A
94	Power Lines/Pylons	2771	0.4	Acceptable	N/A
95	Power Lines/Pylons	2592	0.4	Acceptable	N/A
96	Power Lines/Pylons	2400	0.5	Acceptable	N/A
97	Power Lines/Pylons	2237	0.5	Acceptable	N/A
98	Power Lines/Pylons	2143	0.5	Acceptable	N/A
99	Power Lines/Pylons	2069	0.6	Acceptable	N/A
100	Power Lines/Pylons	2055	0.6	Acceptable	N/A
101	Power Lines/Pylons	2082	0.6	Acceptable	N/A
102	Power Lines/Pylons	2165	0.5	Acceptable	N/A
103	Power Lines/Pylons	2241	0.5	Acceptable	N/A
104	Power Lines/Pylons	2382	0.5	Acceptable	N/A

Tag	Description	Distance (m)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
105	Power Lines/Pylons	2522	0.4	Acceptable	N/A
106	Power Lines/Pylons	2694	0.4	Acceptable	N/A
107	Power Lines/Pylons	2835	0.4	Acceptable	N/A
108	Power Lines/Pylons	2996	0.3	Acceptable	N/A
109	Power Lines/Pylons	3175	0.3	Acceptable	N/A
110	Power Lines/Pylons	3361	0.3	Acceptable	N/A
111	Pan	1934	0.6	Acceptable	N/A
112	Dam	2859	0.4	Acceptable	N/A
113	Farm Buildings/Structures	2522	0.4	Acceptable	Too Low
114	Dam	3255	0.3	Acceptable	N/A
115	Informal Housing	3443	0.3	Acceptable	Too Low
116	Dam	3386	0.3	Acceptable	N/A
117	Olifants River	3407	0.3	Acceptable	N/A
118	Olifants River	3190	0.3	Acceptable	N/A
119	Olifants River	3351	0.3	Acceptable	N/A
120	Hydrocensus Borehole (NBH24 - Livestock and crop watering)	1443	0.9	Acceptable	N/A
121	Monitoring Borehole (DFTNM11)	116	29.9	Acceptable	N/A
122	Hydrocensus Borehole (NBH22 - Livestock watering)	936	1.7	Acceptable	N/A
123	Monitoring Borehole (NBH5)	2665	0.4	Acceptable	N/A
124	Hydrocensus Borehole (NBH6 - Dormant)	2489	0.4	Acceptable	N/A
125	Hydrocensus Borehole (NBH20 - Drinking water)	729	2.4	Acceptable	N/A
126	Hydrocensus Borehole (NBH21 - Drinking water)	848	1.9	Acceptable	N/A
127	Hydrocensus Borehole (NBH23 - Drinking water)	1318	1.0	Acceptable	N/A
128	Monitoring Borehole (DFTNM1)	2881	0.4	Acceptable	N/A
129	Monitoring Borehole (DFTNM2)	2899	0.4	Acceptable	N/A
130	Monitoring Borehole (DFTNM3)	3479	0.3	Acceptable	N/A
131	Monitoring Borehole (DFTNM4)	3211	0.3	Acceptable	N/A
132	Monitoring Borehole (DFTNM5)	2724	0.4	Acceptable	N/A
133	Monitoring Borehole (DFTNM6)	2167	0.5	Acceptable	N/A
134	Monitoring Borehole (DFTNM7)	71	59.0	Problematic	N/A
135	Monitoring Borehole (DFTNM8)	1793	0.7	Acceptable	N/A
136	Monitoring Borehole (DFTNM9)	1553	0.8	Acceptable	N/A
137	Monitoring Borehole (DFTNM10)	654	2.7	Acceptable	N/A
138	Monitoring Borehole (DFTNM12)	15	511.9	Problematic	N/A
139	Monitoring Borehole (DFTNM13)	1954	0.6	Acceptable	N/A
140	Monitoring Borehole (DFTNH1)	546	3.5	Acceptable	N/A
141	Monitoring Borehole (DFBH)	1958	0.6	Acceptable	N/A
142	Emalayinini Community Borehole (ECBH)	716	2.4	Acceptable	N/A
143	Dam	2627	0.4	Acceptable	N/A
144	Dam	2356	0.5	Acceptable	N/A
145	Farm Buildings/Structures	293	8.3	Acceptable	Unpleasant
146	Informal Housing	252	10.2	Problematic	Unpleasant
147	Mine Buildings(Workshop)	1550	0.8	Acceptable	N/A
148	Sub Station	1634	0.8	Acceptable	N/A
149	Sub Station	1701	0.7	Acceptable	N/A
150	Sub Station	1600	0.8	Acceptable	N/A
151	Water Tank	1833	0.7	Acceptable	N/A
152	Mine Buildings/Structures	1585	0.8	Acceptable	N/A

Tag	Description	Distance (m)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
153	Bridge	3327	0.3	Acceptable	N/A
154	Conveyor	1634	0.8	Acceptable	N/A
155	Mine Buildings/Structures	1549	0.8	Acceptable	N/A
156	Power Lines/Pylons	247	10.5	Acceptable	N/A
157	Power Lines/Pylons	238	11.1	Acceptable	N/A
158	Power Lines/Pylons	286	8.6	Acceptable	N/A
159	Power Lines/Pylons	362	6.2	Acceptable	N/A
160	Power Lines/Pylons	449	4.6	Acceptable	N/A
161	Power Lines/Pylons	1613	0.8	Acceptable	N/A
162	Power Lines/Pylons	1366	1.0	Acceptable	N/A
163	Power Lines/Pylons	1752	0.7	Acceptable	N/A
164	Power Lines/Pylons	1351	1.0	Acceptable	N/A
165	Power Lines/Pylons	1398	1.0	Acceptable	N/A

- ***Maximum charge per delay – 1800 kg***

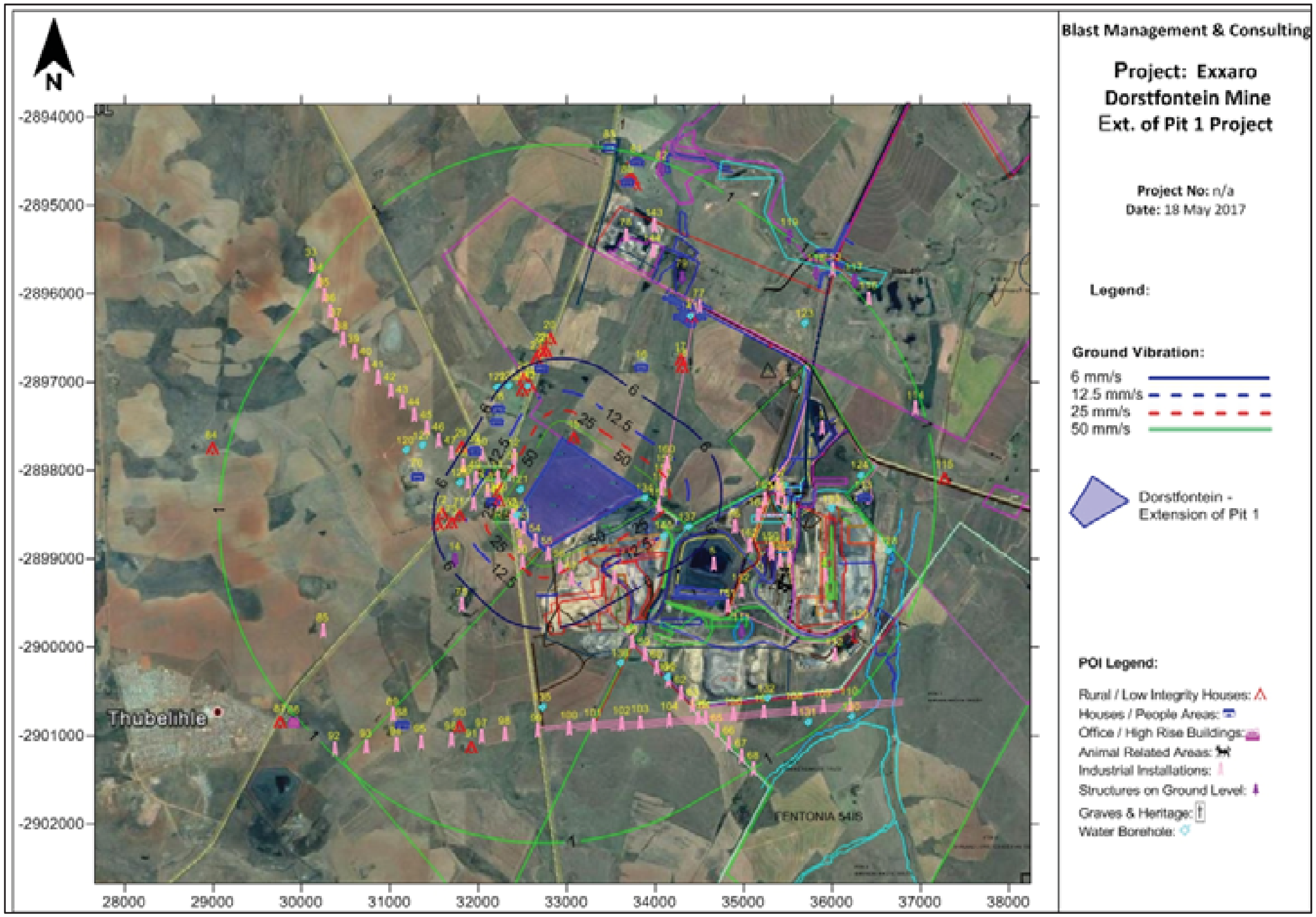


Figure 16: Ground vibration influence from maximum charge for Pit Area

Table 10: Ground vibration evaluation for maximum charge for Pit Area

Tag	Description	Distance (m)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
1	PCD's	2172	1.8	Acceptable	N/A
2	Plant Area	1586	2.8	Acceptable	N/A
3	Pit 1	691	8.8	Acceptable	N/A
4	Pit 2	2285	1.7	Acceptable	N/A
5	Co-disposal facility	1144	4.4	Acceptable	N/A
6	Impilo Primary School	833	6.8	Acceptable	Unpleasant
7	R544 Road	11	2511.4	Problematic	N/A
8	R544 Road	6	6500.1	Problematic	N/A
9	R544 Road	173	59.4	Acceptable	N/A
10	R544 Road	285	29.7	Acceptable	N/A
11	R547 and R544 Road Intersection	402	18.5	Acceptable	N/A
12	R544 Road	372	20.6	Acceptable	N/A
13	R547 Road	488	14.2	Acceptable	N/A
14	Pan	807	7.1	Acceptable	N/A
15	Ruins	87	152.3	Problematic	Intolerable
16	Buildings/Structures	1170	4.2	Acceptable	Perceptible
17	Informal Housing	1495	3.0	Acceptable	Perceptible
18	Ruins	1443	3.2	Acceptable	Perceptible
19	Informal Housing	1973	2.1	Acceptable	Perceptible
20	Informal Housing	1146	4.4	Acceptable	Perceptible
21	Informal Housing	1008	5.2	Acceptable	Perceptible
22	Informal Housing	1027	5.1	Acceptable	Perceptible
23	Informal Housing	953	5.6	Acceptable	Unpleasant
24	Informal Housing	710	8.4	Problematic	Unpleasant
25	Informal Housing	719	8.3	Problematic	Unpleasant
26	Informal Housing	797	7.2	Problematic	Unpleasant
27	Farm Buildings/Structures	734	8.1	Acceptable	Unpleasant
28	Farm Buildings/Structures	791	7.3	Acceptable	Unpleasant
29	Informal Housing	937	5.8	Acceptable	Unpleasant
30	Dam	687	8.8	Acceptable	N/A
31	Cement Dam	294	28.5	Acceptable	N/A
32	Building/Structure	776	7.5	Acceptable	Unpleasant
33	Power Lines/Pylons (no electrical lines)	3442	1.0	Acceptable	N/A
34	Power Lines/Pylons (no electrical lines)	3287	1.0	Acceptable	N/A
35	Power Lines/Pylons (no electrical lines)	3137	1.1	Acceptable	N/A
36	Power Lines/Pylons (no electrical lines)	2992	1.2	Acceptable	N/A
37	Power Lines/Pylons (no electrical lines)	2850	1.2	Acceptable	N/A
38	Power Lines/Pylons (no electrical lines)	2719	1.3	Acceptable	N/A
39	Power Lines/Pylons (no electrical lines)	2532	1.5	Acceptable	N/A
40	Power Lines/Pylons (no electrical lines)	2337	1.6	Acceptable	N/A
41	Power Lines/Pylons (no electrical lines)	2145	1.8	Acceptable	N/A
42	Power Lines/Pylons (no electrical lines)	1953	2.1	Acceptable	N/A
43	Power Lines/Pylons (no electrical lines)	1761	2.4	Acceptable	N/A
44	Power Lines/Pylons (no electrical lines)	1572	2.8	Acceptable	N/A
45	Power Lines/Pylons (no electrical lines)	1377	3.4	Acceptable	N/A
46	Power Lines/Pylons (no electrical lines)	1186	4.2	Acceptable	N/A
47	Power Lines/Pylons (no electrical lines)	993	5.3	Acceptable	N/A
48	Power Lines/Pylons (no electrical lines)	803	7.1	Acceptable	N/A
49	Power Lines/Pylons (no electrical lines)	610	10.4	Acceptable	N/A
50	Power Lines/Pylons (no electrical lines)	418	17.5	Acceptable	N/A
51	Power Lines/Pylons (no electrical lines)	228	40.4	Acceptable	N/A

Tag	Description	Distance (m)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
52	Power Lines/Pylons (no electrical lines)	34	556.9	Problematic	N/A
53	Power Lines/Pylons (no electrical lines)	8	4268.6	Problematic	N/A
54	Power Lines/Pylons (no electrical lines)	7	4675.0	Problematic	N/A
55	Power Lines/Pylons (no electrical lines)	70	208.3	Problematic	N/A
56	Power Lines/Pylons (no electrical lines)	260	33.7	Acceptable	N/A
57	Power Lines/Pylons (no electrical lines)	453	15.7	Acceptable	N/A
58	Power Lines/Pylons (no electrical lines)	1415	3.3	Acceptable	N/A
59	Power Lines/Pylons (no electrical lines)	1608	2.7	Acceptable	N/A
60	Power Lines/Pylons (no electrical lines)	1799	2.3	Acceptable	N/A
61	Power Lines/Pylons (no electrical lines)	1991	2.0	Acceptable	N/A
62	Power Lines/Pylons (no electrical lines)	2182	1.8	Acceptable	N/A
63	Power Lines/Pylons (no electrical lines)	2375	1.6	Acceptable	N/A
64	Power Lines/Pylons (no electrical lines)	2568	1.4	Acceptable	N/A
65	Power Lines/Pylons (no electrical lines)	2763	1.3	Acceptable	N/A
66	Power Lines/Pylons (no electrical lines)	2953	1.2	Acceptable	N/A
67	Power Lines/Pylons (no electrical lines)	3147	1.1	Acceptable	N/A
68	Power Lines/Pylons (no electrical lines)	3339	1.0	Acceptable	N/A
69	Dam	658	9.4	Acceptable	N/A
70	Farm Buildings/Structures	1191	4.1	Acceptable	Perceptible
71	Informal Housing	615	10.3	Problematic	Unpleasant
72	Informal Housing	819	6.9	Problematic	Unpleasant
73	Informal Housing	704	8.5	Problematic	Unpleasant
74	Informal Housing	864	6.4	Problematic	Unpleasant
75	Cement Dam	1101	4.6	Acceptable	N/A
76	Mine Activity	1128	4.5	Acceptable	N/A
77	Road	2111	1.9	Acceptable	N/A
78	Dam	2411	1.6	Acceptable	N/A
79	Pan	2279	1.7	Acceptable	N/A
80	Farm Buildings/Structures	2994	1.2	Acceptable	Perceptible
81	Farm Buildings/Structures	3245	1.0	Acceptable	Perceptible
82	Pan	3262	1.0	Acceptable	N/A
83	Farm Buildings/Structures	3338	1.0	Acceptable	Perceptible
84	Informal Housing	3505	0.9	Acceptable	Perceptible
85	Reservoir	2503	1.5	Acceptable	N/A
86	Hospital/Clinic - Thubelihle	3378	1.0	Acceptable	Perceptible
87	Thubelihle Village Houses	3497	0.9	Acceptable	Perceptible
88	Farm Buildings/Structures	2559	1.4	Acceptable	Perceptible
89	Cement Dam	2536	1.5	Acceptable	N/A
90	Informal Housing	2214	1.8	Acceptable	Perceptible
91	Informal Housing	2387	1.6	Acceptable	Perceptible
92	Power Lines/Pylons	3277	1.0	Acceptable	N/A
93	Power Lines/Pylons	3007	1.2	Acceptable	N/A
94	Power Lines/Pylons	2771	1.3	Acceptable	N/A
95	Power Lines/Pylons	2592	1.4	Acceptable	N/A
96	Power Lines/Pylons	2400	1.6	Acceptable	N/A
97	Power Lines/Pylons	2237	1.7	Acceptable	N/A
98	Power Lines/Pylons	2143	1.8	Acceptable	N/A
99	Power Lines/Pylons	2069	1.9	Acceptable	N/A
100	Power Lines/Pylons	2055	1.9	Acceptable	N/A
101	Power Lines/Pylons	2082	1.9	Acceptable	N/A
102	Power Lines/Pylons	2165	1.8	Acceptable	N/A
103	Power Lines/Pylons	2241	1.7	Acceptable	N/A
104	Power Lines/Pylons	2382	1.6	Acceptable	N/A

Tag	Description	Distance (m)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
105	Power Lines/Pylons	2522	1.5	Acceptable	N/A
106	Power Lines/Pylons	2694	1.3	Acceptable	N/A
107	Power Lines/Pylons	2835	1.2	Acceptable	N/A
108	Power Lines/Pylons	2996	1.2	Acceptable	N/A
109	Power Lines/Pylons	3175	1.1	Acceptable	N/A
110	Power Lines/Pylons	3361	1.0	Acceptable	N/A
111	Pan	1934	2.1	Acceptable	N/A
112	Dam	2859	1.2	Acceptable	N/A
113	Farm Buildings/Structures	2522	1.5	Acceptable	Perceptible
114	Dam	3255	1.0	Acceptable	N/A
115	Informal Housing	3443	1.0	Acceptable	Perceptible
116	Dam	3386	1.0	Acceptable	N/A
117	Olifants River	3407	1.0	Acceptable	N/A
118	Olifants River	3190	1.1	Acceptable	N/A
119	Olifants River	3351	1.0	Acceptable	N/A
120	Hydrocensus Borehole (NBH24 - Livestock and crop watering)	1443	3.2	Acceptable	N/A
121	Monitoring Borehole (DFTNM11)	116	103.0	Problematic	N/A
122	Hydrocensus Borehole (NBH22 - Livestock watering)	936	5.8	Acceptable	N/A
123	Monitoring Borehole (NBH5)	2665	1.4	Acceptable	N/A
124	Hydrocensus Borehole (NBH6 - Dormant)	2489	1.5	Acceptable	N/A
125	Hydrocensus Borehole (NBH20 - Drinking water)	729	8.1	Acceptable	N/A
126	Hydrocensus Borehole (NBH21 - Drinking water)	848	6.6	Acceptable	N/A
127	Hydrocensus Borehole (NBH23 - Drinking water)	1318	3.6	Acceptable	N/A
128	Monitoring Borehole (DFTNM1)	2881	1.2	Acceptable	N/A
129	Monitoring Borehole (DFTNM2)	2899	1.2	Acceptable	N/A
130	Monitoring Borehole (DFTNM3)	3479	0.9	Acceptable	N/A
131	Monitoring Borehole (DFTNM4)	3211	1.1	Acceptable	N/A
132	Monitoring Borehole (DFTNM5)	2724	1.3	Acceptable	N/A
133	Monitoring Borehole (DFTNM6)	2167	1.8	Acceptable	N/A
134	Monitoring Borehole (DFTNM7)	71	203.1	Problematic	N/A
135	Monitoring Borehole (DFTNM8)	1793	2.4	Acceptable	N/A
136	Monitoring Borehole (DFTNM9)	1553	2.9	Acceptable	N/A
137	Monitoring Borehole (DFTNM10)	654	9.5	Acceptable	N/A
138	Monitoring Borehole (DFTNM12)	15	1762.5	Problematic	N/A
139	Monitoring Borehole (DFTNM13)	1954	2.1	Acceptable	N/A
140	Monitoring Borehole (DFTNH1)	546	12.1	Acceptable	N/A
141	Monitoring Borehole (DFBH)	1958	2.1	Acceptable	N/A
142	Emalayinini Community Borehole (ECBH)	716	8.3	Acceptable	N/A
143	Dam	2627	1.4	Acceptable	N/A
144	Dam	2356	1.6	Acceptable	N/A
145	Farm Buildings/Structures	293	28.7	Problematic	Intolerable
146	Informal Housing	252	35.2	Problematic	Intolerable
147	Mine Buildings(Workshop)	1550	2.9	Acceptable	N/A
148	Sub Station	1634	2.7	Acceptable	N/A
149	Sub Station	1701	2.5	Acceptable	N/A
150	Sub Station	1600	2.8	Acceptable	N/A
151	Water Tank	1833	2.3	Acceptable	N/A
152	Mine Buildings/Structures	1585	2.8	Acceptable	N/A

Tag	Description	Distance (m)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
153	Bridge	3327	1.0	Acceptable	N/A
154	Conveyor	1634	2.7	Acceptable	N/A
155	Mine Buildings/Structures	1549	2.9	Acceptable	N/A
156	Power Lines/Pylons	247	36.2	Acceptable	N/A
157	Power Lines/Pylons	238	38.1	Acceptable	N/A
158	Power Lines/Pylons	286	29.6	Acceptable	N/A
159	Power Lines/Pylons	362	21.4	Acceptable	N/A
160	Power Lines/Pylons	449	15.9	Acceptable	N/A
161	Power Lines/Pylons	1613	2.7	Acceptable	N/A
162	Power Lines/Pylons	1366	3.4	Acceptable	N/A
163	Power Lines/Pylons	1752	2.4	Acceptable	N/A
164	Power Lines/Pylons	1351	3.5	Acceptable	N/A
165	Power Lines/Pylons	1398	3.3	Acceptable	N/A

15.3 Summary of Ground Vibration Levels

The Pit operations were evaluated for expected levels of ground vibration from future blasting operations. Review of the sites and the surrounding installations / houses / buildings / mine infrastructure showed that structures vary in distances from the pit area. The evaluation considered a distance up to 3500 m from the mining area.

The distances between structures and the pit area is the main contributing factor to the levels of ground vibration expected and the subsequent possible influences. It is observed that for the different charge masses evaluated that levels of ground vibration will change as well. In view of the maximum charge specific attention will need to be given to specific areas.

The closest structures to the open pit area are Informal Housing, Ruins, R544 Road, Power Lines/Pylons, Monitoring Boreholes and Farm Buildings/Structures. The planned maximum charge evaluated showed that it could be problematic in terms of potential structural damage and human perception. A maximum of 6500.1 mm/s is expected for the maximum charge.

The nearest public houses are located 252 m from the pit boundary. The ground vibration levels predicted ranged between 0.9 mm/s and 6500.1 mm/s for structures surrounding the open pit area. Ground vibration levels at the nearest buildings where people may be present is 35.2 mm/s. The nearest structures considered in the evaluation showed levels of ground vibration as problematic and could be experienced as intolerable.

There are structures that are better built and some that are of lesser quality integrity. Only a detailed survey will pin point exactly what type of structure is found where.

In view of the above it is believed that specific mitigations will be required near POIs that have been identified as possible concerns such as possible relocation of relevant households.

15.4 Ground Vibration and Human Perception

Considering the effect of ground vibration with regards to human perception, vibration levels calculated were applied to an average of 30Hz frequency and plotted with expected human perceptions on the safe blasting criteria graph (see Figure 17 below). Data applicable to human response only is plotted. The frequency range selected is the expected average range for frequencies that will be measured for ground vibration when blasting is done. The nearest houses are located at 252 m from the Open Pit boundary. Based on the maximum charge it can be seen from Figure 17 that up to a distance of 3505 m people may experience levels of ground vibration as perceptible. At 1191 m and closer the perception of ground vibration could be unpleasant. Closer than 615 m the levels will be intolerable and at distance of 900 m the lowest limit of 6 mm/s may be exceeded.

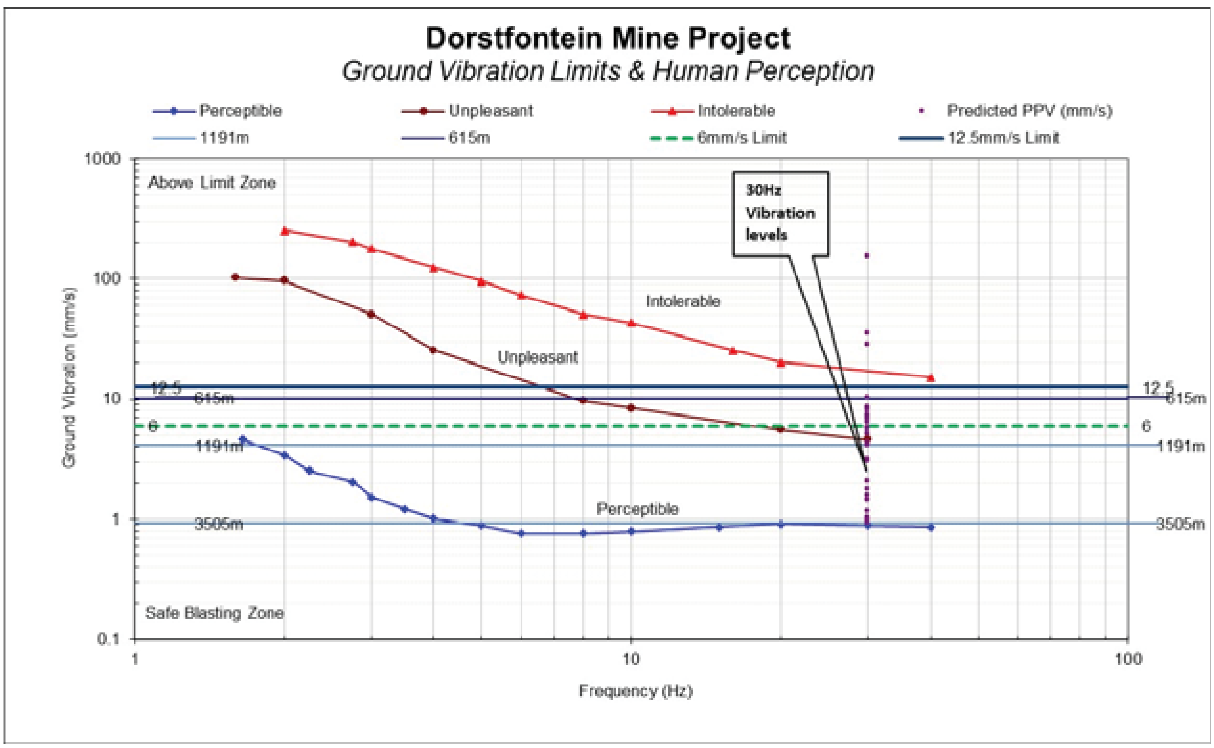


Figure 17: The effect of ground vibration with human perception and vibration limits

15.5 Potential that Vibration Will Upset Adjacent Communities

Ground vibration and air blast generally upset people living in the vicinity of mining operations. There are communities and roads that are within the evaluated area of influence. There are structures in close proximity of the pit area.

Ground vibration levels expected from maximum charge has possibility to be perceptible up to 3505 m. It is certain that lesser charges will reduce this distance for instance at minimum charge this distance is expected to be 1495 m. Within these distance ranges there are a significant number of houses. The anticipated ground vibration levels are certain to have possibility of upsetting the adjacent communities. Intolerable levels are expected up to a distance of 292 m

The importance of good public relations cannot be under stressed. People tend to react negatively on experiencing of effects from blasting such as ground vibration and air blast. Even at low levels when damage to structures is out of the question it may upset people. Proper and appropriate communication with neighbours about blasting, monitoring and actions done for proper control will be required.

15.6 Vibration Impact on Roads

There are district and provincial roads in the vicinity of the project area to be considered. The R544 Provincial road is at closest distance of 6 m from the Pit boundary. Expected ground vibration levels at this provincial road are higher than the recommended limits and changed blasting parameters will have to be applied to ensure levels are within accepted norms. The R547 Provincial road is at closest distance of 402 m and within the recommended limits. No specific actions are required for this road.

15.7 Review of Expected Air Blast

Presented herewith are the expected air blast level contours and discussion of relevant influences. Expected air blast levels were calculated for each POI identified surrounding the mining area and evaluated with regards to possible structural concerns. Tables are provided for each of the different charge models done with regards to:

- "Tag" No. is number corresponding to the location indicated on POI figures.
- "Description" indicates the type of the structure.
- "Distance" is the distance between the structure and edge of the pit area.
- "Air Blast (dB)" is the calculated air blast level at the structure.

- "Possible concern" indicates if there is any concern for structural damage or human perception. Indicators used are:
  - "Problematic" where there is real concern for possible damage – at levels greater than 134 dBL.
  - "Complaint" where people will be complaining due to the experienced effect on structures at levels of 120 dB and higher (not necessarily damaging).
  - "Acceptable" if levels are less than 120 dBL.
  - "Low" where there is very limited possibility that the levels will give rise to any influence on people or structures. Levels below 115 dB could be considered to have low or negligible possibility of influence.

Presented are simulations for expected air blast levels from two different charge masses at the shaft areas. Colour codes used in tables are as follows:

Air blast levels higher than proposed limit is coloured "Red"
Air blast levels indicated as possible Complaint is coloured "Mustard"

- ***Minimum charge per delay - 300 kg***

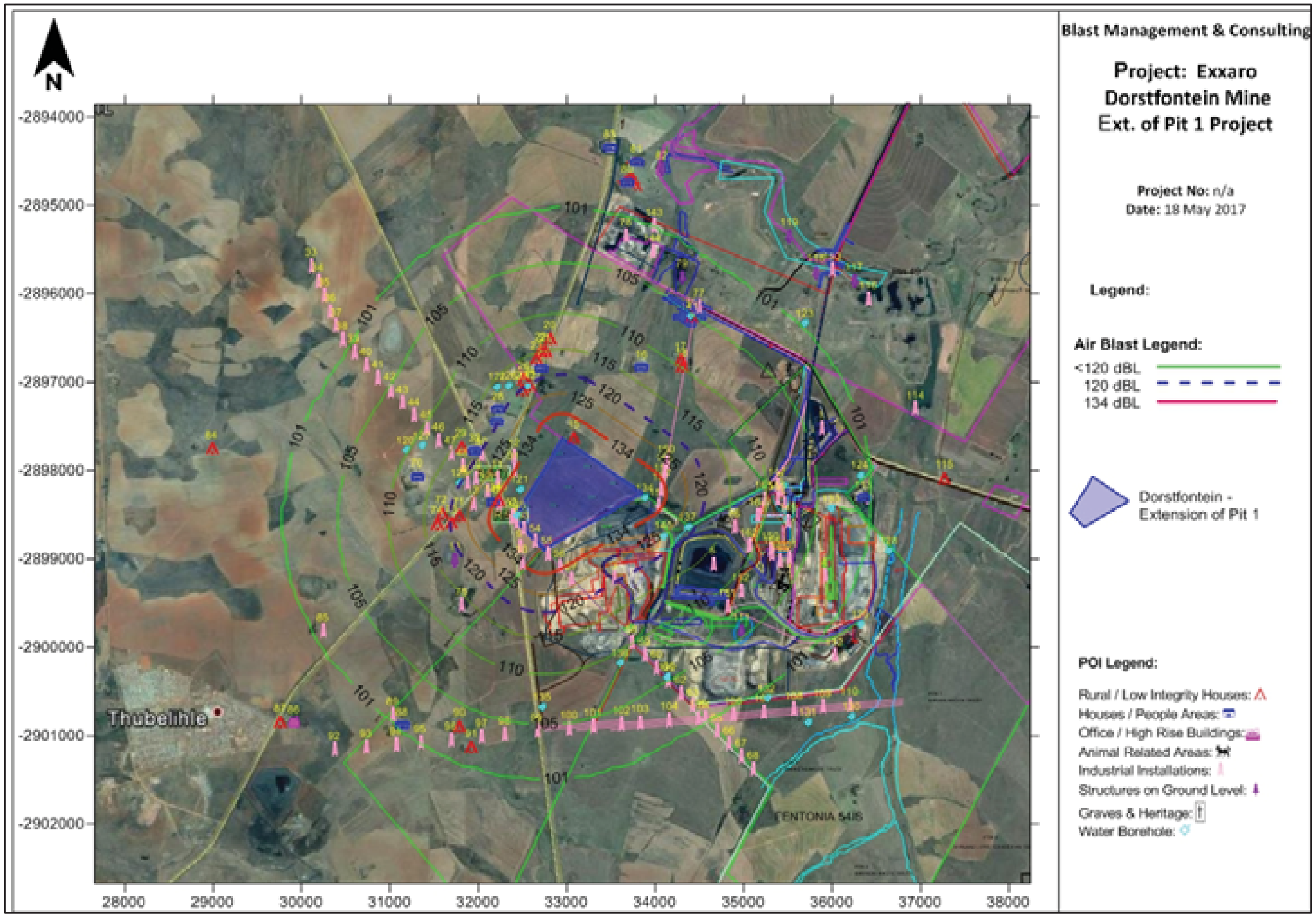


Figure 18: Air blast influence from minimum charge for Pit Area

Table 11: Air blast evaluation for minimum charge for Pit Area

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
1	PCD's	2172	103.8	N/A
2	Plant Area	1586	108.3	N/A
3	Pit 1	691	120.7	N/A
4	Pit 2	2285	102.9	N/A
5	Co-disposal facility	1144	113.2	N/A
6	Impilo Primary School	833	117.9	Acceptable
7	R544 Road	11	182.0	N/A
8	R544 Road	6	192.3	N/A
9	R544 Road	173	141.4	N/A
10	R544 Road	285	133.9	N/A
11	R547 and R544 Road Intersection	402	128.8	N/A
12	R544 Road	372	130.0	N/A
13	R547 Road	488	125.9	N/A
14	Pan	807	118.4	N/A
15	Ruins	87	151.6	N/A
16	Buildings/Structures	1170	112.9	Acceptable
17	Informal Housing	1495	109.2	Acceptable
18	Ruins	1443	109.7	N/A
19	Informal Housing	1973	105.1	Acceptable
20	Informal Housing	1146	113.2	Acceptable
21	Informal Housing	1008	115.0	Acceptable
22	Informal Housing	1027	114.8	Acceptable
23	Informal Housing	953	115.9	Acceptable
24	Informal Housing	710	120.3	Complaint
25	Informal Housing	719	120.1	Complaint
26	Informal Housing	797	118.6	Acceptable
27	Farm Buildings/Structures	734	119.8	Acceptable
28	Farm Buildings/Structures	791	118.7	Acceptable
29	Informal Housing	937	116.1	Acceptable
30	Dam	687	120.8	N/A
31	Cement Dam	294	133.5	N/A
32	Building/Structure	776	118.9	Acceptable
33	Power Lines/Pylons (no electrical lines)	3442	96.9	N/A
34	Power Lines/Pylons (no electrical lines)	3287	97.5	N/A
35	Power Lines/Pylons (no electrical lines)	3137	98.6	N/A
36	Power Lines/Pylons (no electrical lines)	2992	99.1	N/A
37	Power Lines/Pylons (no electrical lines)	2850	99.6	N/A
38	Power Lines/Pylons (no electrical lines)	2719	100.4	N/A
39	Power Lines/Pylons (no electrical lines)	2532	101.6	N/A
40	Power Lines/Pylons (no electrical lines)	2337	102.6	N/A
41	Power Lines/Pylons (no electrical lines)	2145	103.8	N/A
42	Power Lines/Pylons (no electrical lines)	1953	105.3	N/A
43	Power Lines/Pylons (no electrical lines)	1761	106.8	N/A
44	Power Lines/Pylons (no electrical lines)	1572	108.5	N/A
45	Power Lines/Pylons (no electrical lines)	1377	110.4	N/A
46	Power Lines/Pylons (no electrical lines)	1186	112.7	N/A
47	Power Lines/Pylons (no electrical lines)	993	115.3	N/A
48	Power Lines/Pylons (no electrical lines)	803	118.4	N/A
49	Power Lines/Pylons (no electrical lines)	610	122.5	N/A
50	Power Lines/Pylons (no electrical lines)	418	128.2	N/A
51	Power Lines/Pylons (no electrical lines)	228	137.2	N/A

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
52	Power Lines/Pylons (no electrical lines)	34	165.7	N/A
53	Power Lines/Pylons (no electrical lines)	8	187.7	N/A
54	Power Lines/Pylons (no electrical lines)	7	188.7	N/A
55	Power Lines/Pylons (no electrical lines)	70	155.0	N/A
56	Power Lines/Pylons (no electrical lines)	260	135.3	N/A
57	Power Lines/Pylons (no electrical lines)	453	127.0	N/A
58	Power Lines/Pylons (no electrical lines)	1415	110.0	N/A
59	Power Lines/Pylons (no electrical lines)	1608	108.1	N/A
60	Power Lines/Pylons (no electrical lines)	1799	106.4	N/A
61	Power Lines/Pylons (no electrical lines)	1991	104.9	N/A
62	Power Lines/Pylons (no electrical lines)	2182	103.5	N/A
63	Power Lines/Pylons (no electrical lines)	2375	102.3	N/A
64	Power Lines/Pylons (no electrical lines)	2568	101.2	N/A
65	Power Lines/Pylons (no electrical lines)	2763	100.0	N/A
66	Power Lines/Pylons (no electrical lines)	2953	99.1	N/A
67	Power Lines/Pylons (no electrical lines)	3147	98.1	N/A
68	Power Lines/Pylons (no electrical lines)	3339	97.5	N/A
69	Dam	658	121.4	N/A
70	Farm Buildings/Structures	1191	112.6	Acceptable
71	Informal Housing	615	122.4	Complaint
72	Informal Housing	819	118.2	Acceptable
73	Informal Housing	704	120.4	Complaint
74	Informal Housing	864	117.4	Acceptable
75	Cement Dam	1101	113.8	N/A
76	Mine Activity	1128	113.4	N/A
77	Road	2111	104.1	N/A
78	Dam	2411	102.3	N/A
79	Pan	2279	102.9	N/A
80	Farm Buildings/Structures	2994	99.1	Acceptable
81	Farm Buildings/Structures	3245	98.1	Acceptable
82	Pan	3262	97.5	N/A
83	Farm Buildings/Structures	3338	97.5	Acceptable
84	Informal Housing	3505	96.9	Acceptable
85	Reservoir	2503	101.6	N/A
86	Hospital/Clinic - Thubelihle	3378	97.5	Acceptable
87	Thubelihle Village Houses	3497	96.9	Acceptable
88	Farm Buildings/Structures	2559	101.2	Acceptable
89	Cement Dam	2536	101.6	N/A
90	Informal Housing	2214	103.5	Acceptable
91	Informal Housing	2387	102.3	Acceptable
92	Power Lines/Pylons	3277	97.5	N/A
93	Power Lines/Pylons	3007	99.1	N/A
94	Power Lines/Pylons	2771	100.0	N/A
95	Power Lines/Pylons	2592	101.2	N/A
96	Power Lines/Pylons	2400	102.3	N/A
97	Power Lines/Pylons	2237	103.2	N/A
98	Power Lines/Pylons	2143	103.8	N/A
99	Power Lines/Pylons	2069	104.3	N/A
100	Power Lines/Pylons	2055	104.6	N/A
101	Power Lines/Pylons	2082	104.3	N/A
102	Power Lines/Pylons	2165	103.8	N/A
103	Power Lines/Pylons	2241	103.2	N/A
104	Power Lines/Pylons	2382	102.3	N/A

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
105	Power Lines/Pylons	2522	101.6	N/A
106	Power Lines/Pylons	2694	100.4	N/A
107	Power Lines/Pylons	2835	100.0	N/A
108	Power Lines/Pylons	2996	99.1	N/A
109	Power Lines/Pylons	3175	98.1	N/A
110	Power Lines/Pylons	3361	97.5	N/A
111	Pan	1934	105.3	N/A
112	Dam	2859	99.6	N/A
113	Farm Buildings/Structures	2522	101.6	Acceptable
114	Dam	3255	98.1	N/A
115	Informal Housing	3443	96.9	Acceptable
116	Dam	3386	97.5	N/A
117	Olifants River	3407	96.9	N/A
118	Olifants River	3190	98.1	N/A
119	Olifants River	3351	97.5	N/A
120	Hydrocensus Borehole (NBH24 - Livestock and crop watering)	1443	109.7	N/A
121	Monitoring Borehole (DFTNM11)	116	147.4	N/A
122	Hydrocensus Borehole (NBH22 - Livestock watering)	936	116.2	N/A
123	Monitoring Borehole (NBH5)	2665	100.8	N/A
124	Hydrocensus Borehole (NBH6 - Dormant)	2489	101.6	N/A
125	Hydrocensus Borehole (NBH20 - Drinking water)	729	119.9	N/A
126	Hydrocensus Borehole (NBH21 - Drinking water)	848	117.7	N/A
127	Hydrocensus Borehole (NBH23 - Drinking water)	1318	111.1	N/A
128	Monitoring Borehole (DFTNM1)	2881	99.6	N/A
129	Monitoring Borehole (DFTNM2)	2899	99.6	N/A
130	Monitoring Borehole (DFTNM3)	3479	96.9	N/A
131	Monitoring Borehole (DFTNM4)	3211	98.1	N/A
132	Monitoring Borehole (DFTNM5)	2724	100.4	N/A
133	Monitoring Borehole (DFTNM6)	2167	103.8	N/A
134	Monitoring Borehole (DFTNM7)	71	154.7	N/A
135	Monitoring Borehole (DFTNM8)	1793	106.4	N/A
136	Monitoring Borehole (DFTNM9)	1553	108.6	N/A
137	Monitoring Borehole (DFTNM10)	654	121.5	N/A
138	Monitoring Borehole (DFTNM12)	15	178.1	N/A
139	Monitoring Borehole (DFTNM13)	1954	105.3	N/A
140	Monitoring Borehole (DFTNH1)	546	124.2	N/A
141	Monitoring Borehole (DFBH)	1958	105.3	N/A
142	Emalayinini Community Borehole (ECBH)	716	120.2	N/A
143	Dam	2627	100.8	N/A
144	Dam	2356	102.6	N/A
145	Farm Buildings/Structures	293	133.5	Problematic
146	Informal Housing	252	135.7	Problematic
147	Mine Buildings(Workshop)	1550	108.6	N/A
148	Sub Station	1634	108.0	N/A
149	Sub Station	1701	107.2	N/A
150	Sub Station	1600	108.1	N/A
151	Water Tank	1833	106.2	N/A
152	Mine Buildings/Structures	1585	108.3	N/A
153	Bridge	3327	97.5	N/A
154	Conveyor	1634	108.0	N/A
155	Mine Buildings/Structures	1549	108.6	N/A
156	Power Lines/Pylons	247	136.0	N/A
157	Power Lines/Pylons	238	136.6	N/A

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
158	Power Lines/Pylons	286	133.9	N/A
159	Power Lines/Pylons	362	130.4	N/A
160	Power Lines/Pylons	449	127.1	N/A
161	Power Lines/Pylons	1613	108.1	N/A
162	Power Lines/Pylons	1366	110.5	N/A
163	Power Lines/Pylons	1752	106.8	N/A
164	Power Lines/Pylons	1351	110.8	N/A
165	Power Lines/Pylons	1398	110.2	N/A

- ***Maximum charge per delay - 1800 kg***

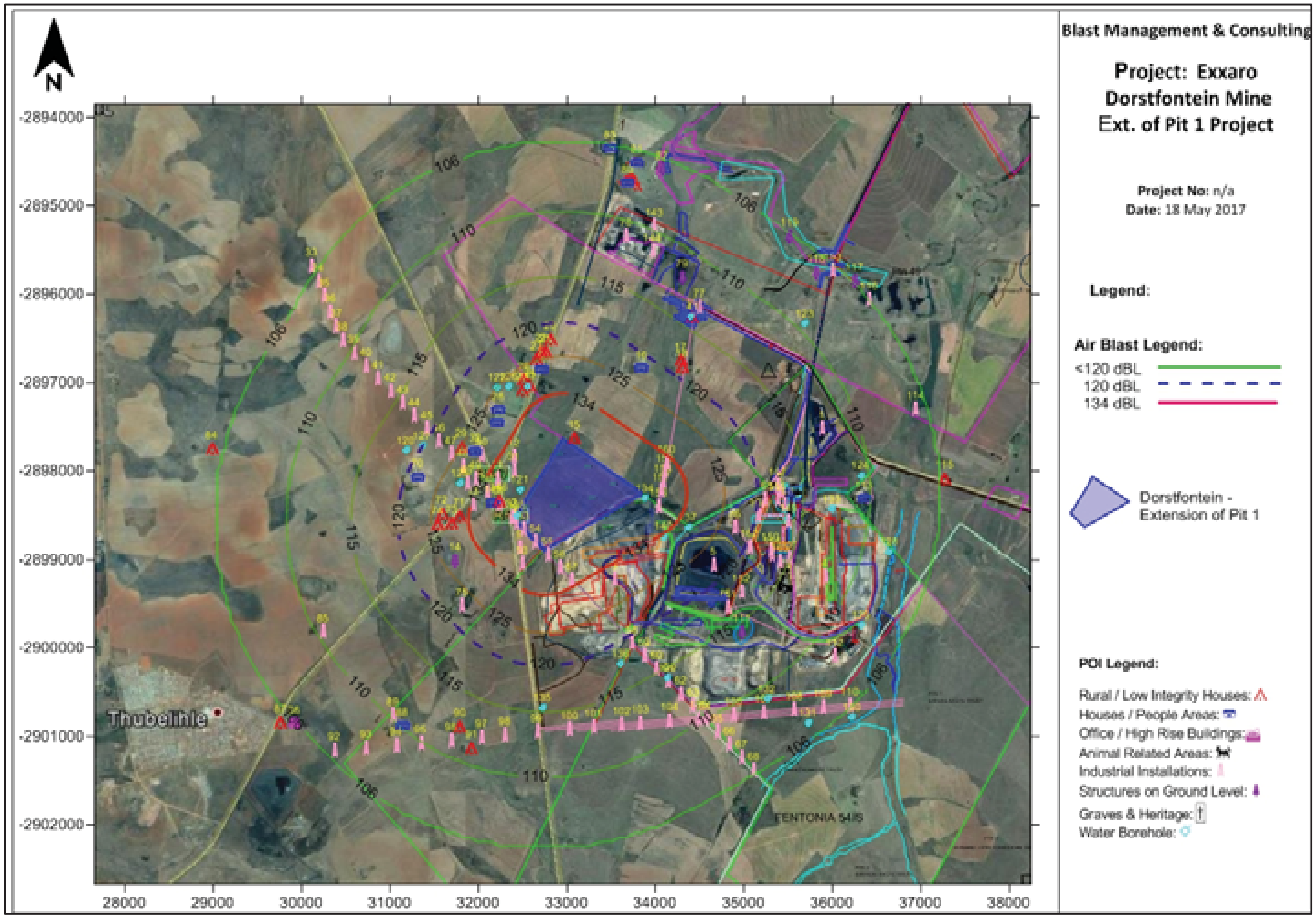


Figure 19: Air blast influence from maximum charge for Pit Area

Table 12: Air blast evaluation for maximum charge for Pit Area

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
1	PCD's	2172	112.6	N/A
2	Plant Area	1586	117.2	N/A
3	Pit 1	691	129.6	N/A
4	Pit 2	2285	111.8	N/A
5	Co-disposal facility	1144	122.1	N/A
6	Impilo Primary School	833	126.8	Complaint
7	R544 Road	11	190.9	N/A
8	R544 Road	6	201.2	N/A
9	R544 Road	173	150.3	N/A
10	R544 Road	285	142.8	N/A
11	R547 and R544 Road Intersection	402	137.7	N/A
12	R544 Road	372	138.9	N/A
13	R547 Road	488	134.8	N/A
14	Pan	807	127.3	N/A
15	Ruins	87	160.5	N/A
16	Buildings/Structures	1170	121.8	Complaint
17	Informal Housing	1495	118.1	Acceptable
18	Ruins	1443	118.6	N/A
19	Informal Housing	1973	114.0	Acceptable
20	Informal Housing	1146	122.1	Complaint
21	Informal Housing	1008	124.0	Complaint
22	Informal Housing	1027	123.7	Complaint
23	Informal Housing	953	124.8	Complaint
24	Informal Housing	710	129.2	Complaint
25	Informal Housing	719	129.0	Complaint
26	Informal Housing	797	127.5	Complaint
27	Farm Buildings/Structures	734	128.7	Complaint
28	Farm Buildings/Structures	791	127.6	Complaint
29	Informal Housing	937	125.1	Complaint
30	Dam	687	129.7	N/A
31	Cement Dam	294	142.4	N/A
32	Building/Structure	776	127.9	Complaint
33	Power Lines/Pylons (no electrical lines)	3442	105.8	N/A
34	Power Lines/Pylons (no electrical lines)	3287	106.4	N/A
35	Power Lines/Pylons (no electrical lines)	3137	107.0	N/A
36	Power Lines/Pylons (no electrical lines)	2992	107.8	N/A
37	Power Lines/Pylons (no electrical lines)	2850	108.5	N/A
38	Power Lines/Pylons (no electrical lines)	2719	109.2	N/A
39	Power Lines/Pylons (no electrical lines)	2532	110.2	N/A
40	Power Lines/Pylons (no electrical lines)	2337	111.5	N/A
41	Power Lines/Pylons (no electrical lines)	2145	112.8	N/A
42	Power Lines/Pylons (no electrical lines)	1953	114.2	N/A
43	Power Lines/Pylons (no electrical lines)	1761	115.6	N/A
44	Power Lines/Pylons (no electrical lines)	1572	117.3	N/A
45	Power Lines/Pylons (no electrical lines)	1377	119.3	N/A
46	Power Lines/Pylons (no electrical lines)	1186	121.5	N/A
47	Power Lines/Pylons (no electrical lines)	993	124.2	N/A
48	Power Lines/Pylons (no electrical lines)	803	127.4	N/A
49	Power Lines/Pylons (no electrical lines)	610	131.5	N/A
50	Power Lines/Pylons (no electrical lines)	418	137.1	N/A
51	Power Lines/Pylons (no electrical lines)	228	146.2	N/A

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
52	Power Lines/Pylons (no electrical lines)	34	174.6	N/A
53	Power Lines/Pylons (no electrical lines)	8	196.6	N/A
54	Power Lines/Pylons (no electrical lines)	7	197.6	N/A
55	Power Lines/Pylons (no electrical lines)	70	163.9	N/A
56	Power Lines/Pylons (no electrical lines)	260	144.2	N/A
57	Power Lines/Pylons (no electrical lines)	453	135.9	N/A
58	Power Lines/Pylons (no electrical lines)	1415	118.9	N/A
59	Power Lines/Pylons (no electrical lines)	1608	117.0	N/A
60	Power Lines/Pylons (no electrical lines)	1799	115.3	N/A
61	Power Lines/Pylons (no electrical lines)	1991	113.8	N/A
62	Power Lines/Pylons (no electrical lines)	2182	112.5	N/A
63	Power Lines/Pylons (no electrical lines)	2375	111.2	N/A
64	Power Lines/Pylons (no electrical lines)	2568	110.1	N/A
65	Power Lines/Pylons (no electrical lines)	2763	108.9	N/A
66	Power Lines/Pylons (no electrical lines)	2953	108.0	N/A
67	Power Lines/Pylons (no electrical lines)	3147	107.0	N/A
68	Power Lines/Pylons (no electrical lines)	3339	106.2	N/A
69	Dam	658	130.3	N/A
70	Farm Buildings/Structures	1191	121.5	Complaint
71	Informal Housing	615	131.4	Complaint
72	Informal Housing	819	127.1	Complaint
73	Informal Housing	704	129.3	Complaint
74	Informal Housing	864	126.3	Complaint
75	Cement Dam	1101	122.7	N/A
76	Mine Activity	1128	122.3	N/A
77	Road	2111	113.0	N/A
78	Dam	2411	111.0	N/A
79	Pan	2279	111.8	N/A
80	Farm Buildings/Structures	2994	107.8	Acceptable
81	Farm Buildings/Structures	3245	106.6	Acceptable
82	Pan	3262	106.4	N/A
83	Farm Buildings/Structures	3338	106.2	Acceptable
84	Informal Housing	3505	105.3	Acceptable
85	Reservoir	2503	110.4	N/A
86	Hospital/Clinic - Thubelihle	3378	106.0	Acceptable
87	Thubelihle Village Houses	3497	105.6	Acceptable
88	Farm Buildings/Structures	2559	110.1	Acceptable
89	Cement Dam	2536	110.2	N/A
90	Informal Housing	2214	112.3	Acceptable
91	Informal Housing	2387	111.1	Acceptable
92	Power Lines/Pylons	3277	106.4	N/A
93	Power Lines/Pylons	3007	107.8	N/A
94	Power Lines/Pylons	2771	108.9	N/A
95	Power Lines/Pylons	2592	110.0	N/A
96	Power Lines/Pylons	2400	111.0	N/A
97	Power Lines/Pylons	2237	112.1	N/A
98	Power Lines/Pylons	2143	112.8	N/A
99	Power Lines/Pylons	2069	113.3	N/A
100	Power Lines/Pylons	2055	113.3	N/A
101	Power Lines/Pylons	2082	113.2	N/A
102	Power Lines/Pylons	2165	112.6	N/A
103	Power Lines/Pylons	2241	112.0	N/A
104	Power Lines/Pylons	2382	111.1	N/A

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
105	Power Lines/Pylons	2522	110.4	N/A
106	Power Lines/Pylons	2694	109.4	N/A
107	Power Lines/Pylons	2835	108.6	N/A
108	Power Lines/Pylons	2996	107.8	N/A
109	Power Lines/Pylons	3175	106.8	N/A
110	Power Lines/Pylons	3361	106.0	N/A
111	Pan	1934	114.2	N/A
112	Dam	2859	108.5	N/A
113	Farm Buildings/Structures	2522	110.4	Acceptable
114	Dam	3255	106.4	N/A
115	Informal Housing	3443	105.8	Acceptable
116	Dam	3386	106.0	N/A
117	Olifants River	3407	105.8	N/A
118	Olifants River	3190	106.8	N/A
119	Olifants River	3351	106.0	N/A
120	Hydrocensus Borehole (NBH24 - Livestock and crop watering)	1443	118.6	N/A
121	Monitoring Borehole (DFTNM11)	116	156.3	N/A
122	Hydrocensus Borehole (NBH22 - Livestock watering)	936	125.1	N/A
123	Monitoring Borehole (NBH5)	2665	109.5	N/A
124	Hydrocensus Borehole (NBH6 - Dormant)	2489	110.5	N/A
125	Hydrocensus Borehole (NBH20 - Drinking water)	729	128.8	N/A
126	Hydrocensus Borehole (NBH21 - Drinking water)	848	126.5	N/A
127	Hydrocensus Borehole (NBH23 - Drinking water)	1318	120.0	N/A
128	Monitoring Borehole (DFTNM1)	2881	108.3	N/A
129	Monitoring Borehole (DFTNM2)	2899	108.3	N/A
130	Monitoring Borehole (DFTNM3)	3479	105.6	N/A
131	Monitoring Borehole (DFTNM4)	3211	106.6	N/A
132	Monitoring Borehole (DFTNM5)	2724	109.2	N/A
133	Monitoring Borehole (DFTNM6)	2167	112.6	N/A
134	Monitoring Borehole (DFTNM7)	71	163.7	N/A
135	Monitoring Borehole (DFTNM8)	1793	115.4	N/A
136	Monitoring Borehole (DFTNM9)	1553	117.5	N/A
137	Monitoring Borehole (DFTNM10)	654	130.4	N/A
138	Monitoring Borehole (DFTNM12)	15	187.1	N/A
139	Monitoring Borehole (DFTNM13)	1954	114.2	N/A
140	Monitoring Borehole (DFTNH1)	546	133.1	N/A
141	Monitoring Borehole (DFBH)	1958	114.1	N/A
142	Emalayinini Community Borehole (ECBH)	716	129.1	N/A
143	Dam	2627	109.7	N/A
144	Dam	2356	111.4	N/A
145	Farm Buildings/Structures	293	142.5	Problematic
146	Informal Housing	252	144.7	Problematic
147	Mine Buildings(Workshop)	1550	117.6	N/A
148	Sub Station	1634	116.8	N/A
149	Sub Station	1701	116.2	N/A
150	Sub Station	1600	117.1	N/A
151	Water Tank	1833	115.0	N/A
152	Mine Buildings/Structures	1585	117.2	N/A
153	Bridge	3327	106.2	N/A
154	Conveyor	1634	116.8	N/A
155	Mine Buildings/Structures	1549	117.6	N/A
156	Power Lines/Pylons	247	145.0	N/A
157	Power Lines/Pylons	238	145.5	N/A

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
158	Power Lines/Pylons	286	142.8	N/A
159	Power Lines/Pylons	362	139.3	N/A
160	Power Lines/Pylons	449	136.1	N/A
161	Power Lines/Pylons	1613	117.0	N/A
162	Power Lines/Pylons	1366	119.4	N/A
163	Power Lines/Pylons	1752	115.7	N/A
164	Power Lines/Pylons	1351	119.6	N/A
165	Power Lines/Pylons	1398	119.1	N/A

15.8 Summary of Findings for Air Blast

Review of the air blast levels indicates the same concerns than with ground vibration. Air blast predicted for the maximum charge ranges between 105.3 and 160.5 dB for all the POI's considered. This includes the nearest points such as the Ruins, Informal Housing & Farm Buildings/Structures. These levels may contribute to effects such as rattling of roofs or door or windows and is expected to be damaging. The current accepted limit on air blast is 134 dB. Damages are only expected to occur at levels greater than 134dB. On prediction it is expected that air blast will be greater than 134 dB at a distance of 500 m and closer from the pit boundary. Baseline data does show that there were exceeding's of air blast limits on occasions. Care will have to be taken and control on blast preparation will have to be more accurate.

The Ruins, Informal Housing & Farm Buildings/Structures are the only POI's that were identified where air blast could be problematic and expected air blast is more than 134 dBL. The rest of the POI's showed levels lower than 134 dB. Power lines and the Road are closer but air blast does not have any influence on these installations.

Complaints from air blast are normally based on the actual effects that are experienced due to rattling of roof, windows, doors etc. These effects could startle people and raise concern of possible damage.

The calculations for air blast are based on the use of basic rules for stemming length and stemming material. It is maintained that if stemming control is not exercised this effect could be greater with greater range of complaints or damage. The project area is located such that "free blasting" – meaning no controls on blast preparation – will not be possible. Controls will be required.

15.9 Fly-rock Unsafe Zone

The occurrence of fly rock in any form will have a negative impact if found to travel outside the unsafe zone or within the safe boundary. The safe boundary may be anything between 10 m or 1000 m. A general safe boundary is normally considered to be a radius of 500 m or greater from the blast; but needs to be qualified and determined as best possible.

Calculations are used to help and assist determining safe distances. A safe distance from blasting is calculated following rules and guidelines from the International Society of Explosives Engineers (ISEE) Blasters Handbook. Using this calculation the minimum safe distances can be determined that should be cleared of people, animals and equipment. Figure 20 shows the results from the ISEE calculations for fly rock range based on a 165mm diameter blast hole and 4.1 m stemming length. Based on these values a possible fly rock range with a safety factor of 2 was calculated to be 297 m. The absolute minimum unsafe zone is then the 297 m. This calculation is a guideline and any distance cleared should not be less. The occurrence of fly rock can however never be 100 % excluded. Best practices should be implemented at all times. The occurrence of fly rock can be mitigated but the possibility of the occurrence thereof can never be eliminated. Figure 21 shows the area around the open pit that incorporates the 297 m unsafe zone.

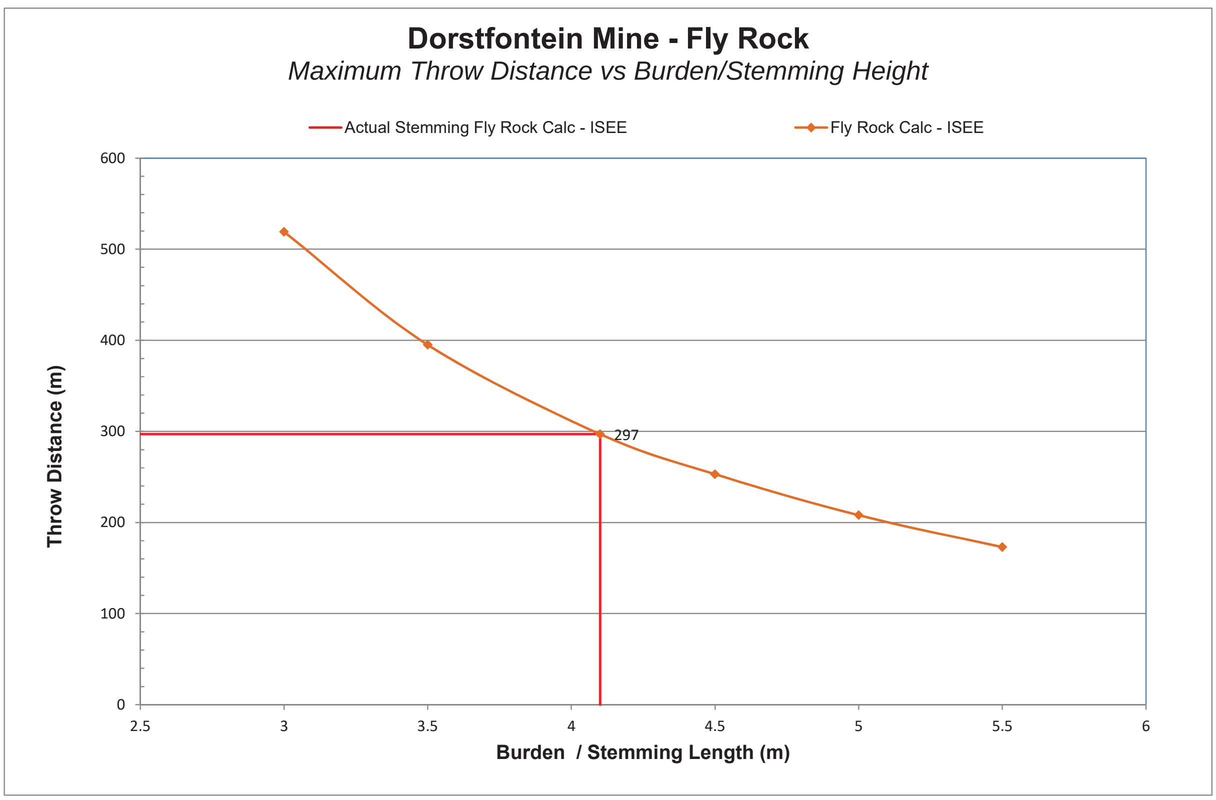


Figure 20: Fly rock prediction calculation

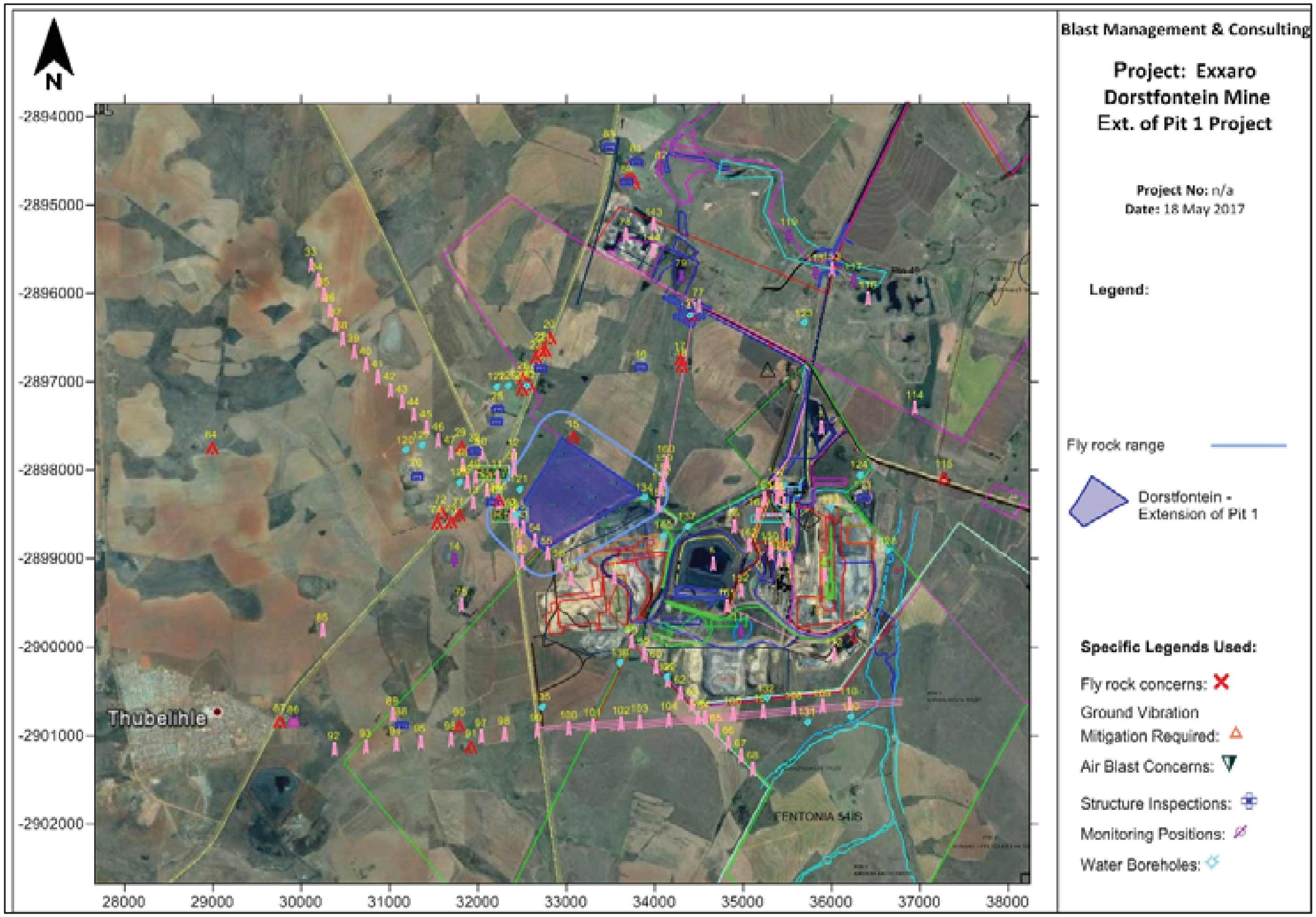


Figure 21: Predicted Fly Rock Exclusion Zone for Pit Area

Review of the calculated unsafe zone showed twenty POI's for the Open Pit are within the unsafe zone. This includes mainly the Monitoring Boreholes, R544 Road, Power Lines/Pylons, Informal Housing (POI 146) and Farm Buildings/Structures (POI 145). Table 13 below shows the POI's of concern and coordinates.

Table 13: Fly rock concern POI's

Tag	Description	Y	X
7	R544 Road	-32411.34	2898516.23
8	R544 Road	-32430.57	2898586.93
9	R544 Road	-32471.36	2898864.71
10	R544 Road	-32494.64	2899047.76
15	Ruins	-33084.41	2897629.65
31	Cement Dam	-32402.71	2897990.66
51	Power Lines/Pylons	-32239.56	2898372.81
52	Power Lines/Pylons	-32379.09	2898516.87
53	Power Lines/Pylons	-32512.41	2898659.42
54	Power Lines/Pylons	-32648.89	2898803.65
55	Power Lines/Pylons	-32783.12	2898949.30
56	Power Lines/Pylons	-32921.80	2899089.90
121	Monitoring Borehole (DFTNM11)	-32471.32	2898215.65
134	Monitoring Borehole (DFTNM7)	-33884.24	2898313.26
138	Monitoring Borehole (DFTNM12)	-32438.40	2898512.31
145	Farm Buildings/Structures	-32170.87	2898361.12
146	Informal Housing	-32236.60	2898332.07
156	Power Lines/Pylons	-34040.40	2898401.29
157	Power Lines/Pylons	-34072.76	2898222.94
158	Power Lines/Pylons	-34091.12	2898122.59

15.10 Noxious Fumes

The occurrence of fumes in the form the NOx gas is not a given and very dependent on various factors as discussed in Section 11.6. However, the occurrence of fumes should be closely monitored. Furthermore, nothing can be stated as to fume dispersal to nearby farmsteads, but if anybody is present in the path of the fume cloud, it could be problematic.

15.11 Water Borehole Influence

Boreholes for water were evaluated for possible influence from blasting. Twenty-Three Hydrocensus/Monitoring boreholes were provided that could possibly be influenced due to excessive ground vibration at minimum and maximum charge. The expected levels of ground vibration for twenty of these boreholes inside the area evaluated are well within the limit applied for water boreholes. There are three monitoring boreholes at POI 121, POI 134 and POI 138 that are in close proximity of the blasting areas. The calculation indicated that expected ground vibration levels are greater than the limits and could be problematic. These boreholes will have to be relocated. The ground water specialist will need to make recommendations regarding relocation of the boreholes. Table 14 shows all the identified boreholes. Figure 22 shows the location of the boreholes in the area. At all other identified boreholes the expected levels of ground vibration were found to be within acceptable limits. The limit for boreholes of 50 mm/s is expected at a distance of 195 m from a blast.

Table 14: Identified Boreholes

Tag	Description	-Y	-X	Specific Limit (mm/s)	Distance (m)	Predicted PPV (mm/s)
120	Hydrocensus Borehole (NBH24 - Livestock and crop watering)	-31179.38	2897776.18	50	1443	3.2
121	Monitoring Borehole (DFTNM11)	-32471.32	2898215.65	50	116	103.0
122	Hydrocensus Borehole (NBH22 - Livestock watering)	-32215.12	2897055.46	50	936	5.8
123	Monitoring Borehole (NBH5)	-35694.29	2896338.30	50	2665	1.4
124	Hydrocensus Borehole (NBH6 - Dormant)	-36318.39	2898054.45	50	2489	1.5
125	Hydrocensus Borehole (NBH20 - Drinking water)	-31792.81	2898142.73	50	729	8.1
126	Hydrocensus Borehole (NBH21 - Drinking water)	-32341.19	2897046.13	50	848	6.6
127	Hydrocensus Borehole (NBH23 - Drinking water)	-31363.23	2897719.02	50	1318	3.6
128	Monitoring Borehole (DFTNM1)	-36643.31	2898912.39	50	2881	1.2
129	Monitoring Borehole (DFTNM2)	-36325.12	2899747.99	50	2899	1.2
130	Monitoring Borehole (DFTNM3)	-36222.26	2900792.48	50	3479	0.9
131	Monitoring Borehole (DFTNM4)	-35729.40	2900854.27	50	3211	1.1
132	Monitoring Borehole (DFTNM5)	-35261.45	2900582.65	50	2724	1.3
133	Monitoring Borehole (DFTNM6)	-35997.95	2898434.18	50	2167	1.8
134	Monitoring Borehole (DFTNM7)	-33884.24	2898313.26	50	71	203.1
135	Monitoring Borehole (DFTNM8)	-32725.79	2900677.93	50	1793	2.4
136	Monitoring Borehole (DFTNM9)	-33609.51	2900186.05	50	1553	2.9
137	Monitoring Borehole (DFTNM10)	-34369.15	2898640.27	50	654	9.5
138	Monitoring Borehole (DFTNM12)	-32438.40	2898512.31	50	15	1762.5
139	Monitoring Borehole (DFTNM13)	-34138.78	2900342.55	50	1954	2.1

Tag	Description	-Y	-X	Specific Limit (mm/s)	Distance (m)	Predicted PPV (mm/s)
140	Monitoring Borehole (DFTNH1)	-34099.02	2898739.27	50	546	12.1
141	Monitoring Borehole (DFBH)	-34396.45	2896259.40	50	1958	2.1
142	Emalayinini Community Borehole (ECBH)	-32558.04	2897039.07	50	716	8.3

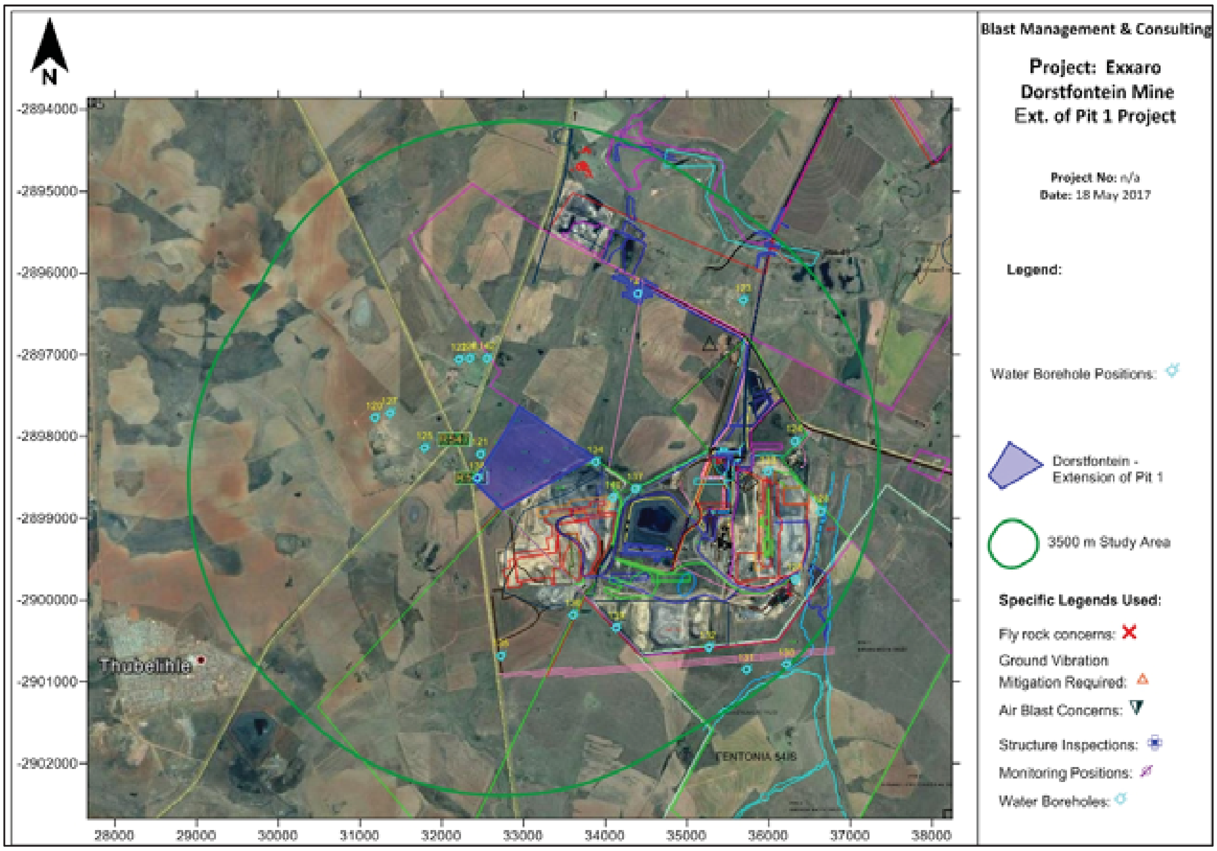


Figure 22: Location of the Hydrocensus/Monitoring boreholes

15.12 Environmental Impact Assessment

The impact assessment must be undertaken for the pre-construction, construction, operational and decommissioning phases of the proposed development.

The anticipated impacts to each environmental element documented in the baseline must be described under initial assessment, direct and indirect impacts cumulative impact/s, mitigation measures and residual impact. The initial assessment must outline the existing level of impact by current activities. Mitigation measures for the additional impact must be recorded and the residual impact calculated. Further, the cumulative impacts associated with the proposed development must be assessed in terms of a local scale.

The anticipated impacts associated with the proposed project must be assessed according to SRK's standardised impact assessment methodology which is presented below. This methodology has been utilised for the assessment of environmental impacts where the consequence (severity of impact, spatial scope of impact and duration of impact) and likelihood (frequency of activity and frequency of impact) have been considered in parallel to provide an impact rating and hence an interpretation in terms of the level of environmental management required for each impact.

The first stage of any impact assessment is the identification of potential environmental activities[2] aspects[3] and impacts which may occur during the commencement and implementation of a project. This is supported by the identification of receptors[4] and resources[5] which allows for an understanding of the impact pathway and an assessment of the sensitivity to change. Environmental impacts[6] (social and biophysical) are then identified based on the potential interaction between the aspects and the receptors/resources.

The significance of the impact is then assessed by rating each variable numerically according to defined criteria as outlined in Table 15. The purpose of the rating is to develop a clear understanding of influences and processes associated with each impact. The severity[7], spatial scope[8] and duration[9] of the impact together comprise the consequence of the impact and when summed can obtain a maximum value of 15. The frequency of the activity[10] and the frequency of the impact[11] together comprise the likelihood of the impact occurring and can obtain a maximum value of 10. The values for likelihood and consequence of the impact are then read off a significance rating matrix table as shown in Table 16.

This matrix thus provides a rating on a scale of 1 to 150 (low, medium low, medium high or high) based on the consequence and likelihood of an environmental impact occurring.

Natural and existing mitigation measures, including built-in engineering designs, are included in the pre-mitigation assessment of significance. Measures such as demolishing of infrastructure, and reinstatement and rehabilitation of land, are considered post-mitigation.

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[2]An ***activity*** is a distinct process or task undertaken by an organisation for which a responsibility can be assigned. Activities also include facilities or pieces of infrastructure that are possessed by an organisation.

[3]An ***environmental aspect*** is an 'element of an organisations activities, products and services which can interact with the environment'. The interaction of an aspect with the environment may result in an impact.

[4]***Receptors*** comprise, but are not limited to people or man-made structures.
[5]***Resources*** include components of the biophysical environment.
[6]***Environmental impacts*** are the consequences of these aspects on environmental resources or receptors of particular value or sensitivity, for example, disturbance due to noise and health effects due to poorer air quality. Receptors can comprise, but are not limited to, people or human-made systems, such as local residents, communities and social infrastructure, as well as components of the biophysical environment such as aquifers, flora and palaeontology. In the case where the impact is on human health or well-being, this should be stated. Similarly, where the receptor is not anthropogenic, then it should, where possible, be stipulated what the receptor is.
[7]***Severity*** refers to the degree of change to the receptor status in terms of the reversibility of the impact; sensitivity of receptor to stressor; duration of impact (increasing or decreasing with time); controversy potential and precedent setting; threat to environmental and health standards.
[8]***Spatial scope*** refers to the geographical scale of the impact.
[9]***Duration*** refers to the length of time over which the stressor will cause a change in the resource or receptor.
[10]***Frequency of activity*** refers to how often the proposed activity will take place.
[11]***Frequency of impact*** refers to the frequency with which a stressor (aspect) will impact on the receptor.

Table 15: Criteria for Assessing Significance of Impacts

CONSEQUENCE

SEVERITY OF IMPACT	**RATING**
Insignificant / non-harmful	1
Small / potentially harmful	2
Significant / slightly harmful	3
Great / harmful	4
Disastrous / extremely harmful	5

SPATIAL SCOPE OF IMPACT	**RATING**
Activity specific	1
Mine specific (within the mine boundary)	2
Local area (within 5 km of the mine boundary)	3
Regional (Greater Rustenburg area)	4
National	5

DURATION OF IMPACT	**RATING**
One day to one month	1
One month to one year	2
One year to ten years	3
Life of operation	4
Post closure / permanent	5

LIKELIHOOD

FREQUENCY OF ACTIVITY / DURATION OF ASPECT	**RATING**
Annually or less / low	1
6 monthly / temporary	2
Monthly / infrequent	3
Weekly / life of operation / regularly / likely	4
Daily / permanent / high	5

FREQUENCY OF IMPACT	**RATING**
Almost never / almost impossible	1
Very seldom / highly unlikely	2
Infrequent / unlikely / seldom	3
Often / regularly / likely / possible	4
Daily / highly likely / definitely	5

Table 16: Interpretation of Impact Rating

Consequence

Likelihood															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
	3	6	9	12	15	18	21	24	27	30	33	36	39	42	45
	4	8	12	16	20	24	28	32	36	40	44	48	52	56	60
	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75
	6	12	18	24	30	36	42	48	54	60	66	72	78	84	90
	7	14	21	28	35	42	49	56	63	70	77	84	91	98	105
	8	16	24	32	40	48	56	64	72	80	88	96	104	112	120
	9	18	27	36	45	54	63	72	81	90	99	108	117	126	135
	10	20	30	40	50	60	70	80	90	100	110	120	1	140	150

(red)	**High**	76 to 150	Improve current management
(orange)	**Medium High**	40 to 75	Maintain current management
(yellow)	**Medium Low**	26 to 39	
(green)	**Low**	1 to 25	No management required

SIGNIFICANCE = CONSEQUENCE x LIKELIHOOD

15.12.1 Assessment

Table 17: Risk Assessment Outcome before mitigation

ASPECT	POTENTIAL ENVIRONMENTAL IMPACT (NATURE OF THE IMPACT)	ENVIRONMENTAL SIGNIFICANCE BEFORE MITIGATION							RECOMMENDED MITIGATION MEASURES	ENVIRONMENTAL SIGNIFICANCE AFTER MITIGATION						
		Consequence			Likelihood (Probability)		Significance (Degree to which impact may cause irreplaceable loss of resources)	SRK Methodology		Consequence			Likelihood (Probability)		Significance (Degree to which impact may cause irreplaceable loss of resources)	SRK Methodology
		Severity	Spatial	Duration	Frequency: Activity	Frequency: Impact				Severity	Spatial	Duration	Frequency: Activity	Frequency: Impact		
Blasting	Ground vibration Impact on houses	4	3	4	5	4	**99**	**MH Maintain Current Management**	Reduce Charge Mass/Delay over decreasing distance towards POI's of concern, Relocate POI's of concern at least 600m	2	3	4	5	3	**72**	**LM Maintain Current Management**
	Ground vibration Impact on boreholes	4	3	4	5	4	**99**	**MH Maintain Current Management**	Reduce Charge Mass/Delay over decreasing distance towards POI's of concern, Re-drill boreholes further away	2	3	4	5	3	**72**	**LM Maintain Current Management**
	Ground vibration Impact on roads	4	3	4	5	4	**99**	**MH Maintain Current Management**	Reduce Charge Mass/Delay over decreasing distance towards POI's of concern, Reroute roads	2	3	4	5	3	**72**	**LM Maintain Current Management**

	Air blast Impact on houses	4	3	4	5	4	**99**	**MH Maintain Current Management**	Reduce Charge Mass/Delay over decreasing distance towards POI's of concern, Relocate POI's of concern at least 600m	2	3	4	5	3	**72**	**LM Maintain Current Management**	
	Air blast Impact on boreholes	1	3	4	5	3	**64**	**LM Maintain Current Management**	None	1	3	4	5	3	**64**	**LM Maintain Current Management**	
	Air blast Impact on roads	1	3	4	5	3	**64**	**LM Maintain Current Management**	None	1	3	4	5	3	**64**	**LM Maintain Current Management**	
	Fly Rock Impact on houses	5	3	4	5	4	**108**	**H Maintain Current Management**	Increase stemming length, controls put in place for management of stemming lengths, Relocate POI's of concern at least 600m	2	3	4	5	3	**72**	**LM Maintain Current Management**	
	Fly Rock Impact on boreholes	2	3	4	5	4	**81**	**MH Maintain Current Management**	Increase stemming length, controls put in place for management of stemming lengths	2	3	4	5	3	**72**	**LM Maintain Current Management**	
	Fly Rock Impact on roads	5	3	4	5	4	**108**	**H Maintain Current Management**	Increase stemming length, controls put in place for management of stemming lengths	2	3	4	5	3	**72**	**LM Maintain Current Management**	

	Impact of Fumes - Houses	3	3	4	5	4	**90**	**MH Maintain Current Management**	Use correct product, Control product quality, prevent sleep time for charged blast holes, same day charge and blast	2	3	4	5	3	**72**	**LM Maintain Current Management**	
	Impact of Fumes - Boreholes	1	3	4	5	3	**64**	**LM Maintain Current Management**	None	1	3	4	5	3	**64**	**LM Maintain Current Management**	
	Impact of Fumes - Roads	1	3	4	5	3	**64**	**LM Maintain Current Management**	None	1	3	4	5	3	**64**	**LM Maintain Current Management**	

15.13 Mitigation Measures

Nineteen POI's were identified that showed concerns with regards to ground vibration levels expected. These POI's varies in distance from the pit area – directly next to the pit area up to 864 m. The concern may also not just be ground vibration but due to close proximity to the pit area the blasting operations could have a negative effect on the livelihood of people within close proximity of the mine.
On the basis if ground vibration needs to be mitigated then the following will be applicable. The following mitigations measures proposed are general mitigation measures. Any further detail mitigations will require active involvement on the project at operational level. The current mitigation measures presented is considered sufficient at this stage of the project.

Though no specific mitigation detail for air blast and fly rock is provided it will required adjustments after considering the ground vibration levels. Mitigation for air blast and fly rock control is very similar and is based on the following. Air blast and fly rock can be controlled using proper charging methodology irrespective of the blast hole diameter and patterns used. The most effective way to mitigate air blast is the design of the stemming length and stemming material. This will require changed blast design to ensure energy levels remain as expected but with increased stemming lengths and the use of proper stemming material. The use of a crushed product with size of 10 % of the blasthole diameter is the recommended material.

Specific ground vibration impacts are expected at the following POI's identified.
Table 18 shows list of POI's that will need to be considered as defined above. Figure 23 shows the location of these POI's in relation to the open pit area.

Table 18: Structures at the Open Pit Area identified as problematic

Tag	Description	Y	X	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz
7	R544 Road	-32411.34	2898516.23	150	11	1800	2511.4	Problematic
8	R544 Road	-32430.57	2898586.93	150	6	1800	6500.1	Problematic
15	Ruins	-33084.41	2897629.65	6	87	1800	152.3	Problematic
24	Informal Housing	-32583.56	2897031.00	6	710	1800	8.4	Problematic
25	Informal Housing	-32497.05	2897079.17	6	719	1800	8.3	Problematic
26	Informal Housing	-32518.54	2896968.50	6	797	1800	7.2	Problematic
52	Power Lines/Pylons	-32379.09	2898516.87	75	34	1800	556.9	Problematic
53	Power Lines/Pylons	-32512.41	2898659.42	75	8	1800	4268.6	Problematic
54	Power Lines/Pylons	-32648.89	2898803.65	75	7	1800	4675.0	Problematic
55	Power Lines/Pylons	-32783.12	2898949.30	75	70	1800	208.3	Problematic
71	Informal Housing	-31786.25	2898507.93	6	615	1800	10.3	Problematic

Tag	Description	Y	X	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz
72	Informal Housing	-31583.96	2898479.66	6	819	1800	6.9	Problematic
73	Informal Housing	-31698.03	2898592.36	6	704	1800	8.5	Problematic
74	Informal Housing	-31537.16	2898597.66	6	864	1800	6.4	Problematic
121	Monitoring Borehole (DFTNM11)	-32471.32	2898215.65	50	116	1800	103.0	Problematic
134	Monitoring Borehole (DFTNM7)	-33884.24	2898313.26	50	71	1800	203.1	Problematic
138	Monitoring Borehole (DFTNM12)	-32438.40	2898512.31	50	15	1800	1762.5	Problematic
145	Farm Buildings/Structures	-32170.87	2898361.12	25	293	1800	28.7	Problematic
146	Informal Housing	-32236.60	2898332.07	6	252	1800	35.2	Problematic

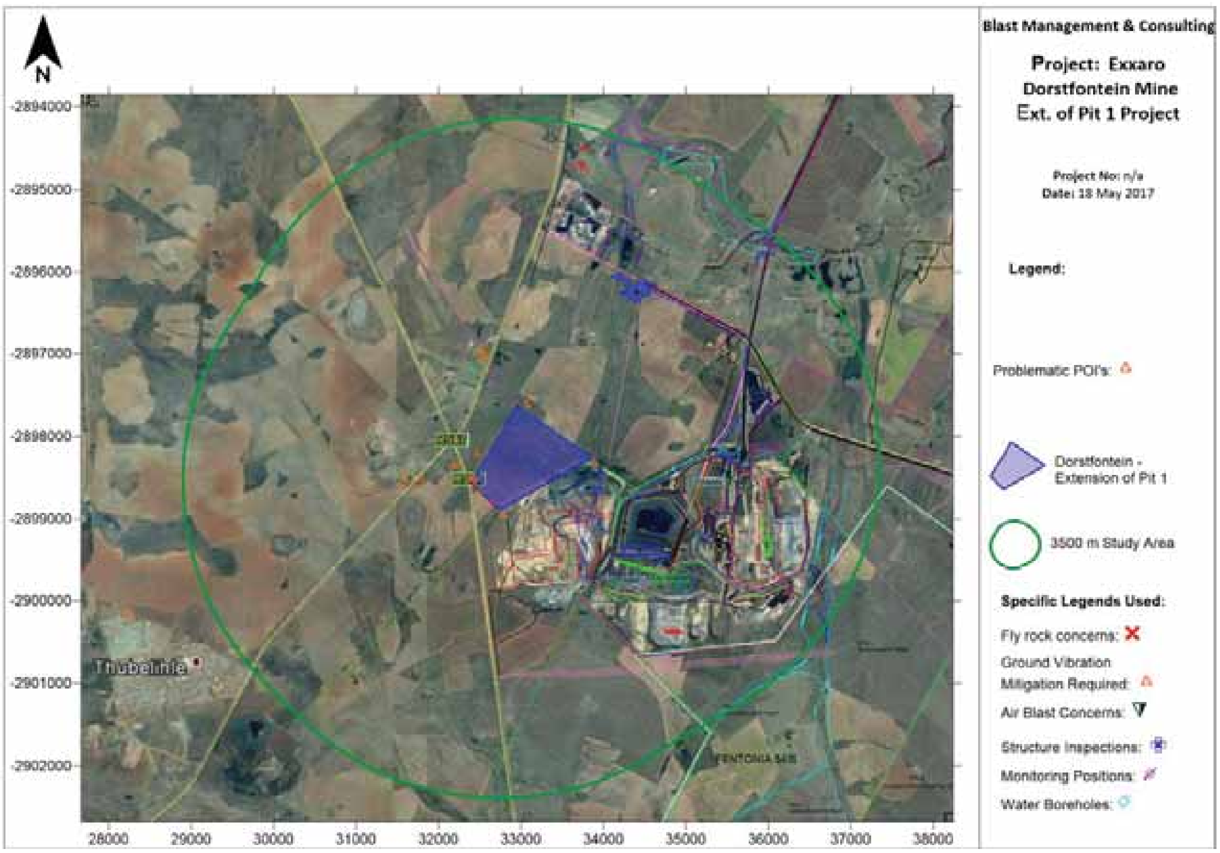

Figure 23: Structures identified where ground vibration mitigation will be required at Pit Area

Mitigation of ground vibration for this can be done applying the following methods:

- Do blast design that considers the actual blasting and the ground vibration levels to be adhered too.

- Change the initiating system to facilitate less blast holes detonating simultaneously making using of electronic initiation that allow for single hole firing.
- Do design for smaller diameter blast holes that will use fewer explosives per blasthole.

Considering the basic mitigation reduction of ground vibration is achieved by reducing the charge mass per delay and distance between source and receptor. These mitigations are guidelines that can be used when doing a final detail blast design. Table 19 shows mitigation in the form of maximum charge mass allowed and minimum distance require for the maximum charge used in the evaluation. Firstly the maximum charge mass per delay that will satisfy the required limits for the actual distance between blast area and point of concern is shown. Secondly the minimum distance required to satisfy limits for the maximum charge used in evaluation. These factors are highlighted yellow.

Table 19: Mitigation measures for ground vibration

Tag	Description	Y	X	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz
Maximum Charge allowed at current distance								
7	R544 Road	-32411.34	2898516.23	150	11	30	150.0	Acceptable
8	R544 Road	-32430.57	2898586.93	150	6	8	150.0	Acceptable
15	Ruins	-33084.41	2897629.65	6	87	17	6.0	Acceptable
24	Informal Housing	-32583.56	2897031.00	6	710	1097	6.0	Acceptable
25	Informal Housing	-32497.05	2897079.17	6	719	1126	6.0	Acceptable
26	Informal Housing	-32518.54	2896968.50	6	797	1383	6.0	Acceptable
52	Power Lines/Pylons	-32379.09	2898516.87	75	34	98	75.0	Acceptable
53	Power Lines/Pylons	-32512.41	2898659.42	75	8	5	75.0	Acceptable
54	Power Lines/Pylons	-32648.89	2898803.65	75	7	5	75.0	Acceptable
55	Power Lines/Pylons	-32783.12	2898949.30	75	70	410	75.0	Acceptable
71	Informal Housing	-31786.25	2898507.93	6	615	825	6.0	Acceptable
72	Informal Housing	-31583.96	2898479.66	6	819	1462	6.0	Acceptable
73	Informal Housing	-31698.03	2898592.36	6	704	1078	6.0	Acceptable
74	Informal Housing	-31537.16	2898597.66	6	864	1628	6.0	Acceptable
121	Monitoring Borehole (DFTNM11)	-32471.32	2898215.65	50	116	632	50.0	Acceptable
134	Monitoring Borehole (DFTNM7)	-33884.24	2898313.26	50	71	236	50.0	Acceptable
138	Monitoring Borehole (DFTNM12)	-32438.40	2898512.31	50	15	10	50.0	Acceptable
145	Farm Buildings/Structures	-32170.87	2898361.12	25	293	1475	25.0	Acceptable
146	Informal Housing	-32236.60	2898332.07	6	252	139	6.0	Acceptable
Minimum distance required for maximum charge								

Tag	Description	Y	X	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz
7	R544 Road	-32411.34	2898516.23	150	88	1800	150.0	Acceptable
8	R544 Road	-32430.57	2898586.93	150	88	1800	150.0	Acceptable
15	Ruins	-33084.41	2897629.65	6	909	1800	6.0	Acceptable
24	Informal Housing	-32583.56	2897031.00	6	909	1800	6.0	Acceptable
25	Informal Housing	-32497.05	2897079.17	6	909	1800	6.0	Acceptable
26	Informal Housing	-32518.54	2896968.50	6	909	1800	6.0	Acceptable
52	Power Lines/Pylons	-32379.09	2898516.87	75	146	1800	75.0	Acceptable
53	Power Lines/Pylons	-32512.41	2898659.42	75	146	1800	75.0	Acceptable
54	Power Lines/Pylons	-32648.89	2898803.65	75	146	1800	75.0	Acceptable
55	Power Lines/Pylons	-32783.12	2898949.30	75	146	1800	75.0	Acceptable
71	Informal Housing	-31786.25	2898507.93	6	909	1800	6.0	Acceptable
72	Informal Housing	-31583.96	2898479.66	6	909	1800	6.0	Acceptable
73	Informal Housing	-31698.03	2898592.36	6	909	1800	6.0	Acceptable
74	Informal Housing	-31537.16	2898597.66	6	909	1800	6.0	Acceptable
121	Monitoring Borehole (DFTNM11)	-32471.32	2898215.65	50	196	1800	50.0	Acceptable
134	Monitoring Borehole (DFTNM7)	8	-33884.24	2898313.26	33884.24	-2898313.26	50	196
138	Monitoring Borehole (DFTNM12)	8	-32438.40	2898512.31	32438.40	-2898512.31	50	196
145	Farm Buildings/Structures	2	-32170.87	2898361.12	32170.87	-2898361.12	25	323
146	Informal Housing	1	-32236.60	2898332.07	32236.60	-2898332.07	6	909

16 Closure Phase: Impact Assessment and Mitigation Measures

During the closure phase no mining, drilling and blasting operations are expected. It is uncertain if any blasting will be done for demolition. If any demolition blasting will be required it will be reviewed as civil blasting and addressed accordingly.

17 Alternatives (Comparison and Recommendation)

No specific alternative mining methods are currently under discussion or considered for drilling and blasting.

18 Recommendations

18.1 Regulatory requirements

Regulatory requirements indicate specific requirements for all non-mining structures and installations within 500 m from the mining operation. The mine will have to apply for the necessary authorisations as prescribed in the various acts. Table 20 shows list of these installations. Figure 24 below shows the 500 m boundary around the Pit area. The location of non-mining installations is clearly observed. Should this chicken farm be relocated this requirement will not be applicable.

Table 20: List of installations identified within the regulatory 500 m

Tag	Description	Y	X
7	R544 Road	-32411.34	2898516.23
8	R544 Road	-32430.57	2898586.93
9	R544 Road	-32471.36	2898864.71
10	R544 Road	-32494.64	2899047.76
11	R547 and R544 Road Intersection	-32218.20	2898080.94
12	R544 Road	-32406.95	2897838.43
13	R547 Road	-31943.92	2898375.85
15	Ruins	-33084.41	2897629.65
31	Cement Dam	-32402.71	2897990.66
50	Power Lines/Pylons	-32104.08	2898231.53
51	Power Lines/Pylons	-32239.56	2898372.81
52	Power Lines/Pylons	-32379.09	2898516.87
53	Power Lines/Pylons	-32512.41	2898659.42
54	Power Lines/Pylons	-32648.89	2898803.65
55	Power Lines/Pylons	-32783.12	2898949.30
56	Power Lines/Pylons	-32921.80	2899089.90
57	Power Lines/Pylons	-33058.83	2899232.90
121	Monitoring Borehole (DFTNM11)	-32471.32	2898215.65
134	Monitoring Borehole (DFTNM7)	-33884.24	2898313.26
138	Monitoring Borehole (DFTNM12)	-32438.40	2898512.31
145	Farm Buildings/Structures	-32170.87	2898361.12
146	Informal Housing	-32236.60	2898332.07
156	Power Lines/Pylons	-34040.40	2898401.29
157	Power Lines/Pylons	-34072.76	2898222.94
158	Power Lines/Pylons	-34091.12	2898122.59
159	Power Lines/Pylons	-34110.19	2898013.25
160	Power Lines/Pylons	-34130.45	2897909.83

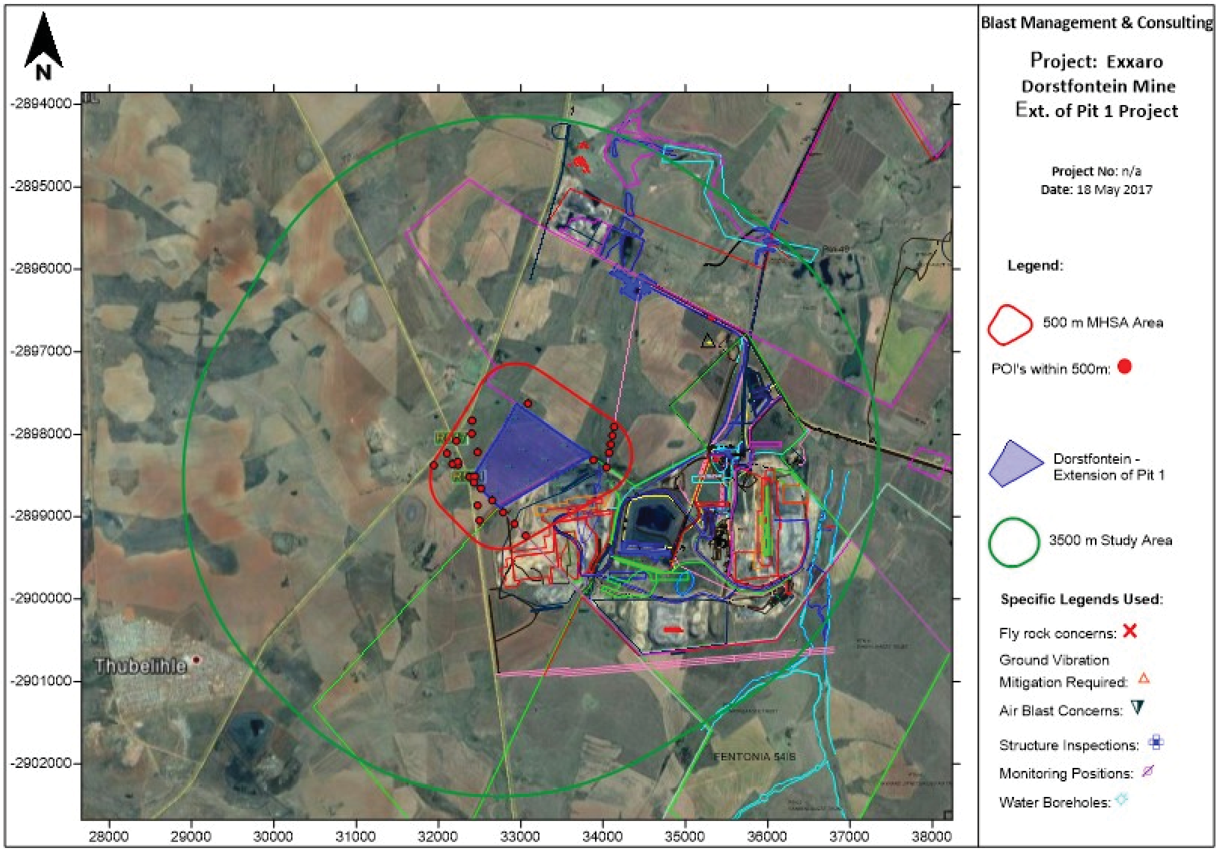

Figure 24: Regulatory 500 m range for Pit Area

18.2 Blast Designs

Blast designs can be reviewed prior to first blast planned and done. Specific attention can be given to the possible use of electronic initiation rather than conventional timing systems. This will allow for single blasthole firing instead of multiple blast holes resulting in less charge mass per delay. Consideration must also be given structures surrounding the blast intended. This may require changed drilling diameters, blasting patterns, charging configurations (single charge, decking etc.) or initiation system. A detail design cannot be done at this stage by the author as much more information is required than currently available.

18.3 Safe Blasting Distance and Evacuation

The calculated minimum safe distance is 297 m. This is the estimated area that must be cleared at least around a blast before firing. General evacuation used in the mining industry is at least 500 m from any blast. The final blast designs that may be used will determine the final decision on safe distance to evacuate people and animals. This distance may be greater pending the final code of practice of the mine and responsible blaster's decision on safe distance. The blaster has a legal obligation concerning the safe distance and he needs to determine this distance.

18.4 Road Closure

The R547 and R544 provincial roads are located within 500 m from the pit area. When blasting is to be done within 500 m (or a distance as determined by the mine's SOP) from these roads it will be required that road closure will be required. The road closure to be done for the period during the blast for the shortest possible time period. The mines code of practise will however need to define what the closure distances are and should be adhered too. It must be noted that this is a farming community and there may be smaller roads that needs to be considered in this process.

18.5 Test Blasting

At all four sides of the pit area are POI's of concern. First blasting done in the pit must be setup to be used as a test blast to establish a way forward and planning for future blasts. It is recommended that such a blast be done and detail monitoring done and used to help define blasting operations going forward. This test blast can be based on the existing design and only after this blast it may be necessary to define if changes are required or not.

18.6 Power lines

There is currently powerline infrastructure in close proximity of the pit. There are no electrical lines connected. The mine must confirm if these are still to be used or will be demolished. If demolished it will be positive with less restraints on the blasting operations specifically where these powerline pylons were of concern.

18.7 Photographic Inspections

The option of photographic survey of all structures up to 1500 m from the pit areas is recommended. The mine will be operating for a significant number of years. This will give advantage on any negotiations with regards to complaints from neighbours. This process can however only succeed if done in conjunction with a proper monitoring program. At 1500 m at vibration level of 3.0 mm/s is expected for the maximum charge used. This level of ground vibration is already perceptible and people in structures could experience ground vibration negatively. Figure 25 shows the structures within the 1500 m area for the pit area to be considered. Table 21 shows list of structures identified for inspection. The list indicates a point used. This point may refer to a multiple number of structures in the area of the specific point.

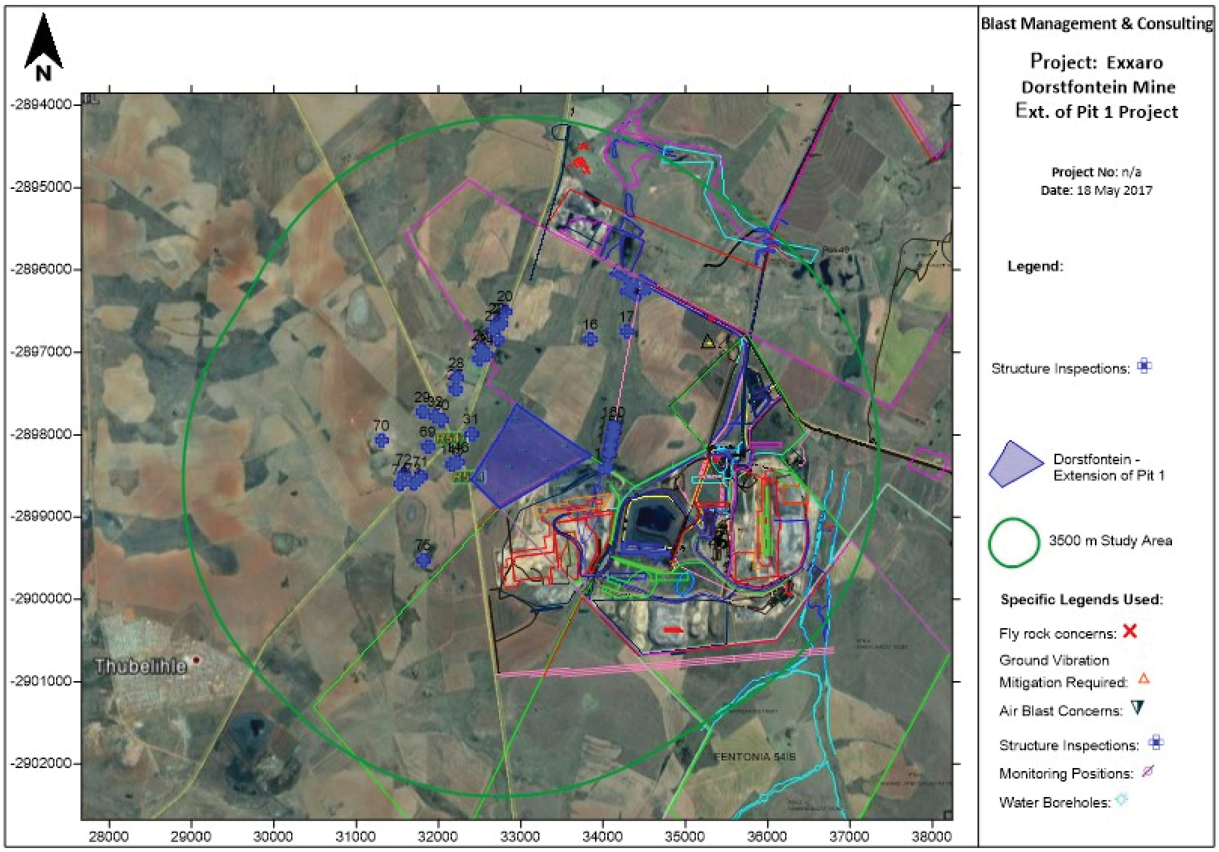

Figure 25: Structures within 1500 m area around pit area identified for structure inspections.

Table 21: List of structures identified for inspections

Tag	Description	Y	X
6	Impilo Primary School	-32712.93	2896841.82
16	Buildings/Structures	-33848.79	2896839.11
17	Informal Housing	-34288.36	2896745.80
20	Informal Housing	-32812.43	2896503.49
21	Informal Housing	-32760.19	2896650.95
22	Informal Housing	-32711.65	2896641.32
23	Informal Housing	-32660.01	2896732.14
24	Informal Housing	-32583.56	2897031.00

25	Informal Housing	-32497.05	2897079.17
26	Informal Housing	-32518.54	2896968.50
27	Farm Buildings/Structures	-32213.19	2897452.24
28	Farm Buildings/Structures	-32225.60	2897308.85
29	Informal Housing	-31809.18	2897725.58
30	Dam	-32042.52	2897823.99
31	Cement Dam	-32402.71	2897990.66
32	Building/Structure	-31964.94	2897780.13
69	Dam	-31876.54	2898142.33
70	Farm Buildings/Structures	-31310.53	2898068.18
71	Informal Housing	-31786.25	2898507.93
72	Informal Housing	-31583.96	2898479.66
73	Informal Housing	-31698.03	2898592.36
74	Informal Housing	-31537.16	2898597.66
75	Cement Dam	-31818.19	2899523.98
145	Farm Buildings/Structures	-32170.87	2898361.12
146	Informal Housing	-32236.60	2898332.07
156	Power Lines/Pylons	-34040.40	2898401.29
157	Power Lines/Pylons	-34072.76	2898222.94
158	Power Lines/Pylons	-34091.12	2898122.59
159	Power Lines/Pylons	-34110.19	2898013.25
160	Power Lines/Pylons	-34130.45	2897909.83

18.8 Recommended Ground Vibration and Air Blast Levels

The ground vibration and air blast levels limits recommended for blasting operations in this area are provided in Table 22.

Table 22: Recommended ground vibration air blast limits

<table>
<tr><th>Structure Description</th><th>Ground Vibration Limit (mm/s)</th><th>Air Blast Limit (dBL)</th></tr>
<tr><td>National Roads/Tar Roads:</td><td>150</td><td>N/A</td></tr>
<tr><td>Electrical Lines:</td><td>75</td><td>N/A</td></tr>
<tr><td>Railway:</td><td>150</td><td>N/A</td></tr>
<tr><td>Transformers</td><td>25</td><td>N/A</td></tr>
<tr><td>Water Wells</td><td>50</td><td>N/A</td></tr>
<tr><td>Telecoms Tower</td><td>50</td><td>134</td></tr>
<tr><td>General Houses of proper construction</td><td>USBM Criteria or 25 mm/s</td><td rowspan="3">Shall not exceed 134dB at point of concern but 120 dB preferred</td></tr>
<tr><td>Houses of lesser proper construction</td><td>12.5</td></tr>
<tr><td>Rural building – Mud houses</td><td>6</td></tr>
</table>

18.9 Blasting Times

A further consideration of blasting times is when weather conditions could influence the effects yielded by blasting operations. It is recommended not to blast too early in the morning when it is still cool or when there is a possibility of an atmospheric inversion or too late in the afternoon in winter. Do not blast in fog or in the dark. Refrain from blasting when wind is blowing strongly in the direction of an outside receptor. Do not blast with low overcast clouds. These 'do nots' stem from the influence that weather has on air blast. The energy of air blast cannot be increased but it is distributed differently and therefore is difficult to mitigate.

It is recommended that a standard blasting time be adhered to and blasting notice boards setup at various routes around the project area that will inform the community of blasting dates and times.

18.10 Monitoring

A monitoring programme for recording blasting operations is recommended. This process will be mainly for the development of the different decline shafts. The following elements should be part of such a monitoring program:

- Ground vibration and air blast results
- Blast Information summary
- Meteorological information at time of the blast
- Video Recording of the blast
- Fly rock observations

Most of the above aspects do not require specific locations of monitoring. Ground vibration and air blast monitoring requires identified locations for monitoring. Monitoring of ground vibration and air blast is done to ensure that the generated levels of ground vibration and air blast comply with recommendations. Proposed positions were selected to indicate the nearest points of interest at which levels of ground vibration and air blast should be within the accepted norms and standards as proposed in this report. The monitoring of ground vibration will also qualify the expected ground vibration and air blast levels and assist in mitigating these aspects properly. This will also contribute to improved relationships with the neighbours. Nine monitoring positions were identified for the mine. Monitoring positions are indicated in Figure 26 and Table 23 lists the positions with coordinates. These points will need to be re-defined with the initial first blast and consider the final blast design that will be applicable.

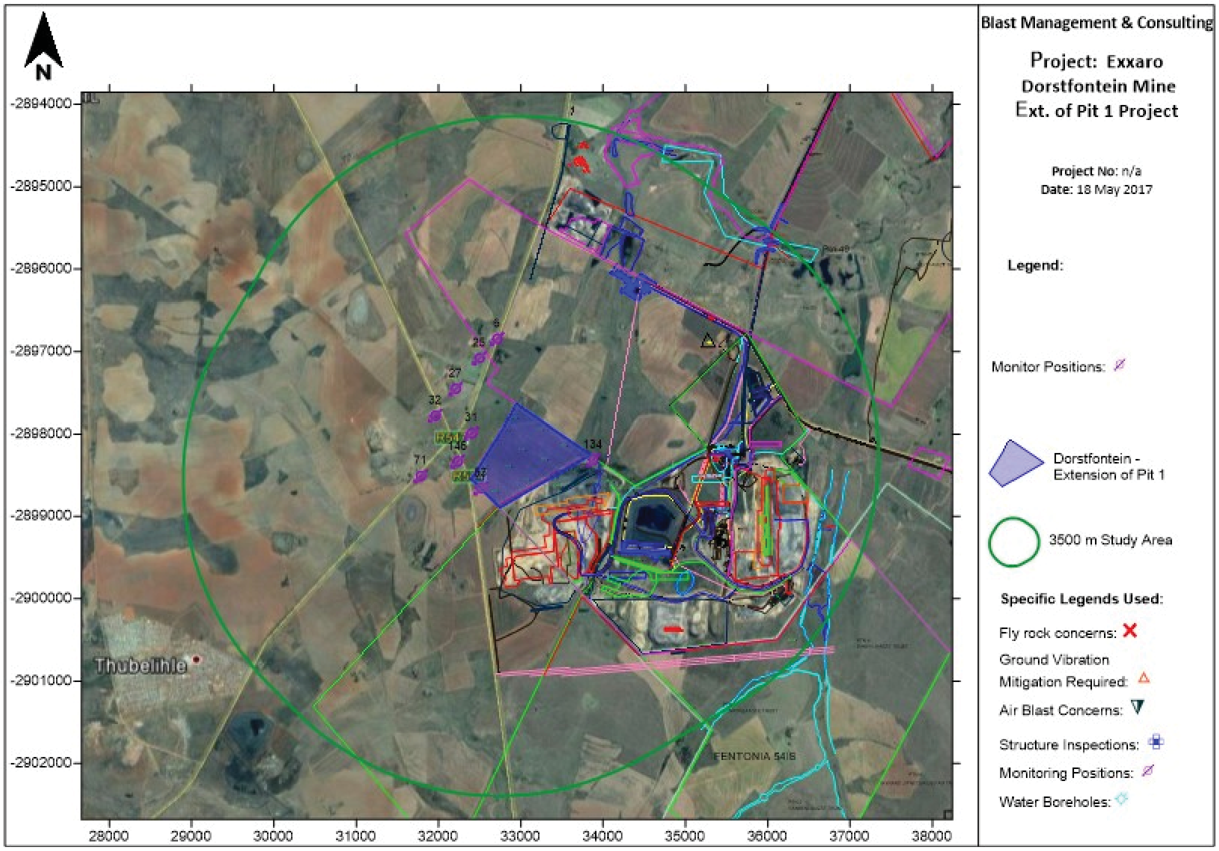

Figure 26: Monitoring Positions suggested for Pit Area.

Table 23: List of possible monitoring positions

Tag	Description	Y	X
6	Impilo Primary School	-32712.93	2896841.82
25	Informal Housing	-32497.05	2897079.17
27	Farm Buildings/Structures	-32213.19	2897452.24
31	Cement Dam	-32402.71	2897990.66
32	Building/Structure	-31964.94	2897780.13
53	Power Lines/Pylons	-32512.41	2898659.42
71	Informal Housing	-31786.25	2898507.93
134	Monitoring Borehole (DFTNM7)	-33884.24	2898313.26
146	Informal Housing	-32236.60	2898332.07

18.11 Third Party Monitoring

Third party consultation and monitoring should be considered for all ground vibration and air blast monitoring work. This will bring about unbiased evaluation of levels and influence from an independent group. Monitoring could be done using permanent installed stations. Audit functions may also be conducted to assist the mine in maintaining a high level of performance with regards to blast results and the effects related to blasting operations.

18.12 Video monitoring of each blast

Video of each blast will help to define if fly rock occurred and from where. Immediate mitigation measure can then be applied if necessary. The video will also be a record of blast conditions.

18.13 Relocation

There are various public houses and installations in close proximity of the pit area. The greatest concerns originate from animal related installations (Chicken Farm) that are located up to 301 m from the pit area. The mine indicated that relocation of installations within 500 m will be done. It is recommended that this chicken farm should be relocated. This is a process that will require careful planning and execution.

19 Knowledge Gaps

The data provided by the project applicant and information gathered was sufficient to conduct this study. Surface surroundings change continuously and this should be taken into account prior to initial blasting operations is considered for the Pit extension. This report may need to be reviewed and updated if necessary. This report is based on data provided and internationally accepted methods and methodology used for calculations and predictions.

20 Conclusion

Blast Management & Consulting (BM&C) was contracted as part of the Environmental Impact Assessment (EIA) to perform review of possible impacts with regards to blasting operations on the proposed extension of Pit 1 of the Dorstfontein East Mine Project located in the Mpumalanga Province of South Africa. Ground vibration, air blast, fly rock and fumes are some of the aspects resulting from blasting operations. The report concentrates on the possible influences of ground vibration, air blast and fly rock. It intends to provide information, calculations, predictions, possible influences and mitigation of blasting operations for the project.

The evaluation of effects yielded by blasting operations was evaluated over an area as wide as a 3500 m radius from where blasting will take place. The range of structures observed and considered in this evaluation ranged between rural buildings, farm buildings, industrial buildings, power lines and provincial roads.

The project area does have houses and communities at very close distance to the project area. The nearest house or buildings is found 293 m away. There are various farmsteads and small settlements in the area. Specific attention will be required for adjustments in the blasting operations to ensure expected levels of ground vibration and air blast are within the required limits. Consideration will need to be given to relocation of households in close proximity to the pit area. A recommended distance should at least be all within 500 m from area. There are also regulations that will need to be followed for permission to conduct blasting operations as these installations area within 500 m from the blast operations. Ground vibration at structures and installations other than the identified problematic structures is well below any specific concern for inducing damage. The ground vibration levels predicted for all installations evaluated surrounding the pit area ranged between 0.9 mm/s and very high. Ground vibration levels at the nearest buildings where people may be present is 28.7 mm/s.

Air blast predicted for the maximum charge ranges between 105 and 143 dB for all the POI's considered. Air blast observed and predicted showed greater concern than ground vibration. In view of the predicted levels the probability of damages exist if blasting operations does not take careful planning of stemming length and material into consideration. Damages are only expected to occur at levels greater than 134dB. On prediction it is expected that air blast will be greater than 134 dB at a distance of 500 m and closer to the pit boundary. Various private installation is within 500 m from the pit boundary. Air blast that could lead to complaints is expected to reach distances of 1250 m from the pit area. The levels at other private houses or settlements are expected to be within limits and not damaging.

An exclusion zone for safe blasting was also calculated. The exclusion zone was established to be at least 297 m. Normal practice observed in mines is a 500 m exclusion zone. The minimum distance recommended is 297 m. This distance may be greater but not less.

Recommendations were made that should be considered, specifically for review of blast designs, monitoring of ground vibration and air blast, safe blasting zones, safe ground vibration and air blast limits, blast designs, blasting times and relocations of infrastructure to be considered.

Providing opinion if the project may continue it can be indicated that only with recommended mitigations and careful planning of blasting operations it is possible. The pit is located such that free blasting will not be possible and will require detail planning and considerations of the recommendations. Considering this there is no reason to believe that this operation cannot continue.

This concludes this investigation for the extension of Pit 1 of the Dorstfontein East Mine Project.

21 Curriculum Vitae of Author

J D Zeeman was a member of the Permanent Force - SA Ammunition Core for period January 1983 to January 1990. During this period, work involved testing at SANDF Ammunition Depots and Proofing ranges. Work entailed munitions maintenance, proofing and lot acceptance of ammunition.

From July 1992 to December 1995, Mr Zeeman worked at AECI Explosives Ltd. Initial work involved testing science on small scale laboratory work and large scale field work. Later, work entailed managing various testing facilities and testing projects. Due to restructuring of the Technical Department, Mr Zeeman was retrenched but fortunately was able to take up an appointment with AECI Explosives Ltd.'s Pumpable Emulsion Explosives Group for underground applications.

From December 1995 to June 1997 Mr Zeeman provided technical support to the Underground Bulk Systems Technology business unit and performed project management on new products.

Mr Zeeman started Blast Management & Consulting in June 1997. The main areas of focus are Pre-blast monitoring, Insitu monitoring, Post-blast monitoring and specialized projects.

Mr Zeeman holds the following qualifications:

1985 - 1987	Diploma: Explosives Technology, Technikon Pretoria
1990 - 1992	BA Degree, University Of Pretoria
1994	National Higher Diploma: Explosives Technology, Technikon Pretoria
1997	Project Management Certificate: Damelin College
2000	Advanced Certificate in Blasting, Technikon SA

Member: International Society of Explosives Engineers

Blast Management & Consulting has been active in the mining industry since 1997, with work being done at various levels for all the major mining companies in South Africa. Some of the projects in which BM&C has been involved include:

Iso-Seismic Surveys for Kriel Colliery in conjunction with Bauer & Crosby Pty Ltd.; Iso-Seismic surveys for Impala Platinum Limited; Iso-Seismic surveys for Kromdraai Opencast Mine; Photographic Surveys for Kriel Colliery; Photographic Surveys for Goedehoop Colliery; Photographic Surveys for Aquarius Kroondal Platinum – Klipfontein Village; Photographic Surveys for Aquarius – Everest South Project; Photographic Surveys for Kromdraai Opencast Mine; Photographic inspections for various other companies, including Landau Colliery, Platinum Joint Venture – three mini-pit areas; Continuous ground vibration and air blast monitoring for various coal mines; Full auditing and control with consultation on blast preparation, blasting and resultant effects for clients, e.g. Anglo Platinum Ltd, Kroondal Platinum Mine, Lonmin Platinum, Blast Monitoring Platinum Joint Venture – New Rustenburg N4 road; Monitoring of ground vibration induced on surface in underground mining environment; Monitoring and management of blasting in close relation to water pipelines in opencast mining environment; Specialized testing of explosives characteristics; Supply and service of seismographs and VOD measurement equipment and accessories; Assistance in protection of ancient mining works for Rhino Minerals (Pty) Ltd.; Planning, design, auditing and monitoring of blasting in new quarry on new road project, Sterkspruit, with Africon, B&E International and Group 5 Roads; Structure Inspections and Reporting for Lonmin Platinum Mine Limpopo Pandora Joint Venture 180 houses – whole village; Structure Inspections and Reporting for Lonmin Platinum Mine Limpopo Section - 1000 houses / structures.

BM&C have installed a world class calibration facility for seismographs, which is accredited by Instantel, Ontario Canada as an accredited Instantel facility. The projects listed above are only part of the capability and professional work that is done by BM&C.

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