BLASTING IMPACT ASSESSMENT REPORT

DMRE REF NUMBER: LP 6/2/2/477 MR

COMPILED FOR A PROPOSED SOUTH 3 OPENCAST MINING LOCATED WITHIN WINTERVELDT 293 KT FARM SITUATED IN SEKHUKHUNE DISTRICT MUNICIPALITY OF THE LIMPOPO PROVINCE.

Prepared for:

Segope
SAFETY WATER & ENVIRONMENTAL SERVICES

Prepared by:

CHARMDANE MINING SERVICES

Ndaa, Let's do it the royal way

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2024

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List of Acronyms used in this Report.

ANFO-Ammonium Nitrate Fuel Oil

APP-Air Pressure Pulse

B-Burden (m)

BH-Blast Hole

RPP-Rock Pressure Pulse

USBM-United States Bureau of Mine

MR-Mining Right

1 Introduction

Anglo American Platinum Rustenburg Platinum Mines Limited (RPM) and African Rainbow Minerals Mining Consortium Limited (ARM MC), as part of a Joint Venture, are applying to amend their existing approved Modikwa Platinum Mine (MPM) South 2 Shaft Environmental Management Programme (EMP) which was approved in 2014 (DMR Reference: LP 6/2/2/477) to include the proposed South 3 Opencast Project and mining related infrastructures and activities associated with their South 3 Opencast Operation. MPM appointed Segope Water and Environmental Services (Segope Consulting) as an independent Environmental Assessment Practitioner (EAP) to undertake an integrated environmental authorisation process and the associated stakeholder engagement to meet the requirements of NEMA, MPRDA and NWA.

It's important to conduct a thorough Environmental Impact Assessment (EIA) for mining operations to ensure that potential environmental and safety issues are addressed adequately. This is in accordance with the Minerals and Petroleum Resources Development Act (MPRDA). Charmdane Mining Services have been appointed by the EAP Segope Consulting to conduct Blasting Impact Assessment for the aforementioned project.

Location: The South 3 Opencast Project is situated on the Winterveldt 293 KT Farm, which is owned by the Samancor Chrome, and for which MPM has a lease agreement. Access to South 3 Project area is through a gravel road which joins a tarred road leading to R555 in Steelpoort town which then joins the regional road (R37) from Burgersfort. Refer to the locality map below.

Mining Methodology: The applicant intends to extract the applied mineral through Open Cast mining method which will employ drilling and blasting technique, hence this study will review the possible impacts of blasting.

Possible Impacts: The EIA is expected to address the potential environmental impacts of blasting operations, including ground vibration, air blast, and fly rock. These are common issues associated with mining and can have various effects on the surrounding environment, infrastructure, and public safety.

Mitigation Measures: The report should provide recommendations and strategies for controlling these potential impacts to acceptable levels. This could include implementing safety measures to protect nearby communities and structures, as well as ensuring that the environment is not unduly harmed by the mining activities. It's important to conduct a thorough and impartial EIA to assess the potential impacts and ensure that the necessary steps are taken to minimize adverse effects and protect the environment and the safety of nearby communities. Regulatory authorities and stakeholders typically require such assessments to be conducted before granting mining rights or permits.

Table 1: Details of the compiler

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Report Date	2024/07/30

Table 2: Details of the Project

Farm name	RE of the farm Winterveld 293 KT
Application area (ha)	~ 4219,578 ha the entire farm
Magisterial District:	Sekhukhune
Distance and direction from nearest town	About 20km East of Burgersfort
Mining Method	Open Cast mining method which will employ drilling and blasting technique

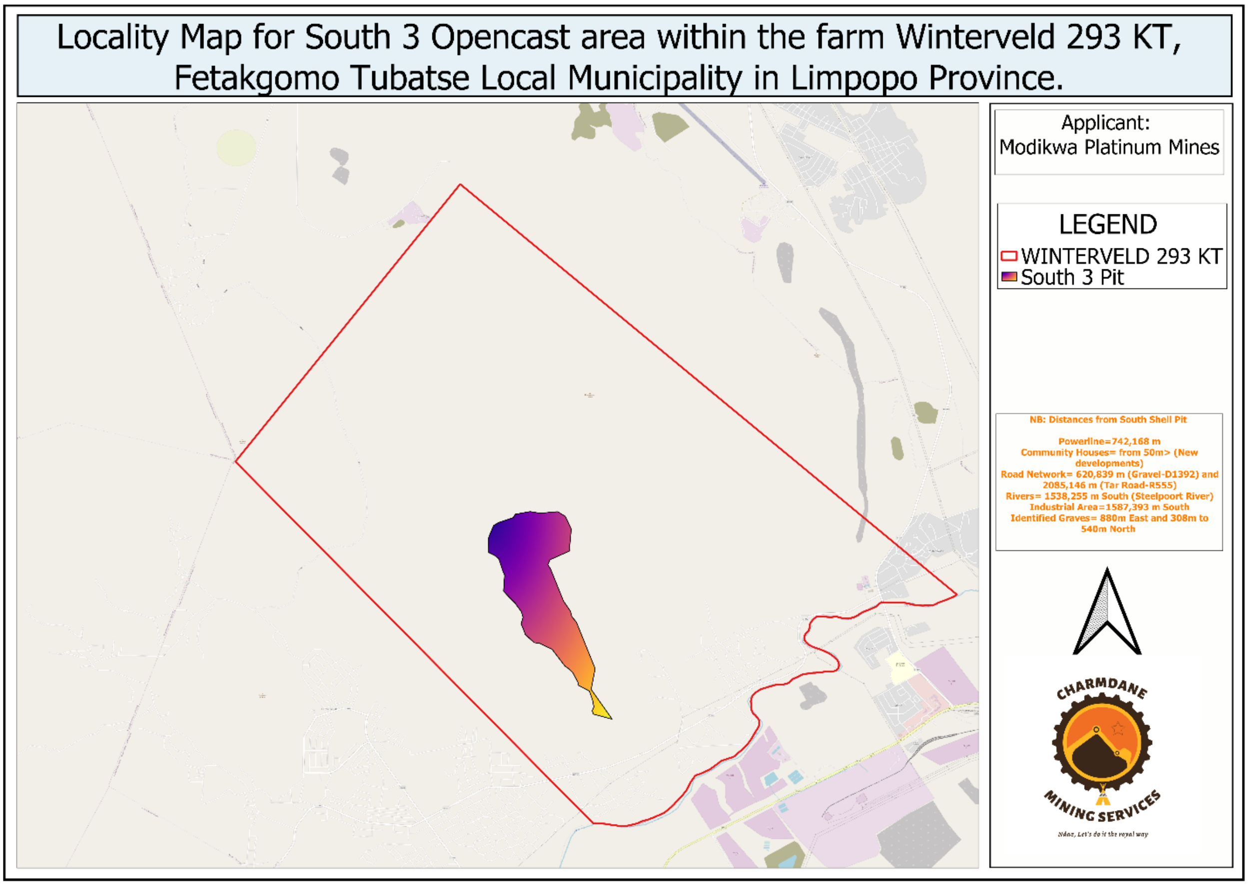


Figure 1: Locality Map of the Study Area

Figure 2: Satellite Map of the Project Area

2 Objectives

The objective of the study can be defined as outlining the expected environmental effects that blasting operations could have on the surrounding environment with regards to expected ground vibration, air blast and fly rock and proposing specific mitigation measures if required. These effects are investigated in relation to the blast site area and surrounds of possible influence on nearby powerlines, houses and the owners or occupants.

The study will assess the impact of the proposed Project on the following:

- Community Houses and Graves
- Existing powerlines
- River and Wetlands
- Roads
- Livestock and wild animals

The objectives were dealt with whilst taking specific protocols into consideration in this report: • National Environmental Management Act No. 107 of 1998; • Mine Health and

Safety Act No. 29 of 1996; • Mineral and Petroleum Resources Development Act No. 28 of 2002; and • Explosives Act No. 15 of 2003.

- **National Environmental Management Act No. 107 of 1998 (NEMA)**: This act is a cornerstone of environmental legislation in South Africa. It provides the legal framework for environmental protection, management, and sustainable development. The EIA process under NEMA ensures that potential environmental impacts are assessed, and appropriate mitigation measures are implemented.
- **Mine Health and Safety Act No. 29 of 1996**: This act focuses on the health and safety of people working in the mining industry. It sets out the legal requirements for ensuring the health and safety of employees in mines. The assessment would address the safety measures necessary to protect workers in the mining and blasting operations.
- **Mineral and Petroleum Resources Development Act No. 28 of 2002 (MPRDA)**: This is the primary legislation governing mining rights and exploration in South Africa. It outlines the processes and requirements for obtaining mining rights, including the need for Environmental Impact Assessments and compliance with environmental and social responsibilities.
- **Explosives Act No. 15 of 2003**: This act regulates the manufacture, storage, sale, transportation, and use of explosives. In the context of mining, it would pertain to the handling and use of explosives for blasting operations. Compliance with this act is crucial to ensure safety and security.

3 Scope of Blast Impact Study

The scope of the study is determined by the terms of reference to achieve the objectives and the scope is based on 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 1500 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.

4 Methodology

The detailed plan of study consists of the following sections:

- **Site Review:** Review of area using aerial imagery, screening report and information from the client with intention to understand the location of the site and its surroundings;
- **Identifying surface** structures / installations that are found within the project site. A list of Point of Interests (POI's) are created that will be used for evaluation;
- **Site evaluation:** This consists of evaluation of the proposed mining operation and the possible influences from blasting operation. The methodology is modelling the expected impact based on the expected drilling. Various accepted mathematical equations are applied to determine the attenuation of ground vibration, air blast and fly rock. These values are then calculated over the distance investigated from site and shown as amplitude level contours. Overlaying these contours on the location of the various receptors then gives an indication of the possible impacts and the expected results of potential impacts. Evaluation of each receptor according to the predicted levels then gives an indication of the possible mitigation measures to be applied. The possible environmental and/or social impacts are then addressed in the detailed EIA phase investigation; and
- **Reporting:** All data is prepared in a single report and provided for review.

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.

5 South African Acts considered

5.1 Mine Health and Safety Act 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]).

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.

5.2 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.

5.3 Mineral and Petroleum Resources Development Act 28 Of 2002

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

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.

6 Blasting Operation

Drilling and blasting is the controlled use of explosives and other methods such as gas pressure blasting pyrotechnics, to break rock for excavation. It is practiced most often in mining (in this case chrome), quarrying and civil engineering such as dam, tunnel or road construction. The result of rock blasting is often known as a rock cut.

Drilling and blasting currently utilizes many different varieties of explosives with different compositions and performance properties. Higher velocity explosives are used for relatively hard rock in order to shatter and break the rock, while low velocity explosives are used in soft rocks to generate more gas pressure and a greater heaving effect. For instance, an early 20th-century blasting manual compared the effects of black powder to that of a wedge, and dynamite to that of a hammer. The most commonly used explosives in mining today are ANFO based blends due to lower cost than dynamite.

Figure 3: Accessories for Blasting

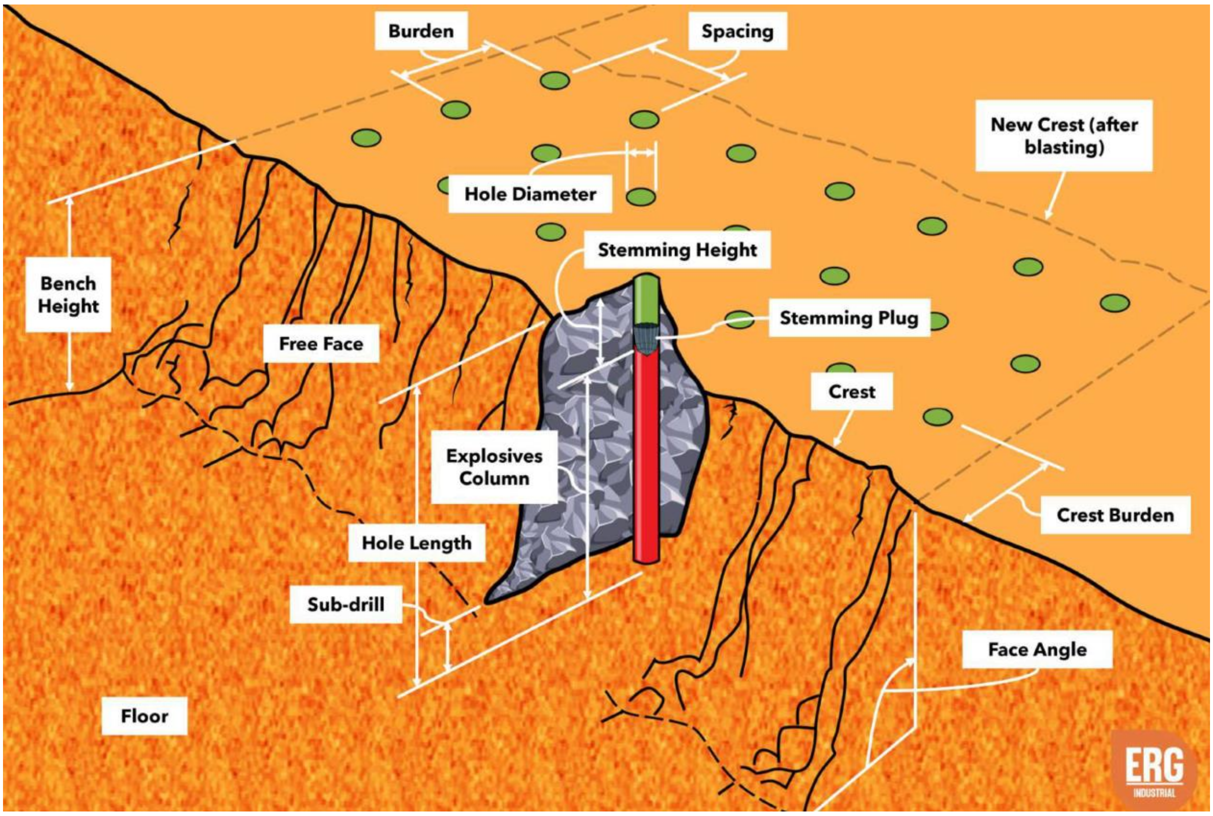


Figure 4: Blasting Design and Planning

7 Site Investigation

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

- A highly sensitive area of 500m around the proposed mining area. Normally, this 500m 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 pit area;
- An area 500m to 1500m around the mine area can be considered as being a medium sensitive area. In this area, the possibility of impact is still expected, but it 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 upset people; and

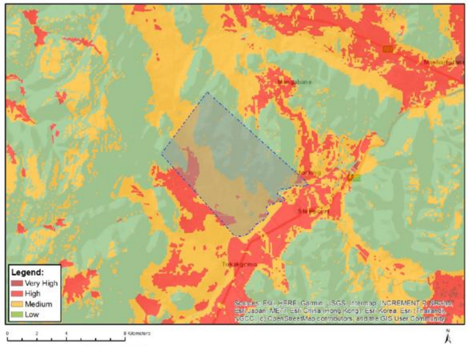
- An area greater than 1500m is considered low sensitivity area. In this area, it is relatively certain that influences will be low with low possibility of damages and limited possibility to upset people.

Desktop studies was done to preliminary check the orientation and the feel of the environment where the proposed project is located. As part of desktop studies screening tool was used to assess the applied area and its surroundings. The following information was gathered from the screening report and collaborated with site assessment.

7.1 Screening Tool results

The following section represents the results of the screening for environmental sensitivity of the proposed footprint for relevant environmental themes associated with the project classification. It is the duty of the EAP to ensure that the environmental themes provided by the screening tool are comprehensive and complete for the project.

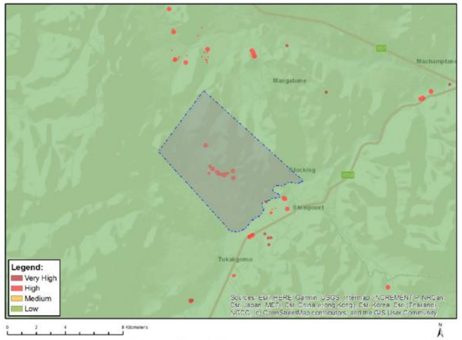
MAP OF RELATIVE AGRICULTURE THEME SENSITIVITY



Very High sensitivity	High sensitivity	Medium sensitivity	Low sensitivity
	X		

Sensitivity Features:

MAP OF RELATIVE ARCHAEOLOGICAL AND CULTURAL HERITAGE THEME SENSITIVITY



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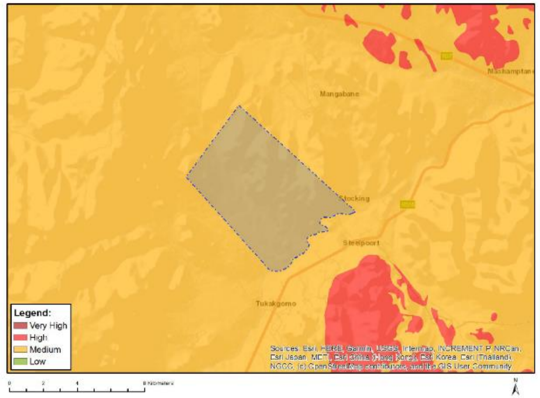
MAP OF RELATIVE PALEONTOLOGY THEME SENSITIVITY



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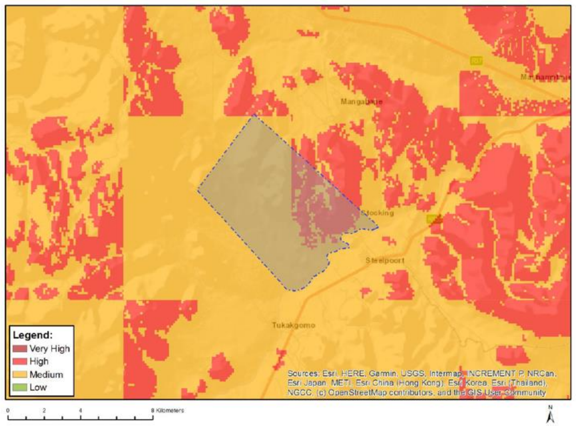
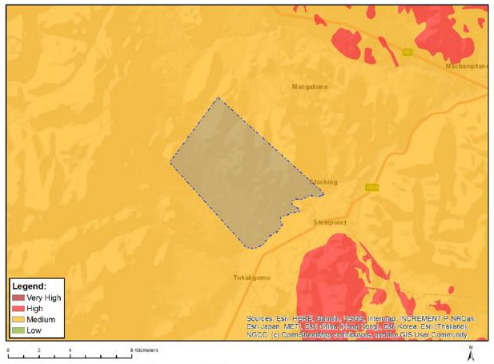
MAP OF RELATIVE ANIMAL SPECIES THEME SENSITIVITY



MAP OF RELATIVE PALEONTOLOGY THEME SENSITIVITY



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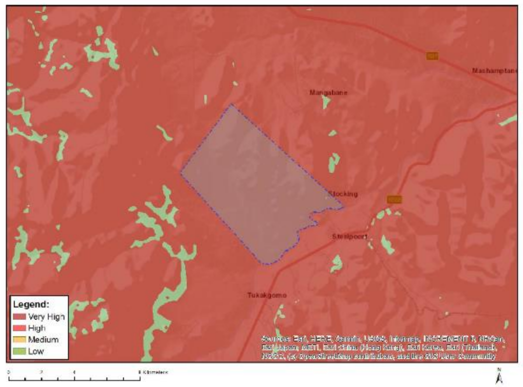
MAP OF RELATIVE TERRESTRIAL BIODIVERSITY THEME SENSITIVITY



Very High sensitivity	High sensitivity	Medium sensitivity	Low sensitivity
X			

Figure 5: Screening Results

From the screening report it was found that the project is highly sensitive on the animal species, terrestrial biodiversity and heritage. This gave the blasting impact assessor an indication of possible mammals and graves/burial sites on site that may be affected by blasting activity.

Charmdane Mining (Pty) Ltd conducted desktop study on the area of interest to identify the infrastructures/features that may be affect by blasting activity. Blasting Impact Assessment (site) was the conducted on the 24th July 2024, the following discoveries was found on site:

Features	**Distance from the Mining Area**
Eskom Powerlines	Powerline=742,168 m South main powerline, there are poles within the community and ranges between 510-600m away from the proposed operation.
Identified Graves	880m East and 308m to 540m North
Transnet Railway line & infrastructures	Not found on site
Community Houses	Within the MR closest house is about 51m east of Soth Shell pit.
Road Network	Gravel roads 620,839 m south (Gravel-D1392), series of unnamed gravel road and about 2085,146 m south there is a Tar Road-R555
Dams, Wetlands, streams and animal habitat	Non-Perennial (less than 80m-Tubatsane River) and perennial river system = 1538,255 m South (Steelpoort River)
Propose Modikwa Infrastructure (Offices Area)	Less than 250m from North Shell
Other Mining operations	About 3km North 4,5 North West

Photos 1: Infrastructures, Powerlines and water tank stand (about 595,1m East of the South Shell Pit)

Photos 2: Different types of houses around the mining area

Photos 3: State of some houses closer to the proposed operation

Photos 4: Ariel overview of infrastructures closer to South Shell Pit

Photo 5: Graves identified within the proposed open cast and outside

7.2 Geological Setting

The area is underlain by the mafic phase of the Bushveld Complex namely rocks of the Critical and Main Zones. The Main Zone comprises gabbros and ferrogabbros, whilst the Critical Zone includes alternating sequences of gabbros, norites, anorthosites, pyroxenites and chromitites.

The entire layered sequence strikes NNW to SSE, and dips to the southwest at 10° to 12°, with local deviations in the dip resulting in gradients of nearly 20. There are several instances where some gentle 'rolling' of the reef horizons have been recorded, and normally steeper dips are noted closer to outcrop (as opposed to at depth).

The outcrop positions of the two economic horizons normally occur within the areas of low relief, and much of the outcrop is masked by fairly extensive development of black turf, as well as, in places, transported sediments. On the farms Maandagshoek, Onverwacht and Winterveld however, the UG2 (and occasionally the Merensky Reef) outcrops in a series of rather elongate hills. Although frequently covered with scree material, much of this outcrop has been marked by a series of trenches and pits, many of which date from the early pioneer prospecting.

The Merensky and UG2 are separated by approximately 245 to 360 metres of mafic and ultramafic cumulate rocks. Economic PGM mineralisation occurs within the UG2 Reef horizon and Merensky Reef pyroxenites. The structural setting is characterized by NNE – SSW dykes, faults and fractures.

The UG1 usually consists of a series of chromitite layers up to 2 metres in thickness. In some cases, several layers or stringers of chromitite are "detached" from the bottom or top of the main layer.These appear to diverge into the footwall/hangingwall anorthosite, only to converge again and join the main layer. The lenses of anorthosite so formed are usually impregnated with numerous chromite grains.

Below the main layer there is always a zone of anorthosite, up to 5 metres in thickness, which contains elongated blebs and stringers of chromitite. These occur below the "detached" chromitite zone described above. Bifurcation of chromitite layers within the UG1 sequence is very common.

The intimate association of chromitite and anorthosite is a characteristic of the UG1 chromitite unit throughout the Bushveld Complex. Layers of norite, leuconorite, anorthosite and pyroxenite, approximately 80 to 90 metres thick, overlies the UG1 and is, in turn, overlain by the UG2 layer.

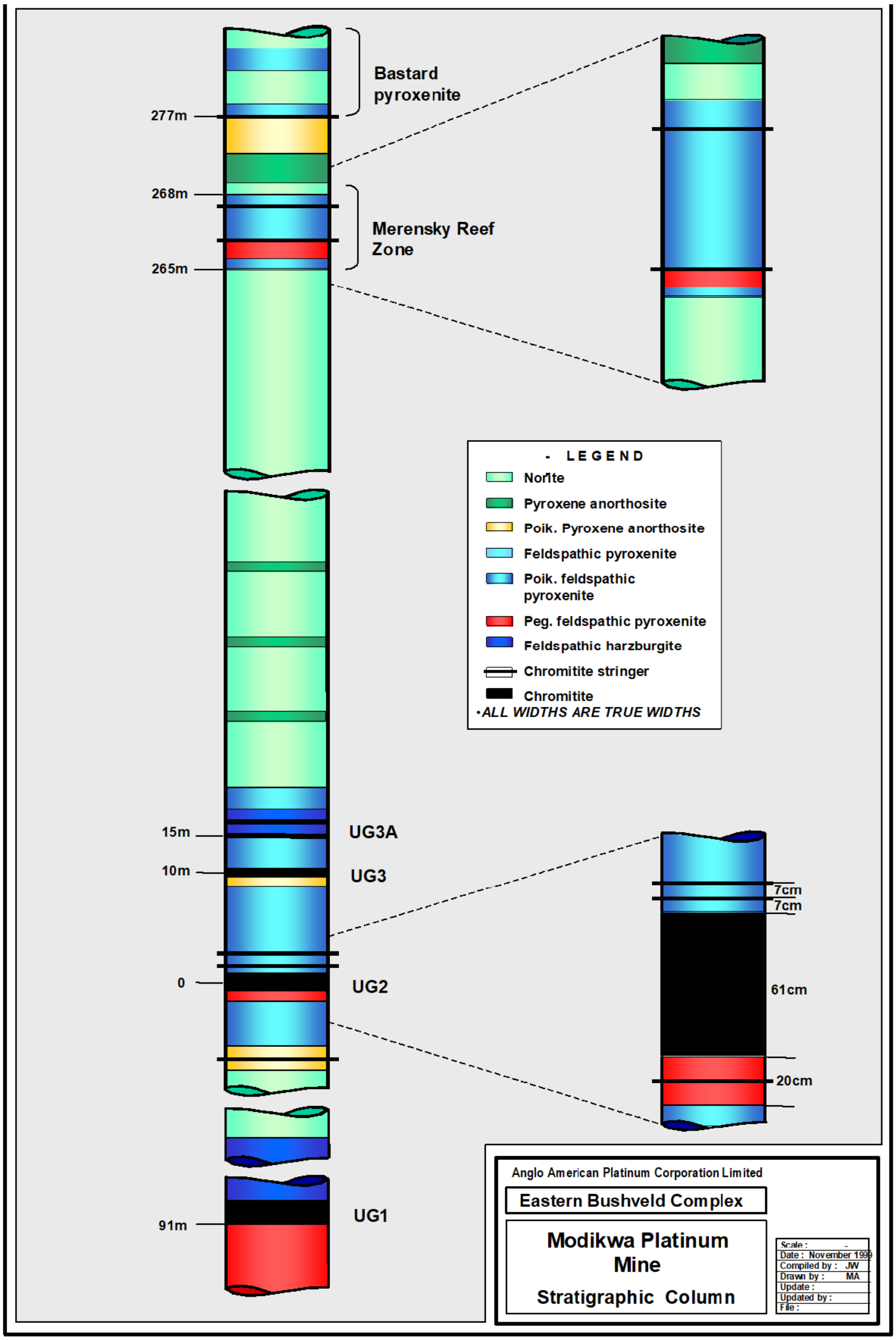


Figure 6: The Stratigraphy of the project area (from client)

8 Buffer zone map and Model of Blasting Vibration

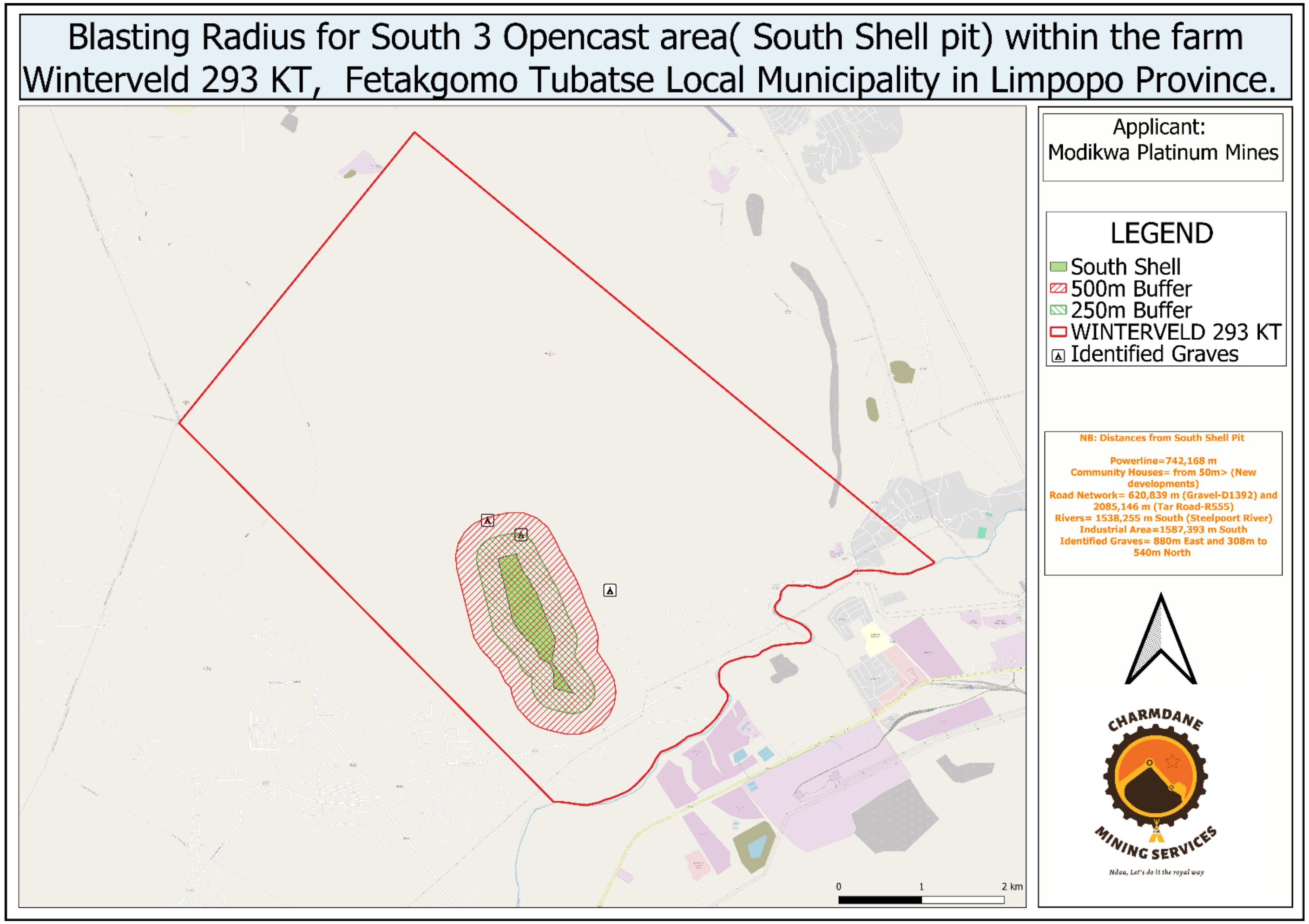


Figure 7: South Shell Blasting Radius and nearby infrastructures

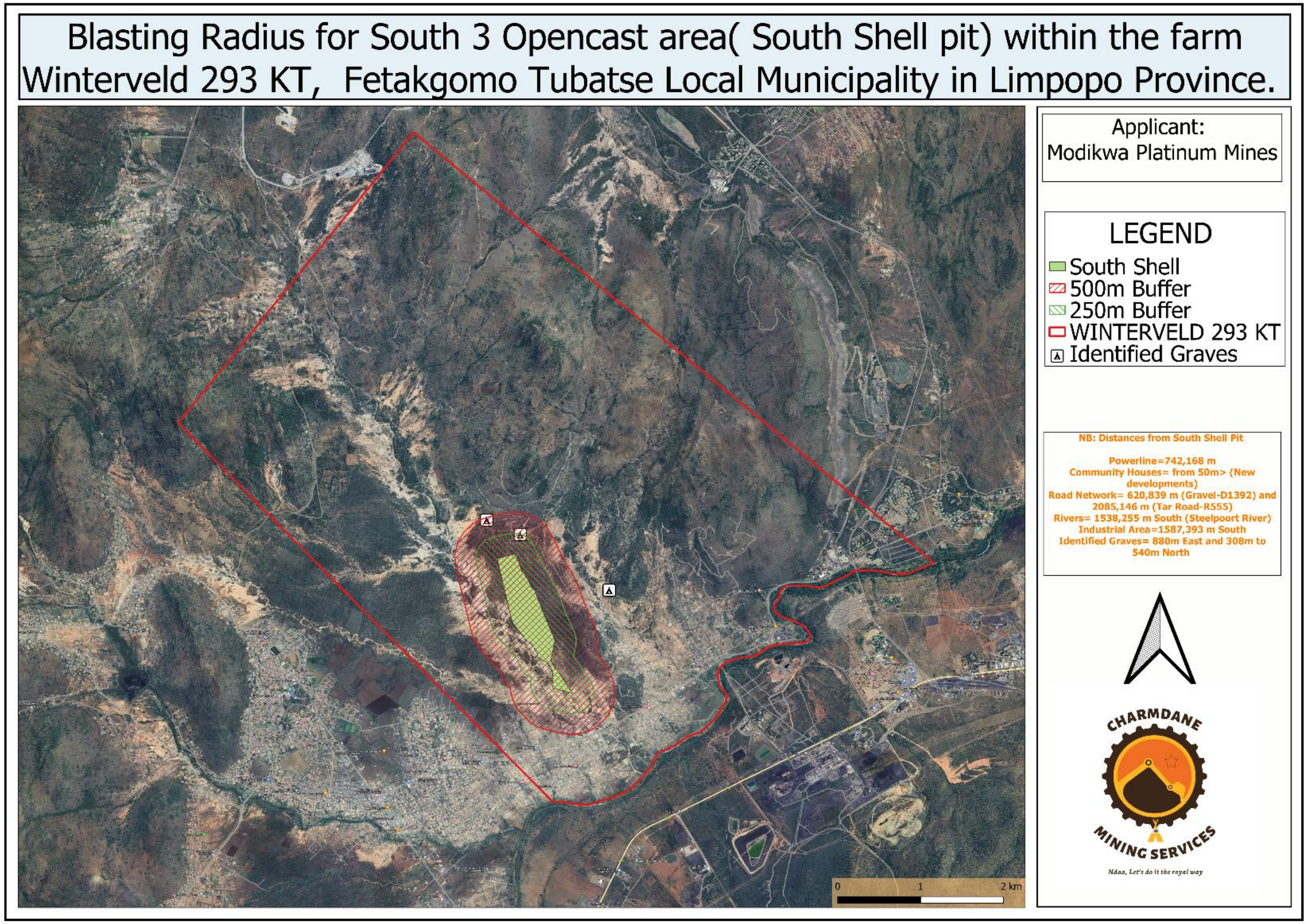


Figure 8: Satellite Map for South Shell Blasting Radius and nearby infrastructures

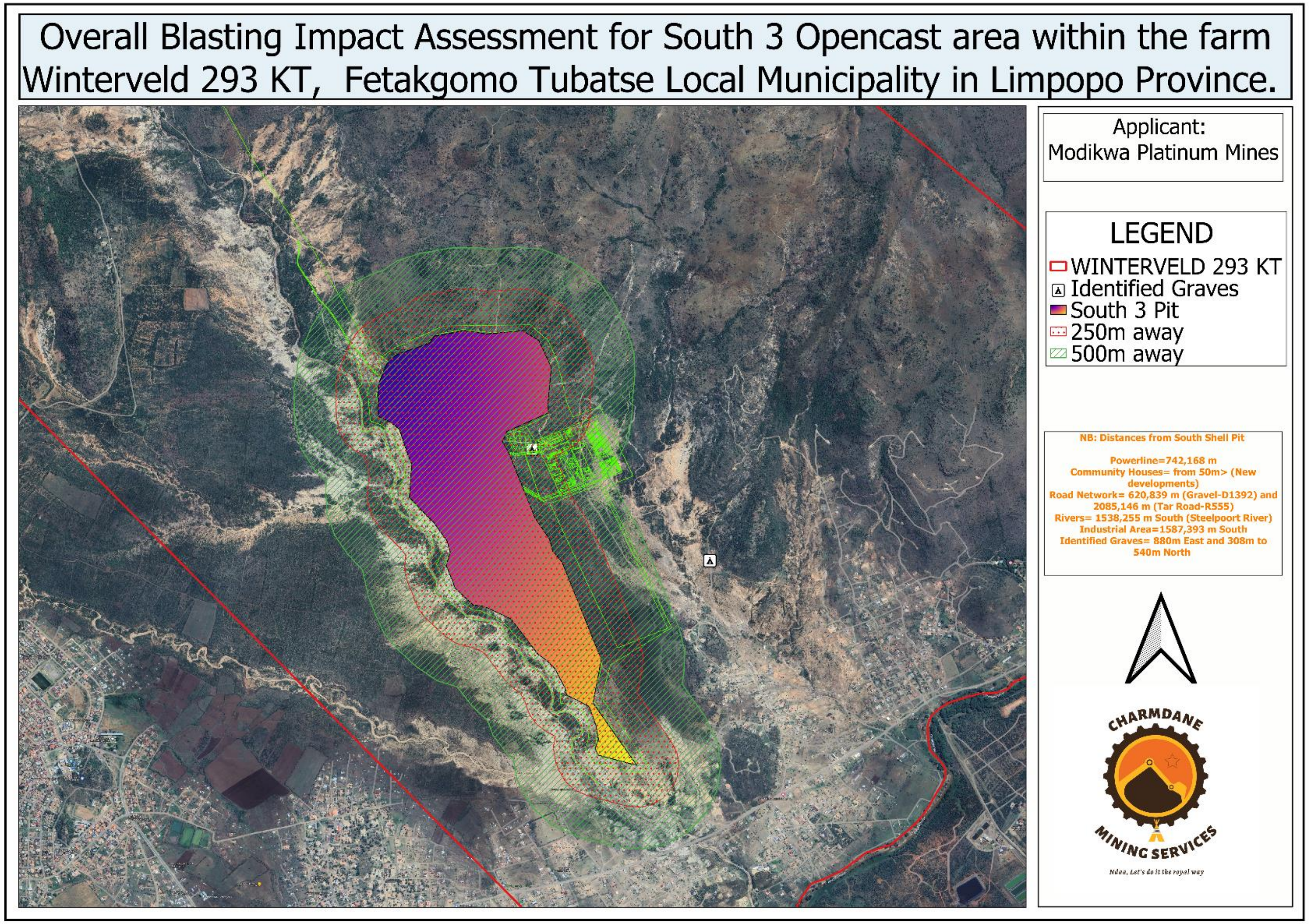


Figure 9: Overall Blasting Impact Assessment for the South 3 Open Cast area

9 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 are a 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 standard.

9.1 Ground vibration limitations on structures

Ground vibration is measured in velocity with units of millimetres per second (mm/s). it 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 traditionally 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 higher frequency and lower oscillation is synonymous with 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.

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.

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.

Table 3: Speed limits per environmental and manmade features

Feature/Material	Vibration speed limit
National roads/tar roads	150mm/s
Steel pipelines:	50mm/s
Electrical lines (Eskom)	75mm/s
Sasol Pipelines	25mms/s
Railways	150mm/s
Concrete less than 3 days old 1	5mm/s
Concrete after 10 days	200mm/s
Houses	5mm/s
Sensitive plant equipment: or 2	12mm/s or 25mm/s, depending on type. (Some switches could trip at levels of less than 25mm/s)
Waterwells or Boreholes	50mm/s

Considering the limitation on table above, this report is based on the following: USBM (United States Bureau of Mine) criteria for safe blasting; Consideration of private structures in influence; Should structures be in poor condition, the basic limit of 25mm/s is halved to 12.5mm/s or when structures are in very poor condition limits will be restricted to 6mm/s. It is a standard accepted method to reduce the limit allowed with poorer condition of structures; Traditionally 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, and Input from other consultants in the field locally and internationally. High impact is anticipated on the infrastructures within the proposed area.

9.2 Noise and Vibration

Sources of noise emissions associated with mining may include noise from vehicle engines, loading and unloading of rock into steel dumpers, chutes, power generation, and other sources related to construction and mining activities. Additional examples of noise sources include shovelling, ripping, drilling, blasting, transport (including corridors for rail, road, and conveyor belts), crushing, grinding, and stockpiling. Good practice in the prevention and control of noise sources should be established based on the prevailing land use and the proximity of noise receptors such as communities or community use areas.

- Development of blast design, including a blasting-surfaces survey, to avoid over confined charges, and a drill-hole survey to check for deviation and consequent blasting recalculations;
- Implementation of ground vibration and overpressure control with appropriate drilling grids; and
- Adequately designing the foundations of primary crushers and other significant sources of vibrations.

There is an infrastructure/house closer to south shell pit which is less than 50m way, this infrastructure will be impacted when blasting activity commences on the pit. There is also notable developments closer to the South Shell pit which is within the 500m blasting radius. This area should be avoided at all cost as the impact is very high.

Photo 6: New Development within 500m blasting radius

10 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 and the levels that are experienced are "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 4.5mm/s as unpleasan. This guideline helps with managing ground vibration and the complaints that could be received due to blast induced ground vibration.

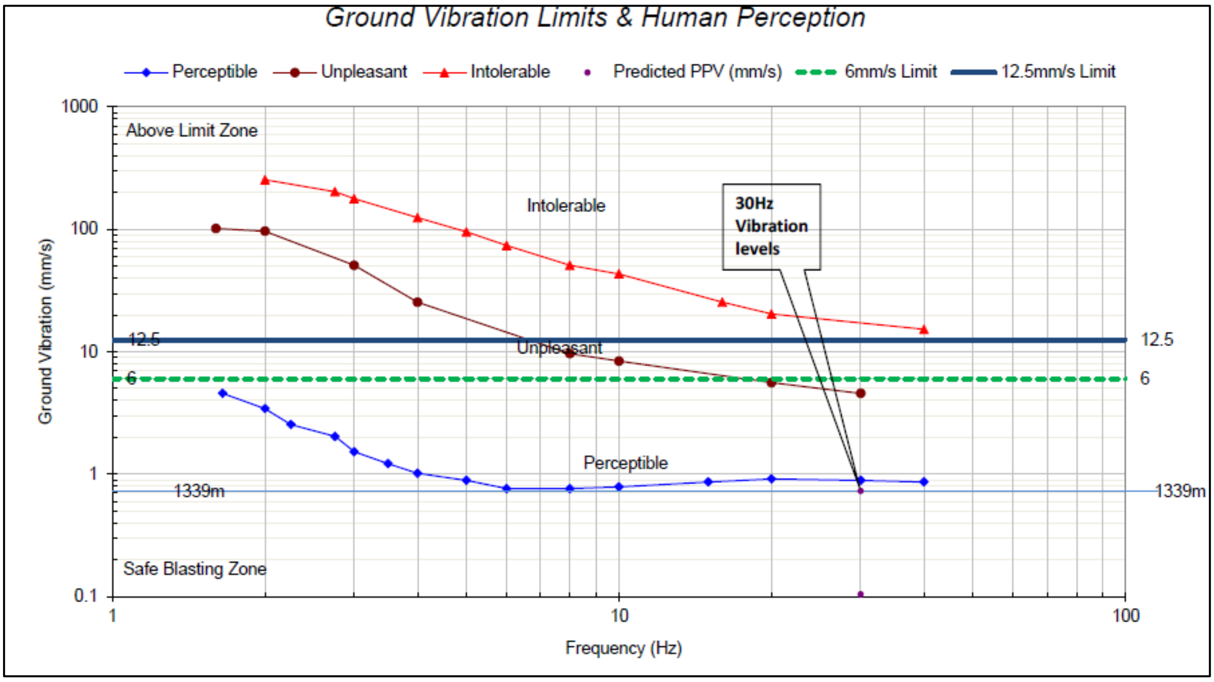


Figure 10: Typical example of USBM Analysis with Human Perception

11 Air blast limitations on structures

Air blast or air-overpressure is a pressure wave generated from the blasting process. It is measured as pressure in pascal (Pa) and reported as a decibel value (dBL). Air blast is normally associated with frequency levels less than 20Hz, which is at the threshold for hearing. Air blast can be influenced by meteorological conditions such as, 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). Air 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); and
- Venting of blast holes or blowouts; the gas release pulse (GRP).

The general recommended limit for air blast currently applied in South Africa is 134dB. This is based on work done by the USBM. The USBM also indicates that the level is reduced to 128dB 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 135dB 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 4: 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. Based on this project there is a house located within a project area and close to the proposed blasting area, the impact on the property and people will be high and the proposed mitigations will be based on the agreement between our client and the landowner. If the terms are of relocating, then impact on dwellers will be distorted and if not evaluations of existing infrastructure should be conducted before blasting.

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 of air blast on structures that startle people will also be reduced, which in turn reduces the reasons for complaints. These effects are sometimes erroneously identified as ground vibration and considered to be damaging the structure. In this report, initial limits for evaluating conditions have been set at 120dB, 120dB to 134dB and greater than 134dB. The USBM limits for nuisance are 134dB. The cracks below may not be due to current blasting activity, with time these cracks may expand.

The figures mentioned above are based on a literature review, as the project is still in its greenfield stage. Considering the blasting radius of 500m, the community houses located at a distance of 500m or more from the blasting area are expected to experience minimal impacts. However, areas within a 500m radius from the blasting area will likely experience high impacts.

12 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. The movement should be in the direction of the free face, and therefore the orientation of the blast is important. Material or elements travelling outside of this expected range 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; and

- 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. would be fly rock.

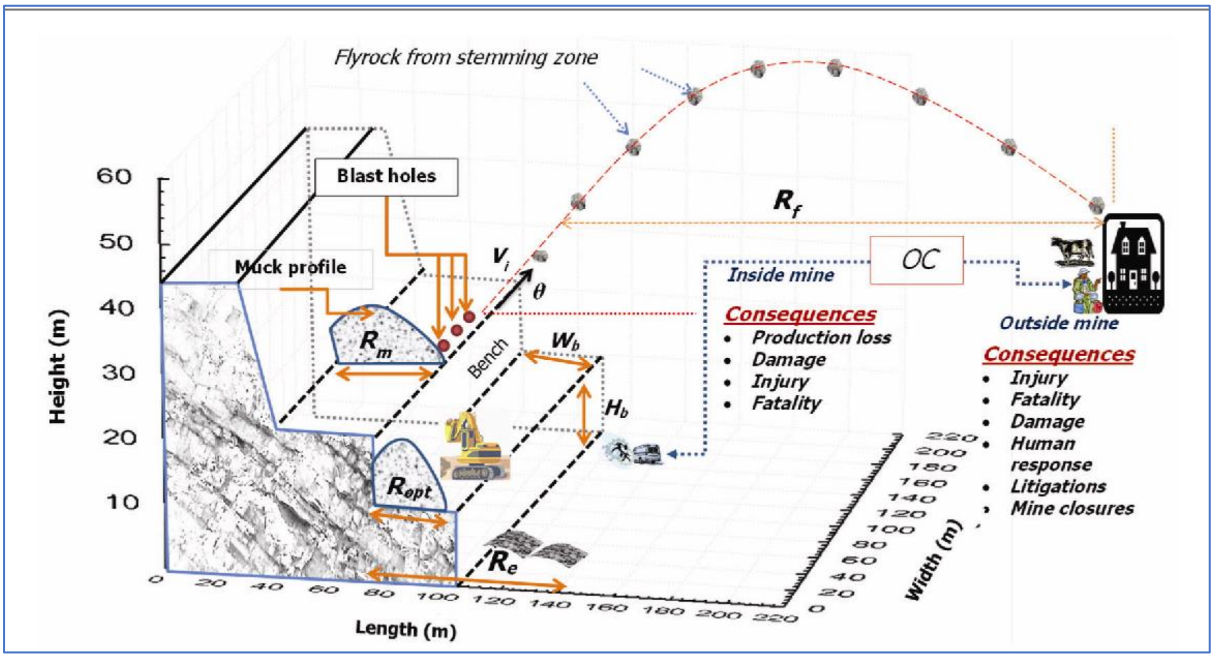


Figure 11: Schematic of fly rock terminology

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; and
- 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.

Figure 12: Illustration of Fly Rock Situation

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. This report was based on a prediction calculation defined by the International Society of Explosives Engineers (ISEE) to assist with determining minimum distance.

13 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 undesirable. These fumes present themselves as red brown cloud after the blast has detonated. It has been reported that 10ppm to 20ppm can be mildly irritating.

Exposure to 150ppm or more (no time period given) has been reported to cause death from pulmonary oedema. It has been predicted that 50% lethality would occur following exposure to 174ppm 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. This is a least concern since the applicant has been in mining industry for decades and cases related to noxious fume were not reported.

Figure 13: Typical Example of Dangerous Gas -Noxious Fume

14 Impact of Vibration to the 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 communication and more 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; and

- Monitoring of blasting and re-optimising the blasting design in the light of results, changing conditions and experience should be carried out as standard.

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.

Bench Height (m):	5.0	**Accessories Type:**	Shock tube
BH Depth Incl. Sub drill (m):	6.64	**Down hole Timing (ms):**	350
BH Diameter (mm):	127	**Surface Timing - I/H (ms):**	17
Burden (m):	3.4	**Surface Timing - I/R (ms):**	42
Spacing (m):	4	**Booster / Primer (gr.):**	150
Explosive Type:	Anfo	**Delay Pattern:**	V1
Charge per BH (kg):	48	**Charge per delay (kg/delay):**	240
Stemming Length (m):	1.91	**Powder Factor (kg/m3):**	0.76

Figure 14: Blast Design Technical Information

Review of the type of structures that are found within the possible influence zone of the proposed mining area and the limitations that may be applicable, different limiting levels of ground vibration will be required. This is due to the typical structures and installations observed surrounding the site and location of the project area. Structures types and qualities vary greatly, and this calls for limits to be considered as follows: 6mm/s, 12.5mm/s levels and 25mm/s at least.

Based on the designs presented on expected drilling and charging design, the following figure shows expected ground vibration levels (PPV) for various distances calculated at the two different charge masses. The proposed charge masses are 48kg and 240kg.

No.	Distance (m)	Expected PPV (mm/s) for 48 kg Charge	Expected PPV (mm/s) for 240 kg Charge
1	50.0	43.8	165.4
2	100.0	22.5	84.7
3	150.0	7.2	27.0
4	200.0	4.5	16.8
5	250.0	3.1	11.6
6	300.0	2.3	8.6
7	400.0	1.4	5.3
8	500.0	1.0	3.7
9	600.0	0.7	2.7
10	700.0	0.6	2.1
11	800.0	0.5	1.7
12	900.0	0.4	1.4
13	1000.0	0.3	1.2
14	1250.0	0.2	0.8
15	1500.0	0.2	0.6
16	1750.0	0.1	0.5
17	2000.0	0.1	0.4
18	2500.0	0.1	0.3
19	3000.0	0.1	0.2
20	3500.0	0.0	0.1

Figure 15: Expected Ground Vibration at Various Distances

15 Air Blast

The prediction of air blast as a pre-operational effect is difficult to define exactly. There are many variables that have influence on the outcome of air blast. Air blast is the direct result from the blast process, although influenced by meteorological conditions, wind strength and direction, the final blast layout, timing, stemming, accessories used, covered or not covered etc. all has an influence on the outcome of the result. Air blast is also an aspect that can be controlled to a great degree by applying basic rules. In most cases mainly an indication of typical levels can be obtained. The indication of levels or the prediction of air blast in this report is used to predefine possible indicators of concern. Standard accepted prediction equations are applied for the prediction of air blast. A standard cube root scaling prediction formula is applied for air blast predictions.

As discussed earlier the prediction of air blast is very subjective. The following figure shows Air Blast Predicted Values.

No.	Distance (m)	Air blast (dB) for 48 kg Charge	Air blast (dB) for 240 kg Charge
1	50.0	140.9	144.2
2	100.0	138.4	141.7
3	150.0	134.2	137.5
4	200.0	132.4	135.7
5	250.0	131.0	134.3
6	300.0	129.9	133.2
7	400.0	128.1	131.4
8	500.0	126.7	130.0
9	600.0	125.6	128.9
10	700.0	124.7	128.0
11	800.0	123.8	127.1
12	900.0	123.1	126.4
13	1000.0	122.4	125.8
14	1250.0	121.1	124.4
15	1500.0	120.0	123.3
16	1750.0	119.0	122.3
17	2000.0	118.2	121.5
18	2500.0	116.8	120.1
19	3000.0	115.7	119.0
20	3500.0	114.7	118.1

Figure 16: Air Blast Predicted Values

Figure 17: Proposed Mining Activity against the Community

16 Impact Assessment and Mitigation Measures During Operational Phase

The area surrounding the proposed mining area was reviewed for structures, traffic, roads, human interface, animals' interface etc. This section concentrates on the outcome of the desktop studies, predictions the possible effects of ground vibration, air blast and fly rock specifically to these points of interest or possible interfaces. Blasting further away from the boxcut will certainly have lesser influence on the surroundings. A worst case is then applicable within the proposed pit. As explained previously reference is only made to some structures and these references covers the extent of all structures surrounding the proposed 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 Regional Road;
- Air blast Modelling Results;
- Impact of fly rock; and
- 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.

17 Assessment Methodology

The **Environmental Significance** scale evaluates the importance of a particular impact. This evaluation needs to be undertaken in the relevant context, as an impact can either be ecological or social, or both. The evaluation of the significance of an impact relies heavily on the values of the person making the judgement. For this reason, impacts of especially a social nature need to reflect the values of the affected society. A four-point impact significance scale was applied and presented in Table 5.

Table 5:Environmental significance rating scale:

Description	Significance ratings
These impacts would constitute a major and usually permanent change to the (natural and/or social) environment, and usually result in severe or very severe effects, or beneficial or very beneficial effects.	Very High
These impacts will usually result in long term effects on the social and/or natural environment. Impacts rated as high will need to be considered by the project decision makers as constituting an important and usually long-term change to the (natural and/or social) environment. These would have to be viewed in a serious light.	High
These impacts will usually result in medium to long term effects on the social and/or natural environment. Impacts rated as moderate will need to be considered by the project decision makers as constituting an important and usually medium-term change to the (natural and/or social) environment. These impacts are real but not substantial.	Moderate
These impacts will usually result in medium to short term effects on the social and/or natural environment. Impacts rated as low are generally fairly unimportant and usually constitute a short-term change to the (natural and/or social) environment. These impacts are not substantial and are likely to have little real effect.	Low

The **Degree of Difficulty of Mitigating** the various impacts ranges from very difficult to easily achievable. The four categories used are listed and explained in Table 6 below. The practical feasibility of the measures, financial feasibility of the measures and their potential effectiveness was taken into consideration in deciding on the appropriate degree of difficulty.

Table 6: Degree of Mitigation Difficulty Rating Scale

Degree of Difficulty	Description
The impact could be mitigated but it would be very difficult to ensure effectiveness and/or to technically/financially achieve	Very difficult
The impact could be mitigated but there will be some difficulty in ensuring effectiveness and/or implementation	Difficult
The impact can be effectively mitigated without much difficulty or cost	Achievable
The impact can be easily and effectively mitigated	Easily achievable

Impacts that are of high to very high significance and difficult to very difficult to mitigate are 'extreme' environmental or social risks to the project. Those impacts that are less significant and easier to mitigate are rated as 'major' to 'medium' to 'minor' i.e. generally impacts of low to moderate significance for which mitigation is achievable to easily achievable. Impacts may potentially be of very high significance, but if the mitigation is easily achievable, they are rated as 'medium' risks, as per Table 5.

Table 7: Risk Categories

Risk Description	Risk
Significant mitigatory actions would be required to reduce these risks. In some cases, it may not be possible to reduce these extreme risks meaning they are likely to prevent the option from being used (raised as red flags in this assessment).	Extreme
These risks are of a serious nature, and without effective mitigation measures would be major hindrances to the project. These would need to be monitored and managed, and in combination Major risks may necessitate the use of a different option to achieve the projects objectives.	Major
These risks are of a less serious nature but still important and need to be reduced to As Low As Reasonably Possible (ALARP) for the benefit of the environment or social network affected. In	Medium

isolation these risks are generally insufficient to prevent the project from proceeding.	
These risks are generally acceptable to the project and environment, and mitigation is desirable but not essential. Best practice, however, should be followed and the risks mitigated to prevent a cumulative effect of such impacts.	Minor

18 Assessment of Blasting Impacts on Ground vibration

18.1 Impact 1.1: Ground vibration and Noise Impacts

Operation: Low or minimum ground vibration is expected outside the blasting radius, this means the community will have less impacts from the blasting operation. Ground vibration levels may have a Low-Medium impact on nearby sensitive residential buildings and structures. Nevertheless, proposed mitigation measures will reduce vibration levels to within acceptable limits, safeguarding these structures from potential damage. Levels will be less than 120 dB at surrounding residential dwellings but may be audible, this will have low-medium risk for noise impact.

18.2 Impact 1.2: Air Blast

Blasting operations causes air blast. The amplitude of air blast will depend on the type, size and preparation of blastholes when blasting operations conducted. Air blast are of importance when surface structures near or around the operation needs to be protected from damage.

Construction: No specific blasting operations will be expected during construction phase. Operation: Blasting operations is planned for the operation. In Closure phase no specific blasting operations will be expected during rehabilitation phase.

18.3 Impact 1.3: Fly rock

Blasting operations could cause fly rock. The distance and quantity of fly rock is dependent on the blast preparation and specific the stemming lengths and material.

Fly rock are of importance when areas need to be cleared for blasting and people and equipment moved to a safe distance.

Construction: No specific blasting operations will be expected during construction phase. Operation: Blasting operations is planned for the operation. People should be notified before blasting activity.

The assessment highlights the potential impacts of blasting activities on surrounding residential areas and infrastructure. Mitigation measures are proposed to reduce ground vibration levels and minimize fly rock risks. The findings and recommendations of this report will inform the development of a site-specific blast design to ensure safe and responsible mining operations.

19 Recommendations

The following recommendations are proposed are based on best practice to be applied and IFC recommendations.

- Blast designs can be reviewed prior to first blast planned and done. Site conditions may change, or present certain difficulties not envisaged now. This will confirm if planned designs are applicable and expected outcomes are still within acceptable norms and standards.
- There is no specific concern for fly rock currently. The current proposed stemming lengths used provides for some control on fly rock. Consideration can be given to increase this length for better control. Specific designs where distances between blast and point of concern are known should be considered. Recommended stemming length should range between 20 and 30 times the blasthole diameter. In cases for better fly control this should range between 30 and 34 times the blast holes diameter. Increased stemming lengths will also contribute to more acceptable air blast levels.
- Calculated minimum safe distance is 595m. 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.

- During blasting care must be taken to ensure all people and animals cleared to outside the unsafe area as determined by the blaster.
- 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 atmospheric inversion or too late in the afternoon in winter. Do not blast in fog. Do not blast 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 is fixed.
- 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.

IFC Recommendations for use of Explosives

Blasting activities that may result in safety impacts are typically related to accidental explosion and poor coordination and communication of blasting activities. Recommended explosives management practices include:

- Using, handling, and transporting explosives in accordance with local and / or national explosives safety regulations;
- Assigning certified blasters or explosives experts to conduct blasts;
- Actively managing blasting activities in terms of loading, priming, and firing explosives, drilling near explosives, misfired shots and disposal;
- Adoption of consistent blasting schedules, minimizing blast-time changes;
- Specific warning devices (e.g. horn signals, flashing lights) and procedures should be implemented before each blasting activity to alert all workers and third parties in the surrounding areas (e.g. the resident population). Warning procedures may need to include traffic limitation along local roadways and railways;

- Specific personnel training on explosives handling and safety management should be conducted;
- Blasting-permit procedures should be implemented for all personnel involved with explosives (handling, transport, storage, charging, blasting, and destruction of unused or surplus explosives);
- Blasting sites should be checked post-blast by qualified personnel for malfunctions and unexploded blasting agents, prior to resumption of work;
- Specific audited procedures should be implemented for all activities related to explosives (handling, transport, storage, charging, blasting, and destruction of unused or surplus explosives) in accordance with relevant national or internationally recognized fire and safety codes; and
- Qualified security personnel should be used to control transport, storage, and use of explosives on site.
- Noise levels at the nearest sensitive receptor should meet the noise guidelines in the General EHS Guidelines;
- Where necessary, noise emissions should be minimized and controlled through the application of techniques which may include:
- Implementation of enclosure and cladding of processing plants;
- Installation of proper sound barriers and / or noise containments, with enclosures and curtains at or near the source equipment (e.g. crushers, grinders, and screens);
- Installation of natural barriers at facility boundaries, such as vegetation curtains or soil berms; and
- Optimization of internal-traffic routing, particularly to minimize vehicle reversing needs (reducing noise from reversing alarm) and to maximize distances to the closest sensitive receptors.
- Mechanical ripping should be used, where possible, to avoid or minimize the use of explosives and;
- Use of specific blasting plans, correct charging procedures and blasting ratios, delayed /micro delayed or electronic detonators, and specific in-situ blasting tests (the use of downhole initiation with short-delay detonators improves fragmentation and reduces ground vibrations);
- All people or livestock within 500 m from a blast should be moved before and during a blast;

- Mine should initiate a forum to inform the close residents about the likely vibration and air blast levels, the proposed blasting schedule and warning methodology the mine will employ before a blast as well as a warning to residents that, when they are indoors during a blast, vibration of windows and ceilings may appear excessive. The local community members must be notified of times when blasts will be undertaken and the community must know that the potential impact of vibration was assessed.
- The mine should warn road users on the tar road transecting the mining area before and during blasting events (such as a red light flashing with clear signs that blasting is taking place);
- Mine to prevent blasting in adverse meteorological conditions (overcast conditions, strong wind blowing in direction of local community, early in the mornings or late in the afternoon);
- The mine must keep full records of each blast (blast design, timing, explosive mass per blast hole, stemming, subdrill, spacing, burden, meteorological conditions during the blast, etc.); and
- Any evidence of fly rock is noted and the blast be analysed for possible improvements. Measures to be included in the EMPr and Environmental Authorization include:
- his report must be updated if the blast design is changed where more than 2597 kg explosives are detonated per delay;
- This report must be updated if the location of the proposed opencast pits is moved with more than 100 m;
- This report must be updated if the blast parameters changed with the mine making use of borehole with a larger diameter than considered in this report (165 mm), or the mine would consider bench heights higher than 24 m (blastholes deeper than 24 m

20 Knowledge Gaps

The data provided from client and information gathered was enough to conduct this study. Surface surroundings change continuously, and this should be considered prior to initial blasting operations. 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.

21 Conclusion

Charmdane Mining (Pty) Ltd conducted desktop study on the area of interest to identify the infrastructures/features that may be affect by blasting activity.

The objective of the study was to outline the expected environmental effects that blasting operations could have on the surrounding environment with regards to expected ground vibration, air blast and fly rock and proposing specific mitigation measures if required. In this case there are infrastructures (Eskom powerlines, Transnet railway lines and a community).

Considering the blasting radius of 500m, the community houses located at a distance of 500m or more from the blasting area are expected to experience minimal impacts. However, areas within a 500m radius from the blasting area will likely experience high impacts.

This report may need to be reviewed and updated if necessary. This concludes this investigation for the proposed Mining Project. There is no reason to believe that this operation cannot continue if attention is given to the recommendations made.

Monitoring of the infrastructure on a quarterly basis will assist the applicant to minimise liability should any of the infrastructure be damaged through blasting activity.

22 References

Berger P. R., & Associates Inc., Bradfordwoods, Pennsylvania, 15015, Nov 1980, Survey

of Blasting Effects on Ground Water Supplies in Appalachia., Prepared for United States Department of Interior Bureau of Mines.

BME Training Module – Vibration, air blast and fly rock, Module V, Dated 5 August 2001.

Chiapetta F., Van Vreden A., 2000. Vibration/Air blast Controls, Damage Criteria, Record Keeping and Dealing with Complaints. 9th Annual BME Conference on Explosives, Drilling and Blasting Technology, CSIR Conference Centre, Pretoria, 2000.

ISEE The Blasters' Handbook, 18th Edition, Cleveland, Ohio: International Society of

Explosives Engineers; 2011.

Mechanical vibration and shock – Vibration of buildings – Guidelines for the measurement and evaluation of their effects on buildings, SABS ISO 4886:1990.

Oriard, L.L., 1999, The Effects of Vibration and Environmental Forces: A guide for Investigation of Structures, International Society of Explosives Engineers, Cleveland, Ohio, USA.

Persson P.A., Holmberg R. and Lee J., 1994, Rock Blasting and Explosives Engineering,

Boca Raton, Florida: CRC Press.

Richards A. B., Moore A.J., Terrock Consulting Engineers Pty Ltd., 2002, Fly rock Control

– By Chance or Design, Paper Presented at ISEE Conference – New Orleans.

Rowland, J.H.(III), Mainiero R., and Hurd D.A.(Jr.), Factors Affecting Fumes Production of an Emulsion and Anfo/Emulsion Blends.

Blast Management & Consulting (BM&C) Blast Report – (2017) Blast Impact Assessment Proposed Triton Ancuabe Graphite Mine Phase 2 Project,Ancuabe, Mozambique