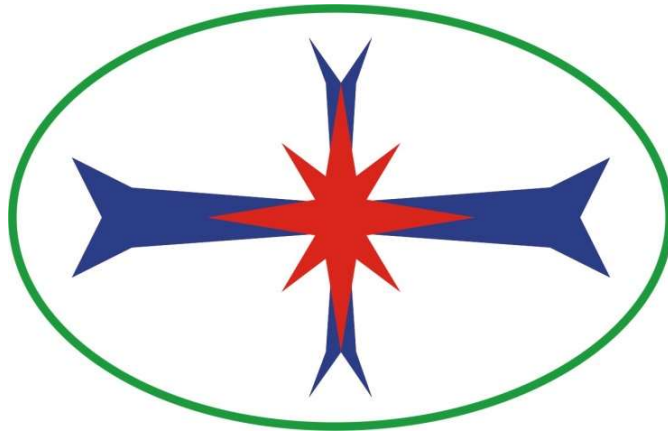



# Blast Management & Consulting



Quality Service on Time

## **Report: Blast Impact Assessment Proposed Xivono Mining (Pty) Ltd Weltevreden Mine Project**

Date:	31 October 2019
BM&C Ref No:	Digby Wells_Xivono Weltevreden Coal Mining Project_EIARReport_191018V00
DMR Ref No:	n/a
Client Ref No:	MBU5710
Signed:	
Name:	JD Zeeman

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**ii. 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.

**iii. Legal Requirements**


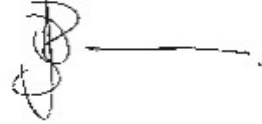
In terms of the NEMA 2014 EIA Regulations contained in GN R982 of 04 December 2014 (as amended by GN R 326 of 07 April 2017) all specialist studies must comply with Appendix 6 of the NEMA EIA Regulations, 2014 (as amended). Table 1 shows the requirements as indicated above.

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 25

Legal Requirement		Relevant Section in Specialist study
(b)	a declaration that the specialist is independent in a form as may be specified by the competent authority;	Section ii
(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 8
(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 11
(g)	an identification of any areas to be avoided, including buffers;	Section 11
(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 11
(i)	a description of any assumptions made and any uncertainties or gaps in knowledge;	Section 9
(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 17
(k)	any mitigation measures for inclusion in the EMPr;	Section 17.13
(l)	any conditions/aspects for inclusion in the environmental authorisation;	Section 21
(m)	any monitoring requirements for inclusion in the EMPr or environmental authorisation;	Section 20
(n)	a reasoned opinion (Environmental Impact Statement)-	Section 23
	as to whether the proposed activity or portions thereof should be authorised; and	Section 23
	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 23
(o)	a description of any consultation process that was undertaken during the course of preparing the specialist report;	Section 12
(p)	a summary and copies of any comments received during any consultation process and where applicable all responses thereto; and	Section 12
(q)	any other information requested by the competent authority.	None

**iv. Document Control:**

Name & Company	Responsibility	Action	Date	Signature
C Zeeman Blast Management & Consulting	Document Preparation	Report Prepared	25/10/2019	
JD Zeeman Blast Management & Consulting	Consultant	Report Finalise	31/10/2019	



## Table of Contents

<b>1</b>	<b>Executive Summary.....</b>	<b>12</b>
<b>2</b>	<b>Introduction.....</b>	<b>14</b>
<b>3</b>	<b>Objectives.....</b>	<b>14</b>
<b>4</b>	<b>Scope of blast impact study.....</b>	<b>15</b>
<b>5</b>	<b>Study area .....</b>	<b>16</b>
<b>6</b>	<b>Methodology .....</b>	<b>17</b>
<b>7</b>	<b>Site Investigation .....</b>	<b>18</b>
<b>8</b>	<b>Season applicable to the investigation .....</b>	<b>18</b>
<b>9</b>	<b>Assumptions and Limitations .....</b>	<b>18</b>
<b>10</b>	<b>Legal Requirements .....</b>	<b>18</b>
10.1	MINE HEALTH AND SAFETY ACT 29 OF 1996 (Extracts Only).....	19
10.2	MINERAL AND PETROLEUM RESOURCES DEVELOPMENT ACT 28 OF 2002 (Extracts Only) ..	21
<b>11</b>	<b>Sensitivity of Project .....</b>	<b>21</b>
<b>12</b>	<b>Consultation process.....</b>	<b>25</b>
<b>13</b>	<b>Influence from blasting operations.....</b>	<b>25</b>
13.1	Ground vibration limitations on structures .....	25
13.2	Ground vibration limitations and human perceptions .....	27
13.3	Air blast limitations on structures.....	28
13.4	Air blast limitations and human perceptions.....	29
13.5	Fly rock .....	30
13.6	Noxious Fumes .....	31
13.7	Vibration impact on provincial and national roads.....	31
13.8	Vibration will upset adjacent communities .....	32
13.9	Cracking of houses and consequent devaluation .....	33
<b>14</b>	<b>Baseline Results .....</b>	<b>36</b>
14.1	Structure profile .....	36
<b>15</b>	<b>Blasting Operations.....</b>	<b>61</b>
15.1	Ground Vibration.....	62
15.2	Air blast .....	64
<b>16</b>	<b>Construction Phase: Opencast Impact Assessment and Mitigation Measures.....</b>	<b>66</b>
<b>17</b>	<b>Operational Phase: Opencast Impact Assessment and Mitigation Measures .....</b>	<b>66</b>
17.1	Review of expected ground vibration .....	67
17.1.1	Minimum charge mass per delay – 263 kg – OC1 Opencast Pit .....	69
17.1.2	Maximum charge mass per delay – 1575 kg – OC1 Opencast Pit .....	75
17.1.3	Minimum charge mass per delay – 263 kg – OC2 Opencast Pit .....	81
17.1.4	Maximum charge mass per delay – 1575 kg – OC2 Opencast Pit .....	88
17.2	Summary of ground vibration levels .....	94

17.3	Ground Vibration and human perception.....	95
17.4	Vibration impact on roads.....	96
17.5	Potential that vibration will upset adjacent communities.....	96
17.6	Cracking of houses and consequent devaluation .....	97
17.7	Review of expected air blast .....	97
17.7.1	Minimum charge mass per delay – 263 kg – OC1 Opencast Pit .....	99
17.7.2	Maximum charge mass per delay – 1575 kg – OC1 Opencast Pit .....	105
17.7.3	Minimum charge mass per delay – 263 kg – OC2 Opencast Pit .....	111
17.7.4	Maximum charge mass per delay – 1575 kg – OC2 Opencast Pit .....	118
17.8	Summary of findings for air blast .....	125
17.9	Fly-rock unsafe zone.....	126
17.10	Noxious fumes.....	130
17.11	Water borehole influence .....	130
17.12	Potential Environmental Impact Assessment: Operational Phase .....	132
17.13	Mitigations .....	139
<b>18</b>	<b>Closure Phase: Impact Assessment and Mitigation Measures .....</b>	<b>146</b>
<b>19</b>	<b>Alternatives (Comparison and Recommendation).....</b>	<b>147</b>
<b>20</b>	<b>Monitoring .....</b>	<b>147</b>
<b>21</b>	<b>Recommendations .....</b>	<b>149</b>
21.1	Regulatory requirements – MHSA Reg. 4.16(2) .....	149
21.1	Regulatory requirements – MHSA Reg. 17.6(a) .....	151
21.2	Possible Relocation .....	154
21.3	Blast Designs.....	154
21.4	Test Blasting .....	154
21.5	Stemming length .....	154
21.6	Safe blasting distance and evacuation.....	154
21.7	Road Closure .....	155
21.8	Photographic Inspections.....	155
21.9	Heritage Concerns .....	159
21.10	Recommended ground vibration and air blast levels .....	159
21.11	Blasting times .....	160
21.12	Third party monitoring.....	160
21.13	Video monitoring of each blast.....	160
<b>22</b>	<b>Knowledge Gaps .....</b>	<b>160</b>
<b>23</b>	<b>Reasoned Opinion.....</b>	<b>161</b>
<b>24</b>	<b>Conclusion .....</b>	<b>161</b>
<b>25</b>	<b>Curriculum Vitae of Author .....</b>	<b>162</b>
<b>26</b>	<b>References .....</b>	<b>165</b>



## List of Acronyms used in this Report

a and b	Site Constant
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)
E	Explosive Mass (kg)
EIA	Environmental Impact Assessment
Freq.	Frequency
GRP	Gas Release Pulse
I&AP	Interested and Affected Parties
k	Factor value
M	Charge Height
m (SH)	Stemming height
Mc	Charge mass per metre column
N	North
NE	North East
NO	Nitrogen Monoxide
NO <sub>2</sub>	Nitrogen Dioxide
NO <sub>x</sub>	Nitrogen Oxide
NO <sub>x</sub> '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	South
SE	South East
SH	Stemming height (m)
SW	South West
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
dB <sub>L</sub>	linear decibel
g	acceleration
g/cm <sup>3</sup>	gram per cubic centimetre
Hz	frequency
kg	kilogram
kg/m <sup>3</sup>	kilogram per cubic metre
kg/t	kilogram per tonne
km	kilometre
kPa	kilopascal
m	metre
m <sup>2</sup>	metre squared
MJ	Mega Joules
MJ/m <sup>3</sup>	Mega Joules per cubic meter
MJ/t	Mega Joules per tonne
mm/s	millimetres per second
mm/s <sup>2</sup>	millimetres per second square
ms	milliseconds
Pa	Pascal
ppm	parts per million
psi	pounds per square inch
θ	theta or angle

## List of Figures

Figure 1: Locality Map of the proposed Project area .....	16
Figure 2: Infrastructure Layout Plan .....	17
Figure 3: Identified sensitive areas for the proposed OC1 Opencast area.....	23
Figure 4: Identified sensitive areas for the proposed OC2 Opencast Area .....	24
Figure 5: USBM Analysis Graph.....	26
Figure 6: USBM Analysis with Human Perception .....	28
Figure 7: Schematic of fly rock terminology .....	30
Figure 8: Example of blast induced damage .....	34
Figure 9: Aerial view and surface plan of the proposed OC1 Opencast mining area with points of interest identified .....	38
Figure 10: Aerial view and surface plan of the proposed OC2 Opencast mining areas with points of interest identified .....	39
Figure 11: Proposed prediction equations.....	65
Figure 12: Ground vibration influence from minimum charge for Pit OC1 Area .....	69
Figure 13: Ground vibration influence from maximum charge for Pit OC1 Area .....	75
Figure 14: Ground vibration influence from minimum charge for OC2 Opencast Area .....	81
Figure 15: Ground vibration influence from maximum charge for OC2 Opencast Area.....	88
Figure 16: The effect of ground vibration with human perception and vibration limits .....	96
Figure 17: Air blast influence from minimum charge for Pit OC1 Area .....	99
Figure 18: Air blast influence from maximum charge for Pit OC1 Area .....	105
Figure 19: Air blast influence from minimum charge for OC2 Opencast Area .....	111
Figure 20: Air blast influence from maximum charge for OC2 Opencast Area .....	118
Figure 21: Fly rock prediction calculation .....	127
Figure 22: Predicted Fly Rock Exclusion Zone for Pit OC1 Area.....	128
Figure 23: Predicted Fly Rock Exclusion Zone for OC2 Opencast Area.....	129
Figure 24: Location of the Boreholes for OC1 and OC2 Opencast Area .....	132
Figure 25: Structures identified at the OC1 Opencast pit area where ground vibration mitigation will be required.....	141
Figure 26: Structures identified at the OC2 Opencast Areas where ground vibration mitigation will be required.....	142
Figure 27: Monitoring Positions suggested for the OC1 and OC2 Opencast area.....	148
Figure 28: Regulatory 500 m range for the Pit OC1 Area .....	150
Figure 29: Regulatory 500 m range for the OC2 Opencast areas .....	151
Figure 30: Regulatory 100 m range for the Pit OC1 Area .....	152
Figure 31: Regulatory 100 m range for the OC2 Opencast areas .....	153
Figure 32: 1500 m area around the Pit OC1 area identified for structure inspections.....	156
Figure 33: 1500 m area around the OC2 Opencast areas identified for structure inspections. ....	157

## List of Tables

Table 1: Legal Requirements for All Specialist Studies Conducted.....	2
Table 2: Damage Limits for Air Blast .....	29
Table 3: Examples of typical non-blasting cracks .....	34
Table 4: POI Classification used .....	37
Table 5: List of points of interest identified (WGS – LO 31°) .....	40
Table 6: Structure Profile .....	47
Table 7: Blast design technical information.....	61
Table 8: Expected Ground Vibration at Various Distances from Charges Applied in this Study .....	63
Table 9: Air Blast Predicted Values .....	65
Table 10: Ground vibration evaluation for minimum charge for OC1 Opencast Area.....	70
Table 11: Ground vibration evaluation for maximum charge for OC1 Opencast Area .....	76
Table 12: Ground vibration evaluation for minimum charge for OC2 Opencast Area.....	82
Table 13: Ground vibration evaluation for maximum charge for OC2 Opencast Area .....	89
Table 14: Air blast evaluation for minimum charge for OC1 Opencast Area .....	100
Table 15: Air blast evaluation for maximum charge for OC1 Opencast Area.....	106
Table 16: Air blast evaluation for minimum charge for OC2 Opencast Area .....	112
Table 17: Air blast evaluation for maximum charge for OC2 Opencast Area.....	119
Table 18: Fly rock concern POI's for OC1 and OC2 Opencast Areas.....	129
Table 19: Identified water boreholes for the Weltevreden Coal Mining Project.....	130
Table 20: Impact Assessment Parameter Ratings.....	134
Table 21: Probability/Consequence Matrix .....	136
Table 22: Significance Rating Description .....	137
Table 23: Risk Assessment Outcome .....	137
Table 24: Structures at Weltevreden Coal Mining Project areas identified as problematic .....	139
Table 25: Mitigation measures for ground vibration: OC1 Opencast Area .....	143
Table 26: Mitigation measures for ground vibration: OC2 Opencast Area .....	145
Table 27: List of possible monitoring positions .....	148
Table 28: List of possible installations within the regulatory 500 m .....	149
Table 29: List of possible installations within the regulatory 100 m .....	153
Table 30: Combined list of structures identified for inspections .....	157
Table 31: Recommended ground vibration air blast limits .....	159

## 1 Executive Summary

Blast Management & Consulting (BM&C) was contracted as part of an Environmental Impact Assessment (EIA) to perform a review of possible impacts with regards to blasting operations in the proposed Weltevreden Coal Mining Project. Ground vibration, air blast, fly rock and fumes are some of the aspects as a result from blasting operations. The report concentrates on the ground vibration, air blast and fly rock and intends to provide information, calculations, predictions, possible influences and mitigations of blasting operations for this project.

The evaluation of effects yielded by blasting operations was evaluated over an area as wide as 3500 m radius for the open pit mining areas considered. The range of structures observed is typical roads (gravel), low cost structures, brick and mortar houses, heritage sites, boreholes and mine installations.

The location of structures around the Weltevreden mining areas are such that the charge evaluated showed possible influences due to ground vibration. The closest structures observed are the informal housing, historical structures, farm buildings, R33 road, heritage sites, Hydrocencus boreholes and a dam/dam wall. 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. There are also regulations that will need to be followed for permission to conduct blasting operations as these installations area is within 500 m and 100 m from the blast operations.

Ground vibrations predicted for the pit areas range between low and very high. Ground vibration levels predicted ranged between 0.3 mm/s and very high for structures surrounding the pit areas. The expected levels of ground vibration for some of these structures are high and will require specific mitigations by adjusting charge mass per delay to reduce the levels of ground vibration. Ground vibration at structures and installations other than the identified problematic structures is well below any specific concern for inducing damage.

Air blast predicted showed some concerns for opencast blasting. High levels may contribute to effects such as rattling of roofs, doors or windows with certain structures that are expected to be damaging, and others could lead to complaints. The current accepted limit on air blast is 134 decibels (dB). Damages are only expected to occur at levels greater than 134dB. It is maintained that if stemming control is not exercised this effect could be greater with greater range of complaints or damage. The pits are located that “free blasting” – meaning no controls on blast preparation – will not be possible. On charges considered, it is expected that air blast will be greater than 134 dB at 97 m and closer to the pit boundary. Twenty-four Points of Interest (POIs) at OC1 and twelve POI’s at OC2, are closer than this distance and could be problematic. Infrastructure at the pit area such as roads, heritage sites, rivers, and Hydrocencus boreholes are present but air blast does not have any influence on these installations.



An exclusion zone for safe blasting was also calculated. The exclusion zone was established to be at least 227 m. The use of the normal practice observed in mines of 500 m exclusion zone will include the informal housing, farm buildings, dam/dam walls, R33 road, heritage sites and Hydrocencus boreholes. The use of minimum 500 m exclusion zone is rather recommended, and it will be required that evacuation be negotiated when blasting is done. Recommendations were made and should be considered.

Specific actions will be required for the pit area such as Mine Health and Safety Act requirements when blasting is done within 500 m from structures and mining within 100 m from structures.

Road closures and the farming community around the pit areas must also be considered.

The pit areas are located such that specific concerns were identified and addressed in the report.

This concludes this investigation for the proposed Weltevreden Coal Mining Project. There is no reason to believe that this operation cannot continue if attention is given to the recommendations made.

## **2 Introduction**

Xivono Mining (Pty) Ltd (hereinafter Xivono) is the holder of an approved Prospecting Right for the proposed Weltevreden Mining Project approximately 8 km south of Belfast in the Mpumalanga Province of South Africa. Xivono proposes to mine two pits, OC1 (162 ha footprint) and OC2 (200 ha footprint) through open pit mining.

The proposed Project area is located within the Nkangala District Municipality (NDM), specifically in Ward 1 of the Emakhazeni Local Municipality (ELM). The nearest large settlements to the site are the town of Belfast (11 km) and its township of Siyathuthuka (15 km). The Prospecting Right includes Portions 28, 29, 30 and 40 of the farm Paardeplaats 380 JT, Portions 2, 3, 10, and a portion of Portions 4, 7, 9, 11, 12, 14 and the Remaining Extent of the farm Weltevreden 381 JT.

This application pertains only to open-pit mining for two pits. The total proposed quantity of coal to be extracted is approximately 15 million tonnes over a 15-year Life of Mine. Currently, Pit OC2 will be mined first with in a west-east direction and Pit OC1 will be mined thereafter in a south-north direction, with an assumed production rate of 150 000 tonnes of coal mined per month for the total pit area. Coal crushing and screening will take place on site and trucked directly to Eskom.

As part of Environmental Impact Assessment (EIA), Blast Management & Consulting (BM&C) was contracted to perform a review of possible impacts from blasting operations and specifically for the proposed Weltevreden Coal Mining Project. 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 outlining the expected environmental effects that blasting operations could have on the surrounding environment; proposing the specific mitigation measures that will be 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, client requirements and general indicators in the various appropriate pieces of South

African legislation. There is no direct reference in the following acts to 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 No. 107 of 1998;
- Mine Health and Safety Act No. 29 of 1996;
- Mineral and Petroleum Resources Development Act No. 28 of 2002;
- Explosives 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 standard for South Africa.

#### **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.

- Background information of the proposed site;
- Blasting Operation Requirements;
- 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 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 the location of blasting operations in relation to surrounding areas according to the regulations from the applicable Acts.
- Impact Assessment;
- Mitigations;
- Recommendations;
- Conclusion.





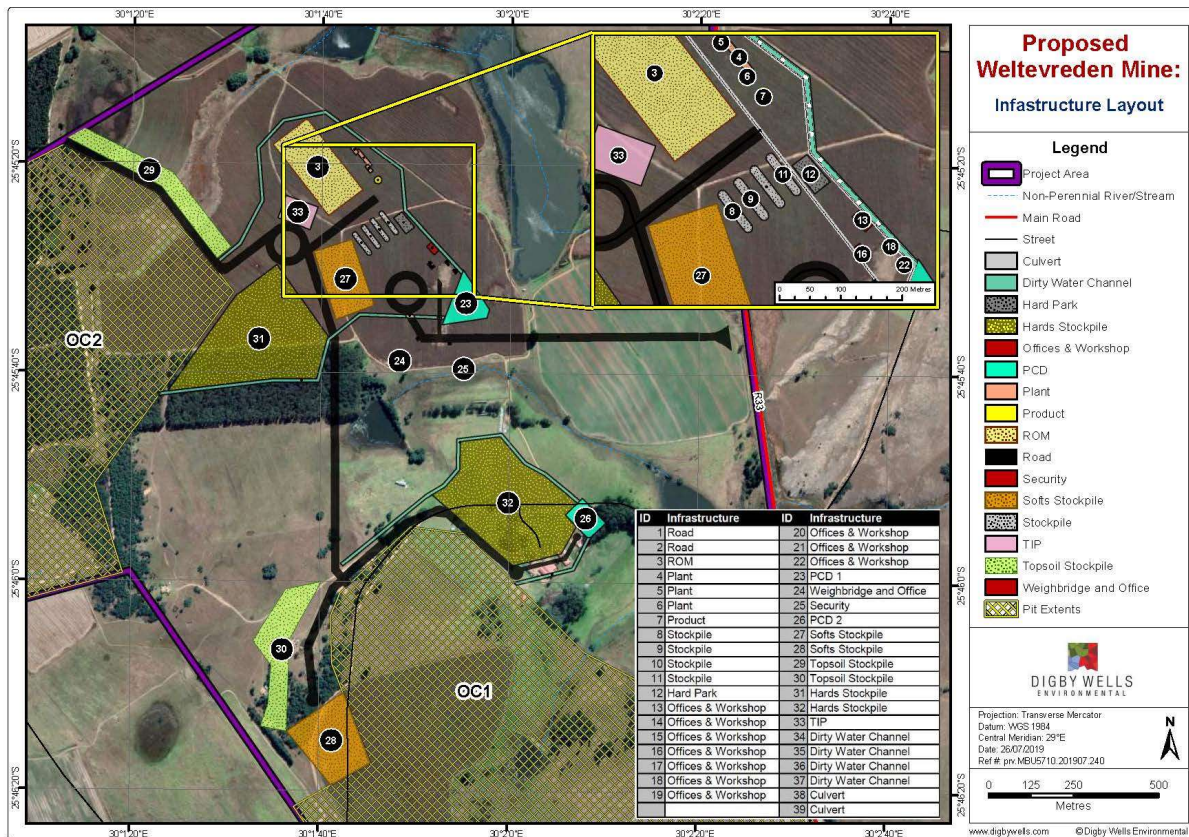


Figure 2: Infrastructure Layout Plan

## 6 Methodology

The detailed plan of study consists of the following sections:

- Site visit: Intention to understand location of the site and its surroundings;
- Identifying surface structures / installations that are found within reason from 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 mining operations and the possible influences from blasting operations. The methodology is modelling the expected impact based on the expected drilling and blasting information provided for the project. 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 or social impacts are then addressed in the detailed EIA phase investigation;

- Information from the bulk sample blasting done is used as guideline for expected drilling and blasting for the application area;
- Reporting: All data is prepared in a single report and provided for review.
- This report evaluates the probable impacts for the following planned operations. The evaluation is also done in order given below for each of the different aspects of probable influences considered:
  - OC1 Opencast Pit
  - OC2 Opencast Pit

## **7 Site Investigation**

The site was visited on 08 October 2019. This site visit was done to get understanding of the location and the structures and installations surrounding the proposed pit areas.

## **8 Season applicable to the investigation**

The drilling and blasting operations are not season dependable. The investigation into the possible effects from blasting operations is not season bounded.

## **9 Assumptions and Limitations**

The following assumptions have been made:

- The Project is evaluated as a new operation with no blasting activities currently being done.
- 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 limitation is that enough data is not available from this operation for a specific confirmation of the predicted values as no blasting activities is currently being done.
- Blast Management & Consulting was not involved in the blast design. The information on blast design applied was provided by the client.
- The work done is based on the author's knowledge and information provided by the project applicant.

## **10 Legal Requirements**

The protocols applied in this document are based on the author's experience, guidelines elicited by the literature research, client requirements and general indicators provided in the various

applicable South African acts. There is no direct reference in the consulted acts specifically regarding limiting levels for ground vibration and air blast. There is however specific requirements and regulations with regards 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 No. 107 of 1998; Mine Health and Safety Act No. 29 of 1996; Mineral and Petroleum Resources Development Act No. 28 of 2002; and the Explosives Act No. 15 of 2003.

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. There are no specific South African standards and the USBM is well accepted as standard for South Africa. Additional criteria required by various institutions in South Africa was also taken into consideration, i.e. Eskom, Telkom, Transnet, Rand Water Board, etc.

In view of the acts consulted, the following guidelines and regulations are noted: (where possible detail was omitted and only some of the information indicated)

#### **10.1 MINE HEALTH AND SAFETY ACT 29 OF 1996 (Extracts Only)**

(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.

17(7) The employer must take reasonable measures to ensure that -

- (a) no mining operations are carried out within a horizontal distance of 100 (one hundred) metres from reserve land, buildings, roads, railways, dams, waste dumps, or any other structure whatsoever including such structures beyond the mining boundaries, or any surface, which it may be necessary to protect in order to prevent any significant risk, unless a lesser distance has been determined safe by risk assessment and all restrictions and conditions determined in terms of the risk assessment are complied with;
- (b) workings coming within 50 (fifty) metres, from any other excavation, workings, restricted area or any other place where there is, or is likely to be a dangerous accumulation of fluid material, noxious or flammable gas are mined subject to such restrictions and stopped at such positions as determined by risk assessment.
- (c) where ground movement, as a result of mining operations, poses significant risk, an effective ground movement monitoring system is in place.
- (d) survey records and plans relating to conditions described in paragraphs (a) and (b) above, are made available to the persons doing the risk assessment.

17(8) No person may erect, establish or construct any buildings, roads, railways, dams, waste dumps, reserve land, excavations or any other structures whatsoever within a horizontal distance of 100 (one hundred) metres from workings, unless a lesser distance has been determined safe -

- (a) in the case of the employer, by risk assessment and all restrictions and conditions determined in terms of the risk assessment are complied with; or
- (b) in the case of any other person, by a professional geotechnical specialist and all restrictions and conditions determined by him or her or by the Chief Inspector of Mines are complied with;

17(9) The person(s) responsible for activities in terms of regulations 17(7)(a) and 17(8) must –

- (a) in the case of an employer, provide the Chief Inspector of Mines with the distance and accompanying restrictions and conditions for comment, and;



(b) in the case of other persons, provide the Chief Inspector of Mines with the distance and accompanying restrictions and conditions for approval.

17(10) No mining operations, erecting, establishment, or construction, as contemplated in regulations 17(7)(a) and 17(8) respectively, may take place until such written comment or approval, as referred to in 17(9)(a) and 17(9)(b), has been obtained.

## **10.2 MINERAL AND PETROLEUM RESOURCES DEVELOPMENT ACT 28 OF 2002 (Extracts Only)**

(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.

The current pit layouts indicate that private installations may be in proximity of the planned pit areas. The Mine Health and Safety Act has specific requirements regarding blasting within 500 m from private installations. This condition will be addressed in the recommendations as well.

## **11 Sensitivity of Project**

A review of the project and the surrounding areas is done before any specific analysis is undertaken and sensitivity mapping is done, 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 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 pit area.
- An area 500 m to 1500 m around the pit 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.

- An area greater than 1500 m 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.

Figure 3 to Figure 4 shows the sensitivity mapping with the identified points of interest (POI) in the surrounding areas for the different proposed Weltevreden Coal Mine Project areas. The specific influences will be determined through the work done for this project in this report.

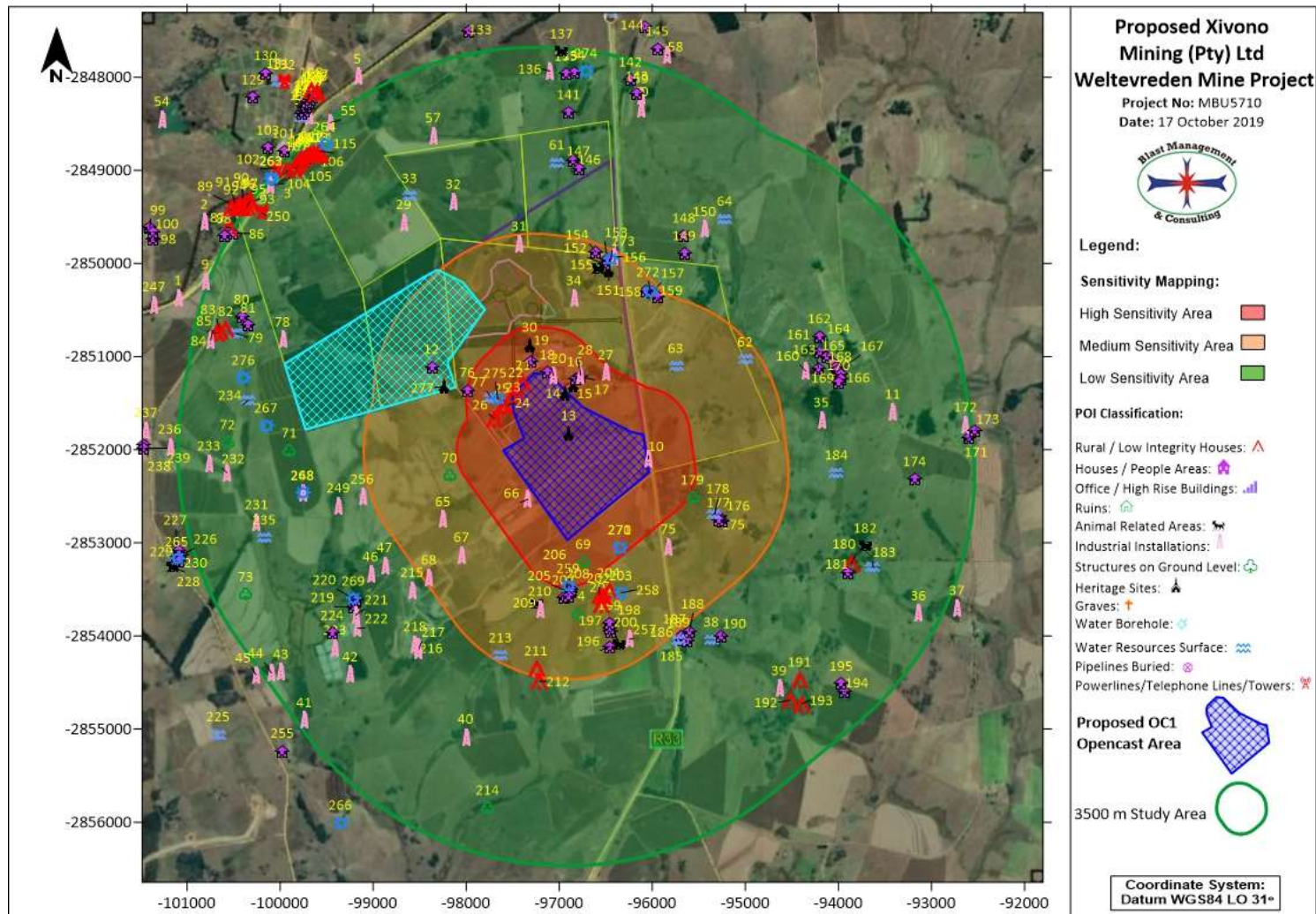


Figure 3: Identified sensitive areas for the proposed Pit OC1 area

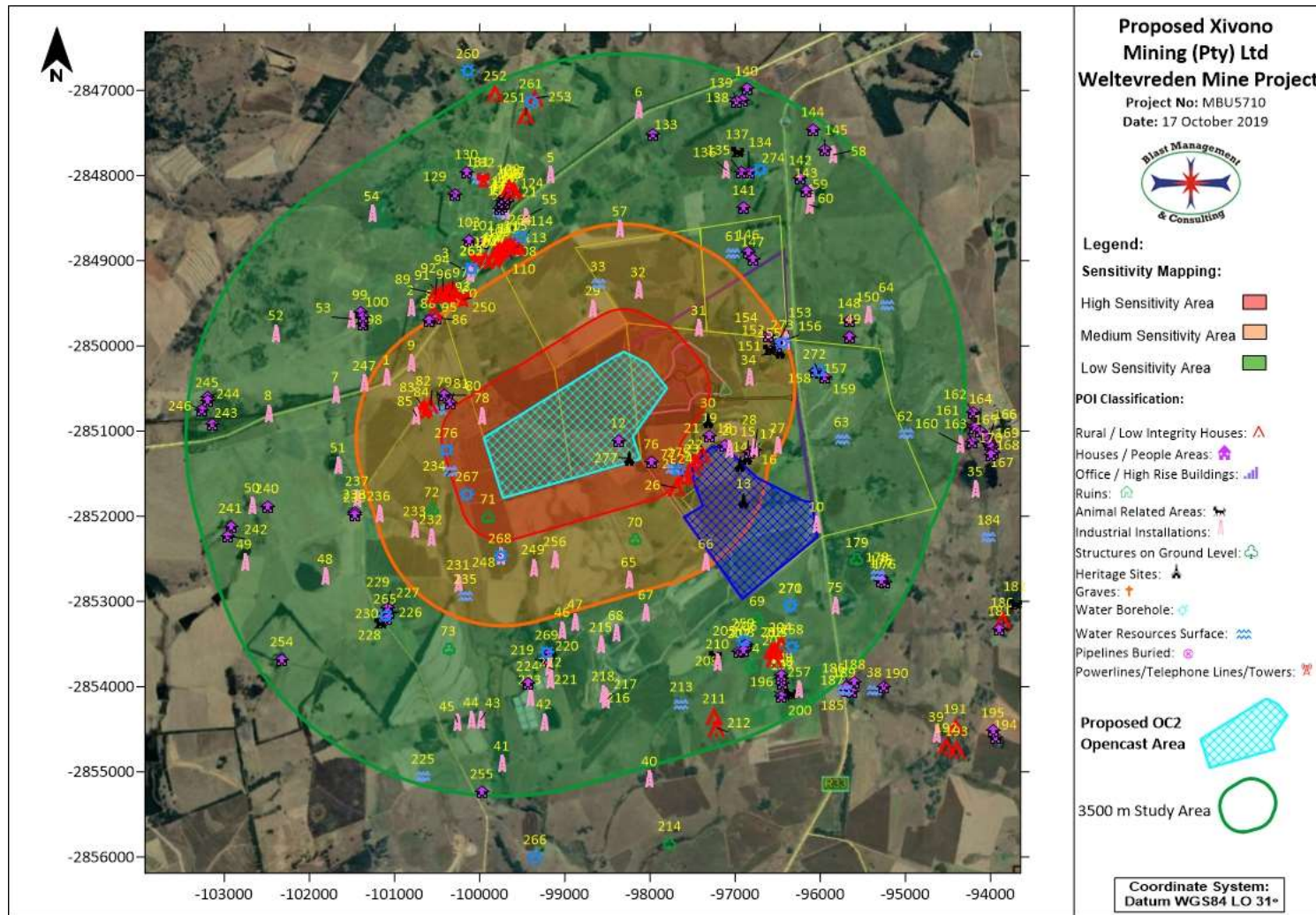


Figure 4: Identified sensitive areas for the proposed Pit OC2 Area

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Directors: JD Zeeman, MG Mthlane

## **12 Consultation process**

No specific consultation with external parties was done. The work done is based on the author's knowledge and information provided by the client.

## **13 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.

### **13.1 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 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 damage.

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. Figure 5 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,
- 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 additional criteria that are used by BM&C.

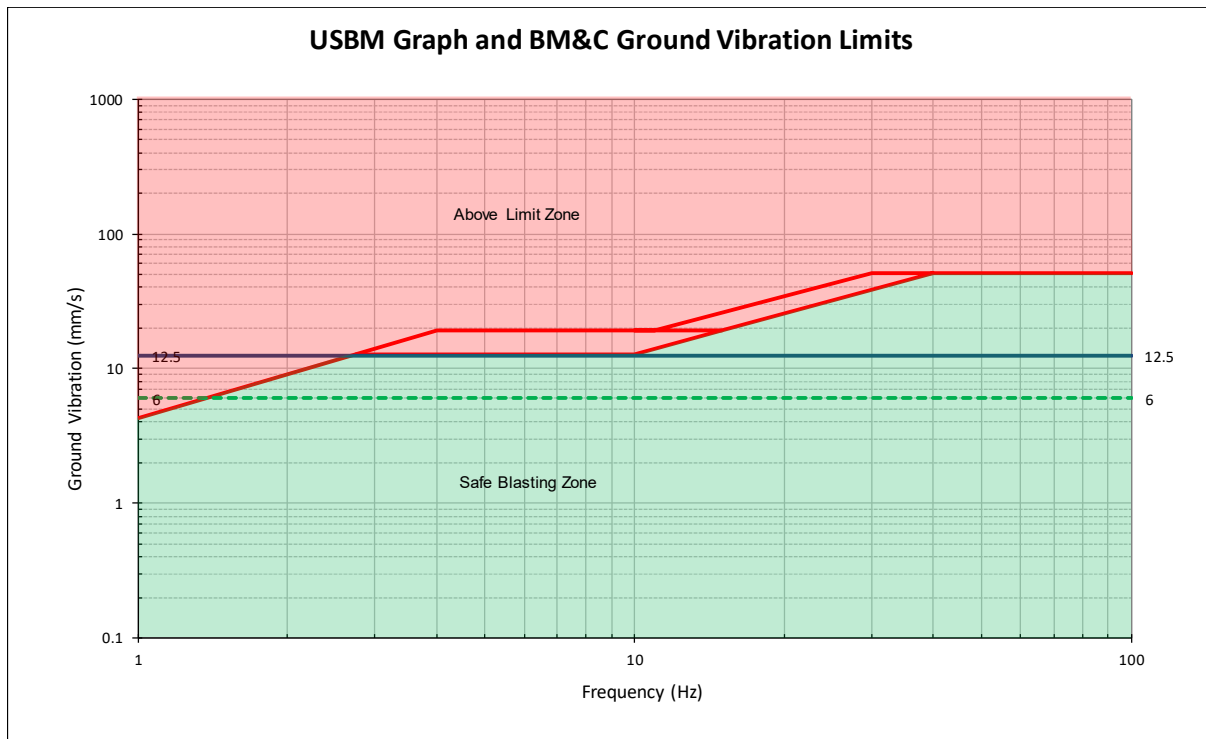


Figure 5: USBM Analysis Graph

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 BM&C;
- Steel pipelines: 50 mm/s (Rand Water Board);
- Electrical lines: 75 mm/s (Eskom);
- Sasol Pipelines: 25 mms/s (Sasol);
- Railways: 150 mm/s BM&C;
- Concrete less than 3 days old: 5 mm/s <sup>1</sup>;

<sup>1</sup> 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.

- Concrete after 10 days: 200 mm/s<sup>2</sup>;
- 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.)<sup>2</sup>;
- Waterwells or Boreholes: 50 mm/s<sup>3</sup>;

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;
- 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;
- Input from other consultants in the field locally and internationally.

### 13.2 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 6). This guideline helps with managing ground vibration and the complaints that could be received due to blast induced ground vibration.

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<sup>2</sup> 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.

<sup>3</sup> 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.

Indicated in Figure 6 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 the evaluation.

Generally, people also assume that any vibration of a structure - windows or roofs rattling - will cause damage to the structure. An air blast is one of the causes of vibration of a structure and is the cause of nine out of ten complaints.

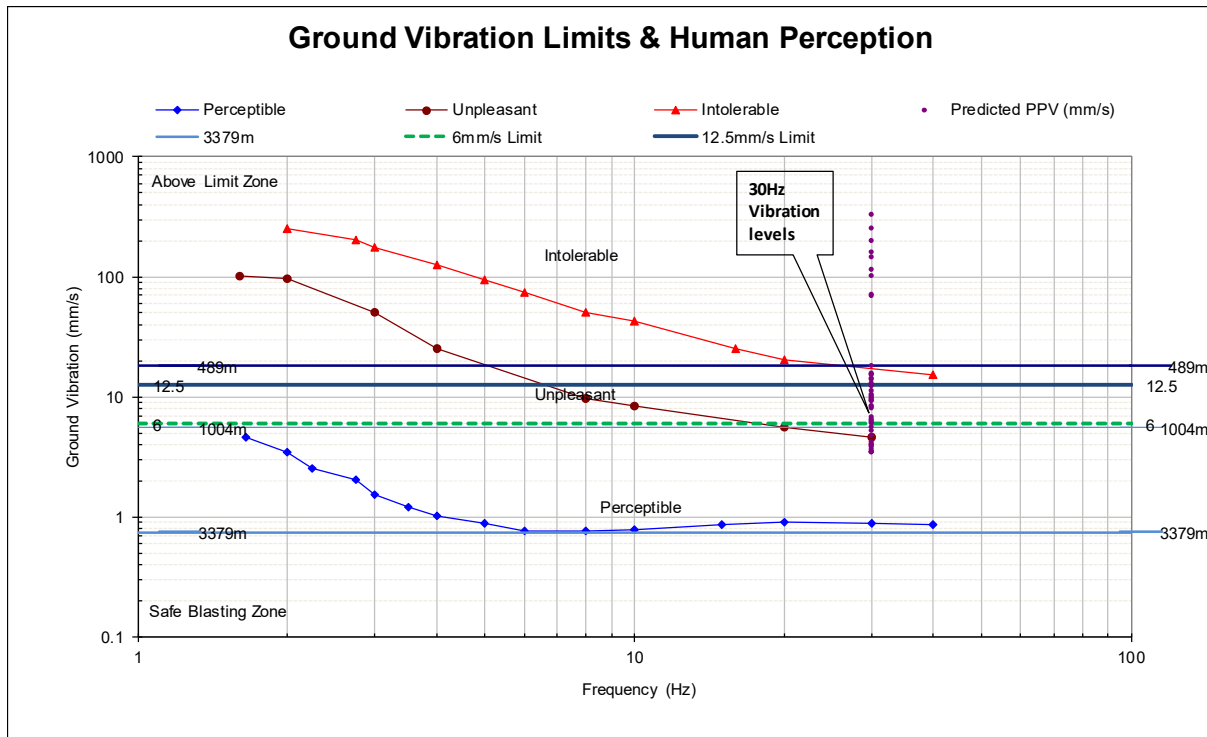


Figure 6: USBM Analysis with Human Perception

### 13.3 Air blast limitations on structures

Air blast or air-overpressure is a pressure wave generated from the blasting process. Air blast is measured as pressure in pascal (Pa) and reported as a decibel linear (dBL) value. Air blast is normally associated with frequency levels less than 20 Hertz (Hz), 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). A blast does also generate sound but for the purpose of possible damage capability, air blast is only considered 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 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 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.

#### 13.4 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 of air blast on structures that startle people will also be reduced, which in turn 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 the structure.

In this report, initial limits for evaluating conditions have been set at 120dB, 120 dB to 134dB and greater than 134dB. The USBM limits for nuisance are 134dB.

### 13.5 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. 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 is considered to be fly rock. Figure 7 shows schematic of 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.

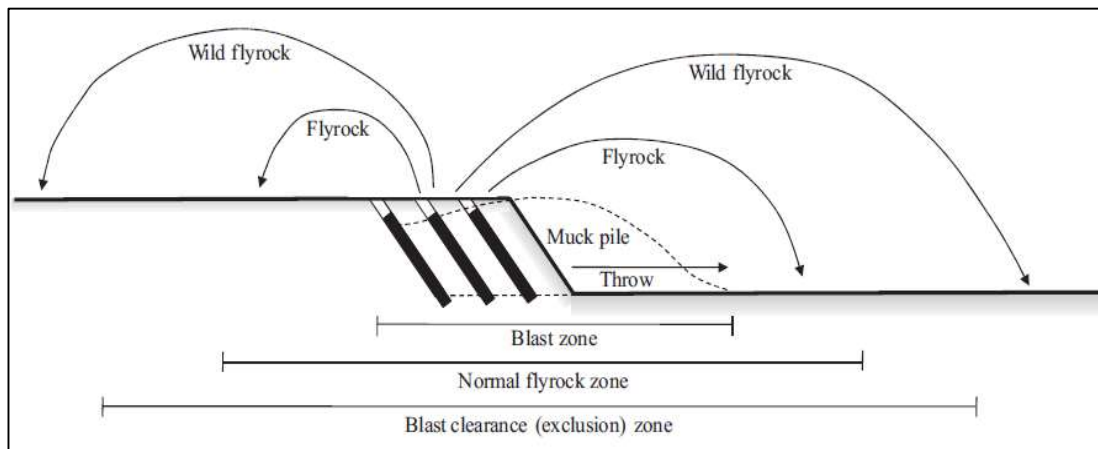


Figure 7: Schematic of fly rock terminology

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, structure, 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 and 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.

### **13.6 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 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 typically include 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.

### **13.7 Vibration impact on provincial and national roads**

The influence of ground vibration on tarred roads is expected when levels are 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 a minimum distance between structure and blast hole to prevent any cracks being formed into the surrounds of a blast hole. Crack formation is not restricted to this distance. Improper timing

arrangements may also cause excessive back break and cracks further than expected. The fact remains 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. Damage can be only be induced 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 of fly rock is considered.

### **13.8 Vibration will upset adjacent communities**

The effects of ground vibration and air blast will have influence on people. These effects tend to create noises in 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 frequent communication with the neighbours. Consider their concerns and address their concerns 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.

### **13.9 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 8 below. A typical 'X' crack formation is observed.

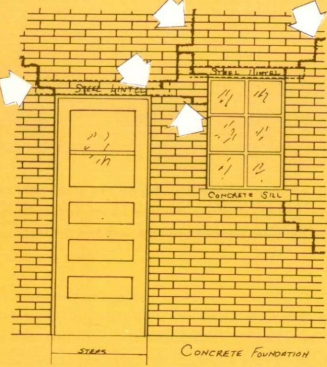
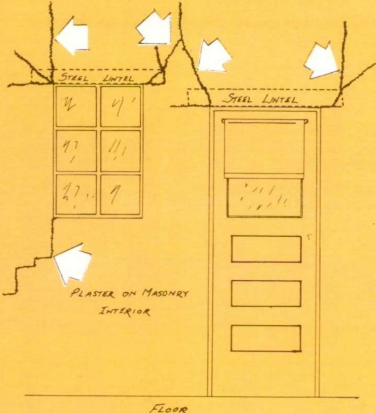
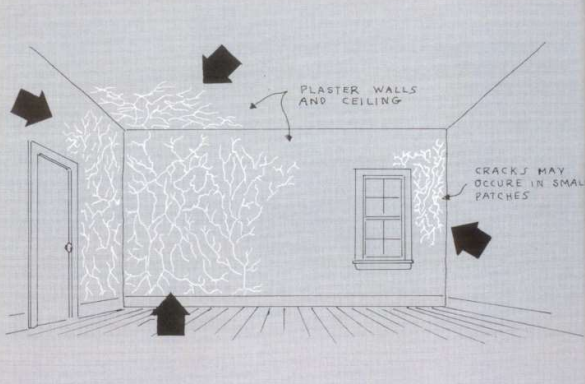
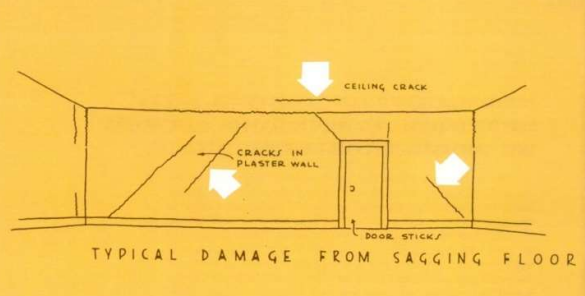


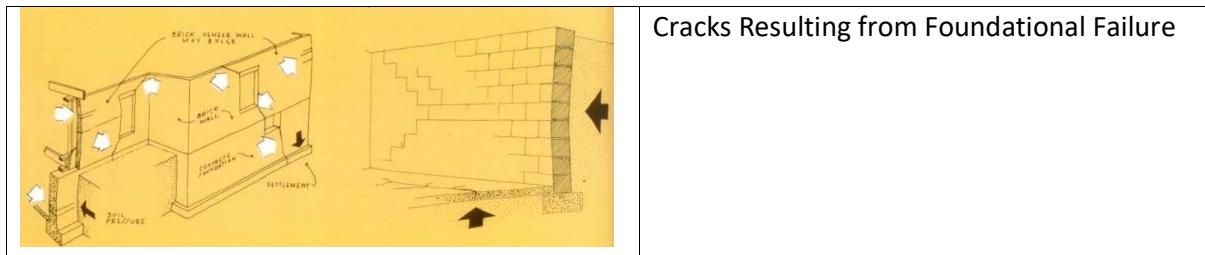
Figure 8: Example of blast induced damage.

The table below with figures show illustrations of non-blasting damage that could be found.

Table 3: Examples of typical non-blasting cracks

A hand-drawn diagram of a concrete block wall. The wall is composed of several rows of rectangular blocks. A vertical crack runs down the center of the wall, with horizontal cracks branching off at each block level. Yellow arrows point to the top and bottom of this vertical crack. A black arrow points to a horizontal crack in the middle of the wall. Labels include 'CONCRETE BLOCK' pointing to a block, 'CONCRETE FLOOR' pointing to the base of the wall, and 'CONCRETE FOUNDATION' pointing to the base of the floor. A black arrow points upwards from the foundation into the floor.	<p>Cracks Resulting from Shrinkage of Concrete Blocks</p>
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	<p>Typical Lintel Cracks</p>
	<p>Typical Lintel Cracks</p>
	<p>“Crazing” Cracks on Plaster</p>
	<p>Plaster Cracks Caused by Sagging Floors</p>



Observing cracks in the form indicated in Figure 8 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, and the general existence of cracks may be due to materials used. 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 must consider the property value inclusive of the total property and not just the house alone. Mining operations may not have influence to change the status quo of any property.

## 14 Baseline Results

The baseline information for the project is limited to observation of the current surroundings of the proposed project. There are currently no blasting operations being conducted that can be measured as part of a baseline study. The study area is evaluated as a “green fields” project.

### 14.1 Structure profile

As part of the baseline, all possible structures in a possible influence area are identified. The site was reviewed and detailed here. The site was reviewed using Google Earth imagery. Information sought during the review was to identify surface structures present within a 3500 m radius from the proposed different opencast boundaries which will require consideration during modelling of blasting operations, e.g. houses, general structures, power lines, pipe lines, reservoirs, mining activity, roads, shops, schools, gathering places, possible historical sites, etc. A list was prepared of all structures in the vicinity of the opencast area. The list includes structures and POIs within the 3500 m boundary – see Table 5 below. A list of structure locations was required to determine the allowable ground vibration limits and air blast limits. Figure 9 shows an aerial view of the pit areas and surroundings with POIs. The type of POIs identified is grouped into different classes. These classes are indicated as “Classification” in Table 4. 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

<b>Class</b>	<b>Description</b>
1	Rural Building and structures of poor construction
2	Private Houses and people sensitive areas
3	Office and High-rise buildings
4	Ruins
5	Animal related installations and animal sensitive areas
6	Industrial buildings and installations
7	Earth like structures – no surface structure
8	Heritage sites (buildings, infrastructure, activity, graves)
9	Graves
10	Water Borehole
11	Water Resources Surface
12	Pipelines Buried
13	Powerlines / Telephone Lines / Towers

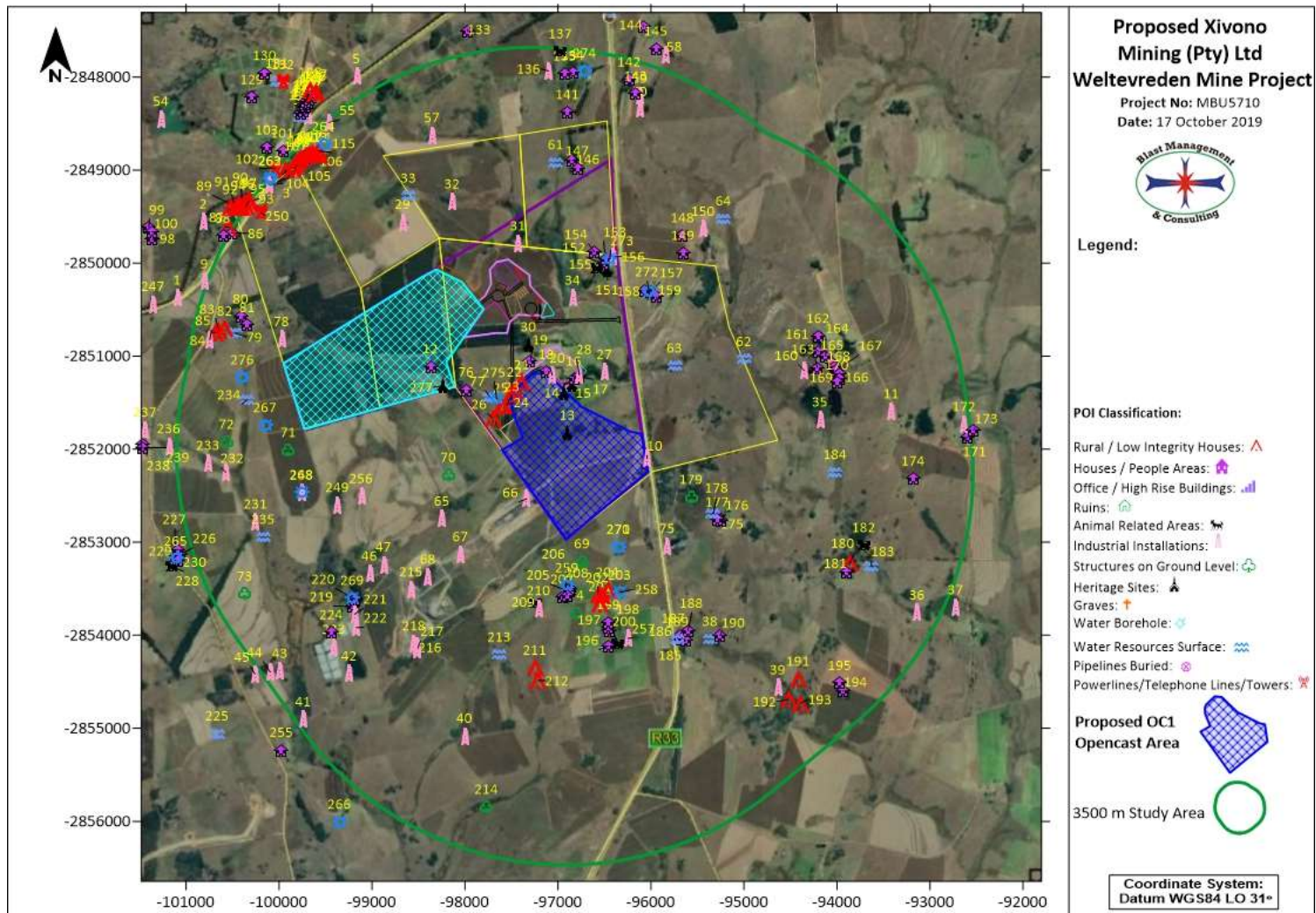


Figure 9: Aerial view and surface plan of the proposed OC1 Opencast mining area with points of interest identified

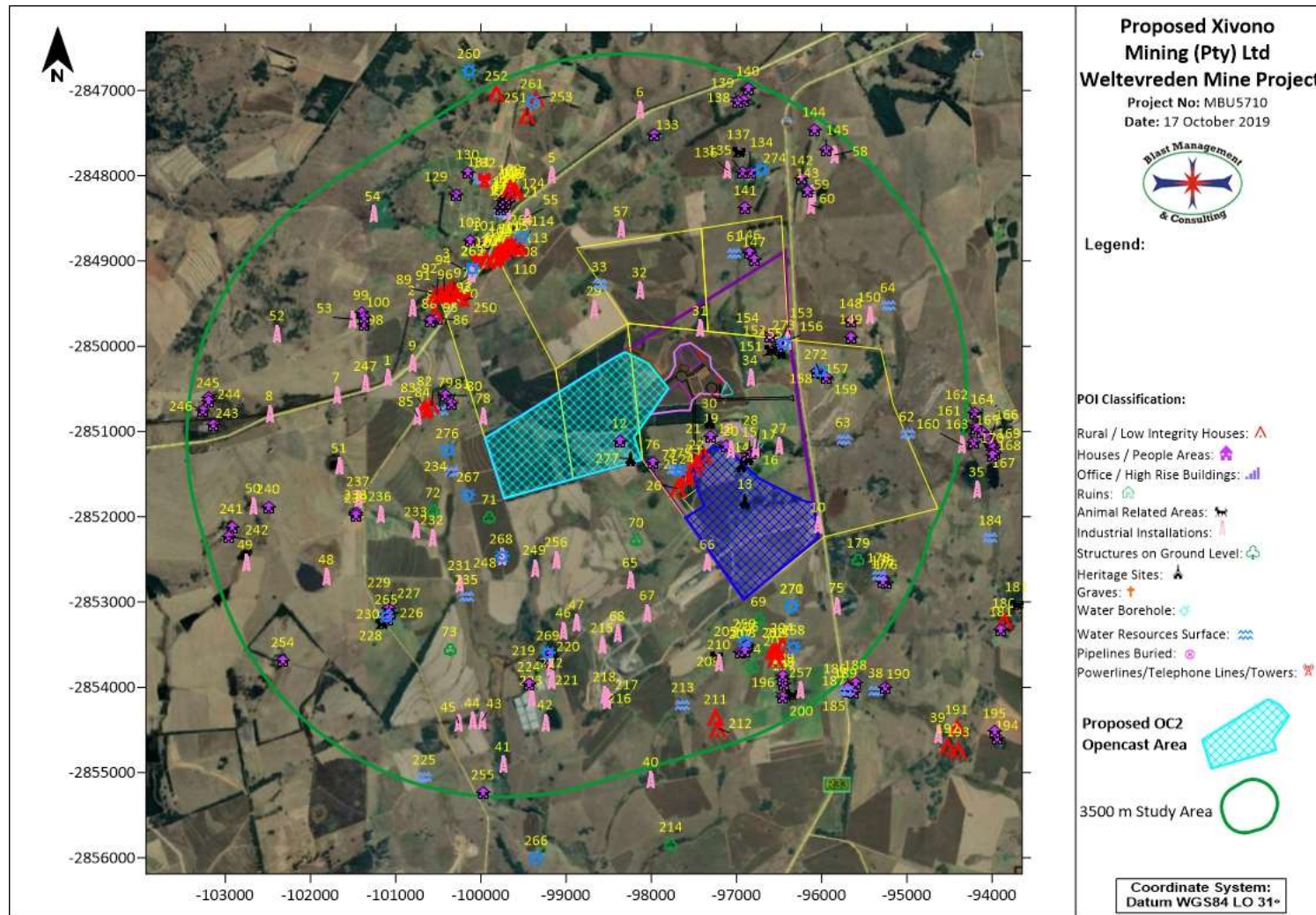


Figure 10: Aerial view and surface plan of the proposed Pit OC2 mining areas with points of interest identified

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Directors: JD Zeeman, MG Mthlane

Table 5: List of points of interest identified (WGS – LO 31°)

Tag	Description	Classification	Y	X
1	Railway Line	6	101090.91	2850371.23
2	Railway Line	6	100808.87	2849552.41
3	Railway Line	6	100103.98	2849154.43
4	Railway Line	6	99690.68	2848417.09
5	Railway Line	6	99164.00	2847992.10
6	Railway Line	6	98130.00	2847224.17
7	Railway Line	6	101693.86	2850572.45
8	Railway Line	6	102478.92	2850790.28
9	N4 Road	6	100797.48	2850198.17
10	R33 Road	6	96041.27	2852098.93
11	Dirt Road	6	93413.52	2851593.38
12	House (Inside OC2 Area)	2	98369.21	2851110.46
13	Heritage Site - Dam/Dam wall (Inside OC1 Area)	6	96896.74	2851823.58
14	Heritage Site -Historical Structures (Inside OC1 Area)	8	96935.27	2851390.88
15	Heritage Site -Historical Structures	8	96854.17	2851304.67
16	Farm Buildings	2	96828.83	2851245.28
17	Farm Buildings	2	96770.14	2851221.39
18	Farmhouse	2	97121.03	2851171.82
19	Farm Buildings	2	97298.12	2851053.48
20	Cement Dam	6	97062.53	2851202.95
21	Informal Housing	1	97387.41	2851281.08
22	Informal Housing	1	97464.21	2851362.12
23	Informal Housing	1	97506.85	2851417.41
24	Informal Housing	1	97581.98	2851530.92
25	Informal Housing	1	97611.50	2851530.51
26	Informal Housing	1	97692.67	2851666.88
27	Dam/Dam wall	6	96499.33	2851170.05
28	Cement Dam	6	96770.76	2851200.82
29	Cement Dam	6	98667.37	2849558.17
30	Heritage Site - Dam/Dam wall	8	97314.63	2850875.42
31	Dam/Dam wall	6	97427.06	2849789.60
32	Dam/Dam wall	6	98135.04	2849340.23
33	Pan	11	98603.50	2849275.47
34	Dam/Dam wall	6	96838.00	2850372.35
35	Dam/Dam wall	6	94180.10	2851683.58
36	Dam/Dam wall	6	93136.92	2853756.08
37	Dam/Dam wall	6	92724.01	2853699.22
38	Pan	11	95363.92	2854040.92
39	Dam/Dam wall	6	94635.03	2854561.71
40	Dam/Dam wall	6	98001.55	2855083.34
41	Dam/Dam wall	6	99737.66	2854905.05



Tag	Description	Classification	Y	X
42	Dam/Dam wall	6	99240.66	2854412.71
43	Dam/Dam wall	6	99984.97	2854384.12
44	Dam/Dam wall	6	100095.98	2854393.70
45	Dam/Dam wall	6	100260.11	2854414.95
46	Dam/Dam wall	6	99024.95	2853336.87
47	Dam/Dam wall	6	98872.83	2853240.80
48	Dam/Dam wall	6	101808.86	2852707.82
49	Dam/Dam wall	6	102759.85	2852534.92
50	Dam/Dam wall	6	102669.82	2851872.49
51	Dam/Dam wall	6	101660.61	2851401.03
52	Dam/Dam wall	6	102389.07	2849849.73
53	Dam/Dam wall	6	101507.89	2849681.68
54	Dam/Dam wall	6	101264.66	2848448.79
55	Dam/Dam wall	6	99456.23	2848486.97
56	Pan	11	99761.63	2848433.26
57	Dam/Dam wall	6	98351.12	2848627.66
58	Dam/Dam wall	6	95846.42	2847755.59
59	Dam/Dam wall	6	96116.56	2848205.18
60	Dam/Dam wall	6	96120.31	2848346.36
61	Pan	11	97021.55	2848918.44
62	River	11	94997.47	2851031.53
63	River	11	95744.38	2851102.29
64	River	11	95218.47	2849522.23
65	Dam/Dam wall	6	98245.04	2852748.76
66	Mine Activity	6	97338.11	2852534.31
67	Mine Activity	6	98045.20	2853129.99
68	Coal Yard	6	98397.04	2853372.39
69	Cultivated Fields	7	96737.10	2853204.17
70	Cultivated Fields	7	98176.84	2852277.14
71	Cultivated Fields	7	99896.73	2852009.25
72	Cultivated Fields	7	100559.71	2851923.30
73	Cultivated Fields	7	100363.43	2853555.34
74	Cultivated Fields	7	96797.72	2853761.57
75	Old Quarry	6	95823.59	2853042.84
76	Farmhouse	2	97982.99	2851362.37
77	Reservoir	11	97730.79	2851445.47
78	Dam/Dam wall	6	99969.87	2850817.47
79	Pan	11	100470.44	2850751.19
80	Farmstead	2	100408.62	2850575.96
81	Farm Buildings	2	100340.12	2850666.54
82	Informal Housing	1	100577.94	2850703.64
83	Informal Housing	1	100651.32	2850726.22

Tag	Description	Classification	Y	X
84	Informal Housing	1	100679.44	2850750.20
85	Gravel Road	6	100744.20	2850822.23
86	Farmstead	2	100511.80	2849674.26
87	Informal Housing	1	100541.80	2849611.68
88	Farm Buildings	2	100598.95	2849708.14
89	Informal Housing	1	100438.77	2849402.69
90	Informal Housing	1	100389.83	2849398.20
91	Informal Housing	1	100475.73	2849396.01
92	Informal Housing	1	100518.92	2849399.91
93	Informal Housing	1	100366.36	2849345.65
94	Informal Housing	1	100429.41	2849358.63
95	Informal Housing	1	100360.69	2849392.26
96	Informal Housing	1	100337.53	2849339.47
97	Informal Housing	1	100316.39	2849327.22
98	Farmstead	2	101362.82	2849745.56
99	Farmhouse	2	101401.65	2849609.01
100	Farm Building	2	101367.60	2849662.05
101	Building/Structures (Packing Sheds)	2	99958.95	2848795.27
102	Communication Tower	13	100047.10	2848978.27
103	Farmstead	2	100125.70	2848758.40
104	Informal Housing	1	99925.30	2849000.74
105	Informal Housing	1	99852.89	2848978.51
106	Informal Housing	1	99838.21	2848954.93
107	Informal Housing	1	99816.87	2848931.96
108	Informal Housing	1	99795.27	2848893.12
109	Informal Housing	1	99768.46	2848866.03
110	Informal Housing	1	99702.65	2848845.45
111	Informal Housing	1	99678.15	2848830.70
112	Informal Housing	1	99643.87	2848818.92
113	Informal Housing	1	99595.56	2848838.37
114	Informal Housing	1	99561.24	2848836.95
115	Informal Housing	1	99571.21	2848794.48
116	Houses	2	99767.90	2848386.00
117	Houses	2	99742.27	2848362.79
118	Houses	2	99725.11	2848331.11
119	Houses	2	99713.13	2848312.59
120	Houses	2	99732.33	2848289.59
121	Houses	2	99694.32	2848277.56
122	Houses	2	99714.08	2848269.57
123	Houses	2	99674.24	2848239.31
124	Houses	2	99655.12	2848214.47
125	Houses	2	99641.08	2848191.54

Tag	Description	Classification	Y	X
126	Informal Housing	1	99611.21	2848178.89
127	Informal Housing	1	99600.45	2848160.98
128	Informal Housing	1	99658.23	2848136.63
129	Farmhouse	2	100288.13	2848216.96
130	Farmhouse	2	100150.37	2847957.68
131	Reservoirs	11	100017.44	2848044.18
132	Communication Tower	13	99955.47	2848056.29
133	Farmstead	2	97971.99	2847511.24
134	Farmstead	2	96838.38	2847954.16
135	Farm Structures	2	96925.23	2847966.01
136	Dam/Dam wall	6	97102.67	2847934.75
137	Kraal	5	96973.83	2847723.56
138	House	2	96918.97	2847110.54
139	Building/Structure	2	96982.12	2847131.81
140	Building/Structure	2	96865.24	2846981.55
141	House	2	96896.42	2848378.95
142	House	2	96230.44	2848028.75
143	House	2	96163.04	2848177.90
144	Farm Buildings	2	96084.48	2847460.78
145	Building/Structure	2	95943.19	2847697.47
146	Farmstead	2	96847.81	2848897.53
147	Farm Buildings	2	96790.52	2848984.32
148	Farmstead	2	95658.08	2849703.30
149	Building/Structure	2	95652.86	2849891.48
150	Dam/Dam wall	6	95438.23	2849632.75
151	Heritage Site -Historical Structures	8	96473.77	2850065.09
152	Farm Structure	2	96512.27	2850011.53
153	House	2	96490.12	2849950.17
154	House	2	96605.37	2849881.78
155	Livestock	5	96590.94	2850052.82
156	Cement Dam	6	96404.62	2849930.51
157	Farmstead	2	96007.00	2850310.06
158	Farm Structure	2	96062.05	2850297.56
159	Farm Structure	2	95943.18	2850364.82
160	Dam/Dam wall	6	94351.69	2851155.87
161	Farmstead	2	94195.39	2850954.37
162	Farmhouse	2	94200.49	2850783.99
163	House	2	94212.20	2851122.08
164	House	2	94121.85	2850997.92
165	House	2	94049.99	2851074.27
166	House	2	94029.58	2851117.35
167	House	2	94008.11	2851154.22

Tag	Description	Classification	Y	X
168	House	2	93975.70	2851191.46
169	House	2	93969.20	2851245.28
170	House	2	93995.39	2851285.31
171	Farmstead	2	92592.48	2851867.90
172	Dam/Dam wall	6	92630.33	2851732.49
173	Farm Structures	2	92533.10	2851794.90
174	Farm Structure	2	93180.44	2852316.62
175	Farmstead	2	95285.23	2852719.64
176	Farm Buildings	2	95241.76	2852773.38
177	House	2	95284.19	2852757.97
178	Reservoir	11	95329.97	2852689.91
179	Marsh	7	95567.30	2852514.97
180	Informal Housing	1	93860.81	2853221.33
181	House	2	93892.23	2853321.24
182	Livestock	5	93709.54	2853031.36
183	River	11	93627.60	2853262.02
184	River	11	94019.18	2852248.34
185	Farmstead	2	95679.91	2854047.60
186	Farm Buildings	2	95626.18	2854058.72
187	Farm Buildings	2	95691.55	2854005.28
188	Farm Building	2	95602.59	2853947.73
189	Reservoir	11	95715.24	2854043.07
190	Farm Structure	2	95255.45	2854002.40
191	Informal Housing	1	94416.47	2854471.06
192	Informal Housing	1	94520.89	2854689.23
193	Informal Housing	1	94395.06	2854730.54
194	Farmstead	2	93938.96	2854598.63
195	Farm Building	2	93968.43	2854513.25
196	Farm Structures	2	96458.70	2854112.79
197	Farm Structures	2	96442.42	2853959.20
198	Farmstead	2	96453.44	2853912.36
199	Farm Building	2	96454.43	2853862.06
200	Livestock	5	96352.26	2854087.24
201	Informal Housing	1	96542.06	2853666.40
202	Informal Housing	1	96564.81	2853568.02
203	Informal Housing	1	96523.17	2853571.47
204	Informal Housing	1	96463.46	2853511.51
205	Kraal	5	96870.33	2853535.28
206	Farmhouse	2	96874.39	2853499.55
207	Farmhouse	2	96949.54	2853585.95
208	Farmhouse	2	96906.46	2853569.40
209	Livestock	5	97234.90	2853644.51









Tag	Description	Classification	Y	X
210	Dam/Dam wall	6	97205.48	2853708.64
211	Informal Housing	1	97245.54	2854349.34
212	Informal Housing	1	97213.87	2854484.22
213	River	11	97628.13	2854208.93
214	Marsh	7	97766.18	2855844.15
215	Mine Buildings	6	98576.78	2853507.65
216	Mine Buildings	6	98515.60	2854112.64
217	Mine Buildings	6	98519.01	2854159.21
218	Mine Building	6	98547.26	2854086.96
219	Farmstead	2	99214.83	2853692.72
220	Farm Building	2	99184.81	2853612.39
221	Nett Shading/Orchards	6	99189.08	2853774.34
222	Agricultural Tunnels	6	99168.06	2853918.59
223	Agricultural Tunnels	6	99408.14	2854126.28
224	Farm Building	2	99434.24	2853967.51
225	Reservoir	11	100660.61	2855057.58
226	Farmstead	2	101061.90	2853130.22
227	Farm Buildings	2	101111.72	2853143.55
228	Farm Building	2	101095.08	2853200.25
229	Farm Buildings	2	101083.68	2853078.06
230	Livestock	5	101155.36	2853262.86
231	Dam/Dam wall	6	100249.97	2852779.73
232	Dam/Dam wall	6	100571.62	2852246.81
233	Dam/Dam wall	6	100758.92	2852149.83
234	River	11	100343.71	2851474.45
235	River	11	100165.68	2852943.08
236	Dam/Dam wall	6	101181.94	2851970.63
237	Dam/Dam wall	6	101438.43	2851792.81
238	Farmhouse	2	101471.04	2851951.00
239	Farm Building	2	101462.00	2851985.86
240	Houses	2	102493.07	2851884.20
241	Farmhouse	2	102925.15	2852115.41
242	Farm Building	2	102965.55	2852233.61
243	Structures	2	103137.65	2850915.66
244	Houses	2	103197.59	2850596.41
245	Houses	2	103197.79	2850639.79
246	Houses	2	103262.35	2850756.49
247	Railway Substation	6	101352.20	2850440.96
248	Pivot Irrigation	6	99753.23	2852468.33
249	Dam/Dam wall	6	99369.24	2852600.00
250	Communication Tower	13	100195.67	2849455.06
251	Informal Settlement	1	99459.95	2847292.94

Tag	Description	Classification	Y	X
252	Informal Settlement	1	99813.40	2847034.62
253	Informal Settlement	1	99353.53	2847087.63
254	Farmstead	2	102319.85	2853679.73
255	Farmstead	2	99972.32	2855233.84
256	Explosives Magazines	6	99113.44	2852504.30
257	Dam/Dam wall	6	96245.34	2854033.48
258	Hydrocencus Borehole (BLYBH3)	10	96328.99	2853536.25
259	Hydrocencus Borehole (BLYBH4)	10	96900.30	2853463.98
260	Hydrocencus Borehole (VSTNF1)	10	100137.87	2846775.79
261	Hydrocencus Borehole (HADECBH)	10	99396.54	2847129.20
262	Hydrocencus Borehole (HADECBH2)	10	100091.25	2849092.28
263	Hydrocencus Borehole (HADECBH3)	10	100095.79	2849089.66
264	Hydrocencus Borehole (REBH1)	10	99516.04	2848722.30
265	Hydrocencus Borehole (ZOEBH)	10	101106.62	2853177.50
266	Hydrocencus Borehole (BLVBH)	10	99345.86	2856006.20
267	Hydrocencus Borehole (DRIBH1)	10	100146.45	2851741.96
268	Hydrocencus Borehole (DRIBH2)	10	99756.73	2852465.87
269	Hydrocencus Borehole (SACBH)	10	99208.48	2853600.77
270	Hydrocencus Borehole (BLYBH2)	10	96348.57	2853052.19
271	Hydrocencus Borehole (VOGBH1)	10	96348.57	2853052.19
272	Hydrocencus Borehole (WELBH2)	10	96021.45	2850303.08
273	Hydrocencus Borehole (ZOEBH2)	10	96441.35	2849959.33
274	Hydrocencus Borehole (GRMBH1)	10	96711.02	2847933.66
275	Hydrocencus Borehole (WELBH6)	10	97660.44	2851458.54
276	Hydrocencus (Spring used for commercial bottled water)	10	100391.22	2851229.14
277	Heritage Site (Graves) - Inside OC2 Pit Area	8	98240.63	2851317.82


During the site visit the structures were observed and the initial POI list verified on site and finalised as represented in this section. Structures ranged from well-built structures, mining structures to informal building styles. Table 6 shows photos of structures found in the area.



Table 6: Structure Profile

Structure Photo	Description
	Brick and Mortar Structures
	
	Water Reservoir

Structure Photo	Description
	
	National Road
	Weir






Structure Photo	Description
	
 	<p>Ruins</p>


Structure Photo	Description
  	<p>Silo</p>




Structure Photo	Description
	<p>Railway Substation</p>
 	<p>Nett Shading/Orchards</p>

Structure Photo	Description
	
	
	<p>Mine Activity</p>



Structure Photo	Description
	<p>Old Brick and Mortar Structure (with damage)</p>



Structure Photo	Description
	<p>Informal Structures (corrugated)</p>






Structure Photo	Description
	Kraal
	Dam
	Structures

Structure Photo	Description
  	



Structure Photo	Description
 <p>2019/10/08 10:17</p> <p>2019/10/08 11:32</p>	<p>Railway Lines</p>
 <p>2019/10/08 11:11</p>	<p>Pivot Irrigation</p>



Structure Photo	Description
 	<p>Windmill</p>
	<p>Marsh</p>

Structure Photo	Description
	
 	<p>Communication Towers</p>



Structure Photo	Description
  	<p>Livestock</p>



Structure Photo	Description
 	Powerlines

## 15 Blasting Operations

Blast design forms the basis of all calculations done for impact assessment. The current planned designs as supplied was applied for impact evaluation. Table 7 shows summary technical information of the blast designs provided.

Table 7: Blast design technical information

<b>Bench Height (m):</b>	15
<b>B/H Diameter (mm):</b>	165
<b>Burden (m):</b>	5
<b>Spacing (m):</b>	5
<b>Drill Pattern:</b>	Staggered1
<b>Explosive Type:</b>	Emulsion

<b>Charge per b/h - (kg):</b>	263
<b>Stemming Length – (m):</b>	4.77
<b>Charge per delay (kg/delay):</b>	1575
<b>Powder Factor (kg/m<sup>3</sup>):</b>	0.70

The above information is applied for predicting ground vibration and air blast. Evaluation of the blasting operations considered a minimum charge and a maximum charge. The minimum charge was derived from the 165 mm diameter single blast hole and the maximum charge was extracted from the blast simulation in JKSimblast. The maximum charge relates to the total number of blast holes that detonates simultaneously based on a blast layout, initiation and timing of the blast. In this case a shock tube type initiation system is considered and expected to have at least four blastholes detonating simultaneously yielding the maximum mass of explosives detonating at once. The minimum charge relates to 263 kg and the maximum charge relates to 1575 kg. These values were applied in all predictions for ground vibration and air blast.

### 15.1 Ground Vibration

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. The site constants are specific to a site where blasting is to be done. In the absence of measured values an acceptable standard set of constants is applied.

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 from source (m)

E = Explosive Mass (kg)

Applicable and accepted factors a & b for new operations is as follows:

a = 1143

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.

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: 6 mm/s, 12.5 mm/s levels and 25 mm/s at least.

Based on the designs presented on expected drilling and charging design, Table 8 shows expected ground vibration levels (PPV) for various distances calculated at the two different charge masses. The charge masses are 263 kg and 1575 kg for the opencast area.

Table 8: Expected Ground Vibration at Various Distances from Charges Applied in this Study

No.	Distance (m)	Expected PPV (mm/s) for 263 kg Charge	Expected PPV (mm/s) for 1575 kg Charge
1	50.0	178.3	780.7
2	100.0	91.3	399.9
3	150.0	29.1	127.4
4	200.0	18.1	79.3
5	250.0	12.5	54.9
6	300.0	9.3	40.6
7	400.0	5.8	25.3
8	500.0	4.0	17.5
9	600.0	3.0	12.9
10	700.0	2.3	10.0
11	800.0	1.8	8.0
12	900.0	1.5	6.6
13	1000.0	1.3	5.6
14	1250.0	0.9	3.9
15	1500.0	0.7	2.9
16	1750.0	0.5	2.2
17	2000.0	0.4	1.8
18	2500.0	0.3	1.2
19	3000.0	0.2	0.9
20	3500.0	0.2	0.7

## 15.2 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. 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:

$$P = a \times \left( \frac{D}{E^{\frac{1}{3}}} \right)^{-b}$$

Where:

- $P$  = Air blast level (mB)
- $D$  = Distance from source (m)
- $E$  = Maximum charge mass per delay (kg)
- $a$  = Constant - (5.37)
- $b$  = Constant - (-0.79)

The constants for  $a$  and  $b$  were then selected according to the information as provided in Figure 11 below. Various types of mining operations are expected to yield different results. The information provided in Figure 11 is based on detailed research that was conducted for each of the different types of mining environments. In this report, the data for “Coal Mines (highwall)” was applied in the prediction of air blast.

Air Overpressure Prediction Equations				
Blasting	Metric Equations mb	U.S. Equations psi	Statistical Type	Source
Open air (no confinement)	$P = 3589 \times SD_3^{-1.38}$	$P = 187 \times SD_3^{-1.38}$	Best Fit	Perkins
Coal mines (parting)	$P = 2596 \times SD_3^{-1.62}$	$P = 169 \times SD_3^{-1.62}$	Best Fit	USBM RI 8485
Coal mines (highwall)	$P = 5.37 \times SD_3^{-0.79}$	$P = 0.162 \times SD_3^{-0.79}$	Best Fit	USBM RI 8485
Quarry face	$P = 37.1 \times SD_3^{-0.97}$	$P = 1.32 \times SD_3^{-0.97}$	Best Fit	USBM RI 8485
Metal Mine	$P = 14.3 \times SD_3^{-0.71}$	$P = 0.401 \times SD_3^{-0.71}$	Best Fit	USBM RI 8485
Construction (average)	$P = 24.8 \times SD_3^{-1.1}$	$P = 1 \times SD_3^{-1.1}$	Best Fit	Oriard (2005)
Construction (highly confined)	$P = 2.48 \times SD_3^{-1.1}$	$P = 0.1 \times SD_3^{-1.1}$	Best Fit	Oriard (2005)
Buried (total confinement)	$P = 1.73 \times SD_3^{-0.96}$	$P = 0.061 \times SD_3^{-0.96}$	Best Fit	USBM RI 8485

*Table 26.7 - Air overpressure prediction equations.*

Figure 11: Proposed prediction equations

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:

$$p_s = 20 \times \log \frac{P}{P_o}$$

Where:

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

As discussed earlier the prediction of air blast is very subjective. Following in Table 9 below is a summary of values predicted according to Equation 2.

Table 9: Air Blast Predicted Values

No.	Distance (m)	Air blast (dB) for 263 kg Charge	Air blast (dB) for 1575 kg Charge
1	50.0	134.4	138.5
2	100.0	131.7	135.7
3	150.0	126.9	131.0
4	200.0	124.9	129.0
5	250.0	123.4	127.5

No.	Distance (m)	Air blast (dB) for 263 kg Charge	Air blast (dB) for 1575 kg Charge
6	300.0	122.2	126.2
7	400.0	120.2	124.3
8	500.0	118.6	122.7
9	600.0	117.4	121.5
10	700.0	116.3	120.5
11	800.0	115.4	119.5
12	900.0	114.6	118.7
13	1000.0	113.9	118.0
14	1250.0	112.4	116.5
15	1500.0	111.2	115.2
16	1750.0	110.1	114.2
17	2000.0	109.2	113.3
18	2500.0	107.7	111.8
19	3000.0	106.4	110.5
20	3500.0	105.3	109.5

## 16 Construction Phase: Opencast Impact Assessment and Mitigation Measures

Currently there is no planned drilling and blasting operations for the construction phase. No specific impact is evaluated for the construction phase.

## 17 Operational Phase: Opencast Impact Assessment and Mitigation Measures

The area surrounding the proposed mining areas was reviewed for structures, traffic, roads, human interface, animal 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. In evaluation, the charge mass scenarios selected as indicated in section 15 is considered with regards to ground vibration and air blast.

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 a 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.

### 17.1 Review of expected ground vibration

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 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 negligible possibility of influence.

Ground vibration is calculated and modelled for the pit area at the minimum and maximum charge mass at specific distances from the opencast mining area. The charge masses applied are according to blast designs discussed in Section 15. These levels are then plotted and overlain 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 opencast 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 be applicable for the type of structures observed surrounding the pit areas. 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"
POI's that are found inside the pit area is coloured "Olive Green"

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



### 17.1.1 Minimum charge mass per delay – 263 kg – OC1 Opencast Pit

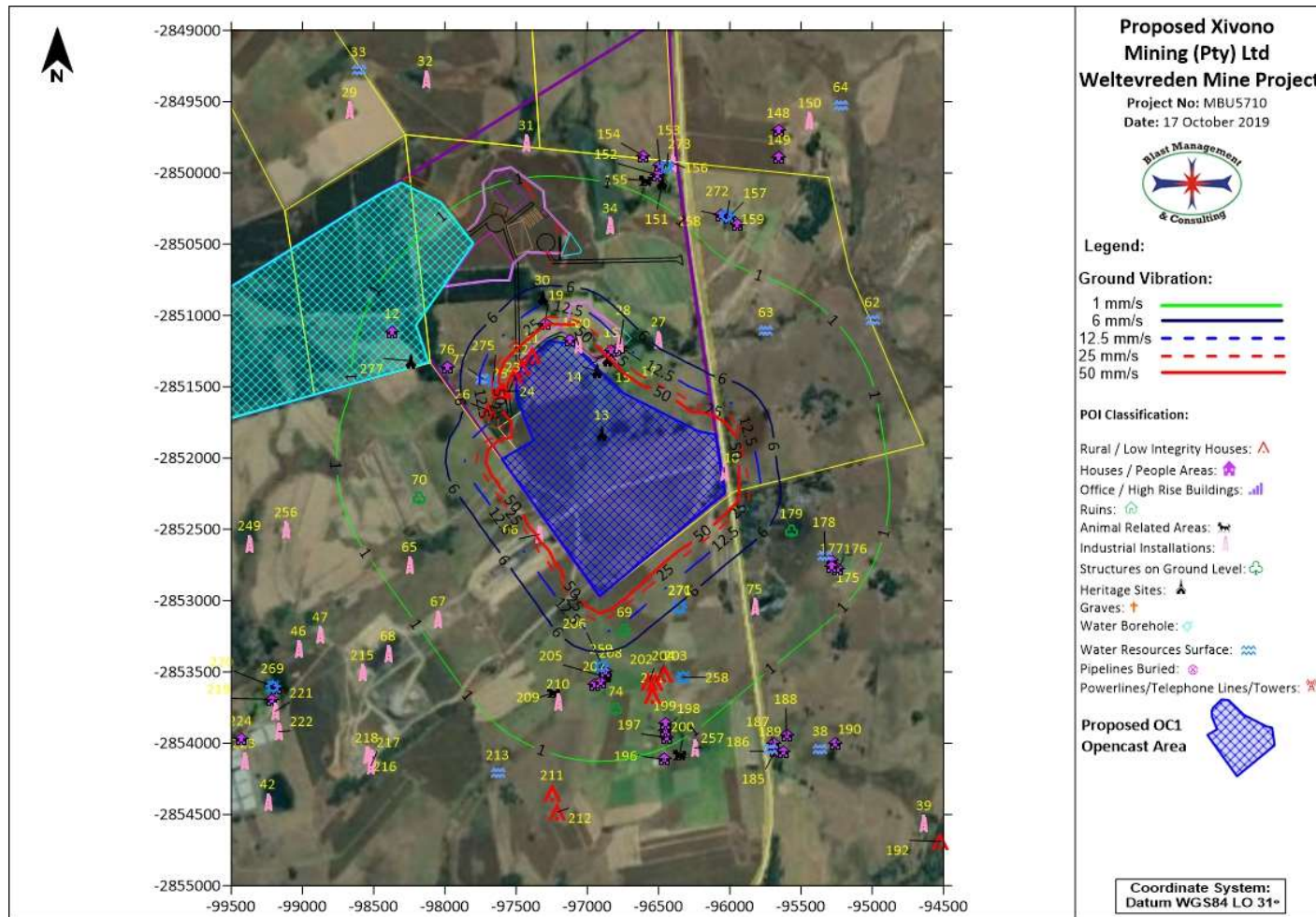


Figure 12: Ground vibration influence from minimum charge for Pit OC1 Area

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Page 69 of 165

Table 10: Ground vibration evaluation for minimum charge for Pit OC1 Area

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
3	Railway Line	150	3445	263	0.2	Acceptable	N/A
10	R33 Road	150	17	263	1044.6	Problematic	N/A
11	Dirt Road	200	2690	263	0.2	Acceptable	N/A
12	House (Inside OC2 Area)	12.5	931	263	1.4	Acceptable	Perceptible
13	Heritage Site - Dam/Dam wall (Inside OC1 Area)	50	-	263	-	-	-
14	Heritage Site -Historical Structures (Inside OC1 Area)	6	-	263	-	-	-
15	Heritage Site -Historical Structures	6	99	263	57.6	Problematic	Intolerable
16	Farm Buildings	12.5	160	263	26.3	Problematic	Intolerable
17	Farm Buildings	12.5	217	263	15.8	Problematic	Unpleasant
18	Farmhouse	12.5	25	263	556.3	Problematic	Intolerable
19	Farm Buildings	12.5	131	263	36.6	Problematic	Intolerable
20	Cement Dam	50	28	263	474.3	Problematic	N/A
21	Informal Housing	6	12	263	1822.7	Problematic	Intolerable
22	Informal Housing	6	5	263	8043.1	Problematic	Intolerable
23	Informal Housing	6	18	263	1008.0	Problematic	Intolerable
24	Informal Housing	6	85	263	74.4	Problematic	Intolerable
25	Informal Housing	6	114	263	45.6	Problematic	Intolerable
26	Informal Housing	6	214	263	16.2	Problematic	Unpleasant
27	Dam/Dam wall	50	443	263	4.9	Acceptable	N/A
28	Cement Dam	50	232	263	14.2	Acceptable	N/A
29	Cement Dam	50	2143	263	0.4	Acceptable	N/A
30	Heritage Site - Dam/Dam wall	50	308	263	8.9	Acceptable	N/A
31	Dam/Dam wall	50	1400	263	0.7	Acceptable	N/A
32	Dam/Dam wall	50	2035	263	0.4	Acceptable	N/A
33	Pan	200	2327	263	0.3	Acceptable	N/A
34	Dam/Dam wall	50	870	263	1.6	Acceptable	N/A
35	Dam/Dam wall	50	1918	263	0.4	Acceptable	N/A
36	Dam/Dam wall	50	3272	263	0.2	Acceptable	N/A
38	Pan	200	1813	263	0.5	Acceptable	N/A
39	Dam/Dam wall	50	2679	263	0.3	Acceptable	N/A
40	Dam/Dam wall	50	2380	263	0.3	Acceptable	N/A
41	Dam/Dam wall	50	3423	263	0.2	Acceptable	N/A
42	Dam/Dam wall	50	2732	263	0.2	Acceptable	N/A
43	Dam/Dam wall	50	3321	263	0.2	Acceptable	N/A
44	Dam/Dam wall	50	3416	263	0.2	Acceptable	N/A
46	Dam/Dam wall	50	1930	263	0.4	Acceptable	N/A
47	Dam/Dam wall	50	1751	263	0.5	Acceptable	N/A
55	Dam/Dam wall	50	3471	263	0.2	Acceptable	N/A
57	Dam/Dam wall	50	2773	263	0.2	Acceptable	N/A
59	Dam/Dam wall	50	3154	263	0.2	Acceptable	N/A
60	Dam/Dam wall	50	3020	263	0.2	Acceptable	N/A

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
61	Pan	200	2275	263	0.3	Acceptable	N/A
62	River	200	1364	263	0.8	Acceptable	N/A
63	River	200	817	263	1.8	Acceptable	N/A
64	River	200	2477	263	0.3	Acceptable	N/A
65	Dam/Dam wall	50	954	263	1.4	Acceptable	N/A
66	Mine Activity	200	92	263	65.5	Acceptable	N/A
67	Mine Activity	200	1013	263	1.2	Acceptable	N/A
68	Coal Yard	150	1441	263	0.7	Acceptable	N/A
69	Cultivated Fields	200	294	263	9.6	Acceptable	N/A
70	Cultivated Fields	200	634	263	2.7	Acceptable	N/A
71	Cultivated Fields	200	2294	263	0.3	Acceptable	N/A
72	Cultivated Fields	200	2958	263	0.2	Acceptable	N/A
73	Cultivated Fields	200	3165	263	0.2	Acceptable	N/A
74	Cultivated Fields	200	802	263	1.8	Acceptable	N/A
75	Old Quarry	200	751	263	2.0	Acceptable	N/A
76	Farmhouse	12.5	490	263	4.1	Acceptable	Perceptible
77	Reservoir	50	230	263	14.4	Acceptable	N/A
78	Dam/Dam wall	50	2548	263	0.3	Acceptable	N/A
79	Pan	200	3050	263	0.2	Acceptable	N/A
80	Farmstead	12.5	3035	263	0.2	Acceptable	Too Low
81	Farm Buildings	12.5	2945	263	0.2	Acceptable	Too Low
82	Informal Housing	6	3166	263	0.2	Acceptable	Too Low
83	Informal Housing	6	3232	263	0.2	Acceptable	Too Low
84	Informal Housing	6	3254	263	0.2	Acceptable	Too Low
85	Gravel Road	200	3303	263	0.2	Acceptable	N/A
86	Farmstead	12.5	3484	263	0.2	Acceptable	Too Low
95	Informal Housing	6	3505	263	0.2	Acceptable	Too Low
96	Informal Housing	6	3516	263	0.2	Acceptable	Too Low
97	Informal Housing	6	3506	263	0.2	Acceptable	Too Low
104	Informal Housing	6	3415	263	0.2	Acceptable	Too Low
105	Informal Housing	6	3379	263	0.2	Acceptable	Too Low
106	Informal Housing	6	3386	263	0.2	Acceptable	Too Low
107	Informal Housing	6	3387	263	0.2	Acceptable	Too Low
108	Informal Housing	6	3400	263	0.2	Acceptable	Too Low
109	Informal Housing	6	3401	263	0.2	Acceptable	Too Low
110	Informal Housing	6	3370	263	0.2	Acceptable	Too Low
111	Informal Housing	6	3364	263	0.2	Acceptable	Too Low
112	Informal Housing	6	3349	263	0.2	Acceptable	Too Low
113	Informal Housing	6	3301	263	0.2	Acceptable	Too Low
114	Informal Housing	6	3278	263	0.2	Acceptable	Too Low
115	Informal Housing	6	3316	263	0.2	Acceptable	Too Low
134	Farmstead	12.5	3253	263	0.2	Acceptable	Too Low
135	Farm Structures	12.5	3232	263	0.2	Acceptable	Too Low
136	Dam/Dam wall	50	3249	263	0.2	Acceptable	N/A
137	Kraal	50	3469	263	0.2	Acceptable	N/A

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
141	House	12.5	2825	263	0.2	Acceptable	Too Low
142	House	12.5	3290	263	0.2	Acceptable	Too Low
143	House	12.5	3166	263	0.2	Acceptable	Too Low
146	Farmstead	12.5	2315	263	0.3	Acceptable	Too Low
147	Farm Buildings	12.5	2236	263	0.3	Acceptable	Too Low
148	Farmstead	12.5	2082	263	0.4	Acceptable	Too Low
149	Building/Structure	12.5	1950	263	0.4	Acceptable	Too Low
150	Dam/Dam wall	50	2285	263	0.3	Acceptable	N/A
151	Heritage Site -Historical Structures	6	1299	263	0.8	Acceptable	Perceptible
152	Farm Structure	12.5	1329	263	0.8	Acceptable	Perceptible
153	House	12.5	1394	263	0.7	Acceptable	Too Low
154	House	12.5	1411	263	0.7	Acceptable	Too Low
155	Livestock	50	1258	263	0.9	Acceptable	N/A
156	Cement Dam	50	1451	263	0.7	Acceptable	N/A
157	Farmstead	12.5	1403	263	0.7	Acceptable	Too Low
158	Farm Structure	12.5	1374	263	0.8	Acceptable	Too Low
159	Farm Structure	12.5	1408	263	0.7	Acceptable	Too Low
160	Dam/Dam wall	50	1874	263	0.5	Acceptable	N/A
161	Farmstead	12.5	2097	263	0.4	Acceptable	Too Low
162	Farmhouse	12.5	2170	263	0.4	Acceptable	Too Low
163	House	12.5	2016	263	0.4	Acceptable	Too Low
164	House	12.5	2147	263	0.4	Acceptable	Too Low
165	House	12.5	2185	263	0.4	Acceptable	Too Low
166	House	12.5	2189	263	0.3	Acceptable	Too Low
167	House	12.5	2198	263	0.3	Acceptable	Too Low
168	House	12.5	2218	263	0.3	Acceptable	Too Low
169	House	12.5	2209	263	0.3	Acceptable	Too Low
170	House	12.5	2173	263	0.4	Acceptable	Too Low
171	Farmstead	12.5	3464	263	0.2	Acceptable	Too Low
172	Dam/Dam wall	50	3444	263	0.2	Acceptable	N/A
174	Farm Structure	12.5	2857	263	0.2	Acceptable	Too Low
175	Farmstead	12.5	891	263	1.5	Acceptable	Perceptible
176	Farm Buildings	12.5	957	263	1.4	Acceptable	Perceptible
177	House	12.5	913	263	1.5	Acceptable	Perceptible
178	Reservoir	50	838	263	1.7	Acceptable	N/A
179	Marsh	200	544	263	3.5	Acceptable	N/A
180	Informal Housing	6	2387	263	0.3	Acceptable	Too Low
181	House	12.5	2402	263	0.3	Acceptable	Too Low
182	Livestock	50	2458	263	0.3	Acceptable	N/A
183	River	200	2617	263	0.3	Acceptable	N/A
184	River	200	2018	263	0.4	Acceptable	N/A
185	Farmstead	12.5	1617	263	0.6	Acceptable	Too Low
186	Farm Buildings	12.5	1660	263	0.6	Acceptable	Too Low
187	Farm Buildings	12.5	1577	263	0.6	Acceptable	Too Low
188	Farm Building	12.5	1589	263	0.6	Acceptable	Too Low

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
189	Reservoir	50	1591	263	0.6	Acceptable	N/A
190	Farm Structure	12.5	1852	263	0.5	Acceptable	Too Low
191	Informal Housing	6	2748	263	0.2	Acceptable	Too Low
192	Informal Housing	6	2850	263	0.2	Acceptable	Too Low
193	Informal Housing	6	2962	263	0.2	Acceptable	Too Low
194	Farmstead	12.5	3153	263	0.2	Acceptable	Too Low
195	Farm Building	12.5	3070	263	0.2	Acceptable	Too Low
196	Farm Structures	12.5	1232	263	0.9	Acceptable	Perceptible
197	Farm Structures	12.5	1097	263	1.1	Acceptable	Perceptible
198	Farmstead	12.5	1050	263	1.2	Acceptable	Perceptible
199	Farm Building	12.5	1005	263	1.3	Acceptable	Perceptible
200	Livestock	50	1252	263	0.9	Acceptable	N/A
201	Informal Housing	6	791	263	1.9	Acceptable	Perceptible
202	Informal Housing	6	694	263	2.3	Acceptable	Perceptible
203	Informal Housing	6	718	263	2.2	Acceptable	Perceptible
204	Informal Housing	6	705	263	2.3	Acceptable	Perceptible
205	Kraal	50	570	263	3.2	Acceptable	N/A
206	Farmhouse	12.5	534	263	3.6	Acceptable	Perceptible
207	Farmhouse	12.5	620	263	2.8	Acceptable	Perceptible
208	Farmhouse	12.5	602	263	2.9	Acceptable	Perceptible
209	Livestock	50	751	263	2.0	Acceptable	N/A
210	Dam/Dam wall	50	798	263	1.8	Acceptable	N/A
211	Informal Housing	6	1422	263	0.7	Acceptable	Too Low
212	Informal Housing	6	1547	263	0.6	Acceptable	Too Low
213	River	200	1434	263	0.7	Acceptable	N/A
214	Marsh	200	3001	263	0.2	Acceptable	N/A
215	Mine Buildings	25	1666	263	0.5	Acceptable	N/A
216	Mine Buildings	25	1968	263	0.4	Acceptable	N/A
217	Mine Buildings	25	1999	263	0.4	Acceptable	N/A
218	Mine Building	25	1979	263	0.4	Acceptable	N/A
219	Farmstead	12.5	2292	263	0.3	Acceptable	Too Low
220	Farm Building	12.5	2221	263	0.3	Acceptable	Too Low
221	Nett Shading/Orchards	25	2319	263	0.3	Acceptable	N/A
222	Agricultural Tunnels	25	2386	263	0.3	Acceptable	N/A
223	Agricultural Tunnels	25	2702	263	0.2	Acceptable	N/A
224	Farm Building	12.5	2630	263	0.3	Acceptable	Too Low
231	Dam/Dam wall	50	2758	263	0.2	Acceptable	N/A
232	Dam/Dam wall	50	2979	263	0.2	Acceptable	N/A
233	Dam/Dam wall	50	3160	263	0.2	Acceptable	N/A
234	River	200	2793	263	0.2	Acceptable	N/A
235	River	200	2728	263	0.2	Acceptable	N/A
248	Pivot Irrigation	150	2199	263	0.3	Acceptable	N/A
249	Dam/Dam wall	50	1863	263	0.5	Acceptable	N/A
250	Communication Tower	25	3333	263	0.2	Acceptable	N/A
256	Explosives Magazines	25	1590	263	0.6	Acceptable	N/A

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
257	Dam/Dam wall	50	1257	263	0.9	Acceptable	N/A
258	Hydrocencus Borehole (BLYBH3)	50	810	263	1.8	Acceptable	N/A
259	Hydrocencus Borehole (BLYBH4)	50	497	263	4.0	Acceptable	N/A
262	Hydrocencus Borehole (HADECBH2)	50	3475	263	0.2	Acceptable	N/A
263	Hydrocencus Borehole (HADECBH3)	50	3481	263	0.2	Acceptable	N/A
264	Hydrocencus Borehole (REBH1)	50	3331	263	0.2	Acceptable	N/A
267	Hydrocencus Borehole (DRIBH1)	50	2558	263	0.3	Acceptable	N/A
268	Hydrocencus Borehole (DRIBH2)	50	2202	263	0.3	Acceptable	N/A
269	Hydrocencus Borehole (SACBH)	50	2233	263	0.3	Acceptable	N/A
270	Hydrocencus Borehole (BLYBH2)	50	424	263	5.2	Acceptable	N/A
271	Hydrocencus Borehole (VOGBH1)	50	424	263	5.2	Acceptable	N/A
272	Hydrocencus Borehole (WELBH2)	50	1398	263	0.7	Acceptable	N/A
273	Hydrocencus Borehole (ZOEBH2)	50	1408	263	0.7	Acceptable	N/A
274	Hydrocencus Borehole (GRMBH1)	50	3288	263	0.2	Acceptable	N/A
275	Hydrocencus Borehole (WELBH6)	50	160	263	26.2	Acceptable	N/A
276	Hydrocencus (Spring used for commercial bottled water)	50	2896	263	0.2	Acceptable	N/A
277	Heritage Site (Graves) - Inside OC2 Pit Area	12.5	751	263	2.0	Acceptable	Perceptible



### 17.1.2 Maximum charge mass per delay – 1575 kg – OC1 Opencast Pit

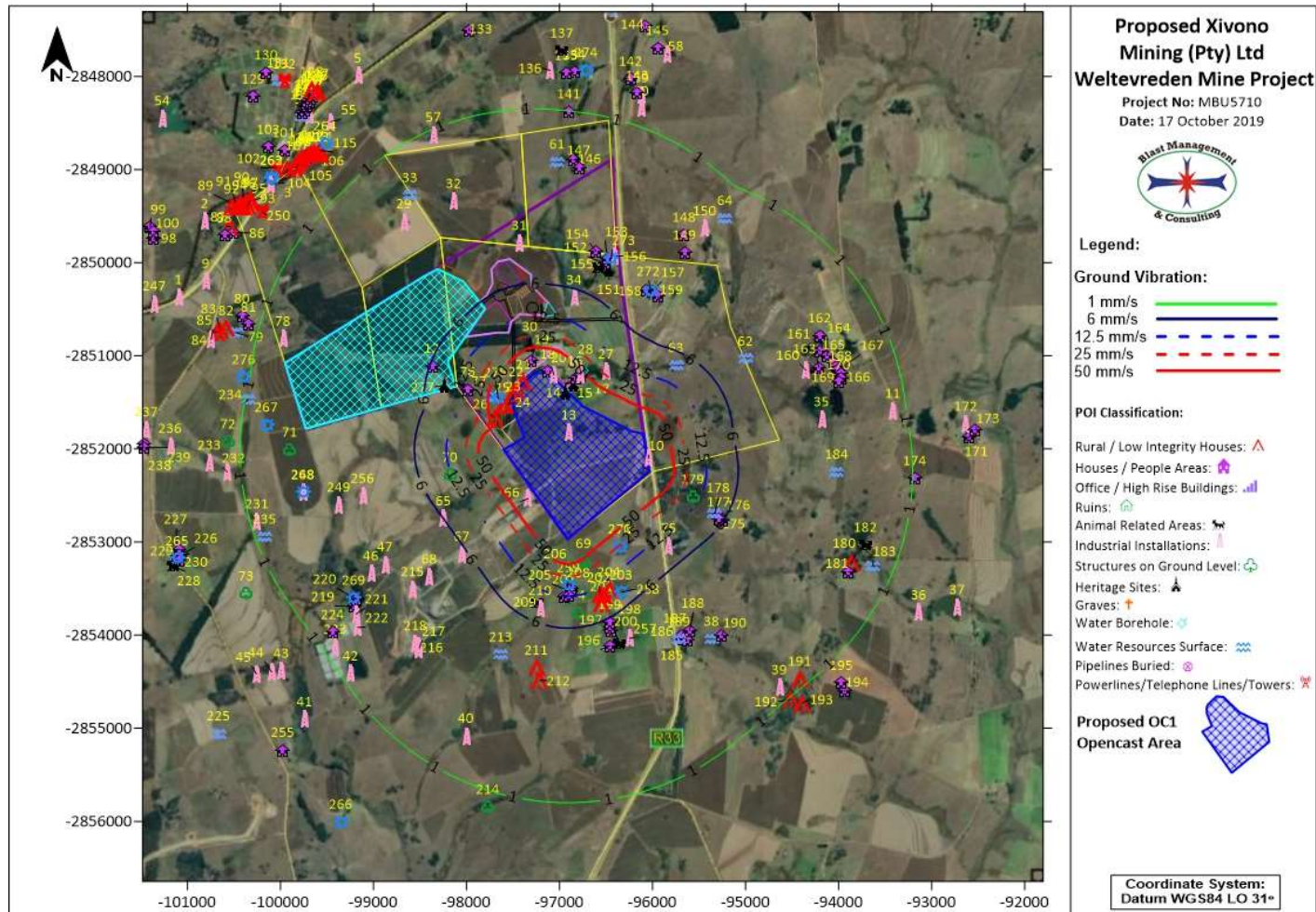


Figure 13: Ground vibration influence from maximum charge for Pit OC1 Area

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Page 75 of 165

Table 11: Ground vibration evaluation for maximum charge for Pit OC1 Area

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
3	Railway Line	150	3445	1575	0.7	Acceptable	N/A
10	R33 Road	150	17	1575	4573.4	Problematic	N/A
11	Dirt Road	200	2690	1575	1.1	Acceptable	N/A
12	House (Inside OC2 Area)	12.5	931	1575	6.3	Acceptable	Unpleasant
13	Heritage Site - Dam/Dam wall (Inside OC1 Area)	50	-	1575	-	-	-
14	Heritage Site -Historical Structures (Inside OC1 Area)	6	-	1575	-	-	-
15	Heritage Site -Historical Structures	6	99	1575	252.0	Problematic	Intolerable
16	Farm Buildings	12.5	160	1575	115.1	Problematic	Intolerable
17	Farm Buildings	12.5	217	1575	69.1	Problematic	Intolerable
18	Farmhouse	12.5	25	1575	2435.4	Problematic	Intolerable
19	Farm Buildings	12.5	131	1575	160.3	Problematic	Intolerable
20	Cement Dam	50	28	1575	2076.7	Problematic	N/A
21	Informal Housing	6	12	1575	7980.2	Problematic	Intolerable
22	Informal Housing	6	5	1575	35214.1	Problematic	Intolerable
23	Informal Housing	6	18	1575	4413.4	Problematic	Intolerable
24	Informal Housing	6	85	1575	325.7	Problematic	Intolerable
25	Informal Housing	6	114	1575	199.7	Problematic	Intolerable
26	Informal Housing	6	214	1575	70.9	Problematic	Intolerable
27	Dam/Dam wall	50	443	1575	21.4	Acceptable	N/A
28	Cement Dam	50	232	1575	62.1	Problematic	N/A
29	Cement Dam	50	2143	1575	1.6	Acceptable	N/A
30	Heritage Site - Dam/Dam wall	50	308	1575	38.8	Acceptable	N/A
31	Dam/Dam wall	50	1400	1575	3.2	Acceptable	N/A
32	Dam/Dam wall	50	2035	1575	1.7	Acceptable	N/A
33	Pan	200	2327	1575	1.4	Acceptable	N/A
34	Dam/Dam wall	50	870	1575	7.0	Acceptable	N/A
35	Dam/Dam wall	50	1918	1575	1.9	Acceptable	N/A
36	Dam/Dam wall	50	3272	1575	0.8	Acceptable	N/A
38	Pan	200	1813	1575	2.1	Acceptable	N/A
39	Dam/Dam wall	50	2679	1575	1.1	Acceptable	N/A
40	Dam/Dam wall	50	2380	1575	1.3	Acceptable	N/A
41	Dam/Dam wall	50	3423	1575	0.7	Acceptable	N/A
42	Dam/Dam wall	50	2732	1575	1.1	Acceptable	N/A
43	Dam/Dam wall	50	3321	1575	0.8	Acceptable	N/A
44	Dam/Dam wall	50	3416	1575	0.7	Acceptable	N/A
46	Dam/Dam wall	50	1930	1575	1.9	Acceptable	N/A
47	Dam/Dam wall	50	1751	1575	2.2	Acceptable	N/A
55	Dam/Dam wall	50	3471	1575	0.7	Acceptable	N/A
57	Dam/Dam wall	50	2773	1575	1.0	Acceptable	N/A
59	Dam/Dam wall	50	3154	1575	0.8	Acceptable	N/A
60	Dam/Dam wall	50	3020	1575	0.9	Acceptable	N/A
61	Pan	200	2275	1575	1.4	Acceptable	N/A



Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
62	River	200	1364	1575	3.3	Acceptable	N/A
63	River	200	817	1575	7.8	Acceptable	N/A
64	River	200	2477	1575	1.2	Acceptable	N/A
65	Dam/Dam wall	50	954	1575	6.0	Acceptable	N/A
66	Mine Activity	200	92	1575	286.6	Problematic	N/A
67	Mine Activity	200	1013	1575	5.4	Acceptable	N/A
68	Coal Yard	150	1441	1575	3.0	Acceptable	N/A
69	Cultivated Fields	200	294	1575	41.9	Acceptable	N/A
70	Cultivated Fields	200	634	1575	11.8	Acceptable	N/A
71	Cultivated Fields	200	2294	1575	1.4	Acceptable	N/A
72	Cultivated Fields	200	2958	1575	0.9	Acceptable	N/A
73	Cultivated Fields	200	3165	1575	0.8	Acceptable	N/A
74	Cultivated Fields	200	802	1575	8.0	Acceptable	N/A
75	Old Quarry	200	751	1575	8.9	Acceptable	N/A
76	Farmhouse	12.5	490	1575	18.1	Problematic	Unpleasant
77	Reservoir	50	230	1575	62.8	Problematic	N/A
78	Dam/Dam wall	50	2548	1575	1.2	Acceptable	N/A
79	Pan	200	3050	1575	0.9	Acceptable	N/A
80	Farmstead	12.5	3035	1575	0.9	Acceptable	Perceptible
81	Farm Buildings	12.5	2945	1575	0.9	Acceptable	Perceptible
82	Informal Housing	6	3166	1575	0.8	Acceptable	Perceptible
83	Informal Housing	6	3232	1575	0.8	Acceptable	Perceptible
84	Informal Housing	6	3254	1575	0.8	Acceptable	Perceptible
85	Gravel Road	200	3303	1575	0.8	Acceptable	N/A
86	Farmstead	12.5	3484	1575	0.7	Acceptable	Too Low
95	Informal Housing	6	3505	1575	0.7	Acceptable	Too Low
96	Informal Housing	6	3516	1575	0.7	Acceptable	Too Low
97	Informal Housing	6	3506	1575	0.7	Acceptable	Too Low
104	Informal Housing	6	3415	1575	0.7	Acceptable	Too Low
105	Informal Housing	6	3379	1575	0.7	Acceptable	Too Low
106	Informal Housing	6	3386	1575	0.7	Acceptable	Too Low
107	Informal Housing	6	3387	1575	0.7	Acceptable	Too Low
108	Informal Housing	6	3400	1575	0.7	Acceptable	Too Low
109	Informal Housing	6	3401	1575	0.7	Acceptable	Too Low
110	Informal Housing	6	3370	1575	0.8	Acceptable	Too Low
111	Informal Housing	6	3364	1575	0.8	Acceptable	Too Low
112	Informal Housing	6	3349	1575	0.8	Acceptable	Too Low
113	Informal Housing	6	3301	1575	0.8	Acceptable	Perceptible
114	Informal Housing	6	3278	1575	0.8	Acceptable	Perceptible
115	Informal Housing	6	3316	1575	0.8	Acceptable	Perceptible
134	Farmstead	12.5	3253	1575	0.8	Acceptable	Perceptible
135	Farm Structures	12.5	3232	1575	0.8	Acceptable	Perceptible
136	Dam/Dam wall	50	3249	1575	0.8	Acceptable	N/A
137	Kraal	50	3469	1575	0.7	Acceptable	N/A
141	House	12.5	2825	1575	1.0	Acceptable	Perceptible

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
142	House	12.5	3290	1575	0.8	Acceptable	Perceptible
143	House	12.5	3166	1575	0.8	Acceptable	Perceptible
146	Farmstead	12.5	2315	1575	1.4	Acceptable	Perceptible
147	Farm Buildings	12.5	2236	1575	1.5	Acceptable	Perceptible
148	Farmstead	12.5	2082	1575	1.7	Acceptable	Perceptible
149	Building/Structure	12.5	1950	1575	1.8	Acceptable	Perceptible
150	Dam/Dam wall	50	2285	1575	1.4	Acceptable	N/A
151	Heritage Site -Historical Structures	6	1299	1575	3.6	Acceptable	Perceptible
152	Farm Structure	12.5	1329	1575	3.5	Acceptable	Perceptible
153	House	12.5	1394	1575	3.2	Acceptable	Perceptible
154	House	12.5	1411	1575	3.2	Acceptable	Perceptible
155	Livestock	50	1258	1575	3.8	Acceptable	N/A
156	Cement Dam	50	1451	1575	3.0	Acceptable	N/A
157	Farmstead	12.5	1403	1575	3.2	Acceptable	Perceptible
158	Farm Structure	12.5	1374	1575	3.3	Acceptable	Perceptible
159	Farm Structure	12.5	1408	1575	3.2	Acceptable	Perceptible
160	Dam/Dam wall	50	1874	1575	2.0	Acceptable	N/A
161	Farmstead	12.5	2097	1575	1.6	Acceptable	Perceptible
162	Farmhouse	12.5	2170	1575	1.6	Acceptable	Perceptible
163	House	12.5	2016	1575	1.8	Acceptable	Perceptible
164	House	12.5	2147	1575	1.6	Acceptable	Perceptible
165	House	12.5	2185	1575	1.5	Acceptable	Perceptible
166	House	12.5	2189	1575	1.5	Acceptable	Perceptible
167	House	12.5	2198	1575	1.5	Acceptable	Perceptible
168	House	12.5	2218	1575	1.5	Acceptable	Perceptible
169	House	12.5	2209	1575	1.5	Acceptable	Perceptible
170	House	12.5	2173	1575	1.5	Acceptable	Perceptible
171	Farmstead	12.5	3464	1575	0.7	Acceptable	Too Low
172	Dam/Dam wall	50	3444	1575	0.7	Acceptable	N/A
174	Farm Structure	12.5	2857	1575	1.0	Acceptable	Perceptible
175	Farmstead	12.5	891	1575	6.7	Acceptable	Unpleasant
176	Farm Buildings	12.5	957	1575	6.0	Acceptable	Unpleasant
177	House	12.5	913	1575	6.5	Acceptable	Unpleasant
178	Reservoir	50	838	1575	7.5	Acceptable	N/A
179	Marsh	200	544	1575	15.2	Acceptable	N/A
180	Informal Housing	6	2387	1575	1.3	Acceptable	Perceptible
181	House	12.5	2402	1575	1.3	Acceptable	Perceptible
182	Livestock	50	2458	1575	1.3	Acceptable	N/A
183	River	200	2617	1575	1.1	Acceptable	N/A
184	River	200	2018	1575	1.7	Acceptable	N/A
185	Farmstead	12.5	1617	1575	2.5	Acceptable	Perceptible
186	Farm Buildings	12.5	1660	1575	2.4	Acceptable	Perceptible
187	Farm Buildings	12.5	1577	1575	2.6	Acceptable	Perceptible
188	Farm Building	12.5	1589	1575	2.6	Acceptable	Perceptible
189	Reservoir	50	1591	1575	2.6	Acceptable	N/A

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
190	Farm Structure	12.5	1852	1575	2.0	Acceptable	Perceptible
191	Informal Housing	6	2748	1575	1.1	Acceptable	Perceptible
192	Informal Housing	6	2850	1575	1.0	Acceptable	Perceptible
193	Informal Housing	6	2962	1575	0.9	Acceptable	Perceptible
194	Farmstead	12.5	3153	1575	0.8	Acceptable	Perceptible
195	Farm Building	12.5	3070	1575	0.9	Acceptable	Perceptible
196	Farm Structures	12.5	1232	1575	3.9	Acceptable	Perceptible
197	Farm Structures	12.5	1097	1575	4.8	Acceptable	Perceptible
198	Farmstead	12.5	1050	1575	5.1	Acceptable	Perceptible
199	Farm Building	12.5	1005	1575	5.5	Acceptable	Perceptible
200	Livestock	50	1252	1575	3.8	Acceptable	N/A
201	Informal Housing	6	791	1575	8.2	Problematic	Unpleasant
202	Informal Housing	6	694	1575	10.2	Problematic	Unpleasant
203	Informal Housing	6	718	1575	9.6	Problematic	Unpleasant
204	Informal Housing	6	705	1575	9.9	Problematic	Unpleasant
205	Kraal	50	570	1575	14.1	Acceptable	N/A
206	Farmhouse	12.5	534	1575	15.7	Problematic	Unpleasant
207	Farmhouse	12.5	620	1575	12.3	Acceptable	Unpleasant
208	Farmhouse	12.5	602	1575	12.9	Problematic	Unpleasant
209	Livestock	50	751	1575	8.9	Acceptable	N/A
210	Dam/Dam wall	50	798	1575	8.1	Acceptable	N/A
211	Informal Housing	6	1422	1575	3.1	Acceptable	Perceptible
212	Informal Housing	6	1547	1575	2.7	Acceptable	Perceptible
213	River	200	1434	1575	3.1	Acceptable	N/A
214	Marsh	200	3001	1575	0.9	Acceptable	N/A
215	Mine Buildings	25	1666	1575	2.4	Acceptable	N/A
216	Mine Buildings	25	1968	1575	1.8	Acceptable	N/A
217	Mine Buildings	25	1999	1575	1.8	Acceptable	N/A
218	Mine Building	25	1979	1575	1.8	Acceptable	N/A
219	Farmstead	12.5	2292	1575	1.4	Acceptable	Perceptible
220	Farm Building	12.5	2221	1575	1.5	Acceptable	Perceptible
221	Nett Shading/Orchards	25	2319	1575	1.4	Acceptable	N/A
222	Agricultural Tunnels	25	2386	1575	1.3	Acceptable	N/A
223	Agricultural Tunnels	25	2702	1575	1.1	Acceptable	N/A
224	Farm Building	12.5	2630	1575	1.1	Acceptable	Perceptible
231	Dam/Dam wall	50	2758	1575	1.0	Acceptable	N/A
232	Dam/Dam wall	50	2979	1575	0.9	Acceptable	N/A
233	Dam/Dam wall	50	3160	1575	0.8	Acceptable	N/A
234	River	200	2793	1575	1.0	Acceptable	N/A
235	River	200	2728	1575	1.1	Acceptable	N/A
248	Pivot Irrigation	150	2199	1575	1.5	Acceptable	N/A
249	Dam/Dam wall	50	1863	1575	2.0	Acceptable	N/A
250	Communication Tower	25	3333	1575	0.8	Acceptable	N/A
256	Explosives Magazines	25	1590	1575	2.6	Acceptable	N/A
257	Dam/Dam wall	50	1257	1575	3.8	Acceptable	N/A

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
258	Hydrocencus Borehole (BLYBH3)	50	810	1575	7.9	Acceptable	N/A
259	Hydrocencus Borehole (BLYBH4)	50	497	1575	17.7	Acceptable	N/A
262	Hydrocencus Borehole (HADECBH2)	50	3475	1575	0.7	Acceptable	N/A
263	Hydrocencus Borehole (HADECBH3)	50	3481	1575	0.7	Acceptable	N/A
264	Hydrocencus Borehole (REBH1)	50	3331	1575	0.8	Acceptable	N/A
267	Hydrocencus Borehole (DRIBH1)	50	2558	1575	1.2	Acceptable	N/A
268	Hydrocencus Borehole (DRIBH2)	50	2202	1575	1.5	Acceptable	N/A
269	Hydrocencus Borehole (SACBH)	50	2233	1575	1.5	Acceptable	N/A
270	Hydrocencus Borehole (BLYBH2)	50	424	1575	23.0	Acceptable	N/A
271	Hydrocencus Borehole (VOGBH1)	50	424	1575	23.0	Acceptable	N/A
272	Hydrocencus Borehole (WELBH2)	50	1398	1575	3.2	Acceptable	N/A
273	Hydrocencus Borehole (ZOEBH2)	50	1408	1575	3.2	Acceptable	N/A
274	Hydrocencus Borehole (GRMBH1)	50	3288	1575	0.8	Acceptable	N/A
275	Hydrocencus Borehole (WELBH6)	50	160	1575	114.7	Problematic	N/A
276	Hydrocencus (Spring used for commercial bottled water)	50	2896	1575	1.0	Acceptable	N/A
277	Heritage Site (Graves) - Inside OC2 Pit Area	12.5	751	1575	8.9	Acceptable	Unpleasant

### 17.1.3 Minimum charge mass per delay – 263 kg – Pit OC2

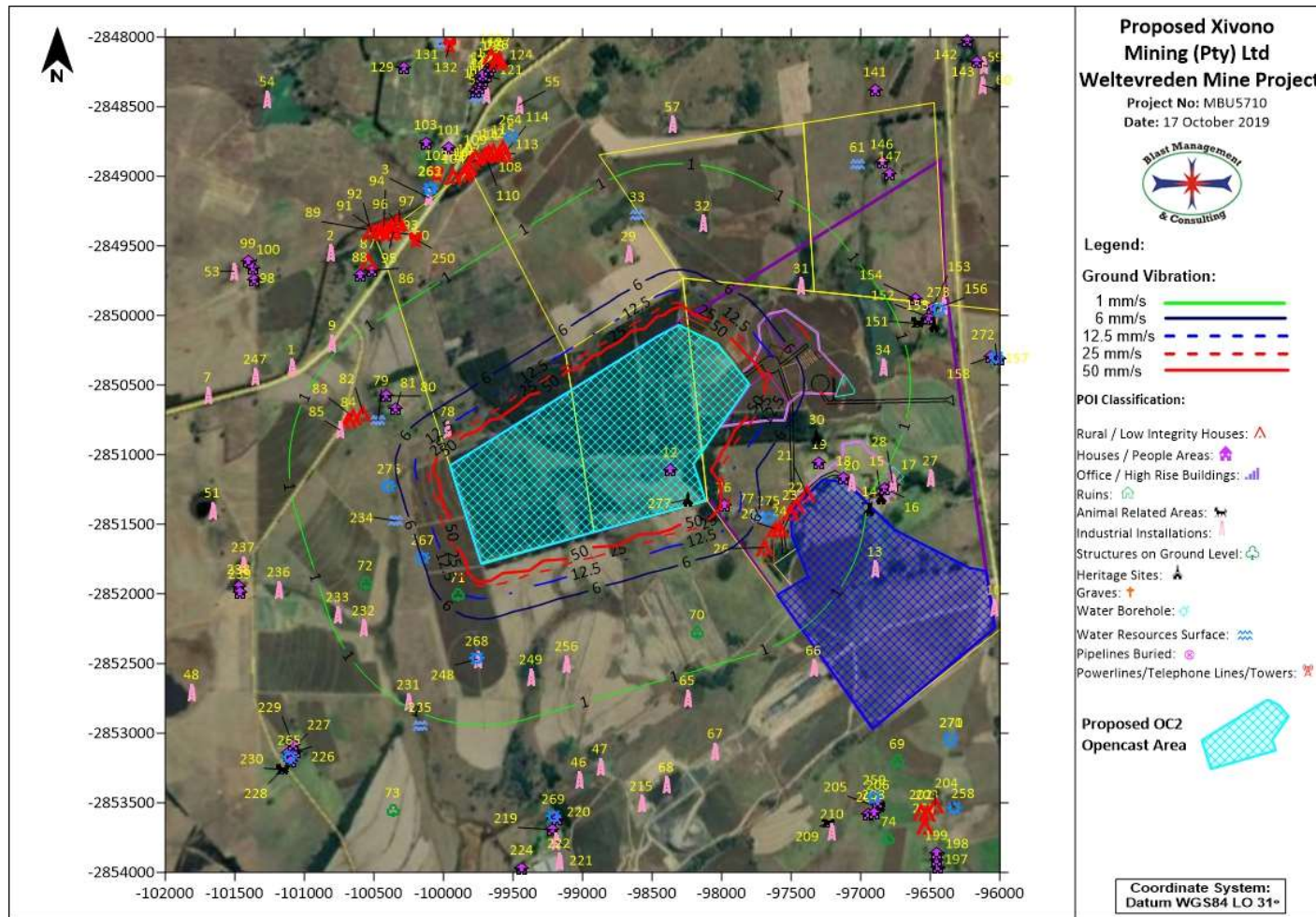


Figure 14: Ground vibration influence from minimum charge for Pit OC2 Area

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Page 81 of 165

Table 12: Ground vibration evaluation for minimum charge for Pit OC2 Area

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
1	Railway Line	150	1343	263	0.8	Acceptable	N/A
2	Railway Line	150	1748	263	0.5	Acceptable	N/A
3	Railway Line	150	1713	263	0.5	Acceptable	N/A
4	Railway Line	150	2120	263	0.4	Acceptable	N/A
5	Railway Line	150	2245	263	0.3	Acceptable	N/A
6	Railway Line	150	2849	263	0.2	Acceptable	N/A
7	Railway Line	150	1816	263	0.5	Acceptable	N/A
8	Railway Line	150	2544	263	0.3	Acceptable	N/A
9	N4 Road	150	1222	263	0.9	Acceptable	N/A
10	R33 Road	150	2215	263	0.3	Acceptable	N/A
12	House (Inside OC2 Area)	12.5	-	263	-	-	-
13	Heritage Site - Dam/Dam wall (Inside OC1 Area)	50	1318	263	0.8	Acceptable	N/A
14	Heritage Site -Historical Structures (Inside OC1 Area)	6	1183	263	1.0	Acceptable	Perceptible
15	Heritage Site -Historical Structures	6	1240	263	0.9	Acceptable	Perceptible
16	Farm Buildings	12.5	1227	263	0.9	Acceptable	Perceptible
17	Farm Buildings	12.5	1261	263	0.9	Acceptable	Perceptible
18	Farmhouse	12.5	946	263	1.4	Acceptable	Perceptible
19	Farm Buildings	12.5	733	263	2.1	Acceptable	Perceptible
20	Cement Dam	50	1011	263	1.2	Acceptable	N/A
21	Informal Housing	6	731	263	2.1	Acceptable	Perceptible
22	Informal Housing	6	653	263	2.6	Acceptable	Perceptible
23	Informal Housing	6	617	263	2.8	Acceptable	Perceptible
24	Informal Housing	6	573	263	3.2	Acceptable	Perceptible
25	Informal Housing	6	545	263	3.5	Acceptable	Perceptible
26	Informal Housing	6	544	263	3.5	Acceptable	Perceptible
27	Dam/Dam wall	50	1468	263	0.7	Acceptable	N/A
28	Cement Dam	50	1249	263	0.9	Acceptable	N/A
29	Cement Dam	50	619	263	2.8	Acceptable	N/A
30	Heritage Site - Dam/Dam wall	50	617	263	2.8	Acceptable	N/A
31	Dam/Dam wall	50	732	263	2.1	Acceptable	N/A
32	Dam/Dam wall	50	748	263	2.1	Acceptable	N/A
33	Pan	200	846	263	1.7	Acceptable	N/A
34	Dam/Dam wall	50	971	263	1.3	Acceptable	N/A
41	Dam/Dam wall	50	3122	263	0.2	Acceptable	N/A
42	Dam/Dam wall	50	2672	263	0.3	Acceptable	N/A
43	Dam/Dam wall	50	2614	263	0.3	Acceptable	N/A
44	Dam/Dam wall	50	2637	263	0.3	Acceptable	N/A
45	Dam/Dam wall	50	2686	263	0.2	Acceptable	N/A
46	Dam/Dam wall	50	1684	263	0.5	Acceptable	N/A
47	Dam/Dam wall	50	1633	263	0.6	Acceptable	N/A
48	Dam/Dam wall	50	2277	263	0.3	Acceptable	N/A
49	Dam/Dam wall	50	3117	263	0.2	Acceptable	N/A
50	Dam/Dam wall	50	2831	263	0.2	Acceptable	N/A



Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
51	Dam/Dam wall	50	1739	263	0.5	Acceptable	N/A
52	Dam/Dam wall	50	2732	263	0.2	Acceptable	N/A
53	Dam/Dam wall	50	2093	263	0.4	Acceptable	N/A
54	Dam/Dam wall	50	2925	263	0.2	Acceptable	N/A
55	Dam/Dam wall	50	1938	263	0.4	Acceptable	N/A
56	Pan	200	2144	263	0.4	Acceptable	N/A
57	Dam/Dam wall	50	1441	263	0.7	Acceptable	N/A
58	Dam/Dam wall	50	3284	263	0.2	Acceptable	N/A
59	Dam/Dam wall	50	2770	263	0.2	Acceptable	N/A
60	Dam/Dam wall	50	2667	263	0.3	Acceptable	N/A
61	Pan	200	1637	263	0.6	Acceptable	N/A
62	River	200	2856	263	0.2	Acceptable	N/A
63	River	200	2146	263	0.4	Acceptable	N/A
64	River	200	2760	263	0.2	Acceptable	N/A
65	Dam/Dam wall	50	1332	263	0.8	Acceptable	N/A
66	Mine Activity	200	1438	263	0.7	Acceptable	N/A
67	Mine Activity	200	1754	263	0.5	Acceptable	N/A
68	Coal Yard	150	1890	263	0.4	Acceptable	N/A
69	Cultivated Fields	200	2331	263	0.3	Acceptable	N/A
70	Cultivated Fields	200	897	263	1.5	Acceptable	N/A
71	Cultivated Fields	200	283	263	10.2	Acceptable	N/A
72	Cultivated Fields	200	835	263	1.7	Acceptable	N/A
73	Cultivated Fields	200	1883	263	0.4	Acceptable	N/A
74	Cultivated Fields	200	2770	263	0.2	Acceptable	N/A
75	Old Quarry	200	2865	263	0.2	Acceptable	N/A
76	Farmhouse	12.5	139	263	33.2	Problematic	Intolerable
77	Reservoir	50	404	263	5.7	Acceptable	N/A
78	Dam/Dam wall	50	230	263	14.4	Acceptable	N/A
79	Pan	200	616	263	2.8	Acceptable	N/A
80	Farmstead	12.5	680	263	2.4	Acceptable	Perceptible
81	Farm Buildings	12.5	567	263	3.2	Acceptable	Perceptible
82	Informal Housing	6	732	263	2.1	Acceptable	Perceptible
83	Informal Housing	6	785	263	1.9	Acceptable	Perceptible
84	Informal Housing	6	800	263	1.8	Acceptable	Perceptible
85	Gravel Road	200	834	263	1.7	Acceptable	N/A
86	Farmstead	12.5	1487	263	0.7	Acceptable	Too Low
87	Informal Housing	6	1556	263	0.6	Acceptable	Too Low
88	Farm Buildings	12.5	1504	263	0.6	Acceptable	Too Low
89	Informal Housing	6	1679	263	0.5	Acceptable	Too Low
90	Informal Housing	6	1657	263	0.6	Acceptable	Too Low
91	Informal Housing	6	1704	263	0.5	Acceptable	Too Low
92	Informal Housing	6	1724	263	0.5	Acceptable	Too Low
93	Informal Housing	6	1689	263	0.5	Acceptable	Too Low
94	Informal Housing	6	1711	263	0.5	Acceptable	Too Low
95	Informal Housing	6	1647	263	0.6	Acceptable	Too Low
96	Informal Housing	6	1679	263	0.5	Acceptable	Too Low



Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
97	Informal Housing	6	1678	263	0.5	Acceptable	Too Low
98	Farmstead	12.5	1943	263	0.4	Acceptable	Too Low
99	Farmhouse	12.5	2066	263	0.4	Acceptable	Too Low
100	Farm Building	12.5	2004	263	0.4	Acceptable	Too Low
101	Building/Structures (Packing Sheds)	12.5	1941	263	0.4	Acceptable	Too Low
102	Communication Tower	25	1832	263	0.5	Acceptable	N/A
103	Farmstead	12.5	2061	263	0.4	Acceptable	Too Low
104	Informal Housing	6	1749	263	0.5	Acceptable	Too Low
105	Informal Housing	6	1730	263	0.5	Acceptable	Too Low
106	Informal Housing	6	1742	263	0.5	Acceptable	Too Low
107	Informal Housing	6	1750	263	0.5	Acceptable	Too Low
108	Informal Housing	6	1772	263	0.5	Acceptable	Too Low
109	Informal Housing	6	1780	263	0.5	Acceptable	Too Low
110	Informal Housing	6	1763	263	0.5	Acceptable	Too Low
111	Informal Housing	6	1763	263	0.5	Acceptable	Too Low
112	Informal Housing	6	1755	263	0.5	Acceptable	Too Low
113	Informal Housing	6	1713	263	0.5	Acceptable	Too Low
114	Informal Housing	6	1696	263	0.5	Acceptable	Too Low
115	Informal Housing	6	1737	263	0.5	Acceptable	Too Low
116	Houses	12.5	2188	263	0.3	Acceptable	Too Low
117	Houses	12.5	2194	263	0.3	Acceptable	Too Low
118	Houses	12.5	2212	263	0.3	Acceptable	Too Low
119	Houses	12.5	2221	263	0.3	Acceptable	Too Low
120	Houses	12.5	2251	263	0.3	Acceptable	Too Low
121	Houses	12.5	2241	263	0.3	Acceptable	Too Low
122	Houses	12.5	2258	263	0.3	Acceptable	Too Low
123	Houses	12.5	2263	263	0.3	Acceptable	Too Low
124	Houses	12.5	2274	263	0.3	Acceptable	Too Low
125	Houses	12.5	2286	263	0.3	Acceptable	Too Low
126	Informal Housing	6	2282	263	0.3	Acceptable	Too Low
127	Informal Housing	6	2292	263	0.3	Acceptable	Too Low
128	Informal Housing	6	2342	263	0.3	Acceptable	Too Low
129	Farmhouse	12.5	2606	263	0.3	Acceptable	Too Low
130	Farmhouse	12.5	2753	263	0.2	Acceptable	Too Low
131	Reservoirs	50	2610	263	0.3	Acceptable	N/A
132	Communication Tower	25	2567	263	0.3	Acceptable	N/A
133	Farmstead	12.5	2578	263	0.3	Acceptable	Too Low
134	Farmstead	12.5	2548	263	0.3	Acceptable	Too Low
135	Farm Structures	12.5	2497	263	0.3	Acceptable	Too Low
136	Dam/Dam wall	50	2446	263	0.3	Acceptable	N/A
137	Kraal	50	2693	263	0.2	Acceptable	N/A
138	House	12.5	3267	263	0.2	Acceptable	Too Low
139	Building/Structure	12.5	3221	263	0.2	Acceptable	Too Low
140	Building/Structure	12.5	3407	263	0.2	Acceptable	Too Low
141	House	12.5	2151	263	0.4	Acceptable	Too Low
142	House	12.5	2826	263	0.2	Acceptable	Too Low

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
143	House	12.5	2758	263	0.2	Acceptable	Too Low
144	Farm Buildings	12.5	3366	263	0.2	Acceptable	Too Low
145	Building/Structure	12.5	3265	263	0.2	Acceptable	Too Low
146	Farmstead	12.5	1765	263	0.5	Acceptable	Too Low
147	Farm Buildings	12.5	1742	263	0.5	Acceptable	Too Low
148	Farmstead	12.5	2284	263	0.3	Acceptable	Too Low
149	Building/Structure	12.5	2231	263	0.3	Acceptable	Too Low
150	Dam/Dam wall	50	2515	263	0.3	Acceptable	N/A
151	Heritage Site -Historical Structures	6	1395	263	0.7	Acceptable	Too Low
152	Farm Structure	12.5	1376	263	0.8	Acceptable	Too Low
153	House	12.5	1419	263	0.7	Acceptable	Too Low
154	House	12.5	1343	263	0.8	Acceptable	Perceptible
155	Livestock	50	1288	263	0.8	Acceptable	N/A
156	Cement Dam	50	1506	263	0.6	Acceptable	N/A
157	Farmstead	12.5	1804	263	0.5	Acceptable	Too Low
158	Farm Structure	12.5	1751	263	0.5	Acceptable	Too Low
159	Farm Structure	12.5	1863	263	0.5	Acceptable	Too Low
175	Farmstead	12.5	3156	263	0.2	Acceptable	Too Low
176	Farm Buildings	12.5	3219	263	0.2	Acceptable	Too Low
177	House	12.5	3174	263	0.2	Acceptable	Too Low
178	Reservoir	50	3103	263	0.2	Acceptable	N/A
179	Marsh	200	2813	263	0.2	Acceptable	N/A
196	Farm Structures	12.5	3243	263	0.2	Acceptable	Too Low
197	Farm Structures	12.5	3121	263	0.2	Acceptable	Too Low
198	Farmstead	12.5	3075	263	0.2	Acceptable	Too Low
199	Farm Building	12.5	3033	263	0.2	Acceptable	Too Low
200	Livestock	50	3277	263	0.2	Acceptable	N/A
201	Informal Housing	6	2821	263	0.2	Acceptable	Too Low
202	Informal Housing	6	2727	263	0.2	Acceptable	Too Low
203	Informal Housing	6	2754	263	0.2	Acceptable	Too Low
204	Informal Housing	6	2741	263	0.2	Acceptable	Too Low
205	Kraal	50	2537	263	0.3	Acceptable	N/A
206	Farmhouse	12.5	2504	263	0.3	Acceptable	Too Low
207	Farmhouse	12.5	2544	263	0.3	Acceptable	Too Low
208	Farmhouse	12.5	2549	263	0.3	Acceptable	Too Low
209	Livestock	50	2481	263	0.3	Acceptable	N/A
210	Dam/Dam wall	50	2551	263	0.3	Acceptable	N/A
211	Informal Housing	6	3145	263	0.2	Acceptable	Too Low
212	Informal Housing	6	3284	263	0.2	Acceptable	Too Low
213	River	200	2905	263	0.2	Acceptable	N/A
215	Mine Buildings	25	1971	263	0.4	Acceptable	N/A
216	Mine Buildings	25	2569	263	0.3	Acceptable	N/A
217	Mine Buildings	25	2613	263	0.3	Acceptable	N/A
218	Mine Building	25	2536	263	0.3	Acceptable	N/A
219	Farmstead	12.5	1974	263	0.4	Acceptable	Too Low
220	Farm Building	12.5	1905	263	0.4	Acceptable	Too Low

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
221	Nett Shading/Orchards	25	2060	263	0.4	Acceptable	N/A
222	Agricultural Tunnels	25	2205	263	0.3	Acceptable	N/A
223	Agricultural Tunnels	25	2363	263	0.3	Acceptable	N/A
224	Farm Building	12.5	2202	263	0.3	Acceptable	Too Low
225	Reservoir	50	3405	263	0.2	Acceptable	N/A
226	Farmstead	12.5	1896	263	0.4	Acceptable	Too Low
227	Farm Buildings	12.5	1941	263	0.4	Acceptable	Too Low
228	Farm Building	12.5	1970	263	0.4	Acceptable	Too Low
229	Farm Buildings	12.5	1875	263	0.5	Acceptable	Too Low
230	Livestock	50	2056	263	0.4	Acceptable	N/A
231	Dam/Dam wall	50	1126	263	1.0	Acceptable	N/A
232	Dam/Dam wall	50	963	263	1.4	Acceptable	N/A
233	Dam/Dam wall	50	1094	263	1.1	Acceptable	N/A
234	River	200	493	263	4.1	Acceptable	N/A
235	River	200	1240	263	0.9	Acceptable	N/A
236	Dam/Dam wall	50	1442	263	0.7	Acceptable	N/A
237	Dam/Dam wall	50	1633	263	0.6	Acceptable	N/A
238	Farmhouse	12.5	1712	263	0.5	Acceptable	Too Low
239	Farm Building	12.5	1714	263	0.5	Acceptable	Too Low
240	Houses	12.5	2665	263	0.3	Acceptable	Too Low
241	Farmhouse	12.5	3147	263	0.2	Acceptable	Too Low
242	Farm Building	12.5	3222	263	0.2	Acceptable	Too Low
243	Structures	12.5	3191	263	0.2	Acceptable	Too Low
244	Houses	12.5	3282	263	0.2	Acceptable	Too Low
245	Houses	12.5	3277	263	0.2	Acceptable	Too Low
246	Houses	12.5	3327	263	0.2	Acceptable	Too Low
247	Railway Substation	25	1541	263	0.6	Acceptable	N/A
248	Pivot Irrigation	150	686	263	2.4	Acceptable	N/A
249	Dam/Dam wall	50	881	263	1.6	Acceptable	N/A
250	Communication Tower	25	1506	263	0.6	Acceptable	N/A
251	Informal Settlement	6	3004	263	0.2	Acceptable	Too Low
252	Informal Settlement	6	3386	263	0.2	Acceptable	Too Low
253	Informal Settlement	6	3158	263	0.2	Acceptable	Too Low
254	Farmstead	12.5	3212	263	0.2	Acceptable	Too Low
255	Farmstead	12.5	3460	263	0.2	Acceptable	Too Low
256	Explosives Magazines	25	859	263	1.6	Acceptable	N/A
257	Dam/Dam wall	50	3291	263	0.2	Acceptable	N/A
258	Hydrocencus Borehole (BLYBH3)	50	2843	263	0.2	Acceptable	N/A
259	Hydrocencus Borehole (BLYBH4)	50	2460	263	0.3	Acceptable	N/A
261	Hydrocencus Borehole (HADECBH)	50	3134	263	0.2	Acceptable	N/A
262	Hydrocencus Borehole (HADECBH2)	50	1759	263	0.5	Acceptable	N/A
263	Hydrocencus Borehole (HADECBH3)	50	1764	263	0.5	Acceptable	N/A
264	Hydrocencus Borehole (REBH1)	50	1769	263	0.5	Acceptable	N/A
265	Hydrocencus Borehole (ZOEHBH)	50	1961	263	0.4	Acceptable	N/A
267	Hydrocencus Borehole (DRIBH1)	50	386	263	6.1	Acceptable	N/A
268	Hydrocencus Borehole (DRIBH2)	50	684	263	2.4	Acceptable	N/A

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
269	Hydrocencus Borehole (SACBH)	50	1887	263	0.4	Acceptable	N/A
270	Hydrocencus Borehole (BLYBH2)	50	2471	263	0.3	Acceptable	N/A
271	Hydrocencus Borehole (VOGBH1)	50	2471	263	0.3	Acceptable	N/A
272	Hydrocencus Borehole (WELBH2)	50	1790	263	0.5	Acceptable	N/A
273	Hydrocencus Borehole (ZOEBH2)	50	1461	263	0.7	Acceptable	N/A
274	Hydrocencus Borehole (GRMBH1)	50	2628	263	0.3	Acceptable	N/A
275	Hydrocencus Borehole (WELBH6)	50	475	263	4.3	Acceptable	N/A
276	Hydrocencus (Spring used for commercial bottled water)	50	464	263	4.5	Acceptable	N/A
277	Heritage Site (Graves) - Inside OC2 Pit Area	12.5	-	263	-	-	-

#### 17.1.4 Maximum charge mass per delay – 1575 kg – Pit OC2 Area

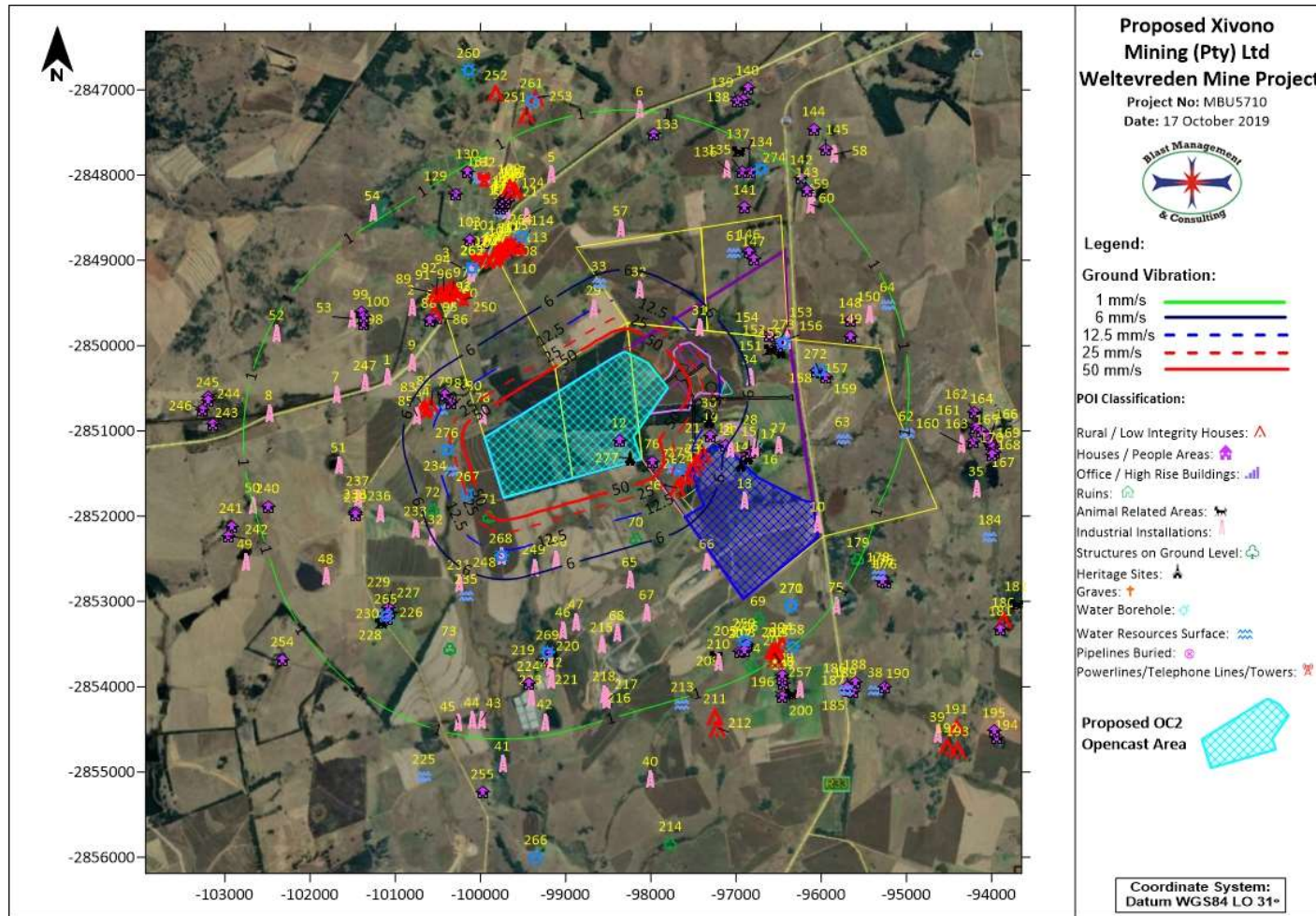


Figure 15: Ground vibration influence from maximum charge for Pit OC2 Area

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Page 88 of 165

Table 13: Ground vibration evaluation for maximum charge for Pit OC2 Area

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
1	Railway Line	150	1343	1575	3.4	Acceptable	N/A
2	Railway Line	150	1748	1575	2.2	Acceptable	N/A
3	Railway Line	150	1713	1575	2.3	Acceptable	N/A
4	Railway Line	150	2120	1575	1.6	Acceptable	N/A
5	Railway Line	150	2245	1575	1.5	Acceptable	N/A
6	Railway Line	150	2849	1575	1.0	Acceptable	N/A
7	Railway Line	150	1816	1575	2.1	Acceptable	N/A
8	Railway Line	150	2544	1575	1.2	Acceptable	N/A
9	N4 Road	150	1222	1575	4.0	Acceptable	N/A
10	R33 Road	150	2215	1575	1.5	Acceptable	N/A
12	House (Inside OC2 Area)	12.5	-	1575	-	-	-
13	Heritage Site - Dam/Dam wall (Inside OC1 Area)	50	1318	1575	3.5	Acceptable	N/A
14	Heritage Site -Historical Structures (Inside OC1 Area)	6	1183	1575	4.2	Acceptable	Perceptible
15	Heritage Site -Historical Structures	6	1240	1575	3.9	Acceptable	Perceptible
16	Farm Buildings	12.5	1227	1575	4.0	Acceptable	Perceptible
17	Farm Buildings	12.5	1261	1575	3.8	Acceptable	Perceptible
18	Farmhouse	12.5	946	1575	6.1	Acceptable	Unpleasant
19	Farm Buildings	12.5	733	1575	9.3	Acceptable	Unpleasant
20	Cement Dam	50	1011	1575	5.5	Acceptable	N/A
21	Informal Housing	6	731	1575	9.3	Problematic	Unpleasant
22	Informal Housing	6	653	1575	11.2	Problematic	Unpleasant
23	Informal Housing	6	617	1575	12.4	Problematic	Unpleasant
24	Informal Housing	6	573	1575	14.0	Problematic	Unpleasant
25	Informal Housing	6	545	1575	15.2	Problematic	Unpleasant
26	Informal Housing	6	544	1575	15.2	Problematic	Unpleasant
27	Dam/Dam wall	50	1468	1575	3.0	Acceptable	N/A
28	Cement Dam	50	1249	1575	3.9	Acceptable	N/A
29	Cement Dam	50	619	1575	12.3	Acceptable	N/A
30	Heritage Site - Dam/Dam wall	50	617	1575	12.4	Acceptable	N/A
31	Dam/Dam wall	50	732	1575	9.3	Acceptable	N/A
32	Dam/Dam wall	50	748	1575	9.0	Acceptable	N/A
33	Pan	200	846	1575	7.3	Acceptable	N/A
34	Dam/Dam wall	50	971	1575	5.8	Acceptable	N/A
41	Dam/Dam wall	50	3122	1575	0.9	Acceptable	N/A
42	Dam/Dam wall	50	2672	1575	1.1	Acceptable	N/A
43	Dam/Dam wall	50	2614	1575	1.1	Acceptable	N/A
44	Dam/Dam wall	50	2637	1575	1.1	Acceptable	N/A
45	Dam/Dam wall	50	2686	1575	1.1	Acceptable	N/A
46	Dam/Dam wall	50	1684	1575	2.4	Acceptable	N/A
47	Dam/Dam wall	50	1633	1575	2.5	Acceptable	N/A
48	Dam/Dam wall	50	2277	1575	1.4	Acceptable	N/A
49	Dam/Dam wall	50	3117	1575	0.9	Acceptable	N/A



Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
50	Dam/Dam wall	50	2831	1575	1.0	Acceptable	N/A
51	Dam/Dam wall	50	1739	1575	2.2	Acceptable	N/A
52	Dam/Dam wall	50	2732	1575	1.1	Acceptable	N/A
53	Dam/Dam wall	50	2093	1575	1.6	Acceptable	N/A
54	Dam/Dam wall	50	2925	1575	0.9	Acceptable	N/A
55	Dam/Dam wall	50	1938	1575	1.9	Acceptable	N/A
56	Pan	200	2144	1575	1.6	Acceptable	N/A
57	Dam/Dam wall	50	1441	1575	3.0	Acceptable	N/A
58	Dam/Dam wall	50	3284	1575	0.8	Acceptable	N/A
59	Dam/Dam wall	50	2770	1575	1.0	Acceptable	N/A
60	Dam/Dam wall	50	2667	1575	1.1	Acceptable	N/A
61	Pan	200	1637	1575	2.5	Acceptable	N/A
62	River	200	2856	1575	1.0	Acceptable	N/A
63	River	200	2146	1575	1.6	Acceptable	N/A
64	River	200	2760	1575	1.0	Acceptable	N/A
65	Dam/Dam wall	50	1332	1575	3.5	Acceptable	N/A
66	Mine Activity	200	1438	1575	3.1	Acceptable	N/A
67	Mine Activity	200	1754	1575	2.2	Acceptable	N/A
68	Coal Yard	150	1890	1575	1.9	Acceptable	N/A
69	Cultivated Fields	200	2331	1575	1.4	Acceptable	N/A
70	Cultivated Fields	200	897	1575	6.7	Acceptable	N/A
71	Cultivated Fields	200	283	1575	44.8	Acceptable	N/A
72	Cultivated Fields	200	835	1575	7.5	Acceptable	N/A
73	Cultivated Fields	200	1883	1575	2.0	Acceptable	N/A
74	Cultivated Fields	200	2770	1575	1.0	Acceptable	N/A
75	Old Quarry	200	2865	1575	1.0	Acceptable	N/A
76	Farmhouse	12.5	139	1575	145.2	Problematic	Intolerable
77	Reservoir	50	404	1575	24.8	Acceptable	N/A
78	Dam/Dam wall	50	230	1575	62.8	Problematic	N/A
79	Pan	200	616	1575	12.4	Acceptable	N/A
80	Farmstead	12.5	680	1575	10.5	Acceptable	Unpleasant
81	Farm Buildings	12.5	567	1575	14.2	Problematic	Unpleasant
82	Informal Housing	6	732	1575	9.3	Problematic	Unpleasant
83	Informal Housing	6	785	1575	8.3	Problematic	Unpleasant
84	Informal Housing	6	800	1575	8.0	Problematic	Unpleasant
85	Gravel Road	200	834	1575	7.5	Acceptable	N/A
86	Farmstead	12.5	1487	1575	2.9	Acceptable	Perceptible
87	Informal Housing	6	1556	1575	2.7	Acceptable	Perceptible
88	Farm Buildings	12.5	1504	1575	2.8	Acceptable	Perceptible
89	Informal Housing	6	1679	1575	2.4	Acceptable	Perceptible
90	Informal Housing	6	1657	1575	2.4	Acceptable	Perceptible
91	Informal Housing	6	1704	1575	2.3	Acceptable	Perceptible
92	Informal Housing	6	1724	1575	2.3	Acceptable	Perceptible
93	Informal Housing	6	1689	1575	2.3	Acceptable	Perceptible
94	Informal Housing	6	1711	1575	2.3	Acceptable	Perceptible
95	Informal Housing	6	1647	1575	2.4	Acceptable	Perceptible

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
96	Informal Housing	6	1679	1575	2.4	Acceptable	Perceptible
97	Informal Housing	6	1678	1575	2.4	Acceptable	Perceptible
98	Farmstead	12.5	1943	1575	1.9	Acceptable	Perceptible
99	Farmhouse	12.5	2066	1575	1.7	Acceptable	Perceptible
100	Farm Building	12.5	2004	1575	1.8	Acceptable	Perceptible
101	Building/Structures (Packing Sheds)	12.5	1941	1575	1.9	Acceptable	Perceptible
102	Communication Tower	25	1832	1575	2.1	Acceptable	N/A
103	Farmstead	12.5	2061	1575	1.7	Acceptable	Perceptible
104	Informal Housing	6	1749	1575	2.2	Acceptable	Perceptible
105	Informal Housing	6	1730	1575	2.3	Acceptable	Perceptible
106	Informal Housing	6	1742	1575	2.2	Acceptable	Perceptible
107	Informal Housing	6	1750	1575	2.2	Acceptable	Perceptible
108	Informal Housing	6	1772	1575	2.2	Acceptable	Perceptible
109	Informal Housing	6	1780	1575	2.1	Acceptable	Perceptible
110	Informal Housing	6	1763	1575	2.2	Acceptable	Perceptible
111	Informal Housing	6	1763	1575	2.2	Acceptable	Perceptible
112	Informal Housing	6	1755	1575	2.2	Acceptable	Perceptible
113	Informal Housing	6	1713	1575	2.3	Acceptable	Perceptible
114	Informal Housing	6	1696	1575	2.3	Acceptable	Perceptible
115	Informal Housing	6	1737	1575	2.2	Acceptable	Perceptible
116	Houses	12.5	2188	1575	1.5	Acceptable	Perceptible
117	Houses	12.5	2194	1575	1.5	Acceptable	Perceptible
118	Houses	12.5	2212	1575	1.5	Acceptable	Perceptible
119	Houses	12.5	2221	1575	1.5	Acceptable	Perceptible
120	Houses	12.5	2251	1575	1.5	Acceptable	Perceptible
121	Houses	12.5	2241	1575	1.5	Acceptable	Perceptible
122	Houses	12.5	2258	1575	1.5	Acceptable	Perceptible
123	Houses	12.5	2263	1575	1.4	Acceptable	Perceptible
124	Houses	12.5	2274	1575	1.4	Acceptable	Perceptible
125	Houses	12.5	2286	1575	1.4	Acceptable	Perceptible
126	Informal Housing	6	2282	1575	1.4	Acceptable	Perceptible
127	Informal Housing	6	2292	1575	1.4	Acceptable	Perceptible
128	Informal Housing	6	2342	1575	1.4	Acceptable	Perceptible
129	Farmhouse	12.5	2606	1575	1.1	Acceptable	Perceptible
130	Farmhouse	12.5	2753	1575	1.0	Acceptable	Perceptible
131	Reservoirs	50	2610	1575	1.1	Acceptable	N/A
132	Communication Tower	25	2567	1575	1.2	Acceptable	N/A
133	Farmstead	12.5	2578	1575	1.2	Acceptable	Perceptible
134	Farmstead	12.5	2548	1575	1.2	Acceptable	Perceptible
135	Farm Structures	12.5	2497	1575	1.2	Acceptable	Perceptible
136	Dam/Dam wall	50	2446	1575	1.3	Acceptable	N/A
137	Kraal	50	2693	1575	1.1	Acceptable	N/A
138	House	12.5	3267	1575	0.8	Acceptable	Perceptible
139	Building/Structure	12.5	3221	1575	0.8	Acceptable	Perceptible
140	Building/Structure	12.5	3407	1575	0.7	Acceptable	Too Low
141	House	12.5	2151	1575	1.6	Acceptable	Perceptible

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
142	House	12.5	2826	1575	1.0	Acceptable	Perceptible
143	House	12.5	2758	1575	1.0	Acceptable	Perceptible
144	Farm Buildings	12.5	3366	1575	0.8	Acceptable	Too Low
145	Building/Structure	12.5	3265	1575	0.8	Acceptable	Perceptible
146	Farmstead	12.5	1765	1575	2.2	Acceptable	Perceptible
147	Farm Buildings	12.5	1742	1575	2.2	Acceptable	Perceptible
148	Farmstead	12.5	2284	1575	1.4	Acceptable	Perceptible
149	Building/Structure	12.5	2231	1575	1.5	Acceptable	Perceptible
150	Dam/Dam wall	50	2515	1575	1.2	Acceptable	N/A
151	Heritage Site -Historical Structures	6	1395	1575	3.2	Acceptable	Perceptible
152	Farm Structure	12.5	1376	1575	3.3	Acceptable	Perceptible
153	House	12.5	1419	1575	3.1	Acceptable	Perceptible
154	House	12.5	1343	1575	3.4	Acceptable	Perceptible
155	Livestock	50	1288	1575	3.7	Acceptable	N/A
156	Cement Dam	50	1506	1575	2.8	Acceptable	N/A
157	Farmstead	12.5	1804	1575	2.1	Acceptable	Perceptible
158	Farm Structure	12.5	1751	1575	2.2	Acceptable	Perceptible
159	Farm Structure	12.5	1863	1575	2.0	Acceptable	Perceptible
175	Farmstead	12.5	3156	1575	0.8	Acceptable	Perceptible
176	Farm Buildings	12.5	3219	1575	0.8	Acceptable	Perceptible
177	House	12.5	3174	1575	0.8	Acceptable	Perceptible
178	Reservoir	50	3103	1575	0.9	Acceptable	N/A
179	Marsh	200	2813	1575	1.0	Acceptable	N/A
196	Farm Structures	12.5	3243	1575	0.8	Acceptable	Perceptible
197	Farm Structures	12.5	3121	1575	0.9	Acceptable	Perceptible
198	Farmstead	12.5	3075	1575	0.9	Acceptable	Perceptible
199	Farm Building	12.5	3033	1575	0.9	Acceptable	Perceptible
200	Livestock	50	3277	1575	0.8	Acceptable	N/A
201	Informal Housing	6	2821	1575	1.0	Acceptable	Perceptible
202	Informal Housing	6	2727	1575	1.1	Acceptable	Perceptible
203	Informal Housing	6	2754	1575	1.0	Acceptable	Perceptible
204	Informal Housing	6	2741	1575	1.1	Acceptable	Perceptible
205	Kraal	50	2537	1575	1.2	Acceptable	N/A
206	Farmhouse	12.5	2504	1575	1.2	Acceptable	Perceptible
207	Farmhouse	12.5	2544	1575	1.2	Acceptable	Perceptible
208	Farmhouse	12.5	2549	1575	1.2	Acceptable	Perceptible
209	Livestock	50	2481	1575	1.2	Acceptable	N/A
210	Dam/Dam wall	50	2551	1575	1.2	Acceptable	N/A
211	Informal Housing	6	3145	1575	0.8	Acceptable	Perceptible
212	Informal Housing	6	3284	1575	0.8	Acceptable	Perceptible
213	River	200	2905	1575	1.0	Acceptable	N/A
215	Mine Buildings	25	1971	1575	1.8	Acceptable	N/A
216	Mine Buildings	25	2569	1575	1.2	Acceptable	N/A
217	Mine Buildings	25	2613	1575	1.1	Acceptable	N/A
218	Mine Building	25	2536	1575	1.2	Acceptable	N/A
219	Farmstead	12.5	1974	1575	1.8	Acceptable	Perceptible

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
220	Farm Building	12.5	1905	1575	1.9	Acceptable	Perceptible
221	Nett Shading/Orchards	25	2060	1575	1.7	Acceptable	N/A
222	Agricultural Tunnels	25	2205	1575	1.5	Acceptable	N/A
223	Agricultural Tunnels	25	2363	1575	1.3	Acceptable	N/A
224	Farm Building	12.5	2202	1575	1.5	Acceptable	Perceptible
225	Reservoir	50	3405	1575	0.7	Acceptable	N/A
226	Farmstead	12.5	1896	1575	1.9	Acceptable	Perceptible
227	Farm Buildings	12.5	1941	1575	1.9	Acceptable	Perceptible
228	Farm Building	12.5	1970	1575	1.8	Acceptable	Perceptible
229	Farm Buildings	12.5	1875	1575	2.0	Acceptable	Perceptible
230	Livestock	50	2056	1575	1.7	Acceptable	N/A
231	Dam/Dam wall	50	1126	1575	4.6	Acceptable	N/A
232	Dam/Dam wall	50	963	1575	5.9	Acceptable	N/A
233	Dam/Dam wall	50	1094	1575	4.8	Acceptable	N/A
234	River	200	493	1575	17.9	Acceptable	N/A
235	River	200	1240	1575	3.9	Acceptable	N/A
236	Dam/Dam wall	50	1442	1575	3.0	Acceptable	N/A
237	Dam/Dam wall	50	1633	1575	2.5	Acceptable	N/A
238	Farmhouse	12.5	1712	1575	2.3	Acceptable	Perceptible
239	Farm Building	12.5	1714	1575	2.3	Acceptable	Perceptible
240	Houses	12.5	2665	1575	1.1	Acceptable	Perceptible
241	Farmhouse	12.5	3147	1575	0.8	Acceptable	Perceptible
242	Farm Building	12.5	3222	1575	0.8	Acceptable	Perceptible
243	Structures	12.5	3191	1575	0.8	Acceptable	Perceptible
244	Houses	12.5	3282	1575	0.8	Acceptable	Perceptible
245	Houses	12.5	3277	1575	0.8	Acceptable	Perceptible
246	Houses	12.5	3327	1575	0.8	Acceptable	Perceptible
247	Railway Substation	25	1541	1575	2.7	Acceptable	N/A
248	Pivot Irrigation	150	686	1575	10.4	Acceptable	N/A
249	Dam/Dam wall	50	881	1575	6.9	Acceptable	N/A
250	Communication Tower	25	1506	1575	2.8	Acceptable	N/A
251	Informal Settlement	6	3004	1575	0.9	Acceptable	Perceptible
252	Informal Settlement	6	3386	1575	0.7	Acceptable	Too Low
253	Informal Settlement	6	3158	1575	0.8	Acceptable	Perceptible
254	Farmstead	12.5	3212	1575	0.8	Acceptable	Perceptible
255	Farmstead	12.5	3460	1575	0.7	Acceptable	Too Low
256	Explosives Magazines	25	859	1575	7.2	Acceptable	N/A
257	Dam/Dam wall	50	3291	1575	0.8	Acceptable	N/A
258	Hydrocencus Borehole (BLYBH3)	50	2843	1575	1.0	Acceptable	N/A
259	Hydrocencus Borehole (BLYBH4)	50	2460	1575	1.3	Acceptable	N/A
261	Hydrocencus Borehole (HADECBH)	50	3134	1575	0.8	Acceptable	N/A
262	Hydrocencus Borehole (HADECBH2)	50	1759	1575	2.2	Acceptable	N/A
263	Hydrocencus Borehole (HADECBH3)	50	1764	1575	2.2	Acceptable	N/A
264	Hydrocencus Borehole (REBH1)	50	1769	1575	2.2	Acceptable	N/A
265	Hydrocencus Borehole (ZOE BH)	50	1961	1575	1.8	Acceptable	N/A
267	Hydrocencus Borehole (DRIBH1)	50	386	1575	26.7	Acceptable	N/A

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
268	Hydrocencus Borehole (DRIBH2)	50	684	1575	10.4	Acceptable	N/A
269	Hydrocencus Borehole (SACBH)	50	1887	1575	2.0	Acceptable	N/A
270	Hydrocencus Borehole (BLYBH2)	50	2471	1575	1.3	Acceptable	N/A
271	Hydrocencus Borehole (VOGBH1)	50	2471	1575	1.3	Acceptable	N/A
272	Hydrocencus Borehole (WELBH2)	50	1790	1575	2.1	Acceptable	N/A
273	Hydrocencus Borehole (ZOEBH2)	50	1461	1575	3.0	Acceptable	N/A
274	Hydrocencus Borehole (GRMBH1)	50	2628	1575	1.1	Acceptable	N/A
275	Hydrocencus Borehole (WELBH6)	50	475	1575	19.0	Acceptable	N/A
276	Hydrocencus (Spring used for commercial bottled water)	50	464	1575	19.8	Acceptable	N/A
277	Heritage Site (Graves) - Inside OC2 Pit Area	12.5	-	1575	-	-	-

## 17.2 Summary of ground vibration levels

The opencast operations were evaluated for expected levels of ground vibration from future blasting operations. Review of the site and the surrounding installations / houses / buildings showed that structures vary in distances from the pit areas. The influences will also vary with distance from the pit areas. The model used for evaluation does indicate low and high levels. It will be imperative to ensure that a monitoring program is done to confirm levels of ground vibration to ensure that ground vibration levels are not exceeded.

The evaluation mainly considered a distance up to 3500 m from the pit areas. Houses and infrastructure found around the different pit areas ranges in distances. Distances ranges from very close to the full extent of the areas considered. The planned maximum charge evaluated showed that for some of these structures and infrastructure ground vibration may be high and could be problematic in terms of potential structural damage and human perception. The ground vibration levels predicted ranged between 0.2 mm/s and very high levels for structures surrounding both the pit areas. In view of the maximum charge specific attention will need to be given to specific areas. High concentration of structures is found close to some of the areas evaluated.

### Pit OC1:

Various POI's were identified as problematic. Two POI's are found within the boundaries of the pit area. Evaluation of minimum charge showed that ground vibration may be problematic for 13 other POI's that ranges in distance from next to the pit up to 217 m. Structures beyond 217 m showed levels of ground vibration to be within accepted norms with no concerns for negative influence. Evaluation of maximum charge showed 24 POI's ranging from next to the pit up to 791 m could experience ground vibration levels as problematic. Houses beyond 791 m from the pit area showed

levels within accepted norms with no concern for damage from maximum charge evaluated. On a human perception scale, 25 POI's were identified that will experience ground vibration as intolerable and unpleasant.

#### Pit OC2:

Various POI's were identified as problematic. Evaluation of minimum charge showed that ground vibration expected is greater than proposed limit for one POI. Twelve POI's were identified as problematic for maximum charge evaluated. The nearest structure is located 139 m from pit boundary. House structures beyond 1227 m showed levels of ground vibration to be within accepted norms with no concerns for negative influence. On human perception scale thirteen POI's were identified that will experience ground vibration as unpleasant.

Six Heritage Sites which include graves, dam walls and historical structures were identified by the Heritage Specialist. The Heritage Specialist recommended that certain mitigation measures have to be applied to the historical remains and graveyards and graves which will be affected directly or indirectly during the construction and operational phase for the proposed project.

There are 19 Hydrocencus boreholes identified within the mining right area and it is uncertain what the long-term plan will be for these boreholes. Only one borehole closest to Pit OC1 area was found that could possibly be negatively influenced. Expected levels of ground vibration is greater than proposed limit for this borehole.

There are a significant number of houses located in the area between the two open pit areas. BM&C does not have any specific information on the planned actions regarding these structures. These structures are considered as is in the evaluation. Should these structures or households be relocated the impact level will certainly be reduced.

Mitigation of ground vibration was considered and discussed in Section 17.13. A detailed inspection of the area and accurate identification of structures will also need to be done to ensure the levels of ground vibration allowable and limit to be applied.

### **17.3 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 30 Hz frequency and plotted with expected human perceptions on the safe blasting criteria graph (see Figure 16 below). The frequency range selected is the expected average range for frequencies that will be measured for ground vibration when blasting is done. Based on the maximum charge and ground vibration predicted over distance it can



be seen from Figure 16 that up to a distance of 3379 m people may experience levels of ground vibration as perceptible, up to 1004 m as unpleasant and up to 489 m as intolerable.

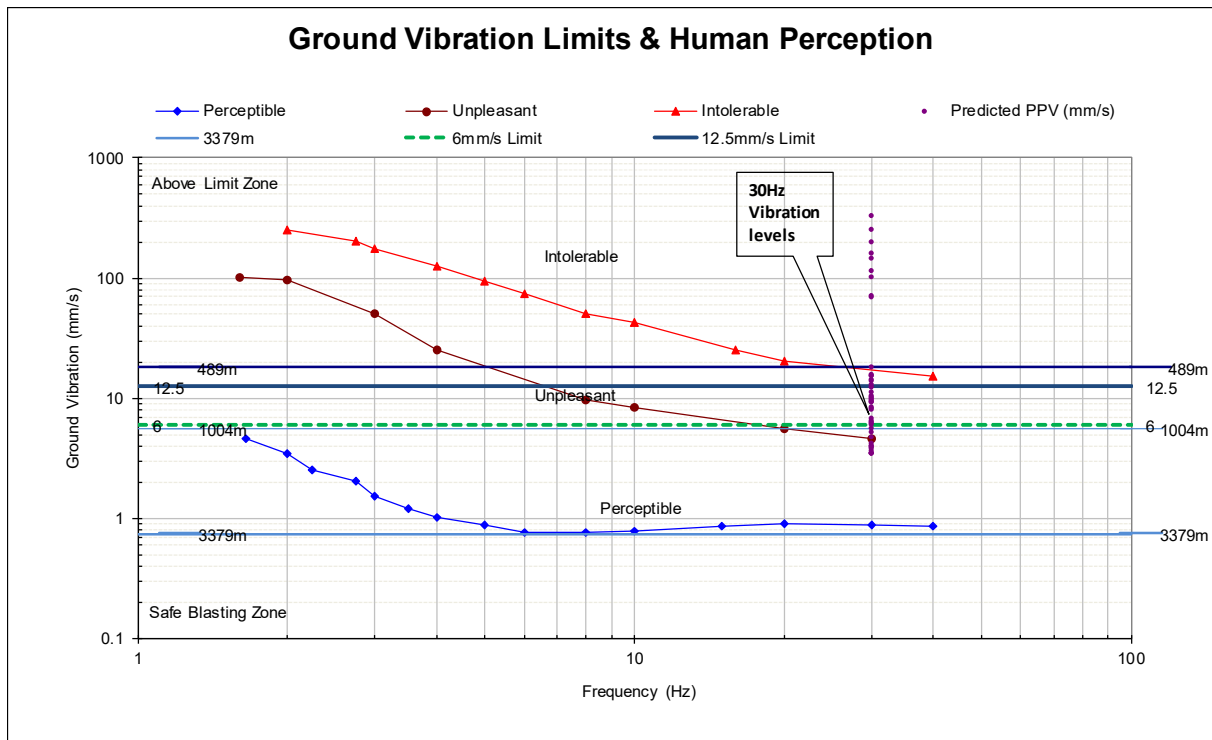


Figure 16: The effect of ground vibration with human perception and vibration limits

#### 17.4 Vibration impact on roads

There are various gravel roads in the vicinity of the project area and needs to be considered. There may be people and animals on these routes and will require careful planning to main safe blasting radius. There is no specific concern regarding the ground vibration impact on the gravel roads.

The N4 National road is closest to the Pit OC2 at 1222 m with no specific concern identified.

The R33 Provincial Road is directly next to the Pit OC1 area on the eastern side and expected ground vibration levels are very high and could be problematic. Final mine designs will need to consider the location of the R33 road next to the Pit OC1 area and adjustments to blast design and operations will be required. Further it will be required that clearance distances are set, and road travel managed during blasting operations.

#### 17.5 Potential that vibration will upset adjacent communities

Ground vibration and air blast generally upset people living in the vicinity of mining operations. There are settlements of people in proximity of planned operations. These buildings/structures are located such that levels of ground vibration predicted may be problematic and damaging.

Ground vibration levels expected from maximum charge has possibility to be perceptible up to 3379 m. It is certain that lesser charges will reduce this distance for instance at minimum charge this distance is expected to be 1344 m. Within these distance ranges there are still a significant number of houses and ground vibration predicted may be experienced as intolerable.

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

#### **17.6 Cracking of houses and consequent devaluation**

The structures found in the areas of concern ranges from informal building style to brick and mortar structures. There are various buildings found within the 3500 m range from the mining area. Building style and materials will certainly contribute to additional cracking apart from influences such as blasting operations.

The presence of general vertical cracks, horizontal and diagonal 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. Thus, damage in the form of cracks will be present. Exact costing of devaluation for normal cracks observed is difficult to estimate. Mining operations may not have influence to change the status quo of any property if correct precautions are considered.

The proposed limits as applied in this document i.e. 6 mm/s, 12.5 mm/s and 25 mm/s are considered enough to ensure that additional damage is not introduced to the different categories of structures. It is expected that, should levels of ground vibration be maintained within these limits, the possibility of inducing damage is limited.

#### **17.7 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 areas 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 dB;
  - “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 dB;
  - “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 each pit area. 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”
POI’s that are found inside the pit area is coloured “Olive Green”

### 17.7.1 Minimum charge mass per delay – 263 kg – OC1 Opencast Pit

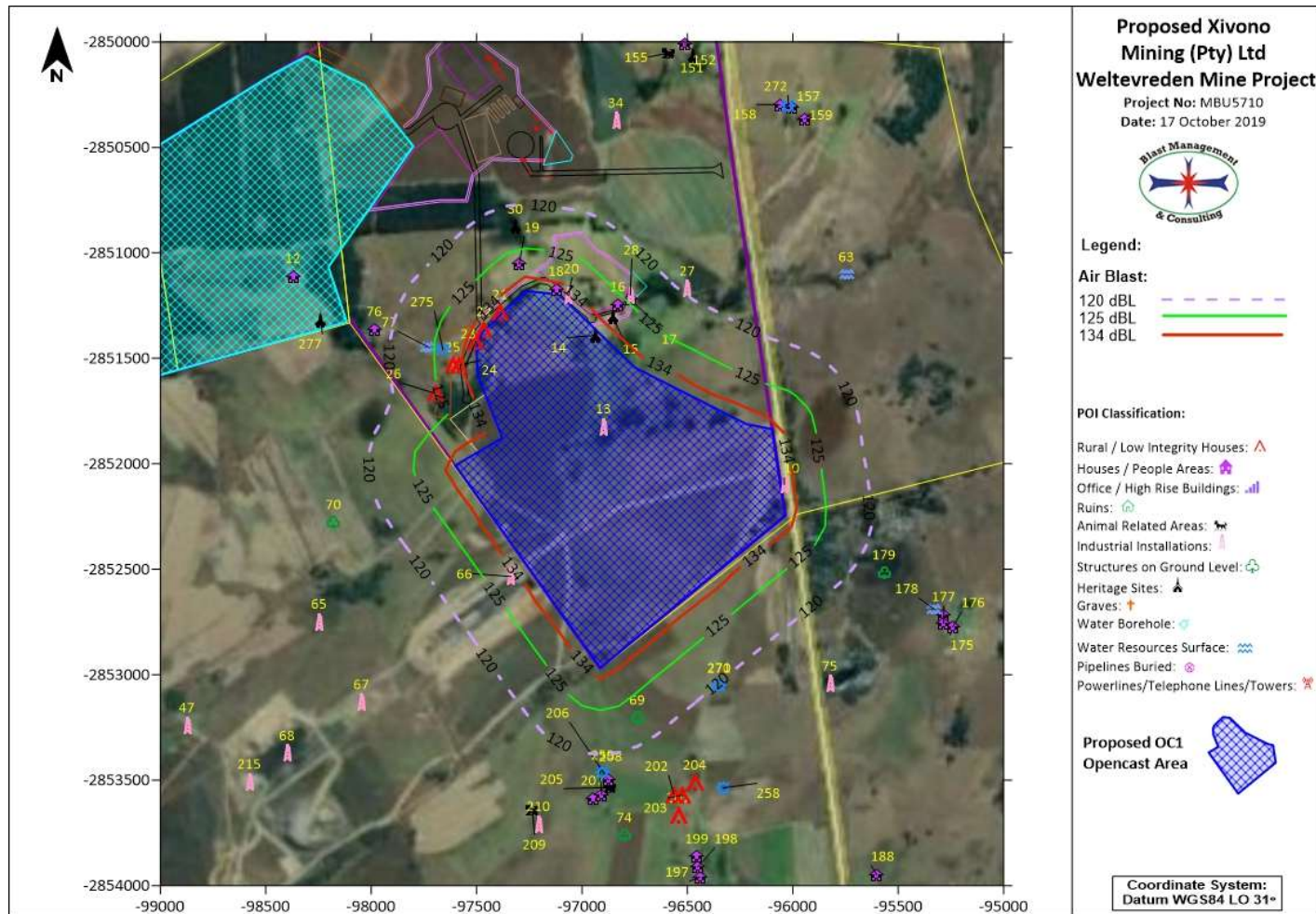


Figure 17: Air blast influence from minimum charge for Pit OC1 Area

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Page 99 of 165

Table 14: Air blast evaluation for minimum charge for Pit OC1 Area

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
3	Railway Line	3445	105.5	N/A
10	R33 Road	17	141.8	N/A
11	Dirt Road	2690	107.2	N/A
12	House (Inside OC2 Area)	931	114.4	Acceptable
13	Heritage Site - Dam/Dam wall (Inside OC1 Area)	317	-	-
14	Heritage Site -Historical Structures (Inside OC1 Area)	19	-	-
15	Heritage Site -Historical Structures	99	129.7	Complaint
16	Farm Buildings	160	126.5	Complaint
17	Farm Buildings	217	124.4	Complaint
18	Farmhouse	25	139.2	Problematic
19	Farm Buildings	131	127.9	Complaint
20	Cement Dam	28	138.5	N/A
21	Informal Housing	12	144.1	Problematic
22	Informal Housing	5	150.3	Problematic
23	Informal Housing	18	141.6	Problematic
24	Informal Housing	85	130.8	Complaint
25	Informal Housing	114	128.8	Complaint
26	Informal Housing	214	124.5	Complaint
27	Dam/Dam wall	443	119.5	N/A
28	Cement Dam	232	123.9	N/A
29	Cement Dam	2143	108.7	N/A
30	Heritage Site - Dam/Dam wall	308	122.0	N/A
31	Dam/Dam wall	1400	111.7	N/A
32	Dam/Dam wall	2035	109.0	N/A
33	Pan	2327	108.1	N/A
34	Dam/Dam wall	870	114.8	N/A
35	Dam/Dam wall	1918	109.5	N/A
36	Dam/Dam wall	3272	105.8	N/A
38	Pan	1813	109.9	N/A
39	Dam/Dam wall	2679	107.2	N/A
40	Dam/Dam wall	2380	108.1	N/A
41	Dam/Dam wall	3423	105.5	N/A
42	Dam/Dam wall	2732	107.0	N/A
43	Dam/Dam wall	3321	105.8	N/A
44	Dam/Dam wall	3416	105.5	N/A
46	Dam/Dam wall	1930	109.5	N/A
47	Dam/Dam wall	1751	110.1	N/A
55	Dam/Dam wall	3471	105.5	N/A
57	Dam/Dam wall	2773	107.0	N/A
59	Dam/Dam wall	3154	106.2	N/A
60	Dam/Dam wall	3020	106.4	N/A

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
61	Pan	2275	108.2	N/A
62	River	1364	111.8	N/A
63	River	817	115.3	N/A
64	River	2477	107.7	N/A
65	Dam/Dam wall	954	114.3	N/A
66	Mine Activity	92	130.3	N/A
67	Mine Activity	1013	113.8	N/A
68	Coal Yard	1441	111.4	N/A
69	Cultivated Fields	294	122.3	N/A
70	Cultivated Fields	634	117.0	N/A
71	Cultivated Fields	2294	108.2	N/A
72	Cultivated Fields	2958	106.6	N/A
73	Cultivated Fields	3165	106.0	N/A
74	Cultivated Fields	802	115.4	N/A
75	Old Quarry	751	115.9	N/A
76	Farmhouse	490	118.8	Acceptable
77	Reservoir	230	124.0	N/A
78	Dam/Dam wall	2548	107.6	N/A
79	Pan	3050	106.4	N/A
80	Farmstead	3035	106.4	Acceptable
81	Farm Buildings	2945	106.6	Acceptable
82	Informal Housing	3166	106.0	Acceptable
83	Informal Housing	3232	106.0	Acceptable
84	Informal Housing	3254	106.0	Acceptable
85	Gravel Road	3303	105.8	N/A
86	Farmstead	3484	105.5	Acceptable
95	Informal Housing	3505	105.3	Acceptable
96	Informal Housing	3516	105.3	Acceptable
97	Informal Housing	3506	105.3	Acceptable
104	Informal Housing	3415	105.5	Acceptable
105	Informal Housing	3379	105.5	Acceptable
106	Informal Housing	3386	105.5	Acceptable
107	Informal Housing	3387	105.5	Acceptable
108	Informal Housing	3400	105.5	Acceptable
109	Informal Housing	3401	105.5	Acceptable
110	Informal Housing	3370	105.8	Acceptable
111	Informal Housing	3364	105.8	Acceptable
112	Informal Housing	3349	105.8	Acceptable
113	Informal Housing	3301	105.8	Acceptable
114	Informal Housing	3278	105.8	Acceptable
115	Informal Housing	3316	105.8	Acceptable
134	Farmstead	3253	106.0	Acceptable
135	Farm Structures	3232	106.0	Acceptable
136	Dam/Dam wall	3249	106.0	N/A



Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
137	Kraal	3469	105.5	N/A
141	House	2825	106.8	Acceptable
142	House	3290	105.8	Acceptable
143	House	3166	106.0	Acceptable
146	Farmstead	2315	108.2	Acceptable
147	Farm Buildings	2236	108.4	Acceptable
148	Farmstead	2082	108.9	Acceptable
149	Building/Structure	1950	109.3	Acceptable
150	Dam/Dam wall	2285	108.2	N/A
151	Heritage Site -Historical Structures	1299	112.1	Acceptable
152	Farm Structure	1329	112.0	Acceptable
153	House	1394	111.7	Acceptable
154	House	1411	111.5	Acceptable
155	Livestock	1258	112.3	N/A
156	Cement Dam	1451	111.4	N/A
157	Farmstead	1403	111.7	Acceptable
158	Farm Structure	1374	111.8	Acceptable
159	Farm Structure	1408	111.5	Acceptable
160	Dam/Dam wall	1874	109.6	N/A
161	Farmstead	2097	108.9	Acceptable
162	Farmhouse	2170	108.6	Acceptable
163	House	2016	109.2	Acceptable
164	House	2147	108.7	Acceptable
165	House	2185	108.6	Acceptable
166	House	2189	108.6	Acceptable
167	House	2198	108.6	Acceptable
168	House	2218	108.4	Acceptable
169	House	2209	108.6	Acceptable
170	House	2173	108.6	Acceptable
171	Farmstead	3464	105.5	Acceptable
172	Dam/Dam wall	3444	105.5	N/A
174	Farm Structure	2857	106.8	Acceptable
175	Farmstead	891	114.7	Acceptable
176	Farm Buildings	957	114.2	Acceptable
177	House	913	114.5	Acceptable
178	Reservoir	838	115.1	N/A
179	Marsh	544	118.1	N/A
180	Informal Housing	2387	107.9	Acceptable
181	House	2402	107.9	Acceptable
182	Livestock	2458	107.7	N/A
183	River	2617	107.4	N/A
184	River	2018	109.2	N/A
185	Farmstead	1617	110.6	Acceptable

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
186	Farm Buildings	1660	110.5	Acceptable
187	Farm Buildings	1577	110.8	Acceptable
188	Farm Building	1589	110.7	Acceptable
189	Reservoir	1591	110.7	N/A
190	Farm Structure	1852	109.8	Acceptable
191	Informal Housing	2748	107.0	Acceptable
192	Informal Housing	2850	106.8	Acceptable
193	Informal Housing	2962	106.6	Acceptable
194	Farmstead	3153	106.2	Acceptable
195	Farm Building	3070	106.2	Acceptable
196	Farm Structures	1232	112.5	Acceptable
197	Farm Structures	1097	113.3	Acceptable
198	Farmstead	1050	113.6	Acceptable
199	Farm Building	1005	113.8	Acceptable
200	Livestock	1252	112.4	N/A
201	Informal Housing	791	115.5	Acceptable
202	Informal Housing	694	116.4	Acceptable
203	Informal Housing	718	116.2	Acceptable
204	Informal Housing	705	116.3	Acceptable
205	Kraal	570	117.8	N/A
206	Farmhouse	534	118.2	Acceptable
207	Farmhouse	620	117.2	Acceptable
208	Farmhouse	602	117.4	Acceptable
209	Livestock	751	115.9	N/A
210	Dam/Dam wall	798	115.4	N/A
211	Informal Housing	1422	111.5	Acceptable
212	Informal Housing	1547	111.0	Acceptable
213	River	1434	111.4	N/A
214	Marsh	3001	106.4	N/A
215	Mine Buildings	1666	110.5	N/A
216	Mine Buildings	1968	109.3	N/A
217	Mine Buildings	1999	109.2	N/A
218	Mine Building	1979	109.2	N/A
219	Farmstead	2292	108.2	Acceptable
220	Farm Building	2221	108.4	Acceptable
221	Nett Shading/Orchards	2319	108.2	N/A
222	Agricultural Tunnels	2386	107.9	N/A
223	Agricultural Tunnels	2702	107.2	N/A
224	Farm Building	2630	107.4	Acceptable
231	Dam/Dam wall	2758	107.0	N/A
232	Dam/Dam wall	2979	106.4	N/A
233	Dam/Dam wall	3160	106.2	N/A
234	River	2793	107.0	N/A
235	River	2728	107.0	N/A

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
248	Pivot Irrigation	2199	108.6	N/A
249	Dam/Dam wall	1863	109.6	N/A
250	Communication Tower	3333	105.8	N/A
256	Explosives Magazines	1590	110.7	N/A
257	Dam/Dam wall	1257	112.3	N/A
258	Hydrocencus Borehole (BLYBH3)	810	115.4	N/A
259	Hydrocencus Borehole (BLYBH4)	497	118.7	N/A
262	Hydrocencus Borehole (HADECBH2)	3475	105.5	N/A
263	Hydrocencus Borehole (HADECBH3)	3481	105.5	N/A
264	Hydrocencus Borehole (REBH1)	3331	105.8	N/A
267	Hydrocencus Borehole (DRIBH1)	2558	107.6	N/A
268	Hydrocencus Borehole (DRIBH2)	2202	108.6	N/A
269	Hydrocencus Borehole (SACBH)	2233	108.4	N/A
270	Hydrocencus Borehole (BLYBH2)	424	119.8	N/A
271	Hydrocencus Borehole (VOGBH1)	424	119.8	N/A
272	Hydrocencus Borehole (WELBH2)	1398	111.7	N/A
273	Hydrocencus Borehole (ZOEHB2)	1408	111.5	N/A
274	Hydrocencus Borehole (GRMBH1)	3288	105.8	N/A
275	Hydrocencus Borehole (WELBH6)	160	126.5	N/A
276	Hydrocencus (Spring used for commercial bottled water)	2896	106.6	N/A
277	Heritage Site (Graves) - Inside OC2 Pit Area	751	115.9	Acceptable

### 17.7.2 Maximum charge mass per delay – 1575 kg – OC1 Opencast Pit

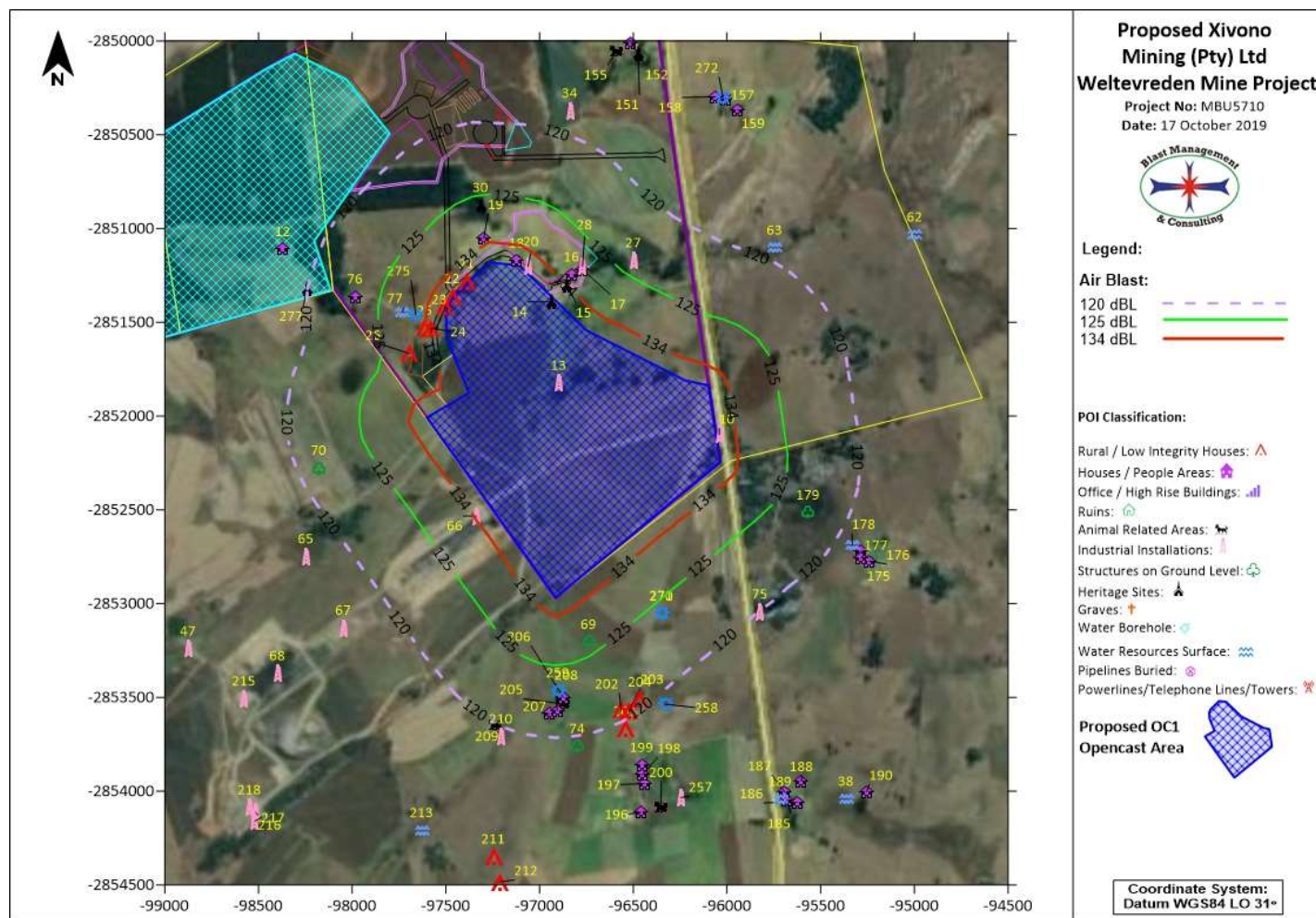


Figure 18: Air blast influence from maximum charge for Pit OC1 Area

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Table 15: Air blast evaluation for maximum charge for Pit OC1 Area

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
3	Railway Line	3445	109.5	N/A
10	R33 Road	17	145.9	N/A
11	Dirt Road	2690	111.2	N/A
12	House (Inside OC2 Area)	931	118.5	Acceptable
13	Heritage Site - Dam/Dam wall (Inside OC1 Area)	317	-	-
14	Heritage Site -Historical Structures (Inside OC1 Area)	19	-	-
15	Heritage Site -Historical Structures	99	133.8	Problematic
16	Farm Buildings	160	130.6	Complaint
17	Farm Buildings	217	128.4	Complaint
18	Farmhouse	25	143.3	Problematic
19	Farm Buildings	131	131.9	Complaint
20	Cement Dam	28	142.6	N/A
21	Informal Housing	12	148.2	Problematic
22	Informal Housing	5	154.4	Problematic
23	Informal Housing	18	145.7	Problematic
24	Informal Housing	85	134.9	Problematic
25	Informal Housing	114	132.9	Complaint
26	Informal Housing	214	128.6	Complaint
27	Dam/Dam wall	443	123.6	N/A
28	Cement Dam	232	128.0	N/A
29	Cement Dam	2143	112.8	N/A
30	Heritage Site - Dam/Dam wall	308	126.1	N/A
31	Dam/Dam wall	1400	115.7	N/A
32	Dam/Dam wall	2035	113.1	N/A
33	Pan	2327	112.2	N/A
34	Dam/Dam wall	870	118.9	N/A
35	Dam/Dam wall	1918	113.6	N/A
36	Dam/Dam wall	3272	109.9	N/A
38	Pan	1813	113.9	N/A
39	Dam/Dam wall	2679	111.3	N/A
40	Dam/Dam wall	2380	112.1	N/A
41	Dam/Dam wall	3423	109.6	N/A
42	Dam/Dam wall	2732	111.1	N/A
43	Dam/Dam wall	3321	109.8	N/A
44	Dam/Dam wall	3416	109.6	N/A
46	Dam/Dam wall	1930	113.5	N/A
47	Dam/Dam wall	1751	114.2	N/A
55	Dam/Dam wall	3471	109.5	N/A
57	Dam/Dam wall	2773	111.1	N/A
59	Dam/Dam wall	3154	110.2	N/A
60	Dam/Dam wall	3020	110.5	N/A

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
61	Pan	2275	112.4	N/A
62	River	1364	115.9	N/A
63	River	817	119.4	N/A
64	River	2477	111.8	N/A
65	Dam/Dam wall	954	118.3	N/A
66	Mine Activity	92	134.4	N/A
67	Mine Activity	1013	117.9	N/A
68	Coal Yard	1441	115.5	N/A
69	Cultivated Fields	294	126.4	N/A
70	Cultivated Fields	634	121.1	N/A
71	Cultivated Fields	2294	112.3	N/A
72	Cultivated Fields	2958	110.6	N/A
73	Cultivated Fields	3165	110.2	N/A
74	Cultivated Fields	802	119.5	N/A
75	Old Quarry	751	120.0	N/A
76	Farmhouse	490	122.9	Complaint
77	Reservoir	230	128.0	N/A
78	Dam/Dam wall	2548	111.7	N/A
79	Pan	3050	110.3	N/A
80	Farmstead	3035	110.5	Acceptable
81	Farm Buildings	2945	110.6	Acceptable
82	Informal Housing	3166	110.2	Acceptable
83	Informal Housing	3232	110.1	Acceptable
84	Informal Housing	3254	109.9	Acceptable
85	Gravel Road	3303	109.8	N/A
86	Farmstead	3484	109.5	Acceptable
95	Informal Housing	3505	109.5	Acceptable
96	Informal Housing	3516	109.3	Acceptable
97	Informal Housing	3506	109.5	Acceptable
104	Informal Housing	3415	109.6	Acceptable
105	Informal Housing	3379	109.6	Acceptable
106	Informal Housing	3386	109.6	Acceptable
107	Informal Housing	3387	109.6	Acceptable
108	Informal Housing	3400	109.6	Acceptable
109	Informal Housing	3401	109.6	Acceptable
110	Informal Housing	3370	109.6	Acceptable
111	Informal Housing	3364	109.8	Acceptable
112	Informal Housing	3349	109.8	Acceptable
113	Informal Housing	3301	109.8	Acceptable
114	Informal Housing	3278	109.9	Acceptable
115	Informal Housing	3316	109.8	Acceptable
134	Farmstead	3253	109.9	Acceptable
135	Farm Structures	3232	110.1	Acceptable
136	Dam/Dam wall	3249	109.9	N/A



Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
137	Kraal	3469	109.5	N/A
141	House	2825	111.0	Acceptable
142	House	3290	109.9	Acceptable
143	House	3166	110.2	Acceptable
146	Farmstead	2315	112.3	Acceptable
147	Farm Buildings	2236	112.5	Acceptable
148	Farmstead	2082	113.0	Acceptable
149	Building/Structure	1950	113.4	Acceptable
150	Dam/Dam wall	2285	112.3	N/A
151	Heritage Site -Historical Structures	1299	116.2	Acceptable
152	Farm Structure	1329	116.1	Acceptable
153	House	1394	115.7	Acceptable
154	House	1411	115.7	Acceptable
155	Livestock	1258	116.4	N/A
156	Cement Dam	1451	115.4	N/A
157	Farmstead	1403	115.7	Acceptable
158	Farm Structure	1374	115.8	Acceptable
159	Farm Structure	1408	115.7	Acceptable
160	Dam/Dam wall	1874	113.7	N/A
161	Farmstead	2097	112.9	Acceptable
162	Farmhouse	2170	112.7	Acceptable
163	House	2016	113.2	Acceptable
164	House	2147	112.8	Acceptable
165	House	2185	112.6	Acceptable
166	House	2189	112.6	Acceptable
167	House	2198	112.6	Acceptable
168	House	2218	112.5	Acceptable
169	House	2209	112.6	Acceptable
170	House	2173	112.7	Acceptable
171	Farmstead	3464	109.5	Acceptable
172	Dam/Dam wall	3444	109.5	N/A
174	Farm Structure	2857	110.8	Acceptable
175	Farmstead	891	118.8	Acceptable
176	Farm Buildings	957	118.3	Acceptable
177	House	913	118.6	Acceptable
178	Reservoir	838	119.2	N/A
179	Marsh	544	122.2	N/A
180	Informal Housing	2387	112.1	Acceptable
181	House	2402	112.0	Acceptable
182	Livestock	2458	111.9	N/A
183	River	2617	111.4	N/A
184	River	2018	113.2	N/A
185	Farmstead	1617	114.7	Acceptable

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
186	Farm Buildings	1660	114.5	Acceptable
187	Farm Buildings	1577	114.9	Acceptable
188	Farm Building	1589	114.8	Acceptable
189	Reservoir	1591	114.8	N/A
190	Farm Structure	1852	113.8	Acceptable
191	Informal Housing	2748	111.1	Acceptable
192	Informal Housing	2850	110.8	Acceptable
193	Informal Housing	2962	110.6	Acceptable
194	Farmstead	3153	110.2	Acceptable
195	Farm Building	3070	110.3	Acceptable
196	Farm Structures	1232	116.6	Acceptable
197	Farm Structures	1097	117.3	Acceptable
198	Farmstead	1050	117.7	Acceptable
199	Farm Building	1005	118.0	Acceptable
200	Livestock	1252	116.5	N/A
201	Informal Housing	791	119.6	Acceptable
202	Informal Housing	694	120.5	Complaint
203	Informal Housing	718	120.2	Complaint
204	Informal Housing	705	120.4	Complaint
205	Kraal	570	121.9	N/A
206	Farmhouse	534	122.3	Complaint
207	Farmhouse	620	121.3	Complaint
208	Farmhouse	602	121.5	Complaint
209	Livestock	751	120.0	N/A
210	Dam/Dam wall	798	119.6	N/A
211	Informal Housing	1422	115.6	Acceptable
212	Informal Housing	1547	115.0	Acceptable
213	River	1434	115.5	N/A
214	Marsh	3001	110.5	N/A
215	Mine Buildings	1666	114.5	N/A
216	Mine Buildings	1968	113.4	N/A
217	Mine Buildings	1999	113.3	N/A
218	Mine Building	1979	113.3	N/A
219	Farmstead	2292	112.3	Acceptable
220	Farm Building	2221	112.5	Acceptable
221	Nett Shading/Orchards	2319	112.2	N/A
222	Agricultural Tunnels	2386	112.1	N/A
223	Agricultural Tunnels	2702	111.2	N/A
224	Farm Building	2630	111.4	Acceptable
231	Dam/Dam wall	2758	111.1	N/A
232	Dam/Dam wall	2979	110.6	N/A
233	Dam/Dam wall	3160	110.2	N/A
234	River	2793	111.0	N/A
235	River	2728	111.2	N/A

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
248	Pivot Irrigation	2199	112.6	N/A
249	Dam/Dam wall	1863	113.8	N/A
250	Communication Tower	3333	109.8	N/A
256	Explosives Magazines	1590	114.8	N/A
257	Dam/Dam wall	1257	116.4	N/A
258	Hydrocencus Borehole (BLYBH3)	810	119.5	N/A
259	Hydrocencus Borehole (BLYBH4)	497	122.8	N/A
262	Hydrocencus Borehole (HADECBH2)	3475	109.5	N/A
263	Hydrocencus Borehole (HADECBH3)	3481	109.5	N/A
264	Hydrocencus Borehole (REBH1)	3331	109.8	N/A
267	Hydrocencus Borehole (DRIBH1)	2558	111.5	N/A
268	Hydrocencus Borehole (DRIBH2)	2202	112.6	N/A
269	Hydrocencus Borehole (SACBH)	2233	112.5	N/A
270	Hydrocencus Borehole (BLYBH2)	424	123.9	N/A
271	Hydrocencus Borehole (VOGBH1)	424	123.9	N/A
272	Hydrocencus Borehole (WELBH2)	1398	115.7	N/A
273	Hydrocencus Borehole (ZOEBH2)	1408	115.7	N/A
274	Hydrocencus Borehole (GRMBH1)	3288	109.9	N/A
275	Hydrocencus Borehole (WELBH6)	160	130.6	N/A
276	Hydrocencus (Spring used for commercial bottled water)	2896	110.7	N/A
277	Heritage Site (Graves) - Inside OC2 Pit Area	751	120.0	Acceptable

### 17.7.3 Minimum charge mass per delay – 263 kg – Pit OC2

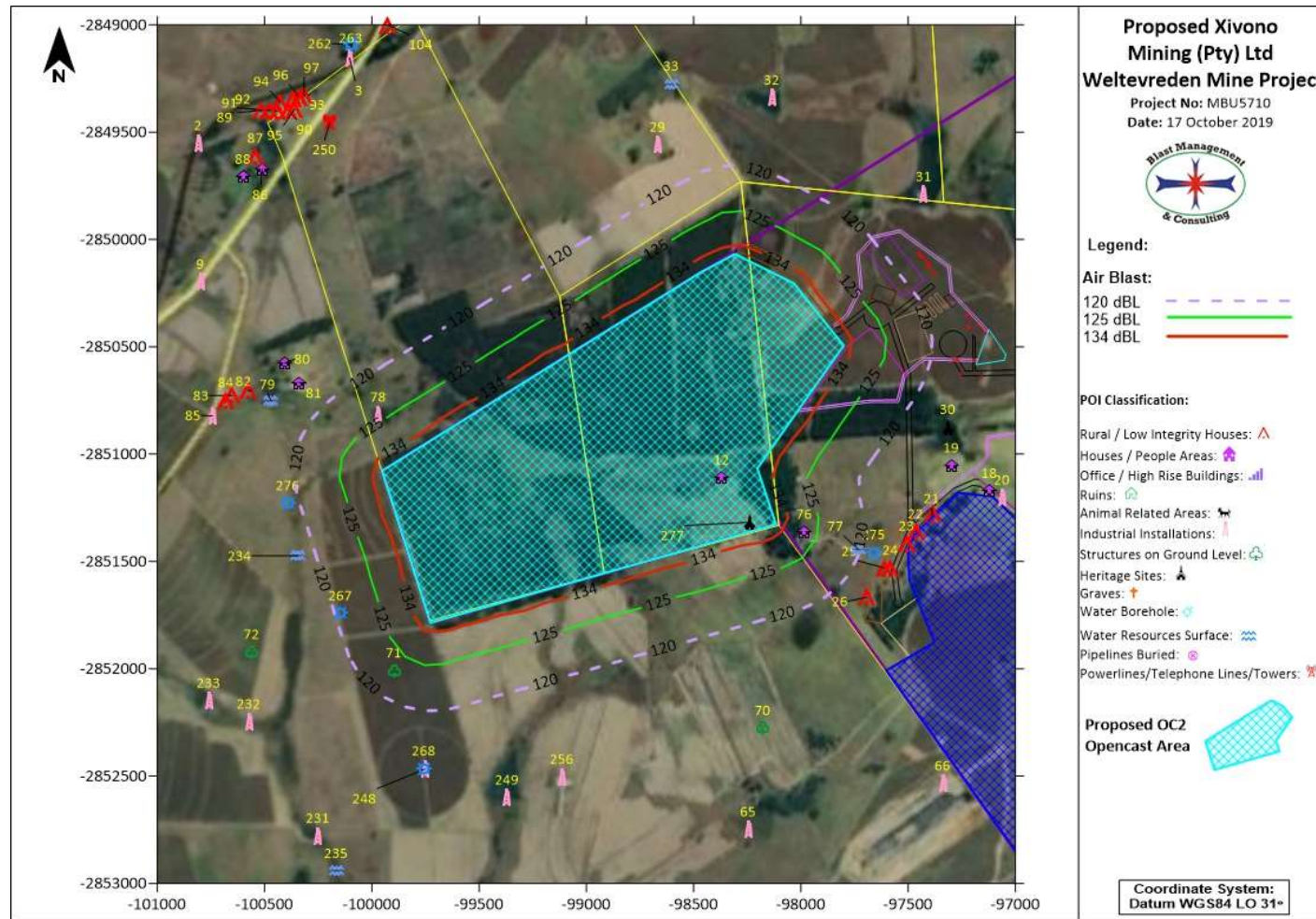


Figure 19: Air blast influence from minimum charge for Pit OC2

Table 16: Air blast evaluation for minimum charge for Pit OC2

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
1	Railway Line	1343	111.9	N/A
2	Railway Line	1748	110.1	N/A
3	Railway Line	1713	110.2	N/A
4	Railway Line	2120	108.7	N/A
5	Railway Line	2245	108.4	N/A
6	Railway Line	2849	106.8	N/A
7	Railway Line	1816	109.9	N/A
8	Railway Line	2544	107.6	N/A
9	N4 Road	1222	112.5	N/A
10	R33 Road	2215	108.6	N/A
12	House (Inside OC2 Area)	172	-	-
13	Heritage Site - Dam/Dam wall (Inside OC1 Area)	1318	112.0	N/A
14	Heritage Site -Historical Structures (Inside OC1 Area)	1183	112.8	Acceptable
15	Heritage Site -Historical Structures	1240	112.4	Acceptable
16	Farm Buildings	1227	112.5	Acceptable
17	Farm Buildings	1261	112.3	Acceptable
18	Farmhouse	946	114.3	Acceptable
19	Farm Buildings	733	116.1	Acceptable
20	Cement Dam	1011	113.8	N/A
21	Informal Housing	731	116.1	Acceptable
22	Informal Housing	653	116.9	Acceptable
23	Informal Housing	617	117.2	Acceptable
24	Informal Housing	573	117.7	Acceptable
25	Informal Housing	545	118.1	Acceptable
26	Informal Housing	544	118.1	Acceptable
27	Dam/Dam wall	1468	111.3	N/A
28	Cement Dam	1249	112.4	N/A
29	Cement Dam	619	117.2	N/A
30	Heritage Site - Dam/Dam wall	617	117.2	N/A
31	Dam/Dam wall	732	116.1	N/A
32	Dam/Dam wall	748	115.9	N/A
33	Pan	846	115.1	N/A
34	Dam/Dam wall	971	114.1	N/A
41	Dam/Dam wall	3122	106.2	N/A
42	Dam/Dam wall	2672	107.2	N/A
43	Dam/Dam wall	2614	107.4	N/A
44	Dam/Dam wall	2637	107.4	N/A
45	Dam/Dam wall	2686	107.2	N/A
46	Dam/Dam wall	1684	110.3	N/A
47	Dam/Dam wall	1633	110.6	N/A
48	Dam/Dam wall	2277	108.2	N/A
49	Dam/Dam wall	3117	106.2	N/A

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
50	Dam/Dam wall	2831	106.8	N/A
51	Dam/Dam wall	1739	110.2	N/A
52	Dam/Dam wall	2732	107.0	N/A
53	Dam/Dam wall	2093	108.9	N/A
54	Dam/Dam wall	2925	106.6	N/A
55	Dam/Dam wall	1938	109.3	N/A
56	Pan	2144	108.7	N/A
57	Dam/Dam wall	1441	111.4	N/A
58	Dam/Dam wall	3284	105.8	N/A
59	Dam/Dam wall	2770	107.0	N/A
60	Dam/Dam wall	2667	107.2	N/A
61	Pan	1637	110.6	N/A
62	River	2856	106.8	N/A
63	River	2146	108.7	N/A
64	River	2760	107.0	N/A
65	Dam/Dam wall	1332	112.0	N/A
66	Mine Activity	1438	111.4	N/A
67	Mine Activity	1754	110.1	N/A
68	Coal Yard	1890	109.6	N/A
69	Cultivated Fields	2331	108.1	N/A
70	Cultivated Fields	897	114.7	N/A
71	Cultivated Fields	283	122.6	N/A
72	Cultivated Fields	835	115.1	N/A
73	Cultivated Fields	1883	109.6	N/A
74	Cultivated Fields	2770	107.0	N/A
75	Old Quarry	2865	106.8	N/A
76	Farmhouse	139	127.4	Complaint
77	Reservoir	404	120.1	N/A
78	Dam/Dam wall	230	124.0	N/A
79	Pan	616	117.2	N/A
80	Farmstead	680	116.5	Acceptable
81	Farm Buildings	567	117.8	Acceptable
82	Informal Housing	732	116.1	Acceptable
83	Informal Housing	785	115.6	Acceptable
84	Informal Housing	800	115.4	Acceptable
85	Gravel Road	834	115.1	N/A
86	Farmstead	1487	111.2	Acceptable
87	Informal Housing	1556	111.0	Acceptable
88	Farm Buildings	1504	111.1	Acceptable
89	Informal Housing	1679	110.3	Acceptable
90	Informal Housing	1657	110.5	Acceptable
91	Informal Housing	1704	110.3	Acceptable
92	Informal Housing	1724	110.2	Acceptable
93	Informal Housing	1689	110.3	Acceptable



Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
94	Informal Housing	1711	110.2	Acceptable
95	Informal Housing	1647	110.6	Acceptable
96	Informal Housing	1679	110.3	Acceptable
97	Informal Housing	1678	110.5	Acceptable
98	Farmstead	1943	109.3	Acceptable
99	Farmhouse	2066	109.0	Acceptable
100	Farm Building	2004	109.2	Acceptable
101	Building/Structures (Packing Sheds)	1941	109.3	Acceptable
102	Communication Tower	1832	109.8	N/A
103	Farmstead	2061	109.0	Acceptable
104	Informal Housing	1749	110.1	Acceptable
105	Informal Housing	1730	110.2	Acceptable
106	Informal Housing	1742	110.2	Acceptable
107	Informal Housing	1750	110.1	Acceptable
108	Informal Housing	1772	110.1	Acceptable
109	Informal Housing	1780	109.9	Acceptable
110	Informal Housing	1763	110.1	Acceptable
111	Informal Housing	1763	110.1	Acceptable
112	Informal Housing	1755	110.1	Acceptable
113	Informal Housing	1713	110.2	Acceptable
114	Informal Housing	1696	110.3	Acceptable
115	Informal Housing	1737	110.2	Acceptable
116	Houses	2188	108.6	Acceptable
117	Houses	2194	108.6	Acceptable
118	Houses	2212	108.6	Acceptable
119	Houses	2221	108.4	Acceptable
120	Houses	2251	108.4	Acceptable
121	Houses	2241	108.4	Acceptable
122	Houses	2258	108.4	Acceptable
123	Houses	2263	108.4	Acceptable
124	Houses	2274	108.2	Acceptable
125	Houses	2286	108.2	Acceptable
126	Informal Housing	2282	108.2	Acceptable
127	Informal Housing	2292	108.2	Acceptable
128	Informal Housing	2342	108.1	Acceptable
129	Farmhouse	2606	107.4	Acceptable
130	Farmhouse	2753	107.0	Acceptable
131	Reservoirs	2610	107.4	N/A
132	Communication Tower	2567	107.6	N/A
133	Farmstead	2578	107.6	Acceptable
134	Farmstead	2548	107.6	Acceptable
135	Farm Structures	2497	107.7	Acceptable
136	Dam/Dam wall	2446	107.9	N/A
137	Kraal	2693	107.2	N/A

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
138	House	3267	105.8	Acceptable
139	Building/Structure	3221	106.0	Acceptable
140	Building/Structure	3407	105.5	Acceptable
141	House	2151	108.7	Acceptable
142	House	2826	106.8	Acceptable
143	House	2758	107.0	Acceptable
144	Farm Buildings	3366	105.8	Acceptable
145	Building/Structure	3265	106.0	Acceptable
146	Farmstead	1765	110.1	Acceptable
147	Farm Buildings	1742	110.2	Acceptable
148	Farmstead	2284	108.2	Acceptable
149	Building/Structure	2231	108.4	Acceptable
150	Dam/Dam wall	2515	107.6	N/A
151	Heritage Site -Historical Structures	1395	111.7	Acceptable
152	Farm Structure	1376	111.8	Acceptable
153	House	1419	111.5	Acceptable
154	House	1343	111.9	Acceptable
155	Livestock	1288	112.2	N/A
156	Cement Dam	1506	111.1	N/A
157	Farmstead	1804	109.9	Acceptable
158	Farm Structure	1751	110.1	Acceptable
159	Farm Structure	1863	109.6	Acceptable
175	Farmstead	3156	106.2	Acceptable
176	Farm Buildings	3219	106.0	Acceptable
177	House	3174	106.0	Acceptable
178	Reservoir	3103	106.2	N/A
179	Marsh	2813	106.8	N/A
196	Farm Structures	3243	106.0	Acceptable
197	Farm Structures	3121	106.2	Acceptable
198	Farmstead	3075	106.2	Acceptable
199	Farm Building	3033	106.4	Acceptable
200	Livestock	3277	105.8	N/A
201	Informal Housing	2821	106.8	Acceptable
202	Informal Housing	2727	107.0	Acceptable
203	Informal Housing	2754	107.0	Acceptable
204	Informal Housing	2741	107.0	Acceptable
205	Kraal	2537	107.6	N/A
206	Farmhouse	2504	107.7	Acceptable
207	Farmhouse	2544	107.6	Acceptable
208	Farmhouse	2549	107.6	Acceptable
209	Livestock	2481	107.7	N/A
210	Dam/Dam wall	2551	107.6	N/A
211	Informal Housing	3145	106.2	Acceptable
212	Informal Housing	3284	105.8	Acceptable

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
213	River	2905	106.6	N/A
215	Mine Buildings	1971	109.3	N/A
216	Mine Buildings	2569	107.6	N/A
217	Mine Buildings	2613	107.4	N/A
218	Mine Building	2536	107.6	N/A
219	Farmstead	1974	109.3	Acceptable
220	Farm Building	1905	109.5	Acceptable
221	Nett Shading/Orchards	2060	109.0	N/A
222	Agricultural Tunnels	2205	108.6	N/A
223	Agricultural Tunnels	2363	108.1	N/A
224	Farm Building	2202	108.6	Acceptable
225	Reservoir	3405	105.5	N/A
226	Farmstead	1896	109.5	Acceptable
227	Farm Buildings	1941	109.3	Acceptable
228	Farm Building	1970	109.3	Acceptable
229	Farm Buildings	1875	109.6	Acceptable
230	Livestock	2056	109.0	N/A
231	Dam/Dam wall	1126	113.1	N/A
232	Dam/Dam wall	963	114.2	N/A
233	Dam/Dam wall	1094	113.3	N/A
234	River	493	118.7	N/A
235	River	1240	112.4	N/A
236	Dam/Dam wall	1442	111.4	N/A
237	Dam/Dam wall	1633	110.6	N/A
238	Farmhouse	1712	110.2	Acceptable
239	Farm Building	1714	110.2	Acceptable
240	Houses	2665	107.2	Acceptable
241	Farmhouse	3147	106.2	Acceptable
242	Farm Building	3222	106.0	Acceptable
243	Structures	3191	106.0	Acceptable
244	Houses	3282	105.8	Acceptable
245	Houses	3277	105.8	Acceptable
246	Houses	3327	105.8	Acceptable
247	Railway Substation	1541	111.0	N/A
248	Pivot Irrigation	686	116.5	N/A
249	Dam/Dam wall	881	114.8	N/A
250	Communication Tower	1506	111.1	N/A
251	Informal Settlement	3004	106.4	Acceptable
252	Informal Settlement	3386	105.5	Acceptable
253	Informal Settlement	3158	106.2	Acceptable
254	Farmstead	3212	106.0	Acceptable
255	Farmstead	3460	105.5	Acceptable
256	Explosives Magazines	859	115.0	N/A
257	Dam/Dam wall	3291	105.8	N/A

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
258	Hydrocencus Borehole (BLYBH3)	2843	106.8	N/A
259	Hydrocencus Borehole (BLYBH4)	2460	107.7	N/A
261	Hydrocencus Borehole (HADECBH)	3134	106.2	N/A
262	Hydrocencus Borehole (HADECBH2)	1759	110.1	N/A
263	Hydrocencus Borehole (HADECBH3)	1764	110.1	N/A
264	Hydrocencus Borehole (REBH1)	1769	110.1	N/A
265	Hydrocencus Borehole (ZOEBH)	1961	109.3	N/A
267	Hydrocencus Borehole (DRIBH1)	386	120.4	N/A
268	Hydrocencus Borehole (DRIBH2)	684	116.5	N/A
269	Hydrocencus Borehole (SACBH)	1887	109.6	N/A
270	Hydrocencus Borehole (BLYBH2)	2471	107.7	N/A
271	Hydrocencus Borehole (VOGBH1)	2471	107.7	N/A
272	Hydrocencus Borehole (WELBH2)	1790	109.9	N/A
273	Hydrocencus Borehole (ZOEBH2)	1461	111.3	N/A
274	Hydrocencus Borehole (GRMBH1)	2628	107.4	N/A
275	Hydrocencus Borehole (WELBH6)	475	119.0	N/A
276	Hydrocencus (Spring used for commercial bottled water)	464	119.2	N/A
277	Heritage Site (Graves) - Inside OC2 Pit Area	43	-	-

#### 17.7.4 Maximum charge mass per delay – 1575 kg – Pit OC2

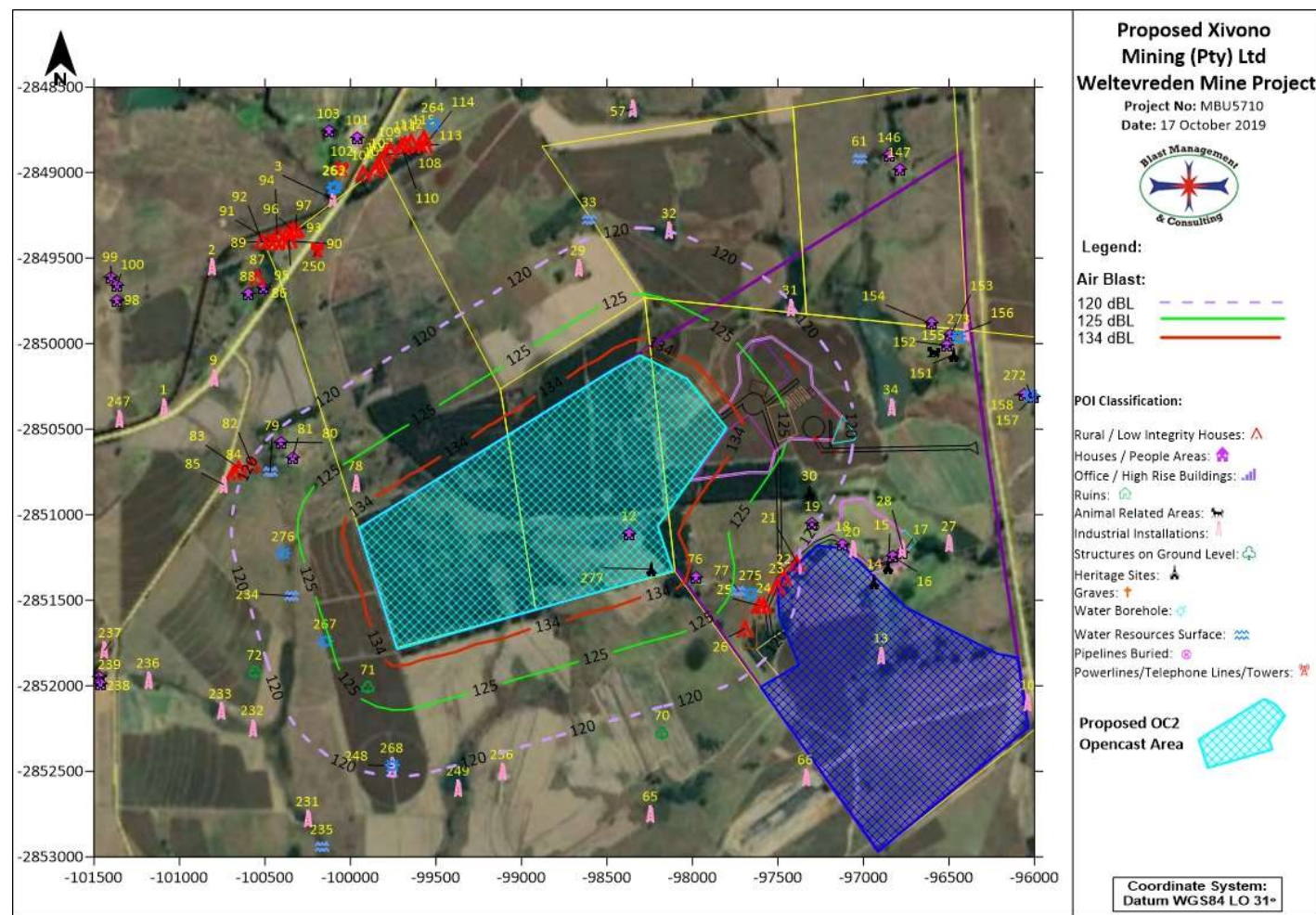


Figure 20: Air blast influence from maximum charge for Pit OC2 Area

Table 17: Air blast evaluation for maximum charge for Pit OC2 Area

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
1	Railway Line	1343	116.0	N/A
2	Railway Line	1748	114.2	N/A
3	Railway Line	1713	114.4	N/A
4	Railway Line	2120	112.8	N/A
5	Railway Line	2245	112.5	N/A
6	Railway Line	2849	110.8	N/A
7	Railway Line	1816	113.9	N/A
8	Railway Line	2544	111.7	N/A
9	N4 Road	1222	116.6	N/A
10	R33 Road	2215	112.5	N/A
12	House (Inside OC2 Area)	172	-	-
13	Heritage Site - Dam/Dam wall (Inside OC1 Area)	1318	116.1	N/A
14	Heritage Site -Historical Structures (Inside OC1 Area)	1183	116.9	Acceptable
15	Heritage Site -Historical Structures	1240	116.5	Acceptable
16	Farm Buildings	1227	116.6	Acceptable
17	Farm Buildings	1261	116.4	Acceptable
18	Farmhouse	946	118.4	Acceptable
19	Farm Buildings	733	120.1	Complaint
20	Cement Dam	1011	117.9	N/A
21	Informal Housing	731	120.1	Complaint
22	Informal Housing	653	120.9	Complaint
23	Informal Housing	617	121.3	Complaint
24	Informal Housing	573	121.8	Complaint
25	Informal Housing	545	122.2	Complaint
26	Informal Housing	544	122.2	Complaint
27	Dam/Dam wall	1468	115.4	N/A
28	Cement Dam	1249	116.5	N/A
29	Cement Dam	619	121.3	N/A
30	Heritage Site - Dam/Dam wall	617	121.3	N/A
31	Dam/Dam wall	732	120.1	N/A
32	Dam/Dam wall	748	120.0	N/A
33	Pan	846	119.1	N/A
34	Dam/Dam wall	971	118.2	N/A
41	Dam/Dam wall	3122	110.2	N/A
42	Dam/Dam wall	2672	111.3	N/A
43	Dam/Dam wall	2614	111.4	N/A
44	Dam/Dam wall	2637	111.3	N/A
45	Dam/Dam wall	2686	111.2	N/A
46	Dam/Dam wall	1684	114.4	N/A
47	Dam/Dam wall	1633	114.7	N/A
48	Dam/Dam wall	2277	112.4	N/A
49	Dam/Dam wall	3117	110.2	N/A



Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
50	Dam/Dam wall	2831	110.8	N/A
51	Dam/Dam wall	1739	114.2	N/A
52	Dam/Dam wall	2732	111.1	N/A
53	Dam/Dam wall	2093	112.9	N/A
54	Dam/Dam wall	2925	110.7	N/A
55	Dam/Dam wall	1938	113.5	N/A
56	Pan	2144	112.8	N/A
57	Dam/Dam wall	1441	115.5	N/A
58	Dam/Dam wall	3284	109.9	N/A
59	Dam/Dam wall	2770	111.1	N/A
60	Dam/Dam wall	2667	111.3	N/A
61	Pan	1637	114.6	N/A
62	River	2856	110.8	N/A
63	River	2146	112.8	N/A
64	River	2760	111.1	N/A
65	Dam/Dam wall	1332	116.0	N/A
66	Mine Activity	1438	115.5	N/A
67	Mine Activity	1754	114.2	N/A
68	Coal Yard	1890	113.7	N/A
69	Cultivated Fields	2331	112.2	N/A
70	Cultivated Fields	897	118.7	N/A
71	Cultivated Fields	283	126.6	N/A
72	Cultivated Fields	835	119.2	N/A
73	Cultivated Fields	1883	113.7	N/A
74	Cultivated Fields	2770	111.1	N/A
75	Old Quarry	2865	110.8	N/A
76	Farmhouse	139	131.5	Complaint
77	Reservoir	404	124.2	N/A
78	Dam/Dam wall	230	128.0	N/A
79	Pan	616	121.3	N/A
80	Farmstead	680	120.6	Complaint
81	Farm Buildings	567	121.9	Complaint
82	Informal Housing	732	120.1	Complaint
83	Informal Housing	785	119.6	Acceptable
84	Informal Housing	800	119.5	Acceptable
85	Gravel Road	834	119.2	N/A
86	Farmstead	1487	115.3	Acceptable
87	Informal Housing	1556	115.0	Acceptable
88	Farm Buildings	1504	115.2	Acceptable
89	Informal Housing	1679	114.4	Acceptable
90	Informal Housing	1657	114.5	Acceptable
91	Informal Housing	1704	114.4	Acceptable
92	Informal Housing	1724	114.3	Acceptable
93	Informal Housing	1689	114.4	Acceptable

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
94	Informal Housing	1711	114.4	Acceptable
95	Informal Housing	1647	114.6	Acceptable
96	Informal Housing	1679	114.4	Acceptable
97	Informal Housing	1678	114.4	Acceptable
98	Farmstead	1943	113.5	Acceptable
99	Farmhouse	2066	113.0	Acceptable
100	Farm Building	2004	113.2	Acceptable
101	Building/Structures (Packing Sheds)	1941	113.5	Acceptable
102	Communication Tower	1832	113.8	N/A
103	Farmstead	2061	113.0	Acceptable
104	Informal Housing	1749	114.2	Acceptable
105	Informal Housing	1730	114.3	Acceptable
106	Informal Housing	1742	114.2	Acceptable
107	Informal Housing	1750	114.2	Acceptable
108	Informal Housing	1772	114.1	Acceptable
109	Informal Housing	1780	114.0	Acceptable
110	Informal Housing	1763	114.1	Acceptable
111	Informal Housing	1763	114.1	Acceptable
112	Informal Housing	1755	114.2	Acceptable
113	Informal Housing	1713	114.4	Acceptable
114	Informal Housing	1696	114.4	Acceptable
115	Informal Housing	1737	114.2	Acceptable
116	Houses	2188	112.6	Acceptable
117	Houses	2194	112.6	Acceptable
118	Houses	2212	112.6	Acceptable
119	Houses	2221	112.5	Acceptable
120	Houses	2251	112.4	Acceptable
121	Houses	2241	112.5	Acceptable
122	Houses	2258	112.4	Acceptable
123	Houses	2263	112.4	Acceptable
124	Houses	2274	112.4	Acceptable
125	Houses	2286	112.3	Acceptable
126	Informal Housing	2282	112.3	Acceptable
127	Informal Housing	2292	112.3	Acceptable
128	Informal Housing	2342	112.2	Acceptable
129	Farmhouse	2606	111.4	Acceptable
130	Farmhouse	2753	111.1	Acceptable
131	Reservoirs	2610	111.4	N/A
132	Communication Tower	2567	111.5	N/A
133	Farmstead	2578	111.5	Acceptable
134	Farmstead	2548	111.7	Acceptable
135	Farm Structures	2497	111.8	Acceptable
136	Dam/Dam wall	2446	111.9	N/A
137	Kraal	2693	111.2	N/A

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
138	House	3267	109.9	Acceptable
139	Building/Structure	3221	110.1	Acceptable
140	Building/Structure	3407	109.6	Acceptable
141	House	2151	112.7	Acceptable
142	House	2826	111.0	Acceptable
143	House	2758	111.1	Acceptable
144	Farm Buildings	3366	109.8	Acceptable
145	Building/Structure	3265	109.9	Acceptable
146	Farmstead	1765	114.1	Acceptable
147	Farm Buildings	1742	114.2	Acceptable
148	Farmstead	2284	112.3	Acceptable
149	Building/Structure	2231	112.5	Acceptable
150	Dam/Dam wall	2515	111.7	N/A
151	Heritage Site -Historical Structures	1395	115.7	Acceptable
152	Farm Structure	1376	115.8	Acceptable
153	House	1419	115.6	Acceptable
154	House	1343	116.0	Acceptable
155	Livestock	1288	116.3	N/A
156	Cement Dam	1506	115.2	N/A
157	Farmstead	1804	113.9	Acceptable
158	Farm Structure	1751	114.2	Acceptable
159	Farm Structure	1863	113.8	Acceptable
175	Farmstead	3156	110.2	Acceptable
176	Farm Buildings	3219	110.1	Acceptable
177	House	3174	110.1	Acceptable
178	Reservoir	3103	110.3	N/A
179	Marsh	2813	111.0	N/A
196	Farm Structures	3243	109.9	Acceptable
197	Farm Structures	3121	110.2	Acceptable
198	Farmstead	3075	110.3	Acceptable
199	Farm Building	3033	110.5	Acceptable
200	Livestock	3277	109.9	N/A
201	Informal Housing	2821	111.0	Acceptable
202	Informal Housing	2727	111.2	Acceptable
203	Informal Housing	2754	111.1	Acceptable
204	Informal Housing	2741	111.1	Acceptable
205	Kraal	2537	111.7	N/A
206	Farmhouse	2504	111.8	Acceptable
207	Farmhouse	2544	111.7	Acceptable
208	Farmhouse	2549	111.7	Acceptable
209	Livestock	2481	111.8	N/A
210	Dam/Dam wall	2551	111.5	N/A
211	Informal Housing	3145	110.2	Acceptable
212	Informal Housing	3284	109.9	Acceptable

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
213	River	2905	110.7	N/A
215	Mine Buildings	1971	113.4	N/A
216	Mine Buildings	2569	111.5	N/A
217	Mine Buildings	2613	111.4	N/A
218	Mine Building	2536	111.7	N/A
219	Farmstead	1974	113.4	Acceptable
220	Farm Building	1905	113.6	Acceptable
221	Nett Shading/Orchards	2060	113.0	N/A
222	Agricultural Tunnels	2205	112.6	N/A
223	Agricultural Tunnels	2363	112.1	N/A
224	Farm Building	2202	112.6	Acceptable
225	Reservoir	3405	109.6	N/A
226	Farmstead	1896	113.7	Acceptable
227	Farm Buildings	1941	113.5	Acceptable
228	Farm Building	1970	113.4	Acceptable
229	Farm Buildings	1875	113.7	Acceptable
230	Livestock	2056	113.1	N/A
231	Dam/Dam wall	1126	117.2	N/A
232	Dam/Dam wall	963	118.3	N/A
233	Dam/Dam wall	1094	117.4	N/A
234	River	493	122.8	N/A
235	River	1240	116.5	N/A
236	Dam/Dam wall	1442	115.5	N/A
237	Dam/Dam wall	1633	114.7	N/A
238	Farmhouse	1712	114.4	Acceptable
239	Farm Building	1714	114.4	Acceptable
240	Houses	2665	111.3	Acceptable
241	Farmhouse	3147	110.2	Acceptable
242	Farm Building	3222	110.1	Acceptable
243	Structures	3191	110.1	Acceptable
244	Houses	3282	109.9	Acceptable
245	Houses	3277	109.9	Acceptable
246	Houses	3327	109.8	Acceptable
247	Railway Substation	1541	115.1	N/A
248	Pivot Irrigation	686	120.6	N/A
249	Dam/Dam wall	881	118.8	N/A
250	Communication Tower	1506	115.2	N/A
251	Informal Settlement	3004	110.5	Acceptable
252	Informal Settlement	3386	109.6	Acceptable
253	Informal Settlement	3158	110.2	Acceptable
254	Farmstead	3212	110.1	Acceptable
255	Farmstead	3460	109.5	Acceptable
256	Explosives Magazines	859	119.0	N/A
257	Dam/Dam wall	3291	109.9	N/A

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
258	Hydrocencus Borehole (BLYBH3)	2843	110.8	N/A
259	Hydrocencus Borehole (BLYBH4)	2460	111.9	N/A
261	Hydrocencus Borehole (HADECBH)	3134	110.2	N/A
262	Hydrocencus Borehole (HADECBH2)	1759	114.1	N/A
263	Hydrocencus Borehole (HADECBH3)	1764	114.1	N/A
264	Hydrocencus Borehole (REBH1)	1769	114.1	N/A
265	Hydrocencus Borehole (ZOEBH)	1961	113.4	N/A
267	Hydrocencus Borehole (DRIBH1)	386	124.5	N/A
268	Hydrocencus Borehole (DRIBH2)	684	120.6	N/A
269	Hydrocencus Borehole (SACBH)	1887	113.7	N/A
270	Hydrocencus Borehole (BLYBH2)	2471	111.8	N/A
271	Hydrocencus Borehole (VOGBH1)	2471	111.8	N/A
272	Hydrocencus Borehole (WELBH2)	1790	114.0	N/A
273	Hydrocencus Borehole (ZOEBH2)	1461	115.4	N/A
274	Hydrocencus Borehole (GRMBH1)	2628	111.4	N/A
275	Hydrocencus Borehole (WELBH6)	475	123.1	N/A
276	Hydrocencus (Spring used for commercial bottled water)	464	123.3	N/A
277	Heritage Site (Graves) - Inside OC2 Pit Area	43	-	-

## **17.8 Summary of findings for air blast**

Review of the air blast levels indicates the same concerns than ground vibration for the different opencast pit areas. Air blast predicted for the maximum charge for the opencast pit areas ranges between low and up to 154.4 dB for all the POI's considered. This includes the nearest points such as the Informal Housing. These levels may contribute to possible damage and effects such as rattling of roofs and/or door and/or windows that could lead to complaints.

### **OC1 Opencast Pit:**

Eighteen POI's were identified where air blast will be a concern for maximum charge evaluated. Twelve POI's were identified where levels are expected to be significant enough to lead to complaints. Six POI's were identified where expected levels were greater than limits and be problematic and may lead to damages.

### **Pit OC2**

One POI was identified where expected level of air blast will be concern. Level is less than limit but such that it could lead to complaints. Eleven POI's were identified where air blast will be less than set limits for maximum charge evaluated but could result in complaints. Levels expected are than 120 dB for the maximum charge evaluated. The rest of POI's identified were far away enough that no concern for damages were registered.

The current accepted limit on air blast is 134 dBL. Damages are only expected to occur at levels greater than 134 dBL. Prediction shows that air blast will be greater than 134 dB at distance of 97 m and closer to any of the opencast pit boundaries. Informal Housing, Farmhouses, Historical Structures are closer and could be problematic. Infrastructure at the evaluated areas such as roads, cement dam and Mine Activity are present, but air blast does not have any influence on these installations.

The same is applicable with ground vibration evaluated where there are a significant number of houses located in the area between the two opencast areas. BM&C does not have any specific information on the planned actions regarding these structures. These structures are considered as is in the evaluation. Should these structures or households be relocated the impact level will certainly be reduced.

The possible negative effects from air blast are expected to be lesser than that of ground vibration. It is maintained that if stemming control is not exercised this effect could be greater with greater range of complaints or damage. The pits are located such that "free blasting" – meaning no controls on blast preparation – will not be possible.



## 17.9 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. This unsafe zone may be anything between 10 m or 1000 m. A general unsafe zone applied by most mines is normally considered to be within a radius of 500 m from the blast; but needs to be qualified and determined as best possible.

Calculations are also 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 21 shows the results from the ISEE calculations for fly rock range based on a 165 mm diameter blast hole and 4.77 m stemming length. Based on these values a possible fly rock range with a safety factor of 2 was calculated to be 227 m. The absolute minimum unsafe zone is then the 227 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 22 and Figure 23 shows the area around the opencast pits that incorporates the 227 m unsafe zone.

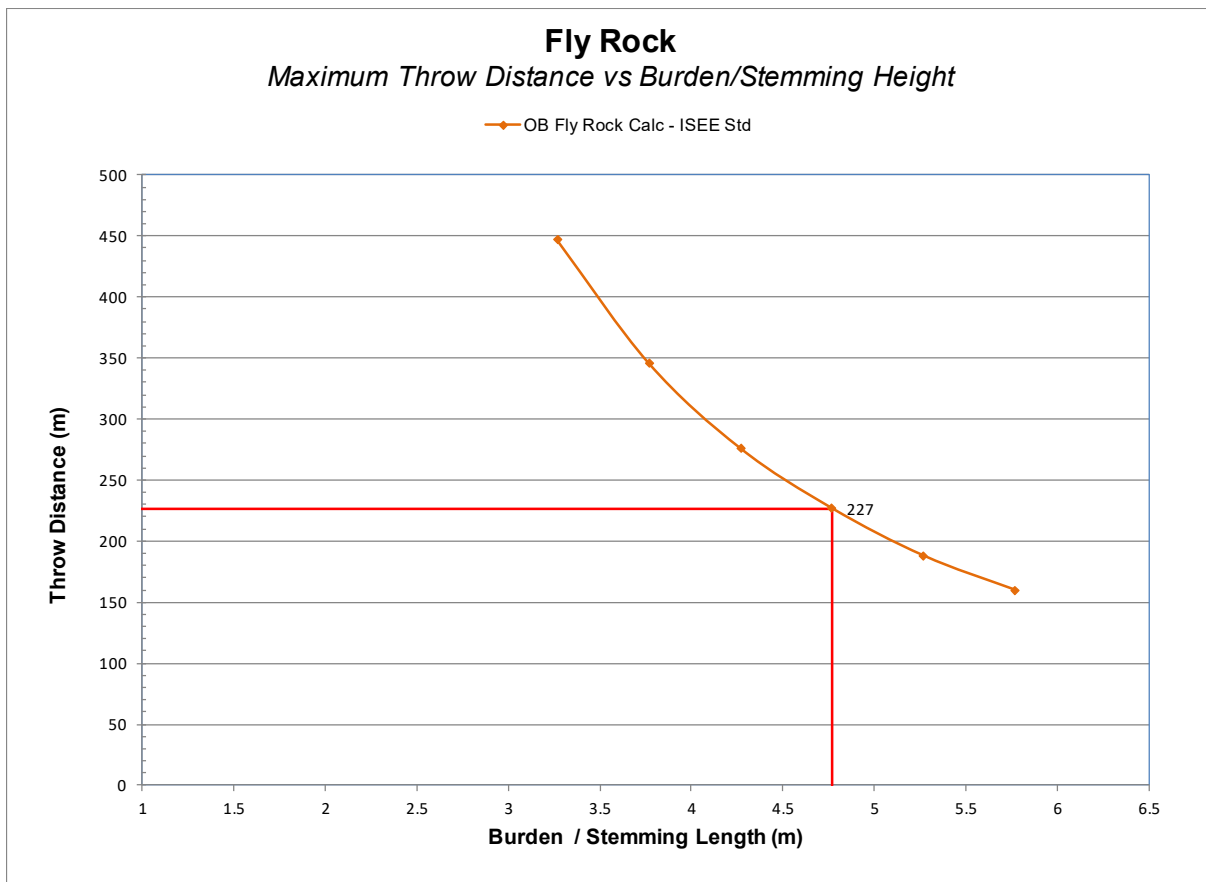


Figure 21: Fly rock prediction calculation

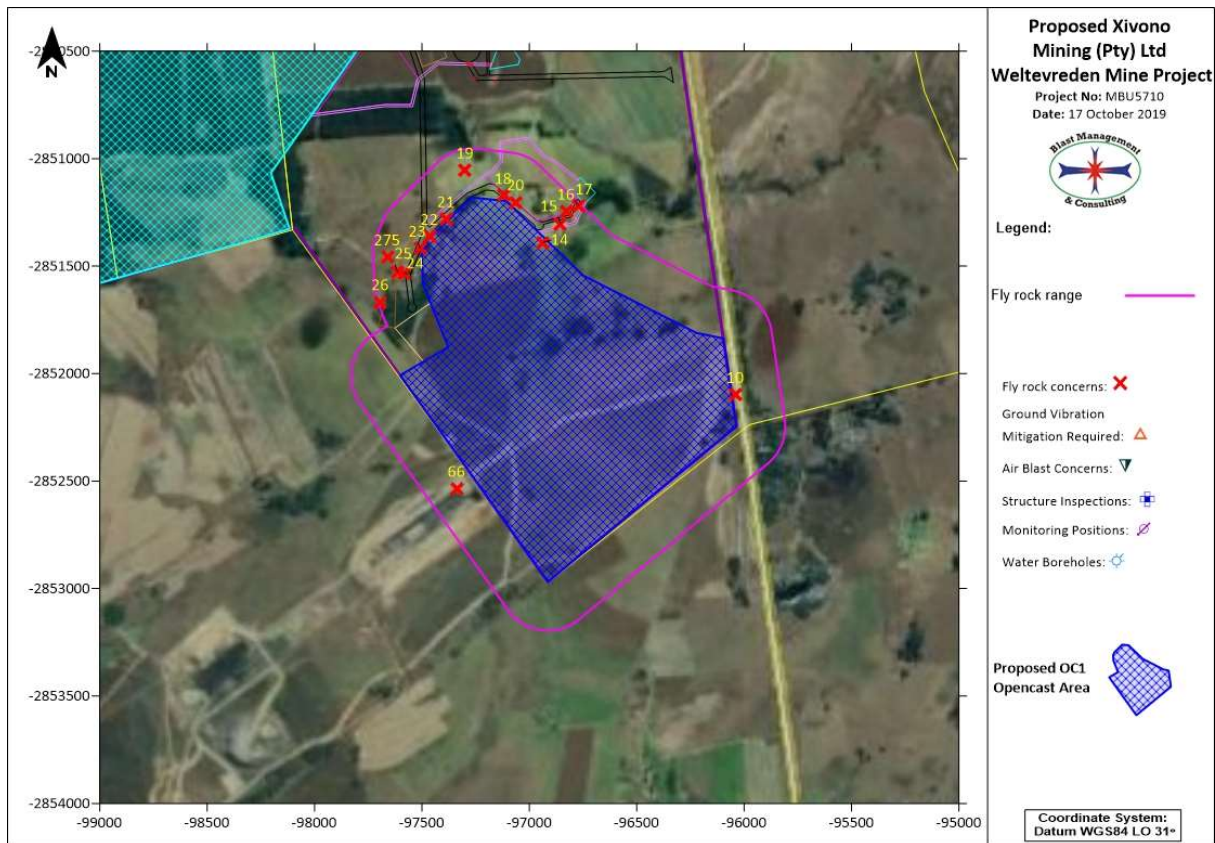


Figure 22: Predicted Fly Rock Exclusion Zone for Pit OC1 Area

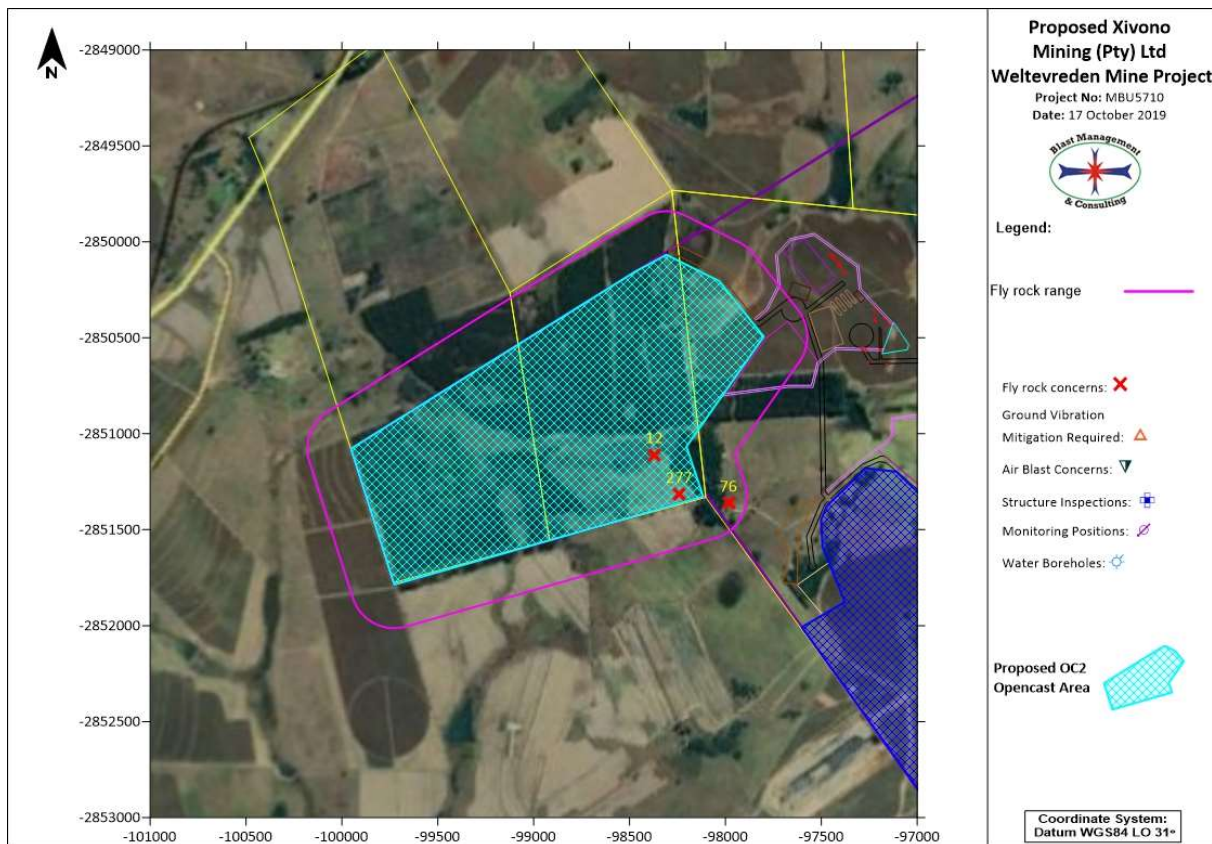


Figure 23: Predicted Fly Rock Exclusion Zone for Pit OC2 Area

Review of the calculated unsafe zone showed sixteen POI's for OC1 Pit (including one POI that falls within the Pit area) and three POI's for Pit OC2 (including two POI's that falls within the Pit Area) are within the unsafe zone. This includes mainly the Farm Buildings, Informal Housing, Road, Hydrocencus Borehole and Heritage Site. Table 18 below shows the POI's of concern and coordinates.

Table 18: Fly rock concern POI's for Pit OC1 and Pit OC2 Areas

Tag	Description	Y	X
<b>OC1 Pit Area</b>			
10	R33 Road	96041.27	2852098.93
14	Heritage Site -Historical Structures (Inside OC1 Area)	96935.27	2851390.88
15	Heritage Site -Historical Structures	96854.17	2851304.67
16	Farm Buildings	96828.83	2851245.28
17	Farm Buildings	96770.14	2851221.39
18	Farmhouse	97121.03	2851171.82

Tag	Description	Y	X
19	Farm Buildings	97298.12	2851053.48
20	Cement Dam	97062.53	2851202.95
21	Informal Housing	97387.41	2851281.08
22	Informal Housing	97464.21	2851362.12
23	Informal Housing	97506.85	2851417.41
24	Informal Housing	97581.98	2851530.92
25	Informal Housing	97611.50	2851530.51
26	Informal Housing	97692.67	2851666.88
66	Mine Activity	97338.11	2852534.31
275	Hydrocencus Borehole (WELBH6)	97660.44	2851458.54
<b>Pit OC2 Area</b>			
12	House (Inside OC2 Area)	98369.21	2851110.46
76	Farmhouse	97982.99	2851362.37
277	Heritage Site (Graves) - Inside OC2 Pit Area	98240.63	2851317.82

### 17.10 Noxious fumes

The occurrence of fumes in the form the NO<sub>x</sub> gas is not a given and very dependent on various factors as discussed in Section 13.6. 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.

### 17.11 Water borehole influence

Location of boreholes for water was evaluated for possible influence from blasting. Nineteen Hydrocencus boreholes for Pit OC1 and Pit OC2 areas were identified within the influence areas for the Weltevreden Coal Mining Project. Only one borehole at OC1 Pit Area was identified as problematic with expected levels of ground vibration greater than limits. A mitigation plan will be required to determine if this borehole will be retained or replaced. Table 19 shows all the identified boreholes. Figure 24 shows the location of the boreholes in the area.

Table 19: Identified water boreholes for the Weltevreden Coal Mining Project

Tag	Description	Y	X
<b>Pit OC1 and Pit OC2</b>			
258	Hydrocencus Borehole (BLYBH3)	71596.20	2989650.01
259	Hydrocencus Borehole (BLYBH4)	96328.99	2853536.25
260	Hydrocencus Borehole (VSTNF1)	96900.30	2853463.98

Tag	Description	Y	X
261	Hydrocencus Borehole (HADECBH)	100137.87	2846775.79
262	Hydrocencus Borehole (HADECBH2)	99396.54	2847129.20
263	Hydrocencus Borehole (HADECBH3)	100091.25	2849092.28
264	Hydrocencus Borehole (REBH1)	100095.79	2849089.66
265	Hydrocencus Borehole (ZOE BH)	99516.04	2848722.30
266	Hydrocencus Borehole (BLVBH)	101106.62	2853177.50
267	Hydrocencus Borehole (DRIBH1)	99345.86	2856006.20
268	Hydrocencus Borehole (DRIBH2)	100146.45	2851741.96
269	Hydrocencus Borehole (SACBH)	99756.73	2852465.87
270	Hydrocencus Borehole (BLYBH2)	99208.48	2853600.77
271	Hydrocencus Borehole (VOGBH1)	96348.57	2853052.19
272	Hydrocencus Borehole (WELBH2)	96348.57	2853052.19
273	Hydrocencus Borehole (ZOE BH2)	96021.45	2850303.08
274	Hydrocencus Borehole (GRMBH1)	96441.35	2849959.33
275	Hydrocencus Borehole (WELBH6)	96711.02	2847933.66
276	Hydrocencus (Spring used for commercial bottled water)	97660.44	2851458.54
<b>OC1 Opencast Problem borehole</b>			
275	Hydrocencus Borehole (WELBH6)	97660.44	2851458.54



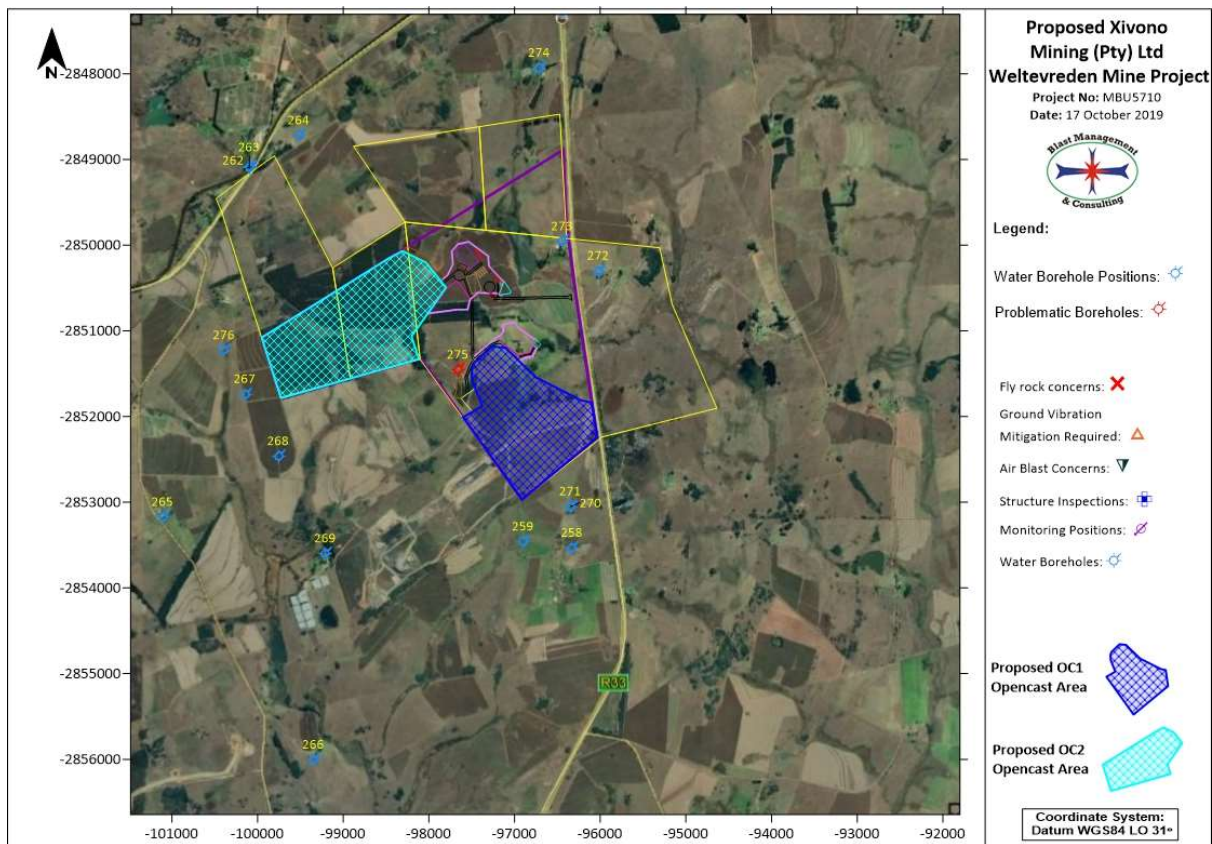


Figure 24: Location of the Boreholes for Pit OC1 and Pit OC2 Area

### 17.12 Potential Environmental Impact Assessment: Operational Phase

Details of the impact assessment methodology used to determine the significance of blasting impacts are provided below.

The significance rating process follows the established impact/risk assessment formula:

$$\text{Significance} = \text{Consequence} \times \text{Probability} \times \text{Nature}$$

Where

$$\text{Consequence} = \text{Intensity} + \text{Extent} + \text{Duration}$$

And

$$\text{Probability} = \text{Likelihood of an impact occurring}$$

And

$$\text{Nature} = \text{Positive (+1) or negative (-1) impact}$$

Note: In the formula for calculating consequence, the type of impact is multiplied by +1 for positive impacts and -1 for negative impacts.

The matrix calculates the rating out of 147, whereby Intensity, Extent, Duration and Probability are each rated out of seven as indicated in Table 22: . The weight assigned to the various parameters is then multiplied by +1 for positive and -1 for negative impacts.

Impacts are rated prior to mitigation and again after consideration of the mitigation measure proposed in this report. The significance of an impact is then determined and categorised into one of eight categories, as indicated in Table 21, which is extracted from Table 20. The description of the significance ratings is discussed in Table 22: .

It is important to note that the pre-mitigation rating takes into consideration the activity as proposed, i.e. there may already be certain types of mitigation measures included in the design (for example due to legal requirements). If the potential impact is still considered too high, additional mitigation measures are proposed.

Table 20: Impact Assessment Parameter Ratings

Rating	Intensity/Replaceability		Extent	Duration/Reversibility	Probability
	Negative Impacts (Nature = -1)	Positive Impacts (Nature = +1)			
7	Irreplaceable loss or damage to biological or physical resources or highly sensitive environments. Irreplaceable damage to highly sensitive cultural/social resources.	Noticeable, on-going natural and / or social benefits which have improved the overall conditions of the baseline.	<u>International</u> The effect will occur across international borders.	Permanent: The impact is irreversible, even with management, and will remain after the life of the project.	Definite: There are sound scientific reasons to expect that the impact will definitely occur. >80% probability.
6	Irreplaceable loss or damage to biological or physical resources or moderate to highly sensitive environments. Irreplaceable damage to cultural/social resources of moderate to highly sensitivity.	Great improvement to the overall conditions of a large percentage of the baseline.	<u>National</u> Will affect the entire country.	Beyond project life: The impact will remain for some time after the life of the project and is potentially irreversible even with management.	Almost certain / Highly probable: It is most likely that the impact will occur. <80% probability.
5	Serious loss and/or damage to physical or biological resources or highly sensitive environments, limiting ecosystem function. Very serious widespread social impacts. Irreparable damage to highly valued items.	On-going and widespread benefits to local communities and natural features of the landscape.	<u>Province/ Region</u> Will affect the entire province or region.	Project Life (>15 years): The impact will cease after the operational life span of the project and can be reversed with sufficient management.	Likely: The impact may occur. <65% probability.
4	Serious loss and/or damage to physical or biological resources or moderately sensitive environments, limiting ecosystem function. On-going serious social issues. Significant damage to structures / items of cultural significance.	Average to intense natural and / or social benefits to some elements of the baseline.	<u>Municipal Area</u> Will affect the whole municipal area.	Long term: 6-15 years and impact can be reversed with management.	Probable: Has occurred here or elsewhere and could therefore occur. <50% probability.

Rating	Intensity/Replaceability		Extent	Duration/Reversibility	Probability
	Negative Impacts (Nature = -1)	Positive Impacts (Nature = +1)			
3	Moderate loss and/or damage to biological or physical resources of low to moderately sensitive environments and, limiting ecosystem function. On-going social issues. Damage to items of cultural significance.	Average, on-going positive benefits, not widespread but felt by some elements of the baseline.	<u>Local</u> Local extending only as far as the development site area.	Medium term: 1-5 years and impact can be reversed with minimal management.	Unlikely: Has not happened yet but could happen once in the lifetime of the project, therefore there is a possibility that the impact will occur. <25% probability.
2	Minor loss and/or effects to biological or physical resources or low sensitive environments, not affecting ecosystem functioning.  Minor medium-term social impacts on local population. Mostly repairable. Cultural functions and processes not affected.	Low positive impacts experience by a small percentage of the baseline.	<u>Limited</u> Limited to the site and its immediate surroundings.	Short term: Less than 1 year and is reversible.	Rare / improbable: Conceivable, but only in extreme circumstances. The possibility of the impact materialising is very low as a result of design, historic experience or implementation of adequate mitigation measures. <10% probability.
1	Minimal to no loss and/or effect to biological or physical resources, not affecting ecosystem functioning.  Minimal social impacts, low-level repairable damage to commonplace structures.	Some low-level natural and / or social benefits felt by a very small percentage of the baseline.	<u>Very limited/Isolated</u> Limited to specific isolated parts of the site.	Immediate: Less than 1 month and is completely reversible without management.	Highly unlikely / None: Expected never to happen. <1% probability.

Table 21: Probability/Consequence Matrix

Probability	Significance																				
	7	6	5	4	3	2	1	-21	-20	-19	-18	-17	-16	-15	-14	-13	-12	-11	-10	-9	-8
7	-147	-140	-133	-126	-119	-112	-105	-98	-91	-84	-77	-70	-63	-56	-49	-42	-35	-28	-21	21	28
6	-126	-120	-114	-108	-102	-96	-90	-84	-78	-72	-66	-60	-54	-48	-42	-36	-30	-24	-18	18	24
5	-105	-100	-95	-90	-85	-80	-75	-70	-65	-60	-55	-50	-45	-40	-35	-30	-25	-20	-15	15	20
4	-84	-80	-76	-72	-68	-64	-60	-56	-52	-48	-44	-40	-36	-32	-28	-24	-20	-16	-12	12	16
3	-63	-60	-57	-54	-51	-48	-45	-42	-39	-36	-33	-30	-27	-24	-21	-18	-15	-12	-9	9	12
2	-42	-40	-38	-36	-34	-32	-30	-28	-26	-24	-22	-20	-18	-16	-14	-12	-10	-8	-6	6	8
1	-21	-20	-19	-18	-17	-16	-15	-14	-13	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	3	4
Consequence																					5
																					6
																					7
																					8
																					9
																					10
																					11
																					12
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																					20
																					21

Table 22: Significance Rating Description

Score	Description	Rating
109 to 147	A very beneficial impact that may be sufficient by itself to justify implementation of the project. The impact may result in permanent positive change	Major (positive) (+)
73 to 108	A beneficial impact which may help to justify the implementation of the project. These impacts would be considered by society as constituting a major and usually a long-term positive change to the (natural and / or social) environment	Moderate (positive) (+)
36 to 72	A positive impact. These impacts will usually result in positive medium to long-term effect on the natural and / or social environment	Minor (positive) (+)
3 to 35	A small positive impact. The impact will result in medium to short term effects on the natural and / or social environment	Negligible (positive) (+)
-3 to -35	An acceptable negative impact for which mitigation is desirable. The impact by itself is insufficient even in combination with other low impacts to prevent the development being approved. These impacts will result in negative medium to short term effects on the natural and / or social environment	Negligible (negative) (-)
-36 to -72	A minor negative impact requires mitigation. The impact is insufficient by itself to prevent the implementation of the project but which in conjunction with other impacts may prevent its implementation. These impacts will usually result in negative medium to long-term effect on the natural and / or social environment	Minor (negative) (-)
-73 to -108	A moderate negative impact may prevent the implementation of the project. These impacts would be considered as constituting a major and usually a long-term change to the (natural and / or social) environment and result in severe changes.	Moderate (negative) (-)
-109 to -147	A major negative impact may be sufficient by itself to prevent implementation of the project. The impact may result in permanent change. Very often these impacts are immitigable and usually result in very severe effects. The impacts are likely to be irreversible and/or irreplaceable.	Major (negative) (-)

Table 23: Risk Assessment Outcome

Dimension	Rating	Motivation	Significance
Blasting operations in the proposed Weltevreden Coal Mining Project			
Impact Description:			
Ground vibration impact on:			
R33 Road			
Heritage Site -Historical Structures			
Farm Buildings			
Cement Dam			
Informal Housing			
Reservoir			
Hydrocencus Borehole			
Dam/Dam wall			
Prior to Mitigation/Management			
Duration	4	Ground vibration is expected to be high at nearest infrastructure	Moderate (negative) - 77
Extent	3	Ground vibration may extend nearby settlements	
Intensity	4	Intensity is expected to be greater than permitted levels	
Probability	7	The probability of damage is high due to high levels of ground vibration	
Nature	Negative		
Mitigation/Management Actions			



Specific blast design to be done, shorter blast holes, smaller diameter blast hole, using electronic initiation instead of shock tube systems to obtain single hole firing.			
Monitor ground vibration and air blast from blasting operations			
Relocation of nearest households			
Protection of sensitive heritage sites with blast design mitigations			
Post-Mitigation			
Duration	4	Duration will depend on area blasted and closest infrastructure	Negligible (negative) - 27
Extent	3	Management of blasting and possible relocation	
Intensity	2	Intensity can be reduced with proper management of blasting operations	
Probability	3	The probability can be reduced.	
Nature	Negative		
Dimension	Rating	Motivation	Significance
Blasting operations in the proposed Weltevreden Coal Mining Project			
Impact Description:			
Air blast impact on:			
Heritage Site -Historical Structures			
Farmhouse			
Informal Housing			
Prior to Mitigation/Management			
Duration	4	Air blast is expected to be high at nearest infrastructure	Moderate (negative) - 77
Extent	3	Air blast may extend nearby settlements	
Intensity	4	Intensity is expected to be greater than permitted levels	
Probability	7	The probability of damage is high due to high levels of air blast	
Nature	Negative		
Mitigation/Management Actions			
Specific blast design to be done, shorter blast holes, smaller diameter blast hole, use of specific stemming materials to manage air blast, increased stemming lengths to reduce air blast effect. Used of specific stemming to manage fly rock - crushed aggregate of specific size. Re-design with increased stemming lengths.			
Monitor ground vibration and air blast from blasting operations			
Post-Mitigation			
Duration	4	Duration will depend on area blasted and closest infrastructure	Negligible (negative) - 27
Extent	3	Management of blasting and possible relocation	
Intensity	2	Intensity can be reduced with proper management of blasting operations	
Probability	3	The probability can be reduced.	
Nature	Negative		
Dimension	Rating	Motivation	Significance
Blasting operations in the proposed Weltevreden Coal Mining Project			
Impact Description:			
Fly rock impact on:			
R33 Road			
Heritage Site -Historical Structures			
Farm Buildings			
Farmhouse			
Cement Dam			
Informal Housing			
Hydrocencus Borehole			
Prior to Mitiaation/Manaagement			

Duration	4	Fly rock may be experienced during the blasting operations in the pit areas	Moderate (negative) 77
Extent	3	Infrastructure is present within the unsafe area	
Intensity	4	Damages may occur if fly rock is created	
Probability	7	There are infrastructure in close proximity of the blasting area that could be negatively influenced	
Nature	Negative		
Mitigation/Management Actions			
Specific blast design to be done, shorter blast holes, smaller diameter blast hole, use of specific stemming materials to manage air blast, increased stemming lengths to reduce air blast effect.			
Monitor fly rock situation using video camera			
Protection of sensitive heritage sites with blast design mitigations			
Post-Mitigation			
Duration	4	Duration will depend on area blasted and closest infrastructure	Negligible (negative) - 27
Extent	3	Management of blasting and possible relocation	
Intensity	2	Intensity can be reduced with proper management of blasting operations	
Probability	3	The probability can be reduced.	
Nature	Negative		

### 17.13 Mitigations

In review of the evaluations made in this report it is certain that specific mitigation will be required with regards to ground vibration. Ground vibration is the primary possible cause of structural damage and requires more detailed planning in preventing damage and maintaining levels within accepted norms. Air blast and fly rock can be controlled using proper charging methodology irrespective of the blasthole diameter and patterns used. Ground vibration requires more detailed planning and forms the focus for mitigation measures.

Specific impacts are expected at the following POI's identified. Table 24 shows list of POI's that will need to be considered. Figure 25 to Figure 26 shows the location of these POI's in relation to the pit areas.

Table 24: Structures at Weltevreden Coal Mining Project areas identified as problematic

Tag	Description	Y	X
<b>OC1 Opencast Area</b>			
10	R33 Road	96041.27	2852098.93
14	Heritage Site -Historical Structures (Inside OC1 Area)	96935.27	2851390.88
15	Heritage Site -Historical Structures	96854.17	2851304.67
16	Farm Buildings	96828.83	2851245.28
17	Farm Buildings	96770.14	2851221.39
18	Farmhouse	97121.03	2851171.82

Tag	Description	Y	X
19	Farm Buildings	97298.12	2851053.48
20	Cement Dam	97062.53	2851202.95
21	Informal Housing	97387.41	2851281.08
22	Informal Housing	97464.21	2851362.12
23	Informal Housing	97506.85	2851417.41
24	Informal Housing	97581.98	2851530.92
25	Informal Housing	97611.50	2851530.51
26	Informal Housing	97692.67	2851666.88
28	Cement Dam	96770.76	2851200.82
66	Mine Activity	97338.11	2852534.31
76	Farmhouse	97982.99	2851362.37
77	Reservoir	97730.79	2851445.47
201	Informal Housing	96542.06	2853666.40
202	Informal Housing	96564.81	2853568.02
203	Informal Housing	96523.17	2853571.47
204	Informal Housing	96463.46	2853511.51
206	Farmhouse	96874.39	2853499.55
208	Farmhouse	96906.46	2853569.40
275	Hydrocencus Borehole (WELBH6)	97660.44	2851458.54
<b>Pit OC2 Area</b>			
12	House (Inside OC2 Area)	98369.21	2851110.46
21	Informal Housing	97387.41	2851281.08
22	Informal Housing	97464.21	2851362.12
23	Informal Housing	97506.85	2851417.41
24	Informal Housing	97581.98	2851530.92
25	Informal Housing	97611.50	2851530.51
26	Informal Housing	97692.67	2851666.88
76	Farmhouse	97982.99	2851362.37
78	Dam/Dam wall	99969.87	2850817.47
81	Farm Buildings	100340.12	2850666.54
82	Informal Housing	100577.94	2850703.64
83	Informal Housing	100651.32	2850726.22
84	Informal Housing	100679.44	2850750.20
277	Heritage Site (Graves) - Inside Pit OC2 Area	98240.63	2851317.82

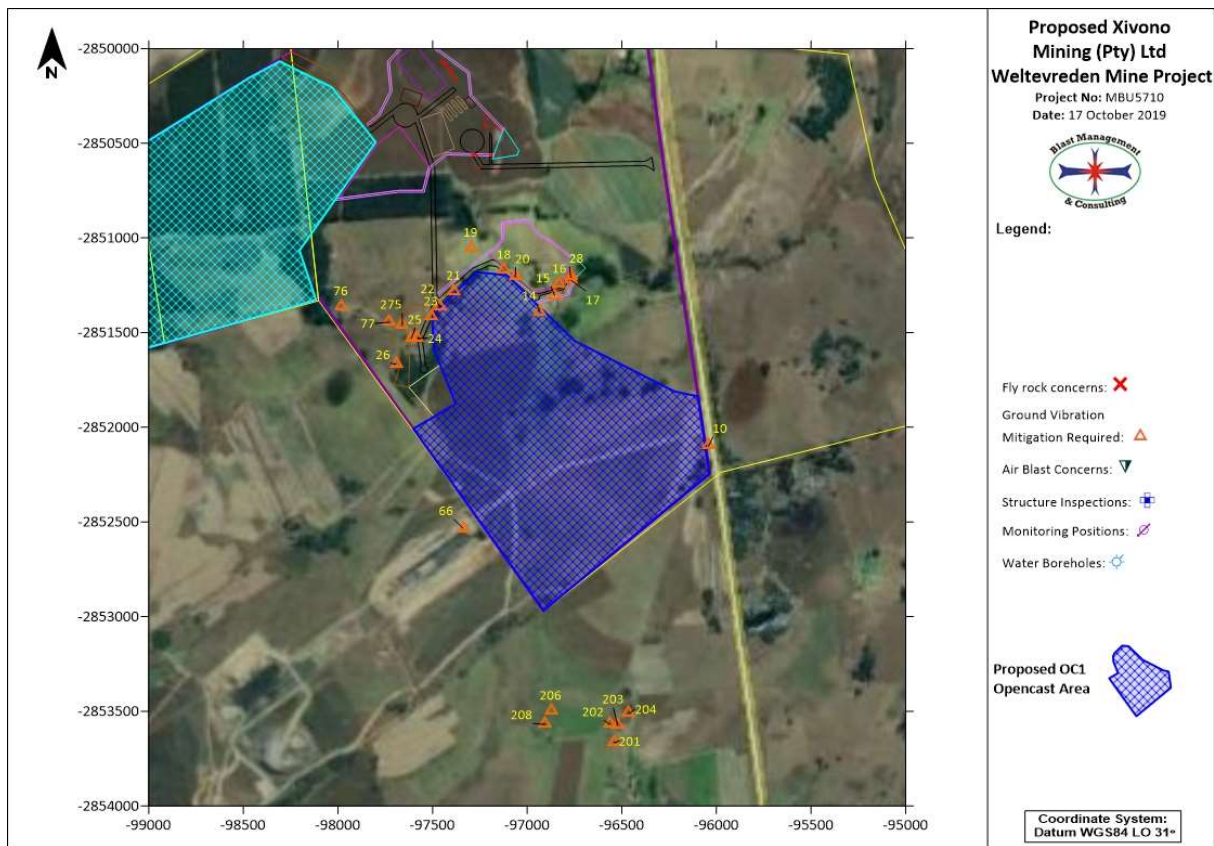


Figure 25: Structures identified at the Pit OC1 area where ground vibration mitigation will be required.

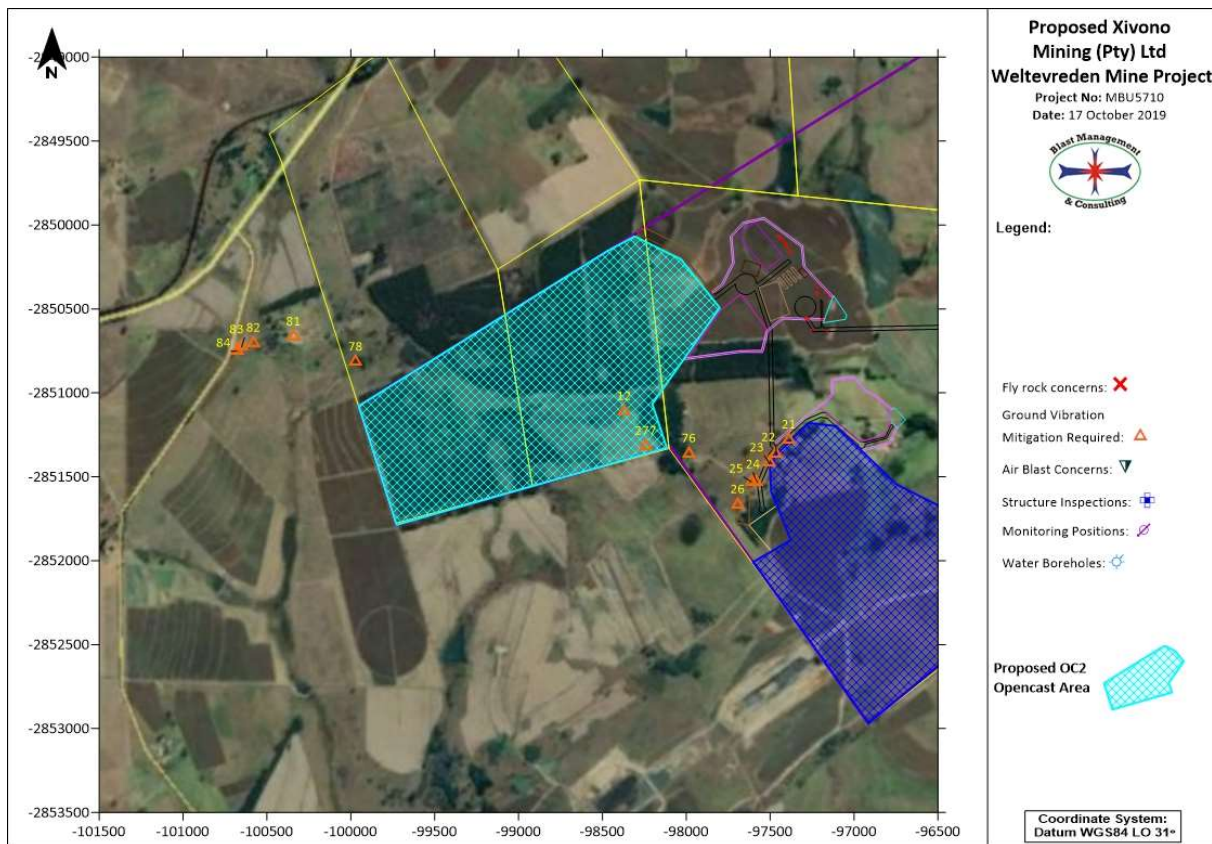


Figure 26: Structures identified at the Pit OC2 Areas where ground vibration mitigation will be required.

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.
- Only apply electronic initiation systems to facilitate single hole firing.
- Do design for smaller diameter blast holes that will use fewer explosives per blasthole.

The following Table 25 and Table 26 shows mitigation in the form of maximum charge mass that will be allowed to maintain safe levels of ground vibration and minimum distance between blast and POI required for the maximum charge to yield safe levels of ground vibration. Indicated, as well is the minimum distances required to maintain safe ground vibration levels for maximum charge and minimum charge. Review of the data clearly indicates that there are POI's that are too close to the pit areas to facilitate proper blasting operations. The charge masses are just too low for any proper blasting operations of this type.

Table 25: Mitigation measures for ground vibration: Pit OC1 Area

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz
10	R33 Road	150	17	1575	4573.4	Problematic
14	Heritage Site -Historical Structures (Inside OC1 Area)	6	19	1575	3752.8	Problematic
15	Heritage Site -Historical Structures	6	99	1575	252.0	Problematic
16	Farm Buildings	12.5	160	1575	115.1	Problematic
17	Farm Buildings	12.5	217	1575	69.1	Problematic
18	Farmhouse	12.5	25	1575	2435.4	Problematic
19	Farm Buildings	12.5	131	1575	160.3	Problematic
20	Cement Dam	50	28	1575	2076.7	Problematic
21	Informal Housing	6	12	1575	7980.2	Problematic
22	Informal Housing	6	5	1575	35214.1	Problematic
23	Informal Housing	6	18	1575	4413.4	Problematic
24	Informal Housing	6	85	1575	325.7	Problematic
25	Informal Housing	6	114	1575	199.7	Problematic
26	Informal Housing	6	214	1575	70.9	Problematic
28	Cement Dam	50	232	1575	62.1	Problematic
76	Farmhouse	12.5	490	1575	18.1	Problematic
77	Reservoir	50	230	1575	62.8	Problematic
201	Informal Housing	6	791	1575	8.2	Problematic
202	Informal Housing	6	694	1575	10.2	Problematic
203	Informal Housing	6	718	1575	9.6	Problematic
204	Informal Housing	6	705	1575	9.9	Problematic
206	Farmhouse	12.5	534	1575	15.7	Problematic
208	Farmhouse	12.5	602	1575	12.9	Problematic
275	Hydrocencus Borehole (WELBH6)	50	160	1575	114.7	Problematic
<b>Maximum allowable charge for current distance</b>						
Tag	Description	Specific Limit (mm/s)	Distance (m)	Maximum allowable charge for current distance (kg)		
10	R33 Road	150	17	25		
14	Heritage Site -Historical Structures (Inside OC1 Area)	6	19	1		
15	Heritage Site -Historical Structures	6	99	17		
16	Farm Buildings	12.5	160	107		
17	Farm Buildings	12.5	217	198		
18	Farmhouse	12.5	25	3		
19	Farm Buildings	12.5	131	71		
20	Cement Dam	50	28	17		
21	Informal Housing	6	12	0		
22	Informal Housing	6	5	0		
23	Informal Housing	6	18	1		
24	Informal Housing	6	85	12		
25	Informal Housing	6	114	23		
26	Informal Housing	6	214	79		
28	Cement Dam	50	232	1210		
76	Farmhouse	12.5	490	1006		
77	Reservoir	50	230	1194		



201	Informal Housing	6	791	1078
202	Informal Housing	6	694	829
203	Informal Housing	6	718	889
204	Informal Housing	6	705	857
206	Farmhouse	12.5	534	1195
208	Farmhouse	12.5	602	1522
275	Hydrocencus Borehole (WELBH6)	50	160	576

**Minimum distance required for maximum charge**

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Minimum distance required for charge (m)
10	R33 Road	150	17	1575	136
14	Heritage Site -Historical Structures (Inside OC1 Area)	6	19	1575	956
15	Heritage Site -Historical Structures	6	99	1575	956
16	Farm Buildings	12.5	160	1575	613
17	Farm Buildings	12.5	217	1575	613
18	Farmhouse	12.5	25	1575	613
19	Farm Buildings	12.5	131	1575	613
20	Cement Dam	50	28	1575	264
21	Informal Housing	6	12	1575	956
22	Informal Housing	6	5	1575	956
23	Informal Housing	6	18	1575	956
24	Informal Housing	6	85	1575	956
25	Informal Housing	6	114	1575	956
26	Informal Housing	6	214	1575	956
28	Cement Dam	50	232	1575	264
76	Farmhouse	12.5	490	1575	613
77	Reservoir	50	230	1575	264
201	Informal Housing	6	791	1575	956
202	Informal Housing	6	694	1575	956
203	Informal Housing	6	718	1575	956
204	Informal Housing	6	705	1575	956
206	Farmhouse	12.5	534	1575	613
208	Farmhouse	12.5	602	1575	613
275	Hydrocencus Borehole (WELBH6)	50	160	1575	264

**Minimum distance required for minimum charge**

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Minimum distance required for charge (m)
10	R33 Road	150	17	263	56
14	Heritage Site -Historical Structures (Inside OC1 Area)	6	19	263	391
15	Heritage Site -Historical Structures	6	99	263	391
16	Farm Buildings	12.5	160	263	250
17	Farm Buildings	12.5	217	263	250
18	Farmhouse	12.5	25	263	250
19	Farm Buildings	12.5	131	263	250
20	Cement Dam	50	28	263	108
21	Informal Housing	6	12	263	391
22	Informal Housing	6	5	263	391
23	Informal Housing	6	18	263	391
24	Informal Housing	6	85	263	391



25	Informal Housing	6	114	263	391
26	Informal Housing	6	214	263	391
28	Cement Dam	50	232	263	108
76	Farmhouse	12.5	490	263	250
77	Reservoir	50	230	263	108
201	Informal Housing	6	791	263	391
202	Informal Housing	6	694	263	391
203	Informal Housing	6	718	263	391
204	Informal Housing	6	705	263	391
206	Farmhouse	12.5	534	263	250
208	Farmhouse	12.5	602	263	250
275	Hydrocensus Borehole (WELBH6)	50	160	263	108

Table 26: Mitigation measures for ground vibration: Pit OC2 Area

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz
12	House (Inside OC2 Area)	12.5	172	1575	101.6	Problematic
21	Informal Housing	6	731	1575	9.3	Problematic
22	Informal Housing	6	653	1575	11.2	Problematic
23	Informal Housing	6	617	1575	12.4	Problematic
24	Informal Housing	6	573	1575	14.0	Problematic
25	Informal Housing	6	545	1575	15.2	Problematic
26	Informal Housing	6	544	1575	15.2	Problematic
76	Farmhouse	12.5	139	1575	145.2	Problematic
78	Dam/Dam wall	50	230	1575	62.8	Problematic
81	Farm Buildings	12.5	567	1575	14.2	Problematic
82	Informal Housing	6	732	1575	9.3	Problematic
83	Informal Housing	6	785	1575	8.3	Problematic
84	Informal Housing	6	800	1575	8.0	Problematic
277	Heritage Site (Graves) - Inside OC2 Pit Area	12.5	43	1575	1008.2	Problematic
<b>Maximum allowable charge for current distance</b>						
Tag	Description	Specific Limit (mm/s)	Distance (m)	Maximum allowable charge for current distance (kg)		
12	House (Inside OC2 Area)	12.5	172	124		
21	Informal Housing	6	731	920		
22	Informal Housing	6	653	736		
23	Informal Housing	6	617	656		
24	Informal Housing	6	573	565		
25	Informal Housing	6	545	512		
26	Informal Housing	6	544	511		
76	Farmhouse	12.5	139	81		
78	Dam/Dam wall	50	230	1194		
81	Farm Buildings	12.5	567	1350		
82	Informal Housing	6	732	924		
83	Informal Housing	6	785	1063		

84	Informal Housing	6	800	1104	
277	Heritage Site (Graves) - Inside OC2 Pit Area	12.5	43	8	
<b>Minimum distance required for maximum charge</b>					
Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Minimum distance required for maximum charge (m)
12	House (Inside OC2 Area)	12.5	172	1575	613
21	Informal Housing	6	731	1575	956
22	Informal Housing	6	653	1575	956
23	Informal Housing	6	617	1575	956
24	Informal Housing	6	573	1575	956
25	Informal Housing	6	545	1575	956
26	Informal Housing	6	544	1575	956
76	Farmhouse	12.5	139	1575	613
78	Dam/Dam wall	50	230	1575	264
81	Farm Buildings	12.5	567	1575	613
82	Informal Housing	6	732	1575	956
83	Informal Housing	6	785	1575	956
84	Informal Housing	6	800	1575	956
277	Heritage Site (Graves) - Inside OC2 Pit Area	12.5	43	1575	613
<b>Minimum distance required for minimum charge</b>					
Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Minimum distance required for maximum charge (m)
12	House (Inside OC2 Area)	12.5	172	263	250
21	Informal Housing	6	731	263	391
22	Informal Housing	6	653	263	391
23	Informal Housing	6	617	263	391
24	Informal Housing	6	573	263	391
25	Informal Housing	6	545	263	391
26	Informal Housing	6	544	263	391
76	Farmhouse	12.5	139	263	250
78	Dam/Dam wall	50	230	263	108
81	Farm Buildings	12.5	567	263	250
82	Informal Housing	6	732	263	391
83	Informal Housing	6	785	263	391
84	Informal Housing	6	800	263	391
277	Heritage Site (Graves) - Inside OC2 Pit Area	12.5	43	263	250

## 18 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.

## **19 Alternatives (Comparison and Recommendation)**

The alternatives to consider will be very dependent on the hardness of the overburden. It is possible that the coal may be soft enough to be mechanically excavated. If hard overburden can be mechanically removed it will reduce risk associated with blasting operations. No specific alternative mining methods are currently under discussion or considered for drilling and blasting.

## **20 Monitoring**

A monitoring programme for recording blasting operations is recommended. 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 proper relationships with the neighbours.

Seventeen monitoring positions were identified as possible locations that will need to be considered. Not all points will be required at once but active monitoring and observation of where blasting is done will dictate the requirements for the areas around the pit. Some of these points may be applicable to more than one location to be monitored. Some of the points will be applicable to multiple pit areas. Monitoring positions are indicated in Figure 27 and Table 27 lists the positions with coordinates. These points will need to be re-defined after the first blasts done and the monitoring programme defined.

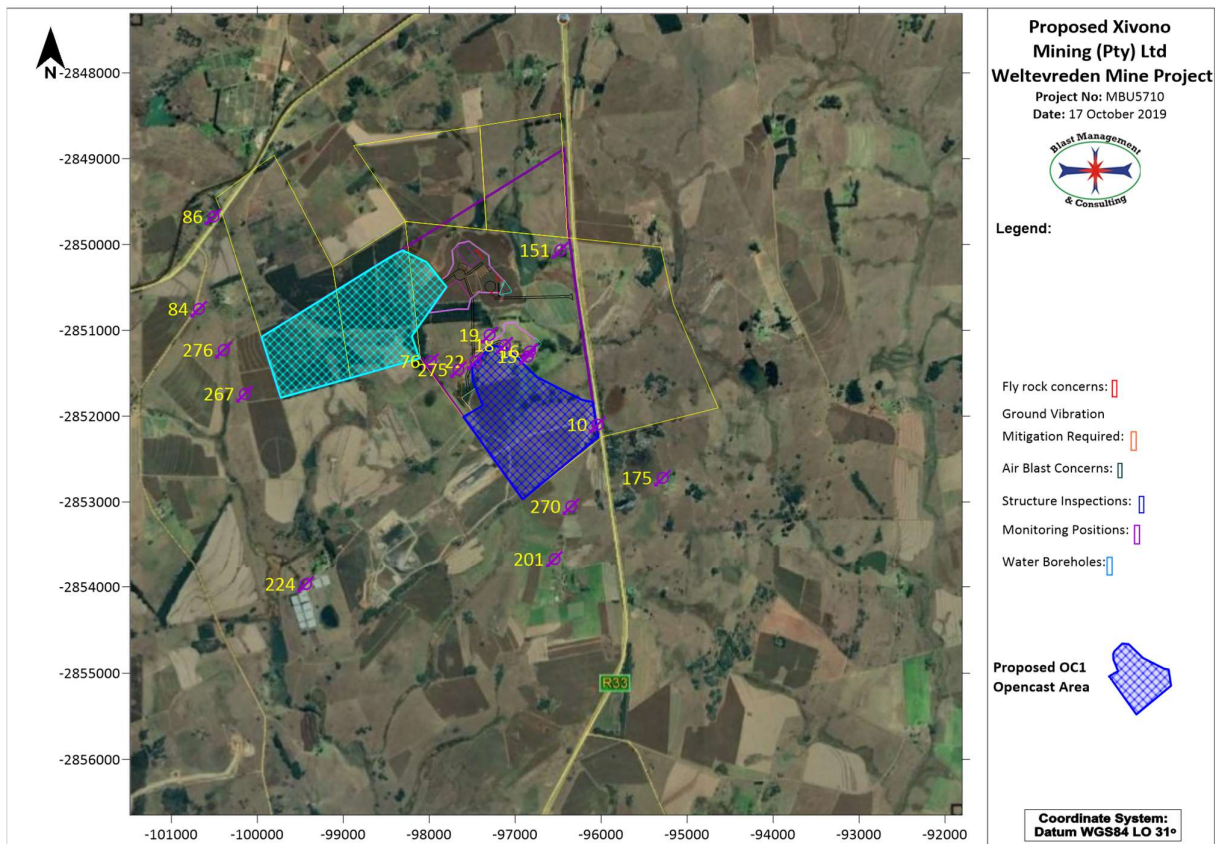


Figure 27: Monitoring Positions suggested for the Pit OC1 and Pit OC2 area

Table 27: List of possible monitoring positions

Tag	Description	Classification	Y	X
10	R33 Road	6	96041.27	2852098.93
15	Heritage Site -Historical Structures	8	96854.17	2851304.67
16	Farm Buildings	2	96828.83	2851245.28
18	Farmhouse	2	97121.03	2851171.82
19	Farm Buildings	2	97298.12	2851053.48
22	Informal Housing	1	97464.21	2851362.12
76	Farmhouse	2	97982.99	2851362.37
84	Informal Housing	1	100679.44	2850750.20
86	Farmstead	2	100511.80	2849674.26
151	Heritage Site -Historical Structures	8	96473.77	2850065.09
175	Farmstead	2	95285.23	2852719.64
201	Informal Housing	1	96542.06	2853666.40
224	Farm Building	2	99434.24	2853967.51
267	Hydrocencus Borehole (DRIBH1)	10	100146.45	2851741.96
270	Hydrocencus Borehole (BLYBH2)	10	96348.57	2853052.19
275	Hydrocencus Borehole (WELBH6)	10	97660.44	2851458.54
276	Hydrocencus (Spring used for commercial bottled water)	10	100391.22	2851229.14

## 21 Recommendations

The following recommendations are proposed.

### 21.1 Regulatory requirements – MHSA Reg. 4.16(2)

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, and specifically Mine Health and Safety Act Reg 4.16. Table 28 shows list of these installations. Figure 28 to Figure 29 below shows the 500 m boundary around the Opencast Pit areas. The location of non-mining installations is clearly observed.

Table 28: List of possible installations within the regulatory 500 m

Tag	Description	Y	X
<b>OC1 Opencast Area</b>			
10	R33 Road	96041.27	2852098.93
13	Heritage Site - Dam/Dam wall (Inside OC1 Area)	96896.74	2851823.58
14	Heritage Site -Historical Structures (Inside OC1 Area)	96935.27	2851390.88
15	Heritage Site -Historical Structures	96854.17	2851304.67
16	Farm Buildings	96828.83	2851245.28
17	Farm Buildings	96770.14	2851221.39
18	Farmhouse	97121.03	2851171.82
19	Farm Buildings	97298.12	2851053.48
20	Cement Dam	97062.53	2851202.95
21	Informal Housing	97387.41	2851281.08
22	Informal Housing	97464.21	2851362.12
23	Informal Housing	97506.85	2851417.41
24	Informal Housing	97581.98	2851530.92
25	Informal Housing	97611.50	2851530.51
26	Informal Housing	97692.67	2851666.88
27	Dam/Dam wall	96499.33	2851170.05
28	Cement Dam	96770.76	2851200.82
30	Heritage Site - Dam/Dam wall	97314.63	2850875.42
66	Mine Activity	97338.11	2852534.31
69	Cultivated Fields	96737.10	2853204.17
76	Farmhouse	97982.99	2851362.37
77	Reservoir	97730.79	2851445.47
259	Hydrocencus Borehole (BLYBH4)	96900.30	2853463.98
270	Hydrocencus Borehole (BLYBH2)	96348.57	2853052.19
271	Hydrocencus Borehole (VOGBH1)	96348.57	2853052.19

Tag	Description	Y	X
275	Hydrocencus Borehole (WELBH6)	97660.44	2851458.54
<b>Pit OC2 Area</b>			
12	House (Inside OC2 Area)	98369.21	2851110.46
71	Cultivated Fields	99896.73	2852009.25
76	Farmhouse	97982.99	2851362.37
77	Reservoir	97730.79	2851445.47
78	Dam/Dam wall	99969.87	2850817.47
234	River	100343.71	2851474.45
267	Hydrocencus Borehole (DRIBH1)	100146.45	2851741.96
275	Hydrocencus Borehole (WELBH6)	97660.44	2851458.54
276	Hydrocencus (Spring used for commercial bottled water)	100391.22	2851229.14
277	Heritage Site (Graves) - Inside OC2 Pit Area	98240.63	2851317.82

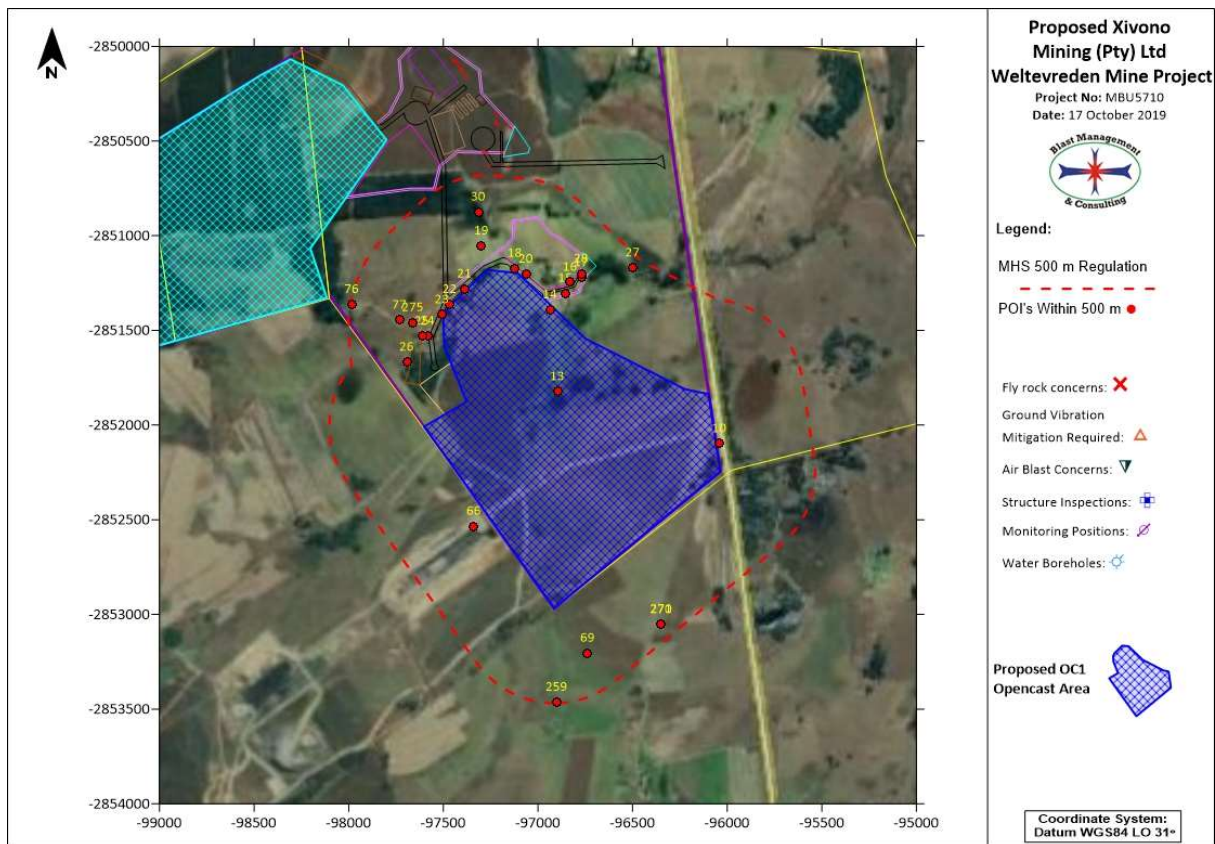


Figure 28: Regulatory 500 m range for the Pit OC1 Area



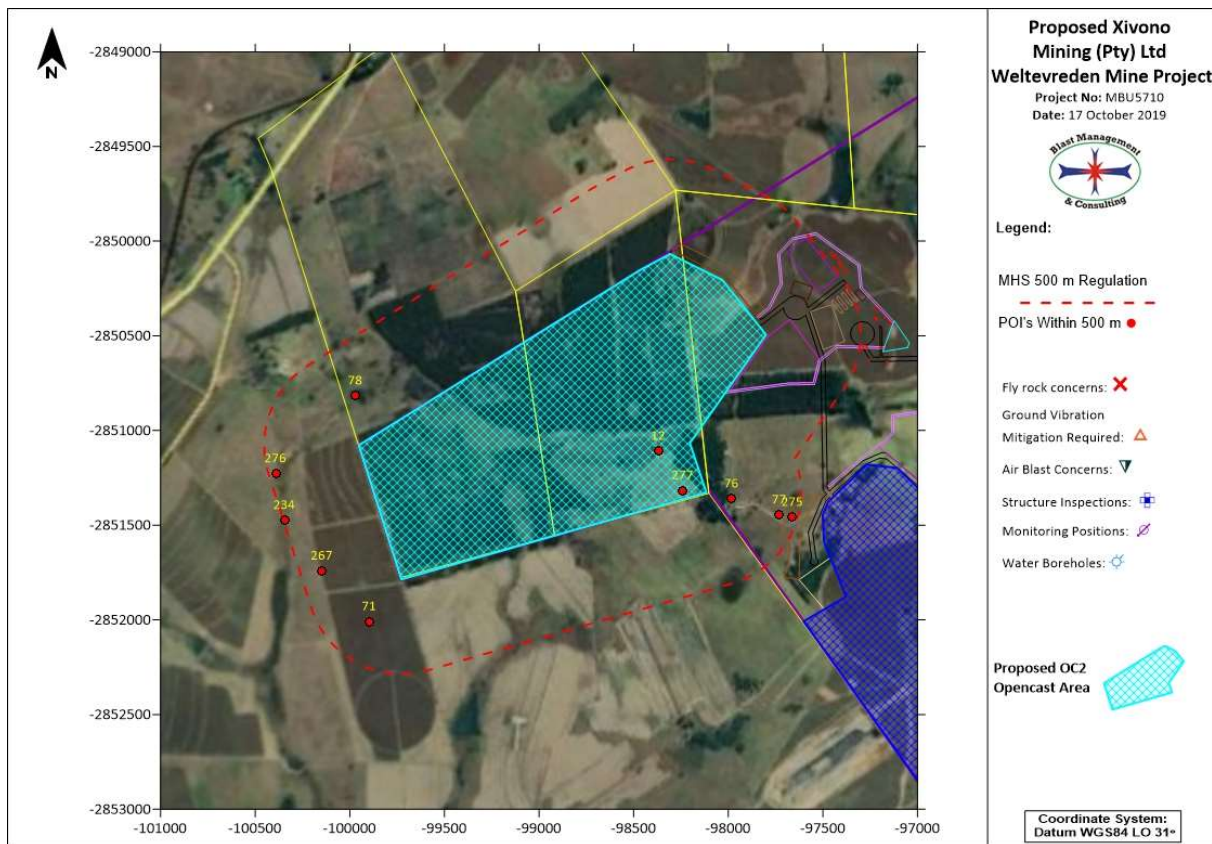


Figure 29: Regulatory 500 m range for the Pit OC2 areas

### 21.1 Regulatory requirements – MHSA Reg. 17.6(a)

On review of the pit area's location, it is such that Mine Health and Safety act regulation 17.6(a) will be applicable and will need to be considered. The location of Pit boundary is closer than 100 m from private installations and the necessary legal requirements will need to be addressed. Figure 30 to Figure 31 shows the pit with 100 m boundary that will need to be considered with indication of infrastructure within the 100 m. Please note that an icon may represent more than one structure / installation. Table 29 shows list of POI's identified.



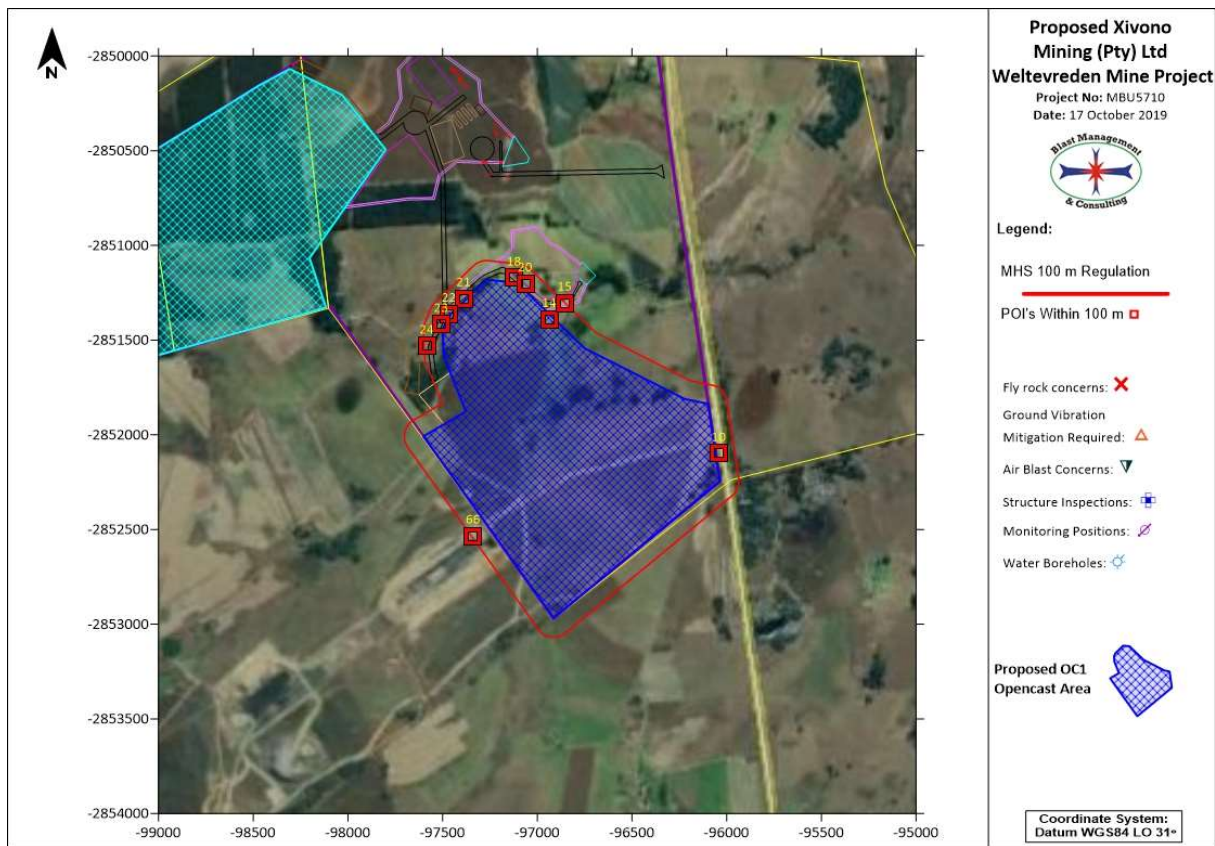


Figure 30: Regulatory 100 m range for the Pit OC1 Area

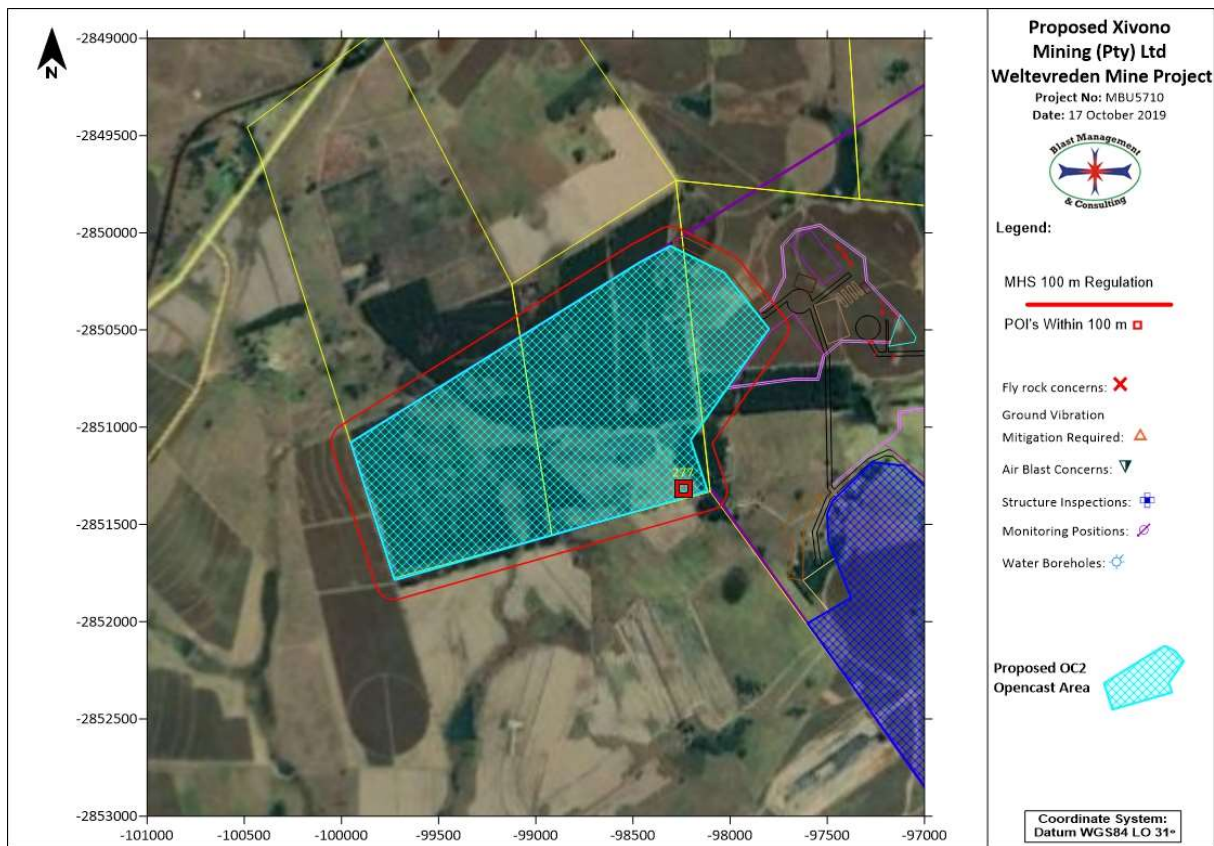


Figure 31: Regulatory 100 m range for the OC2 Opencast areas

Table 29: List of possible installations within the regulatory 100 m

Tag	Description	Y	X
<b>OC1 Opencast Area</b>			
10	R33 Road	96041.27	2852098.93
14	Heritage Site -Historical Structures (Inside OC1 Area)	96935.27	2851390.88
15	Heritage Site -Historical Structures	96854.17	2851304.67
18	Farmhouse	97121.03	2851171.82
20	Cement Dam	97062.53	2851202.95
21	Informal Housing	97387.41	2851281.08
22	Informal Housing	97464.21	2851362.12
23	Informal Housing	97506.85	2851417.41
24	Informal Housing	97581.98	2851530.92
66	Mine Activity	97338.11	2852534.31
<b>OC2 Opencast Area</b>			
277	Heritage Site (Graves) - Inside OC2 Pit Area	98240.63	2851317.82

## **21.2 Possible Relocation**

There are eleven houses / settlements identified within 500 m from the OC1 and OC2 operations. Some of these POI's are very close to the pit boundaries. This is specific to the area between the two opencast areas. Consideration should be given to relocate these households. Specific attention should be given to those closer than 250 m. Relocation will reduce the general impact on the surrounding areas of the opencast pits.

## **21.3 Blast Designs**

Based on the above mitigation requirements it will be necessary to review planned blast design in more detail. A detail design with blast planning will be required for efficient and safe mining of these pits. Blast designs should be reviewed prior to first blast planned and done. The geology for the pit areas and the required drill depths should be confirmed. Due to stripping of topsoil that will take place there may be variances in required final depths and thus design applied to be confirmed.

## **21.4 Test Blasting**

It is always good to conduct a first test blast to confirm levels and ground vibration and air blast. 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.

## **21.5 Stemming length**

The current proposed stemming length used provides for good control on fly rock. The ratio of stemming versus drill diameter is 28.9. This ratio is good and should provide for well controlled fly rock and air blast. Recommended stemming length should range between 20 and 30 times the blast hole diameter. In cases for significant fly control this should range between 30 and 34 times the blast holes diameter.

## **21.6 Safe blasting distance and evacuation**

Calculated minimum safe distance is 227 m. 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.

### **21.7 Road Closure**

The N4 National road is closest to the OC2 Opencast area at 1222 m. There is no concern identified regarding the N4. The R33 Provincial Road is located adjacent to the Pit OC1 area on the eastern side and expected ground vibration levels are very high and could be problematic. Final mine designs will need to consider the location of the R33 road next to the Pit OC1 area with changed design for blasting as distance towards the road decreases. Further it will be required that clearance distances are set, and road travel managed during blasting operations. There are various other gravel roads in the vicinity of the project area and needs to be considered. There may be people and animals on these routes and will require careful planning to maintain safe blasting radius.

### **21.8 Photographic Inspections**

The option of photographic survey of all structures up to 1500 m from the pit area 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 on structural issues due to blasting. This process can however only succeed if done in conjunction with a proper monitoring program. It is expected that ground vibration levels will be significantly less than proposed limits at 1500 m, but this process will ensure record of the pre-blasting status of the nearest structures to the pit area. At 1500 m the expected level of ground vibration will be perceptible. Figure 32 and Figure 33 shows extent of the range of 1500 m around the different Opencast Pit areas with POI's identified. It must be noted that a point may represent a group of structures found in the vicinity of the point identified. All structures identified is considered irrespective of possible future re-locations.

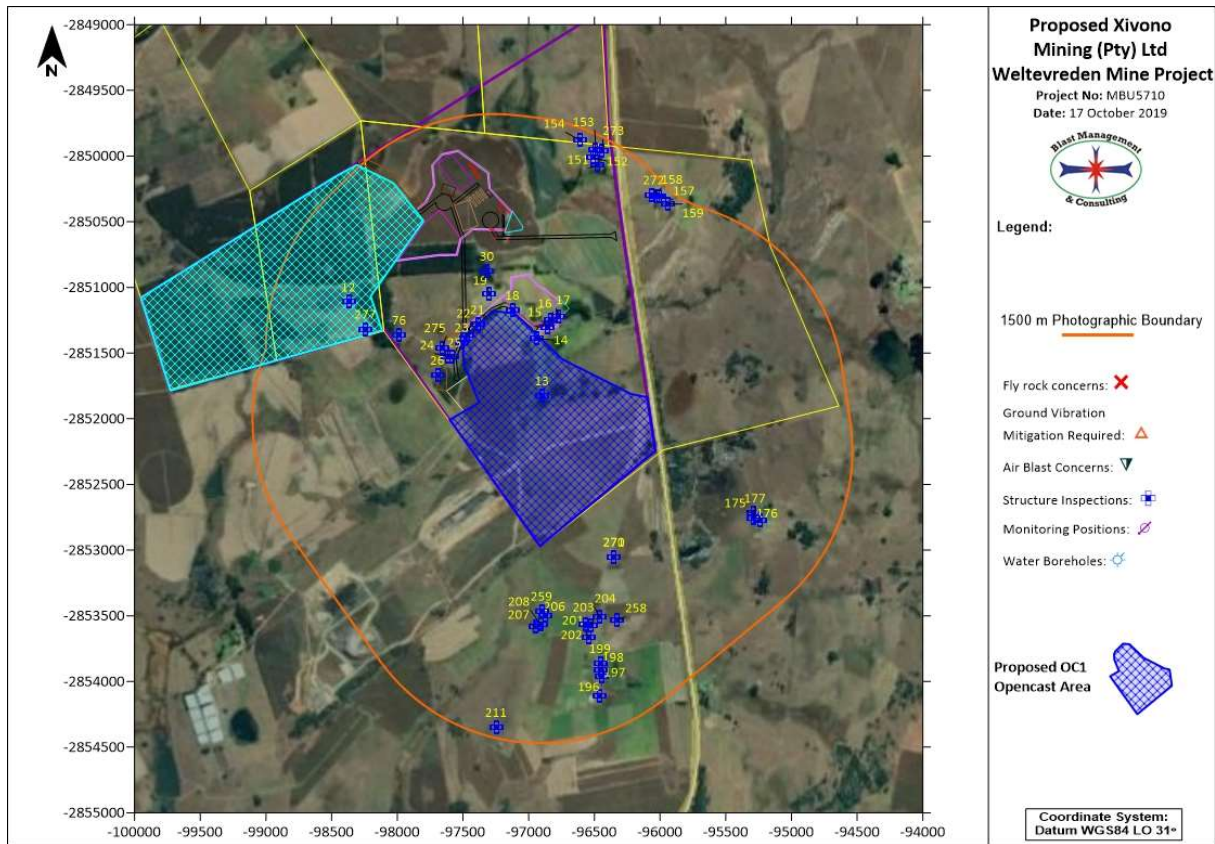


Figure 32: 1500 m area around the Pit OC1 area identified for structure inspections.



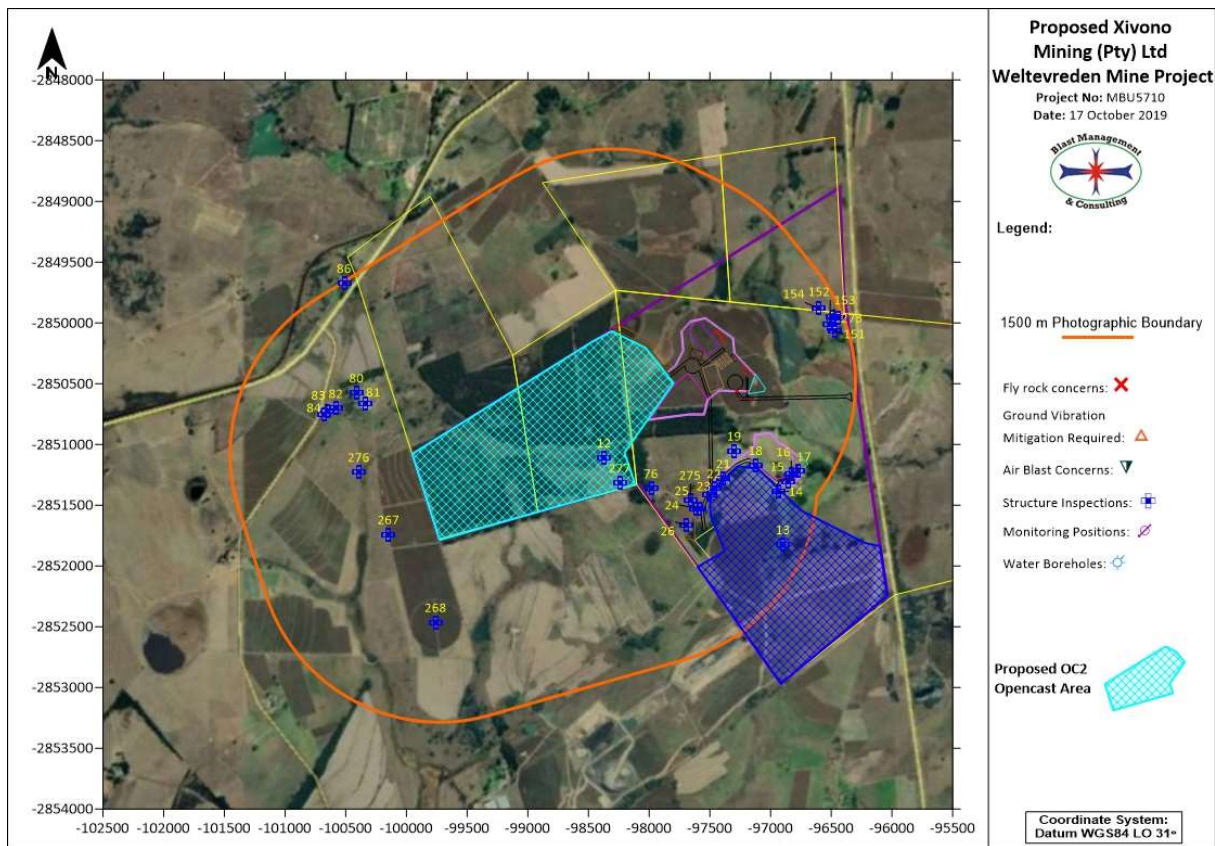


Figure 33: 1500 m area around the Pit OC2 area identified for structure inspections.

Table 30: Combined list of structures identified for inspections

Tag	Description	Y	X
<b>OC1 Opencast Area</b>			
12	House (Inside OC2 Area)	98369.21	2851110.46
13	Heritage Site - Dam/Dam wall (Inside OC1 Area)	96896.74	2851823.58
14	Heritage Site -Historical Structures (Inside OC1 Area)	96935.27	2851390.88
15	Heritage Site -Historical Structures	96854.17	2851304.67
16	Farm Buildings	96828.83	2851245.28
17	Farm Buildings	96770.14	2851221.39
18	Farmhouse	97121.03	2851171.82
19	Farm Buildings	97298.12	2851053.48
21	Informal Housing	97387.41	2851281.08
22	Informal Housing	97464.21	2851362.12
23	Informal Housing	97506.85	2851417.41
24	Informal Housing	97581.98	2851530.92
25	Informal Housing	97611.50	2851530.51
26	Informal Housing	97692.67	2851666.88
30	Heritage Site - Dam/Dam wall	97314.63	2850875.42
76	Farmhouse	97982.99	2851362.37



151	Heritage Site -Historical Structures	96473.77	2850065.09
152	Farm Structure	96512.27	2850011.53
153	House	96490.12	2849950.17
154	House	96605.37	2849881.78
157	Farmstead	96007.00	2850310.06
158	Farm Structure	96062.05	2850297.56
159	Farm Structure	95943.18	2850364.82
175	Farmstead	95285.23	2852719.64
176	Farm Buildings	95241.76	2852773.38
177	House	95284.19	2852757.97
196	Farm Structures	96458.70	2854112.79
197	Farm Structures	96442.42	2853959.20
198	Farmstead	96453.44	2853912.36
199	Farm Building	96454.43	2853862.06
201	Informal Housing	96542.06	2853666.40
202	Informal Housing	96564.81	2853568.02
203	Informal Housing	96523.17	2853571.47
204	Informal Housing	96463.46	2853511.51
206	Farmhouse	96874.39	2853499.55
207	Farmhouse	96949.54	2853585.95
208	Farmhouse	96906.46	2853569.40
211	Informal Housing	97245.54	2854349.34
258	Hydrocencus Borehole (BLYBH3)	96328.99	2853536.25
259	Hydrocencus Borehole (BLYBH4)	96900.30	2853463.98
270	Hydrocencus Borehole (BLYBH2)	96348.57	2853052.19
271	Hydrocencus Borehole (VOGBH1)	96348.57	2853052.19
272	Hydrocencus Borehole (WELBH2)	96021.45	2850303.08
273	Hydrocencus Borehole (ZOEBH2)	96441.35	2849959.33
275	Hydrocencus Borehole (WELBH6)	97660.44	2851458.54
277	Heritage Site (Graves) - Inside OC2 Pit Area	98240.63	2851317.82
<b>OC2 Opencast Area</b>			
12	House (Inside OC2 Area)	98369.21	2851110.46
13	Heritage Site - Dam/Dam wall (Inside OC1 Area)	96896.74	2851823.58
14	Heritage Site -Historical Structures (Inside OC1 Area)	96935.27	2851390.88
15	Heritage Site -Historical Structures	96854.17	2851304.67
16	Farm Buildings	96828.83	2851245.28
17	Farm Buildings	96770.14	2851221.39
18	Farmhouse	97121.03	2851171.82
19	Farm Buildings	97298.12	2851053.48
21	Informal Housing	97387.41	2851281.08
22	Informal Housing	97464.21	2851362.12
23	Informal Housing	97506.85	2851417.41

24	Informal Housing	97581.98	2851530.92
25	Informal Housing	97611.50	2851530.51
26	Informal Housing	97692.67	2851666.88
76	Farmhouse	97982.99	2851362.37
80	Farmstead	100408.62	2850575.96
81	Farm Buildings	100340.12	2850666.54
82	Informal Housing	100577.94	2850703.64
83	Informal Housing	100651.32	2850726.22
84	Informal Housing	100679.44	2850750.20
86	Farmstead	100511.80	2849674.26
151	Heritage Site -Historical Structures	96473.77	2850065.09
152	Farm Structure	96512.27	2850011.53
153	House	96490.12	2849950.17
154	House	96605.37	2849881.78
267	Hydrocencus Borehole (DRIBH1)	100146.45	2851741.96
268	Hydrocencus Borehole (DRIBH2)	99756.73	2852465.87
273	Hydrocencus Borehole (ZOEBH2)	96441.35	2849959.33
275	Hydrocencus Borehole (WELBH6)	97660.44	2851458.54
276	Hydrocencus (Spring used for commercial bottled water)	100391.22	2851229.14
277	Heritage Site (Graves) - Inside OC2 Pit Area	98240.63	2851317.82

## 21.9 Heritage Concerns

Six Heritage Sites which include graves, dam walls and historical structures were identified by the Heritage Specialist. The Heritage Specialist recommended that certain mitigation measures must be applied to the historical remains and graveyards and graves which will be affected directly or indirectly during the construction phase for the proposed project.

### 21.10 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 31.

Table 31: Recommended ground vibration air blast limits

Structure Description	Ground Vibration Limit (mm/s)	Air Blast Limit (dBL)
National Roads/Tar Roads:	150	N/A
Electrical Lines:	75	N/A
Railway:	150	N/A
Transformers	25	N/A

Structure Description	Ground Vibration Limit (mm/s)	Air Blast Limit (dBL)
Water Wells	50	N/A
Telecoms Tower	50	134
General Houses of proper construction	USBM Criteria or 25 mm/s	Shall not exceed 134dB at point of concern but 120 dB preferred
Houses of lesser proper construction	12.5	
Rural building – Mud houses	6	

### 21.11 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 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 not's' 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 and blasting notice boards setup at various routes around the project area that will inform the community of blasting dates and times.

### 21.12 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.

### 21.13 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.

## 22 Knowledge Gaps

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

## **23 Reasoned Opinion**

The author is of the opinion that with careful planning of blasting operations and necessary permissions blasting operations will be possible. A changed consideration of blast designs will be required and with considering the recommendations the operations can be done safely.

## **24 Conclusion**

Blast Management & Consulting (BM&C) was contracted as part of Environmental Impact Assessment (EIA) to perform a review of possible impacts with regards to blasting operations in the proposed Weltevreden Mining Project opencast operations. Ground vibration, air blast, fly rock and fumes are some of the aspects as a result from blasting operations. The report concentrates on the ground vibration, air blast and fly rock and intends to provide information, calculations, predictions, possible influences and mitigations of blasting operations for this project.

The evaluation of effects yielded by blasting operations was evaluated over an area as wide as 3500 m for the Opencast mining areas considered. The range of structures observed is typical roads (gravel), low cost structures, brick and mortar houses, heritage sites, boreholes and mine installations.

The location of structures around the Weltevreden Coal Mining Opencast areas are such that the charge evaluated showed possible influences due to ground vibration. The closest structures observed are the Informal Housing, Historical Structures, Farm Buildings, R33 Road, Heritage Sites, Hydrocencus Boreholes and Dam/dam wall. 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. There are also regulations that will need to be followed for permission to conduct blasting operations as these installations area within 500 m and 100 m from the blast operations.

Ground vibrations predicted for the pit areas ranged between low and very high. Ground vibration levels predicted ranged between 0.3 mm/s and very high for structures surrounding the pit areas. The expected levels of ground vibration for some of these structures are high and will require specific mitigations in the way of adjusting charge mass per delay to reduce the levels of ground vibration. Ground vibration at structures and installations other than the identified problematic structures is well below any specific concern for inducing damage.

Air blast predicted showed some concerns for opencast blasting. High levels may contribute to effects such as rattling of roofs or door or windows with limited points that are expected to be damaging and others could lead to complaints. The current accepted limit on air blast is 134 dBL. Damages are only expected to occur at levels greater than 134dB. It is maintained that if stemming control is not exercised this effect could be greater with greater range of complaints or damage. The pits are located such that “free blasting” – meaning no controls on blast preparation – will not be possible. On charges considered it is expected that air blast will be greater than 134 dB at 97 m and closer to the pit boundary. Twenty-four POI’s at OC1 Opencast and twelve POI’s at OC2 Opencast, are closer than this distance and could be problematic. Infrastructure at the pit area such as roads, heritage sites, rivers, and Hydrocensus boreholes are present but air blast does not have any influence on these installations.

An exclusion zone for safe blasting was also calculated. The exclusion zone was established to be at least 227 m. The use of the normal practice observed in mines of 500 m exclusion zone will include the Informal Housing, Farm Buildings, Dam/dam walls, R33 Road, Heritage Sites and Hydrocensus Boreholes. The use of minimum 500 m exclusion zone is rather recommended, and it will be required that evacuation be negotiated when blasting is done. Recommendations were made and should be considered.

Specific actions will be required for the pit area such as Mine Health and Safety Act requirements when blasting is done within 500 m from structures and mining within 100 m from structures.

Closure of roads and considering the farming community around the pit areas must also be considered.

The pit areas are located such that specific concerns were identified and addressed in the report.

This concludes this investigation for the proposed Weltevreden Coal Mining Project. There is no reason to believe that this operation cannot continue if attention is given to the recommendations made.

## **25 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 AECl 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 AECl 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, in-situ 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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