MP4 Project Stage 3 Blasting Vibration and Airblast effects assessment OGNZL Macraes New Zealand

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26 October 2023

I am a mining engineer who has specialised knowledge and experience in explosives technology and commercial blasting applications for my 50+ year career. I work in most areas of civil and mining blasting including opencut and construction blasting. A major portion of my work in the past 50+ years has been in managing Risk Assessments, blasting project evaluation, auditing blasting performances and training engineers and shotfirers in safe & efficient blasting.

Limit of Liability

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1. SCOPE OF THIS REPORT

This report:

- Summarises the vibration and airblast effects of overburden blasting activity for three proposed open pit extensions that form the basis of the additional mine life - the MP4 project - at Macraes Gold Project (**Macraes**).
- Considers the status of the residences and other potentially sensitive sites that are of relevance to the effects of vibration and airblast from blasting.
- Performs modelling and calculations of predicted vibration and airblast levels based on historical blast designs similar to those recently used at other OceanaGold New Zealand Limited (OGNZL) sites as similar blasting parameters will be used for the proposed MP4 open pit extensions.
- Presents data and reports conclusions on the overall blasting vibration and airblast effects of the proposed mining extensions on nearby residences and other potentially sensitive sites in the surrounding environment including heritage sites.

2. EXECUTIVE SUMMARY

A. OceanaGold (New Zealand) Limited (OGNZL) operates the Macraes Gold Project at Macraes Flat in North Otago. OGNZL is proposing to extend three of the existing open pits.

B. The potential for vibration and airblast to disturb the integrity and/or amenity of identified neighbouring sensitive sites has been assessed and specific ‘Proximity’ blast designs have been shown to ensure compliance with existing resource consent conditions.

C. There are conservative safety factors built into the calculations for vibration and airblast levels caused by blasting in the proposed pit extensions. In particular all predictions of vibration and airblast are conservative because the actual distances from blasting to the sensitive sites are likely to be significantly further away than those calculated in the environmental predictions.

D. OGNZL regularly conducts specific ‘Proximity’ blast designs when near boundaries of sensitive sites and residences to ensure that vibration levels remain below consented limits.

E. Historic/Heritage sites will be protected by the use of stated ‘Proximity’ blast designs and regular condition surveys.

F. Other consequences of blasting, such as flyrock and dust are unlikely to be of concern due to the extended distances to occupied sites and the Macraes Road will be closed whenever blasting has any possibility of endangering persons or vehicles traveling in the area.

G. Because of compliance with District Plan rules and Australian/NZ Standards, the adverse effects of blasting will be no more than minor.

3. SUMMARY OF PROPOSED ACTIVITIES

OGNZL operates both open pit and underground gold mines at Macraes Flat in North Otago. OGNZL is proposing to extend the existing Coronation, Innes Mills, & Golden Bar open pits.

These open pit extensions have been considered in this blasting impacts study (Figure 1)

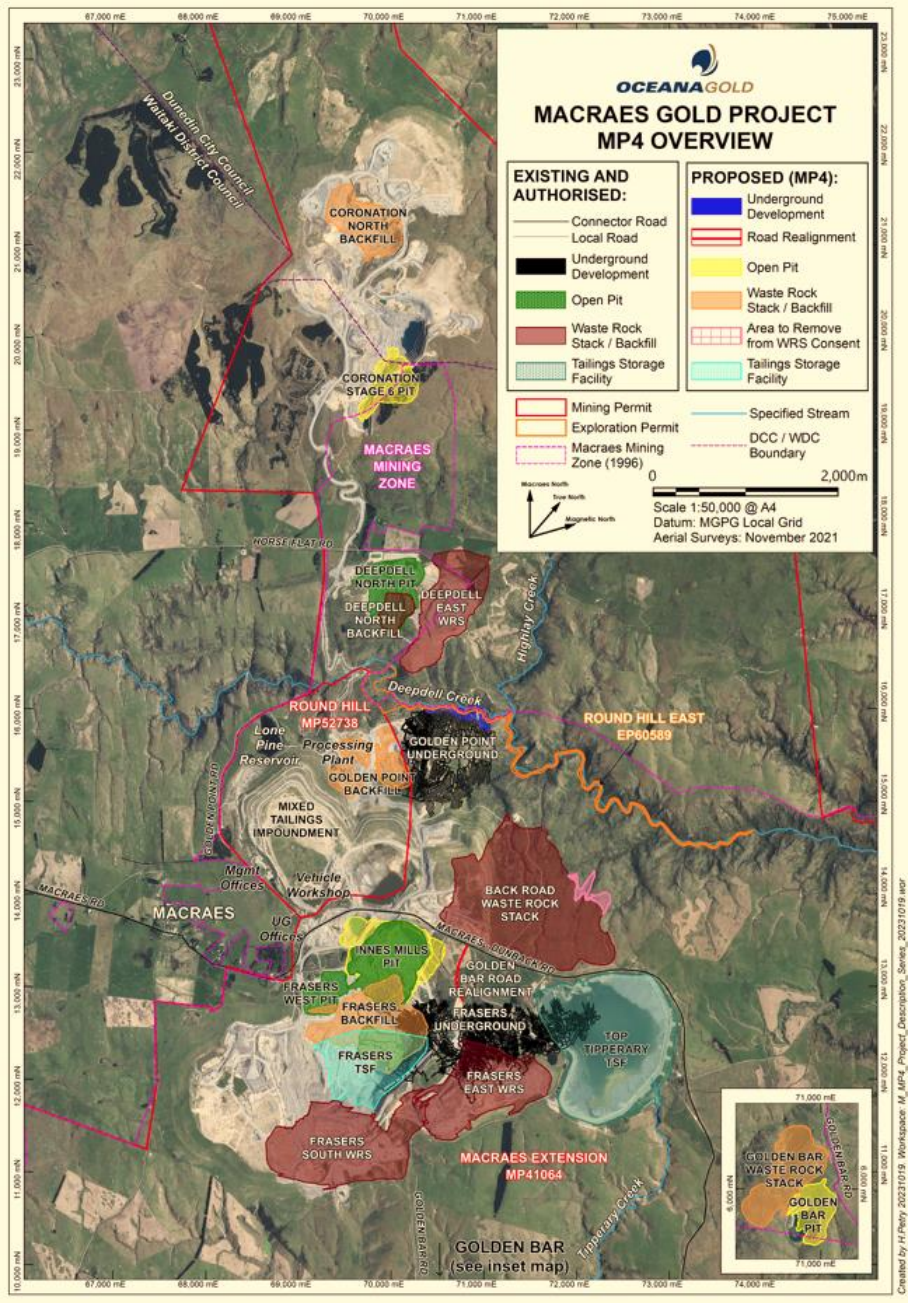

Figure 1: Macraes MP4 Overview showing pit locations

The proposed extraction areas will involve drilling and blasting using the same equipment and processes as are currently used in active areas of the Macraes mining operation.

Best blasting practices and appropriate mitigation measures, as currently employed, will ensure that the impacts of the proposed activities are acceptable to the surrounding residences and compliant with the Waitaki District Plan rules.

The Australian and New Zealand Standard for vibration is AS2187.2.2006 and this has been used as the basis for consent conditions for previous projects at Macraes. The relevant table is included in Appendix A:

The existing consent conditions are appropriate for the proposed pit extensions and sets limits of:

- PPV of 5mm/s measured at the notional boundary of any dwelling not owned by OGNZL (provided it may be exceeded up to 5% of the total number of blasts over 12 months). This level shall not exceed 10mm/s at any time.
- Airblast overpressure measured within the notional boundary of any dwelling not owned by OGNZL shall not exceed a peak non-frequency weighted level of 115 decibels (provided it may be exceeded up to 5% of the total number of blasts over 12 months). This level shall not exceed 120 decibels at any time.

4. HISTORICAL / HERITAGE SITES

The Conditions of Consent for Historic/Heritage buildings states that no damage shall occur to their structural state and requires regular checks by an expert. Additionally, the Waitaki District Plan 'III_06 Macraes Mining Rules 2010 section 6.5.2 Vibration' states:

Vibration: activities shall be conducted such that the ground vibration levels measured either at the Macraes Mining Zone boundary or the boundary of the Golden Point Historic Reserve shall not exceed 10mm per second peak particular velocity measured in the frequency range 3 hertz and 12 hertz.

Airblast levels at all Historic/Heritage sites should remain less than those prescribed in III_06 Macraes Mining Rules 2010 section 6.5.3. "Activities shall be conducted such that the following air blast peak over sound pressure measured either at the Macraes Mining Zone Boundary or any building within the Golden Point Historic Reserve shall not exceed 128 dBL."

Historical buildings are generally the closest structures to the proposed blasting, and we have performed basic vibration and airblast calculations for each site. It is our opinion that the expected vibration and airblast levels are unlikely to cause any greater deteriorations of the old buildings than normal seasonal variations caused by weather, climate, temperatures, or seismic forces.

The historical buildings are not used for accommodation so are at almost all times unoccupied. Whenever blasting is to be conducted in proximity to historical buildings, the OGNZL 500m safety perimeter procedure will ensure that there are no people present.

Condition 39 of WDC consent 201.2020.1519 and 201.2020.1514 is an appropriate means of protecting heritage/historic buildings. The consent requires a baseline condition survey should be carried out prior to the commencement of blasting at any new mine area to determine the status of Historic/Heritage structures. If required due to proximity to the heritage/historic buildings, this would be done by a suitably qualified person who would document the condition of buildings prior to commencement of new blasting impacts.

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After initial inspections before blasting commences in any new area, ongoing inspections of the Historic/Heritage sites will be conducted at intervals to maintain the assurance of the integrity of the buildings as per the consent conditions. This process continues to be an appropriate means of protecting the heritage structures.

Historically, the airblast limit has been marginally exceeded a small number of times when blasting less than 300m from a sensitive site, (Appendix C). If permissible limits are likely to be approached or exceeded, then basic design modifications as outlined in this report will ensure compliance with consent conditions.

5. BLAST DESIGN CHARACTERISTICS

Blast designs for the open pit extensions, including drilling, charging, stemming, and firing procedures will be essentially the same as those used at the existing Macraes mining operations and in particular at Frasers West open pit, where historic data shows that vibration and airblast overpressure levels at all nearby residential properties (which are those closest to the operation) have complied with the consent levels and those of AS2187.2.

This assessment has used the current and historical blast design values to calculate predicted environmental effects for each of the proposed mining extensions. Table 1 gives an indication of typical blast design parameters for the types of blasting employed at the existing open pits including explosives charge mass per hole, and per delay interval (MIC = Maximum Instantaneous Charge).

We have listed the parameters for 'Normal'' blasting which may be applied when at greater distances from any sensitive site. 'Normal'' blasting is what is used in most instances for overburden stripping. In circumstances such as near pit limits, where more cautious blasting is appropriate, to maintain control and minimize any environmental disturbances, more conservative blast designs are used. These are termed 'Proximity' blasting and relate to additional measures of control applied to ensure that blasting impacts remain below consent limits.

Typical blasthole designs and configurations may have up to three holes per delay (MIC) for Ore blasts and two holes per delay (MIC) for Waste blasts.

Table 1: Typical blast parameters – OGNZL Openpits

Design parameters	Proximity	Normal
Diameter (mm)	102mm	200mm
Explosive MIC	60kg	400kg

It is a simple matter to make design changes to the mass of explosives firing at one instance for vibration control or modifying the explosive's confinement through adjustments to stemming lengths for airblast reduction.

6. CONSENT CONDITIONS

The Consent conditions for vibration and airblast state target levels for residences of 5 mm/s and 115 dBL, respectively, and these are considered by world wide experience to be reasonable for human comfort.

In this report, for each proposed open pit extension, we have considered the predicted vibration and airblast levels at the nearest sensitive sites and particularly residential houses.

There are only a few houses in proximity to the proposed extension areas. For each proposed pit extension, the closest privately-owned houses are highlighted and the predicted vibrations and airblast calculated. The proximity to particular Heritage sites is also identified in each case where blasting vibrations might possibly be such that particular attention needs to be given to blastdesign and implementation.

We have included comments on factors that have the most effect on vibration and airblast levels.

In relation to other potential blasting impacts such as flyrock, fumes and dust generation, OGNZL's 'Management Plan - Open Pit Explosives 2021' outlines procedures as below relating to notifications and protection of all persons and property, particularly from Flyrock:

- 5.9 Blast Exclusion Zones
- 5.11.6 Blast Notifications
- 5.11.9 Closure of private or leased property
- 5.11.10 Closure of public roads

Mitigation measures are specifically addressed in the OGNZL's Principal Hazard Management Plan 2020 and the Management Plan - Open Pit Explosives 2021. By continuing to apply these mitigation measures successfully used at Macraes Gold Project over recent years, there is assurance that OGNZL will continue to manage these effects to acceptable levels and meet consent conditions.

6.1 Existing resource consent conditions Macraes

OGNZL holds a number of resource consents for mining operations at Macraes Gold Project which impose conditions upon blasting activities:

- WDC 201.2019.1454;
- WDC 201.2013.360 and DCC LUC-2013-225;
- WDC 201.2020.1514;
- ORC RM16.138 and DCC LUC-2016-234; and
- LUC-2013-225A and WDC 201.2016.779 and 201.2013.360.1).

OGNZL proposes that the same parameters and conditions outlined below will apply to the proposed extensions.

Blasting shall be restricted to within the following hours:

- Monday-Friday: 9am to 5.30pm
- Saturday and Sunday: 10am to 4.30pm

"Vibration due to blasting or any other activity associated with the mining operation, when measured at any point within the notional boundary of any dwelling not owned by the consent holder, school or church outside the Macraes Mining Project Mineral Zone as defined by the Waitaki District Plan, deemed operative on 23 August 2010 shall not exceed a peak particle velocity measured in the frequency range 3-12 Hz of 5 mm/sec provided this level may be exceeded on up to 5% of the total number of blasts over a period of 12 months. The level shall not exceed 10 mm/sec at any time."

"Airblast overpressure from blasting associated with the mining operation, when measured at any point within the notional boundary of any dwelling not owned by the consent holder, school or church outside the Macraes Mining Project Mineral Zone as defined by the Waitaki District Plan, deemed operative on 23 August 2010 shall not exceed a peak non-frequency-weighted (Linear or flat) level of 115 decibels (dB), provided this level may be exceeded on up to 5% of the total number of blasts over a period of 12 months. The level shall not exceed 120 dB (Linear peak) at any time. For the purpose of this consent, C-frequency- weighting may be considered equivalent to the Linear or Flat-frequency- weighting. "

The consent holder shall produce a report each year summarising the results of the Noise, Airblast and Vibration Monitoring. The report shall be included in the Project Overview and Annual Work and Rehabilitation Programme.

It is techNIck Consulting's opinion that these conditions provide appropriate protection of amenity for people living and working in the vicinity of the proposed pit extensions.

Also outlined in the section on Conditions of Consent for Historic/Heritage buildings:

Activities shall be conducted such that the ground vibration levels measured either at the Macraes Mining Zone boundary or the boundary of the Golden Point Historic Reserve shall not exceed 10mm per second peak particular velocity measured in the frequency range 3 hertz and 12 hertz.

Activities shall be conducted such that the Airblast peak over pressure measured either at the Macraes Mining Zone Boundary or any building within the Golden Point Historic Reserve shall not exceed 128 dBL."

7. BLAST-INDUCED VIBRATIONS

Vibration levels are calculated and stated as a peak particle velocity ('PPV') and measured in millimetres per second (mm/s).

The Waitaki District Plan (WDC Reference: 201.2013.360) refers to vibration limits consistent with the Standard AS 2187.2 and this is in the context of preserving the comfort and amenity of persons at occupied premises and not specifically for the prevention of damage to buildings which the Standard recognises as involving much higher levels of vibration.

Predicted vibration levels for properly designed, drilled and charged blasts can be calculated but these can only be verified and calibrated by taking site readings from actual blasts. In fact, blasting has already been successfully carried out in the various open pits over many years and considerable information is available to allow quality predictions for each pit extension. This means that measured vibration data is available well before any further blasting is carried out in close proximity to houses or historic / heritage sites and this allows immediate analysis and adjustment of blast designs so as to remain below consent levels.

We have used survey data to determine the distances from the various pit boundaries to nearby houses and Historic/Heritage sites. It is rare to blast right up to the boundary and it is likely that due to the weak nature of the weathered rock, much of the upper overburden will be removed by excavation without blasting. This means that the final blasting areas are

likely to be further away than those indicated in the calculations (see Appendix B – Open Pit Sections near boundary).

When approaching the final pit limits for the open pit extensions, the explosives charge (kg) per hole and Maximum Instantaneous Charge can be further reduced by limiting bench heights and hole diameters and this will result in substantially reduced vibrations and airblast. This is a simple technique that OGNZL regularly employs if vibrations or airblast ever approach allowable levels and is reflected in the vibration prediction tables as 'Proximity' designs.

8. PREDICTION OF VIBRATION LEVELS FOR OPENCUT MINING

The AS2187.2 default formula used for predicting vibration levels is:

$$\mathbf{V} = \mathbf{K} \times \left(\frac{\sqrt{\mathbf{W}}}{\mathbf{D}} \right)^{1.6}$$

where:

V = peak particle velocity (PPV) or (RPPV)
W = explosives charge per delay (kg)
D = distance to damageable "target" (m)
K is a constant related to rock properties & blast design

RPPV refers to the 'Resultant' peak particle velocity which is the value taken from the accumulation of the vertical radial, and transverse individual planes. This is the most common reference applied to vibration limits and upon which the AS Standard 2187.2 is based.

AS2187.2 recognizes a range of potential 'K' values because of the wide range of geological formations world-wide. The 'K' value depends on geological conditions and the nature of the type of blast design.

For all proposed pit extensions, we have performed calculations using the AS2187.2 formula, with a 'K' value of 1200 which is at the higher end of "back-calculated" values from the historical OGNZL records.

The following extract is from the Standard AS 2187.2 (2006). Table 2 forms the basis of the existing resource consent conditions for blasting operations at Macraes.

Table 2: VIBRATION LIMITS FOR HUMAN COMFORT

APPENDIX J TABLE J4.5(A) GROUND VIBRATION LIMITS FOR HUMAN COMFORT

Category	Type of blasting operations	Peak component particle velocity (mm/s)
Sensitive site*	Operations lasting longer than 12 months or more than 20 blasts.	5 mm/s for 95% blasts per year 10 mm/s maximum unless agreement is reached with the occupier that a higher limit may apply
Sensitive site*	Operations lasting for less than 12 months or 20 blasts.	10 mm/s maximum unless agreement is reached with occupier that a higher limit may apply
Occupied non-sensitive sites, such as factories and commercial premises	All blasting	25 mm/s maximum unless agreement is reached with occupier that a higher limit may apply. For sites containing equipment sensitive to vibration, the vibration should be kept below manufacturer's specifications or levels that can be shown to adversely affect the equipment operation

* Sensitive site includes occupied private houses & low rise residential buildings, theatres, schools, etc

9. PREDICTION OF AIRBLAST LEVELS

Predictive calculations for airblast can vary because of the diversity of blasting configurations and the effects of pit orientation, weather and topography. For example, strong winds will increase the airblast levels in the down-wind direction. According to AS2187.2, an airblast level of 115 to 120 dBL is considered reasonable for human comfort at occupied premises, and well below any damage threshold.

We have perused documents relating to seasonal wind directions in the area including "Macraes Mine - Summary of Ambient Air Monitoring Results for 2016.doc"; of January 2018 and "DDN3 Wind Rose" for Macraes Flat.

As outlined in the "Management Plan - Noise, Airblast and Vibration MAC-205-PLN-002-1",it is incumbent on the mine operations management to make an assessment of the weather conditions on the day of a proposed open pit blast and to make changes to the time of a blast if conditions are unfavourable. This site Management Plan should be reviewed and updated as necessary.

In practice, Airblast levels are readily reduced simply by increasing the stemming length on blastholes, and this technique would typically be used, if necessary, in the higher bench levels where airblast is not much reduced by enclosure within the pit itself.

Airblast will reduce as the mine benches get deeper with time. As such the airblast levels are expected to remain less than 115 dBL at the nearest residences and 120 dBL at any sensitive historical sites throughout the mining life of all the proposed open pit extensions. It is unlikely that this level will be exceeded under normal operating conditions, although extra attention may be needed if the prevailing wind is very strong and toward any closer residences.

AS 2187.2 2006: section J7.2 'Airblast overpressure', indicates that airblast levels are commonly estimated using the following scaling formula: Note that the kPa pressure needs to be converted to dBL and this is calculated in the airblast values for each site.

$$P = K_a X \left(\frac{R}{Q^{1/3}} \right)^{\alpha}$$

Where:

- P = pressure (kPa)
- Q = explosives charge mass (kg)
- R = distance from charge (m)
- Ka = site constant
- a = site exponent

$$P = 40 X \left(\frac{R}{Q^{1/3}} \right)^{-1.45}$$

10. MEASURES TO REDUCE VIBRATION AND AIRBLAST

The site Management Plan 'Noise, Airblast and Vibration' allows for the following management and mitigation measures to be employed to reduce vibration and airblast levels and impacts:

1. Style of blast - OGNZL employs "Paddock" or "Choke" blasting rather than free face blasts. This type of blasting generates less airblast than alternative free-face blasting.
2. Accurate survey and layout of drill hole positions
3. Checking depths and angles of holes after drilling (lower airblast)
4. Rechecking hole depths immediately before charging (lower vibration)
5. Control maximum explosives charge per delay (lower vibration)
6. Suitable priming practices including the location of the primer
7. Continuous monitoring of explosives charging (lower vibration)
8. Ensuring stemming quality and quantity are as per design (lower airblast)
9. Charge confinement – Depth of burial / Stemming length (lower airblast)
10. Designing blast initiation sequence to avoid excessive timing overlaps (lower vibration)
11. Considering the effect of topography, bunds, deep pits (lower airblast)
12. Minimise exposed detonating cord initiation system (lower airblast)
13. Adapt to atmospheric conditions – inversions or strong, unfavourable wind direction and choice of blast time (lower airblast)

11. GENERIC RECOMMENDATIONS FOR ALL OPEN PITS

- Standard initiation practices of firing multiple blastholes on separate millisecond delay intervals as per industry best practice. This has been part of all mine blasting at Macraes, literally for decades.

- Within a single pit, initiation of blasting on different benches should be offset (not simultaneous) to ensure no cumulative effects.
- Between different pits, initiation of blasting should be offset (not simultaneous).
- As has been the case in the past at Macraes mining areas, and consistent with the Noise, Airblast and Vibration Monitoring Plan requirements, vibration monitoring shall be conducted at the nearest neighbour's residence and at any other sites considered sensitive or vulnerable. Such monitoring allows actual vibration levels and frequencies from all blasting activities to be recorded and reviewed, and on the basis of such readings, adjustments can be made to the predictive calculations and to ongoing blast designs to ensure compliance and human comfort.
- There may be a need to establish new monitoring positions for the proposed pit extensions based on the proximity of any sensitive sites.

12. CORONATION PIT EXTENSION (STAGE 6)

The Coronation open pit is located around 3.5km NW of the main Macraes operation (Figure 1). The proposed pit extension (Stage 6) consists of an approximately 250m expansion to the east Figure 2). The expanded pit is not as deep as the deepest part of the current Coronation Stage 5 Pit.

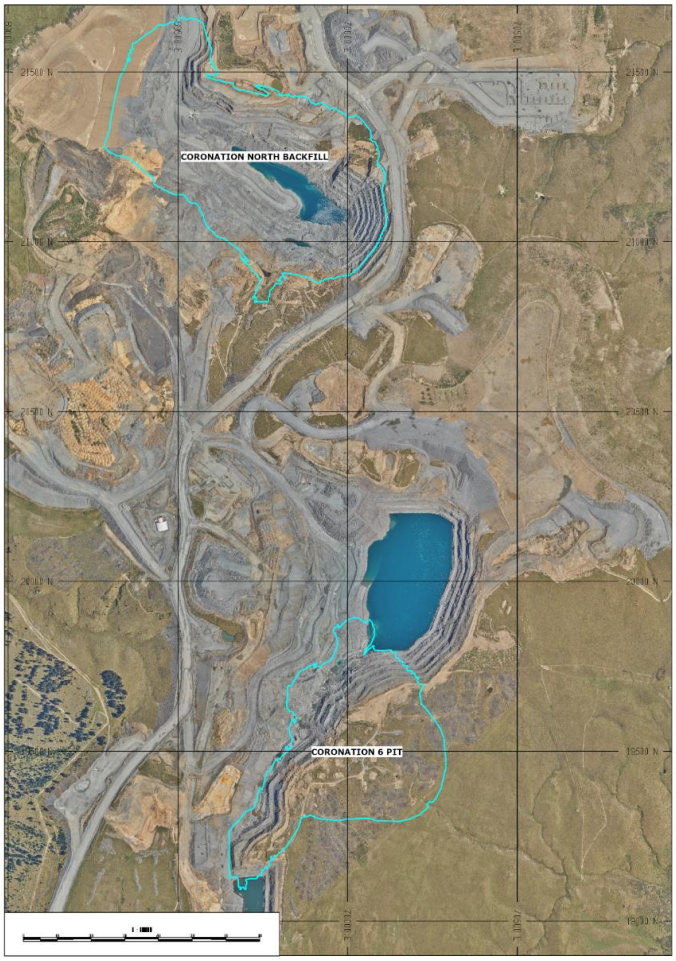

Figure 2: Coronation Pit extension (Stage 6)

a) Blast Design Characteristics

Blast designs for the Coronation Stage 6 Pit will be essentially the same as those used at other mine pits so we have used these values to calculate predicted environmental effects. As the pit progresses and gets deeper, levels of vibration, airblast and flyrock, and any associated risks, will reduce.

b) Sensitive Area

Only one privately-owned residence has been identified at range of 2250m from potential blasting activities. All other residences are well beyond any distance of concern.

- C Howard's residence = ~ 2250m from Coronation Stage 6 Pit

There are no historic sites that will be adversely affected by blasting.

c) Vibration predictions

Calculations are based on the AS2187.2 formula, with a 'K' value of 1200 which is at the higher end of the value "back-calculated" from the historical OGNZL records (Table 3). This means that there is a built-in safety factor in these vibration impact predictions.

Table 3: Vibration predictions for Coronation Pit extension

Coronation Vibration predictions	**'K' =**	1200	1200
	MIC = kg	**60**	**400**
Site	Distance (m)	**PPV** mm/s	**PPV** mm/s
Nearest Residence –C Howards	2250	**1.3**	**4.1**

(MIC = maximum instantaneous charge)

Nearest occupied house = C Howard's residence = 2250m (PPV limit 5 mm/s)

Based on the above calculations, the vibration levels should remain below the prescribed limits for all normal blasting. In the unlikely event that levels approach the allowable limits, then it may be necessary to design the closest overburden blasts such that the Maximum Instantaneous Charge is reduced. This is common practice near pit limits and is easily achieved by changing hole diameters, bench heights or initiation timing.

We understand that there are no other sensitive sites within 2250m of the blasting locations.

d) Airblast

An airblast level of 115 to 120 dBL is considered reasonable for human comfort. The following table (Table 4) gives an indication of calculated air over-pressure values for Waste and Ore blasting using the AS 2187.2 formula:

Table 4: Airblast predictions for Coronation Pit extension

Coronation Airblast predictions	**MIC kg**	**60**	**400**
Site of Interest	Distance	**dBL**	**dBL**
Nearest Residence –C Howards	2250	**53**	**73**

(MIC = maximum instantaneous charge)

Nearest occupied house = C Howard's residence = 2250m

The expected airblast levels at C Howard's residence are well below the 115 dBL safe limits stated in the Standard. It is unlikely that this level will be exceeded at any occupied residences under normal operating conditions.

e) Flyrock, Fumes, Dust

Other consequences of blasting, such as flyrock, fumes and dust generation can be adequately addressed by continuing to apply the mitigation measures successfully used at Macraes by OGNZL over recent years.

f) Conclusions - Coronation Pit Extension

1. For the Coronation Stage 6 Pit, we note that any environmental impacts of the proposed blasting program will be less than minor fored the neighbouring residences.

2. Airblast is predicted to be lower than the proposed consent levels at the residence and will remain compliant.

g) References Coronation Pit

1) Coronation Stage 6 Open Pit Project Description August 2023.

13. GOLDEN BAR EXTENSION (STAGE 2)

Golden Bar Stage 2 Pit is a 'satellite mine' located approximately 5.5km south east of the main Macraes operations (Figure 1). The proposed pit extension consists of an approximately 200m expansion to the north east (Figure 3).

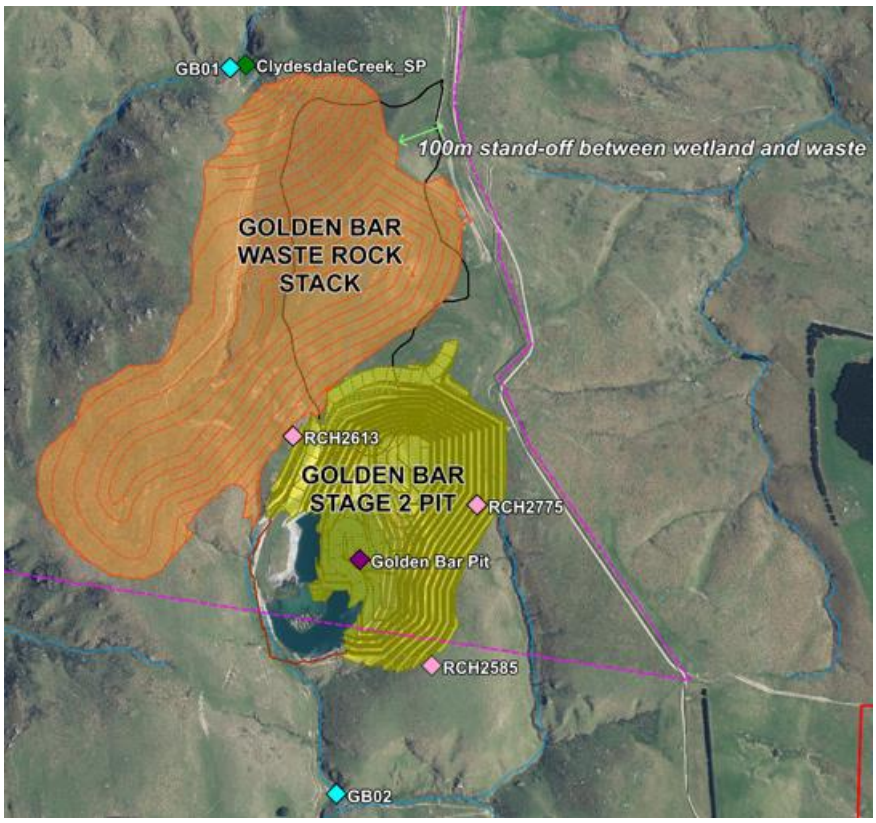

Figure 3: Golden Bar Pit extension (Stage 2)

As seen in Figure 3, the proposed pit crest is currently very close to the current Golden Bar Road. As the pit extension progresses and gets deeper, the levels of vibration, airblast and flyrock, and any associated risk, will reduce.

a) Blast Design Characteristics

Blast designs for the Golden Bar pit extension will be essentially the same as those used at other open pits so we have used these values to calculate predicted environmental effects.

b) Sensitive Areas

In assessing blasting impacts, the mine survey (Table 5) and GIS shows sites that are most relevant.

Table 5: Sensitive Sites – Golden Bar

Golden Bar Pit

DWELLINGS	Location	ROADS	HISTORIC
NONE	*Stoneburn*	*Golden Bar Road*	*NONE*
	3,150	275	

No privately-owned residence has been identified within any range of concern from potential blasting activities. There are no historic buildings within 2500 metres of the pit. Blasting will have no adverse impacts.

Roads:

Note that there are no specific vibration levels stated in the AS2187.2 standard, or in any consent conditions for roads. Global experience shows that roads, especially unsealed roads like Golden Bar Road, are very resistant to damage from blasting vibrations and are not regarded as sensitive.

The significant blasting risk in relation to roads is the impact of flyrock on persons and this matter is covered in the section on the 'Management Plan Open Pit Explosives 2021' with procedures relating to notifications, clearances and protection of all persons and property from Flyrock.

c) Vibration predictions

Calculations are based on the AS2187.2 formula, with a 'K' value of 1200 which is above the value "back-calculated" from the historical OGNZL records (Table 6). This means that there is a built-in safety factor in these vibration impact predictions.

Table 6: Vibration predictions for Golden Bar Pit extension

Golden Bar Vibration predictions	**'K' =**	1200	1200
	MIC = kg	**60**	**400**
Site	Distance (m)	**PPV** mm/s	**PPV** mm/s
Stoneburn	3150	**0.9**	**2.8**

(MIC = maximum instantaneous charge)

Based on the above calculations the vibration levels for any potential sensitive site should remain well below the prescribed limits for all normal blasting.

d) Airblast

Table 7 gives an indication of calculated air over-pressure values for Waste and Ore blasting using the AS 2187.2 formula (occupied residences highlighted):

Table 7: Airblast predictions for Golden Bar Pit extension

Golden Bar Airblast predictions	MIC kg	120	400
Site of Interest	Distance	**dBL**	**dBL**
Stoneburn	3150	**50**	**62**

(MIC = maximum instantaneous charge)

No privately-owned residence or sensitive site has been identified within a range of 3150 metres from potential blasting activities.

e) Flyrock, Fumes, Dust

Other consequences of blasting, such as flyrock, fumes and dust generation can be adequately addressed by continuing to apply the mitigation measures successfully used at the site over recent years.

f) Conclusions - Golden Bar Pit Extension

1. For the Golden Bar Stage 2 Pit, techNick Consulating has not identified any environmental impacts for the proposed blasting program that are likely to cause unacceptable effects or discomfort as there are no neighbouring houses or sensitive sites.

2. Airblast is predicted to be lower than the proposed consent levels at residences and will remain compliant.

3. As in the past at the site, issues concerning vibration, airblast and flyrock can be managed using best practice techniques to ensure compliance and blasting effects will be less than minor.

g) References Golden Bar

1) Golden Bar Stage 2 Open Pit Project Description March 2022.

14. INNES MILLS PIT EXTENSION (STAGES 8-10)

The proposed Innes Mills Stage 8-10 pit extension is a 200m expansion to the east. The expanded pit goes deeper than the deepest part of the previously mined and planned Innes Mill Pit within the MP3 consent area (Figure 4). As the pit progresses and gets deeper, risks and the levels of vibration, airblast and flyrock diminish.

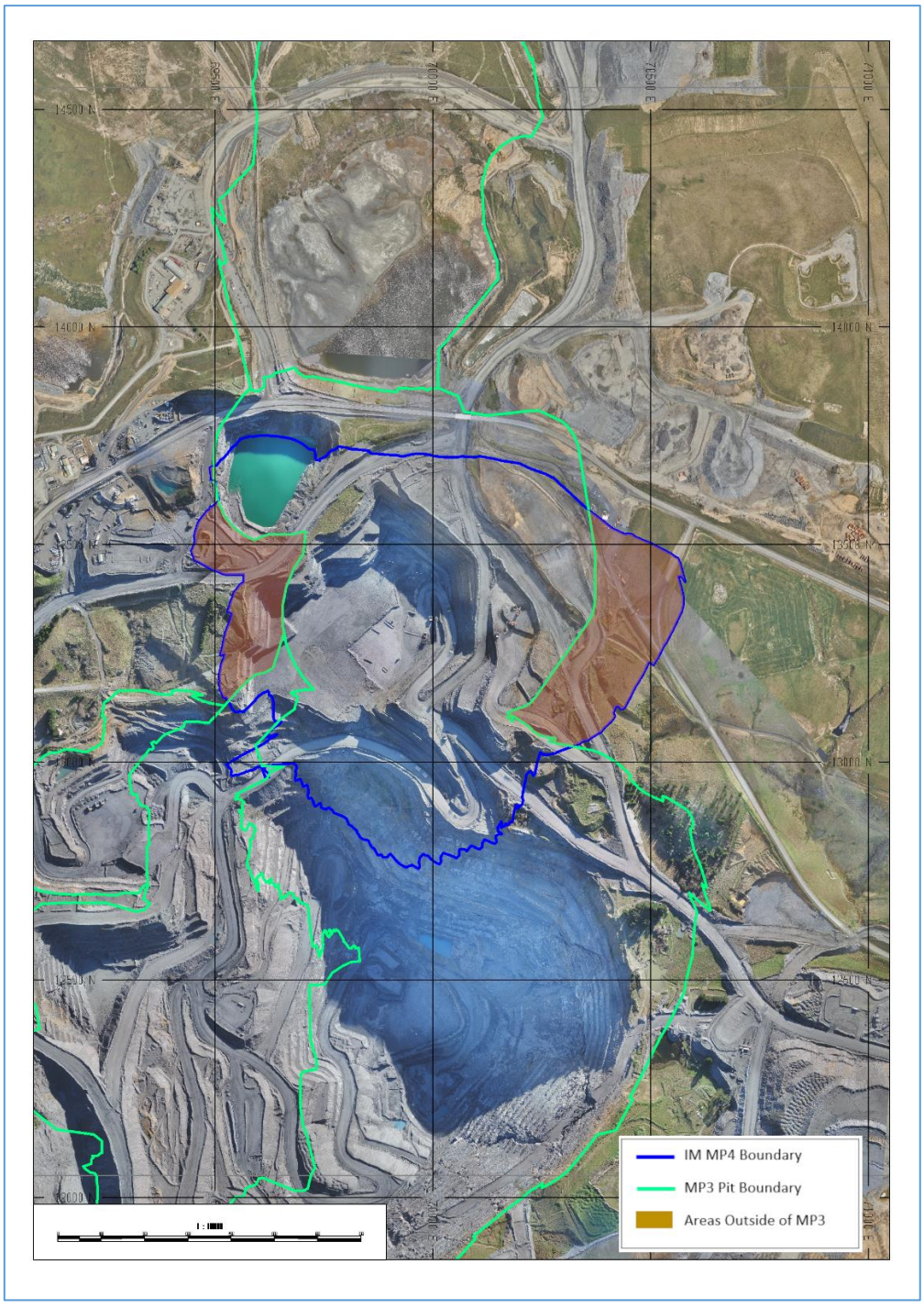

Figure 4: Innes Mills Pit extension (Stages 8-10)

a) Blast Design Characteristics

Blast designs for the Innes Mill Stage 8-10 Pit will be essentially the same as those used at other open pits so we have used these values to calculate predicted environmental effects.

b) Sensitive Areas - Innes Mill

In assessing blasting impacts, Table 8 from mine survey and GIS data indicates the proximity of those sensitive sites that are most relevant.

Table 8: Closest relevant sites to pit boundaries - Innes Mill extension

IMOP LOM 18-08-2022			
Blasting	**Dwellings (senstive sites)**		
design Diam	**J Howard**	**O'Connell**	**C Howard**
Hole 102mm	1170	2170	4280
Hole 200mm	1634	2519	4281

Note that we have included distances for each of the two styles of blasting with their respective hole diameters that will be employed.

Only one privately-owned residence (J Howard) has been identified within a distance that could potentially be impacted by blasting activities. Any sites beyond this will not experience blasting impacts of concern.

Proximity blasting will be employed within 1600m of J Howard's residence. Beyond this, normal production blasting will be used.

Roads are insensitive to high levels of blasting vibration or airblast. As roadways can be constructed in many ways it is not possible to be precise as to what vibration levels might cause any cosmetic road surface disturbance but effects will be no more than minor.

When the IM Pit is close to Macraes-Dunback public road the only significant blasting hazard will be risk of flyrock causing injury to persons or damage to property left on the road. The Blast Management Plan outlines the procedures to clear and maintain a safety perimeter from the nearest points on the road to any blast. This ensures that there is no risk of injury or damage.

c) Vibration predictions for Innes Mill Project

Calculations in Table 9 are based on the AS2187.2 formula, with a 'K' value of 1200 which according to the description of the rock mass and previous experience at the site is at the higher end of expectations.

Table 9: Vibration predictions for Innes Mill extension

Innes Mill Vibration predictions	**'K' =**	1200			1200
Blast type / kg MIC	102mm **kg**	**60**		200mm **kg**	**400**
Site from Blast	Distance (m)	PPV mm/s		Distance (m)	PPV mm/s
Golden Pt Reserve	2612	**1.1**		2529	**3.6**
J Howards	1170	**2.9**		1634	**6.1**
O'Connells	2170	**1.4**		2519	**3.6**
C Howards	4280	**0.6**		4281	**1.9**

(MIC = maximum instantaneous charge)

The only calculated vibration prediction exceeding the base 5 mm/s residential level is for J. Howards' residence for full production blasting and is highlighted pink in Table 9.

The Consent condition states that this level may be exceeded up to 5% of the total number of blasts over a period of 12 months. The level shall not exceed 10 mm/sec at any time. This means that the consent conditions are likely to be fully met since most vibrations will be less than 5 mm/s with an occasional value around 6 mm/s and always under the maximum of 10 mm/s. In the event that actual vibration readings approach the 5mm/s base limit, any ongoing blasts can be redesigned with the Maximum Instantaneous Charge reduced to about 200kg which gives a predicted vibration level of 4.0 mm/s.

This practice of adjusting blast designs is common near any sensitive sites at Macraes and is expressed in the OGNZL Management Plan Noise, Airblast and Vibration Plan and is easily achieved by changing hole diameters, bench heights or initiation timing consistent with that Plan.

There will be no issues in regard to cumulative effects from blasting across the site as the blast management plan ensures that there is time separation of blasts in close proximity.

Vibration levels can be measured by placing monitoring instruments near any sensitive site prior to firing a blast. The accumulated data from blasts conducted at more distant locations around the open pit will allow the engineering team to regularly interpret and adjust designs and predictions to ensure compliance with agreed safe limits.

d) Airblast

An airblast level of 115 to 120 dBL is considered reasonable for human comfort. Table 10 gives an indication of calculated air over-pressure values for Waste and Ore blasting using the AS 2187.2 formula (occupied residences highlighted).

Table 10: Airblast predictions for Innes Mill Pit extension

Innes Mill Airblast predictions					
Blast type / kg MIC	102mm **kg**	**60**		200mm **kg**	**400**
Site (m) from Blast	Distance	**dBL**		Distance	**dBL**
Golden Pt Reserve	2612	**49**		2529	**69**
J Howards	1170	**73**		1634	**84**
O'Connells	2170	**54**		2519	**69**
C Howards	4280	**36**		4281	**53**

The expected airblast levels at all the residences are below the 115 dBL safe limits stated in the Standard. It is very unlikely that this level will be exceeded at occupied residences under normal operating conditions.

If it ever became necessary, blast designs could be modified in accordance with the Management Plan Open Pit Explosives and the earlier section referring to management and mitigation measures for airblast "Measures to reduce vibration and airblast". Basic 'Proximity' blast design procedures as previously and currently employed at Macraes can be applied to reduce airblast to acceptable levels.

e) Flyrock, Fumes, Dust

Other consequences of blasting, such as flyrock, fumes and dust generation can be adequately addressed by continuing to apply the mitigation measures successfully used at Macraes over recent years.

f) Conclusions – Innes Mill Pit extension

1. For the Innes Mill Stage 8-10 Pit, if 'Normal' production blasting was to be continued right up to the closest boundary, J Howard's property and possibly O'Connell's may experience vibrations that exceed the lower permissible level of 5 mm/s, although they will remain below the upper permissible limit of 10 mm/s at all times. Where vibrations approach the 5mm/s limit, 'Proximity' blasting options will ensure that no permissible limits will be exceeded for residences.

2. Where blasting is required in areas of the pit closest to Historic sites, Vibration levels that comply with Consent conditions and the District Plan rules will be assured by employing appropriate blasting designs.

3. Airblast is predicted to be lower than proposed consent levels at residences and historical sites and will remain compliant.

4. As in the past at the site, issues concerning vibration, airblast and flyrock can be managed using quality practice techniques to ensure compliance and that blasting effects will be no more than minor.

g) References

1) Innes Mill Open Pit Project Description August 2023

15. OVERALL SUMMARY AND CONCUSIONS

1. Blasting will start at larger distances from any sensitive sites and measurements of vibration and airblast will be recorded and analysed as the open pits progress toward the sensitive receptors and sites.
2. It is recommended that the following existing consent conditions are used for MP4 as these conditions are appropriate to ensure the protection for residential amenity and the integrity and amenity of historic structures:
    - **Vibration***: activities shall be conducted such that the ground vibration levels measured either at the Macraes Mining Zone boundary or the boundary of the Golden Point Historic Reserve shall not exceed 10mm per second peak particular velocity measured in the frequency range 3 hertz and 12 hertz.*
    - **Airblast** levels at all Historic/Heritage sites should remain less than those prescribed in III_06 Macraes Mining Rules 2010 section 6.5.3. *"Activities shall be conducted such that the following air blast peak over sound pressure measured either at the Macraes Mining Zone Boundary or any building within the Golden Point Historic Reserve shall not exceed 128 dBL."*
3. Activities shall be conducted such that the following airblast peak over sound pressure measured either at the Macraes Mining Zone Boundary or any building within the Golden Point Historic Reserve shall not exceed 128 dB linear unweighted.
4. The hours of blasting shall be restricted to Monday-Friday 9am to 5.30pm and Saturday and Sunday 10am to 4.30pm
5. There are conservative safety factors built into all calculations used for this assessment of vibration and airblast levels caused by blasting in the proposed pit extensions.
6. The potential for blasting vibrations to disturb the integrity and/or amenity of the specified neighbouring sensitive sites has been assessed and blast designs indicated so as to comply with consent conditions, the District Plan rules and Standard AS 2187.2.
7. To ensure compliance with consent conditions, vibration levels will be managed by on-going measuring and analysing actual vibrations at the sites and, if required due to proximity, surveying the condition of historic/heritage buildings at an agreed interval before and after blasts.
8. The potential for airblast to disturb the integrity of the specified neighbouring sites has been assessed and blast designs indicated that comply with Consent conditions, the District Plan rules and Standard AS 2187.2
9. OGNZL regularly uses specific 'Proximity' blast designs when near boundaries of sensitive sites and residences to ensure that vibration levels remain below consented limits. If OGNZL continues to conduct blasting in this way, then no residences will experience vibration levels above the currently consented and District Plan limits which have proven to be acceptable to the residents.
10. Other consequences of blasting, such as fly rock and dust are unlikely to be of concern due to the extended distances to occupied sites. Potential hazards can be adequately addressed by continuing to apply the mitigation measures successfully used at the Macraes Gold Project mine sites over many years.
11. Macraes-Dunback Road will be blocked and guarded by sentries at safe locations from every blast so no people are at risk in any way. Impacts of blasting vibrations on roadways are rarely considered because of the nature of road construction and heavy traffic impacts.

12. When necessary, it is recommended that the Noise, Airblast and Vibration Monitoring Plan shall be reviewed and updated to ensure on-going compliance with blasting related consent conditions
13. Because of compliance with District Plan rules and NZ / International Standards, adverse impacts of blasting will be less than minor.

16. REFERENCES - GENERAL

1. Australian Standard AS 2187.2-2006 EXPLOSIVES-STORAGE & USE - USE OF EXPLOSIVES ISBN: 0-7337-7225-0
2. Management Plan Open Pit Explosives - Approved date: Sep 2020 Revision Sep 2021. Document ID: MAC-350-PRO-006
3. Principal Hazard Management Plan - Explosives PHMP Approved date: Nov 2020. Document ID: MAC-257-PHM-006
4. “Management Plan Noise, Airblast and Vibration MAC-205-PLN-002-1”
5. Report: "Macraes Phase III Vibration and Air Blast Assessment Orica 2010"
6. Plans showing the location of the proposed development in relation to the current Macraes gold project and sensitive residences in the broader locality. "M_A1_Coro_ConsentingBasemap_20130327.pdf"
7. Map distances to nearest residences from the perimeter of proposed openpit.
8. Oriard, Lewis L. (2002) Explosives Engineering, Construction Vibrations and Geotechnology ISBN: 1-892396-13-0
9. III_06 Macraes Mining Rules section 6 - MACRAES MINING PROJECT MINERAL ZONE

17. QUALIFICATIONS AND EXPERIENCE

- My areas of expertise are explosives and blasting and environmental impacts including airblast and vibration effects.

- I hold a Bachelor of Engineering (Mining). I have 50 years' experience in explosives and blasting practices. A summary of my curriculum vitae is attached as Annexure 1. More detailed listings of projects and experience are included as Appendices in my previous technical reports for OGNZL as listed in the “RESOURCES” section below,

- Prior to establishing TechNick Limited in 1982, I worked as a technical blasting engineer with ICI Australia from 1971 in opencut mines and quarries where blast design and environmental management was a major part of my responsibilities.

- With respect to the Resource Management Act 1991 (RMA), I have prepared evidence for clients covering a number of projects and policies including preparing evidence in relation to the obtaining of consents for previous expansions of OceanaGold’s operations at its Macraes sites. A selection of these includes the OGNZL Coronation Project in 2012 and 2015, Golden Point UG, Frasers West and on other blasting matters for South Taranaki District Council.

Yours faithfully

Nick Elith B.E. (Mining)
Explosives Engineer
Special Blasting Applications

18. APPENDIX A – GROUND VIBRATION LIMITS FOR HUMAN COMFORT

AS2187.2 APPENDIX J

Category	Type of blasting operations	Peak component particle velocity (mm/s)
Sensitive site*	Operations lasting longer than 12 months or more than 20 blasts.	5 mm/s for 95% blasts per year 10 mm/s maximum unless agreement is reached with the occupier that a higher limit may apply
Sensitive site*	Operations lasting for less than 12 months or 20 blasts.	10 mm/s maximum unless agreement is reached with occupier that a higher limit may apply
Occupied non-sensitive sites, such as factories and commercial premises	All blasting	25 mm/s maximum unless agreement is reached with occupier that a higher limit may apply. For sites containing equipment sensitive to vibration, the vibration should be kept below manufacturer's specifications or levels that can be shown to adversely affect the equipment operation

* Sensitive site includes occupied private houses & low rise residential buildings, theatres, schools.

19. APPENDIX B – OPEN PIT SECTIONS NEAR BOUNDARY

Examples from Frasers West blasting – Typical distances to closest blastholes from openpit extraction boundary. The extraction closest to the pit limit will be removed without any blasting. This means that actual distances from blasting areas to buildings or sites inside or outside the boundary are likely to be further than those used in vibration calculations.

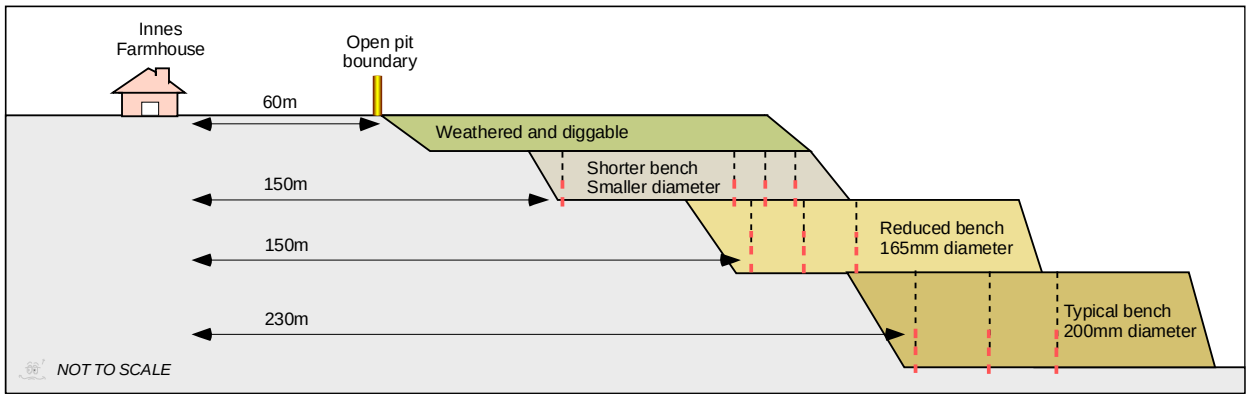

Figure 8: Distances to actual blastholes - Innes Farmhouse

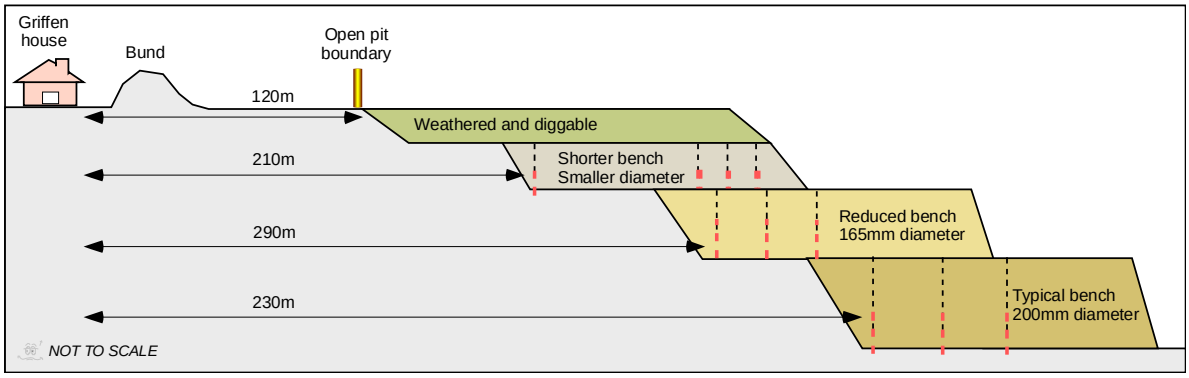

Figure 9: Distances to actual blastholes - Griffen house

20. APPENDIX C VIBRATION MONITORING DATA, GRIFFEN HOUSE

VIBRATION EXCEEDANCES:

Date	Blast Shot Number	Monitor	PPV	Hz	dB	Comment
10/06/2021 12:41 pm	1894	Halfway Parkup	5.5 mm/s	22.3 Hz	117.0 dB	Exceedance
12/08/2021 15:30	1925	Griffen House	10.1	11.6 Hz	130.6	Exceedance
24/09/2021 12:30 pm	1943	Griffen House	11.8	19.0 Hz	128.9	No exceedance - frequency above limit of 15Hz
1/10/2021 3:30 pm	1951	Griffen House	11.9	6.7 Hz	132.8	Exceedance
21/12/2021 3:30 pm	2010	Griffen House	10.5	17.7 Hz	126.1	No exceedance - frequency above limit of 15Hz

Residential Sites: (J.Howards Macraes, Halfway Parkup, Gay Tan Cottage)

Recorded Events	206	
Events below 5mm/s	205	
Events between 5-10mm/s	1	
% between 5-10mm/s	0.5%	*(below limit of 5%)*
Events above 10mm/s	0	*(below limit of 0)*

Non-Residential Sites: (Innes Farmhouse, Griffen House, Battery)

Recorded Events	206	
Events below 10mm/s	204	
Events above 10mm/s	2	*(above limit of 0)*

OVERPRESSURE EXCEEDANCES:

Date	Blast Shot Number	Monitor	PPV	Hz	dB	Comment
19/03/2021	1831	Halfway Parkup	3.6 mm/s	8.5 Hz	116.0 dB	Exceedance
5/05/2021 3:32 pm	1866	Halfway Parkup	1.0 mm/s	9.0 Hz	117.0 dB	Exceedance
10/06/2021 12:41 pm	1894	Halfway Parkup	5.5 mm/s	22.3 Hz	117.0 dB	Exceedance
23/07/2021 3:00 pm	1913	Griffen House	5.0 mm/s	6.4 Hz	129.4	Exceedance
9/08/2021 15:30	1919	Griffen House	5.0 mm/s	8.3 Hz	134.6	Exceedance
12/08/2021 15:30	1925	Griffen House	10.1	11.6 Hz	130.6	Exceedance
17/09/2021 9:33 am	1937	Griffen House	4.5 mm/s	8.5 Hz	128.6	Exceedance
21/09/2021 12:30 pm	1942	Griffen House	8.8 mm/s	4.7 Hz	128.8	Exceedance
24/09/2021 12:30 pm	1943	Griffen House	11.8	19.0 Hz	128.9	Exceedance
1/10/2021 3:30 pm	1951	Griffen House	11.9	6.7 Hz	132.8	Exceedance
5/10/2021 3:30 pm	1953	Halfway Parkup	1.2 mm/s	51.2 Hz	117.0 dB	Exceedance
14/01/2022 3:30 pm	2026	Halfway Parkup	0.9 mm/s	10.2 Hz	118.0 dB	Exceedance
6/02/2022 3:30 pm	2036	Halfway Parkup	1.4 mm/s	6.8 Hz	116.0 dB	Exceedance
16/02/2022 3:30 pm	2046	Halfway Parkup	1.4 mm/s	6.5 Hz	117.0 dB	Exceedance
18/03/2022 3:30 pm	2072	Halfway Parkup	1.5 mm/s	11.4 Hz	119.0 dB	Exceedance

Residential Sites: (J.Howards Macraes, Halfway Parkup)

Recorded Events	206	
Events below 115dB	200	
Events between 115-120dB	6	
% between 115-120dB	3%	*(below limit of 5%)*
Events above 120dB	0	*(below limit of 0)*

Non-Residential Sites: (Innes Farmhouse, Griffen House, Gay Tan Cottage, Battery)

Recorded Events	206	
Events below 128dB	199	
Events above 128dB	7	*(above limit of 0)*