Report to

NSW Quarry Services

Blast Management Plan & Control - Church Hill Quarry

Prepared By:

HEILIG & PARTNERS PTY. LTD.

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Heilig & Partners Pty Ltd
P.O. Box 176
Sumner Park. QLD 4074
Telephone: +61 7 3715 7599
Facsimile: +61 7 3715 7588
Email: group@heiligandpartners.com.au

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1. BACKGROUND

This Blast Design, Management and Control report is prepared to provide a framework for the procedures to maintain best practice controls to manage potential environmental impacts during the drilling and blasting activities linked with the winning of quarry rock from Church Hill Quarry. The company also extracts material from Bates Quarry. The blasting procedures for the Bates Quarry are covered in a separate management plan. Both plans reflect similar goals although the modelling results showing the expected explosive weights and vibration/air overpressure impacts differ.

The objective of this document is therefore to:

- Describe how NSW Quarry Services and their sub contractors propose to manage blasting activities and related potential environmental impacts such as vibration, airblast overpressure and flyrock during the blasting activities. It sets out the performance requirements and procedures to ensure that potential environmental impacts associated with blasting activities are adequately identified and controlled for the project.
- This document is applicable to all the drilling and blasting activities during the Church Hill project. This document has been prepared to address the requirements of a Blasting Management Plan (BMP).

In addition to this blast management document, NSW Quarries will ensure that the engaged drilling and blasting sub-contractor for the Church Hill Quarry will have developed their own comprehensive site blasting management regime. Presently drilling and blasting activities for the other NSW Quarry Services operation (Bates Quarry) are undertaken by Sequel Drilling & Blasting who have produced a comprehensive suite of procedures covering both workplace health and safety and safe blasting practices. Copies of these documents can be provided upon request.

All blasting activities within the quarry will be carried out in accordance with the requirements of the sub-contractors management procedures.

1.1. Performance Criteria

The objectives of the blasting activities required as part of the quarry rock recovery is to:

- Minimise the impact of vibration and airblast overpressure associated with blasting activities to acceptable levels;
- Protect the amenity of residents;
- Prevent damage to adjacent public utilities, structures and buildings resulting from vibration and air overpressure;
- Minimise the environmental impact by minimising noise, vibration and airblast overpressure to comply with the New South Wales environmental guidelines[1].

In addition to the above mentioned environmental objectives and performance criteria, all drilling and blasting activities will necessarily meet the following objectives:

- Safety of all personnel;
- Control of flyrock;
- Fragmentation and diggability commensurate with excavating equipment.

[1] "*Assessing Vibrations: A technical guideline*". Produced by the Department of Environment and Conservation, NSW 2006

The proximity of residential properties towards the east, and to a similar extent towards the north, along Crescent Head Road at distances of several hundred metres will ensure that all appropriate measures are included in the blast design and loading process to minimise any occurrence of unnecessarily high vibration or overpressure levels as well as strict control over eliminating flyrock.

1.2. Performance Limits

Vibration and airblast overpressure limits indicated under the project plan are based on the New South Wales vibrations guidelines which are based upon the ANZECC document of 1990[2], which states:

Ground Vibration

- *The recommended maximum level for ground vibration is 5mm/s (peak particle velocity);.*
- *The level of 5mm/s may be exceeded on up to 5% of the total number of blasts over a period of 12 months. However, the level of should not exceed 10mm/s at any time.*

Airblast Overpressure:

- *The recommended maximum level for airblast overpressure is 115dBL.*
- *The level of 115dBL may be exceeded on up to 5% of the total number of blasts over a period of 12 months. However, the level of should not exceed 120dBL at any time.*

In addition to the quantitative levels specified in the ANZECC document, blasting will also adopt the other appropriate measures. These criteria are the most stringent presented in the international literature and will therefore be protective of infrastructure and amenity.

2. QUARRY LOCATION

Only a small number of properties are noted around the planned quarry area. The location of the quarry area and the adjacent receivers is shown in the following figure.

Figure 1 – Plan of the area (Google Earth) showing the Church Hill Quarry as a red shaded zone. Nearest residential properties are also shown.

[2] Australia and New Zealand Environment Council (1990), "*Technical basis for guidelines to minimise annoyance due to blasting overpressure and ground vibration*"

It is noted that around the planned blast area:

- The nearest residential property is towards the east and is approximately 100 metres from the planned access road to the quarry from Crescent Head Road. Blasting activities for the quarry will be further west of the access road and further than 100 metres from the property;
- The closest infrastructure towards the west is the upgraded Pacific Highway. At the most western limit of any possible extraction works, the nearest property towards the west is on the western side of the Pacific Highway and more than 300 metres from blasting;
- Residential properties to the north are along the southern side of Crescent Head Road and approximately 75 metres from the quarry northern boundary although blasting will not occur as far north as the boundary;
- There is a property towards the south-east. The property is more than 200 metres from the quarry area.

3. DRILLING AND BLASTING METHOD

It is proposed to complete the winning of the quarry material using a combination of drilling and blasting techniques, together with very limited, if any, hydraulic hammering where any oversize material is encountered. It is proposed that blasting will be sub-contracted to Sequel Drill & Blast. NSW Quarry Services intend to utilise the professional services of this same contractor for the blasting at Church Hill as the current blasting at Bates Quarry. The same level of quality assurance that has been applied to all previous aspects of the blasting process by the same contractor will continue.

The scale of blasting will be controlled primarily by the plan and benching strategy for the quarry and importantly, a restricted scale of blasting as a requirement to comply with both vibration and air overpressure levels at the adjacent properties. A requirement for no flyrock outside of the blast area is critical. The blast design is therefore based upon:

- A blasthole diameter of between 89 and 102mm, drilled using conventional and modern hydraulic drilling rig equipment;
- A nominal blasthole length varying between 4 metres and 10 metres depending upon the geometry of the benches and permissible explosive quantities for environmental compliance. Higher bench heights may be feasible depending upon blast results, although any bench face exceeding 10 metres would be unlikely. This will however be confirmed via measured vibration and air overpressure results;
- A nominal blasthole pattern with a burden and spacing of around 3 metres depending upon the blasthole diameter and bench height selected;
- A single explosive charge per blasthole, independently sequenced to restrict the maximum explosive quantity per delay to a value permitting compliance at the nearest property. The explosive quantity may vary depending upon the extent of fragmentation and digging rates. The maximum instantaneous explosive weight (weight per blasthole or MIC) is around 120 kilograms but more likely less than 50 kilograms for the majority of the quarry in order to achieve compliance;
- The uncharged collar height is designed to control both air overpressure levels and the uncontrolled flyrock. The current level is 2.5 metres;
- The powder factor is expected to vary to provide fragmentation and diggability commensurate with the excavation techniques considered by the NSW Quarries (*ie*. very limited use of hydraulic hammers). Presently used powder factors are 0.5kg/m^3.

4. DRILLING AND BLASTING IMPACTS

Any effects associated with blasting activities will be controlled to ensure safe working procedures for all personnel, safety of adjacent equipment and infrastructure (including residential buildings) and a minimum disturbance to persons located around the works area.

The environmental impacts from blasting will be controlled to acceptable levels specified in Section 1 of this Blast Management Plan.

Blasting will only be undertaken during standard construction hours specified in the local blasting permit, generally between the hours of 7:30 am to 4:30pm Monday to Saturday. Blasting will typically be undertaken after the middle of the day and only when fine weather conditions prevail. Blast times may also be coordinated with suitable times for adjacent residents. It is proposed that discussion with residents occur several days prior to blasting to minimise any disturbance, particularly for those residents that may work evening shifts. Blasting will not occur on rainy days of days of inclement weather. No blasting will occur on Sunday or gazetted public holidays. Blasting outside these hours will only be undertaken in unforeseen circumstances (e.g. safety issue with explosives) or the event of an emergency.

Blasting will generally be limited to one blast per day and this single blast will occur once per month on average.

4.1. Drill and Blast Vibration

The primary factors known to influence the level of ground vibration from blasting include:

a) The weight of explosive per delay;
b) The distance between the blastholes and the point of measurement;
c) The local geological conditions and the influence of geology and topography on vibration attenuation.

Consistent with the recommendations of the Australian Standard[3], the most common form of the vibration equation to predict the amplitude of ground vibration from blasting at any distance from the blasthole and is given as:

$$PPV = K\left(\frac{d}{\sqrt{w}}\right)^{-\beta}$$

where d is the distance between the blastholes and the point of measurement;
w is the maximum instantaneous charge weight per delay;
K and β are site specific constants.

Based on the above equation, the expected level of ground vibration can be determined for a given distance and maximum charge weight.

A relationship between the level of vibration, the quantity of explosive and the distance from the blast has been derived vibration measurements from blasting activities at the Bates Quarry which is considered representative of the vibration characteristics for the Church Hill Quarry. An equation consistent with the format described above has been developed and used to estimate the level of ground vibration.

$$PPV = 3986\left(\frac{d}{\sqrt{w}}\right)^{-1,80}$$

[3] AS2187.2-2006, "*Explosives – Storage, transport and use Part 2: Use of explosives*"

The following Figure 2 shows the measured vibration level as a function of distance from the blasthole for varying quantities of explosive and distance for blasts 1 to 4 completed at the Bates Quarry during 2014.

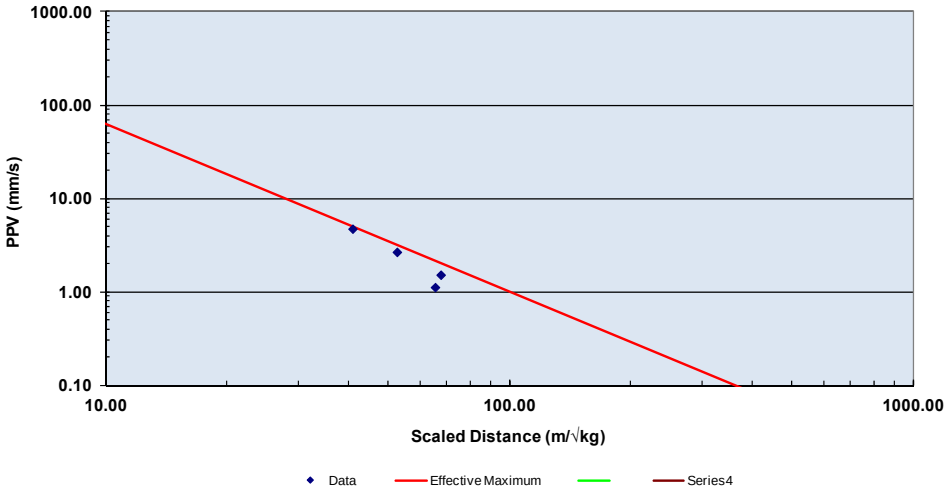


Figure 2 – Graph showing the measured vibration levels plotted as function of the scaled distance term

Explosive quantities per blasthole vary according to several factors, including the bench height, the blasthole diameter, the explosive density and the uncharged collar length. Based upon these factors, the following explosive weights for different combinations of these parameters can be determined:

Design Option	Design Description	Bench Height	Blasthole Diameter	Explosive Weight per Hole
A	Small bench height with 89mm diameter blasthole required where vibration control necessary	4 metres	89mm	14 kilograms
B		6 metres	89mm	29 kilograms
C	Typical blasting scale for quarrying where environmental effects can be controlled	12 metres	89mm	72 kilograms
D		15 metres	102mm	122 kilograms

Table 1 – Blast design parameters and associated explosive quantities per blasthole

The following graph shows the expected permissible explosive quantities per blasthole ranging up to 100 kilograms based upon the separation distance between the blast zone and the closest potentially affected resident. The explosive quantities are based upon complying with a 5mm/s vibration limit.

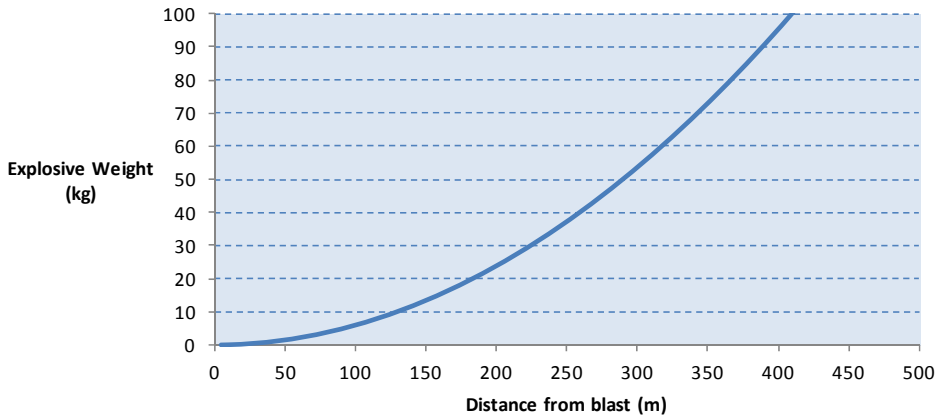


Figure 2: Explosive weight as a function of distance for compliance with 5mm/s

4.2. Air Overpressure

The United States Bureau of Mines (USBM)[4] have undertaken perhaps the most extensive review of overpressure and its effects and have proposed the form of the relationship showing the expected level of overpressure as a function of distance and explosive quantity. Using this form of this equation, a reference equation for estimating the overpressure is shown below:

$$dBL = 165 - 24 \times log\left(\frac{d}{\sqrt[3]{w}}\right)$$

where dBL is the level of overpressure complying on 95% of occasions and *d* and *w* are as per the vibration relationship.

Unlike ground vibration, geology has a negligible impact on the levels of air overpressure. The overpressure level is affected by blast design, in particular the proximity of the explosive charges to the free surface. Also unlike ground vibration, overpressure level is significantly affected by local conditions including:

- Topography and vegetation with treed areas or other elevated features aiding in affecting the measured level of overpressure. Properties on the leeward side of the hill will commonly measure overpressure up to 5dBL less than those of the windward side;
- Atmospheric conditions with wind direction, humidity and temperature inversions combining to affect overpressure levels by as much as 10dBL for upwind versus downwind areas of the blast;
- Orientation of blast with measurements point in front of the blast receiving levels up to 5dBL greater than those points directly behind the blast.

4.3. Blast Modelling of Explosive Quantities

The proposed relationships can be used to assess the effects of the planned scale of blasting for the Church Hill quarry.

The analyses given in Plate A shows the expected explosive quantities that can be used in the different sections of the quarry based upon compliance with 5mm/s at the nearest properties. The scale of quarrying and corresponding bench heights should be based upon the predicted quantities in Plate A. The modelling results are shown for any extent of blasting within the quarry limit extractive area. Blasting will be restricted in the section of the quarry closest to the perimeters and therefore the calculated vibration contours are considered to be worst case scenarios. Where a contour of a particular value approaches a property, only when blasting at the closest point to the property will this level of vibration be experienced.

Plate A shows the expected location of vibration contours for quarrying with explosive quantities modelled to comply at the nearest sensitive receivers with a 5mm/s vibration limit on 95% of occasions. Those locations lying nearer to the quarry than say the 2½ mm/s contour will on occasions receive vibration levels exceeding 2½ mm/s, but predicted to be not more than 5mm/s. Those further from quarry than the same 2½ mm/s contour are predicted to receive vibration less than 2½ mm/s. Importantly, the contours show the maximum extent of the vibration and not that which would be produced from each and every blast. When blasting in south-west section of the quarry, the level of vibration at properties towards the east will fall to low vibration values. Only when blasting in the

[4] Siskind, D.E., Stachura, V.J., and Stagg, M.S., 1980. "*Structure Response and Damage Produced by Airblast from Surface Mining*", United States Bureau of Mines, Report of Investigations No 8485.

eastern section of the pit will be the level of vibration reach the maximum expected value for those properties south west of the quarry. Plate A also indicates:

- When compared to the Bates Quarry blasting, the scale of blasting at Church Hill will be of a smaller scale;
- Residential properties along Crescent Head Road impact on the permissible explosive quantities that can be used and ultimately control the scale of quarrying in these areas;
- For the northern and eastern sections of the quarry area, should blasting continue to the outer limits, it is predicted that these areas will require low explosive quantities per blasthole. Where any blasting occurs within 200 metres of a property, the modelling suggests that explosive quantities will be around 25 kilograms per blasthole to comply with the 5mm/s vibration criterion. This will necessarily restrict the bench height and the blasthole diameter;
- The properties around the quarry and in particular those along Crescent Head will receive perceptible levels of vibration although these are predicted to remain within the compliance values;
- Explosive quantities per blasthole are expected to increase as the location of the blasting activities progress towards the southern and western sections of the quarry. When blasting occurs towards the south-western limits of extraction, the explosive quantity can increase towards the modelled 100 kilogram level;
- Blasting in the most southern section of the quarry is predicted to be possible with explosive weights approaching 100 kilograms per blasthole and remain compliant with a 5mm/s vibration limit at the adjacent properties.

Plate B shows the expected location of the different air overpressure contours based upon compliance with 115dBL at the adjacent properties. The information shown on Plate B indicates that the blast design can be controlled to comply with the 115dBL limit although may be more challenging than compliance with the ground vibration limit, depending upon other conditions such as wind direction, wind speed and the direction of blast initiation.

Plate B indicates:

- Similarly to the constraints discussed for the vibration impacts, the impact of complying with the 115dBL criterion at the adjacent residential properties in Crescent Head Road is modelled to restrict the scale of quarrying that can be undertaken;
- Explosive quantities will be restricted in the eastern section of the quarry, possibly to a larger extent than for the vibration control with the 5mm/s criterion;
- Design adjustments to blast, such as always firing away from the closest potentially affected property can reduce the overpressure levels to lesser values. It is often observed that providing the quarry design can be adjusted to achieve vibration compliance, the overpressure level can be reduced to permissible values by adjustments to the uncharged blast hole collar, the front row burden or the initiation sequence.

5. ENVIRONMENTAL MITIGATION MEASURES

Environmental mitigation measures will be incorporated into each blast to minimise the impact of the following effects:

- Vibration;
- Airblast overpressure;
- Flyrock.

5.1. Vibration

Mitigation measures to reduce vibration effects during blast activities could include:

- Ensuring all relevant areas associated with blast activities have been properly analysed to determine scale of blasting required.
- Ensuring only exact quantity of explosives is used for each hole.
- Condition surveys by NSW Quarry Services for adjacent structures where the owner has expressed concern in relation to the possibility of damage;
- Periodic vibration and airblast overpressure monitoring to confirm that vibrations being induced by the blasting activities are at or below design limits specified in Section 1.

5.2. Airblast Overpressure

Mitigation measures to reduce airblast overpressure during blast activities include:

- Ensure all relevant areas associated with blast activities have been properly analysed to determine scale of blasting required;
- Notification and/or discussions with the residents as to the effect of the blasting activities;
- Ensure only exact quantity of explosives is used for each hole;
- Periodic vibration and airblast overpressure monitoring to confirm that vibrations being induced by the blasting activities are at or below design limits specified in Section 1;
- All blasts designed with a minimum uncharged collar length.

5.3. Flyrock

Mitigation measures to control flyrock and ensure safety of protection of properties could include:

- An increased minimum uncharged collar lengths (beyond that recommended in the Australian Standard AS2187.2) is applied to all blastholes;
- Ensuring that all design criteria are measured, documented and adhered to prior to any blasting activity proceeding.

All blast designs and their implementation will be strictly quality controlled to control the possibility of flyrock. The proximity of the nearest residential property towards the east ensures that this will remain a key objective of blast design. Eliminating flyrock is paramount to the design. It is suggested that all blast designs are recorded by video and reviewed to determine the appropriateness of the uncharged collar lengths. Where stemming ejection occurs, or face bursting is observed, the blast design should be immediately adjusted to eliminate such events.

6. CONDITION SURVEYS AND COMPLAINTS

Where a complaint from an adjacent property owner regarding the blasting activities is registered with NSW Quarry Services, or their drilling and blasting sub-contractor, the following procedures shall be followed:

- The complainant shall be contacted by management of NSW Quarry Services to discuss the nature of the complaint;
- Where the complaint relates to infrastructure damage and the source of the damage can be directly related to the blasting activity, NSW Quarry Services shall rectify the damage within an appropriate timeframe;
- Where the nature of the complaints relates to personal amenity, subsequent blasting activities shall be monitored to confirm compliance with the permissible vibration and air overpressure limits specified in the ANZECC document;
- In the event that the nature of the complaint cannot be resolved, or an agreeable path to resolution determined, a joint meeting between the complainant, NSW Quarry Services and

the local government agency or representative should be convened to further discuss the matter.

The following table shows the human perception as a function of vibration levels, as given in the International literature linking human response and vibration.

Vibration Range		*Effect*
Lower	*Upper*	
0 mm/s	0.5 mm/s	Imperceptible
0.5 mm/s	1 mm/s	Barely Noticeable
1 mm/s	5 mm/s	Easily Noticeable
5 mm/s	10 mm/s	Distinctly Noticeable
10 mm/s		Strongly Noticeable

Table 2- Expected effect of vibration from blasting activities

The performance criteria specified in Section 1 of this plan therefore limit vibration levels to those classed as "*easily noticeable*" rather than "*distinctly noticeable*".

7. BLASTING ACTIVITIES

7.1. Pre-Blast Activities

Prior to undertaking drilling and blasting, the following actions will be completed:

- Provide reasonable notice of intended blasting and the anticipated effects on the nearby commercial premises and occupants of these premises;
- Blasting notification NSW WorkCover covering the jurisdiction of the proposed blasting activities for the intended period of blasting;
- If required, NSW Quarry Services generate a condition survey report of adjacent infrastructure, including an assessment of the susceptibility of the infrastructure to vibration related effects;
- Preliminary review assessing the expected maximum explosive quantities for control of vibration.

7.2. Community Consultation

NSW Quarry Services personnel, or representatives from their drilling and blasting sub-contractor, will undertake community consultation with any potentially affected residents prior to the commencement of blasting. Information describing the nature and likely timing of the blast and any likely adverse effects will be conveyed to all residences and other potentially affected building occupants prior to commencement of blasting activities. NSW Quarry Services will respond to all issues of concern and complaints promptly and efficiently and relay any necessary information through to the appropriate persons.

7.3. Preparation of Drilling Area

The area where blasting will be undertaken will be prepared to a condition to enable accurate drilling.

7.4. Design and Layout of Blastholes

Drilling of blastholes will be completed using modern hydraulic drilling equipment supplied and operated by a recognised drilling and blasting sub contractor (presently Sequel Drill & Blast). Key issues include:

- The subcontractor will establish a drilling pattern, including blasthole depths, and record the information on a blast pattern design worksheet;
- The quantity of explosive which will be loaded into each blasthole will be identified and clearly marked on the plan;
- The total quantity of explosive for each blast will be calculated and reconciled against the designed quantity;
- The blasthole burden and spacing will be measured as accurately as possible.

The nearest distance to the closest property, or other sensitive receiver, will be used to calculate the expected level of vibration for scale of blasting that will be undertaken. Should the predicted vibration level be non-compliant, the blast pattern will be adjusted accordingly to ensure compliance.

7.5. Blasthole Drilling

On the completion of each blasthole, or group of blastholes, the driller will measure and confirm the depth of the hole and, if it is within tolerance, plug the collar of the hole. Variation in the depth, re-drilled holes or other amendments will be marked on the drilling loading sheet.

7.6. Transport and Storage of Explosives

Transport and storage requirements for blasting activities will be in accordance with the Explosives Act.

Explosives will not be stored on site. The quantity of explosive and detonators will be transported on the day of the blast from the magazines in approved vehicles. Any unused explosive will be returned to an off-site magazine at the completion of loading.

7.7. Priming and Loading of the Blasthole

The following key issues will be included as part of the priming and loading methods:

- Prior to priming a blasthole, the shotfirer will confirm the depth of the blasthole is consistent with the depth indicated on the blasting plan depth. The measured depth will be recorded on the blasthole loading plan;
- If a short hole is encountered, the shotfirer will ensure the depth is adequate to eliminate the possibility of flyrock, or otherwise the blasthole will not be loaded;
- If any blastholes are loaded with loose poured ANFO, the quantity of explosive will be carefully measured;
- Where blastholes are loaded with bulk emulsion, the weight of explosive per blasthole will be recorded;
- Any overloaded blastholes will be not be blasted, but will have the explosive removed;
- Quantity of explosive loaded into each blasthole, or deck, will be reported on the blast loading plan;
- The total quantity of explosive loaded into the blast will be reconciled against the quantity indicated on the submitted blast plan. Where the quantities differ, a comment for the variation will be included on the blast loading plan.

7.8. Stemming of Blastholes

The stemming of blastholes is a **critical and important** task and will be administered slowly and accurately. The bridging of stemming in a blasthole will result in stemming material ejecting, producing overpressure, flyrock and poor fragmentation. In addition:

- The stemming material will consist of a graded crushed aggregate with a diameter of around 10 to 20mm;
- The stemming length will be measured and written onto the blast loading sheet;
- All blastholes will be stemmed before the surface tie up commences.

7.9. Surface Tie Up

Blasting, including the loading, stemming and sequencing of blastholes will be completed in accordance with all appropriate legalisation. Key issues include:

- The shotfirer will determine the tie up;
- The blast pattern will indicate the proposed tie up sequence, clearly identifying the different delay elements that will be used. This will be used to confirm the explosive quantity will comply with accepted vibration level at the nearest potentially sensitive receiver;
- A timing sequence will be shown and calculate the maximum instantaneous explosive quantity. This quantity of explosive (MIC) will be clearly identified on the loading plan;
- When the total shot has been tied in, all connections will be checked and surface delay elements covered with sand or similar to reduce noise from the delays exploding and reduce shrapnel from the bunch blocks.

7.10. Firing

Firing of the blast will be under the control of the shotfirer. The following key issues will be addressed:

- Prior to firing, the shotfirer will confirm with the NSW Quarry Services personnel or their representative of the intent to blast;
- The area will be cleared to ensure all personnel are a safe distance from the blasting activities;
- Control points to block access to the blast site, including internal access to the blast area from within the site;
- Prior to the blast, a siren of sufficient loudness will be sounded to alert all adjacent personnel of the immediate intention to blast, including residents around the blast area.

7.11. Misfires

Should there be a cut-off (severing of the leads to the detonators, either surface or in-hole) during the blast, compliance with the Explosives Act will be followed. The following checks for cut-offs will be implemented:

- After the blast is fired, the shotfirer will visually inspect entire shot for evidence of misfires.
- If found, the shotfirer will notify NSW Quarry Services management;
- The shotfirer will decide if it is safe to re-fire shot;
- The same method of initiation will be used;
- If the shot is unable to be fired safely, a mitigation plan will be assessed.

If a misfire (unexploded explosive) is detected during excavation:

- Stay well clear;
- Warn all personnel in the area;
- The shift boss will notify the shotfirer immediately;
- A detailed and safe excavation plan will be formulated and implemented;

7.12. Reconciliations and Reporting

After each blast, NSW Quarry Services or their representative will have in their possession the following documents:

- A pre-blast sheet confirming that the expected level of vibration at each of the nearest sensitive receivers complies with the vibration limits;
- A completed drilling sheet prepared by the shotfirer showing the measured depth of each blasthole. The sheet will identify and clearly mark any "*short*" blastholes;
- A blast loading plan showing the depth of each blasthole, quantity of explosive in each blasthole and the uncharged stemming length. The initiation sequence will also be shown. Reconciled explosive quantities used versus the designed quantity will also be shown and any variations accounted for;
- A signed blast summary sheet showing that each of these forms been received and no variations between the intended and implemented design exist. The sheet will also confirm that the blast covers are in place and in accordance with designed set out.

These requests are in accordance with the specifications listed in the Australian Standards AS2187.2 document.

8. MONITORING OF BLASTING ACTIVITIES

It is proposed that a detailed monitoring program for both vibration and air overpressure levels is initially undertaken until such time that sufficient data are available to allow a satisfactory prediction of both vibration and overpressure values from the proposed blast design. The measured data should be analysed to develop site specific relationships for both vibration and air overpressure and based upon these relationships, it may be necessary to undertake a revised set of modelling to determine or establish possible effects of the required environmental compliance on the quarry design. It is further recommended that a series of single hole trials may be necessary to better define the vibration relationship for the site. Following the dedicated vibration and overpressure monitoring during the initial stages on blasting at the quarry, periodic monitoring of vibration and air overpressure levels from the blasting activities should continue to be undertaken

In addition, monitoring may be required should complaints from adjacent residents be received.

The vibration monitoring system should consist of a series of individual monitors which will be positioned at strategic locations around the quarry. Each vibration monitor will have four recording channels. An external geophone (transducer) will monitor ground vibration in three directions (transverse, vertical and longitudinal particle velocities) and report the level in mm/s. An external microphone will measure the level of overpressure, reporting the data in units of dBL. The monitors will be configured with a vibration threshold trigger to record blast events which exceed a minimum value, typically around 0.3mm/s. The recording duration will be set to exceed the duration of the blast.

Vibration and air overpressure monitoring should be undertaken by persons with appropriate experience. Monitoring equipment should meet the specifications of the Australian Standards AS2187.2. Section J.

9. AUTHORS STATEMENT

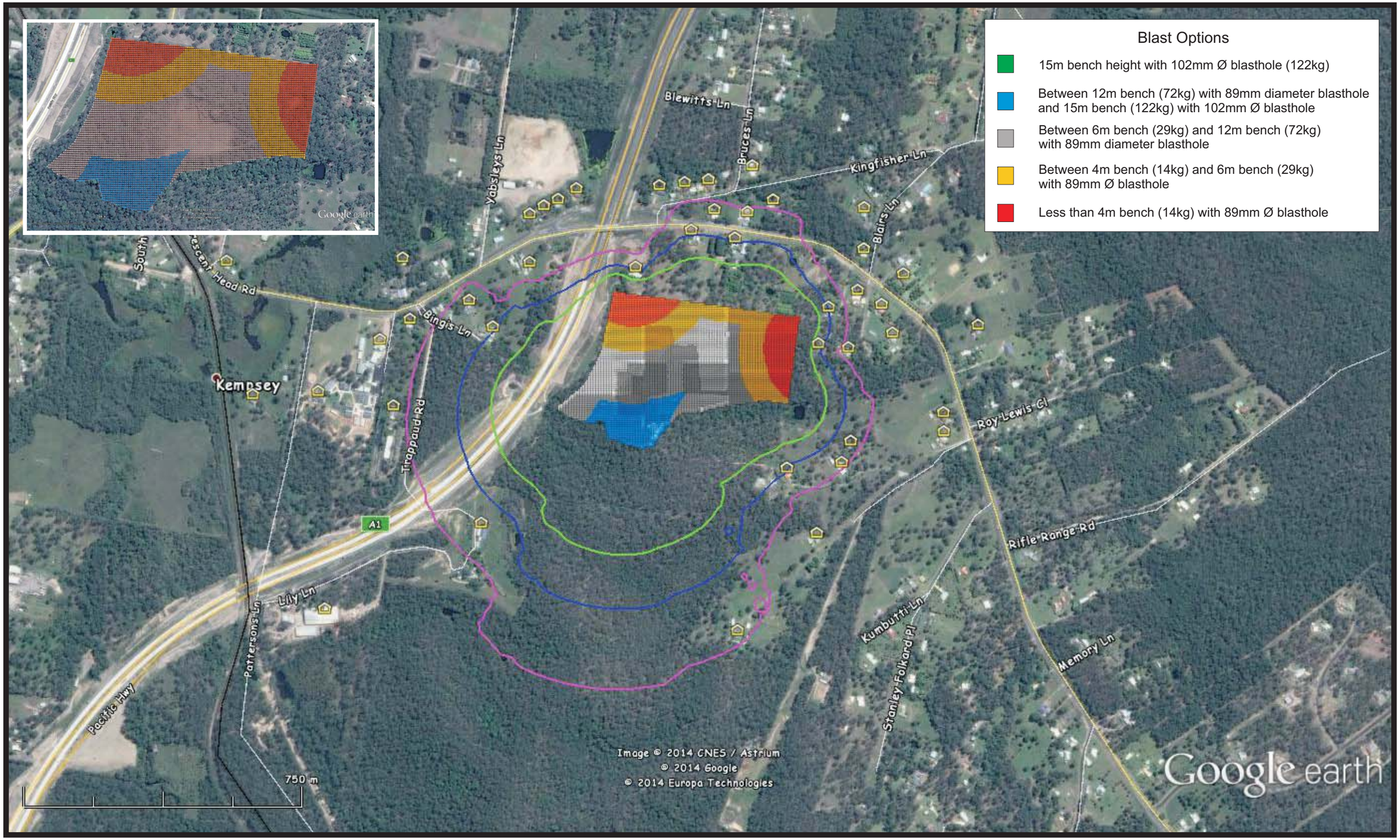
The author of the document is Dr. John Heilig. I am the Principal of Heilig & Partners Pty Ltd., a consulting engineering company based in Brisbane Australia. I hold the qualifications of Bachelor of Engineering (BE) Honours and a Doctor of Philosophy (PhD), both from the University of Queensland in Australia.

I have worked in the mining and civil industry for more than 25 years and have extensive domestic and international experience in the measurement, assessment and impact of vibration and air overpressure from blasting and civil construction projects. I have been associated extensively with these analyses and prediction at more than 500 sites throughout the world. I have also provided advice to large scale projects in Australia and overseas continuously over the previous 25 year period.

I have been engaged by NSW Quarry Services to review the proposed blasting and potential impacts of the Church Hill Quarry project. I confirm that I have made all enquiries that I believe are desirable and appropriate and that no matters of significance that I regard as relevant have, to my knowledge, been withheld from the document.

John Heilig

Dr. John Heilig
Principal: Heilig & Partners Pty Ltd
RPEQ 6304



LEGEND

- Expected 10 mm/s Vibration Contour
- Expected 5 mm/s Vibration Contour
- Expected 2.5 mm/s Vibration Contour

SCALE

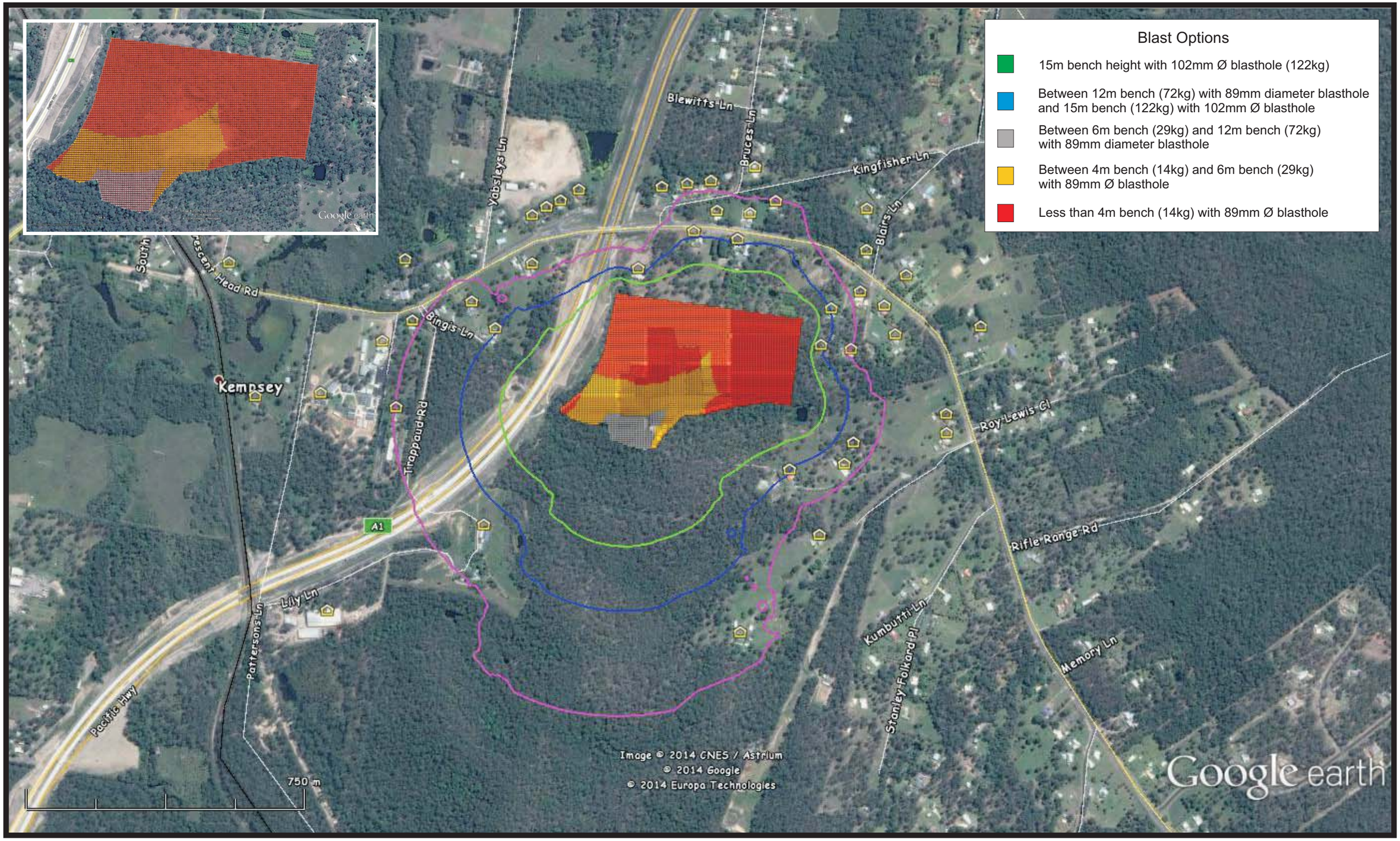
0 150 300 450 600 750m

Project Description: NSW Quarry Services - CHURCH HILL QUARRY - Predicted vibration levels from blasting activities designed to comply with 5mm/s criterion at adjacent properties

HEILIG & PARTNERS Engineered Excellence
P.O. Box 176
Sumner Park Business Centre
QLD. 4074. Australia
Telephone +61 7 3715 7599
Mobile 0419 196 369
Facsimile +61 7 3715 7588
Email john@heiligandpartners.com.au

NSWQUARRY SERVICES

Plate No. A	Date Drawn: 2 July 2014
Scale as Shown	Ref No: NSW Quarry Services



LEGEND

- Expected 120dBL Overpressure Contour
- Expected 115dBL Overpressure Contour
- Expected 110dBL Overpressure Contour

SCALE

0 150 300 450 600 750m

Project Description: NSW Quarry Services - CHURCH HILL QUARRY - Predicted overpressure levels from blasting activities designed to comply with 115dBL criterion at adjacent properties

HEILIG & PARTNERS Engineered Excellence
P.O. Box 176
Sumner Park Business Centre
QLD. 4074. Australia
Telephone +61 7 3715 7599
Mobile 0419 196 369
Facsimile +61 7 3715 7588
Email john@heiligandpartners.com.au
NSWQUARRY SERVICES

Plate No. B	**Date Drawn: 2 July 2014**
Scale as Shown	**Ref No: NSW Quarry Services**