EXPLOTECH

Specialists in Explosives, Blasting and Vibration
Consulting Engineers

Blast Impact Analysis
Proposed Childs Pit and Quarry Expansion
Township of Macaulay, in the Town of Bracebridge, in the District of Muskoka

Submitted to:

Fowler Construction
Company Limited
1206 Rosewarne Drive
Bracebridge, Ontario
Canada
P1L 1T9

LICENSED PROFESSIONAL ENGINEER
R. J. CYR
PROVINCE OF ONTARIO

Prepared by

Explotech Engineering Ltd.
58 Antares Drive, Unit 5
Ottawa, Ontario
K2E 7W6

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EXECUTIVE SUMMARY

Explotech Engineering Ltd. was retained in April 2020 to provide a Blast Impact Analysis for the Fowler Construction Ltd. proposed extension of the Childs Pit and Quarry operation located on Part of Lots 14, 15, 16 & 17, Concession 9, and Lots 15 & 16, Concession 10 in the Geographic Township of Macaulay, in the Town of Bracebridge, in the District of Muskoka.

Vibration levels assessed in this report are based on the Ministry of the Environment, Conservation and Parks (MECP) Model Municipal Noise Control By-law with regard to guidelines for blasting in Mines and Quarries. We have assessed the area surrounding the proposed licence area as it relates to potential damage from blasting operations and compliance with the aforementioned By-law document.

We have inspected the property and reviewed the available site plans. Explotech is of the opinion that the planned aggregate extraction on the proposed site can be carried out safely and within MECP guidelines as set out in NPC 119 of the By-Law.

Recommendations are included in this report to advocate for blasting operations which are carried out in a safe and productive manner and to suitably manage and mitigate the possibility of damage to any buildings, structures or residences surrounding the site.

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INTRODUCTION

The proposed extension of the Childs Pit and Quarry is located on Bonnie Lake Road bounded by the existing Childs Pit to the North and West, Bonnie Lake Road to the East, and undeveloped forested areas as well as Sage Creek to the South. The legal description for the subject property is Part of Lots 14, 15, 16 & 17, Concession 9, and Lots 15 & 16, Concession 10 in the Geographic Township of Macaulay, in the Town of Bracebridge, in the District of Muskoka.

This Blast Impact Analysis has been prepared based on the MECP Model Municipal Noise Control By-law with regard to Guidelines for Blasting in Mines and Quarries (NPC 119). In addition, we have assessed the area surrounding the proposed licence with regard to potential damage from blasting operations.

While not specifically required as part of the scope of the Blast Impact Analysis under the Aggregate Resources Act, this report also touches on the topics of the flyrock and residential water wells for general informational purposes only. Exhaustive details related to residential water wells are addressed in the hydrogeological report while specific flyrock control is addressed at the operational level given significant influences related to blast design, geology and field accuracy. Additionally, potential impacts on the adjacent electrical transmission towers and nearby waterbodies are discussed to confirm compliance with applicable external corporate policies and guidelines.

Given that mining operations have not been undertaken in the past on this property, site-specific blast monitoring data is not available. We have therefore applied data generated across a spectrum of quarries and construction projects which provides a conservative approximation of anticipated vibration levels from the operation. It has been our experience that this data represents a conservative starting point for blasting operations. It is a recommendation of this report that a vibration monitoring program be initiated on-site upon the commencement of blasting operations and maintained for the duration of all blasting activities to permit timely adjustment to blast parameters as required. Ultimately, the quarry will be required to operate to the MECP guideline limits for ground vibration and overpressure based on actual measurements taken during blast times.

Recommendations are included in this report to advocate for blasting operations which are carried out in a safe and productive manner and to suitably manage and mitigate the possibility of damage to any buildings, structures or residences surrounding the property.

EXISTING CONDITIONS

The licenced area for the proposed Childs Pit and Quarry Extension encompasses a total area of approximately 163.1HA, with an extraction area of approximately 143.2HA when allowing for setbacks and sterilized areas.

The site is separated into five (5) distinct extraction phases. The phases are designated A1, A2, B1, B2(i) and B2(ii) with extraction initially commencing at the North boundary of Phase A and progressing southerly along Phase A1 and Phase A2 (Refer to Appendix A).

The topography of the proposed extension area is generally lowest in the Southwest (Phase B1) at an elevation in the order 308masl rising towards the North with the highest elevation (339masl) lying approximately at the midpoint of Phase A1. The design final quarry floor elevation varies for different phases ranging between 270masl – 320masl leading to the execution of up to five (5) benches to achieve final grade.

While the proposed quarry property does not directly border on the Muskoka River North Branch, blasting will be required within approximately 290m of the river, and within 95m to Sage Creek.

The majority of the adjacent residential development in the area is limited to the East of the proposed extension area along Bonnie Lake Road. Areas to the North, South and West are largely characterized by undeveloped forested areas. The closest sensitive receptors adjacent the extraction limits as defined by the MECP are as follows:

Table 1: Closest Sensitive Receptors

Municipal Address	***Separation Distance to Closest Point of Extraction (m)***	***Direction from Extraction Limits***
1000 Alpine Ranch Road	1373	West
1001 Alpine Ranch Road	1065	West
1160 Springdale Shores	872	South
63 Arrowridge Road	1893	North
1530 Bonnie Lake Road	847	Northeast
1515 Bonnie Lake Road	844	Northeast
1507 Bonnie Lake Road	823	Northeast
1498 Bonnie Lake Road	777	Northeast
1492 Bonnie Lake Road	722	Northeast

1482 Bonnie Lake Road	668	Northeast
1481 Bonnie Lake Road	511	Northeast
1478 Bonnie Lake Road	515	Northeast
1016 Bonnie Lake Camp Road	464	East
1005 Bonnie Lake Camp Road	472	East
1439 Bonnie Lake Road	326	East
1390 Bonnie Lake Road	455	East
1407 Bonnie Lake Road	380	East
1387 Bonnie Lake Road	344	East
1350 Bonnie Lake Road	486	East
1367 Bonnie Lake Road	349	East
1310 Bonnie Lake Road	500	East
1309 Bonnie Lake Road	388	East
1300 Bonnie Lake Road	413	East
1303 Bonnie Lake Road	346	East
1290 Bonnie Lake Road	320	East
1285 Bonnie Lake Road	282	East
1280 Bonnie Lake Road	256	East
1270 Bonnie Lake Road	115	East
1269 Bonnie Lake Road	106	East
1260 Bonnie Lake Road	85	East
1254 Bonnie Lake Road	92	East
1240 Bonnie Lake Road	100	East
1239 Bonnie Lake Road	30	East
1228 Bonnie Lake Road	138	East
1235 Bonnie Lake Road	72	South
1218 Bonnie Lake Road	332	South
1213 Bonnie Lake Road	384	South
1190 Bonnie Lake Road	465	South
1193 Bonnie Lake Road	674	South
1189 Bonnie Lake Road	830	South
1186 Bonnie Lake Road	909	South
1183 Bonnie Lake Road	852	South
1174 Bonnie Lake Road	1032	South
1166 Bonnie Lake Road	1030	South
1165 Bonnie Lake Road	815	South
1163 Bonnie Lake Road	928	South

PROPOSED MINERAL EXTRACTION

The extraction operations will begin at the North boundary of Phase A1 and A2 concurrently, and progress in a southerly direction to the phase boundary (Refer to Appendix A). Extraction will leverage the Phase 1 / Phase 2A South face located within the existing Childs pit/quarry licence thereby eliminating the need for a sinking cut. Phase A1 will be extracted in up to five (5) lifts to a final floor elevation of 270masl, while Phase A2 will be extracted in up to three (3) lifts to a final floor elevation of 300masl.

Phase B2(i) will leverage the face created during the Phase A blasting to eliminate the need for a sinking cut and will continue a Southerly retreat to the South extraction limits. Phase B2(ii) will leverage the face created by the Phase B2(i) extraction and will retreat in a generally East / Southeast direction to the East extraction limits.

Phase B1 will leverage the faces created by the Phase B2(i) and Phase 3 extraction thereby eliminating the requirement for a sinking cut. Phase B1 will retreat towards the Hydro One easement from both the East and West.

Phase B will be extracted to a depth of between 310masl and 320masl necessitating the performance of one (1) bench to achieve the design floor depth.

The direction of retreat has been selected so as to permit operations the greatest opportunity to mitigate overpressure, which is the most environmentally dependent derivative of blasting operations, while still allowing for the control of ground vibrations through proper blast design. This direction of retreat will also alleviate any hazards associated with rock movement.

Granite Quarries in Ontario normally employ 76 to 152mm diameter blast holes. For a 7.5m – 15m bench, this would employ 30kg to 260kg of explosive load per hole, suggesting that blast designs to achieve and maintain compliance with MECP guideline limits are readily feasible. The choice of hole diameter and bench height will govern the maximum number of holes to be fired per period.

As extraction retreats towards the surrounding properties, it may be necessary and/or appropriate to vary operational aspects of the drilling and blasting program in response to monitoring program results and observed outcomes.

It is a recommendation of this report that all blasts shall, as a minimum, be monitored at the nearest sensitive receptors, or closer, in front and behind any given blast in order to ensure compliance with applicable guideline limits and to permit timely adjustment to blast designs as required.

BLAST VIBRATION AND OVERPRESSURE LIMITS

The Ontario MECP guidelines for blasting in quarries are among the most stringent in North America.

Studies by the U.S. Bureau of Mines have shown that normal temperature and humidity changes can cause more damage to residences than blast vibrations and overpressure in the range permitted by the MECP. The limits suggested by the MECP are as follows.

***Vibration*___________** 12.5mm/sec Peak Vector Sum (PVS)

***Overpressure*_______** 128 dBL Peak Sound Pressure Level (PSPL)

The above guidelines apply when blasts are being monitored. Cautionary levels are slightly lower and apply when blasts are not monitored on a routine basis. It is a recommendation of this report that all blasts at the operation be monitored to quantify and record ground vibration and overpressure levels employing a minimum of two (2) digital seismographs, one installed at the closest sensitive receptor behind the blast, or closer, and one installed at the closest sensitive receptor in front of the blast, or closer.

BLAST MECHANICS AND DERIVATIVES

The detonation of explosives within a borehole results in the development of very high gas and shock pressures. This energy is transmitted to the surrounding rock mass, crushing the rock immediately surrounding the borehole (approximately 1 borehole radius) and permanently distorts the rock to several borehole diameters (5-25, depending on the rock type, prevalence of joint sets, etc.).

The intensity of this stress wave decays quickly so that there is no further permanent deformation of the rock mass. The remaining energy from the detonation travels through the unbroken material in the form of a pressure wave or shock front which, although it causes no plastic deformation of the rock mass, is transmitted in the form of vibrations.

Particle velocity is the descriptor of choice when dealing with vibrations because of its superior correlation with the appearance of cosmetic cracking. As such, for the purposes of this report, ground vibration units have been listed in mm/s.

In addition to the ground vibrations, overpressure or air vibrations are generated through the direct action of the explosive venting through cracks in the rock or through the indirect action of the rock movement. In either case, the result is a pressure wave which travels through the air, measured in decibels (or dB) for the purposes of this report.

VIBRATION AND OVERPRESSURE THEORY

Transmission and decay of vibrations and overpressure can be estimated by the development of attenuation relations. These relations utilize empirical data relating measured velocities at specific separation distances from the vibration source to predict particle velocities at variable distances from the source. While the resultant prediction equations are reliable, divergence of data occurs as a result of a wide variety of variables, most notably site-specific geological conditions and blast geometry and design for ground vibrations and local prevailing climatic conditions for overpressure.

In order to circumvent this scatter and improve confidence in forecast vibration levels, probabilistic and statistical modeling is employed to increase conservatism built into prediction models, usually by the application of 95% confidence lines to attenuation data.

The attenuation relations are not designed to conclusively predict vibration levels at a specific location as a result of a specific blast design, application of this probabilistic model creates confidence that for any given scaled distance, 95% of the resultant velocities will fall below the calculated 95% regression line.

While the data still provides insight into probable vibration intensities, attenuation relations for overpressure tends to be less reliable and precise than results for ground vibrations. This is due primarily to wider variations in variables outside of the influence of the blast design which impact propagation of the vibrations. Atmospheric factors such as temperature gradients and prevailing winds (refer to Appendix B), as well as local topography can all serve to significantly alter overpressure attenuation characteristics.

Our experience and analysis demonstrates that blast overpressure is greatest when blasting towards receptors, and blast vibrations are greatest when retreating towards the receptors.

GROUND VIBRATION LEVELS AT THE NEAREST SENSITIVE RECEPTOR

The most commonly used formula for predicting PPV is known as the Bureau of Mines (BOM) prediction formula or Propagation Law. We have used this formula to predict the PPV's at the closest house for the initial operations.

$$PPV = k\left(\frac{d}{\sqrt{w}}\right)^{e}$$

Where, PPV = the predicted peak particle velocity (mm/s)

K, e = site factors

d = distance from receptor (m)

w = maximum explosive charge per delay (kg)

The value of K and e are variable and influenced by many factors (i.e. rock type, geology, thickness of overburden, etc.). As such, these site factors are developed empirically through the measurement of vibration characteristics at the specific operations of interested.

The portion of the BOM prediction formula contained within the parentheses is referred to as the Scaled Distance and represents another important PPV relation. It correlates the separation distance between a blast and receptor to the energy (usually expressed as explosive weight) released at any given instant in time. The two most popular approaches are square root scaling and cube root scaling:

$$\left(SDSR = \frac{R}{\sqrt{W}}\right) \qquad \left(SDCR = \frac{R}{\sqrt[3]{W}}\right)$$

Where, SDSR = Scaled distance square root method

SDCR = Scaled distance cube root method

R = Separation distance between receptor site and blast (m)

W = Maximum explosive load per delay period (kg)

Historically, square root scaling is employed in situations whereby the explosive load is distributed in a long column (i.e. blasthole) while cube root scaling is employed for point charges. In accordance with industry standard, square root scaling was adopted for ground vibration analysis for the purposes of this report.

For a distance of 790m (the standoff distance to the nearest sensitive receptor for the initial blasting, namely 1407 Bonnie Lake Road) and a maximum explosive load per delay of 122kg (102mm diameter hole, 15m depth, 2.5m surface collar and 1 hole per delay), we can calculate the maximum PPV at the closest building using the following formulae:

Imperial Equations:

Oriard 50% Bound (2002)	$v = 160(\frac{D}{\sqrt{W}})^{-1.6}$
Oriard 90% Bound (2002)	$v = 242(\frac{D}{\sqrt{W}})^{-1.6}$
Quarry Production Blast (Bulletin 656 – 1971)	$v = 182(\frac{D}{\sqrt{W}})^{-1.82}$
Typical limestone Quarry (Pader report – 1995)	$v = 52.2(\frac{D}{\sqrt{W}})^{-1.38}$
Typical Coal Mine (RI8507 1980)	$v = 133(\frac{D}{\sqrt{W}})^{-1.5}$

Metric Equations:

General Blasting (Dupont)	$v = 1140(\frac{D}{\sqrt{W}})^{-1.6}$
Construction Blasting (Dowding 1998)	$v = 1326(\frac{D}{\sqrt{W}})^{-1.38}$
Agg. Quarry Blasting (Explotech 2005)	$v = 5175(\frac{D}{\sqrt{W}})^{-1.76}$
Agg. Quarry blasting (Explotech 2003)	$v = 7025(\frac{D}{\sqrt{W}})^{-1.85}$

The equations described above accommodate for a range of geological conditions. The proposed blast parameters were applied to the formulae to estimate a range of the potential vibrations to be imparted on the closest sensitive receptor behind the blast. As discussed in previous sections, the MECP guideline for blast-induced vibration is 12.5 mm/s (0.5 in/s). Appendix C demonstrates that the maximum (i.e. worst-case) calculated value for the vibration intensities imparted on the closest sensitive receptor behind the blast based on all equations is 3.66mm/s for the initial blasting, well below the MECP guideline limit. All blasts will be monitored for overpressure and ground vibrations with blast designs adjusted in response to readings on site in order to confirm consistent compliance with established limits.

All vibration calculations and tables going forward will utilize the formula providing the worst case scenario for all geological conditions (Construction Blasting (Dowding 1998)).

An ***example*** of this calculation is as follows:

For a distance of 790m (the standoff distance to the nearest sensitive receptor for the initial blasting, namely 1407 Bonnie Lake Road) and a maximum explosive load per delay of 122kg (102mm diameter hole, 15m deep, 2.5m surface collar and 1 hole per delay), we can calculate the maximum PPV at the closest sensitive receptor as follows:

$$PPV = 1326\left(\frac{790}{\sqrt{122}}\right)^{-1.38} = 3.66mm/s$$

The calculated 95% predicted PPV (based on the proposed blasting data discussed above) would be 3.66mm/s, well below the MECP guideline limit. It is understood that as separation distance to the receptors decreases, adjustments to blast designs may be necessary to maintain compliance with the guideline limits.

Similarly, the above equation used to calculate PPV can be reformatted to find an approximation of the distance at which a vibration velocity of 12.5mm/s would occur if all blasting parameters are kept the same as used in the equation above:

$$12.5 = 1326\left(\frac{d}{\sqrt{122}}\right)^{-1.38} = 324.3m$$

The above result suggests that design modifications to the above preliminary design would be required once blasting operations encroach to within 324.3m of the properties behind blasting operations. Fortunately, vibration data will be continually collected and analyzed as the sensitive receptors are approached in order to confirm the requirement for any design modifications. An abundance of design modifications are available which would readily maintain vibration intensities below guideline limits.

Given the separation distances that will be involved at the Childs Pit and Quarry Extension, Table 2 below provides initial guidance on maximum loads per delay based on various separation distances. The following maximum loads per delay were derived from the equation for ground vibrations listed above and are based on a maximum intensity of 12.5mm/s:

Table 2: Maximum Load per Delay to Maintain 12.5mm/s at Various Separation Distances

Separation distance between sensitive receptor and closest borehole (meters)	Maximum recommended explosive load per delay (Kilograms)
800	742
600	417
500	289
450	234
400	185
350	142
300	104
250	72
200	46
150	26
100	11

It is noteworthy that the above values are typically conservative and are intended as a guideline only as the ground vibration attenuation equation is based on a calculated 95% regression line. Actual loads employed shall be based on the results of the monitoring program in place and adjusted as necessary.

The closest separation distance between a sensitive receptor and any potential blast over the life of the licence is 30m. While blasting at this separation distance is feasible from a technological perspective, given current blasting technology and techniques, market economics will dictate the feasibility of extracting rock at lesser separation distances. Monitoring and changes in blasting designs will be required in order to confirm all blasts are within MECP guidelines when blasting comes closer to adjacent sensitive receptors.

OVERPRESSURE LEVELS AT THE NEAREST SENSITIVE RECEPTOR

It is unusual for overpressure to reach damaging levels and when it does, the evidence is typically immediate and obvious in the form of broken windows in the area. However, overpressure remains of interest due to its ability to travel further distances as well as cause audible sounds and excitation in windows and walls.

Air overpressure decays in a known manner in a uniform atmosphere, however, a uniform atmosphere is not a normal condition. As such, air overpressure attenuation is far more variable due to its intimate relationship with environmental influences. Air vibrations decay slower than ground vibrations with an average decay rate of 6dBL for every doubling of distance.

Air overpressure levels are analyzed using cube root scaling based on the following equation:

$$P = k\left(\frac{d}{\sqrt[3]{w}}\right)^{e}$$

Where, P = the peak overpressure level (psi – imperial, Pa, dB - metric)
K, e = site factors
d = distance from receptor (ft – imperial, m - metric)
w = maximum explosive charge per delay (lbs – imperial, kg - metric)

The value of K and e are variable and are influenced by many factors (i.e. rock type, geology, thickness of overburden, environmental conditions, etc.). As such, these site factors are developed empirically through the measurement of overpressure characteristics at the specific operations of interested.

As discussed in previous sections, the MECP guideline for blast-induced overpressure is 128dBL. For a distance of 1010m (the standoff distance to the nearest sensitive receptor in front of the initial blasting, namely 1482 Bonnie Lake Road) and a maximum explosive load of 122kg (102mm diameter hole, 15m deep, 2.5m surface collar and 1 hole per delay), we can calculate the overpressure at the nearest receptor in front of the blast using the following equations:

Imperial Equations:

USBM RI8485 (Behind Blast)	$P = 0.056(\frac{D}{\sqrt[3]{W}})^{-0.515}$
USBM RI8485 (Front of Blast)	$P = 1.317(\frac{D}{\sqrt[3]{W}})^{-0.966}$
USBM RI8485 (Full Confined)	$P = 0.061(\frac{D}{\sqrt[3]{W}})^{-0.96}$
Construction Average (Oriard 2005)	$P = 1(\frac{D}{\sqrt[3]{W}})^{-1.1}$

Metric Equations:

Ontario Quarry - dB (Explotech)	$P = 159(\frac{D}{\sqrt[3]{W}})^{-0.0456}$
Limestone - dB (Explotech)	$P = 206(\frac{D}{\sqrt[3]{W}})^{-0.1}$
Ontario Quarry - Pa (Explotech)	$P = 1222(\frac{D}{\sqrt[3]{W}})^{-0.669}$

Based on these equations, the maximum calculated value for the overpressure intensities imparted on the closest sensitive receptor based on all equations is 124.8 dB(L) for the initial blasting (Refer to Appendix C for an overview of the results).

$$P = 159\left(\frac{1010}{\sqrt[3]{122}}\right)^{-0.0456} = 124.8dB(L)$$

Based on the above calculation and the assumed blast parameters, and the conservatism built into the equations, overpressures from blasting operations can remain compliant with the MECP NPC 119 guideline limit of 128dBL. The design method of retreat has been planned so as to direct overpressures generated as much as practicable in the direction of vacant lands. All overpressure calculations and tables going forward will utilize the formula providing the worst case scenario for all geological conditions (Ontario Quarry – dB (Explotech)).

We reiterate that air overpressure attenuation is far more variable due to its intimate relationship with environmental influences and as such, the equation employed is less reliable than that developed for ground vibration. Overpressure monitoring performed on site shall be used to guide blast design as it pertains to the control of blast overpressures. As demonstrated in Appendix B, atmospheric factors such as temperature gradients and prevailing winds as well as local topography can all serve to significantly alter overpressure attenuation characteristics.

Given the intimate correlation between overpressure and environmental conditions as stated previously, care must be taken to avoid blasting on days when weather patterns are less favourable. Extraction directions have been selected so as to minimize overpressure impacts on adjacent receptors.

Table 3 below can be used as an initial guide showing maximum loads per delay based on various separation distances for receptors in front of the blast face. The following maximum loads per delay are derived from the air overpressure equation above and are based on a peak overpressure level of 128dB(L):

Table 3: Maximum Loads per Delay to Maintain 128dB(L) at Various Separation Distances for Receptors in Front of the Face

Separation distance between sensitive receptor and closest blasthole (meters)	Maximum recommended explosive load per delay (Kilograms)
800	326
600	137
500	79
450	58
400	40
350	27
300	17
250	9
200	5
150	2
100	0.6

We note that the above values are conservative and are intended as a guideline only as the air overpressure attenuation equation is based on a calculated 95% regression line. Actual loads employed shall be based on the results of the monitoring program in place.

ADDITIONAL CONSIDERATIONS OUTSIDE OF THE BLAST IMPACT ANALYSIS SCOPE

The following headings are addressed for general information purposes and are not strictly required as part of the scope of the Blast Impact Analysis as required under the ARA to assess compliance with MECP NPC-119 guidelines. Considerations for the Hydro transmission towers can be expanded upon under separate cover with direct input from the utility owners as required. The hydrogeological study prepared by Golder Associates Ltd. (2020) as part of the licence application will address residential water wells in detail. Considerations for aquatic species are further addressed in the RiverStone Environmental Solutions Inc. report. Flyrock control is addressed at the operational level given significant influences related to blast design, geology and field accuracy which render concrete recommendations related to control inappropriate at the licencing phase.

FLYROCK

Flyrock is the term used to define rocks which are propelled from the blast area by the force of the explosion. This action is a predictable and necessary component of a blast and requires that every blast have an exclusion zone established within which no persons or property which may be harmed are permitted.

Government regulations strictly prohibit the ejection of flyrock off of a quarry property. The regulations regarding flyrock are enforced by the Ministries of Natural Resources, Environment and Labour. In the event of an incident where flyrock does leave a site, the punitive measures include suspension / revocation of licences and fines to both the blaster and quarry owner / operator. Fortunately, flyrock incidents are extremely rare due to the possible serious consequences of such an event. It is in the best interest of all, stakeholders and non-stakeholders, to ensure that dangerous flyrock does not occur. Through proper blast planning and design, it is possible to control and mitigate the possibility for flyrock.

THEORETICAL HORIZONTAL FLYROCK CALCULATIONS

Flyrock occurs when explosives in a hole are poorly confined by the stemming or rock mass and the high pressure gas breaks out of confinement and launches rock fragments into the air. The three primary sources of fly rock are as follows:

- **Face burst:** Lack of confinement by the rock mass in front of the blast hole results in fly rock in front of the face.

- **Cratering:** Insufficient stemming height or weakened collar rock results in a crater being formed around the hole collar with rock projected in any direction.

- **Stemming Ejection:** Poor stemming practice can result in a high angle throw of the stemming material and loose rocks in the blasthole wall and collar.

The horizontal distance flyrock can be thrown (L_H) from a blast hole is determined using the expression:

$$L_H = \frac{V_o^{\,2} Sin 2\theta_0}{g} \qquad [1]$$

where: V_o = launch velocity (m/s)
θ_0 = launch angle (degrees)
g = gravitational constant (9.8 m/s^2)

The theoretical maximum horizontal distance fly rock will travel occurs when θ_0 = 45 degrees, thereby yielding the equation:

$$L_{H\max} = \frac{V_o^{\,2}}{g} \qquad [2]$$

The normal range of launch velocity for blasting is between 10m/s - 30m/s. To calculate the launch velocity of a blast the following formula is used:

$$V_o = k\left(\frac{\sqrt{m}}{B}\right)^{1.3} \qquad [3]$$

where: k = a constant
m = charge mass per meter (kg/m)
B = burden (m)

By combining equations 2 and 3 and taking into account the different sources of fly rock, the following equations can be used to calculate the maximum fly rock thrown from a blast:

Face burst:
$$L_{H\max} = \frac{k^2}{g} * \left(\frac{\sqrt{m}}{B}\right)^{2.6}$$

Cratering:
$$L_{H\max} = \frac{k^2}{g} * \left(\frac{\sqrt{m}}{SH}\right)^{2.6}$$

Stemming Ejection:
$$L_{H\max} = \frac{k^2}{g} * \left(\frac{\sqrt{m}}{SH}\right)^{2.6} Sin2\theta$$

where:
θ = drill hole angle
L_{hmax} = maximum flyrock throw (m)
m = charge mass per meter (kg/m)
B = burden (m)
SH = stemming height (m)
g = gravitational constant
k = a constant

The range for the constant k is 13.5 for soft rocks and 27 for hard rocks. Given the proposed licence area is predominantly granite, we have applied a k value of 27. The explosive density is assigned to be 1.2 g/cm^3 for emulsion products and the drill hole angles are assumed to be 90 degrees (i.e. vertical).

For calculation purposes, we have applied the initial blasting parameters which utilize 102mm (4”) diameter holes on a 3.05m x 3.05m (10’ x 10’) pattern, with a lift height of 15m (49’) and a collar length of 2.5m (8’). The following does not apply to sinking cuts which will require highly specialized designs and additional considerations for flyrock. Based on a free face blast, maximum anticipated horizontal flyrock projection distances are calculated as follows in Table 4:

Table 4 – Maximum Flyrock Horizontal

***Collar* Lengths** (m)	**Maximum Throw Face Burst** (m)	**Maximum Throw Cratering and Stemming Ejection** (m)
1.5	48	504
2.0	48	238
2.5	48	133
3.0	48	83
3.5	48	56

Different collar lengths are displayed in the table above to account for over or under loaded holes. As demonstrated with these various collar lengths, any deviation, no matter how slight, can greatly affect these maximum values. The current proposed initial blasting parameters have the potential to send flyrock 133m assuming all holes achieve the designed collar lengths of 2.5m. Blast mats or sand can be placed on top of the initial blast to further reduce the distance for potential flyrock.

Through proper blast design and diligence in inspecting the geology before every blast, flyrock can readily be maintained within the quarry limits. It may be necessary to increase collars and adjust designs accordingly when blasting along the perimeter to accommodate the reduced deportation distance to receptors and to maintain flyrock within the property limits. The operational plan for the quarry has been designed to retreat towards the closest receptors thereby projecting flyrock and overpressures away from the receptors.

TRANSMISSION AND HYDRO TOWERS

Hydro One Transmission towers encroach the Proposed Extension area at the Southwest limit and run through Phase B1 noted on the proposed Operational Plan (refer to Appendix A). The MECP guideline for blast-induced vibration (12.5mm/s) does not apply to transmission/hydro towers as they are not classified as sensitive receptors. In order to safeguard the integrity of these structures, Hydro One has set a vibration limit of 50mm/s at the foundations of the transmission towers.

It is widely accepted that normal temperature and humidity changes as well as wind loads can cause more damage to structures than blast vibrations at the 50mm/s limit. Notwithstanding, as per direction from Hydro One, calculations will be based on the 50mm/s limit. The tower shall be monitored for ground vibration and overpressure when vibration calculations suggest vibrations in excess of 35mm/s at the tower base. Based on the proposed Operations Plan for the Childs Pit and Quarry Extension, initial blasting operations are anticipated to be approximately 600m from the closest tower, however, will reach as close as 30m throughout the course of extraction at the Southern limits of the Extension in Phase B1.

Applying the equation from Predicated Vibration Limits at the Nearest Sensitive Receptor, for a distance of 600m (the conservative standoff distance to the transmission tower for the initial blasting) and a maximum explosives load per delay of 122kg (102mm diameter hole, 15m deep, 2.5m surface collar and 1 hole per delay), we can calculate the maximum PPV at the transmission tower for the initial blast as follows:

$$PPV = 1326\left(\frac{600}{\sqrt{122}}\right)^{-1.38} = 5.35mm/s$$

The calculated 95% predicted PPV (based on the proposed blasting data discussed above) would be 5.35mm/s, which is below the limit of 50mm/s. While this value resides below the 50mm/s threshold, it is anticipated that design modifications will be necessary to maintain compliance as the separation distance to some of the towers decreases and column loads increase. Fortunately, a variety of blast design alternatives are available to accomplish this including but not limited to reductions in blast hole diameter, change in explosives types, adjustment in bench heights and decking of holes.

RESIDENTIAL WATER WELLS

Possible impacts to the water quality and production capacity of groundwater supply wells is a common concern for residents near blasting operations. Complaints related to changes in water quality often include the appearance of turbidity, water discolouration and changes in water characteristics (including nitrate, e-coli, and coliform contamination). Complaints regarding water production most often involve loss of quantity production, air in water and damage to well screens and casings. A review of research and common causes of these problems indicates that most of these concerns are not related to blasting and can be shown to be the direct impact of environmental factors and poor well construction and maintenance.

There is an intuitive belief that blasting operations have dramatic and disastrous impacts on residential water wells for large distances around such operations. Unfortunately, there is no scientific basis for such claims. Outside of the immediate radius of approximately 20-25 blasthole diameters from a loaded hole, there is no permanent ground displacement. As such, barring blasting activity within several meters of an existing well, the probability of damage to residential wells is essentially non-existent.

Despite the scientific support for the above conclusion, numerous studies have been performed to verify the validity of this statement. These studies have investigated the effects of blasting on varied well configurations and in varied geological mediums to permit conclusions to be readily extrapolated to diverse blasting operations. The conclusion of these studies has confirmed that with the exception of possible temporary increases in turbidity, blasting operations did not result in any permanent impact on wells outside of the immediate blast zone of the blast until vibration levels reached exceedingly high intensities. Applying universally accepted threshold levels for ground vibrations eliminates the possibility for any long term adverse effects on wells in the vicinity of blasting operations.

In a study by Froedge (1983), blast vibration levels of up to 32.3mm/s were recorded at the bottom of a shallow well located at a distance of 60 meters (200 feet) from an open pit blast. There was no report of visible damage to the well nor was there any change in the water pumping flow rate. This study concluded that the commonly accepted limit of 50mm/s PPV level is adequate to protect wells from any damage. We reiterate, the current guideline limit for vibrations from quarry and mining operations is 12.5mm/s.

Rose et al. (1991) studied the effect of blasting in close proximity to water wells near an open pit mine in Nevada, USA. Blasts of up to 70 kilograms of explosives per delay period were detonated at a distance of 75 meters (245 feet) from a deep water well. There was no reported visible damage to the well. Fluctuations in water level and flow rate were evident immediately after the blast. However, the well water level and flow rate quickly stabilized.

The U.S. Bureau of Mines conducted a study (Robertson et al., 1990) to determine the changes in well capacity and water quality. This involved pumping from wells before and after nearby blasting. One experiment with a well in sandstone showed no change in well capacity after blasts induced PPV's at the surface of 84mm/s and there was no change in water level after PPV's of 141mm/s, well above the current guideline limit of 12.5mm/s.

Matheson et al. (1997) brought together available information on the most common complaints, the possible causes of the complaints and the relation between blasting and the complaint causes. This study yet again reaffirmed the fact that the attribution of well problems to blast sources are unfounded.

The MECP vibration limit of 12.5mm/s effectively excludes any possibility of damage to residential water wells. Based on available research and our extensive experience in Ontario quarry blasting, blasting at the Childs Pit and Quarry Extension will induce no permanent adverse impacts on the residential water wells on properties surrounding the site.

BLAST IMPACT ON ADJACENT WATERCOURSES

The detonation of explosives in or near water can produce compressive shock waves which initiate damage to the internal organs of fish in close proximity, ultimately resulting in the death of the organism. Additionally, ground vibrations imparted on active spawning beds have the ability to adversely impact the incubating eggs and spawning activity. In an effort to alleviate adverse impacts on fish populations as a result of blasting, the Department of Fisheries and Oceans (DFO) developed the Guidelines for the Use of Explosives In or Near Canadian Fisheries Waters (1998). This publication establishes limits for water overpressure and ground vibrations which are intended to mitigate impacts on aquatic organisms while providing sufficient flexibility for blasting to proceed. Specifically, water overpressures are to be limited to 100kPa and, in the presence of active spawning beds, ground vibrations at the bed are to be limited to 13mm/s.

The Muskoka River North Arm is located to the West of the licence area with a minimum separation distance of approximately 290m at its closest point which is in Phase B1. The Sage Creek comes within 95m of the closest point of blasting, however all extraction in that phase will remain above the water table and maintain surface water flow to the Creek. Based on this separation distance, water overpressures generated by the blasting will reside well below the DFO 100Kpa guideline limit and will have no impact on the adult fish populations present.

Spawning beds within the river and creek may be present and active during limited periods of the year. When blasting at the quarry during the active spawning period, vibration monitoring will be required at the shoreline adjacent the closest spawning area in order to ensure compliance with DFO limits for ground vibration. Given the 95m separation distance, revisions to blast designs to accommodate the DFO 13mm/s guideline vibration limit is anticipated.

The generation of suspended solids within the watercourse as a result of the blasting activities will be negligible and grossly subordinate to suspended solids generated as a result of spring runoff and rain activity.

Table 5 below is presented as initial guidance showing maximum permissible loads per delay based on various separation distances from spawning beds. The following maximum loads per delay are derived from the equation for ground vibrations listed earlier in this report and are based on a maximum vibration intensity of 13.0mm/s as experienced at the active spawning habitat:

Table 5: Maximum Loads per Delay to Maintain 13.0mm/s at Various Separation Distances

Separation distance between possible spawning bed and closest borehole (meters)	Maximum recommended explosive load per delay (Kilograms)
500	306
450	248
400	196
350	150
300	110
250	76
200	49
150	27
100	12
75	6
50	3
30	1

RECOMMENDATIONS

It is recommended that the following conditions be applied for all blasting operations at the proposed Childs Pit and Quarry Extension:

1. An attenuation study shall be undertaken by an independent blasting consultant during the first 12 months of operation in order to obtain sufficient quarry data for the development of site specific attenuation relations. Blast designs and parameters implemented during the study period shall be representative of typical production blasts anticipated for the quarry. This study will be used to confirm the applicability of the initial guideline parameters and assist in developing future blast designs.

2. All blasts shall be monitored for both ground vibration and overpressure at the closest privately owned sensitive receptors adjacent the site, or closer, with a minimum of two (2) instruments – one installed in front of the blast and one installed behind the blast.

3. Blasts shall be designed to maintain vibrations below 13mm/s at the location of the closest identified active spawning bed as per DFO guidelines. When blasting during active spawning season, a minimum of one supplemental vibration monitor shall be installed on the shoreline adjacent to the closest spawning bed to confirm the vibration levels.

4. The guideline limits for vibration and water overpressure shall adhere to standards as outlined in the publications *Guidelines For the Use of Explosives In or Near Canadian Fisheries Waters (1998)* or any such document, regulation or guideline which supersedes this standard.

5. The guideline limits for ground vibration and air overpressure shall adhere to standards as outlined in the Model Municipal Noise Control By-law publication NPC 119 (1978) or any such document, regulation or guideline which supersedes this standard.

6. In the event of an exceedance of NPC 119 limits or any such document, regulation or guideline which supersedes this standard, blast designs and protocol shall be reviewed prior to any subsequent blasts and revised accordingly in order to return the operations to compliant levels.

7. Blasts shall be designed to maintain vibrations at the transmission towers in the Hydro One Corridor below 50mm/s or any such document, regulation or corporate policy in effect at the time. When vibration calculations suggest vibrations at the towers may exceed 35mm/s, the closest tower shall be monitored for ground vibration.

8. Orientation of the aggregate extraction operation will be designed and maintained so that the direction of the overpressure propagation and flyrock from the face will be away from structures as much as possible.

9. Blast designs shall be continually reviewed with respect to fragmentation, ground vibration and overpressure. Blast designs shall be modified as required to maintain compliance with current applicable guidelines and regulations.

10. Detailed blast records shall be maintained in accordance with current industry best practices.

The blast parameters described within this report are supported by the modelling in the attached appendices. As the quarry progresses and as site-specific data is collected from the on-going operation, the blast parameters can be refined, as necessary, to maintain continual compliance with MECP Guidelines.

CONCLUSION

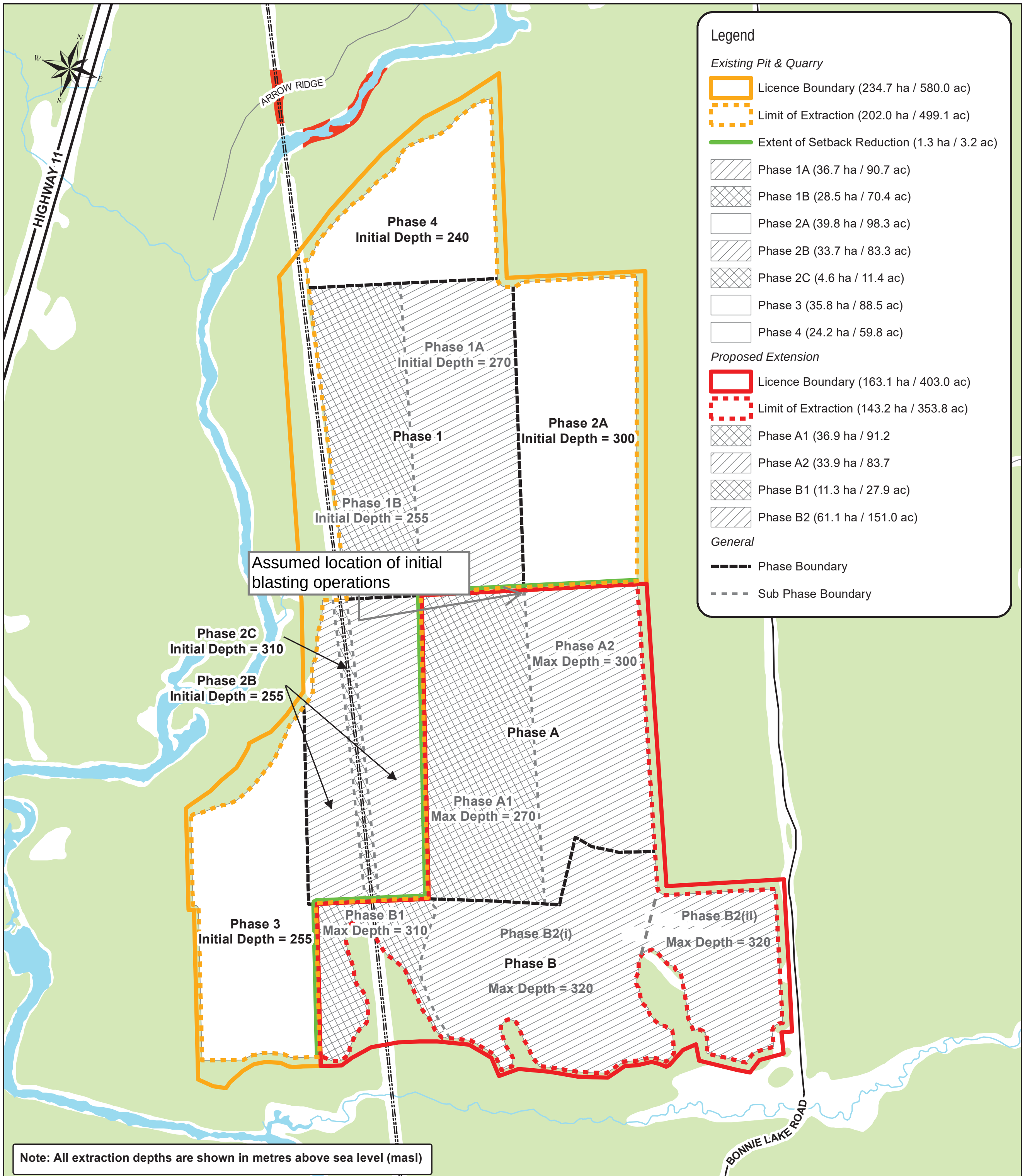
The blast parameters described within this report will provide a good basis for the initial blasting operations at this location. As site specific blast vibration and overpressure data becomes available, it will be possible to refine these parameters on an on-going basis.

Blasting operations required for operations at the proposed Fowler Childs Pit and Quarry Extension site can be carried out safely and within governing guidelines set by the Ministry of the Environment, Conservation and Parks.

Modern blasting techniques will permit blasting to take place with explosives charges below allowable charge weights ensuring that blast vibrations and overpressure will remain minimal at the nearest receptors.

EXPLOTECH

Appendix A



Existing Childs Pit and Quarry

- Unlimited tonnage limit
- Hours of operation are 24/7 excluding statutory holidays
- Entrance/Exit on Bonnie Lake Road
- Currently processing is permitted anywhere on-site except for 30m from the licence boundary or 90m from a residential use.
- Processing currently occurs within Phase 1 of the existing sand and gravel pit extraction and uses an internal haul route to access Bonnie Lake Road (See Landholding map)
- Four phases – permitted to extract to 195 masl. Aggregate operations will generally follow in sequence but may vary from time to time due to material quality or production demands.
- Extraction is currently within Phase 1 and includes extraction of sand and gravel above the bedrock.
- A portion of Phase 2 includes the hydro corridor within the extraction limit. Within the corridor, extraction is permitted outside of the tower bases to a maximum depth of 310 masl.
- Approved rehabilitation plan is to two lakes (see Rehabilitation map)
- Although the existing Childs Pit/Quarry is permitted to extract to 195 masl, Fowler in conjunction with a water resources expert have designed an initial quarry depth for the existing quarry which Fowler will stay above for the foreseeable future based on the amount of reserves and market demand in the area. Although not required, Fowler proposes to add a note to the existing Childs Pit/Quarry site plan which states that prior to extraction in the existing site proceeding below the initial elevations noted on the Proposed Phasing and Extraction Depth figure, Fowler will be required to obtain updated an Environmental Compliance Approval and Permit to Take Water from the Ministry of Environment, Conservation and Parks to ensure surrounding water resources and wells are appropriately protected and/or mitigated.

Childs Pit and Quarry Extension

- 2 million tonnes per year
- Hours of operation are 24/7 excluding statutory holidays.
- Processing is proposed anywhere on-site except for 30m from the licence boundary (except where adjacent to the existing Childs Pit and Quarry licence boundary) or 90m from a residential use.
- Utilizes existing entrance/exit on Bonnie Lake Road
- Two phases with variable extraction depths
- If approved, extraction would commence immediately at the north boundary of Phase A and progress in a southerly direction. Phase A and B can be operated concurrently with the existing Childs Pit and Quarry.
- At the commencement of the operation this will allow the existing Childs Pit and Quarry to operate as a sand and gravel pit and as a quarry in the extension lands.
- At the commencement of operations aggregate will be transported back to the existing processing area in Phase 1 of the existing Childs Pit and Quarry for processing.
- Extraction in Phase B will remain above the water table and maintain surface water flow to Sage Creek.

Figure #3

Proposed Phasing & Extraction Depth

Child's Pit & Quarry Extension

1235 Bonnie Lake Road
Town of Bracebridge
District of Muskoka

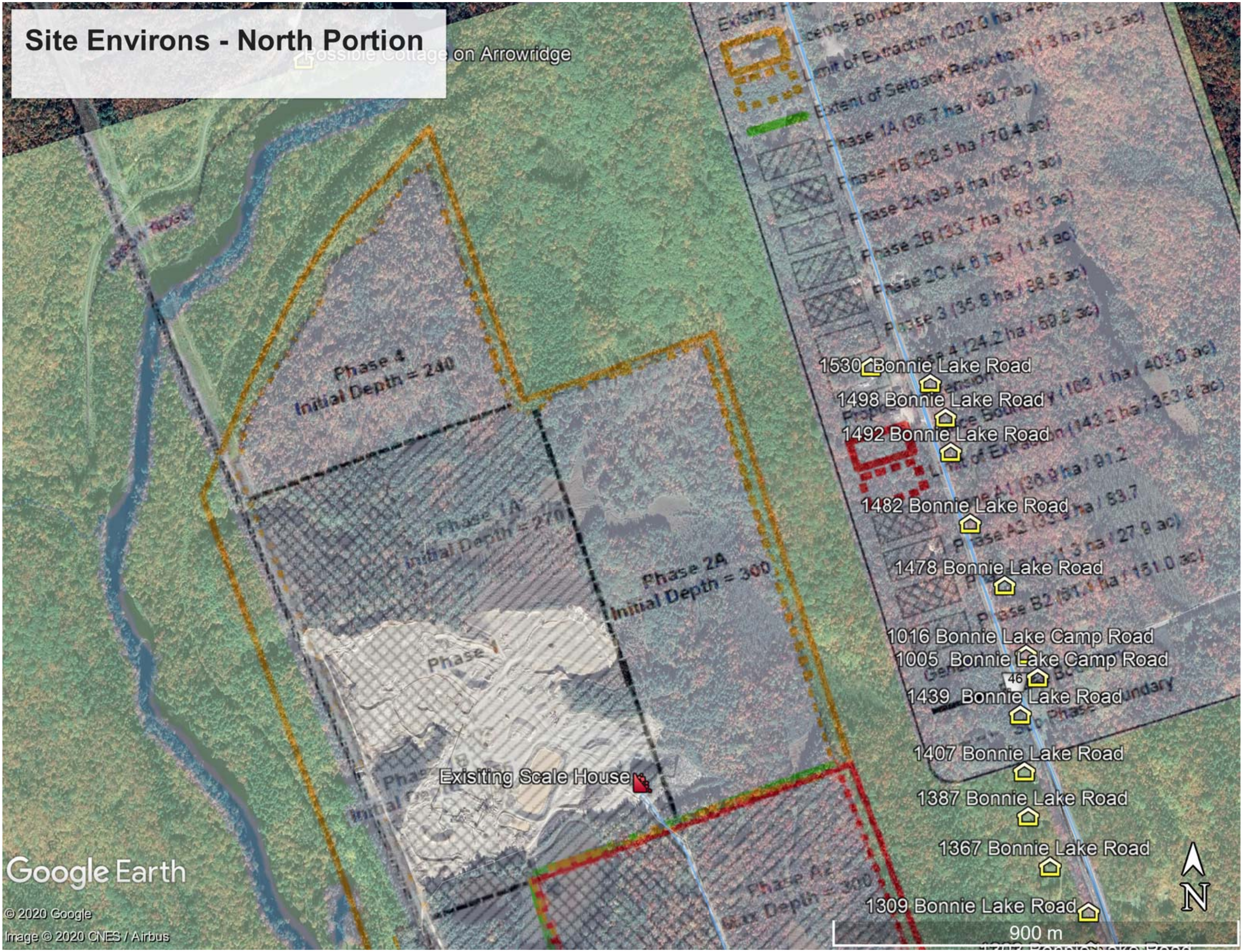
DATE: March 2020

SOURCES: Land Information Ontario. Contains information licensed under the Open Government Licence - Ontario

0 50 100 200 300 400 Meters (1:12,500)

N:\Brian\1515C - Fowler - Childs Quarry\Drawings\Figures\Proposed Extraction Phasing and Depth - March 2020\GIS

MHBC PLANNING URBAN DESIGN & LANDSCAPE ARCHITECTURE


Site Environs - North Portion
Possible Cottage on Arrowridge
Phase 4
Initial Depth = 240
Phase 1A
Initial Depth = 270
Phase 2A
Initial Depth = 300
Exisiting Scale House
1530 Bonnie Lake Road
1498 Bonnie Lake Road
1492 Bonnie Lake Road
1482 Bonnie Lake Road
1478 Bonnie Lake Road
1016 Bonnie Lake Camp Road
1005 Bonnie Lake Camp Road
1439 Bonnie Lake Road
1407 Bonnie Lake Road
1387 Bonnie Lake Road
1367 Bonnie Lake Road
1309 Bonnie Lake Road
Google Earth
© 2020 Google
Image © 2020 CNES / Airbus
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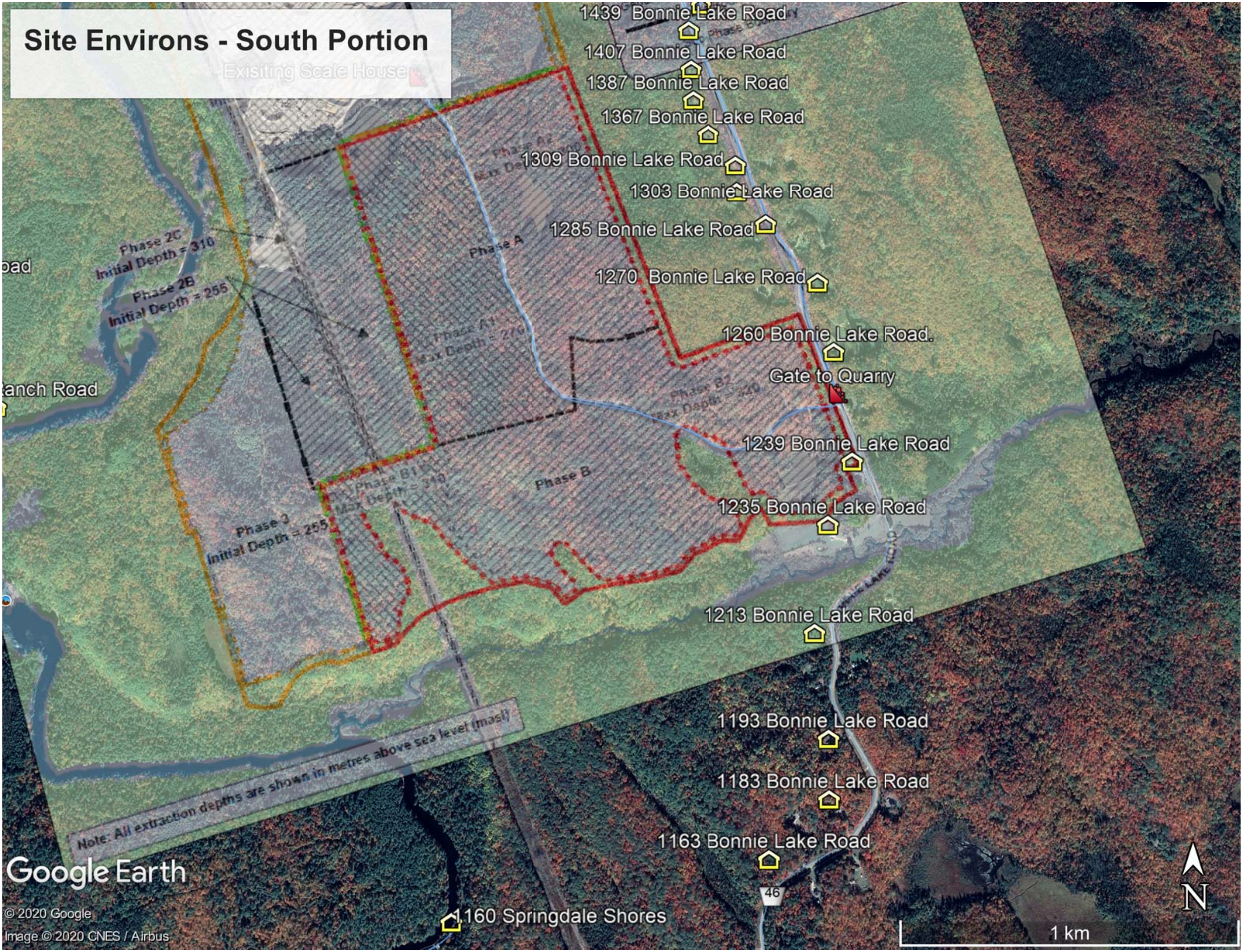
Site Environs - South Portion
Exisiting Scale House
1439 Bonnie Lake Road
1407 Bonnie Lake Road
1387 Bonnie Lake Road
1367 Bonnie Lake Road
1309 Bonnie Lake Road
1303 Bonnie Lake Road
1285 Bonnie Lake Road
1270 Bonnie Lake Road
1260 Bonnie Lake Road.
Gate to Quarry
1239 Bonnie Lake Road
1235 Bonnie Lake Road
1213 Bonnie Lake Road
1193 Bonnie Lake Road
1183 Bonnie Lake Road
1163 Bonnie Lake Road
1160 Springdale Shores
Phase 2C
Initial Depth = 310
Phase 2B
Initial Depth = 255
Phase A
Phase B
Phase 3
Initial Depth = 255
Note: All extraction depths are shown in metres above sea level (masl)
Google Earth
© 2020 Google
Image © 2020 CNES / Airbus
46
N
1 km

Site Environs - Overview
Possible Cottage on Arrowridge
1530 Bonnie Lake Road
1492 Bonnie Lake Road
1482 Bonnie Lake Road
1478 Bonnie Lake Road
1016 Bonnie Lake Camp Road
1439 Bonnie Lake Road
Bonnie Lake
Exisiting Scale House
1387 Bonnie Lake Road
1367 Bonnie Lake Road
1309 Bonnie Lake Road
1303 Bonnie Lake Road
1285 Bonnie Lake Road
1270 Bonnie Lake Road
1000 Alpine Ranch Road
1260 Bonnie Lake Road.
Gate to Quarry
1001 Alpine Ranch Road
1239 Bonnie Lake Road
1235 Bonnie Lake Road
1213 Bonnie Lake Road
1193 Bonnie Lake Road
1183 Bonnie Lake Road
1163 Bonnie Lake Road
1160 Springdale Shores
11
Google Earth
© 2020 Google
Image © 2020 CNES / Airbus
N
2 km

EXPLOTECH

Appendix B

EXPLOTECH

PREVAILING METEOROLOGICAL CONDITIONS

Medians provided by Environment
Canada Canadian Climate Normals
1981-2010 Muskoka A, Ontario

Date	Wind Direction	Wind Velocity Km/h	Temperature (Deg Celcius)
January	SE	13.6	-10.3
February	N	13.6	-8.4
March	SE	14.8	-3.1
April	S	14.8	4.8
May	SE	13.5	11.4
June	SW	12.2	16.2
July	S	11.5	18.7
August	S	10.7	17.8
September	S	11.8	13.4
October	SE	13.1	7.2
November	W	13.9	0.8
December	NW	13.2	-5.9

** Data is not available specifically for the proposed quarry location. Nearest weather station is Muskoka A, Ontario

EXPLOTECH

Appendix C

EXPLOTECH

Ground Vibrations

Imperial Equations

Equation 1	Equation 2	Equation 3	Equation 4	Equation 5
Oriard 50% Bound (2002)	Oriard 90% Bound (2002)	Typical Production Blast (Bulletin 656 – 1971)	Typical limestone Quarry (Pader report – 1995)	Typical Coal Mine (RI8507 1980)
$v = 160 \left(\frac{D}{\sqrt{W}}\right)^{-1.6}$	$v = 242\left(\frac{D}{\sqrt{W}}\right)^{-1.6}$	$v = 182 \left(\frac{D}{\sqrt{W}}\right)^{-1.82}$	$v = 52.2\left(\frac{D}{\sqrt{W}}\right)^{-1.38}$	$v = 133\left(\frac{D}{\sqrt{W}}\right)^{-1.5}$

Metric Equations

Equation 1	Equation 2	Equation 3	Equation 4
DuPont General (1968)	Construction Blasting (Dowding 1998)	Agg. Quarry Blasting (Explotech 2005)	Agg. Quarry blasting (Explotech 2003)
$v = 1140 \left(\frac{D}{\sqrt{W}}\right)^{-1.6}$	$v = 1326\left(\frac{D}{\sqrt{W}}\right)^{-1.38}$	$v = 5175\left(\frac{D}{\sqrt{W}}\right)^{-1.76}$	$v = 7025\left(\frac{D}{\sqrt{W}}\right)^{-1.85}$

D (m)	W (Kg)	PPV1 (mm/s)	PPV2 (mm/s)	PPV3 (mm/s)	PPV4 (mm/s)	PPV5 (mm/s)	PPV1 (mm/s)	PPV2 (mm/s)	PPV3 (mm/s)	PPV4 (mm/s)
790	122	**1.2**	**1.9**	**0.5**	**1.2**	**1.7**	**1.2**	**3.7**	**2.8**	**2.6**

Air Overpressure

Imperial Equations

Equation 1	Equation 2	Equation 3	Equation 4
USBM RI8485 (Behind Blast)	USBM RI8485 (Front of Blast)	USBM RI8485 (Full Confined)	Construction Average
$P = 0.056 \left(\frac{D}{\sqrt[3]{W}}\right)^{-0.515}$	$P = 1.317 \left(\frac{D}{\sqrt[3]{W}}\right)^{-0.966}$	$P = 0.061 \left(\frac{D}{\sqrt[3]{W}}\right)^{-0.96}$	$P = 1 \left(\frac{D}{\sqrt[3]{W}}\right)^{-1.1}$

Metric Equations

Equation 1	Equation 2	Equation 3
Ontario Quarry (Explotech 2013)	Limestone (Explotech 2011)	Ontario Quarry (Explotech 2012)
$P = 159\left(\frac{D}{\sqrt[3]{W}}\right)^{-0.0456}$	$P = 206 \left(\frac{D}{\sqrt[3]{W}}\right)^{-0.1}$	$P = 1222 \left(\frac{D}{\sqrt[3]{W}}\right)^{-0.669}$

D (m)	W (Kg)	OP1 (dB)	OP2 (dB)	OP3 (dB)	OP4 (dB)	OP1 (dB)	OP2 (dB)	OP3 (dB)
1010	122	**117.8**	**120.8**	**94.4**	**111.1**	**124.8**	**121.1**	**124.8**

EXPLOTECH

Appendix D

Robert J. Cyr, P. Eng.

Principal, Explotech Engineering Ltd.

EDUCATION

Bachelor of Applied Science,
Civil Engineering, Queen's University

PROFESSIONAL AFFILIATIONS

Association of Professional Engineers of Ontario (APEO)
Association of Professional Engineers and Geoscientists of BC (APEG)
Association of Professional Engineers, Geologists and Geophysicists of Alberta
Association of Professional Engineers and Geoscientists of New Brunswick
Association of Professional Engineers of Nova Scotia
Association of Professional Engineers and Geoscientists Manitoba
Professional Engineers and Geoscientists Newfoundland and Labrador
Northwest Territories and Nunavut Association of Professional Engineers (NAPEG)
International Society of Explosives Engineers (ISEE)
Ontario Stone Sand & Gravel Association (OSSGA)
Surface Blaster Ontario Licence 450109

SUMMARY OF EXPERIENCE

Over thirty five years experience in many facets of the construction and mining industry has provided the expertise and experience required to efficiently and accurately address a comprehensive range of engineering and construction conditions. Sound technical training is reinforced by formidable practical experience providing the tools necessary for accurate, comprehensive analysis and application of feasible solutions. Recent focus on vibration analysis, blast monitoring, blast design, damage complaint investigation for explosives consumers and specialized consulting to various consulting engineering firms.

PROFESSIONAL RECORD

2001 – Present	-Principal, Explotech Engineering Ltd.
1996 – 2001	-Leo Alarie & Sons Limited - Project Engineer/Manager
1993 – 1996	-Rideau Oxford Developments Inc. – Project Manager
1982 – 1993:	-Alphe Cyr Ltd. – Project Coordinator/Manager

Mitch Malcomson, P.Eng.

Explotech Engineering Ltd.

EDUCATION

Bachelor of Engineering,
Civil Engineering with Concentration in Business Management,
Carleton University

PROFESSIONAL AFFILIATIONS

Association of Professional Engineers of Ontario (APEO)
Association of Professional Engineers and Geoscientists of BC (APEG)
International Society of Explosives Engineers (ISEE)
Ontario Stone Sand and Gravel Association (OSSGA)

SUMMARY OF EXPERIENCE

A Senior Engineer and Project Organizer for Explotech Engineering Ltd. Mitch holds a Bachelor of Engineering degree from Carleton University in Civil Engineering with a Concentration in Business Management. Mitch has strong analytical, technical, business and leadership skills. As a Project Organizer, Mitch is responsible for operational strategies, scheduling and contract procurement. As a Senior Engineer, the technical responsibilities include detailed blast designs, blast investigations and reviews, implementation of vibration monitoring programs, development of monitoring Equipment/ technologies and building structural assessments for the drilling and blasting portions of mining, quarrying and construction projects across Canada.

PROFESSIONAL RECORD

2008 – Present - Engineer / Project Manager, Explotech Engineering Ltd.

Mark Morelli, B.Eng.

Explotech Engineering Ltd.

EDUCATION

Bachelor of Engineering,
Civil Engineering, Carleton University

PROFESSIONAL AFFILIATIONS

International Society of Explosives Engineers (ISEE)

SUMMARY OF EXPERIENCE

A technician working for Explotech Engineering Ltd., Mark holds a Bachelor of Engineering degree in Civil Engineering and has strong technical, leadership, interpersonal, communication, and presentation skills. Recent focus on blast monitoring, data management, scheduling, job estimations, vibration analysis, damage complaint investigation and attenuation anlysis.

PROFESSIONAL RECORD

2006 – Present	- Technician, Explotech Engineering Ltd.
2003 – 2004	- Labourer, Hydracorp Canada Ltd.
2002 – 2003	- Labourer, Quad Construction

Bradley Lavoie, B.Eng.

Explotech Engineering Ltd.

EDUCATION

Bachelor of Engineering,
Mechanical Engineering, Laurentian University

SUMMARY OF EXPERIENCE

A technician working for Explotech Engineering Ltd., Bradley holds a Bachelor of Engineering degree from Laurentian University in Mechanical Engineering. Bradley has strong analytical, technical, and interpersonal skills. Recent projects have focused on blast monitoring, vibration analysis and job estimation.

PROFESSIONAL RECORD

2018 – Present - Technician, Explotech Engineering Ltd.

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Appendix E

EXPLOTECH

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EXPLOTECH

Blasting Terminology

ANFO:	Ammonium Nitrate and Fuel Oil – explosive product
ANFO WR:	Water resistant ANFO
Blast Pattern:	Array of blast holes
Body hole:	Those blast holes behind the first row of holes (Face Holes)
Burden:	Distance between the blast hole and a free face
Column:	That portion of the blast hole above the required grade
Column Load:	The portion of the explosive loaded above grade
Collar:	That portion of the blast hole above the explosive column, filled with inert material, preferably clean crushed stone
Face Hole:	The blast holes nearest the free face
Overpressure:	A compressional wave in air caused by the direct action of the unconfined explosive or the direct action of confining material subjected to explosive loading.
Peak Particle Velocity*:*	The rate of change of amplitude, usually measured in mm/s or in/s. This is the velocity or excitation of the particles in the ground resulting from vibratory motion.
Scaled distance:	An equation relating separation distance between a blast and receptor to the energy (usually expressed as explosive weight) released at any given instant in time.
Sensitive Receptor:	Sensitive land use may include recreational uses which are deemed by the municipality or provincial agency to be sensitive; and/or any building or associated amenity area (i.e. may be indoor or outdoor space) which is not directly associated with the industrial use, where humans or the natural environment may be adversely affected by emissions generated by the operation of a nearby industrial facility. For example, the building or amenity area may be associated with residences, senior citizen homes, schools,

	day care facilities, hospitals, churches and other similar institutional uses, or campgrounds.
Spacing:	Distance between blast holes
Stemming:	Inert material, preferably clean crushed stone applied into the blast hole from the surface of the rock to the surface of the explosive in the blast hole.
Sub-grade:	That portion of the blast hole drilled band loaded below the required grade
Toe Load:	The portion of explosive loaded below grade