EXPLOTECH

Specialists in Explosives, Blasting and Vibration
Consulting Engineers

Blast Impact Analysis
Milton Quarry East Extension
Part of Lots 11 and 12, Concession 1
Town of Halton Hills
Regional Municipality of Halton

Submitted to:

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EXECUTIVE SUMMARY

Explotech Engineering Ltd. was retained in September 2020 to provide a Blast Impact Analysis for the proposed Milton Quarry East Extension located on Part of Lots 11 and 12, Concession 1 (former geographic Township of Esquesing), Town of Halton Hills, Regional Municipality of Halton.

Vibration levels assessed in this report are based on the Ministry of the Environment, Conservation, and Parks Model Municipal Noise Control By-law (NPC119) with regard to Guidelines for Blasting in Mines and Quarries. We have assessed the area surrounding the proposed Aggregate Resources Act licence with regard to potential damage from blasting operations and compliance with the aforementioned by-law document.

We have inspected the site and reviewed the available site plans. Explotech Engineering Ltd. is of the opinion that the planned aggregate extraction extension on the site can be carried out safely and within Ministry of the Environment, Conservation, and Parks 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 property.

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INTRODUCTION

Dufferin Aggregates, a division of CRH Canada Group Inc. (CRH) has applied for a Class A Licence for the property legally described as Part of Lots 11 and 12, Concession 1 (former geographic Township of Esquesing), Town of Halton Hills, Regional Municipality of Halton. The proposed name for the operation is the Milton Quarry East Extension.

This Blast Impact Analysis is based on the Ministry of the Environment, Conservation and Parks (MECP) Model Municipal Noise Control By-law (NPC 119) with regard to guidelines for blasting in mines and quarries. We have additionally assessed the area surrounding the proposed license with regard to potential damage from blasting operations. It is a recommendation of this report that the ongoing vibration monitoring program be continued on the existing licenced site as well as on the proposed Milton Quarry East Extension lands and that this monitoring program be maintained for the duration of all blasting activities to permit timely adjustment to blast parameters as required.

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 flyrock, fish habitat, and residential water wells for general informational purposes only. Exhaustive details related to residential water wells and fish habitat shall be addressed in the hydrogeological report and natural environment report respectively while specific flyrock control is addressed at the operational level given significant influences related to blast design, geology and field accuracy.

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

EXISTING CONDITIONS

The current operating licensed area for the Dufferin Aggregates Milton Quarry is operated under two separate licences: The Main and North Quarry (ARA Licence No. 5481), and the Milton Extension Quarry (ARA Licence No. 608621). The Main and North Quarry is described as Part of Lots 7 to 13, Concession 7, Town of Milton, and Part of Lots 8 to 10, Concession 1, Town of Halton Hills. The Milton Extension Quarry is described as Part of Lots 13 and 14, Concession 1, Town of Halton Hills, and Part of Lots 12 to 14, Concession 7, Town of Milton. The quarry area in its entirety is bound by Nassagaweya Sixth Line to the West, 15 Side Road and Nassagaweya Esquesing Townline to the North, Regional Road 25, Dublin Line to the East and Campbellville Road to the South. The lands immediately surrounding the existing and proposed licences are bound by mostly wetlands and woodlots and are sparsely populated.

The proposed Milton Quarry East Extension is located immediately South of the Milton Extension Quarry and will utilize existing quarry infrastructure. The proposed East Extension lands are bound by Regional Road 25 and Dublin Line to the East, and the existing Milton Quarry in the remaining cardinal directions (North, South, and West).

The licenced area for the proposed Milton Quarry East Extension lands encompasses a total area of approximately 30.2HA. The associated extraction area is approximately 15.9HA when allowing for setbacks.

The closest sensitive receptors located to the existing Milton Quarry licence boundary and the proposed Milton East Quarry Extension licence boundaries are listed in Table 1 below as well as on the Sensitive Receptor Overview contained in Appendix A:

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Receptor Number	Sensitive Receptor	Straight Line Distance from Milton Quarry Extraction Limit to Receptor (m)	Straight Line Distance from proposed Milton Quarry East Extension Extraction Limit to Receptor (m)
Table 1:Sensitive Receptors In the Vicinity of the Milton East Quarry Extension			
R1	10272 Regional Road 25	1163	1624
R2	10270 Regional Road 25	1371	1763
R3	10162 Regional Road 25	1052	1620
R4	9689 Dublin Line*	409	1599
R5	9640 Dublin Line	390	1809
R6	9606 Dublin Line	447	1897
R7	9346 Dublin Line	998	2641
R8	9315 Tremaine Road	810	2706
R9	9519 Sixth Line Nassagaweya	45	2103
R10	10314 Sixth Line Nassagaweya	212	1364
R11	10350 Sixth Line Nassagaweya	293	1452
R12	10388 Sixth Line Nassagaweya	295	1475
R13	10401 Sixth Line Nassagaweya	90	1274
R14	10449 Sixth Line Nassagaweya	214	1297
R15	10499 Sixth Line Nassagaweya	324	1146
R16	10589 Sixth Line Nassagaweya	691	1575
R17	10580 Nassagaweya-Esquesign Townline	306	1246
R18	10664 Nassagaweya Esquesing Townline	666	1516
R19	10670 Nassagaweya Esquesing Townline	723	1574
R20	10649 Nassagaweya-Esquesign Townline	559	1401
R21	6190 15 Side Road	902	1699
R22	6452 15 Side Road	1022	1736

Table 1:Sensitive Receptors In the Vicinity of the Milton East Quarry Extension			
Receptor Number	**Sensitive Receptor**	**Straight Line Distance from Milton Quarry Extraction Limit to Receptor (m)**	**Straight Line Distance from proposed Milton Quarry East Extension Extraction Limit to Receptor (m)**
R23	6390 15 Side Road	1105	1809
R24	6419 15 Side Road	1216	1929

* Commercial properties or Non-Sensitive Receptors

As noted above in Table 1, all adjacent sensitive receptors are located closer to the existing Milton Quarry operations (Licences 5481 and 608621) then the proposed Milton Quarry East Extension.

PROPOSED AGGREGATE EXTRACTION

The proposed Milton Quarry East Extension operations for Phase 1 will commence as a continuation of the existing Milton Quarry and eliminate the requirement for a sinking cut. Initial blasting will be located approximately 1100m from the closest sensitive receptor, namely R15 (10499 Nassagaweya Sixth Line). Extraction will retreat in a general Site South direction (actual cardinal retreat is Southeast) to a proposed maximum extraction depth of 302.5masl.

Extraction in Phase 2 will commence at the Phase 1 / Phase 2 interface, thereby eliminating the need for a sinking cut. Extraction will retreat in a general Site East direction (actual cardinal retreat Northeast) to a proposed maximum extraction depth of 302.5masl.

As quarry operations advance across the property, the closest sensitive receptors to the extraction perimeter will vary with the governing structures and approximate closest separation distances being as follows:

Northwest corner: R15 - 10499 Sixth Line Nassagaweya – 1146m
Southeast corner: R3 - 10162 Regional Road 25 – 1620m
Southwest corner: R13 - 10401 Nassagaweya Sixth Line – 1274m

Current practice at the Milton Quarry employs between 89mm and 114mm diameter blast holes with a typical load per delay of between 50kg and 210kg per period. Calculations contained within this report suggest blast designs currently being used at the Milton Quarry will remain compliant at the closest adjacent sensitive receptors.

It is a recommendation of this report that all blasts shall, at a minimum, be monitored at the nearest sensitive receptors, or closer, in front and behind any given blast in order to ensure constant compliance with MECP 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 Particle Velocity (PPV)

Overpressure _______ 128 dB Peak Sound Pressure Level (PSPL)

The above guidelines apply when blasts are being monitored. 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 in front of the blast, or closer, and one installed at the closest sensitive receptor behind 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 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 though 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 vibrations 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 toward receptors, and blast vibrations are greatest when retreating in the direction of the receptor.

GROUND VIBRATION AND OVERPRESSURE ATTENUATION STUDY

A comprehensive network of seismographs was installed by Explotech to measure ground vibration and air overpressure intensities at four (4) blasts conducted in October 2020 at the existing Milton Quarry in Milton, Ontario. Monitor locations were established in linear arrays emanating from the blast site to assess the rate of decay of the ground vibration and overpressure. All ground vibration data was plotted using square root scaling from blast vibration data collected (refer to Appendix C). Overpressure data was plotted employing cube root scaling (refer to Appendix C).

It should again be noted that given the high dependence on local environmental conditions, overpressure prediction is far less reliable as a means of blast control.

VIBRATION LEVELS AT THE NEAREST SENSITIVE RECEPTOR

The most commonly used formula for predicting PPV is known as 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 calculated 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 is variable and is 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 interest.

Based on the vibration data collected from the October 2020 attenuation study, the values for "e" and "K" have been established at -1.523 and 1290.4 respectively for receptors falling behind the blast at the Milton Quarry site.

For a distance of 1146m (the standoff distance to the closest sensitive receptor for the initial Phase 1 blasting, namely R15 – 10499 Nassagaweya Sixth Line) and a maximum explosive load per delay of 190kg, 114.3mm diameter hole, 18.6m hole deep, 3m surface collar and 1 hole per delay), we can calculate the maximum PPV as follows:

$$PPV = 1290.4\,(\frac{1146}{\sqrt{190}})^{-1.523} = 1.54mm/s$$

As discussed in previous sections of this report, the MECP guideline for blast-induced vibration is 12.5mm/s (0.5in/s). The calculated 95% predicted PPV (based on a standoff distance to the closest sensitive receptor for the initial Phase 1 blasting) would be 1.54mm/s, below the MECP guideline limit. It is understood that adjustments to blast designs are available at the blasters disposal should the monitoring program deem changes necessary.

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 at a receptor behind the blast if all blasting parameters are kept the same as used in the example above:

$$12.5 = 1290.4\,(\frac{d}{\sqrt{190}})^{-1.523} = 289.5m$$

The above result suggests that design modifications to the above preliminary design would be required once blasting operations encroach to within 289.5m of sensitive receptors surrounding the quarry extraction operations. Given the minimum separation distance to the closest sensitive receptor is in excess of 1km, the above blast design could be utilized over the life of the proposed licence. Furthermore, as a result of the advanced separation distance between blasting operations and sensitive receptors at this particular location, blast designs could be adjusted to employ significantly higher loads per delay in comparison to current designs employed at the existing licences. Vibration data will be continually collected and analyzed as part of the Compliance Monitoring Program as the sensitive receptors are approached in order to confirm the requirement for any design modifications.

Given the separation distances that will be involved with the proposed Milton Quarry East 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 developed through the October 2020 attenuation study and are based on a maximum intensity of 12.5mm/s:

Table 2: Maximum Loads 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)
1500	5100
1400	4440
1300	3830
1200	3250
1100	2740
1000	2260

It is noteworthy that the above values are typically conservative and are intended as a guideline only as the ground vibration attenuation equitation 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.

OVERPRESSURE LEVELS AT THE NEAREST SENSITIVE RECEPTOR

It is unusual for overpressure to reach damaging levels, and when it does, the evidence is 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 (dB)
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 are 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 overpressure characteristics at the specific operations of interest.

Based on the overpressure data collected from the October 2020 attenuation study, the values for “e” and “K” have been established at -0.123 and 222.3 respectively for receptors falling in front of the blast at the Milton Quarry East Extension site.

As discussed in previous sections, the MECP guideline for blast-induced overpressure is 128dBL. For a distance of 1146m (i.e. the standoff distance to the closest sensitive receptor for the initial Phase 1 blasting, (namely R15 – 10499 Nassagaweya Sixth Line) and a maximum explosive load of 190kg (114.3mm diameter hole, 18.6m hole depth, 3.0m surface collar and 1 hole per delay), we can calculate the maximum overpressure at the nearest receptor in front of the blast as follows:

$$P = 222.3\ (\frac{1146}{\sqrt[3]{190}})^{-0.123} = 115.90\ dB(L)$$

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.

Similarly, the above equation used to calculate PSPL can be reformatted to find an approximation of the distance at which an overpressure of 128 dB(L) would occur. If all blasting parameters are kept the same as the example above, a distance of 500m from the closest sensitive receptor in front of the blast would have a calculated overpressure of 128dB(L). Once again, the on-site monitoring program will accurately delineate the overpressure intensities and provide guidance for the timing for any design changes.

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)
1500	4800
1400	3900
1300	3100
1200	2450
1100	1850
1000	1400

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 ensure compliance with MECP NPC-119 guidelines. The hydrogeological study prepared as part of the licence application will address residential water wells in detail. The Natural Environment study prepared as part of the licence application will address fish habitat in detail. 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 and Forestry, Environment, Conservation and Parks 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:

$$L_H = \frac{V_o^{\,2} Sin2\theta_0}{g} \qquad [1]$$

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

For flyrock calculation purposes, we have applied the current blasting parameters used in the Milton Quarry which utilize 114.3mm (4.5”) diameter holes on a 4m x 4m (13’x 13’) pattern, with total depths of up to 20m (’) and a collar length of 3m (10’).

The range for the constant k is 13.5 for soft rocks and 27 for hard rocks. Given the proposed licence area is predominantly limestone, we have applied a k value of 21. The explosive density is assigned to be 1.2 g/cc for emulsion products and the drill hole angles are assumed to be 90 degrees (i.e. vertical).

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)
2.0	32	193
2.5	32	108
3.0	32	67
3.5	32	45
4.0	32	32

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.

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 distance to receptors and to ensure flyrock remains within the property limit.

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 ensure results could be readily extrapolated to all 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 vibrations 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 Milton Quarry East 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 Natural Environment study prepared for the application indicated that there was no direct fish habitat within the Natural Environment study area. The nearest location where fish are present are approximately 1.3km removed from the proposed extraction area. Based on this separation distance, water overpressures and ground vibration generated by the blasting will reside below the DFO 100kPa and 13mm/s guideline limit and will have no impact on the fish populations present.

REVIEW OF HISTORICAL MILTON QUARRY DATA

A vibration and overpressure monitoring program has been in place for all blasts conducted at the Milton Quarry in recent years. As part of this analysis, Explotech reviewed the vibration data collected from 2017 through 2020 inclusive. For continuity, the monthly vibration monitoring reports prepared by Explotech are included in Appendix C to this report.

2017-2020 DATA

Vibration monitoring conducted over the course of the 2017 – 2020 blasting campaigns have included the installation of seismographs at the following locations:

- 10664 Nassagaweya Esquesing Townline Road
- 10401 6th Line
- 6390 15 Sideroad
- 10366 Highway 25
- 10454 Highway 25

All vibration monitoring was performed by Explotech. A review of the data supplied confirms that for the four year period from 2017 through 2020 inclusive, all blasts remained compliant with the MECP guideline limit of 12.5mm/s for ground vibrations and air overpressure.

RECOMMENDATIONS

It is recommended that the following conditions be applied for all blasting operations at the proposed Milton Quarry East Extension:

1. All blasts shall be monitored for both ground vibration and overpressure by an independent Blast Consultant at the closest privately owned sensitive receptors adjacent the site, or at a location that is closer than a sensitive receptor, with a minimum of two (2) instruments – one installed in front of the blast and one installed behind the blast.

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

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

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

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

6. Blasting procedures such as drilling and loading shall be reviewed on a yearly basis and modified as required to ensure compliance with industry standards.

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

CONCLUSION

Blasting operations required for mineral extraction at the proposed Milton Quarry East Extension lands can be carried out safely and within governing guidelines set by the Ministry of the Environment, Conservation and Parks.

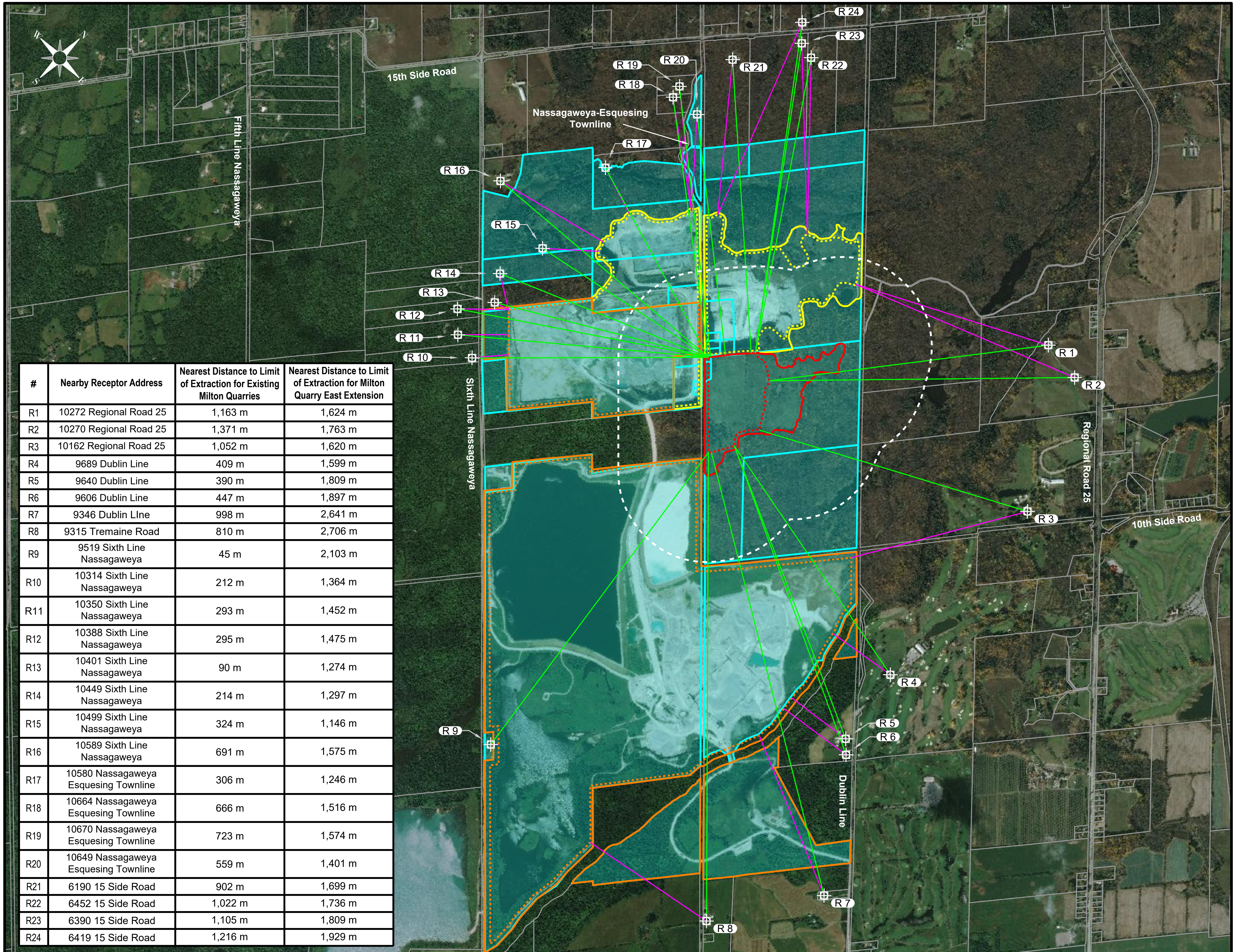
Modern blasting techniques will permit blasting to take place with explosives charges below allowable charge weights ensuring that blast vibrations and overpressure will remain minimal at the nearest receptors and compliant with applicable guideline limits.

Appendix A

Nearby Receptors

Milton Quarry East Extension

Part of Lots 11 and 12, Concession 1
(former Geographic Township of Esquesing)
Town of Halton Hills
Regional Municipality of Halton



#	Nearby Receptor Address	Nearest Distance to Limit of Extraction for Existing Milton Quarries	Nearest Distance to Limit of Extraction for Milton Quarry East Extension
R1	10272 Regional Road 25	1,163 m	1,624 m
R2	10270 Regional Road 25	1,371 m	1,763 m
R3	10162 Regional Road 25	1,052 m	1,620 m
R4	9689 Dublin Line	409 m	1,599 m
R5	9640 Dublin Line	390 m	1,809 m
R6	9606 Dublin Line	447 m	1,897 m
R7	9346 Dublin LIne	998 m	2,641 m
R8	9315 Tremaine Road	810 m	2,706 m
R9	9519 Sixth Line Nassagaweya	45 m	2,103 m
R10	10314 Sixth Line Nassagaweya	212 m	1,364 m
R11	10350 Sixth Line Nassagaweya	293 m	1,452 m
R12	10388 Sixth Line Nassagaweya	295 m	1,475 m
R13	10401 Sixth Line Nassagaweya	90 m	1,274 m
R14	10449 Sixth Line Nassagaweya	214 m	1,297 m
R15	10499 Sixth Line Nassagaweya	324 m	1,146 m
R16	10589 Sixth Line Nassagaweya	691 m	1,575 m
R17	10580 Nassagaweya Esquesing Townline	306 m	1,246 m
R18	10664 Nassagaweya Esquesing Townline	666 m	1,516 m
R19	10670 Nassagaweya Esquesing Townline	723 m	1,574 m
R20	10649 Nassagaweya Esquesing Townline	559 m	1,401 m
R21	6190 15 Side Road	902 m	1,699 m
R22	6452 15 Side Road	1,022 m	1,736 m
R23	6390 15 Side Road	1,105 m	1,809 m
R24	6419 15 Side Road	1,216 m	1,929 m

Legend

- Proposed Milton Quarry East Extension - Licence Boundary
- Proposed Milton Quarry East Extension - Limit of Extraction
- Milton Quarry (1962) - Licence Boundary
- Milton Quarry (1962) - Limit of Extraction
- Milton Quarry Extension (2007) - Licence Boundary
- Milton Quarry Extension (2007) - Limit of Extraction
- Land Owned by Dufferin
- 500m Offset from Proposed Milton Quarry East Extension (white)
- Existing Parcel Fabric
- Receptor's Nearest Distance to Limit of Extraction Existing Milton Quarries
- Receptor's Nearest Distance to Limit of Extraction Milton Quarry East Extension

Date: July 2021

Sources:
Microsoft Corporation Bing Imagery, date unknown
Licence boundaries and limits of extraction are from existing/proposed site plans
Parcel fabric from Municipal Property Assessment Corporation - Last updated prior to 2010

Scale - 1:20,000 ±

0 300 600 Meters

N:\Brian\9061DJ Dufferin - Milton Quarry East Extension\Drawings - Must be in NAD 27\Nearby Receptors\CAD\9061DJ - Nearby Receptors - July 2021.dwg

MHBC PLANNING URBAN DESIGN & LANDSCAPE ARCHITECTURE
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Appendix B

Milton Quarry East Extension

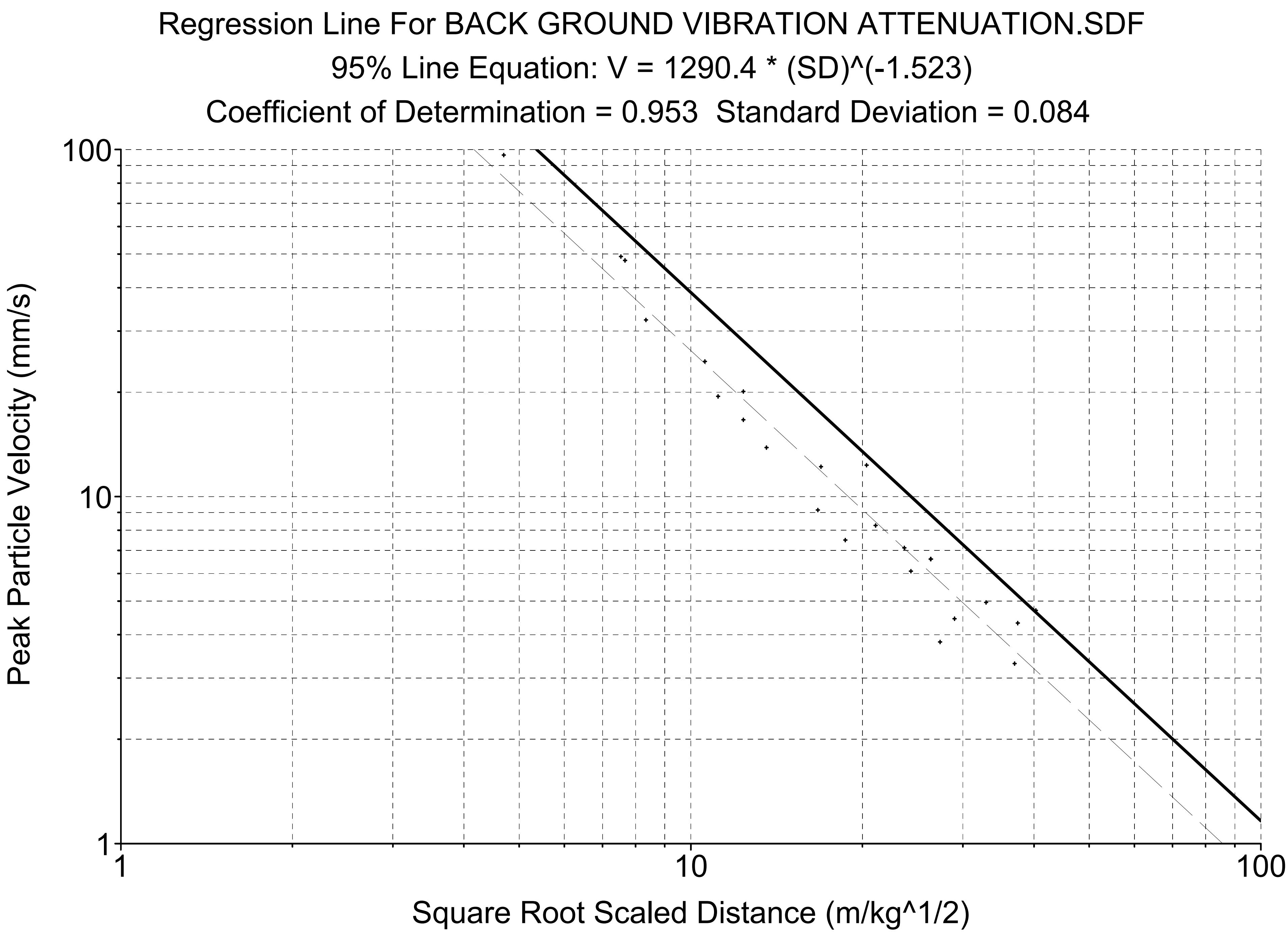
PREVAILING METEOROLOGICAL CONDITIONS

Medians provided by Environment Canada

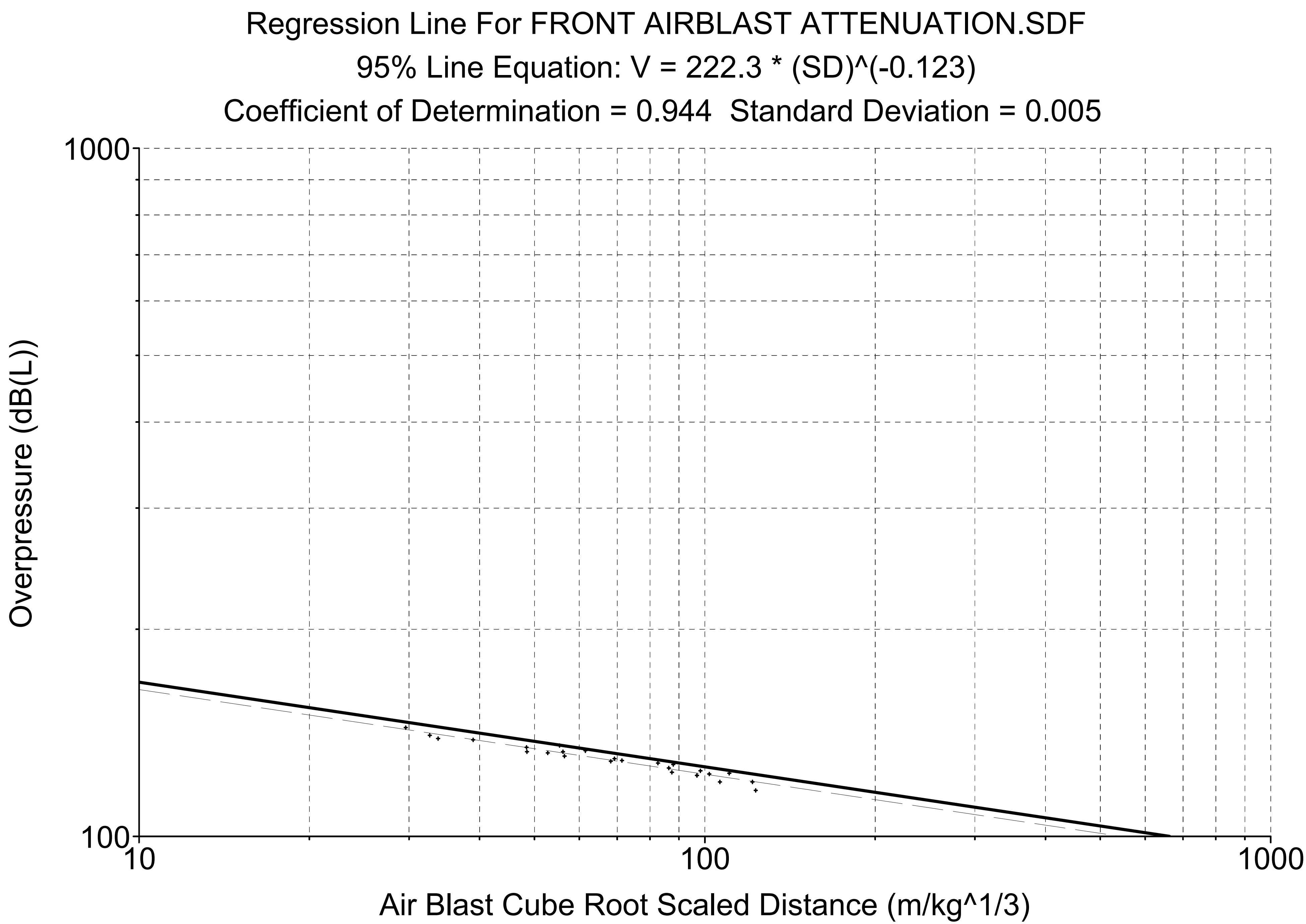
Date	Wind Direction	Wind Velocity Km/h	Temperature (Deg Celsius)
January	W	17.6	- 5.5
February	W	17.0	- 4.5
March	N	16.9	0.1
April	N	16.8	7.1
May	N	14.4	13.1
June	N	13.2	18.6
July	W	12.9	21.5
August	N	11.9	20.6
September	W	12.7	16.2
October	W	14.0	9.5
November	W	15.7	3.7
December	W	16.7	- 2.2

** Data is not available specifically for the proposed quarry location.
Nearest weather station is Toronto Pearson International Airport
** Data is based on averaged climate normals gathered 1981 – 2010.

Appendix C



Regression Line For BACK GROUND VIBRATION ATTENUATION.SDF
95% Line Equation: V = 1290.4 * (SD)^(-1.523)
Coefficient of Determination = 0.953 Standard Deviation = 0.084
Peak Particle Velocity (mm/s)
100
10
1
1
10
100
Square Root Scaled Distance (m/kg^1/2)



Regression Line For FRONT AIRBLAST ATTENUATION.SDF
95% Line Equation: V = 222.3 * (SD)^(-0.123)
Coefficient of Determination = 0.944 Standard Deviation = 0.005
1000
100
Overpressure (dB(L))
10
100
1000
Air Blast Cube Root Scaled Distance (m/kg^1/3)

Appendix D

Specialists in Explosives, Blasting and Vibration
Consulting Engineers

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
International Society of Explosives Engineers (ISEE)
Aggregate Producers Association of Ontario (APAO)
Surface Blaster Ontario Licence 450109

SUMMARY OF EXPERIENCE

Over thirty 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

Andrew Campbell, P.Eng.

Explotech Engineering Ltd.

EDUCATION

Bachelor of Engineering,
Mechanical Engineering, Carleton University

PROFESSIONAL AFFILIATIONS

Association of Professional Engineers of Ontario (APEO)
International Society of Explosive Engineers (ISEE)

SUMMARY OF EXPERIENCE

An engineer working for Explotech Engineering Ltd., Andrew holds a Bachelor of Engineering degree in Mechanical Engineering and has strong analytical, technical, and interpersonal skills. A proven leader in collaborative environments, Andrew is comfortable managing projects, specifying details, and communicating internally and externally. Recent focus on blast designs, blast impact analyses, vibration analysis, damage complaint investigation, blast monitoring, and job estimations.

PROFESSIONAL RECORD

2018 – Present	- Engineer, Explotech Engineering Ltd.
2013 – 2018	- Technician, Explotech Engineering Ltd.
2012 – 2012	- Ride Technician, Canada's Wonderland

Appendix E

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.

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

EXPLOTECH

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