Specialists in Explosives, Blasting and Vibration
Consulting Engineers

Blast Impact Analysis
Proposed Stittsville II Quarry Expansion
Part of Lots 14, 15, and 16, Concession 11
(Former Goulbourn Township)
City of Ottawa, Ontario

Submitted to:

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EXECUTIVE SUMMARY

Explotech Engineering Ltd. (Explotech) was retained in March 2022 to provide a Blast Impact Analysis for the proposed Stittsville II Quarry Extension located on Part of Lots 14, 15 and 16, Concession 11, (former Goulbourn Township), City of Ottawa, Ontario.

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.

Explotech undertook a vibration attenuation study at the existing Stittsville Quarry in April 2022. The resultant data was analyzed in order to develop site specific vibration attenuation characteristics and equations for the purpose of this blast impact analysis.

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

Tomlinson has applied for a Class A Licence for the property legally described as Part of Lots 14, 15 and 16, Concession 11, (former Goulbourn Township), City of Ottawa. The proposed name for the operation is the Stittsville II Quarry 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 vibration monitoring program be continued on the existing licensed site as well as on the proposed Stittsville II Quarry 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 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.

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 existing licensed area for the Stittsville Quarry (Licence 39958) is described as part of Lots 14 and 15, Concession 11, (former Goulbourn Township), Regional Municipality of Ottawa-Carleton. This property is bound by Jinkinson Road to the North and West, the existing Lafarge Bell Quarry to the South and vacant forested and wetlands to the East. The lands surrounding the licence are sparsely populated with the areas of closest and densest development lying to the South / Southeast.

The licenced area for the proposed Stittsville II Quarry Extension lands encompasses a total area of approximately 121.7HA. The associated extraction area is approximately 108.7HA when allowing for setbacks and sterilized areas.

The proposed Stittsville II Quarry Extension is located immediately East of the existing licence described as Part of Lots 14, 15 and 16, Concession 11, (former Goulbourn Township), City of Ottawa. The extension lands are bound by Jinkinson Road to the North, the existing Tomlinson Stittsville Quarry and Lafarge Bell Quarry to the West, the Trans Canada Trail to the South and vacant forested and wetlands to the East. The lands surrounding the licence are sparsely populated with the areas of closest and densest development lying to the North. The closest sensitive receptors surrounding the proposed limit of extraction are listed in Table 1 below as well as in the Sensitive Receptor Overview contained in Appendix A:

Sensitive Receptor Address	Sensitive Receptor or Non Sensitive Receptor	Distance to Receptor (m)	Direction from Extraction Limits
27 Spruce Ridge Road	Sensitive	415	North
31 Spruce Ridge Road	Sensitive	450	North
37 Spruce Ridge Road	Sensitive	510	North
2001 Speedway Road	Non Sensitive	430	Northwest
557 Jinkinson Road	Non Sensitive	290	Northeast
495 Jinkinson Road	Non Sensitive	420	Northeast
423 Jinkinson Road	Sensitive	740	Northeast
385 Jinkinson Road	Sensitive	820	Northeast
7265 Fernbank Road	Sensitive	920	Southeast

Table 1: Closest Sensitive Receptors

PROPOSED AGGREGATE EXTRACTION

As per the Operational Plan (Refer to Appendix A), the proposed initial quarry operations will commence at the Western face of the proposed extension licence extraction limit (located Southwest of the existing Tomlinson Asphalt Plant) and retreat Southeasterly across the extension lands until the extraction limits of Phase 1 are reached. This will eliminate the need for a sinking cut and provide the maximum distance separation to neighbouring receptors. Phase 1 will be extracted in 2 – 3 benches to a depth ranging from 113masl – 115masl given existing topography in Phase 1 of 141masl - 143masl.

Phase 2 is located Southeast of Phase 1 and will be extracted Southeasterly until the extraction limits of Phase 2 are reached. Extraction of Phase 2 will utilize the Southeastern face of Phase 1 and will be extracted in 2 – 3 benches to a depth ranging from 114masl – 119masl given existing topography in Phase 2 of 141masl - 144masl.

Phase 3 is located Southeast of Phase 2 and will be extracted Southeasterly until the extraction limits of Phase 3 are reached. Extraction of Phase 3 will utilize the Southeastern face of Phase 2 and will be extracted in 2 – 3 benches to a depth ranging from 117masl – 122masl given existing topography in Phase 3 of 138masl - 144masl.

Phase 4 is located Northeast of Phase 1 and will be extracted Northeasterly until the extraction limits of Phase 4 are reached. Extraction of Phase 4 will utilize the Northeastern face of Phase 1 and will be extracted in 2 – 3 benches to a depth ranging from 107masl – 111masl given existing topography in Phase 4 of 136masl - 140masl.

Phase 5 is located Southeast of Phase 4 and Northeast of Phase 2. It will be extracted Southeasterly until the extraction limits of Phase 5 are reached. Extraction of Phase 5 will utilize the Southeastern and Northeastern faces of Phase 4 and Phase 2 respectively and will be extracted in 2 – 3 benches to a depth ranging from 109masl – 113masl given existing topography in Phase 5 of 136masl - 139masl.

Phase 6 is located Southeast of Phase 5 and Northeast of Phase 3. It will be extracted Southeasterly until the extraction limits of Phase 6 are reached. Extraction of Phase 6 will utilize the Southeastern and Northeastern faces of Phase 5 and Phase 3 respectively and will be extracted in 2 – 3 benches to a depth ranging from 111masl – 114masl given existing topography in Phase 5 of 135masl - 136masl.

Phase 7 is located North of Phase 1 and Northwest of Phase 4. It will be extracted Northwesterly until the extraction limits of Phase 7 are reached. Extraction of Phase 7 will require the relocation of the asphalt plant and will only take place when extraction of aggregate is required. Extraction of Phase 7 will utilize the Northern and Northwestern faces of Phase 1 and Phase 4 respectively and will be extracted in 2 – 3 benches to a depth ranging from 102masl – 111masl given existing topography in Phase 7 of 136masl - 141masl.

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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(L) 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 in front of the blast, or closer, and one installed at the closest sensitive receptor behind the blast, or closer.

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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 through the air, measured in decibels (or dB(L)) 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 three (3) blasts conducted in April 2022 at the existing Stittsville Quarry in Ottawa, 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 2022 attenuation study, the values for “e” and “K” have been established at -1.582 and 3029.3 respectively for receptors falling behind the blast at the Stittsville II Quarry Extension site.

For a distance of 880m (the standoff distance to the closest sensitive receptor to the initial blasting operations, namely 27 Spruce Ridge Road), and a maximum explosive load per delay of 72.3kg (95mm diameter hole, 10.0m deep, 1.5m surface collar and 1 hole per delay), we can calculate the maximum PPV as follows:

$$PPV = 3029.3\ (\frac{880}{\sqrt{72.3}})^{-1.582} = 1.97mm/s$$

As discussed in previous sections of this report, the MECP guideline for blast-induced vibration is 12.5mm/s. The calculated 95% predicted PPV (based on a standoff distance to the closest sensitive receptor for the initial blasting) would be 1.97mm/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:

$$12.5 = 3029.3\ (\frac{d}{\sqrt{72.3}})^{-1.582} = 273.4m$$

The above result suggests that design modifications to the above preliminary design would be required once blasting operations encroach to within 273m of sensitive receptors surrounding the quarry extraction operations. Fortunately, 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. An abundance of design modifications are available which would readily maintain vibration intensities below guideline limits.

Given the separation distances that will be involved with the Stittsville II 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 developed through the 2022 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)**
1000	967
900	783
800	619
700	473
600	348
500	241
400	154
300	87
200	38

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.

The closest separation distance between a sensitive receptor and the extraction limits of the license is 415m. As per the current example blast designed contained herein, changes in blasting designs would not be required to achieve compliance. The compliance monitoring program will still confirm all blasts are within MECP guidelines when blasting at the Stittsville II Quarry Extension.

Similar to the paragraph above, the closest separation distance between a non-sensitive receptor (namely, 557 Jinkinson Road) and the extraction limits of the license is 290m. Using the above equation and keeping the same blasting parameters with a suggested limit of 50mm/s, the calculation would suggest that once blasting encroaches to 114m removed from 557 Jinkinson Road, modifications may be required. As this distance is less than 290m, modifications would not be required. Again, the compliance monitoring program will still confirm vibration levels in the area when blasting at the Stittsville II Quarry Extension.

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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 6dB(L) 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(L))
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 2022 attenuation study, the values for “e” and “K” have been established at -0.095 and 204.6 respectively for receptors falling in front of the blast at the Stittsville II Quarry Extension site.

As discussed in previous sections, the MECP guideline for blast-induced overpressure is 128dB(L). For a distance of 3235m (i.e. the standoff distance to the closest sensitive receptor in front of the initial blast, namely 60 Links Drive), and a maximum explosive load of 73.2kg (95mm diameter hole, 10.0m deep, 1.5m surface collar and 1 hole per delay), we can calculate the maximum overpressure at the nearest receptor in front of the blast as follows:

$$P = 204.6\left(\frac{3235}{\sqrt[3]{73.2}}\right)^{-0.095} = 108.77\ dB(L)$$

Additionally, we have calculated the maximum overpressure at the closest sensitive receptor to the initial blasting operations regardless of direction. For a distance of 880m (27 Spruce Ridge Road), and a maximum explosive load of 73.2kg, we can calculate the maximum overpressure as follows:

$$P = 204.6\left(\frac{880}{\sqrt[3]{73.2}}\right)^{-0.095} = 123.09\ dB(L)$$

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 585m 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)**
900	269
800	189
700	126
600	80
500	46
400	23.5
300	10
200	2.8

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. Considerations for the TC Energy Pipeline and Enbridge Pipeline can be expanded upon under separate cover with direct input from the owners as required. The hydrogeological study prepared as part of the licence application will address residential water wells 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. Considerations for aquatic species in the adjacent watercourses are further addressed in the WSP report.

TC ENERGY HIGH PRESSURE NATURAL GAS PIPELINE

A TC Energy High Pressure Natural Gas Pipeline runs parallel to the Northeast extraction limit of the proposed quarry extension limits (refer to Appendix A). The MECP guideline for blast-induced vibration (12.5mm/s) does not apply to pipelines as they are not classified as sensitive receptors. TC Energy Policy employs a 50mm/s vibration limit for welded steel pipelines. Based on the proposed Operations Plan for the Stittsville II Quarry extension, initial blasting operations are anticipated to be required approximately 1260m from the subject pipeline, however, will reach as close as 610m throughout the course of extraction. As a sensitive receptor, namely 423 Jinkinson Road, lies in close proximity to the TC energy pipeline, the MECP vibration limit for sensitive receptors (12.5mm/s) will govern for vibrations and thus, the vibrations will be further reduced than the 50mm/s limit described above at the TC Energy right of way (ROW).

Applying the specific site attenuation equation, for a distance of 1260m (the conservative standoff distance to the pipeline for the initial blasting and a maximum explosives load per delay of 73.2kg (95mm diameter hole, 10m deep, 1.5m surface collar and 1 hole per delay), we can calculate the maximum PPV at the pipeline as follows for the initial blast:

$$ppv = 3029.3\left(\frac{1260}{\sqrt{73.2}}\right)^{-1.582} = 0.76mm/s$$

The calculated 95% predicted PPV (based on the proposed blasting data discussed above) would be 0.76mm/s, well below the TC Energy limit of 50mm/s for a steel welded pipeline located adjacent to the proposed quarry. 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.

ENBRIDGE PIPELINE

An Enbridge Pipeline runs adjacent to Jinkinson Road located North of the Northwestern proposed extraction limits of Phase 4 (refer to Appendix A). The MECP guideline for blast-induced vibration (12.5mm/s) does not apply to pipelines as they are not classified as sensitive receptors. Enbridge also employs a 50mm/s vibration limit for pipelines. Based on the proposed Operations Plan for the Stittsville II Quarry extension, initial blasting operations are anticipated to be required approximately 260m from the subject pipeline, however, will reach as close as 50m throughout the course of extraction adjacent Phase 4.

Applying the specific site attenuation equation, for a distance of 260m (the conservative standoff distance to the pipeline for the initial blasting and a maximum explosives load per delay of 73.2kg (95mm diameter hole, 10m deep, 1.5m surface collar and 1 hole per delay), we can calculate the maximum PPV at the pipeline as follows for the initial blast:

$$ppv = 3029.3\left(\frac{260}{\sqrt{73.2}}\right)^{-1.582} = 5.79mm/s$$

The calculated 95% predicted PPV (based on the proposed blasting data discussed above) would be 5.79mm/s, well below the Enbridge limit of 50mm/s for a pipeline located adjacent to the proposed quarry extension. While this initial value resides below the required threshold, it is anticipated that design modifications will be necessary to maintain compliance as the separation distance to the pipeline 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.

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 Stittsville Quarry which utilize 95mm (3 ¾”) diameter holes on a 2.7m x 3.7m (9’x 12’) pattern, with total depths of up to 10m (33’) and a varied collar length.

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 23. 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)
1.5	64	306
2.0	64	145
2.5	64	81
3.0	64	50
3.5	64	34
4.0	64	24

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. However, 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, operations at the Stittsville II Quarry Extension should induce no permanent adverse impacts on the residential water wells on properties surrounding the site with the assumption that the well is in close proximity to the residence (ie similar distance or further removed from the blasting operations as the residence).

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.

As noted by WSP (2023), the Goulbourn Wetland Complex PSW (shown in the image below) represents fish habitat, including potential spawning habitat. WSP (2023) identified the areas of potential spawning in close proximity to the proposed extraction.

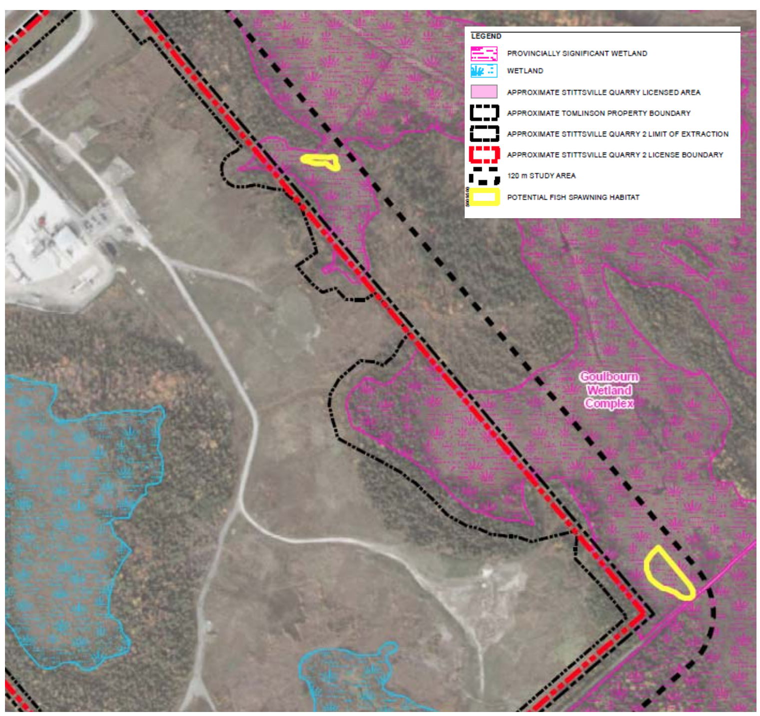


Plate 1 – Location of Goulbourn Wetland Complex PSW and Fish Spawning Habitat in Relation to the Proposed Stittsville Quarry 2

As the Goulbourn Wetland Complex PSW contains fish habitat, it is subject to the DFO overpressure limit of 100kPa. Based on the separation distances provided (30m at the closest point from extraction to the wetland boundary), water overpressures generated by the blasting will need to be designed to remain below the DFO 100kPa guideline limit to ensure no impact on the fish populations present. The table below is taken from the Guidelines for the Use of Explosives In or Near Canadian Fisheries Waters (1998) and provides criteria to be used when designing a blast based on the setback distance from the center of detonation of a confined explosive to achieve 100kPa at the fish habitat for various substrates.

Substrate Type	Weight of Explosive Charge (kg)							
	0.5	1	2	5	10	25	50	100
Rock	3.6	5.0	7.1	11.0	15.9	25.0	35.6	50.3
Frozen Soil	3.3	4.7	6.5	10.4	14.7	23.2	32.9	46.5
Ice	3.0	4.2	5.9	9.3	13.2	20.9	29.5	41.8
Saturated Soil	3.0	4.2	5.9	9.3	13.2	20.9	29.5	41.8
Unsaturated Soil	2.0	2.9	4.1	6.5	9.2	14.5	20.5	29.0

Table 5: Setback Distance (m) from the Centre of Detonation of a Confined Explosive to Fish Habitat to Achieve 100kPa Guideline Criteria for Various Substrates

The above table is to be used as a guideline for designing blasts adjacent to the fish habitat present in the wetland. As a recommendation of this report, the water overpressure shall be measured with a hydrophone at the nearest fish habitat when the blasting begins to encroach within 100m. The results shall then be reviewed by a qualified engineering firm in order to confirm compliance with the DFO 100kPa guideline limit, and additionally determine whether a hydrophone monitoring program is required for subsequent blasts.

The potential spawning habitat is subject to the DFO vibration limit of 13mm/s while spawning is active, which has been noted by WSP as March 15th to July 15th. Vibration monitoring will be required at the edge of the wetland adjacent to the potential spawning habitat, or closer to the blast, in order to ensure compliance with DFO limits for ground vibration. Vibration monitors should be installed when the estimated vibrations at the fish spawning habitat exceed a 50% threshold of the DFO 13mm/s guideline limit (6.5mm/s).

Table 6 below is presented as an initial guide 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 spawning bed:

Separation distance between possible spawning bed and closest borehole (meters)	Maximum recommended explosive load per delay (Kilograms)
400	162
350	124
300	91
250	63
200	40
150	22
100	10
75	5
50	2.5

Table 6: Maximum Loads per Delay to Maintain 13.0mm/s at Various Separation Distances

REVIEW OF HISTORICAL STITTSVILLE QUARRY DATA

A vibration and overpressure monitoring program has been in place for all blasts conducted at the Stittsville Quarry in recent years. As part of this analysis, Explotech has reviewed the vibration data collected from 2019 through 2022 inclusive. For continuity, summaries of the historical data collected and supplied by Tomlinson are included in Appendix C to this report.

2019-2022 DATA

Vibration monitoring conducted by Tomlinson over the course of the 2019 – 2022 blasting campaigns have included the installation of seismographs at the following location:

- Tomlinson Stittsville Quarry Scale House (coordinates: 45.2384, -75.979)

A review of the Tomlinson data supplied confirms that for the four-year period from 2019 through 2022 inclusive, all blasts remained compliant with the MECP guideline limit of 12.5mm/s and 128dB(L) for ground vibrations and overpressures respectively for sensitive receptors with the consideration that the monitor location (scale house) is much closer than any sensitive receptor.

RECOMMENDATIONS

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

1. 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.

2. Blasts shall be designed to maintain vibrations at the TC Energy pipeline below 50mm/s or any such document, regulation or corporate policy in effect at the time. When vibration calculations suggest vibrations at the pipeline may exceed 35mm/s, the pipeline shall be monitored for ground vibration.

3. Blasts shall be designed to maintain vibrations at the Enbridge pipeline below 50mm/s or any such document, regulation or corporate policy in effect at the time. When vibration calculations suggest vibrations at the pipeline may exceed 35mm/s, the pipeline shall be monitored for ground vibration.

4. Blasts shall be designed to maintain water overpressure below 100kPa at the location of the closest fish habitat as per DFO guidelines. While blasting encroaches within 100m of the fish habitat, water overpressure monitoring will be conducted. The results will be reviewed by a qualified engineering firm and confirm compliance with the 100kPa guideline limit, and determine whether additional hydrophone monitoring is required.

5. 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 (March 15 to July 15), a minimum of one supplemental vibration monitor shall be installed on the shoreline closest to the spawning bed to confirm the vibration levels.

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

7. Blasts shall be designed to maintain vibrations at the closest non-sensitive receptors below 50mm/s. When vibration calculations suggest vibrations

may exceed 35mm/s, the buildings shall be monitored for ground vibration.

8. 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.

9. 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.

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

11. 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 current applicable guidelines and regulations.

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

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

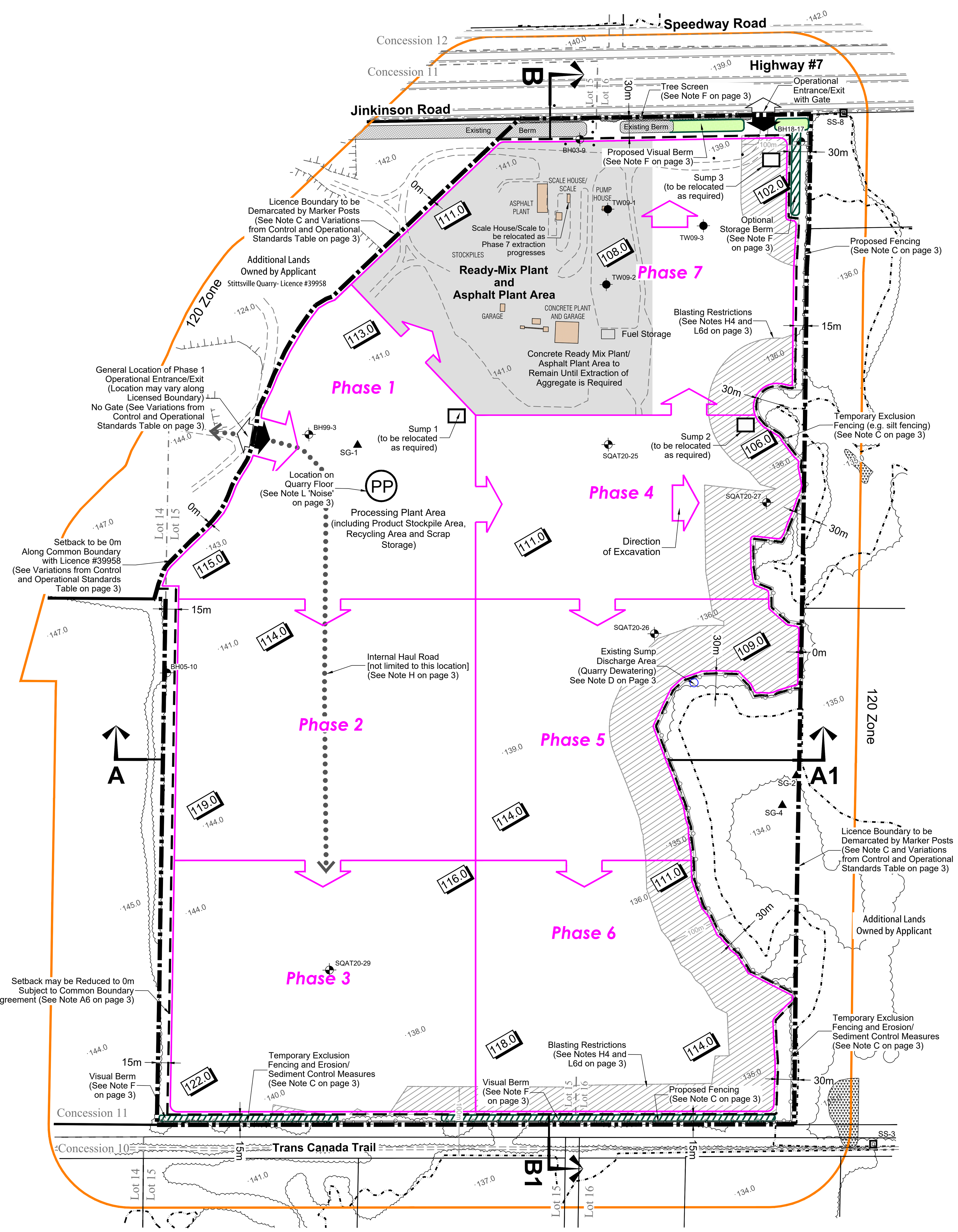
CONCLUSION

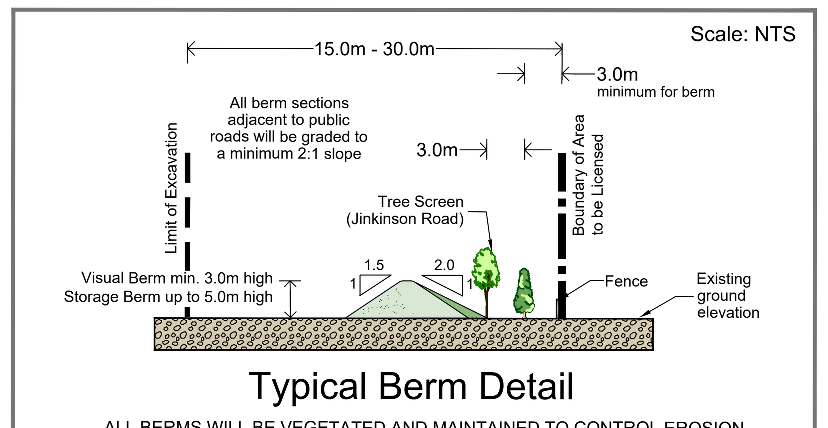
Blasting operations required for mineral extraction at the proposed Stittsville II Quarry Extension lands can be carried out safely and within governing guidelines set by the Ministry of the Environment, Conservation and Parks.

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

SEQUENCE OF OPERATIONS



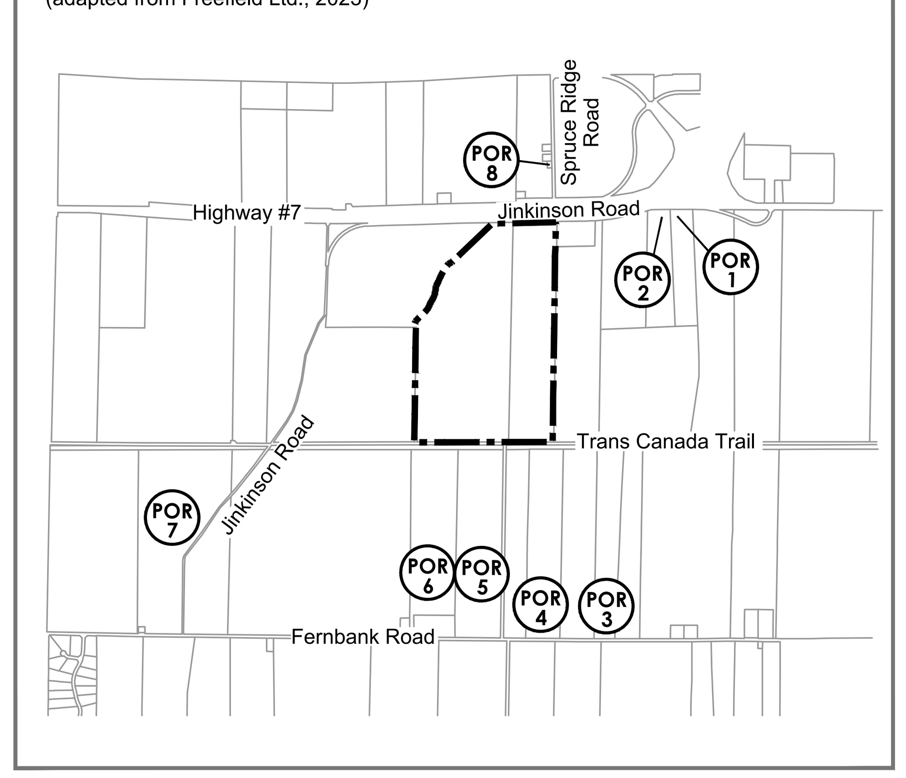


Typical Berm Detail

ALL BERMS WILL BE VEGETATED AND MAINTAINED TO CONTROL EROSION

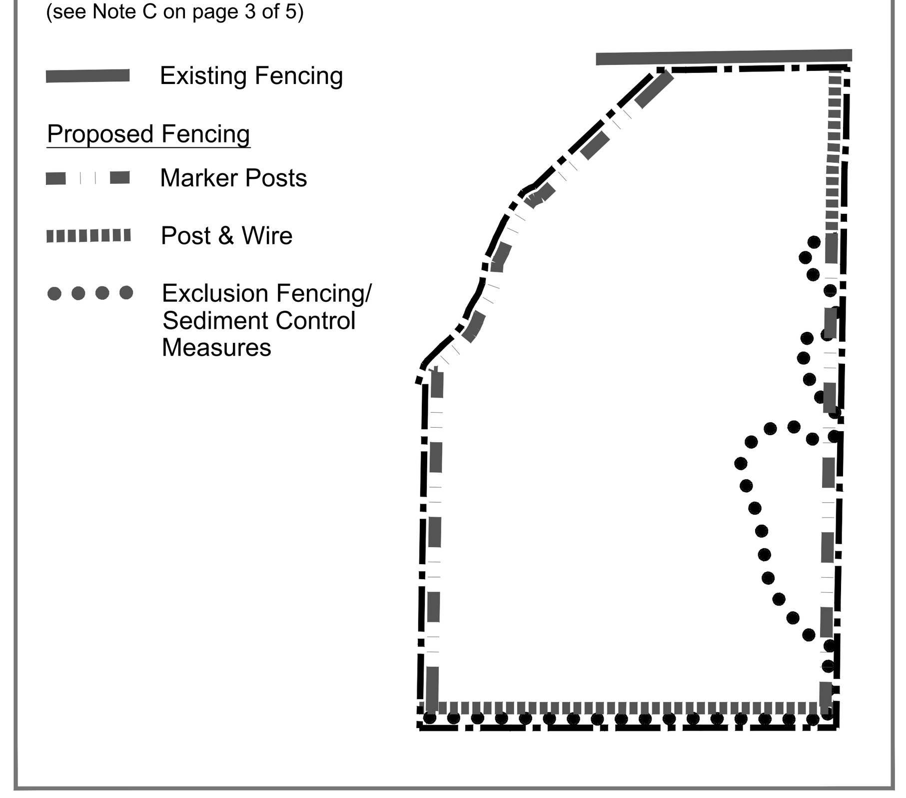
Receptor Locations

(adapted from Freefield Ltd., 2023)



Fencing Detail

(see Note C on page 3 of 5)



Phase Notes:

A. Phase 1
1. Site preparation in Phase 1 to include: establishing fencing/marker posts around the licensed boundary prior to extraction (subject to overrides); temporary turtle exclusion fencing (e.g. silt fencing) shall be installed along the western, eastern and southern portions of the limit of extraction where it abuts natural areas prior to site clearing; removal of vegetation within 5m of limit of extraction where applicable; initial stripping of overburden/topsoil and construct visual berms along Jinkinson Road as shown on Sequence of Operations drawing.
2. Continue with stripping of overburden as shown. Store any excess material in berms.
3. Locate quarry sump and sump outlet to capture and redistribute accumulated water.
4. Construct tree screen in the locations shown on Sequence of Operations.
5. Begin Phase 1 extraction in an easterly direction and to the elevations (maximum depth of extraction) as shown (see Note F on page 3).
6. Phase 1 may be extracted to a maximum depth of 115.0 masl (west portion of Phase) to 107.0 masl (east portion of Phase).
7. Processing for Phase 1 will initially occur in the existing Licence #39958 or when sufficient room is available in this site.
8. Progressive rehabilitation along the east limit of this Phase (1st Lift) may be initiated once the extent of extraction has occurred in this area. Rehabilitation will consist of backfilling of the quarry face to the bench of the next lift.
9. Prepare Phase 2 for extraction

B. Phase 2
1. Strip overburden/topsoil. Store any excess material in berms in areas within the limit of extraction.
2. Commence extraction in a southerly direction and to the elevations (maximum depth of extraction) as shown.
3. Phase 2 may be extracted to a maximum depth of 119.0 masl (southwest portion of Phase) to 113.0 masl (northeast portion of Phase).
4. Progressive rehabilitation along the west limit and a portion of the east limit of this Phase (1st Lift) may be initiated once the extent of extraction has occurred in this area. Rehabilitation will consist of backfilling of the quarry face to the bench of the next lift.
5. Prepare Phase 3 for extraction.

C. Phase 3
1. Continue with stripping of overburden/topsoil following the direction of excavation. Store any excess material in berms.
2. Construct visual berm along south boundary of property with strippings.
3. Begin Phase 3 extraction in an southerly direction and to the elevations (maximum depth of extraction) as shown.
4. Phase 3 may be extracted to a maximum depth of 122.0 masl (southwest portion of Phase) to 116.0 masl (northeast portion of Phase).
5. Initiate progressive rehabilitation along the west and east limit of this Phase (1st Lift) once the extent of extraction has progressed to allow for side slope rehabilitation. Progressive rehabilitation will consist of backfilling of the quarry face to the bench of the next lift.
6. Continue with progressive rehabilitation in Phase 2.
7. Prepare Phase 4 for extraction.

D. Phase 4
1. Strip overburden/topsoil. Store any excess material in berms or use in progressive rehabilitation of previous Phase(s).
2. Commence extraction in an easterly direction and to the elevations (maximum depth of extraction) as shown.
3. Phase 4 may be extracted to a maximum depth of 111.0 masl (west portion of Phase) to 106.0 masl (east portion of Phase).
4. Progressive rehabilitation along the east limit of this Phase (1st Lift) may be initiated once the extent of extraction has occurred in this area. Rehabilitation will consist of backfilling of the quarry face to the bench of the next lift.
5. Continue with progressive rehabilitation in Phase 3.
6. Sump may be relocated from Phase 1 to this Phase once sufficient room is available.
7. Prepare Phase 5 for extraction.

E. Phase 5
1. Strip overburden/topsoil. Store any excess material in berms or use in progressive rehabilitation of previous Phase(s).
2. The direction of extraction will be southerly.
3. Extraction may occur to a maximum depth of 114.0 masl in the southwest portion of the Phase to 109.0 masl in the northeast portion of the Phase.
4. Progressive rehabilitation along the east limit of this Phase (1st Lift) may be initiated once the extent of extraction has occurred in this area. Rehabilitation will consist of backfilling of the quarry face to the bench of the next lift.
5. Continue with progressive rehabilitation in Phase 4.
6. Prepare Phase 6 for extraction.

F. Phase 6
1. Strip overburden/topsoil. Store any excess material in berms or use in progressive rehabilitation of previous Phase(s).
2. The direction of extraction will be southerly.
3. Extraction may occur to a maximum depth of 118.0 masl in the southwest portion of the Phase to 111.0 masl in the northeast portion of the Phase.
4. Progressive rehabilitation along the east limit of this Phase (1st Lift) may be initiated once the extent of extraction has occurred in this area. Rehabilitation will consist of backfilling of the quarry face to the bench of the next lift.
5. Continue with progressive rehabilitation in Phase 5.
6. Prepare Phase 7 for extraction.

G. Phase 7
1. Initiate stripping of overburden/topsoil. Store any excess material in berms or use in progressive rehabilitation of previous Phase(s).
2. Buildings/Plants and associated infrastructure to be relocated as extraction progresses within Phase 7.
3. Sump may be relocated from Phase 4 to this Phase once sufficient room is available.
4. Continue with progressive rehabilitation in Phase 6.

H. Not Shown on Sequence of Operations
1. The concrete ready mix plant, asphalt plant and associated structures will remain on site until the encroachment of extraction in Phase 7 requires the removal of the plants.
2. Remove any equipment, scrap, haul roads and buildings on site.
3. Finalize rehabilitation of site (see Rehabilitation Plan on page 4 for details).

Legal Description

PART OF LOTS 14, 15 and 16
CONCESSION 11
(geographic township of Goulbourn)
CITY OF OTTAWA

Legend

- Boundary of Area to be Licensed
- Limit of Excavation — ALL SETBACKS ARE DRAWN TO SCALE AND SHOW LABELLED DISTANCES
- Existing Fence — PAGE WIRE FENCE UNLESS OTHERWISE NOTED
- Existing Licensed Boundary
- Building/Structure — LOCATION AND USE FOR BUILDINGS ON-SITE AND WITHIN 120m ARE SHOWN ON THIS PAGE
- Drainage Feature — AS LABELLED
- Existing Spot Elevation — METRES ABOVE SEA LEVEL
- General Direction of Excavation — (SEE NOTES ON THIS PAGE)
- Operational Access — MAINTAINED BY A GATE WHICH WILL BE CLOSED WHEN PIT IS NOT IN OPERATION
- Visual Berm — SEE "TYPICAL BERM DETAIL" AND NOTES ON THIS PAGE/PAGE 3 OF 5
- Existing Vegetation
- Optional Storage Berm — SEE "TYPICAL BERM DETAIL" AND NOTES ON THIS PAGE/PAGE 3 OF 5
- Provincially Significant Wetland — (WSP/ONTARIO GEOHUB)
- Proposed Fence — 1.2m HIGH POST & WIRE FENCE UNLESS OTHERWISE NOTED
- Monitoring Well Locations (BH18-17) / Borehole Locations (TW09-2) / Surface Water or Effluent Monitor Locations (SS-3) / Staff Gauge (SG-4) — (WSP)
- Sediment/Erosion Control Measures
- Tree Screen
- Existing Berm
- Proposed Spot Elevation — QUARRY FLOOR (METRES ABOVE SEA LEVEL) BOTTOM OF BOBCAYGEON FORMATION
- Potential Fish Spawning Habitat — (WSP)
- Internal Haul Road — LOCATION TO VARY AS OPERATIONS PROGRESS
- Blasting Restrictions — SEE NOTES ON PAGE 3 OF 5 (EXPLOTECH)
- Cross Sections — SEE PAGE 5 OF 5 FOR EXISTING AND REHABILITATED CROSS SECTIONS

Site Plan Amendments

No.	Date	Description	By

MHBC PLANNING URBAN DESIGN & LANDSCAPE ARCHITECTURE
200 - 540 BINGEMANS CENTRE DR. KITCHENER, ON. N2B 3X9 | P: 519.576.3650 F: 519.576.0121 | WWW.MHBCPLAN.COM

MNRF Approval Stamp

Stamp

DRAFT

north

Applicant

TOMLINSON
R. W. Tomlinson Limited
100 CitiGate Drive, Ottawa Ontario, K2J 6K7
Tel: (613) 822-1867 Fax: (613) 822-6844

DRAFT
Rob Pierce
R.W. Tomlinson Limited
Vice President Planning and Development

Project

Stittsville 2 Quarry

ARA Licence Reference No.

Pre-approval review:

For submission to MNRF October 2023

Plan Scale **1:4,000 (Arch D)**

SCALE

50 0 100 200
METRES

Plot Scale 1:4 [1mm = 4 units] MODEL

Drawn By D.G.S./GC

File No. **9137AI**

Checked By N.D.

File Name

OPERATIONAL PLAN

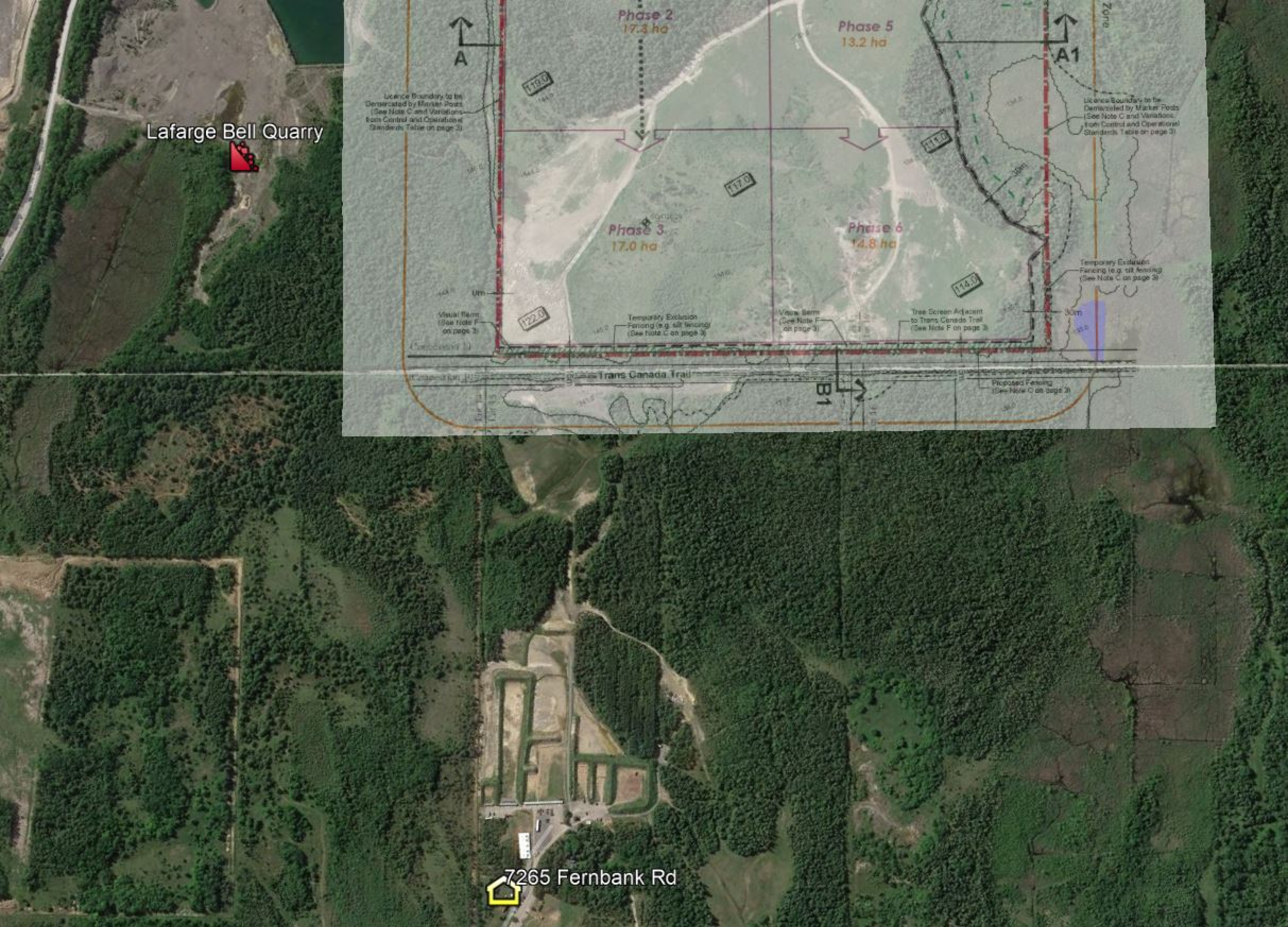
Drawing No.

2 OF 5

K:\9137AI-Tomlinson-Stittsville Quarry 2\A\Operplan 2of5 October2023.dwg


37 Spruce Ridge Rd
31 Spruce Ridge Rd
27 Spruce Ridge Rd
2001 Speedway Rd
SEQUENCE OF OPERATIONS
423 Jinkinson Rd
385 Jinkinson Rd
495 Jinkinson Rd
557 Jinkinson Rd
Cavanagh Henderson Quarry
Lafarge Bell Quarry
7265 Fernbank Rd
36
7


SEQUENCE OF OPERATIONS
Spruce Ridge Rd
37 Spruce Ridge Rd
31 Spruce Ridge Rd
27 Spruce Ridge Rd
2001 Speedway Rd
Speedway Rd
Speedway Rd
Speedway Road
Highway #7
Hwy 7
Trans Canada Hwy
Jinkinson Rd
Jinkinson Rd
Jinkinson Rd
423 Jinkinson Rd
385 Jinkinson Rd
557 Jinkinson Rd
495 Jinkinson Rd
7
36
Ready-Mix Plant
and
Asphalt Plant Area
Phase 7
21.9 ha
Phase 1
120 Zone



Lafarge Bell Quarry
Phase 2
17.3 ha
Phase 5
13.2 ha
Phase 3
17.0 ha
Phase 6
14.8 ha
A
A1
B1
Trans Canada Trail
7265 Fernbank Rd

Appendix B

Stittsville II Quarry

PREVAILING METEOROLOGICAL CONDITIONS

Medians provided by Environment Canada
Canadian Climate Normals 1981-2010
Ottawa MacDonald-Cartier – International Airport

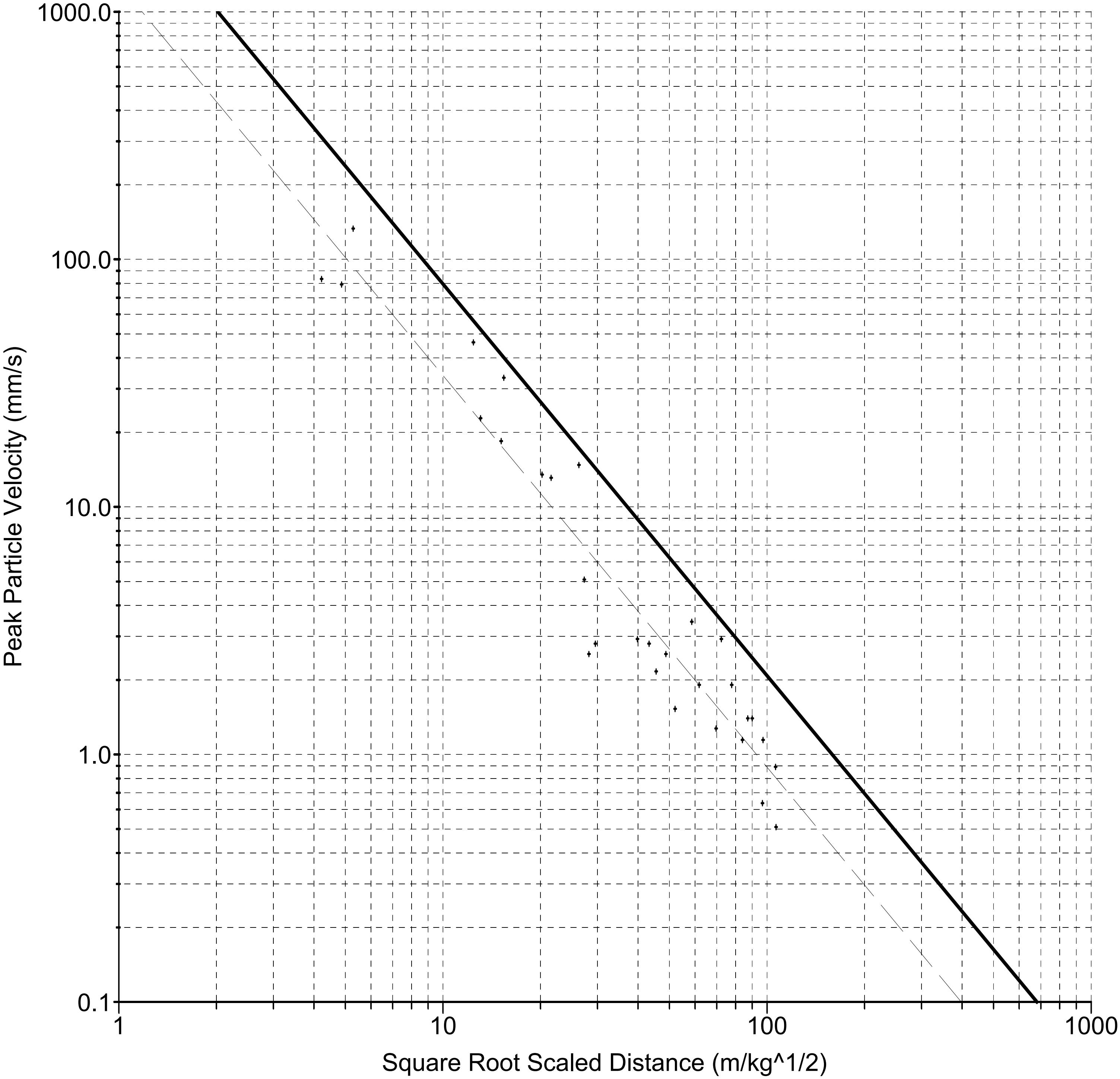
Date	Wind Direction	Max Hourly Wind Velocity Km/h	Temperature (Deg Celsius)
January	W	72	-10.3
February	W	72	-8.1
March	W	72	-2.3
April	E	67	6.3
May	W	64	13.3
June	W	67	18.5
July	W	54	21.0
August	SW	69	19.8
September	S	64	15.0
October	W	80	8.0
November	W	66	1.5
December	W	61	-6.2

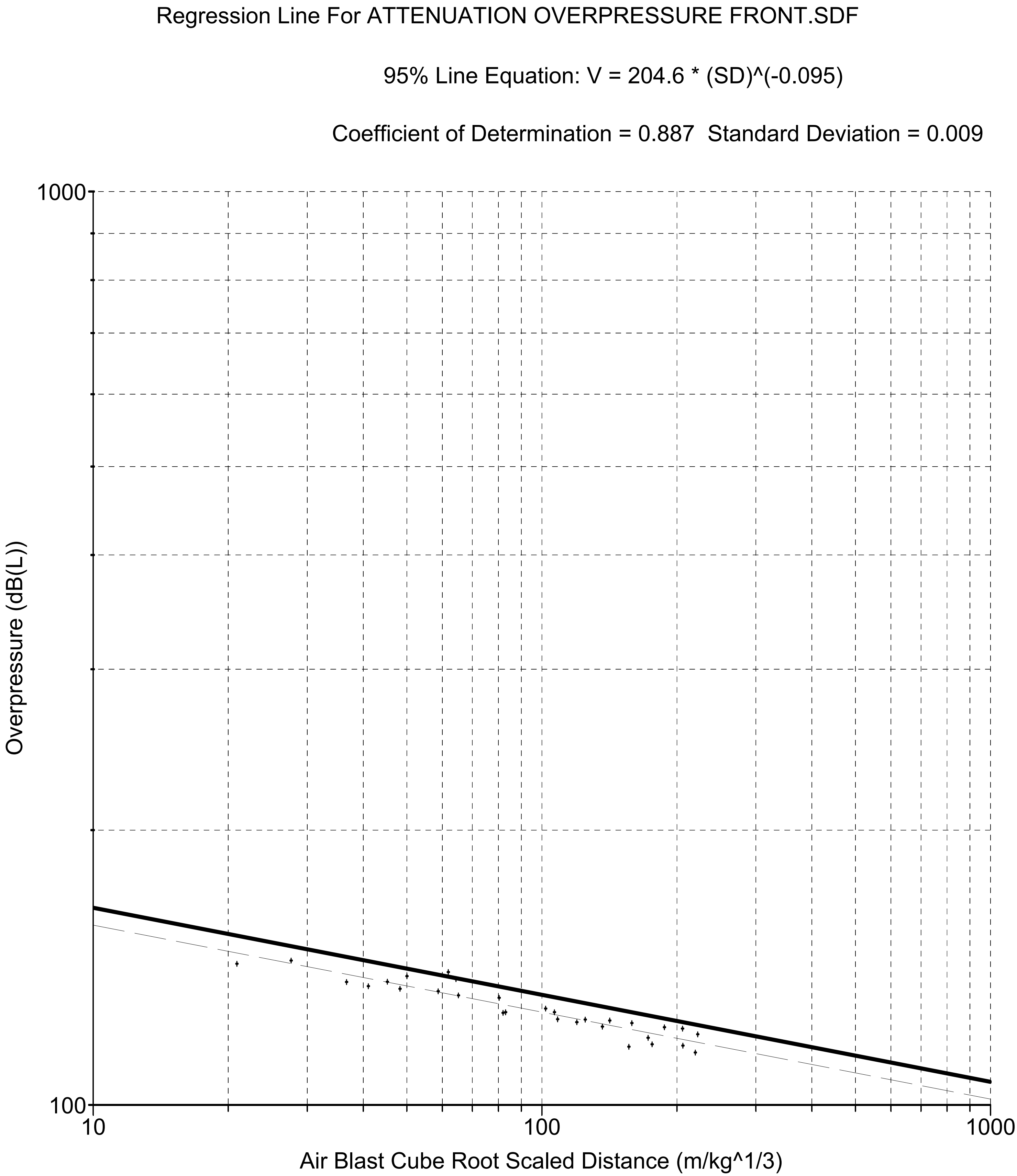
Appendix C

Regression Line For FULL BACK.SDF

95% Line Equation: V = 3029.3 * (SD)^(-1.582)

Coefficient of Determination = 0.923 Standard Deviation = 0.185





Regression Line For ATTENUATION OVERPRESSURE FRONT.SDF
95% Line Equation: V = 204.6 * (SD)^(-0.095)
Coefficient of Determination = 0.887 Standard Deviation = 0.009
1000
100
10
100
1000
Overpressure (dB(L))
Air Blast Cube Root Scaled Distance (m/kg^1/3)

Blast Report Summary

Blast#	Date	Time	Latitude	Longitude	Weather	Wind from	Max Kg/ Delay	Hole Dia. (in.)	Burden	Spacing	# of Holes	Avg Hole Depth (m	Avg Collar Depth (m	Total Tons	Location	Seismo 1 Latitude	Seismo 1 Longitude	(mm/s)	(dbl.)	Distance (m)
	2019																			
1	2019-03-04	11:45:00 AM	45.235	-75.984	Sunny	W	59.6	3.625	3	3.7	110	8.5	1.5	31413	Scale House	45.24	-75.98	1.4	119	526
2	2019-03-08	10:56:00 AM	45.235	-75.984	Sunny	SW	62.1	3.625	3	3.7	137	8.8	1.5	35312	Scale House	45.24	-75.98	1.14	120	556
3	2019-04-25	1:04:00 PM	NA	NA	Sunny	SE	71.6	3.625	3	3.7	129	9.1	1.8	39101	Scale House	45.24	-75.98	0	0	NA
4	2019-05-02	3:46:00 PM	45.232	-75.986	Overcast	E	80.8	3.625	3	4	122	11	1.5	52073	Scale House	45.24	-75.98	1.27	119	909
5	2019-05-08	11:01:00 AM	45.235	-75.984	Sunny	N	61.3	3.625	3	3.7	126	8.7	1.5	35134	Scale House	45.24	-75.98	1.27	117	577
6	2019-05-15	1:50:00 PM	45.233	-75.987	Rain	SW	51.9	3.625	3	4	129	7.6	1.5	33712	Scale House	45.24	-75.98	0	0	865
7	2019-05-27	10:57:00 AM	45.233	-75.987	Overcast	N	53.6	3.625	3	4	114	7.8	1.5	32247	Scale House	45.24	-75.98	0	0	881
8	2019-06-11	11:46:00 AM	45.233	-75.988	Overcast	NW	61.3	3.625	3	4	160	8.7	1.5	30850	Scale House	45.24	-75.98	0	0	900
9	2019-06-24	2:00:00 PM	45.232	-75.986	Partly Cloudy	SE	51.1	3.625	3	4	145	7.5	1.5	38876	Scale House	45.24	-75.98	0	0	906
11	2019-07-22	1:56:00 PM	45.232	-75.985	Partly Cloudy	NE	66.4	3.625	3	4	85	9.3	1.5	29070	Scale House	45.24	-75.98	1.02	0	846
12	2019-07-29	10:30:00 AM	45.234	-75.982	Sunny	SW	57.0	3.625	3	3.7	128	8.2	1.5	35892	Scale House	45.24	-75.98	0	0	577
13	2019-08-15	11:29:00 AM	45.232	-75.986	Sunny	NW	78.3	3.625	3	4	84	10.7	1.5	29939	Scale House	45.24	-75.98	0	0	937
14	2019-08-23	11:59:00 AM	45.232	-75.987	Partly Cloudy	NW	83.4	3.625	3	4	84	11.3	1.5	31649	Scale House	45.24	-75.98	0	0	962
15	2019-09-05	12:02:00 PM	45.232	-75.987	Partly Cloudy	SW	70.6	3.625	2.7	3.7	90	9.8	1.5	24869	Scale House	45.24	-75.98	0	0	980
16	2019-09-26	11:06:00 AM	45.231	-75.987	Overcast	NW	67.2	3.625	2.7	3.7	90	9.4	1.5	24092	Scale House	45.24	-75.98	0	0	1002
17	2019-10-23	11:19:00 AM	45.231	-75.987	Partly Cloudy	SW	64.7	3.625	2.7	3.7	90	9.1	1.5	23731	Scale House	45.24	-75.98	1.02	124	1015
18	2019-10-31	11:26:00 AM	45.231	-75.987	Rain	N	51.9	3.625	2.7	3.7	105	7.6	1.5	22419	Scale House	45.24	-75.98	0	0	1035
19	2019-11-27	10:48:00 AM	45.231	-75.988	Rain	NE	41.7	3.625	2.7	3.7	105	6.4	1.5	19054	Scale House	45.24	-75.98	0	0	1052
20	2019-12-05	12:40:00 PM	45.232	-75.987	Overcast	W	54.5	3.625	2.7	3.7	91	7.9	1.5	22337	Scale House	45.24	-75.98	0	0	936
21	2019-12-11	11:56:00 AM	45.232	-75.987	Overcast	SE	72.0	3.625	2.7	3.7	121	8.1	1.5	29494	Scale House	45.24	-75.98	0	0	1004
	2020																			
1	2020-02-20	10:54:00 AM	45.231	-75.988	Sunny	NW	36.0	3.625	2.7	3.7	126	5.3	1.5	18832	Scale House	45.24	-75.98	0	0	1051
2	2020-03-02	12:55:00 PM	45.235	-75.984	Overcast	E	73.6	4	3	3.4	115	9	1.5	31372	Scale House	45.24	-75.98	1.4	118	590
3	2020-04-03	4:23:00 PM	45.232	-75.987	Partly Cloudy	W	36.0	4	2.7	3.4	88	8.6	1.5	21106	Scale House	45.24	-75.98	0	0	977
4	2020-03-10	11:47:00 AM	45.231	-75.988	Rain	N	40.0	3.625	2.7	3.4	133	5.3	1.5	17278	Scale House	45.24	-75.98	0	0	1087
5	2020-03-20	11:42:00 AM	45.231	-75.988	Overcast	S	49.0	3.625	2.7	3.7	82	5.9	1.5	14522	Scale House	45.24	-75.98	0	0	1063
6	2020-03-30	2:20:00 PM	45.232	-75.988	Rain	NE	50.2	3.625	2.7	3.7	196	7.4	1.5	43474	Scale House	45.24	-75.98	0	0	1026
7	2020-06-26	1:00:00 PM	45.232	-75.988	Partly Cloudy	NW	46.0	3.625	2.7	3.7	207	6.9	1.5	42139	Scale House	45.24	-75.98	0	0	1021
8	2020-07-29	12:09:00 PM	45.232	-75.988	Overcast	SW	46.0	3.625	2.7	3.7	189	6.9	1.5	39551	Scale House	45.24	-75.98	0	0	1014
9	2020-09-08	11:37:00 AM	45.231	-75.988	Partly Cloudy	N	36.6	3.625	2.7	3.4	206	5.8	1.5	32295	Scale House	45.24	-75.98	0	0	1104
10	2020-09-17	11:32:00 AM	45.233	-75.988	Partly Cloudy	N	54.5	3.625	3	3.7	134	7.9	1.5	35331	Scale House	45.24	-75.98	0	0	915
10 (2)	2020-09-22	12:50:00 PM	45.232	-75.988	Partly Cloudy	SW	45.1	3.625	2.7	3.7	188	6.8	1.5	38063	Scale House	45.24	-75.98	0	0	996
11	2020-09-28	12:02:00 PM	45.231	-75.988	Partly Cloudy	SE	35.7	3.625	2.7	3.4	175	5.7	1.5	25039	Scale House	45.24	-75.98	0	0	1124
12	2020-10-01	12:47:00 PM	45.235	-75.984	Overcast	SW	68.1	3.625	3	3.7	138	9.5	1.5	40608	Scale House	45.24	-75.98	2.41	124	614
13	2020-11-11	11:50:00 AM	45.232	-75.988	Overcast	SW	41.7	3.625	2.7	3.7	176	6.4	1.5	34519	Scale House	45.24	-75.98	0	0	1008
14	2020-12-04	12:01:00 PM	45.232	-75.988	Rain	SW	43.4	3.625	2.7	3.7	167	6.6	1.5	33285	Scale House	45.24	-75.98	0	0	984
15	2020-12-16	11:40:00 AM	45.232	-75.988	Overcast	NE	43.4	3.625	2.7	3.7	153	6.6	1.5	31142	Scale House	45.24	-75.98	0	0	987
	2021																			
1	2021-02-01	12:13:00 PM	45.232	-75.988	Sunny	NE	44.3	3.625	2.7	3.7	143	6.7	1.5	28767	Scale House	45.24	-75.98	0	0	987
2	2021-02-22	11:45:00 AM	45.233	-75.988	Snow	SE	41.7	3.625	2.7	3.7	122	6.4	1.5	23833	Scale House	45.24	-75.98	0	0	980
3	2021-03-03	12:21:00 PM	45.233	-75.988	Overcast	W	41.7	3.625	2.7	3.7	130	6.4	1.5	24483	Scale House	45.24	-75.98	0	0	975
4	2021-03-12	1:00:00 PM	45.232	-75.986	Overcast	SW	56.0	3.5	3	4.3	146	9	1.5	50249	Scale House	45.24	-75.98	1.02	125	956
5	2021-03-17	12:43:00 PM	45.233	-75.988	Partly Cloudy	S	45.1	3.625	2.7	3.7	154	6.8	1.5	37486	Scale House	45.24	-75.98	0	0	953
6	2021-04-09	11:48:00 AM	45.231	-75.986	Sunny	SE	68.9	3.625	2.7	3.7	155	9.6	1.5	43292	Scale House	45.24	-75.98	0	0	955
7	2021-04-23	11:45:00 AM	45.231	-75.988	Partly Cloudy	W	35.9	3.5	2.7	3.7	142	6.3	1.5	26326	Scale House	45.24	-75.98	0	0	1091
8	2021-05-31	11:51:00 AM	45.231	-75.986	Partly Cloudy	SW	59.8	3.5	2.7	3.7	155	9.5	1.5	42994	Scale House	45.24	-75.98	1.27	94	966
9	2021-08-04	11:55:00 AM	45.231	-75.987	Sunny	SW	58.0	3.625	2.7	3.7	159	6.6	1.5	31079	Scale House	45.24	-75.98	0	0	1085
10	2021-08-27	11:57:00 AM	45.231	-75.986	NA	NA	60.5	3.5	2.7	3.7	150	9.6	1.5	42616	Scale House	45.24	-75.98	1.65	102	966
11	2021-10-06	12:25:00 PM	45.231	-75.987	Partly Cloudy	SW	38.8	3.5	2.7	3.7	160	6.7	1.5	31549	Scale House	45.24	-75.98	0	0	1086
12	2021-11-11	12:05:00 PM	45.231	-75.987	Overcast	E	45.6	3.5	2.7	3.7	150	7.6	1.5	34611	Scale House	45.24	-75.98	0	0	1069
13	2021-11-18	12:20:00 PM	45.234	-75.982	Rain	W	53.6	3.6	2.7	3.7	157	7.8	1.5	36172	Scale House	45.24	-75.98	1.78	116	556
14	2021-12-02	11:59:00 AM	45.231	-75.986	Rain	S	71.5	3.625	2.7	3.7	139	9.9	1.5	40450	Scale House	45.24	-75.98	1.02	118	977
15	2021-12-10	11:24:00 AM	45.231	-75.987	Overcast	NE	47.1	3.5	2.7	3.7	145	7.8	1.5	35459	Scale House	45.24	-75.98	0	0	1080
	2022																			
1	2022-01-31	11:58:00 AM	45.23	-75.987	Partly Cloudy	SE	55.3	3.625	2.7	3.7	146	8	1.5	35178	Scale House	45.24	-75.98	0	0	1077
2	2022-02-24	2:29:00 PM	45.232	-75.985	Sunny	NW	76.0	3.6	2.7	3.7	129	9.9	1.5	37190	Scale House	45.24	-75.98	0	0	901
3	2022-03-23	11:32:00 AM	45.23	-75.987	Overcast	E	59.6	3.625	2.7	3.7	148	8.5	1.5	38234	Scale House	45.24	-75.98	0	0	1070
4	2022-03-29	11:38:00 AM	45.231	-75.985	Partly Cloudy	W	72.3	3.625	2.7	3.7	117	10	1.5	34322	Scale House	45.24	-75.98	0	0	968
5	2022-04-22	2:25:00 PM	45.234	-75.985	Partly Cloudy	NW	66.4	3.625	3	3.7	138	9.3	1.5	40822	Scale House	45.24	-75.98	1.52	122	632
6	2022-04-21	11:09:00 AM	45.23	-75.987	Overcast	S	59.6	3.625	2.7	3.7	124	8.5	1.5	31904	Scale House	45.24	-75.98	0	0	1078
7	2022-04-26	12:00:00 PM	45.231	-75.985	Overcast	W	72.3	3.625	2.7	3.7	116	10	1.5	34476	Scale House	45.24	-75.98	0	0	973
8	2022-06-03	12:24:00 PM	45.23	-75.986	Partly Cloudy	W	60.4	3.625	2.7	3.7	125	8.6	1.5	32444	Scale House	45.24	-75.98	0	0	1079
9	2022-05-13	12:45:00 PM	45.234	-75.982	Partly Cloudy	SW	55.3	3.625	2.7	3.7	184	8	1.5	42791	Scale House	45.24	-75.98	0	0	558
10	2022-06-20	11:54:00 AM	45.231	-75.985	Sunny	W	80.0	3.625	2.7	3.7	116	10	1.5	33863	Scale House	45.24	-75.98	0	0	982
11	2022-07-26	4:44:00 PM	45.23	-75.986	Partly Cloudy	SW	62.1	3.625	2.7	3.7	127	8.8	1.5	33526	Scale House	45.24	-75.98	0	0	1089
12	2022-08-17	11:58:00 AM	45.231	-75.985	Partly Cloudy	N	80.0	3.625	2.7	3.7	117	10	1.5	33936	Scale House	45.24	-75.98	0	0	983
13	2022-09-08	11:59:00 AM	45.23	-75.986	Sunny	W	63.0	3.625	2.7	3.7	129	8.9	1.5	34564	Scale House	45.24	-75.98	0	0	1084
14	2022-10-05	11:59:00 AM	45.231	-75.985	Sunny	S	72.3	3.625	2.7	3.7	130	10	1.5	34256	Scale House	45.24	-75.98	0	0	990
15	2022-10-18	12:50:00 PM	45.23	-75.986	Overcast	SE	63.8	3.625	2.7	3.7	127	9	1.5	34763	Scale House	45.24	-75.98	0	0	1101
16	2022-11-29	12:04:00 PM	45.231	-75.985	Overcast	S	63.5	3.5	2.7	3.7	117	10	1.5	34361	Scale House	45.24	-75.98	0	0	993
17	2022-12-06	1:05:00 PM	45.23	-75.986	Rain	E	64.7	3.625	2.7	3.7	127	9.1	1.5	35207	Scale House	45.24	-75.98	0	0	1100

Appendix D

EXPLOTECH

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
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

EXPLOTECH

Specialists in Explosives, Blasting and Vibration
Consulting Engineers

Andrew Campbell, P.Eng.

Explotech Engineering Ltd.

EDUCATION & QUALIFICATIONS

Bachelor of Engineering,
Mechanical Engineering, Carleton University

Advanced and Expert (Industry) CadnaA Modelling
DataKustik, Mississauga, Ontario

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. With a focus on blast designs, blast impact analyses, noise monitoring and modelling, damage complaint investigations, vibration analysis, and blast monitoring, Andrew has applied these skills across Canada.

PROFESSIONAL RECORD

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

Michael Tobin, P.Eng.

Explotech Engineering Ltd.

EDUCATION

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

PROFESSIONAL AFFILIATIONS

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

SUMMARY OF EXPERIENCE

An engineer working for Explotech Engineering Ltd., Michael holds a Bachelor of Applied Science degree from Queen's University in Geological Engineering. Michael has strong analytical, technical, and interpersonal skills. Recent projects have focused on blast monitoring, vibration analysis, job estimation, damage complaint investigation and blast design.

PROFESSIONAL RECORD

2021 – Present	- Engineer, Explotech Engineering Ltd.
2017 – 2021	- Technician, Explotech Engineering Ltd.

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.
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,

EXPLOTECH

	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

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