An Appraisal of the
Peer Review by Golder Associates
Of Two Reports Titled
Blast Impact Analysis James Dick Hidden Quarry
By Explotech Engineering Ltd.

By William Hill Mining Consultants Limited

January 31, 2015

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Introduction

This report by William Hill Mining Consultants Limited (HMC) presents an appraisal of the Peer Review by Golder Associates (Golder) dated October 1, 2014 of two reports titled Blast Impact Analysis James Dick Hidden Quarry dated November 19, 2012 (BIA 1) and September 5, 2014 (BIA 2) by Explotech Engineering Ltd (EEL). Details and chronology on both BIAs can be found in an appendix on page 10.

Conclusions and Recommendations

A peer review is defined as a critical appraisal of an article or report by a person equally or better qualified than the author. The review should be as critical about the elements dealt with in the article as with the material which is not included. In the case of the peer review of the Blast Impact Analysis (BIA), Golder has failed to identify some obvious adverse factors omitted in the EEL analysis. With the exception of one critical comment, which EEL failed to address adequately in their revised report, the Golder peer review is of a cosmetic nature altering only minor inconsistencies.

In the opinion of HMC, the peer review by Golder does not meet the standards of quality expected from a reputable company such as Golder Associates, principally because of the lack of analysis into material that had been omitted by EEL. It should also be apparent to an experienced mining engineer, that the BIA has presented a best-case scenario where it is incumbent upon the consultant to investigate the worst of all conditions. A clear example taken from both BIAs is the statement that at a distance of 425 metres, the nearest receptor will receive a shock wave measured in PPVs of 10.1 mm/sec (just under the MOE limits). What is not said, is that at a distance of 165 metres from the same receptor which will be approached not long after commencing operations, the shockwave will be closer to 60mm/sec (five times the MOE limit). This result could have devastating effects on the five homeowners and one business complex within this radius of influence.

HMC recommends that the GET Council request a clarification from Golder on this issue or, the Guelph/Eramosa Township (GET) Council should commission a new critical peer review.

Summary

The revised BIA2 by EEL offers only minor changes from the previous BIA1. The changes in the revised version are mostly superficial in nature or changes in terminology and formula clarification. The only significant change recommended by Golder is the addition of information (page 19 BIA2) dealing with "Blast Impact on Adjacent Watercourses". The subject had previously been dealt with in just three lines in BIA1. Additional discussion on fish habitat and spawning areas will be addressed further in this report.

Only one paragraph titled "Blast Design" in the Golder peer review at the bottom of page 4/5 appears to offer a critical comment –

> *"The report states that special precautions must be implemented as the operations approach within 250 m of any sensitive receptors [page 12]. There is no discussion of what these precautions might be and to what extent they would reduce the ground and air vibration levels."*

The BIA2 included an amendment to conform to the Golder criticism, which Golder accepts in the introductory letter to the peer review along with other minor changes. The letter further concludes that "The report's recommendations are reasonable and acceptable". The following paragraph (from page 12 of the BIA2) displays the changed wording.

> *"Revisions to blast designs, including adjustments to blast hole diameter and spacing, type of explosive, delay sequence, and collar height have proven to be very effective in controlling vibration and overpressure."*

In the opinion of HMC the foregoing mollifying statement does not even begin to address Golder's request. Specifically, the statement does not provide solutions to the problems, which will be encountered in the drilling and blasting operations of the Hidden Quarry (HQ).

The underlying justification for HMC's opinion is detailed in the following six categories which are either dealt with inadequately or not at all both in the BIA and the Golder peer review:

1. Geology and Karst Weathering
2. Unique Characteristics
3. Fly Rock
4. Drilling and Blasting Considerations
5. Blasting Patterns and Powder Factor
6. Shockwaves and Ground Vibrations

1. <u>Geology and Karst Weathering</u>

In any investigation into mining of a deposit, and particularly drilling and blasting, geology of the area is the most important consideration. It appears however, that the only reference to the topic by EEL is "While the resultant prediction equations are reliable, divergence of data occurs as a result of a wide variety of variables, <u>most notably site specific geological conditions</u> etc." (Page 14 BIA and underlined by HMC).

There is no rock outcropping in the quarry area as the surface is covered by gravel. Very little drilling into the extraction zone has been carried out. Almost all of the information on rock characteristics has been provided from one borehole. It is significant that the hole encountered several open fissures. These openings and other features indicate that Karst weathering is probably present although it is termed as microkarst as no cavernous features have yet been encountered. There are other indicators that karstification may have occurred, (such as sink holes and disappearing streams), as karst weathering has been mapped as close as 100 metres to the south of the HQ property by the Ontario Geological Survey. The rocks exposed in this area as a result of stream erosion, are the extension of the Amabel Formation, which is the same rock strata from which the aggregate will be produced.

Drillers and blasters will agree that most aspects of their operation can be controlled with the exception of ground conditions and inherent ground irregularities. Golder appears to have ignored or overlooked the importance of the possibility of karstification and the potential dangers which may result particularly fly rock generation.

2. <u>Unique Characteristics</u>

As no commentary is forthcoming in their peer review, Golder seems to have implicitly accepted the position taken in the BIA, which is, more or less, a "one size fits all" approach. Throughout the BIA references such as "We have therefore applied data generated at a variety of quarries across Ontario which present similar blasting characteristics" (page 3 BIA). With one exception "Based on one Ontario quarry with similar material characteristics" (page 15 BIA) no mention is made of any of the names of the quarries in the sampling. This "trust me" approach is not acceptable in a report of this nature. The questions, which should have been raised with respect to quarry similarities, are as follows:

- Are they in a Karst geological environment?
- Do they mine under water to a depth of 25 metres?
- Do they detonate individual blasts with up to 675 kg of explosives?
- Do they have seven receptors within a 150-metre distance?
- Do they have 18 receptors within a 500-metre distance?
- Is there a highway less than 100 metres from the quarry with average traffic volume of 10,000 vehicles per day?
- Is there a secondary road less than 50 metres from future blasts?

In research of literature there appears to be no other quarry in Ontario, which approaches these almost unique characteristics found in the HQ. The Dolime pit in Guelph (mined by JDCL) appears to be the only quarry, which has characteristics similar to the HQ. The Dolime quarry is mining under water in an urban environment, producing aggregate from the same rock sequence, (the Gasport Formation) as the proposed HQ. The similarities diverge as mining at the Dolime quarry only involves depths of +/-10m and blasting charges of well under 100kg. The closest major highway is 500 metres away with a less traveled road more than 250 metres away from the pit. A significant difference between the Dolime site and the HQ site is that there are no Karst formations in the immediate vicinity of Dolime pit. The Dolime deposit has been buried for 425 million years and only exposed to weathering by mining operations, for about 100 years as compared to at least 15,000 years of weathering in the HQ area.

The quarries, which appear to be similar are those located near Miami, Florida particularly in the area of Miramar City. These quarries are mined underwater with blast-hole depths and blast sizes in the range contemplated for the HQ. The Florida quarries, which were at one time mined at similar distances to the HQ receptors, were forced to leave the area and have since been relocated more than two kilometres distance from any populated areas.

3. Fly Rock

One of the principal problems in the BIA reports and the Golder peer review is the failure to properly address the likelihood of fly rock generation. There is only one brief mention of fly rock which is found in their recommendations (paragraph 4, page 20 of BIA2 and paragraph 3, page 19 of BIA1) which states: "Orientation of the aggregate extraction operation will be designed and maintained so that the direction of the overpressure propagation and fly rock from the face will be away from structures as much as possible".

This statement recognises that the danger of generating fly rock does exist and that they believe the direction of fly rock can be controlled. Neither EEL nor Golder present any other discussion on the subject even though:

- Six sensitive receptors including two business complexes are located closer than 200 metres from the quarry operations (generally considered the danger zone for fly rock);
- 18 homes are within 500 metres which is considered the zone of "wild fly rock" propagation;
- Approximately a one kilometer stretch of Highway 7 (up to 10,000 vehicles per day) plus a further one kilometer of the Sixth Line are also located within the 200 metre danger zone;
- Each blast may contain up to half a tonne of explosives and
- Irregularities in the rock principally due to karstification will provide many opportunities for mishaps in blasting.

This lack of discussion on fly rock implies either a failure by Golder to recognise the safety issue for neighbouring residents and travellers on the roads, or a failure to recognise and understand the risks associated with potential fly rock.

4. Drilling and Blasting Considerations

The proposed blast hole drilling within the HQ will be done with drill hole diameters of 76mm to 152mm, (that is 3 to 6 inches in diameter which are standard for the industry) as recommended by EEL on page 12 of the BIA.

4.1. Small Diameter Holes

First, let us consider the problems associated with the smaller diameter holes. A 76mm diameter blast hole is usually the smallest hole size used in operations of the magnitude of the HQ. This hole diameter is generally associated with quarries and mines employing bench heights (and drill holes), of 10 metres or less. HQ proposes to drill similar holes up to 30 metres in depth, which can result in significant deviation from the vertical, as the direction of penetration is more difficult to control with small diameter holes. Given a proposed drill pattern of 1.8 metres x 1.8 metres (burden and spacing), any "wandering" of the blast holes will result in either overlapping or divergence with a significantly increased potential for misfires or blowouts. It should be noted that even as little as a 3-degree variation in drill angle at the collar would result in a deflection of up to 1.6 metres at the bottom of the hole. Hole deviation, which results in blasting problems, combined with the inherent ground conditions, all heighten the potential for fly rock.

Because JDCL has chosen a mining method based on no dewatering of the excavation, the quarry will remain filled with water throughout its duration. As a result of the decision the drill holes will most likely be filled to some degree with water, which makes it necessary to use water resistant explosives called slurries. Slurries are an ammonium nitrate formulation that does not break down in the presence of water. The one exploratory drill hole penetrating the full depth of the aggregate has revealed that karst weathering exists and open fissures are present. Slurry will tend to flow into any openings caused by karst weathering when pumped into the drill holes, resulting in undesirable accumulations of explosive. When detonated, the result can be uncontrolled explosions and fly rock generation. Control of this problem will necessitate the use of plastic liners in the blast holes, which in the case of the smaller diameter holes is difficult and will present, at the very least, technical challenges.

The quantity of explosives used in quarries is usually based on the quality of the rock. The amount will have to be sufficient to break the rock and provide adequate fragmentation. In the case of the BIA, the recommended amount in the 76 mm diameter holes is 170kg of slurry. This amount of explosive will fill the drill hole to a depth of 3 metres from surface of the rock and provide a powder factor of +/- 0.66kg/tonne of rock. This amount of slurry will create a shock wave, of just under the permissible MOE guidelines, at close to 400 metres from the nearest sensitive receptor.

It is difficult to understand how JDCL will be able to operate within the guidelines of the MOE for permissible ground vibrations when even at a distance of 250 metres from the nearest sensitive receptor, the charge per blast will have to be reduced to 48kg (BIA page 11) to comply with those standards.

4.2. <u>**Large Diameter Holes**</u>

In the case of the larger 152mm diameter drill holes EEL recommends (BIA page 12) a drilling pattern of 3.3 metres x 3.3 metres. With the recommended explosive charge of 675kg per hole, filling the drill hole with slurry up to 3 metres from the surface with a powder factor of 0.79kg/tonne of rock should provide adequate fragmentation. The wider spacing and the larger drill rod diameter will eliminate the orientation problems associated with the smaller holes but will likely result in an overall larger blast on average per event.

The problem with the increased quantity of explosive in the larger drill holes is that the blast will generate shockwaves, which will exceed the MOE guidelines for all 18 sensitive receptors and the fish spawning areas south of the HQ property.

As EEL states, there are remedial measures that can be used to reduce the impact of blasting on the surrounding residences. However, implementing the potential mitigation measures is challenging and it is incumbent upon EEL and Golder to explain in detail their proposed solution(s).

5. Blasting Patterns and Powder Factor

Another shortcoming of the Golder peer review is its lack of detailed review of the initial blasting parameters recommended in the BIA. EEL states in the following in the BIA: *"Quarries in Ontario normally employ 76 to 152mm diameter holes which for a maximum 33m bench would employ 170 to 675kg of explosive load per hole"*.

EEL sets out the initial blasting parameters as blast patterns of 1.8 x 1.8 to 3.3 x 3.3 metres for a distance of 425metres from the nearest sensitive receptor with a maximum explosive load of 150kg in a 76mm diameter hole.

These criteria result in a powder factor (i.e. the quantity of explosives per unit of rock, generally expressed as kg/tonne or pounds/ton) of between 0.67 and 0.79 kg/tonne. This is roughly two to three times the powder factor used in similar mining operations and would result in blowouts with a significant possibility of fly rock.

An example of the devastation that can occur with a higher powder factor took place in at a quarry in Johor, Malaysia on 19^{th} July, 2013 when the powder factor was doubled by mistake. In that instance, fly rock was ejected up to 700m from the blast, killing one person, injuring ten and inflicting extensive property damage.

It is evident that the blasting parameters should have been examined in more detail by EEL and Golder should have commented on this perceived shortcoming in the peer review.

6. Shockwaves and Ground Vibrations

Ground Vibrations and Basis for Prediction

The assumptions for predicting ground vibrations in the BIA appear to be based on the experience of EEL and on theoretical formulae derived from that experience. The BIA includes several references to the derivation of the data and the justification for using it as "a conservative starting point for blasting operations". This follows from "We have therefore applied data generated at a variety of quarries across Ontario which present similar blasting characteristics" (page 3 BIA).

It is interesting to note that in a peer review by Golder on a report prepared by EEL (Miller Braeside Quarry, for the County of Renfrew, April 2007) the theoretical values estimated by EEL as compared to actual seismographic measurements were at a substantial variance. The actual measured values provided by Golder exceeded the EEL theoretical estimates by an average of 91%.

Another example of the possible variance between theoretical estimates and actual blast vibrations is illustrated in the following example taken from the records of Miramar City near Miami in Florida.

"74 seismograph readings (taken by an independent government agency) were compared to the theoretical results using the Bureau of Mines formula and the EEL site specific constants (page 15 BIA). The results of actual readings are far in excess of the theoretical, by an average difference of close to 100%". (HMC report to GET October 21, 2013, page 19).

The quarries in Miramar are mining under water with similar characteristics to the proposed HQ operation.

Perhaps the differences in measurement is explained by the following EEL statement on theoretical predictions versus actual blasting vibrations – "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 etc." (Page 14 BIA and underlined by HMC). It is interesting to note that this appears to be the only reference to geology and its importance in blasting.

Ground Vibrations and Nearest Sensitive Receptors

A short coming in the Golder Peer Review is their agreement with EEL that blasting within the HQ will produce ground vibrations of less than the Ministry of Environment's (MOE) maximum of 12.5mm/sec Peak Particle Velocity (PPV) at the start of the operating life of the quarry when in fact those limits will be exceeded in most of the quarry. The 12.5mm/sec PPV reading of vibrations is based on a generally accepted formula for measuring blasting shock waves transmitted through the ground.

The parameters for the BIA assume that, at a distance of 425 metres to the closest sensitive receptor and with a 150kg explosive charge, shock waves with a magnitude of 10.1mm/sec PPV will be generated. While in theory the assumption is valid, it was not stated in the BIA nor in the Golder peer review that only +/-10% of the quarry operations will be carried out at distances greater than 425 metres from receptors - as shown on the accompanying sketch #1. The remaining 80% of the HQ property will be subjected to shock waves with a magnitude, as measured in PPVs, of 10.1mm/sec or greater, even when allowing for minimum quantities of explosives per blast because the distance to nearest sensitive receptor will be less than 425 metres.

Employing the same formula, an explosive charge of 150kg, but changing the distance to the nearest receptor to 384 metres, generates shock waves measuring 12.5mm/sec PPV, the maximum allowable by MOE. It is important to note that less than 15% of the quarry falls within the limits acceptable by the MOE - as shown on the accompanying sketch #2. It is also important to note that the operation will have exhausted the aggregate resource at the 425-metre distance from sensitive receptors within the first three months of production. Mining will then move to distances closer than 384 metres to the nearest sensitive receptor, which may result in PPV's that exceed the MOE maximum limit.

The schedule of operation proposed by EEL and JDCL is to start the initial operation in the northeastern quadrant of the property at a distance of more than 425 metres from the nearest sensitive receptor. In this case the nearest sensitive receptor is the mushroom farm, and as the blasting advances closer to the receptors, the operation will modify the method of blasting to conform to MOE guidelines. In order to illustrate the problems, which will be encountered in attempting to blast with acceptable shock wave magnitudes, Table # 1 is presented based upon modifying the table on page 11 of the BIA report. The changes made in Table # 1 present the shock waves that will be encountered at various distances using the minimum quantity of explosive of 150kg/hole.

It is unlikely that the explosives charges can be reduced much below 150kg per hole considering that the drill holes will have a depth of between 27 metres and 30 metres and a minimum diameter of 76mm. A reduction in the amount of explosive per hole would have an adverse effect on fragmentation and, more importantly safety [rifling blowout - fly rock]. The effect of blasting vibration at 165 metres is shown because the design of the quarry entails pit limits at that distance from the nearest five sensitive receptors.

Table 1
Blast Vibration [Explosive Charge 150kg/hole]

Distance to Receptor (metres)	Peak Particle Velocity (mm/sec)
150	62.9
165	53.0
200	37.9
250	25.6
300	18.6
350	14.2
400	11.2

Ground Vibrations and Larger Blast Hole Diameter

The Golder Peer Review does not attempt to address the issue of the blasting parameters [page 12 of the BIA] in which EEL propose to use drill holes of up to 152mm in diameter. If the larger blast holes are used the explosive charge will be up to 675kg per hole [page 8 of the BIA]. If the increased amount of explosives is used the resulting shock waves will surpass the MOE guidelines of 12.5mm/sec at a distance of 800m encompassing more than 18 sensitive receptors.

Larger Blasts and Fish Habitat

Larger blast holes (152mm diameter) will probably not be permissible in the southern part of the HQ property as the shockwaves will surpass the acceptable levels of 13mm/sec PPV allowed by the Department of Fisheries and Oceans in the spawning areas in the Brydson Creek south of Highway # 7.

Ground Vibrations and Wetlands Barriers

The barriers, which JDCL plans to install to protect the northwest wetland and the Allen wetland/Brydson Creek to the north, are most sensitive to blasting shock waves. However, neither Golder in its Peer Review nor the BIA include any meaningful discussion of the effect of blasting shock waves on those barriers

The JDCL plan for the HQ incorporates an impervious barrier 20 metres north of the quarry to protect the wetlands. The barriers would consist of trenches excavated down through the gravel to the underlying silt beds. The trenches would be filled with impervious material such as clay to hold back the moisture of the wetlands. The surface water in the quarry would be roughly 8 metres lower than the surface water level in the wetlands north of the barrier.

The problem, not addressed in the BIA nor by Golder is what would be the effect of blasting shockwaves on these barriers. At the distance proposed and an explosive charge of 150kg, the shock waves could be close to 2,200mm/sec. The vibrations may result in the liquefaction of the clays in the barrier and the wetlands, causing the barriers to rupture in the same manner as tailings dams have in seismic events. The barriers will be subjected to the shockwaves of numerous blasts as the quarry progresses from the northeast to the west along the northern boundary of the quarry.

A secondary problem will be how to stabilize the walls of the trench excavated in loose gravel and overburden. No doubt the barrier wall will not meet the "as engineered design". If the water levels on each side of the barrier were close to the same elevation (as in examples provided by JDCL) the problems would be surmountable. However, in the case of the HQ the difference in water level will be close to 8 metres, which poses a major technical challenge.

Ground Vibrations and Brydson Creek Causeway

Another subject overlooked by EEL and Golder is the effect of blasting shockwaves on the proposed causeway, which will be left as a pillar to accommodate the flow of the Brydson Creek through the quarry. The JDCL design calls for leaving a causeway running 30 metres in width on each side of the creek. This design results in a pillar of rock 60 metres in width and 30 metres high, which requires rock mechanics engineering to be certain that its integrity will not be compromised by blasting.

On top of the pillar of rock there will be close to 8 metres of sand, gravel and silt supporting the creek bed. The creek is described as having intermittent flow. However, during spring runoff and in wet weather it does carry a considerable volume of water. In the opinion of HMC it is questionable that the pillar will be able to stand up to the effect of shock waves, which may be as high as to 2200mm/sec PPV. There is the potential that the integrity of the creek bed will be impacted and perhaps permanently disrupted. The spring runoff would be diverted into the quarry, which would require it to be dewatered which could adversely impact the pristine Blue Springs water system. It should be noted that the JDCL proposal is based on zero dewatering from the HQ.

APPENDIX

Appendix 1. **Author's Footnote - Chronology**

On November 19, 2014 a report titled "Technical Peer Review – Blast Impact Analysis (GOLDER) for Hidden Quarry" dated October 1, 2014 by Golder Associates (Golder) was posted on the Guelph/Eramosa Township web site. Appended to the peer review was a revised report by Explotech Engineering Ltd. (EEL) titled "Blast Impact Analysis" (BIA2) dated September 5, 2014.
Presumably the GOLDER report was prepared in response to a request by W. Hill (HMC) for a peer review of the original version of the report titled "Blast Impact Analysis" dated November 19, 2012 (BIA1). The request was made at a meeting in the Rockmosa Centre on August 12, 2014. At that time HMC specifically recommended Golder Associates for preparing the peer review. The underlying reason for the public request by HMC was based on the quality of a similar peer review dated August 25, 2008 by Golder (but not by the same author as this peer review) of a report prepared by EEL titled Blasting Impact Assessment, Miller Braeside Quarry Extension, County of Renfrew, April 2007.

In an introductory letter to the peer review dated October 1, 2014 Golder refers to a Draft Technical Peer Review of BIA1 dated November 1, 2013 written shortly after the presentation of HMC's report titled "Appraisal of the Mining Aspects of Reports etc." to the Guelph Eramosa Township (GET) Council dated October 21, 2013. The Golder Draft Technical Peer Review was not provided to GET.

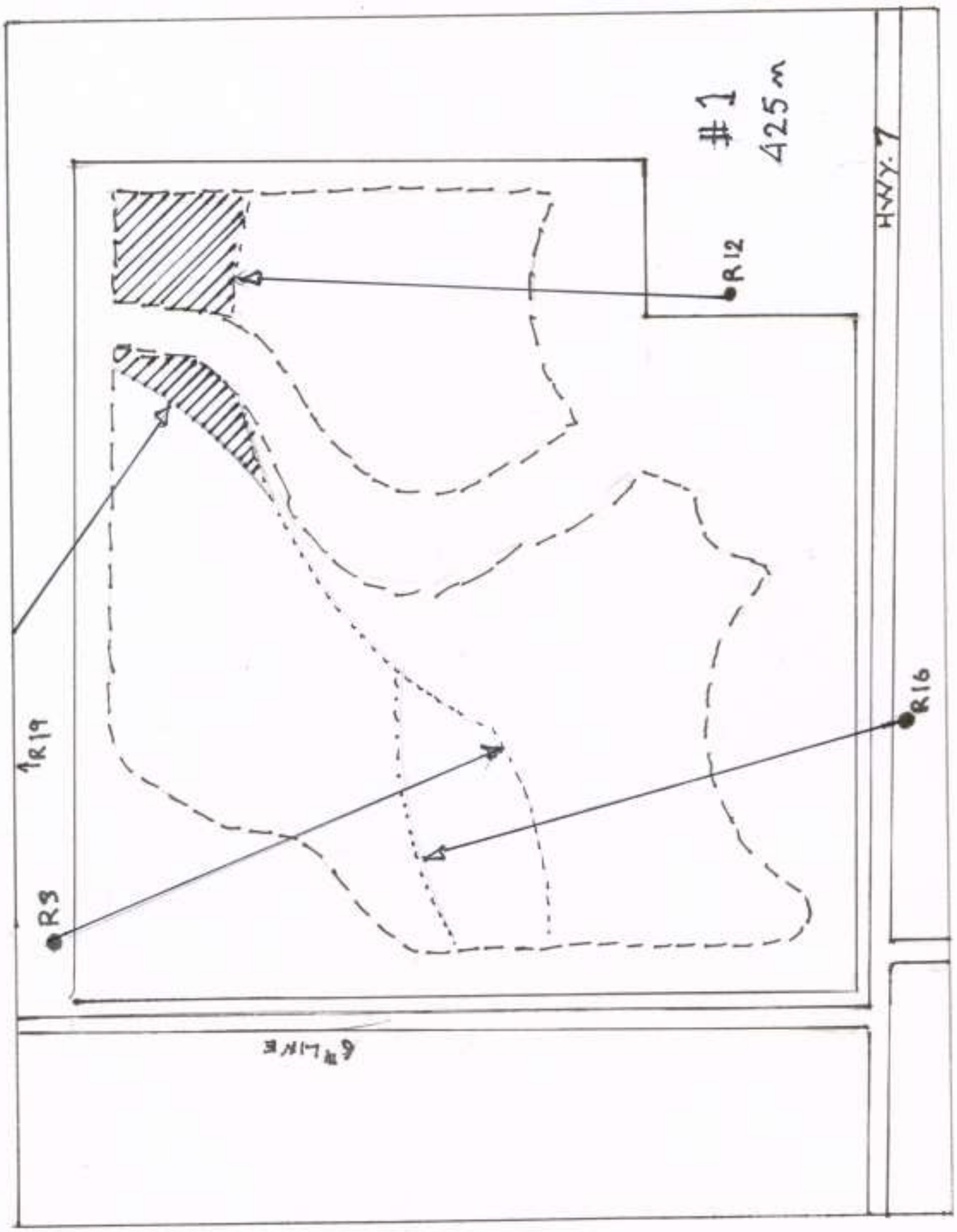
Had HMC been aware of Golder's prior involvement with James Dick Construction Limited (JDCL), HMC would have proposed another independent mining consulting firm to undertake the peer review. GET should have been informed of the existence of the draft report and the prior involvement of Golder with JDCL at the very latest at the time of the HMC request at the meeting on August 12, 2014. Furthermore, GET, not the applicant, is the appropriate body to commission a peer review, as it has in every other case.

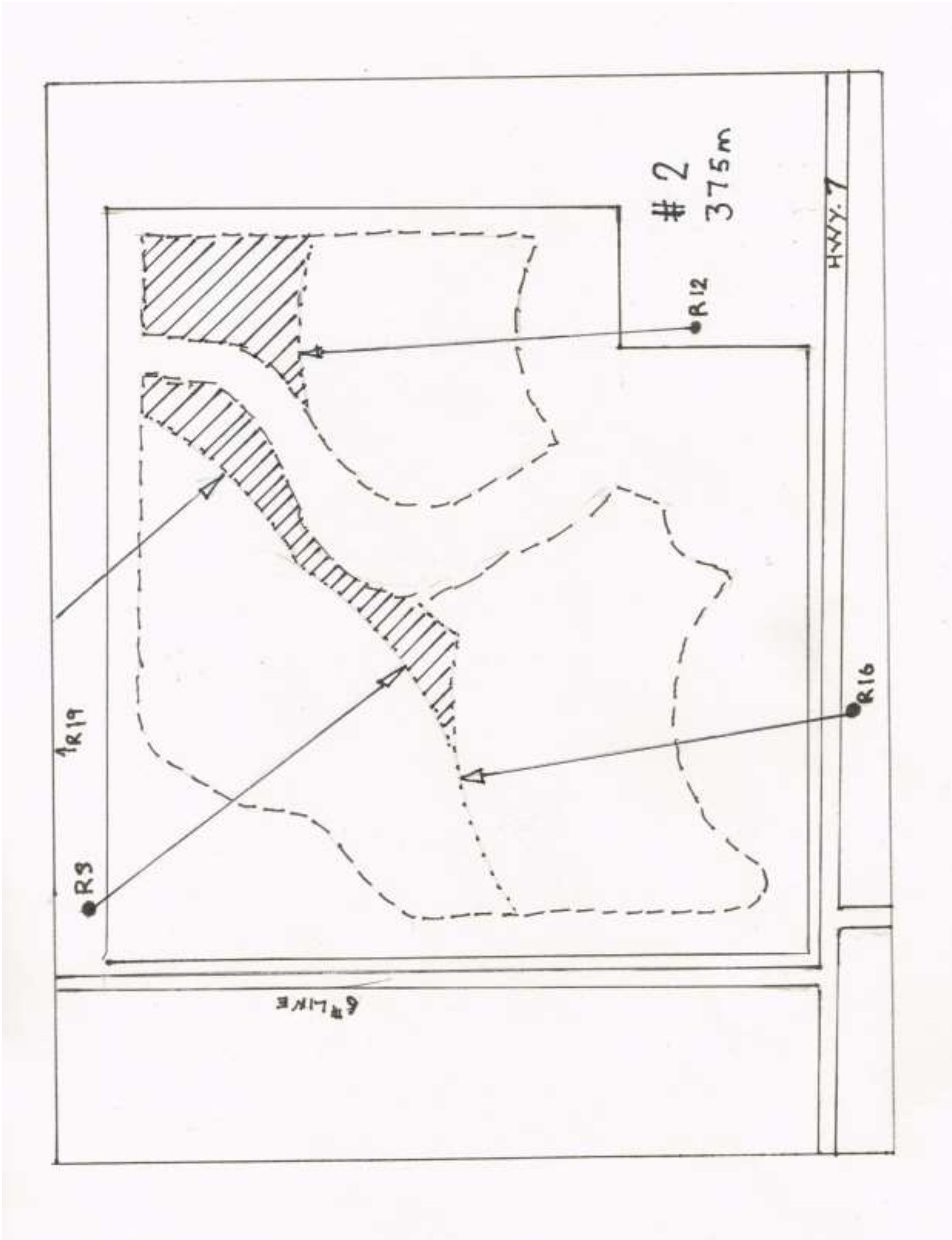
Appendix 2. **Explanatory Notes to Illustrations**

The sketches referred to earlier, on page 7, are shown on the two pages which follow. The final outline of the mined out quarry is shown in both sketches in dashed lines.

Sketch #1 shows the 425 metre radii of influence (in dotted arcs) from the four closest receptors. As referred to on page 7, at 425 metres the shockwaves will have a magnitude of 10.1 mm/sec. The hatched areas in the top right-hand corner of the property represent the only part of the quarry which will have readings of less than 10.1 mm/sec.

Sketch #2 shows the 375 metre radii of influence from the four closest receptors. At this distance the receptors will receive shockwaves with a magnitude of just over 12.5 mm/sec, the limit of acceptable vibrations allowed by the MOE. Again, the hatched area shows the only parts of the quarry which will have vibrations under the limits set by the MOE.


#1
425 m
HWY. 7
R12
R19
R3
R16
6th LINE



#2
375m
HWY. 7
R12
R16
R19
R3
6th LINE