Ministry of the Environment

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27 May 2013

Anne Guiot
Skelton, Brumwell & Associates Inc.
95 Bell Farm Road, Suite 107
Barrie, Ontario
L4M 5G1

Dear Ms. Guiot:

RE: Application for Class A Quarry Licence - Aggregate Resources Act;
Applicant: Miller Paving Limited, Miller Braeside Quarry, (License Ref. No. 16173),
Part Lots 16 & 17, Concession A, Township of McNab/Braeside (McNab),
County of Renfrew

I have reviewed the hydrogeologic aspects of the above-noted application package:

- *"Planning Justification Report, Miller Braeside Quarry Expansion"* Skelton Brumwell & Associates Inc, March 28, 2013.

- *"Hydrogeological Assessment – Final, Proposed Braeside Quarry Expansion"* Jennifer B. Gorrell, July 2012.

- *"Braeside Quarry Expansion, Hydrological Investigation"* Skelton Brumwell & Associates Inc. July 2012.

- *"Natural Environmental Report Level I & II, Braeside Quarry Expansion"* Skelton Brumwell & Associates Inc. Revised December 2, 2011.

- *"Blasting Impact Assessment, Miller Braeside Quarry Extension"* Explotech Engineering Ltd., May 26, 2009.

- *"Site Plan, Miller Braeside Quarry"*Skelton Brumwell & Associates Inc. March 2013.

I have additionally visited the site during June and September 2010. My understanding of the site is further informed by the document, entitled:

- *"Miller Paving Ltd., Braeside Quarry, Permit To Take Water #5425-08WCJUV, Report on 2012 Groundwater Monitoring (Draft)"* BGC Engineering Inc., May 03, 2012.

This document provides groundwater pressure measurements from July 2002 until December 2012. Such information is germane to understanding the quarry's effects on local hydrogeology.

I offer the following comments:

Summary

1. Aggregate material will be extracted from below the established groundwater table.

2. The surrounding residences are not serviced by a municipal water system. Local residents rely on individual water wells for their domestic water supply.

3. At least two separate groundwater flow systems exist within the proposed excavation area.

4. An upper flow system exists within the Bobcaygeon formation. The shallow system conveys groundwater laterally to discharge to the excavation and springs on the flanks of the plateau.

5. A deeper groundwater flow system exists beneath the excavation at elevation 121.8 metres above sea level (masl) or deeper. The zone probably obtains water from a recharge area 500 to 1500 metres east of the site. The most likely discharge area is Ryan Creek, located 500 metres southwest of the site.

6. The 121 masl aquifer supplies residential water wells northwest and southwest of the site. It also provides base flow to Ryan Creek. Any adverse groundwater quality or quantity impacts to this aquifer are unacceptable.

7. The consultant proposes a 5 metre separation thickness between the proposed quarry floor and the underlying artesian aquifer. Substantiation of the separation thickness is required. If this thickness is not effective, the quarry may abruptly flood due to stress relief fractures intersecting the underlying aquifer.

8. To protect local groundwater resources, the Ontario Ministry of the Environment might not permit increased water taking to dewater the quarry under the above scenario. The implications of this should be contemplated.

9. Contamination of the 121 masl aquifer by any quarry activities is unacceptable. In addition to any other regulatory requirement, storage and handling of all potential groundwater contaminants must be restricted to areas having intact natural hydraulic barriers.

10. Deeper monitors should be constructed at the TW 10, TW 12 and TW 13 locations. The new monitors must verify the top elevation of the responsive bedrock aquifer. The monitors must be constructed to provide representative water pressure data of this aquifer.

11. I recommend that, at a minimum, the bi-monthly water pressure data collection frequency be maintained. I strongly recommend the continuous collection of groundwater pressure data via in-well data loggers at monitors TW 9-1, TW 11-1, and the above-recommended deeper monitors at TW 10, TW 12 and TW 13.

My detailed reasons for these comments are provided below.

Quarry Location and Site Description

The Miller Braeside quarry is located approximately 2 kilometres west of Braeside. The existing licensed area is 29.7 hectares. The presently excavated area is 17.1 hectares. The current excavation is located in the southern corner of the property.

At present, the minimum quarry elevation is approximately 134 metres above sea level, or "masl". This elevation is approximately 10 metres below ground surface, or "mbgs".

Figure 2 of the Planning Justification Report depicts land usage near the quarry. I note these features reported within 500 metres of the subject property:

Direction	Features
Northwest	woodlands, Golf Club Road, 24 residential lots, 17 residences, golf course
Northeast	woodlands, open space, Hazelwood Drive, Coady Drive, 14 residential lots (estate residential subdivision), 3 residences
Southwest	Agriculture, Usborne Street. Campbell Drive, Carmichael Side Road, 12 residential lots, 13 residences
Southeast	Woodlands, wetland, County Road 3, Campbell Drive, Carmichael Side Road, 7 residential lots, 7 residences

The surrounding residences are not serviced by a municipal water system. Local residents rely on individual water wells for their domestic water supply. Figure 2 depicts the nearest residence 150 metres southwest of the excavation.

Proposed Quarry Operations

The application is for a Class A license. The proposed annual aggregate extraction will not exceed 1,000,000 tonnes (Ref. Section A, Item 3, Drawing No. 2033 - 3 of 6).

The total proposed license area is 132.7 hectares. Within this area, the proposed extractive area is 68.4 hectares. This is 4 times greater than the existing excavated area. The proposed excavation depth is 27 metres below existing high ground surface.

Two lifts are proposed and designated as “A” and “B”. The “Lift A” proposed base elevation is 133 masl. The “Lift B” proposed elevation is 125 masl. This is the proposed final elevation of the quarry floor. Lift B would also include a pump chamber with base elevation of 123 masl. Aggregate material will be extracted from below the established groundwater table.

Drawing No. 2033 - 3 of 6 depicts the proposed extraction sequence. The proposed sequence is summarized as follows:

Extraction Sequence	Description
1 A+B	South corner of existing excavation
1 B	Remainder of existing excavation
2 A+B	Northeasterly to proposed northeastern extraction limit
3 A+B	Northwesterly to proposed northern extraction limit
4 A+B	Northwesterly to proposed northwest extraction limit
5 A+B	Southwesterly to proposed southwest extraction limit

Geology

Appendix C of the Hydrogeological Assessment Report presents multiple well records and borehole logs. I have additionally consulted the following published references:

- *“Soil Survey of Renfrew County, Report No. 37 of the Ontario Soil Survey”*
- *“Ontario Geological Survey, Map P. 2726: Paleozoic Geology of the Arnprior - Quyon Area, Southern Ontario”*
- *“Ontario Base Map 10 18 3850 50350”*

I note the following:

Overburden

- Farmington Loam: up to 0.3 m thick at well TW 1. Main soil within area of interest.
- White Lake Gravelly Sandy Loam: up to 5.79 m thick at well TW 4 1&2.Associated with coniferous swamp forest at southwest corner of site.

Bedrock

- Bobcaygeon Formation: Limestone present at or near ground surface. Up to 11 metres thick at southern corner of site (well TW 9-1).
- Gull River Formation: Limestone with interbedded shale, at least 19 metres thick, underlying Bobcaygeon Formation .

Bedrock Structure

The quarry exists within the western extent of Western Quebec Seismic Zone. OGS Map P2726 depicts bedrock faults northeast and southwest of the site. Earthquakes up to magnitude 5.0 have been recorded within this region.

On this basis, I do not assume that local bedrock layers are flat and horizontal. Base mapping depicts ground surface dipping at an angle of 0.7 degrees northwestward. This slope is gradual and not easily seen in the field. However, it may have practical consequences on the scale being contemplated.

Appendix C of the Hydrogeological Assessment provides Bobcaygeon / Gull River Formation contact elevations. I note the following:

Drill Hole	Location (true)	Bobcaygeon / Gull River Contact Elevation (masl)
TW 13	West corner	133.48
TW 12	Northwest side	134.7
F	Southeast of sump	135.19
G	east portion of quarry	136.04
TW 11	North side	136.2
TW 10	Northeast corner	136.64
TW 9	Southeast corner	140.74

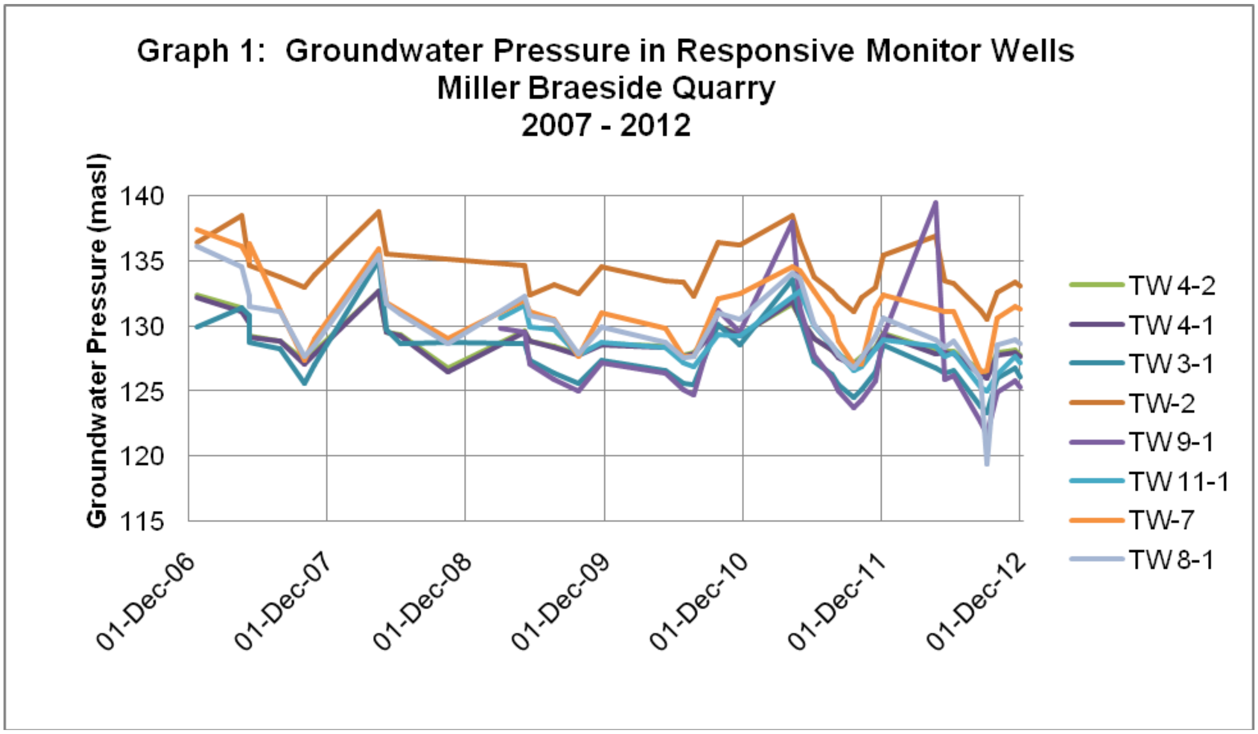
A general trend exists of higher contact elevations to the southeast and lower contact elevations to the northwest. The gradient between TW 9 and TW 13 is 7.26 metres per 850 metres. This equals an angle of 0.5 degrees, which generally conforms to local topography. Bedrock deformation may also cause lesser or greater slopes on a localized scale.

Hydrogeology

The 2012 Permit To Take Water Monitoring Report has informed my hydrogeologic opinions. The report includes groundwater pressure data collected regularly at the site from December 2006 until December 2012.

Hydraulically Active Intervals

Between 2007 and 2012 multiple monitors concurrently detected groundwater pressure variations on the order of 5 to 10 metres. Graph 1 (below) illustrates the historical variability.



The graph shows a distinct seasonal trend. Highest groundwater pressures typically occur during spring. This corresponds to the annual spring snowmelt period. Lowest ground water pressures typically occur post-summer.

Seasonal variability was negligible in monitors terminating at elevations above 121 masl. The seasonal variability is apparently restricted to monitors intersecting bedrock elevations lower than 121 masl. The highest intersected elevation for this responsive zone was 121.81 masl (TW 8-1). This corresponds to the deeper Gull River Formation.

The responsive monitors are distributed hundreds of metres apart throughout the study area. This suggests that the responsive bedrock layer is locally widespread.

Well Test Results

Hydrogeological Assessment Appendix A, Sub-Appendix III presents well test data for wells TW 1 through TW 8. I have examined these well test results. Tests performed at multi-level monitoring locations were particularly informative. Such monitors measure groundwater pressure at separate elevations within the same location.

During the well tests, multi-level monitors distributed throughout the study area were pumped for up to 6 hours. Water pressures at the co-located observation monitors were concurrently observed. Minimal groundwater pressure changes occurred within the co-located observation monitors during the tests. This indicates negligible vertical groundwater flow paths at the site.

Hydrogeological Assessment Appendix A, Figure 14 depicts a zone of groundwater springs within the study area. The springs are depicted on the northeast and southwest flanks of the site at elevations of 137 to 145 masl. The springs generally occur at the Bobcaygeon Formation / Gull River Formation contact. This suggests that infiltrating precipitation is diverted near this contact elevation. Infiltrated groundwater appears to migrate laterally to the springs and existing excavation.

Responsive Bedrock: Suspected Recharge Areas

The data do not support a scenario where infiltrating precipitation at the site migrates downward to the 121 masl aquifer. A lateral groundwater recharge scenario may exist.

Graph 1 (above) depicts general water pressure elevations in the responsive wells on the order of 130 masl. Gravity flow requires a recharge zone above this level. The aquifer's recharge area probably has the following characteristics:

- Water infiltration area above 130 masl.
- Responsive zone of Gull River Formation at or near surface.

Ontario Base Map 10 18 3850 50350 depicts a substantial flat area located 500 metres southeast of the proposed excavation (Lots 13 through 15). This flat zone has an approximate area of 1 km^2. Surface elevations in this area range from 134.5 masl to 139 masl. The base map infers that the area is slightly bowl-shaped. Considerable amounts of snowmelt would accumulate at the required elevation within this area.

Assuming a gradual local bedrock slope, the responsive bedrock zone is probably located less than 10 metres below ground surface throughout this area. By deduction, I conclude that this is the likeliest local recharge area for the responsive bedrock zone. Other potential recharge areas may also exist to the northwest.

Conceptual Model

Two separate groundwater flow systems exist within the proposed excavation area. An upper flow system exists within the Bobcaygeon formation. Within this upper system, precipitation rapidly infiltrates into the permeable Bobcaygeon Formation. The water is laterally diverted at or near the contact with the underlying Gull River Formation. The shallow system conveys groundwater laterally to discharge to the excavation and springs on the flanks of the plateau.

A deeper groundwater flow system exists in the underlying Gull River Formation. The responsive zone's elevation beneath the excavation is 121 masl or deeper. Groundwater in this zone likely infiltrates the subsurface 500 to 1500 metres east of the site. The lower aquifer conveys groundwater westward beneath the proposed excavation. The most likely discharge zone is Ryan Creek, located 500 metres southwest of the site.

Groundwater Resource Significance

Upper System:

The upper groundwater flow system supports springs and some nearby wetlands. Its elevation is higher than that of surrounding residential properties. It is not a groundwater source for local residential water wells. The Ministry of Natural Resources Hydrogeologist addresses the implications of quarrying on wetlands under separate cover.

Lower System:

The lower groundwater system is a confined aquifer. Groundwater pressures exceed the top elevation of the lower aquifer. Artesian conditions exist beneath the proposed excavation. This lower zone supplies residential water wells northwest and southwest of the site. It also provides base flow to Ryan Creek. Adverse groundwater quality or quantity impacts to this system are unacceptable.

Quarry Floor Buckling Risk

Approximately 23 metres of limestone bedrock overlies the deeper confined aquifer. The density of limestone is on the order of 2.5 tonnes per cubic metre. The current downward pressure on the confined aquifer is approximately 57 tonnes per square metre.

On average, the proponent intends to excavate bedrock to 19 metres below existing ground surface. This is equivalent to a 5 story building. This would reduce downward pressure on the aquifer by approximately 80% over spans of several hundred metres. The underlying aquifer imposes upward hydraulic pressure on the quarry floor. I anticipate a net increase in upward stress on the quarry floor as overlying rock is removed.

The fracture resistance of the quarry floor over the contemplated spans is a geotechnical issue beyond the scope of hydrogeology. The consultant proposes a 5 metre separation thickness between the proposed quarry floor and the underlying aquifer. I do not know how this thickness was determined. Substantiation of the separation thickness is required.

The quarry may abruptly flood if stress relief fractures intersect the underlying aquifer. I cannot guarantee that the Ontario Ministry of the Environment would permit increased water taking to dewater the quarry under such a scenario. This should be addressed.

Contamination Risk

The responsive lower aquifer is a local drinking water asset. Under natural conditions, it appears to be hydraulically isolated from surface contaminants within the area under discussion. I attribute this to low-permeable bedrock at or near the Bobcaygeon / Gull River Contact.

Contamination of the responsive lower aquifer by quarry activities is unacceptable. In addition to any other regulatory requirement, all potential groundwater contaminants must be restricted to areas of the site where the natural hydraulic barrier is intact.

<u>Groundwater Monitoring and Contingency Plans</u>

I submit the following comments:

- The TW 10, TW 12 and TW 13 monitors do not intersect the responsive bedrock aquifer. Deeper monitors should be constructed at these locations. The new monitors must verify the top elevation of the responsive bedrock aquifer. The monitors must be constructed to provide representative water pressure data of same.

- The bi-monthly hydrogeologic data collected to date under the existing PTTW conditions is informative. I recommend that, at a minimum, this data collection frequency be maintained.

- I strongly recommend the continuous collection of groundwater pressure data via in-well data loggers. I recommend that these instruments be deployed at monitors TW 9-1, TW 11-1, and the above-recommended deeper monitors at TW 10, TW 12 and TW 13.

- The proposed contingency plans provided are Section A of drawing 2033-5 of 6 is satisfactory.

Sincerely,

Shawn Kinney, M.Sc. P.Geo.
Hydrogeologist
Eastern Region
Ontario Ministry of the Environment
SK/gl

c: GW 02 07 REMB Miller Braeside Quarry Lots 16 & 17, Con A, McNab/Braeside Twp.
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