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November 12, 2013

Via: Email/Mail

Mr. Stan Denhoed, M.Sc., P.Eng.
Harden Environmental Services Ltd.
4622 Nassagaweya-Puslinch Townline Road,
R.R. 1
Moffat, ON L0P 1J0

Dear Mr. Denhoed:

Re: Summary of Drilling and Testing of New Well M15 at Hidden Quarry Site
File No.: 300032475.0000

Thank you for providing R.J. Burnside & Associates Limited (Burnside) with a copy of the June 7, 2013 Harden Environmental Services Ltd. (Harden) letter which documents the drilling and testing of new well M15 at the Hidden Quarry site. The Burnside comments are provided under the same section headings as used in the Harden letter.

2.2 Bedrock

Harden indicates that the uppermost bedrock encountered was the Niagara Falls Member of the Goat Island Formation and is not representative of the Eramosa Formation.

Burnside Comment

This is consistent with OGS Map P955 which indicates the Eramosa Formation extends just to the west of Rockwood and is not present beneath the Hidden Quarry Site.

Gasport Formation

The Gasport Formation is found between 10.03 and 48.50 mbgs (350.00 mamsl to 311.53 mamsl).

Burnside Comment

The extraction will occur in the Niagara Falls Member and the Gasport Formation with the proposed base of the quarry at 320 masl.

2.3 Descriptions of Core Breaks

Harden looked at each core break in the field and at their office and recorded only naturally occurring core breaks as either open or closed fractures. The highest concentrations of open fractures occur between a depth of 20 and 40 mbgs.

Burnside Comment

The bedrock extraction will occur from 10 to 40 mbgs. The upper 10 m of rock is not as fractured and may not fill with water as quickly as the rock from 20 to 40 mbgs resulting in temporary localized dewatering of the shallow fracture system.

3.0 Pumping Tests

Brief pumping tests were completed on M15 at rates of 2.1 L/s (for 60 minutes) and 4.2 L/s (30 minutes) with 1.21 m and 2.67 m of drawdown respectively. Wells M1D, M3 and M13D had no response to pumping. Water levels in M2 declined about 1.23 m. The pumping test data has been used to estimate the Transmissivity and hydraulic conductivity (K) of the bedrock aquifer.

Burnside Comment

A review of Figure 3.17 (Bedrock Groundwater Contours) in the Hydrogeological Investigation Report indicates that M2 is upgradient of M15 and M3 is crossgradient.

Water levels prior to the start of testing were as follows:

	Start
M15	350.69
M1D	352.34
M3	349.40
M13D	354.70
M2	not reported

The borehole log of M15 indicates bedrock was encountered at 9.55 mbgs and flow profiling indicates no flow below 41 m. As a result, the effective aquifer thickness is only 31.45 m which is less than indicated.

Using an average T of 60 m^2/day (from M15) and an aquifer thickness (b) of 31.45 m results in a K of 2.2 x 10^{-5} m/s which is very similar to that calculated by Harden.

The rapid response to pumping at M2 suggests there is a system of interconnected fractures aligned in a northwest direction. The lack of responses in MD, M3 or M13D could be simply due to the limited duration of the test or may indicate that the fracture system present at M2 and M15 is not present at the other locations.

Notation should be added to Figure 5 (Well M2 response)to indicate which portions of the graph represent the pumping test, flow profiling and pumping video.

3.1 Flow Test

The flow testing completed indicates approximately one-third of the M15 yield is derived from fractures between 10 and 36 mbgl, one-third from a single set of fractures at 36 m and a third is obtained from a fracture at 42 mbgs.

Burnside Comment

The flow testing indicates that the flow in the upper portion of the rock is decreased between 19 and 26 m. Similarly, the bedrock between 36 and 42 mbgs produces minimal flow could result in some temporary dewatering of the fractures above these zones while this portion of the rock fills with water during the extraction process.

6.0 Water Quality Results

A water sample collected from M15 had a nitrate concentration of 2.0 mg/L and a chloride concentration of 16.0 mg/L. Iron was not detected.

Burnside Comment

Samples from M2 collected in 1996 had a nitrate concentration of 6.8 mg/L, a chloride concentration of 12 mg/L and iron of 0.68 mg/L. A sample from the Dolime pit following a subaqueous blast had a nitrate concentration of 1.2 mg/L. This indicates that blasting may increase nitrate concentrations in the bedrock aquifer.

Once the quarry pond is created, there will be water mixing from all directions and depths. Harden should provide additional detail on how the exposure of the groundwater to air will impact iron (the concentrations at M2 are already above the Ontario Drinking Water Quality Standards (ODWQS)). Although iron is an aesthetic parameter, Harden should comment on the potential for iron to increase in downgradient wells; possibly causing problems with fixture staining and odours. Similarly, a mass balance calculation should be performed to estimate the nitrate concentration at the downgradient end of the quarry. Once the pond is created during extraction, it is anticipated that surface water pathogens such as Cryptosporidium and Giardia possibly will be present. These have the potential to move rapidly through bedrock fractures, impacting nearby domestic wells.

7.0 Recommended Multi-level Installation Details

Harden proposes that M15 be converted into a multi-level well with the following zones for monitoring:

Monitoring Level	Interval (mbgs)		Interval (mamsl)	
	From	To	From	To
Shallow	10	28	350.03	332.03
intermediate	33	38	327.03	322.03
Deep	40	55	320.03	3,05.03

Burnside Comment

Flow profiling and the pumping video do not indicate any flow below 45 m so there is no need to monitor this interval. Also, the proposed separation between the intermediate and deep monitors is only 2 m which is less than ideal to provide a good separation between the fractures. Burnside recommends the following be considered.

Monitoring Level (including 0.30 m of sand pack above screen)	Interval (mbgs)	
	From	To
Shallow	10	28
Seal	28	34
Intermediate	34	37
Seal	37	40
Deep	40	43

Burnside suggests that the screened interval be 0.3 m less than the monitored interval to allow for the placement of 0.3 m of sand between the top of the screen and the bentonite seal.

Once the multi-level well has been constructed and developed, in situ hydraulic conductivity and water quality testing should be completed.

8.0 Discussion

Based on the installation of M15, Harden offers the following comments regarding the hydrogeological conditions at the site:

1. There are no significant karst features identified in the geological profile. This is in keeping with the observations at M1, M2, M3, M4, M13D and M14D. The core obtained from M15 contains fractures, however, none suggest karstification of the dolostone aquifer.
2. Water bearing zones occur throughout the geological profile. The Gasport Formation is well known for its water bearing ability and this characteristic was confirmed at M15. Water bearing zones occur from the top of bedrock at an elevation of 350 mamsl to an elevation of 318 mamsl. There was no indication of preferential flow through the upper three metres of the geological profile.
3. Lateral hydraulic connectivity within the aquifer occurs at depth. There was a hydraulic response noted in monitor M2 to the pumping of M15. M2 and M15 fully penetrate the dolostone aquifer and the response in M2 verifies that water transmission will occur through the aquifer. This proves that M2 will be a useful monitor during the quarry operation to observe changes in the aquifer during extraction.
4. Hydraulic responses were not observed within the shallow bedrock at M1D, M13D or M3 whose completion elevations are all above 346 mamsl. These wells are completed in the upper 3 m of the bedrock. The lack of immediate hydraulic response is due to a relatively poor hydraulic connectivity between the shallow bedrock and deeper fractures; and poor lateral connectivity in the shallow zone. It is

anticipated that the shallow bedrock zone will ultimately experience a hydraulic response after a prolonged water level change. Although pumping periods were short, the response in the pumping well and in M2 were used to estimate transmissitivity of the aquifer. The near-well transmissivity is estimated to range from 50 m^2/day to 80 m^2/day. This correlates well to the bulk hydraulic conductivity used in the model for the dolostone aquifer. These values also correlate well to the hydraulic testing conducted on the adjacent Mudge property where transmissivity of the aquifer was found to range from 20 to 150 m^2/day.

Burnside Comment

Burnside concurs with the Harden discussion.

Under item 4, the lack of water level response in M1D, M3 and M13D while M15 was pumping appears to indicate a lack of hydraulic conductivity between the shallow bedrock and deeper fractures. However, the drawdown at M2 is consistent with the groundwater flow direction and may also indicate preferential alignment of water bearing fractures in a northwest direction.

9.0 Response to Burnside Comments

Harden provided updated responses to previous Burnside Comments 72, 60, 54 and 56.

Burnside Comments

72. Figure 7 provides a graphical presentation of the flow velocity. It indicates that 66% (2.78 L/s) of the flow is derived from fractures at 36 m and 41 mbgs with 30% (1.3 L/s) of flow found in the upper 36 m. There are several zones in the upper 36 m where there is no significant flow (i.e., from 19 to 26 m). As a result, as excavation proceeds between 19 and 26 m, water to make up the volume of rock removed will need to come from the bedrock between 10 and 19 mbgs. Burnside understands that this effect will decrease as each sinking cut is completed, however, the amount of drawdown during the initial cut should be quantified so that the impacts on nearby domestic wells can be realiably predicted.

60. The short term tests of M15 provide confirmation that the bulk hydraulic conductivity value used in the groundwater model is reasonable. Once the well is converted to a multi-level monitoring well, additional ‘K’ testing should be completed. Since the original groundwater model used a localized zone of higher ‘K’ to simulate conditions on the east side of the site, is there a benefit to including the low flow zone from 36 to 40 mbgs as a separate layer in the near site grid of the model. The Assessment of water quality impacts should consider the potential for nitrate, turbidity and surface water pathogens to move rapidly through fractures such as those seen at 36 and 41 mbgs in M15.

54. M15 was installed to address a concern with lack on onsite information on the bedrock formations. Once the multi-level monitor well is constructed and K tested and set up for long term monitor this comment will be satisfied.

56. Figure R8 indicates that there is a basal silt/till unit that is present throughout the site yet water from Tributary B is hypothesized to enter the bedrock at some point upstream of SW3. Since Harden indicates the water table is not present in the overburden throughout the entire site, there must be areas in the southern portion of the site where the silt unit is thin or absent. This was observed at M15 where granular sediments extended from the surface to the top of the bedrock.

Should you have any questions, please contact the undersigned.

Yours truly,

R.J. Burnside & Associates Limited

Dave Hopkins, P.Geo.
Hydrogeologist
DH:sd

cc: Ms. J. Sheppard, Township of Guleph/Eramosa (Hand Delivery)
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