PEER REVIEW COMMENTS

PROPOSED BURLINGTON QUARRY EXTENSION, NELSON AGGREGATES Co.

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PART A – ADAPTIVE MANAGEMENT PLAN (AMP)

1.0 GENERAL COMMENTS

AMP1 - There is no figure/map showing the location of wetland or stream monitoring locations.

AMP2 – Report appears to be incomplete (see previous comment) and section numbers referenced in the text do not correspond to actual numbers (e.g., references to Section 6).

AMP3 – Although titled "Adaptive", this plan is not so – there is no reference to how the monitoring would be adjusted/revised based on results, particularly in the event of unanticipated impacts. One particular fault is the absence of any contingency recommendations in the event of impacts such as shifting or halting quarry operations.

AMP4 - The Level 1 and 2 Hydrogeology Assessment notes that the Medad Valley is a "significant groundwater discharge area" (Level 1 and 2 Hydrogeology Assessment report). These discharges occur via springs located near the base of the Goat Island/Gasport formations. The locations of springs and one round of discharge estimates (March 2006) had been documented by Dr. Worthington. Given the noted significance of the springs, why are there no plans to monitor spring flows in the valley? There should be background monitoring and on-going monitoring for several springs over at least 2 years prior to quarrying. Estimated impacts are derived via an EPM model even though, as Dr. Worthington notes (Worthington 2006), each spring represents a discrete "karstic groundwater basin" (page 5) of varying sizes – a very specific anisotropic condition.

2. SPECIFIC COMMENTS

AMP5 - Cover Letter (dated April 23, 2020) and Page 2, second paragraph should note the Region of Halton directly as a consulting agency with regard to the AMP.

AMP6 - Page 2, third paragraph – Purpose of the AMP is to "verify that the quarry is operating without causing adverse impacts". No, the purpose of the AMP is to determine whether or not quarry operations impact ground and surface waters, to determine the nature of any impacts and take corrective actions.

AMP7 - Figure 1 – if the site not developing acceptably, then "Adjust/Refine/Modify"; this does not speak directly to quarry operations but could refer to only the monitoring. There should be a step involving quarry operational responses (e.g., stop quarrying). Without this, the plan is not "Adaptive" in any way.

AMP8 - Page 4, third paragraph – "Dewatering post extraction will also lower groundwater levels surrounding the west extension." What are the implications for the karstic subwatersheds feeding the springs in the Medad Valley? What is the final groundwater elevations?

AMP9 - Page 5, second paragraph – "the AMP will become a condition referenced on the approved ARA Site Plans". The most recent version of the site plans does not incorporate the AMP and does not show monitoring locations.

AMP10 - Page 5, footnote – this reference is intended to direct Earthfx's whole approach to setting thresholds. What are this author's qualifications and experience? Has this been peer-reviewed? There must be much greater discussion in the validity of this thesis than just throwing-off a single paper that is not fully reviewed, assessed or further discussed in the AMP.

AMP11 - Page 6, first paragraph – Further to comment AMP10, reference to a discussion regarding setting targets in Section 6 is confusing as Section 6 is titled "Jefferson Salamander Breeding Ponds".

AMP12 - Page 6, Section 4.1 and Table 10 – groundwater quality monitoring should be at least quarterly (as shown in Table 6 for surface water).

AMP13 - Page 7, Section 4.3 – impact assessments will only be undertaken during the first 5 years (of 10) of quarrying (?). The monitoring and assessment, particularly associated with wetlands should be undertaken throughout and following quarrying.

AMP14 - Page 7, Section 4.3 – what is the scientific justification for using thresholds based on a "worst-case" scenario? Thresholds need to reflect actual real-time climatic situations and be set accordingly.

AMP15 - Page 8, first paragraph – it seems obvious that the proposed monitoring well has shown "no drawdown" from the proposed quarry extension when quarrying has not yet occurred?

AMP16 - Page 8, Section 4.3.2, second paragraph – what is the proof for this statement? Even so what if there are false positives – better to be prepared than surprised!

AMP17 - Page 8, Section 4.3.2, third paragraph, last sentence – not clear what this says – it seems evident that there should be concern if levels drop "below a minimum reported".

AMP18 - Page 9, Section 4.3.3, first sentence – either this is self-evident or needs explanation as to how quarrying operations can be the "confirmed reason" for decreasing trends – please detail and indicate what operating adjustments are intended.

AMP19 - Page 10, Section 4.3.4, last paragraph (and page 28 last paragraph) – please provide details of this mounding and to what degree it will be maintained during quarrying despite an approximately 20 m lowering of the bedrock surface combined with pumping. Please provide a description of the height and extent of mounding (now and once new infiltration pond is created).

AMP20 - Page 11, Table 1, right column (and Table 3) – extreme drought based on existing data or simulated?

AMP21 - Page 16, second paragraph – what's the point of simply repeating the process? This should trigger a change in operations (e.g., full stop or re-direction)?

AMP22 - Page 17, Section 4.5.3 – this process/commitment has to be included in the Site Plans.

AMP23 - Page 20, complaint protocol – well contractor must be independent; if both pump condition and over-pumping is ruled out, then licensee's (note spelling in document) operations should be the default.

AMP24 - Page 23, Section 5.2 – why would stations be removed? Presumably they have been selected for specific purposes for impact assessment.

AMP25 - Table 7 – explain why there is no threshold value for SW14 in the Medad valley, located directly downflow from the west quarry extension.

AMP26 - Table 7 – note that flows go to "0 L/s" for SW6 and SW29 – the timing of this "threshold" in the year is important and what is the impact to Lake Medad/Grindstone Creek?

AMP27 - Page 25 – second paragraph, last sentence – if year-round baseflow in the West Arm of the West Branch of the Mount Nemo Tributary is required, why is the threshold for SW6 dry (0 L/s)?

AMP28 - Page 25, third paragraph and fourth paragraph– "Mitigation is discussed in Section 6.4" – correction, this should read "Section 5.4"

AMP29 - Table 8 – these hydroperiod thresholds (0.0 m of water level) seem to be reached very early in the year given the belief that the Halton Till is an "aquitard".

AMP30 - Page 29, additional mitigative measures – are these measures intended to be maintained post-closure if the wetland hydroperiod/stream flow thresholds are exceeded?

AMP31 - Page 39, AMP revisions – any revisions should be based on review of the data/trends and should be separately identified for the southern and western extensions. Why would the AMP be revised for the western extension when only the southern extension is being extracted? This needs to be more clearly defined as it will eventually be part of the Site Plans.

PART B: HALTON TILL PERMEABILITY

POSTULATE: The Halton Till does not have a uniform K; is not an aquitard; and has not been appropriately characterized with regard to wetland hydrology and model layer input.

1.0 WATER LEVEL DRAWDOWN IN WETLANDS

1. The Level 1 and 2 Natural Environment Report states (page 22) *"The numerical simulations confirm that the majority of the wetlands and streams are isolated from the water table by the low permeability Halton Till."* This is echoed on page 24 of the Level 1 and 2 Hydrogeological Assessment report.

2. On page 71 (Section 3.1), the hydrogeological report goes even further referring to the till as an "aquitard", limiting any interaction between surface and groundwater. During the August 10th video call, E.J. Wexler spoke about a "uniform K value for the Halton Till" (personal notes) and, in reference to Golder's MP16, suggested there may be "too much storage in the Halton Till…and [the till] may be even tighter" (personal notes). The Halton Till forms layer 2 in the model and is characterized as a uniform layer having an hydraulic conductivity of 5x10-7 (Table 18-4 and Figure 18-12).

3. However, on page 155 of the Level 1 and 2 Hydrogeological Assessment Report (and in Figure 6.31), in reference to Golder data (MP5), it is noted that Wetland 17 *"both receives and loses to groundwater, depending on the time of year."* Further, the Surface Water Assessment report notes (page 86, Table 42) that three wetlands effectively dry-out ("0.0 m water level") by late April to early May (SW11/13027; SW12/13022; and SW13/13037). These dates are identified in order to determine thresholds should impacts from quarrying result in earlier drying out (mitigation proposed on page 90, third bullet).

2.0 TILL FRACTUREING

4. The determination of matrix permeability (primary permeability) in tills is a grossly misleading determination of the potential for surface water to infiltrate to (in this case) the underlying bedrock. Tills are well known to have fractures, especially finer-grained materials, which create a secondary permeability that can be orders of magnitude higher that the primary permeability. Secondary permeability is achieved through drying-out and contraction over time (especially in fine grained tills); fracturing due to glacial isostatic flexing; soil pipes created by the downward

suffosion of material into underlying bedrock (especially where karst is present); root channels; and animal burrowing.

5. Till fracturing has been well documented. Freed (1993) for example, notes that:

   "Recent studies show (a) fractures in tills can greatly alter…hydraulic conductivity and storativity by allowing more fluids to move through the till…(b) fractures can alter the bulk permeability over the matrix permeability by several orders of magnitude…(c) isolation of surface contaminants from aquifers may not be possible due to fractures in the underlying unweathered till… and (d) fractures increase the median in-situ hydraulic conductivity by three orders of magnitude…"

6. The movement of a contaminant through deep silty clay materials into underlying karstic bedrock was clearly demonstrated during studies into the Smithville Ontario PCB 'spill' during the latter part of the last century (Worthington and Ford 1998). Although not a till per se, the deposit is a 9 – 12 m silty clay glaciolacustine deposit which, based on personal observations, may in fact be a reworked till. Worthington and Ford (1998), based on electrical conductivity measurements, indicated a double permeability with the presence of *"…wide-aperture pathways through the overburden. These pathways currently allow low-EC precipitation to rapidly flow through the overburden…the open fractures would have allowed prompt contamination of the bedrock very shortly after wastes started to leak from their containers."*

3.0 WETLAND HYDROGRAPHY IN THE NELSON STUDY AREA

7. The hydrographic data provided for the study area, originally by Golder (Golder Associates Ltd. data files, 2010), and subsequently in the current investigation's Level 1 and 2 Hydrogeological Assessment report do not support the hypothesis that the Halton Till is a single, continuous tight layer or aquitard.

8. A wetland (or pond) underlain by material having a very low permeability should demonstrate a very gradually lowering water level over the course of the hydroperiod assuming the level is not directly supported by underlying aquifer(s). For example, as the till aquifer level declines following snowmelt and spring precipitation, then the surface water level in the wetland should decrease very gradually over the course of the hydrological period potentially being recharged by rainfall but otherwise demonstrating a gradual but continuous decline.

9. This behaviour was, in fact simulated for Wetland 13032 (Figure 1). Following snowmelt and early precipitation from late March through early April, the water level gradually declines, responding only to rainfall events (as shown by each of the slight upticks) through the season reaching annual lows in late July/early August.

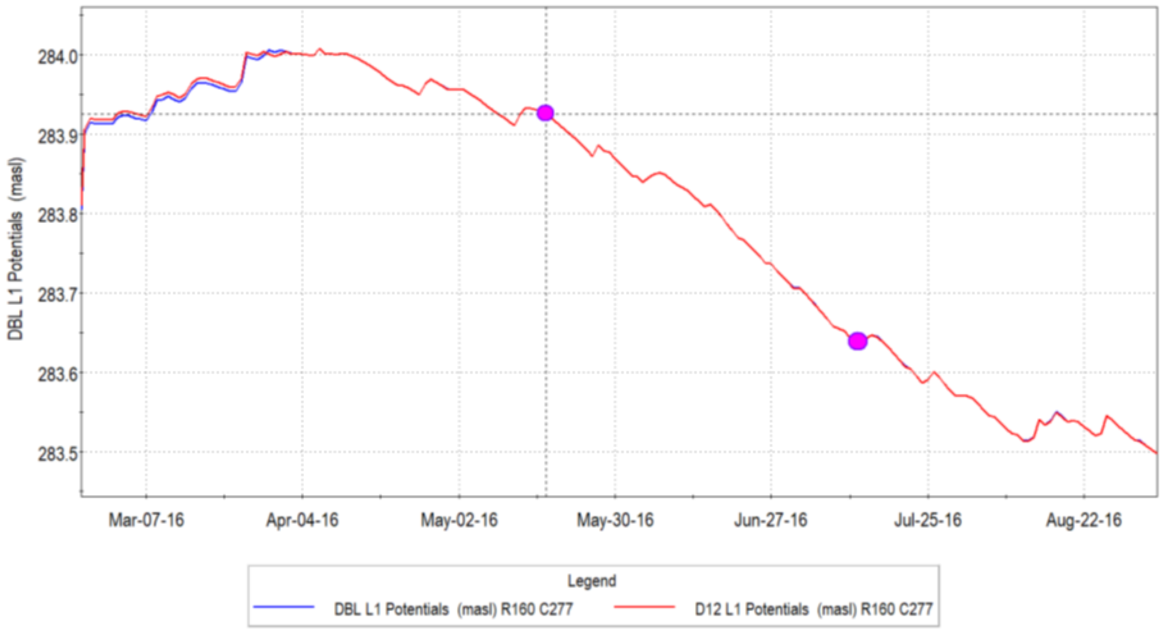

Figure 1. Simulated water level showing a spring recession pattern typical of wetlands underlain by low permeability materials (Figure 6.35 for Wetland 13032 in the Level 1 and 2 Hydrogeological Assessment). In this simulation, lowest wetland water levels are not achieved until August – September.

10. However, this pattern is not demonstrated in all wetlands located on the site. Table 42 (page 86) in the Surface Water Assessment report indicates that levels in at least four wetlands (SW11/13027; SW12/13022; SW13/13016) and SW16/13201) all reach "0" (based on 0.0 m reading on staff gauge) prior to late May on the 20-year monitoring and most prior to the first week of May. These indicate a pattern of snowmelt/spring precipitation fed systems immediately drying out by relatively rapid infiltration through the underlying till unlike the pattern demonstrated in Figure 1.

11. Figure 2 indicates that surface waters in the wetland are in fact directly connected to the underlying bedrock aquifer as shown by the precise correlation between the levels in MP-5 and all underlying wells. This behaviour is particularly well marked during the late Spring to early Winter period of 2007. The data are monthly, hence could mask some delay in response, however, such a direct correlation in levels as shown, even over monthly intervals indicate the presence of a direct hydraulic connection with the bedrock aquifer (compare to Figure 2 to Figure 1).

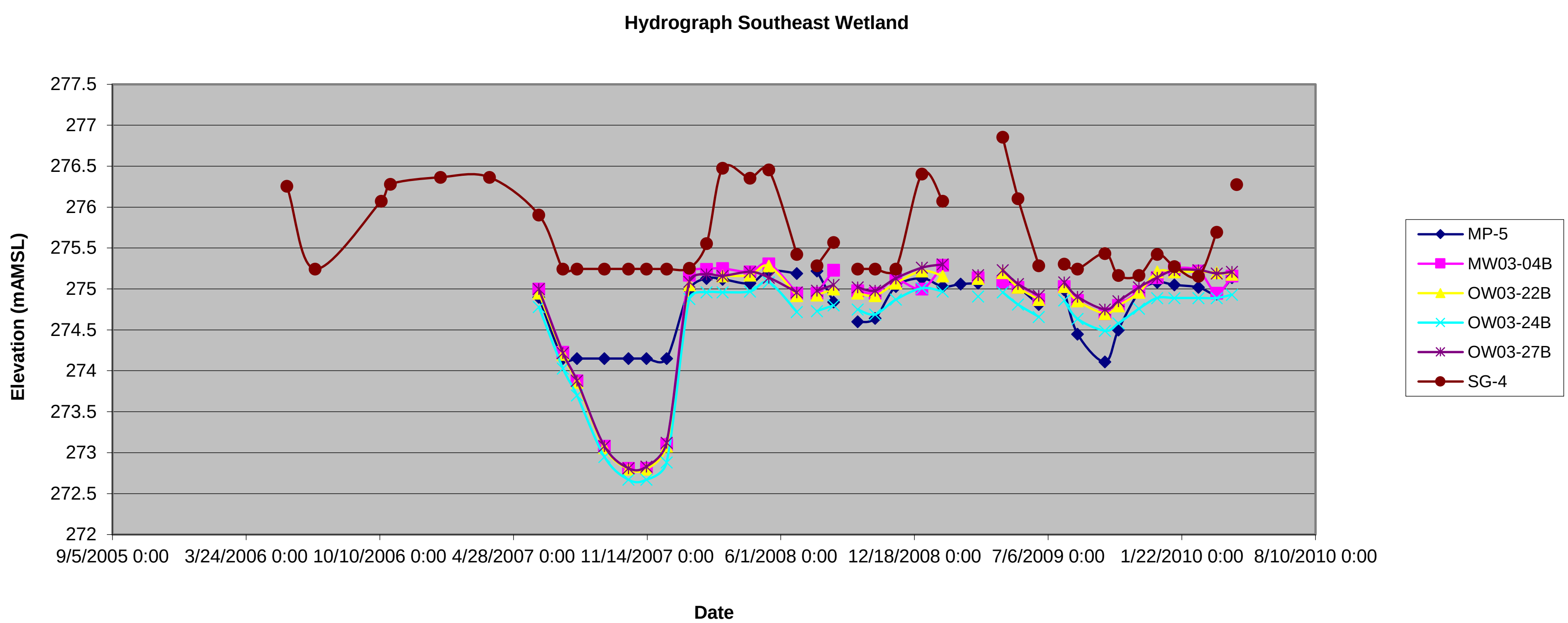

Figure 2. Manual water level hydrograph of MP-5, SG-4, OW3-22B as well as at three adjacent wells (OW03-24B, 27B, and MW03-04B). The “Southeast Wetland” of Golder Associates Ltd. (2006) is equivalent to Wetland 17/13033 in the Earthfx (2020) report (Figure 19-50).

12. Figure 3 shows the results of a 6-day pumping test in bedrock wells located near MP-5 and SG-2 during February 2006. The lack of any evident response in the mini-piezometer and staff guage (brown and blue lines, respectively) was provided as proof of the aquitard characteristic of the Halton Till. However the next year – 2007 – was a drought year and the full year hydrograph for the wells, mini-piezometer and staff guage demonstrate a direct connection (Figure 2). It is clear that a 6-day pumping test is not long enough to determine connectivity.

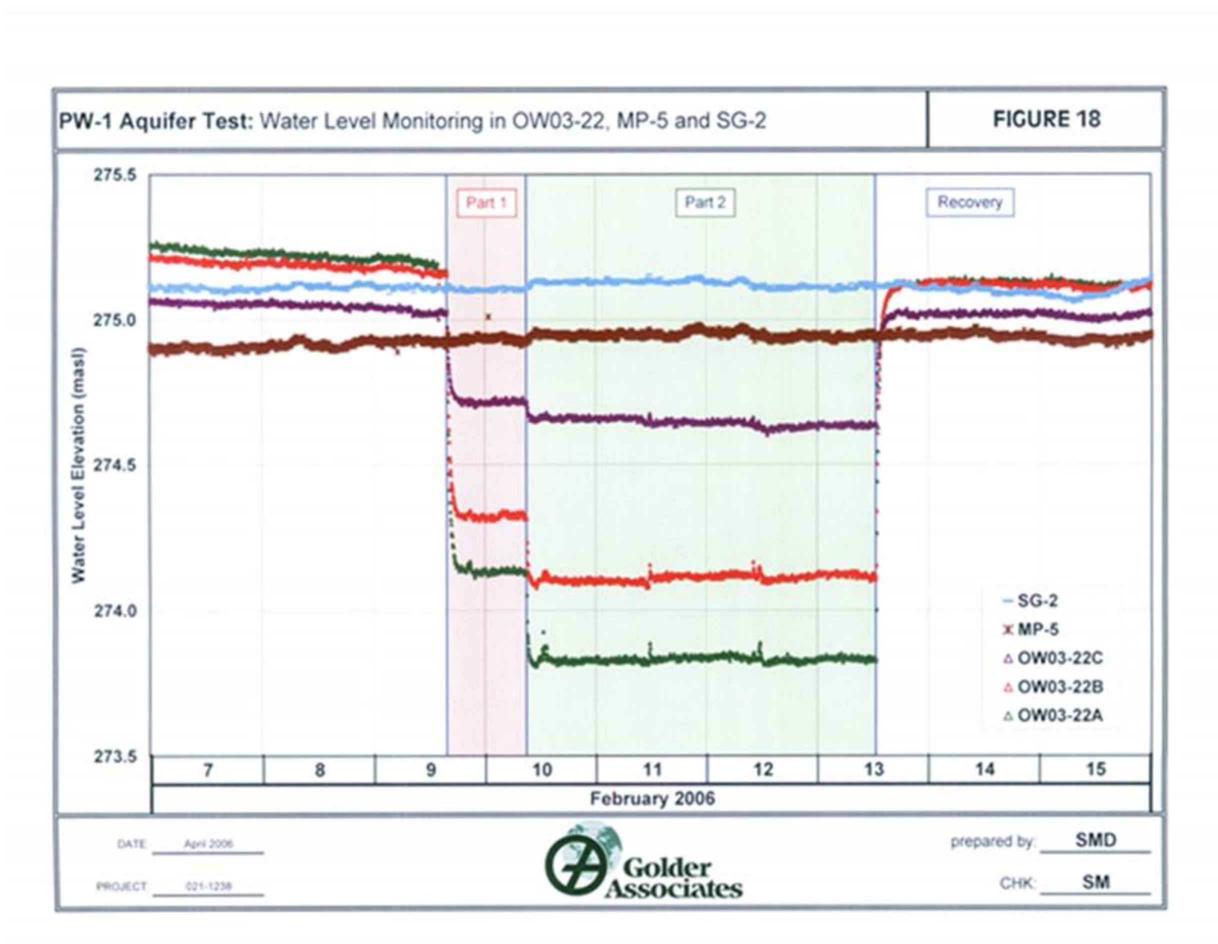

Figure 3: Aquifer pumping test results showing water levels in bedrock wells (OW03), the wetland surface (MP-5), and a staff gauge (SG-2) in the southeast wetland during February 2006 (Golder Associates Ltd. 2006).

4.0 CONCLLUSIONS

i. The Halton Till is not an aquitard;

ii. Although matrix permeability may be very low in this till, overall permeability is much higher and varies across the study area over orders of magnitude.

iii. A short pumping test (e.g., 6 – 10 days) is not sufficient to determine potential connectivity between wetlands and the underlying bedrock aquifer.

iv. Although some wetlands may demonstrate a gradual infiltration through subsoils, most indicate a rapid infiltration through the till following snowmelt.

v. As bedrock groundwater levels decline in each expansion area as quarrying advances, many wetlands will dry-out and will stay dry through most of the hydroperiod until the excavated area(s) re-fills.

vi. The actual permeability and spatial variability of the Halton Till needs to be better defined in order to enhance model efficacy (Layer 2 = unweathered till/aquitard).

5.0 RECOMMENDATIONS

i. A 30-day pumping test should be conducted in at least 2 wetlands (e.g., 17/13033) to determine degree of connectivity between wetlands and the underlying aquifer.

ii. Wetland hydroperiods will be impacted during quarrying and prior to excavation lake filling (and potentially after filling depending on final levels). These impacts need to be assessed and potential mitigation measures should be developed.

iii. The Halton Till layer in the hydrogeological model requires better hydraulic conductivity definition (absolute K values and spatial distribution).

6.0 REFERENCES

Freed, R.L. 1993. A fracture analysis of glacial tills in southwest Michigan. Master Theses. 786. (https://scholarworks.wmich.edu/masters_theses/786).

Worthington, S.R.H. and D.C. Ford (1998). A phased study of continuous water level, electrical conductivity and temperatuer measurements at Smithville. Prepared for Smithville Phase IV Bedrock Remediation Program (deliverable #11): 47 p.

PART C: MEDAD VALLEY GROUNDWATER DISCHARGE

POSTULATE: Groundwater flows to the Medad Valley have not been adequately characterized; these flows involve flow through discrete karst conduits (not EPM); and impacts to the valley and its wetlands have not been adequately defined.

1.0 INTRODUCTION

14. The Medad Valley is a Provincially Significant Wetland (PSW) and lies within the Niagara Escarpment Planning Area. It is also designated as a Provincially Significant Earth and Life Science ANSI. The wetland complex within the valley is formally identified by MNRF as the “Medad Valley Wetland Complex”. The proposed west extension is currently zoned as “Escarpment Rural Area” and the valley itself is predominantly “Escarpment Natural Area” surrounded by “Escarpment Protection Area”.

15. PSW’s are designated as significant natural heritage features under the Provincial Policy Statement which, as defined in the Natural Heritage Reference Manual, specifies no development within a PSW and a full impact assessment is required where developments are proposed within 120 m of the PSW boundary.

16. Ontario Regulation 162/06 (HRCA under the CA Act) also prevents developments within wetlands that “could interfere with the hydrologic function of a wetland, including areas up to 120 meters of all provincially significant wetlands…”

17. The Niagara Escarpment Commission Plan also requires a natural heritage evaluation in cases where a development is proposed within 120 m of any key natural heritage feature or key hydrologic feature (Policy 2.7.6) and the evaluation should demonstrate that “the connectivity between key natural heritage features and key hydrologic features located within 240 meters of each other will be maintained…” (Policy 2.7.6d).

18. Although the Natural Environment Report (Savanta Inc. 2020) and Surface Water Assessment Report (Tatham Engineering 2020) provide some description of form and function of the Medad Valley Wetland Complex, wetland impact assessment is principally associated with fish habitat in creeks within the valley. There is no discussion of wetland water balance and potential impacts on hydrological (other than valley stream flows) and hydrogeological function nor impacts to flora and fauna (other than fish) due to the proposed quarry extension. Wetland water balances are provided for many wetlands but not for the Medad Valley Wetland Complex (Earthfx ID #24).

2.0 LEVEL 2 IMPACT ASSESSMENT

19. The Level 2 Impact Assessment of the Hydrogeological Assessment report (Section 8) refers to the Medad Valley as a *"significant discharge area"* (Page 192, first paragraph). Table 8.1 specifically identifies the need to evaluate springs: "Springs located downgradient of the Site in the Medad Valley, and headwater streams located in and around the Mt. Nemo escarpment area" for which there is a need to "assess potential impact on springs."

20. The Medad Valley Wetland Complex is within 120 m of the proposed western extension development boundary yet Table 8.1 does not identify the need to assess impacts to the wetland complex per se as required under the PPS and under HRCA Regulation 162/06. Although most of the western extension quarry operations will technically occur beyond 120 m (but within the 240 m specified by the NEC), there is no doubt that impacts to groundwater flows to the springs could significantly impact "hydrological and hydrogeological functions" in the Medad Valley Wetland Complex.

21. Although the springs in the Medad Valley are singled out as a target of impact assessment and mitigation in Table 8.1, there is no other mention of springs in the remainder of the document other than a brief note in the summary (Section 11.2, page 324) *"There are other groundwater springs (karst discharge features) in the Medad Valley, but these are masked by the wetlands that fill the valley."*

22. The discharges are not masked as indicated in the Level 1 and 2 Hydrogeological Assessment and have been mapped by Worthington (2006, 2020) as discrete features.

3.0 GROUNDWATER FLOW TO THE MEDAD VALLEY

23. Worthington (2006 and 2020) documented the presence and location of 10 springs in the Medad Valley. He provided one-time flow estimates (March 23, 2006) that ranged between 3 and 32 L/S at the time of observation. Springs G, H, J, and K are all within about 1 km of the western extension and spring J is within about 500 m (see Worthington Figure 1a below). These four springs have a combined flow estimated at 45 L/s.

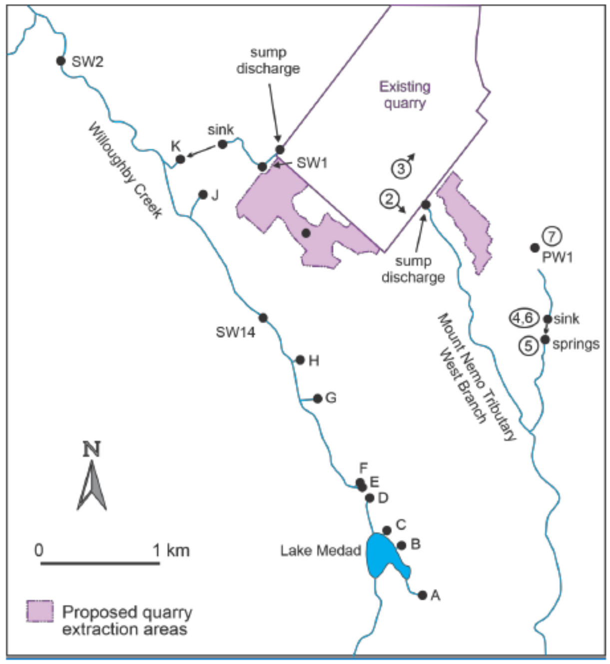

Figure 1a. Location of springs A to K, sinking streams near the quarry, and locations of the photos (circled numbers) shown in Figures 2 to 7.

24. All springs are located at or near the base of the carbonate aquifer (Goat Island/Gasport), either at the top of the Cabot Head or more likely, at the interface of the Irondequoit – Rockway formations (F. Brunton, Ontario Geological Survey, field trip notes, September 2008).

25. In either case, they lie near the base of the valley wall. Spring elevations are not documented but are likely at about 250 m amsl based on visible contour flattening (see Site Plan, Page 2) which is very close to the final quarry floor at 252.5 m. The springs are approximately 20 m below the top of bedrock at the northwest corner of the western extension but will be only a couple of meters below the proposed quarry floor.

26. The northwest corner of the western extension quarry is within 200 m of the base of the Medad Valley wall, thus yielding a pre-development hydraulic gradient in the order of 1:10 and post-development gradient of 1:80; an approximately eight times shallowing of the groundwater surface. Spring J would have a pre-development hydraulic gradient in the order of 1:25 and spring K about 1:50: both well above the post-development condition.

27. The Level 1 and 2 Hydrogeological Assessment (Page 115) notes that:

> *"With increasing distance from the quarry, the difference in head between the shallow and deep system is reduced. At 300 m from the face, the difference in head has decreased to 10 m…and the* ***water levels in the deep system become much more variable (as much as 6 m)****. This variability is due to the effects of seasonal recharge that serve to replenish the lower system. During the spring freshet, higher rates of recharge*

and higher water table are able to fill the vertical fractures and drive flow to the lower system faster than it drains laterally to the quarry... ***at 650 m from the quarry face…up to 4 m in head difference.*** *"* (highlighting mine)

28. These estimates are based on borehole measurements around the existing quarry and EPM model simulations. They represent conditions on the upper bedrock plateau and do not represent conditions between a quarry wall and the escarpment face. The steep hydraulic gradients noted above, in combination with extensive bedrock fracturing (as well documented), creates a very steep potentiometric surface in the unconfined aquifer which drains through fractures and emerge as discrete springs at the base of the escarpment face (a discharge face).

29. The potentiometric surface is not discussed nor portrayed in the Level 1 and 2 Hydrogeological Assessment report however Figure 6-37 provides isolines of the March average simulated groundwater heads. These suggest a groundwater divide at between 265 and 270 m amsl which lies directly within the proposed extension. The figure does not show a detailed potentiometric surface but the steep hydraulic gradients toward the escarpment face, in combination with an approximately 20 m lowering of the plateau surface within the western extension will, without question, lower the divide and, by definition, reduce groundwater flows toward the Medad Valley Wetland Complex.

4.0 KARST (non-EPM) CONSIDERATIONS

30. Worthington (2006) estimates that spring C (27 L/s) has a groundwater basin of 1 to 5 km^2 (Page 5). He also notes that this spring is located 2.4 km *"from the closest point of the [southern] extension lands, and…it seems possible that this spring may drain part of the [southern] extension lands."* The currently proposed southern extension, although smaller in area than that proposed in 2004, remains within about 2.4 km of spring C.

31. Although Worthington was relying on the former Golder model to make these area determinations, that model is also an EPM-based model and neither the Golder Model nor the Earthfx Model account for flow along fractures (secondary permeability) or karst conduits (tertiary permeability). Secondary and/or tertiary permeability pathways in simple sinkhole to spring systems along the escarpment in southern Ontario, can be much longer that 1 km and, in my experience working on the Niagara Escarpment, distances from source to spring in the order of 2 km is not uncommon. Worthington (2020) notes that given the high *"bulk hydraulic conductivity of the aquifer (~10^{-5} to 10^{-4} m/s)…almost all the flow is through the fracture network."*

32. Worthington (2006) mapped and traced karst conduit systems to the south (West Tributary) and north (Willoughby Creek – spring K). The latter indicates that karst conduits directly feeding the Medad Valley springs are, in fact, present. He did not observe sinkholes within the western extension area (Worthington 2020), however, his Figure A7 (partially reproduced below) indicates the presence of "Karst" weathered vugs along bedding planes in borehole BH06-1. These are found at 8.09 m, 8.34 m and 18.79 m below ground surface adjacent to the southern extension area.

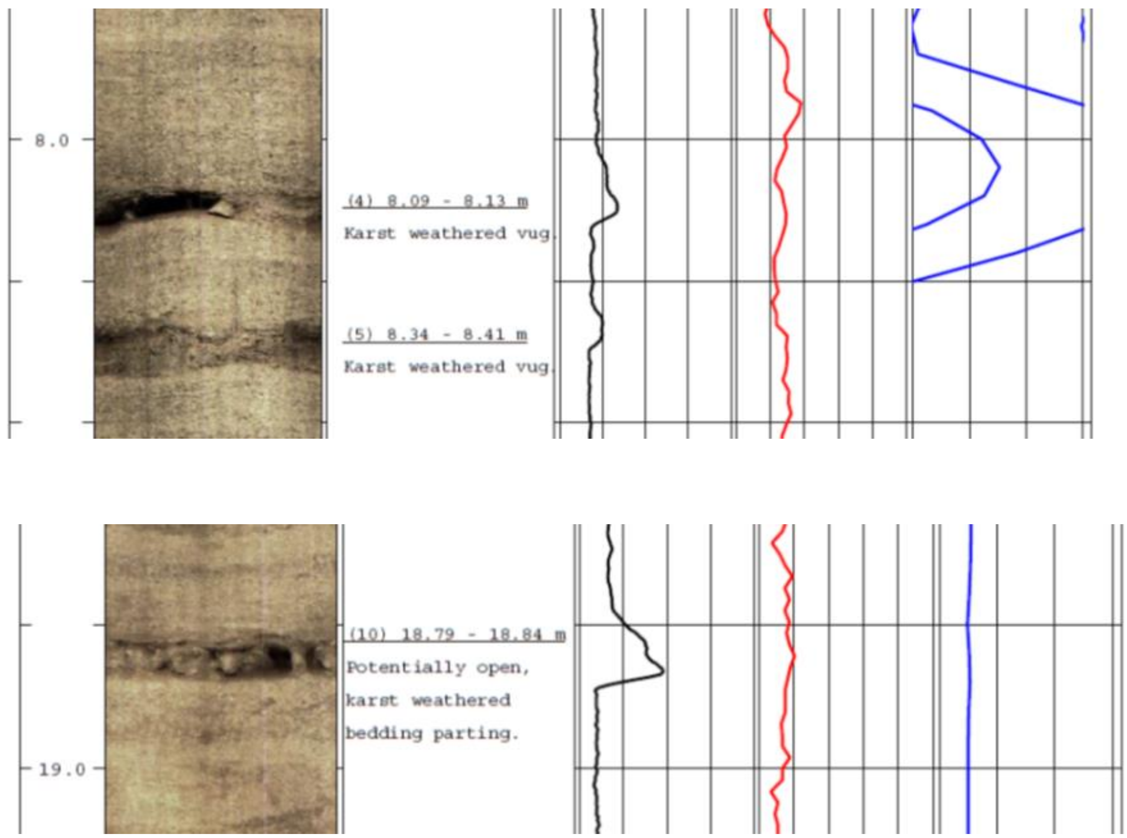

Figure 2. A portion of Figure A7 (Borehole BH06-1) from Worthington (2020).

33. The uppermost vug is particularly interesting being up 4 cm wide and open. It also shows a significantly higher specific conductivity (blue vertical line) than the remainder of the core indicating the presence of carbonate-rich water.

34. Borehole BH06-1 is located northeast of the proposed southern extension. The continuity and extension of these "vugs" are not fully known but at least the uppermost vug provides indications of water transmission which suggests some continuity. This is confirmed by the

flowmeter results from wells OW-03-30 and OW-03-31 (Worthington Figures A8 and A9) which show strong flows in the 7 to 8 mbgs depth.

35. The final quarry floor in the western extension will be at an elevation of 252.5 m amsl which is well below the elevations of all three of the "karst-weathered " bedding planes.

36. The Level 1 and 2 Hydrogeological Assessment also documented open fractures in boreholes located within the western extension. This included references to the presence of "moderately open" fractures in the composite video log (Appendix A, Figure 4.2.3) and several of the borehole logs were annotated as "heavily fractured" (BS01), and "larger fractures" (BS02).

37. The Site Plan and AMP note that an "infiltration pond" will be constructed immediately west of the quarry face in the western extension. The specific role and character of this pond is not detailed in the supporting documentation but appears to serve a dual purpose of water supply for continuing sump operations and providing some form of groundwater mounding. Again, this is not quantified but the infiltration will likely be mostly directed toward the open quarry floor (which is continually drained) and will not provide any significant flow toward the escarpment face in the Medad Valley.

5.0 MEDAD VALLEY GROUNDWATER LEVEL 2 ASSESSMENT

38. The Level 1 and 2 Hydrogeological Assessment report notes (Page 24, Executive Summary) that

    > *"The Medad Valley is a locally significant groundwater discharge area that receives the majority of the groundwater that flows in and around the existing and proposed quarry [western extension]. The development of the West Extension will shift some of the groundwater discharge to the north, through the North Discharge pond, but ultimately all of its discharge* ***simply*** *enters the Medad Valley in a similar manner to the current discharge."* (highlight mine).

39. Further, Section 8.7.6 of the assessment report concludes *"Overall, the construction of the west extension has a minor impact on the Medad Valley. No water is diverted away from this natural discharge zone, but some water is discharged slightly to the north via north quarry discharge stream."*

40. These statements are based on simulated model stream flows for "baseline" (current) and post-quarrying that show net average reductions of about 2 L/s in flow downstream of SW07 (Willoughby Creek below spring J) resulting in "no significant change downstream at SW1."

41. [Note: SW1 is the main quarry discharge station which is located **above** the Medad Valley; it is likely that this is an error as the station below SW07 is SW02 located at Bronte Creek. Worthington (2006) appears to have made the same error in Table 1 although this is corrected in his 2020 karst report.]

42. These statements are based on simulations from an EPM model that can't model flow in individual fractures, particularly if enhanced by karst solution (tertiary permeability). The presence of karst conduits is known to occur based on the presence of the sink to spring system in the Willoughby Creek headwater (spring K).

43. In addition, groundwater discharges to the Medad Valley occur via discrete spring locations which are clearly fed by one or more fractures ("karst discharge features" page 324). Enhanced solution of these fractures is on-going for some distance above the springs. If EPM conditions existed along the Medad Valley escarpment face, the entire lower portion of the face would discharge groundwater not only at discrete spring points.

6.0 CONCLUSIONS

i. The Medad Valley incorporates a Provincially Significant Wetland complex, Provincially Significant Earth and Life Science ANSIs, and significant Niagara Escarpment Natural areas.

ii. The Medad Valley wetlands are within 120 m of the western extension boundary and the proposed quarry is within 240 m of the wetland complex.

iii. The Level 1 and 2 Hydrogeological Assessment report states that the discrete groundwater discharges "springs" in the valley should be assessed for impacts but no assessment is provided.

iv. Assessments are limited to simulated stream flows within the valley based on EPM modelling.

v. "Baseline" conditions in the assessment do not account for impacts to Medad Valley Wetland Complex that may have occurred as a result of the quarrying at the existing quarry which would have shifted the pre-development groundwater divide significantly to the west (cumulative impacts are not considered).

vi. Groundwater flows between the proposed quarry and the Medad Valley are conducted via secondary (fractures) and tertiary (karst) permeability which the model does not simulate.

vii. Quarrying in the western extension (and, to some degree in the southern extension) will lower groundwater divides to the valley resulting in significant reductions in groundwater flow to known springs.

viii. There is no evidence (or explanation) as to how the "Infiltration Pond" will mound groundwater between the western extension and the Medad Valley springs.

ix. Long-term mitigation of reduced groundwater flows to the Medad Valley would best be obtained by creating lakes in the western extension following quarrying.

x. Spring elevations have not been documented but it is likely that there will be in the order of only 2 – 3 m of aquifer available between the western extension quarry floor and the springs.

7.0 Recommendations

i. Continuous spring flow monitoring should be undertaken for (at least) Medad Valley springs C, G, H, J and K commencing at least 2 years prior to quarrying in the western extension and throughout the period of rehabilitation.

ii. Monitoring should include flow, temperature, conductivity and suspended solids, at a minimum, and be added to the AMP with designated targets and contingency triggers and response.

iii. A detailed potentiometric surface should be provided.

iv. Dye trace(s) should be conducted between boreholes in the western extension and the same springs noted above in recommendation #1.

v. Following quarrying, the western extension should be rehabilitated to lakes.

Respectfully submitted,

Daryl W. Cowell, M.Sc., P.Geo. (#0791)
December 21, 2020