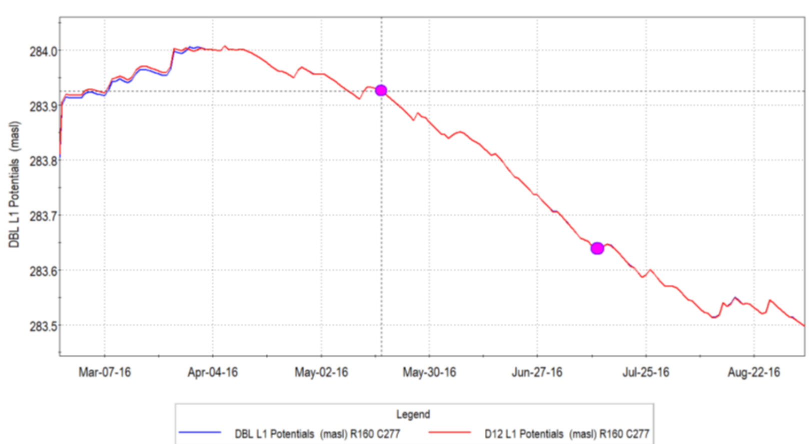
Proposed Burlington Quarry Expansion
JART COMMENT SUMMARY TABLE – Hydrogeology

Please accept the following as feedback from the Burlington Quarry Joint Agency Review Team (JART). Fully addressing each comment below will help expedite the potential for resolutions of the consolidated JART objections and individual agency objections. **Additional, new comments may be provided once a response has been prepared to the comments raised below and additional information provided**.

	JART Comments (February 2021)	Reference	Source of Comment	Applicant Response	JART Response
Report/Date: Level 1 and Level 2 Hydrogeological and Hydrological Impact Assessment Report, April 2020				**Author: Earthfx Incorporated**	
1.	All studies should be coordinated and integrated. In particular, the findings of the Hydrogeologic and Hydrologic Impact Assessment, Surface Water Assessment and Level 1 and 2 Natural Environment Technical Report should inform each other and should be reviewed for consistency.	General	Conservation Halton		
2.	The proposed external catchment diversion along Colling Road should be discussed within the Impact Assessment, with modeling updated if necessary. Identify and address any uncertainty associated with completion of these works within the analysis and report.	General	Conservation Halton		
3.	The report lacks discussion on the realized impact of the existing extraction operation on groundwater in the area throughout its lifespan. (Part 2.2.1 & 2.9.3 (g)). Discussion on cumulative impacts and the objective of minimizing negative impact on surrounding land uses would benefit from the inclusion of such information.	General	Niagara Escarpment Commission		
4.	Review of rehabilitation scenarios should better reflect the requirements of the NEP (2017). Currently there is no concrete evidence that the natural and hydrological features of either expansion sites are being restored or enhanced. • Scenario 1 describes that "the overall hydrogeologic and hydrologic conditions will be similar to the final extraction "phase". Please consider Part 2.9.11 (a) & (b) of the NEP. • Scenario 1 will require perpetual pumping of the site to ensure appropriate water levels. More detail on how this would support other public water management needs should be provided. NEC Staff interpret this to mean supporting existing water management needs, not as a mitigation measure to achieve a proposed after-use. (Part 2.9.11 (j)). • Scenario 2 describes that the whole quarry will be allowed to fill and become a lake. Additionally, groundwater levels will be impacted as will stream segments (key hydrologic features). Please consider 2.9.11 (a) & (b) of the NEP.	General	Niagara Escarpment Commission		
5.	Better integration between the findings of Hydrogeological report and the Natural Environment Technical report should be considered. • Hydro report suggests that the effects of a 3.0% loss to the inflow of groundwater to 5 of 22 wetlands is so small that "it cannot be measured in the field". What type of effects are being measured? How does even a 3.0% loss of groundwater inflow to these key hydrologic features achieve Parts 2.6.3, 2.7.6, 2.9.3 (d & e) of the NEP (2017)?	General	Niagara Escarpment Commission		
6.	The hydrogeological analysis and resulting conclusions rely heavily upon the results of the integrated computer modelling and simulations and does not provide due consideration to conflicting field data. For example, the assumption of the modelling that the local bedrock aquifers behave hydraulically as equivalent porous media when field testing such as pump tests and previously conducted borehole flow testing shows significant variability in hydraulic performance of the under lying bedrock layers. In addition, computer model simulations of groundwater mounding beneath the existing	General	Norbert M. Woerns		

	irrigation ponds in the Western Extension area and the proposed recharge ponds within this area are not supported with field data to confirm groundwater mounding and the recharge characteristic of these ponds.				
7.	The hydrogeological analysis has failed to address the potential for groundwater and surface water contamination and is therefore incomplete.	General	Norbert M. Woerns		
8.	Groundwater quality monitoring is outlined in the AMP report. There is limited documentation of water quality provided in the Earthfx report. Water quality information is provided in Appendix A with a discussion of general water types. There is an incomplete analysis and discussion of ground water quality and the interrelationship of surface water discharge to groundwater quality through infiltration mitigation measures. There is no link between parameters for groundwater quality monitoring and surface water quality monitoring parameters. A discussion is lacking of groundwater water quality results with respect to Ontario Drinking Water Standards (ODWS, 2006), groundwater quality thresholds and mitigation measures. This should be included in the report.	General	Norbert M. Woerns		
9.	The hydrogeological investigations have failed to clarify the issue of overburden hydraulic conductivity and interconnection of the overburden with under lying bedrock. Previous pump test conducted in 2004 by Golder Associates (Golder), (Golder, September 2010) demonstrated apparent hydraulic connectivity between overburden and underlying bedrock underlying wetlands adjacent to previously proposed Nelson Quarry Extension. The pump test completed by Azimuth in the Western Extension lands monitored a nearby surface water level but did not monitor the overburden units during this pump test to determine the degree of hydraulic connectivity between overburden and the underlying bedrock.	General	Norbert M. Woerns		
10.	Hydrographs illustrating groundwater level trends are provided in the documentation however there is incomplete documentation of monitoring data including manual water level measurement from previous studies as well as the current investigations. Some of the missing data was subsequently provided in a computer input file format some of which was not readily decipherable.	General	Norbert M. Woerns		
11.	Borehole logs are provided in Appendix A which includes some boreholes completed by Golder as well as most borehole logs of holes completed as part of the Azimuth Environmental Consulting Inc. (Azimuth). A number of Golder borehole logs are not included. In addition, borehole logs for shallow groundwater monitors installed by Tatham and the logs for boreholes/wells drilled by Keith Lang on the western extension have also not been included in the documentation. Partial monitor detail information on the previously installed Golder groundwater monitors is provided in Table 9.1, page 311. A complete list of borehole logs and information included in the hydrogeological analysis with monitor completion details including piezometers installed near or in wetland features should be included in the documentation. Some of the requested borehole information was subsequently provided and received September 29, 2020. This information was provided in computer model input file formats and was not readily useful for peer review purposes.	General	Norbert M. Woerns		
12.	Appendix A describes the completion of a well survey however no results providing details of this well survey are included in the report. This should be provided in the documentation. Copies of 26 well survey forms were provided, September 29, 2020. Of the 156 private properties included in the well survey, it is not clear what information if any, exists on the remaining well survey properties. A summary table of well information from the well survey should be included in the hydrogeological report. The MECP well record data base would be useful in providing information on local private wells.	General	Norbert M. Woerns		
13.	The documentation is lacking a detailed and comprehensive analysis of vertical hydraulic gradients associated with wetland features and the implications to the computer modelling analysis and conclusions.	General	Norbert M. Woerns		

14.	The report states that 'A total of 5 of the 22 wetlands mapped in and around the quarry receive groundwater in the spring.' Page 23, 6th paragraph. This implies the remaining wetlands do not receive groundwater in the spring. Tatham Surface Water Report indicates only five of the wetlands appear to have been instrumented with piezometers to confirm this. Confirming shallow groundwater level measurements are missing for the remaining wetlands.	General	Norbert M. Woerns		
15.	The report does not discuss cumulative effects i.e., existing impacts vs additional impacts from expansion. The report should include a map showing the existing cone of influence and drawdown resulting from the existing quarry.	General	Norbert M. Woerns		
16.	The investigations have failed to demonstrate through on-site monitoring that the selected 'background monitoring well at 2377 Collins Road has not been affected by the existing quarry operations.	General	Norbert M. Woerns		
17.	The hydrogeological analysis is based upon the assumption that current conditions represent baseline conditions. Predicted changes in groundwater levels are compared to current baseline conditions. There is no discussion of the impacts from the historical operation of the existing quarry and relevance to closure requirements of the existing quarry licence. This should be included in the report.	General	Norbert M. Woerns		
18.	With respect to Rehabilitation Scenario 1 (RHB1), how does the retained consultant know that the infiltration pond for the western extension will provide adequate supplies of water (i.e., quantity and quality) to the deep bedrock (model layers 6 &8) and not short circuit groundwater infiltration to the shallow bedrock (model layers 4&5) and the local overburden sand deposits into which the infiltration pond is to be constructed. This does not appear to have been considered or accounted for in the computer model. There is also no analysis of implications of the proposed infiltration pond to water quality of the downgradient wells. This should be included in the report.	General	Norbert M. Woerns		
19.	Rehabilitation Scenario 1 (RHB1); There is no discussion of seepage into the main quarry area from the rehabilitated lake in Phase 1/2 and long term potential affects on stability of the intervening area and on No. 2 Sideroad. This should be addressed.	General	Norbert M. Woerns		
20.	The statistical methods for establishing groundwater level trends and thresholds appear to rely solely on simulated groundwater levels calibrated against water level data with significant data gaps and simulated climatic conditions. It is not clear that simulated climatic conditions will accurately reflect current climatic data. Threshold levels have only been assigned to deep monitoring wells completed into the lower Amabel Formation. This does not recognize local wells that are completed into shallow zones and their sensitivity to drawdown affects from the proposed quarry expansion. Threshold levels for shallow and intermediate depth wells should be included in the report.	General	Norbert M. Woerns		
21.	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.	General	Daryl W. Cowell & Associates Inc.		
22.	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.	General	Daryl W. Cowell & Associates Inc.		
23.	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)	General	Daryl W. Cowell & Associates Inc.		

	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…"				
24.	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 9.0 – 12.0 metre 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."	General	Daryl W. Cowell & Associates Inc.		
25.	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.	General	Daryl W. Cowell & Associates Inc.		
26.	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.	General	Daryl W. Cowell & Associates Inc.		
27.	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.	General	Daryl W. Cowell & Associates Inc.		
28.	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 metre reading on staff gauge) prior to late May on the 20-year	General	Daryl W. Cowell & Associates Inc.		

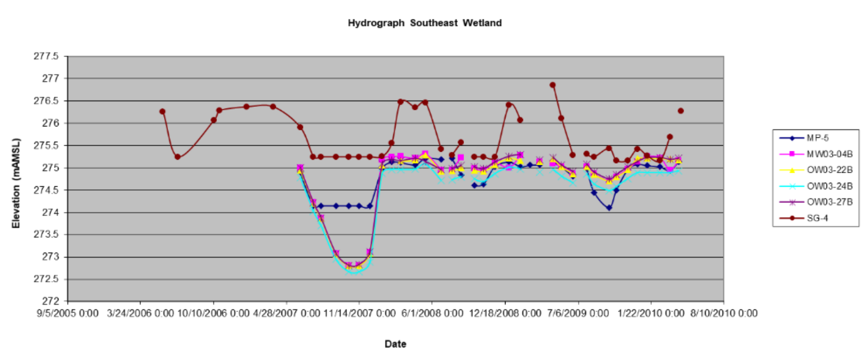
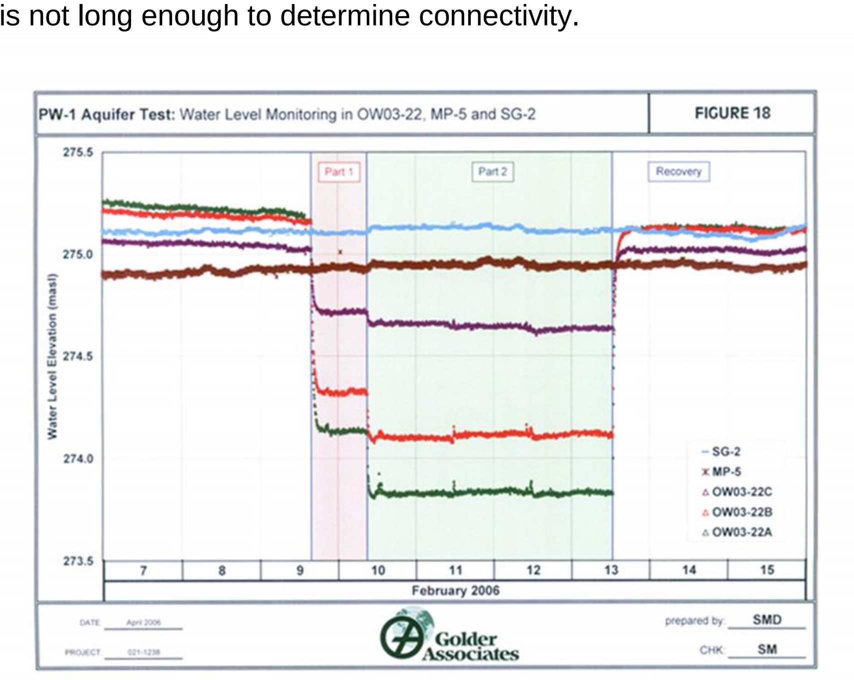
	monitoring and most prior to the first week of May. These indicate a pattern of snowmelt/spring precipitation fed systems immediately drying out by relatively rapid infiltration through the underlying till unlike the pattern demonstrated in Figure 1.				
29.	Figure 2 indicates that surface waters in 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).	General	Daryl W. Cowell & Associates Inc.		
30.	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. 	General	Daryl W. Cowell & Associates Inc.		

	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).				
31.	Recommendation: • 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.	General	Daryl W. Cowell & Associates Inc.		
32.	Recommendation: • 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.	General	Daryl W. Cowell & Associates Inc.		
33.	Recommendation: • The Halton Till layer in the hydrogeological model requires better hydraulic conductivity definition (absolute K values and spatial distribution).	General	Daryl W. Cowell & Associates Inc.		
34.	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.	General	Daryl W. Cowell & Associates Inc.		
35.	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”.	General	Daryl W. Cowell & Associates Inc.		
36.	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 120.0 metres of the PSW boundary.	General	Daryl W. Cowell & Associates Inc.		
37.	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 120.0 meters of all provincially significant wetlands…”	General	Daryl W. Cowell & Associates Inc.		
38.	The Niagara Escarpment Commission Plan also requires a natural heritage evaluation in cases where a development is proposed within 120.0 metres 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 240.0 meters of each other will be maintained…” (Policy 2.7.6d).	General	Daryl W. Cowell & Associates Inc.		
39.	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).	General	Daryl W. Cowell & Associates Inc.		
40.	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.	General	Daryl W. Cowell & Associates Inc.		
41.	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 3.0 and 32.0 litres/second at the time of observation. Springs G, H, J, and K are all within about 1.0 kilometre of the western extension and spring J is within about	General	Daryl W. Cowell & Associates Inc.		

500.0 metres (see Worthington Figure 1a below). These four springs have a combined flow estimated at 45.0 litres/second.

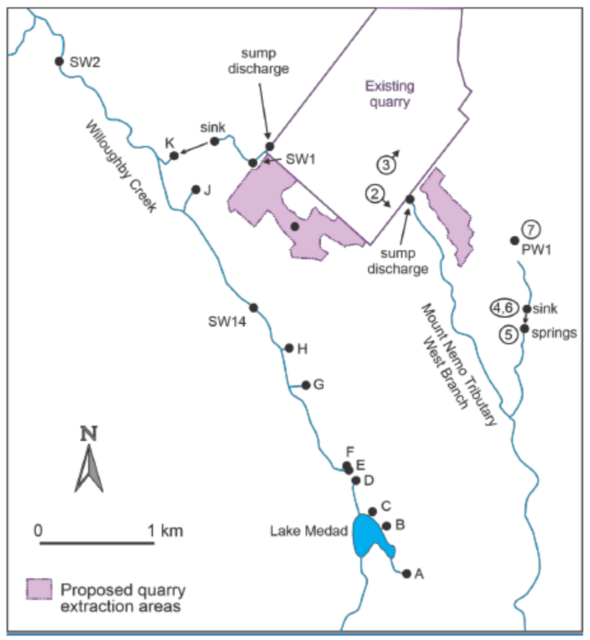
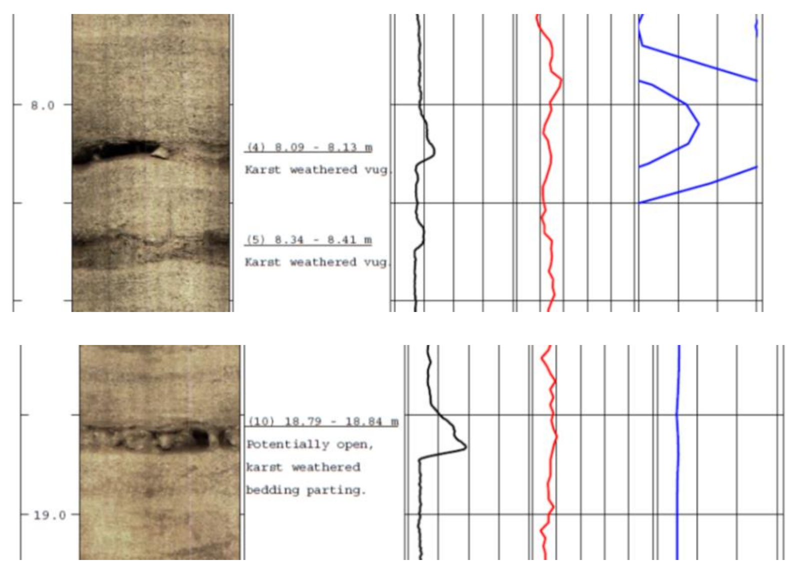


Figure 1a. Location of springs A to K, sinking streams near the quarry, and locations of the photos (circled numbers) shown in Figures 2 to 7.

42.	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).	General	Daryl W. Cowell & Associates Inc.		
43.	In either case, they lie near the base of the valley wall. Spring elevations are not documented but are likely at about 250.0 metres amsl based on visible contour flattening (see Site Plan, Page 2) which is very close to the final quarry floor at 252.5 metres. The springs are approximately 20.0 metres 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.	General	Daryl W. Cowell & Associates Inc.		
44.	The northwest corner of the western extension quarry is within 200.0 metres 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.	General	Daryl W. Cowell & Associates Inc.		
45.	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 265.0 and 270.0 metres 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 20.0 metre 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.	General	Daryl W. Cowell & Associates Inc.		
46.	Worthington (2006) estimates that spring C (27.0 litres/second) has a groundwater basin of 1 to 5.0 square kilometres (Page 5). He also notes that this spring is located 2.4 kilometres “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	General	Daryl W. Cowell & Associates Inc.		

	currently proposed southern extension, although smaller in area than that proposed in 2004, remains within about 2.4 kilometres of spring C.				
47.	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 1.0 kilometre and, in the retained consultant's experience working on the Niagara Escarpment, distances from source to spring in the order of 2.0 kilometres 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."	General	Daryl W. Cowell & Associates Inc.		
48.	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 metres, 8.34 metres and 18.79 metres below ground surface adjacent to the southern extension area.  Figure 2. A portion of Figure A7 (Borehole BH06-1) from Worthington (2020).	General	Daryl W. Cowell & Associates Inc.		
49.	The uppermost vug is particularly interesting being up 4.0 centimetres 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.	General	Daryl W. Cowell & Associates Inc.		
50.	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 7.0 to 8.0 mbgs depth.	General	Daryl W. Cowell & Associates Inc.		
51.	The final quarry floor in the western extension will be at an elevation of 252.5 metres amsl which is well below the elevations of all three of the "karst-weathered" bedding planes.	General	Daryl W. Cowell & Associates Inc.		
52.	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	General	Daryl W. Cowell & Associates Inc.		

	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.				
53.	These statements are based on simulated model stream flows for “baseline” (current) and post-quarrying that show net average reductions of about 2.0 litres/second in flow downstream of SW07 (Willoughby Creek below spring J) resulting in “no significant change downstream at SW1.”	General	Daryl W. Cowell & Associates Inc.		
54.	[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.]	General	Daryl W. Cowell & Associates Inc.		
55.	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).	General	Daryl W. Cowell & Associates Inc.		
56.	Recommendation: • 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.	General	Daryl W. Cowell & Associates Inc.		
57.	Recommendation: • 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.	General	Daryl W. Cowell & Associates Inc.		
58.	Recommendation: • A detailed potentiometric surface should be provided.	General	Daryl W. Cowell & Associates Inc.		
59.	Recommendation: • Dye trace(s) should be conducted between boreholes in the western extension and the same springs noted above in recommendation #1.	General	Daryl W. Cowell & Associates Inc.		
60.	Recommendation: • Following quarrying, the western extension should be rehabilitated to lakes.	General	Daryl W. Cowell & Associates Inc.		
61.	The retained consultant has not commented on the predictions of the potential effects of the proposed extension. It has not been demonstrated that the modelling that has been conducted provides an adequate basis for making such predictions.	General	S.S. Papadopulos & Associates, Inc.		
62.	The Terms of Reference for the Level 1 and 2 Hydrogeologic and Hydrologic Impact Assessment of the Proposed Burlington Quarry Extension are dated February 2020 (Earthfx, Inc., Azimuth Environmental Consulting, Inc., Tatham Engineering, and Worthington Groundwater, February 2020). The field investigations and modelling analyses must have been largely completed by the date of the Terms of Reference.	General	S.S. Papadopulos & Associates, Inc.		
63.	The modelling described in the Level 1/2 report does not achieve the objective of providing defensible predictions of the potential impacts of the proposed development. The analyses described in the Level 1/2 report are extraordinarily complex from a process perspective, but highly simplified with respect to the assignment of material properties. It is not clear what parameters have the greatest influence of the predictions, whether there are sufficient data to constrain the assignment of parameter values, and whether the parameter values inferred through calibration are consistent with the available data.	General	S.S. Papadopulos & Associates, Inc.		
64.	Review of the GSFLOW results suggests that, in general, the calibrated model is capable of matching variations in water levels arising from seasonal climate fluctuations. However, there are fundamental concerns regarding the treatment of the available data and the approaches that have been adopted for simulating groundwater flow in the bedrock. Evidence could not be found in the report that confirmed the	General	S.S. Papadopulos & Associates, Inc.		

	GSFLOW model was capable of yielding acceptable matches to observed declines in groundwater levels arising from ongoing quarry operations.				
65.	Although the model has been developed to predict the potential impacts of the quarry expansion, the predictive capacity of the model has not been demonstrated. In general, the hydrographs presented in the report demonstrate that the model is capable of reproducing changes in water levels that are driven by seasonal variations in climate. However, no comparison is presented between observed and simulated average declines in water levels caused by the quarry operations. The quarry has been operating sufficiently long that it should be possible to identify the declines for at least some key monitoring locations. An appropriate application of the MODFLOW model would be to simulate time-averaged water levels for different positions of the quarry face. Did the position of the quarry face change 2003/2004 and 2007/2010? Has the position of the quarry face changed between 2010 and 2020? The results of time-averaged simulations of the different time periods would be important for confirming that the predicted effects of the quarry expansion on bedrock groundwater levels are within the realm of possibility. Referring the hydrographs in Golder (2010), it is estimated that for OW03-14A, the average level between April 2003 and July 2004 was about 272.0 metres amsl, and between July 2007 and July 2010 the average level was about 261.0 metre amsl. For monitoring well OW03-15A, the average level between April 2003 and July 2004 was about 260.0 metres amsl, while the average level between July 2007 and July 2010 was about 259.0 metres amsl. Substantial drawdowns were also observed at OW03-21. Golder (2010) present hydrographs for three other wells that show clear long-term declining trends and that might be used for this demonstration: Onsite quarry well 5 (Golder, 2010; Figure D.1.77); Onsite quarry well Goodchild (Golder, 2010; Figure D.1.78); and Onsite quarry well Sterrett (Golder, 2010; Figure D.1.79).	General	S.S. Papadopulos & Associates, Inc.		
66.	No mention is made in the report of the two well-instrumented constant-rate pumping tests that have been conducted near the quarry. These tests provide useful opportunities to test the predictive capabilities of the calibrated groundwater flow model. The pumping test conducted in March 2004 is reported in Golder (2004; Appendix B). The pumping test conducted in February 2006 is reported in Golder (2006).	General	S.S. Papadopulos & Associates, Inc.		
67.	Streamflow Monitoring – A relatively small subset of the existing streamflow monitoring locations has been considered in the modelling analyses. Furthermore, inconsistent sets of streamflow monitoring stations have been considered for the GSFLOW calibration and the representation of baseline conditions. It was left with the impression that selective use has been made of the available data in the GSFLOW calibration and the representation of baseline conditions. At a minimum, all stations considered for the representation of baseline conditions should have calibration records that extend across the 10-year period WY2010 to WY2019. In addition, if it is not feasible to include all the existing streamflow monitoring locations in the calibration analyses/baseline conditions simulations, the documentation should include explanations regarding why some stations are included and others are not.	General	S.S. Papadopulos & Associates, Inc.		
68.	Existing Streamflow Monitoring Locations – Referring to Tatham Engineering (2020; Table 2), there are 20 existing streamflow monitoring locations.	General	S.S. Papadopulos & Associates, Inc.		

	<table><tr><td>SW01</td><td>SW23</td></tr><tr><td>SW02</td><td>SW24</td></tr><tr><td>SW06</td><td>SW25</td></tr><tr><td>SW07</td><td>SW26</td></tr><tr><td>SW09</td><td>SW28</td></tr><tr><td>SW10</td><td>SW29</td></tr><tr><td>SW14</td><td>SW30</td></tr><tr><td>SW15</td><td>SW31</td></tr><tr><td>SW21</td><td>SW34</td></tr><tr><td>SW22</td><td>SW35</td></tr></table>				
69.	Monitoring locations for which results from the GSFLOW model calibration are reported – The Level 1/2 Hydrogeological and Hydrological Impact Assessment has been reviewed and it is noted that: • The GSFLOW model has been calibrated for the five (5) year period, WY2010-WY2014 (October 2009 to September 2014); and • The summary of the number of wells for which GSFLOW simulation results are reported in the Level 1/2 report is presented on Table 1. Comparisons between observations and simulation results are presented for 39 locations. No explanation is provided for restricting the GSFLOW calibration to the five-year period 2009-2014. Excellent data are available since 2003, and at a minimum it would be expected there to be some discussion of the consistency between the model results and earlier data. This is particularly important for assessing the ability of the GSFLOW model to match long-term changes in groundwater conditions caused by the evolution of the existing quarry, in particular the 2005-2019 advancement of the south extraction face). Any rationale could not be found for considering only 39 of the 100 monitoring wells in the GSFLOW analyses. At a minimum it would be expected there to be some explanation regarding why some results have been presented for some wells and not others. Table 1. Reported comparisons between observations and GSFLOW simulation results	General	S.S. Papadopulos & Associates, Inc.		

Count	Well for which GSFLOW calibration results are presented	Figure
1	MW03-01 A	Figure 19.29
2	MW03-01 C	Figure 19.29
3	MW03-02 A	Figure 19.28
4	MW03-02 C	Figure 19.28
5	MW03-09 A	Figure 19.25
6	MW03-09 B	Figure 19.25
7	OW03-14 A	Figure 19.23
8	OW03-14 C	Figure 19.23
9	OW03-15 A	Figure 6.24, Figure 19.22
10	OW03-15 C	Figure 6.24, Figure 19.22
11	OW03-17 A	Figure 19.30
12	OW03-17 B	Figure 19.30
13	OW03-18 A	Figure 19.31
14	OW03-18 C	Figure 19.31
15	OW03-19 A	Figure 19.33
16	OW03-19C	Figure 6.34, Figure 19.33
17	OW03-21 A	Figure 6.25, Figure 19.24
18	OW03-21 B	Figure 6.25, Figure 19.24
19	OW03-21 C	Figure 6.25, Figure 19.24
20	OW03-29 A	Figure 6.27, Figure 19.32
21	OW03-29 B	Figure 6.27, Figure 19.32
22	OW03-30 A	Figure 19.26
23	OW03-30 B	Figure 19.26
24	OW03-31 A	Figure 6.26, Figure 19.27
25	OW03-31 B	Figure 6.26, Figure 19.27
26	MP6	Figure 6.30, Figure 19.40
27	MP16	Figure 6.29, Figure 19.44
28	SG-2 (SG2)	Figure 6.31; Figure 19.43
29	MP5	Figure 6.31, Figure 19.43
30	MP-33	Figure 6.33
31	SW5A-SG	Figure 6.34
32	GP03-37	Figure 19.35
33	MP17	Figure 19.36
34	MP13	Figure 19.37
35	MP11	Figure 19.38
36	MP29	Figure 19.39
37	SW13A-SG	Figure 19.41
38	SG-3	Figure 19.42
39	SW16A-SG	Figure 19.45

70.	Monitoring locations recommended for long-term monitoring – The wells recommended for inclusion in the long-term monitoring network are listed on Table 10.1 of the Level 1/2 report. The check marks on Table 2 denote those wells for which GSFLOW calibration results are reported. The results for the GSFLOW calibration are reported for only about half of these wells. The GSFLOW calibration should have included all of the wells recommended for inclusion in the long-term monitoring program. The GSFLOW results represent a prediction of what is likely to occur in the future, and the data from the long-term monitoring program will serve in an ongoing assessment of the realism of that prediction. As a minimum condition for reliability, it should be confirmed that the GSFLOW results provide a reasonable match to data that are already available. Table 2. Wells recommended for long-term monitoring	General	S.S. Papadopulos & Associates, Inc.		

<table>
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<tr><th>Well recommended for long-term monitoring</th><th>Well included in reporting of GSFLOW calibration results?</th></tr>
<tr><td>MW03-01 A</td><td>√</td></tr>
<tr><td>MW03-01 B</td><td>-</td></tr>
<tr><td>MW03-07 A</td><td>-</td></tr>
<tr><td>MW03-07 B</td><td>-</td></tr>
<tr><td>(OW) MW03-09 A</td><td>√</td></tr>
<tr><td>(OW) MW03-09 B</td><td>√</td></tr>
<tr><td>(OW) MW03-14 A</td><td>√</td></tr>
<tr><td>(OW) MW03-14 B</td><td>√</td></tr>
<tr><td>(OW) MW03-15 A</td><td>√</td></tr>
<tr><td>(OW) MW03-15 B</td><td>√</td></tr>
<tr><td>(OW) MW03-17 A</td><td>√</td></tr>
<tr><td>(OW) MW03-17 B</td><td>√</td></tr>
<tr><td>(OW) MW03-18 A</td><td>√</td></tr>
<tr><td>(OW) MW03-18 B</td><td>√</td></tr>
<tr><td>(OW) MW03-19 A</td><td>√</td></tr>
<tr><td>(OW) MW03-19 B</td><td>√</td></tr>
<tr><td>MW03-20 A</td><td>-</td></tr>
<tr><td>MW03-20 B</td><td>-</td></tr>
<tr><td>(OW) MW03-21 A</td><td>√</td></tr>
<tr><td>(OW) MW03-21 B</td><td>√</td></tr>
<tr><td>MW03-28 A</td><td>-</td></tr>
<tr><td>MW03-28 B</td><td>-</td></tr>
<tr><td>(OW) MW03-29 A</td><td>√</td></tr>
<tr><td>(OW) MW03-29 B</td><td>√</td></tr>
<tr><td>(OW) MW03-30 A</td><td>√</td></tr>
<tr><td>(OW) MW03-30 B</td><td>√</td></tr>
<tr><td>BS-01 A</td><td>-</td></tr>
<tr><td>BS-01 B</td><td>-</td></tr>
<tr><td>BS-02 A</td><td>-</td></tr>
<tr><td>BS-02 B</td><td>-</td></tr>
<tr><td>BS-03 A</td><td>-</td></tr>
<tr><td>BS-03 B</td><td>-</td></tr>
<tr><td>BS-04 A</td><td>-</td></tr>
<tr><td>BS-04 B</td><td>-</td></tr>
<tr><td>BS-05 A</td><td>-</td></tr>
<tr><td>BS-05 B</td><td>-</td></tr>
<tr><td>BS-07</td><td>-</td></tr>
<tr><td>P-MW-08</td><td>-</td></tr>
<tr><td>P-MW-09</td><td>-</td></tr>
<tr><td>P-MW-10</td><td>-</td></tr>
<tr><td>P-MW-11</td><td>-</td></tr>
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<tr>
<td>71.</td>
<td>Missing References – Although the Level 1 and Level 2 report is extensive, it is not complete. Complete references for may of the documents cited in the report are missing. Missing references are listed below.

Page 52: Brunton, 2008
Page 52: Brunton, 2009
Page 52: Johnson et al., 1991
Page 54: Liberty et al., 1976
Page 54: Brett et al., 1990
Page 54: Bond et al., 1976
Page 54, 67: Johnson et al., 1992
Page 57: Brett et al., 1995
Page 57: Voss, 1969
Page 57, 103: Golder, 2004 (also Figure 5.9)
Page 71: Karrow, 1987. In addition to including the complete citation in the list of references, the specific map sheet should be indicated, Map 2508.</td>
<td>General</td>
<td>S.S. Papadopulos & Associates, Inc.</td>
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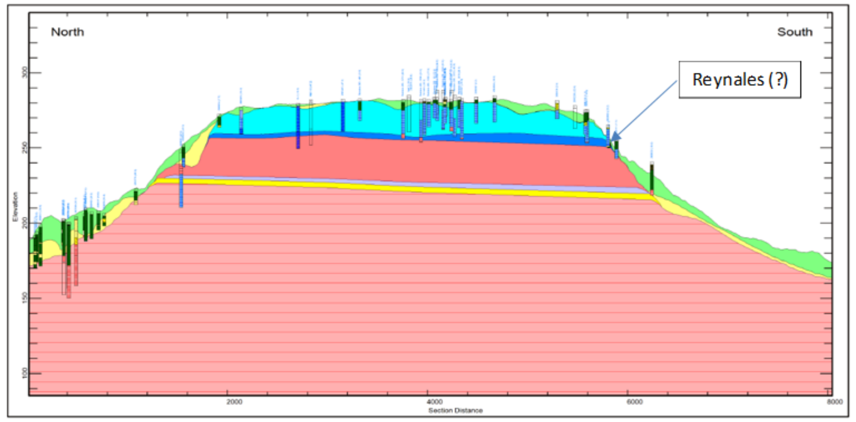
</table>

	Page 71: OGS, 2010 [and Figure 3.26] Page 71: White, 1975 Page 71: Karrow, 2005 Page 71: Chapman and Putnam, 1984 Page 71: Barnett, 1992 Page 82, 132: Earthfx, 2010 Page 82, 132: Hargreaves and Samani, 1982 Page 82: MNRF, 2013 (also Figure 4.9) Page 86: Worthington Water, 2020 Page 86: Worthington, 2020 Page 86: Worthington Groundwater, 2020 Page 104: Golder, 2005 Page 104: Jagger Himms [sic] (2003) [should read "Hims"] Page 104: Charlesworth & Associates (2006) Page 104: Dillon (2008) Page 104: Gartner Lee (2005) Page 104: AECOM (2009) Page 104: OGS (2010) Page 104: Wood (2018a) Page 104: Earthfx (2020) Page 105: Brunton, 2007 Page 109: Kassenaar and Wexler, 2006 Page 121: Huntington and Niswonger, 2014 Page 121: Hunt et al., 2013 Page 121: Ely and Kahle, 2012 Page 121: Tanvir Hassan et al., 2014 Page 121: Niswonger et al., 2014 Page 121: Leavesly et al., 2011 [should be Leavesley] Page 142: The reference in the text of the report is to Golder Associates (2007). Is that to Golder Associates (2007a) or Golder Associates (2007b) in the list of references? Page 143, 512: Chiew and McMahon, 1993 Page 460: [Figure 17.10] MNR, 2013				
72.	Referring to page 92, the analyses are referred to as an "integrated model-driven, quarry assessment approach". The objectives are summarized on page 22: The objective of this Level 2 ARA investigation is to characterize the existing conditions at the Burlington quarry site, describe the development of an integrated groundwater/surface water assessment model, and predict any likely changes to the hydrologic and hydrogeologic conditions at different phases of extraction and final rehabilitation.	Pages 22 and 92	S.S. Papadopulos & Associates, Inc.		
73.	It is reported 5 out of 22 wetlands receive a groundwater discharge (less than 3.0% of the total inflows). Is this based on monitoring or model results? What year does this represents? How does this relate to potentially wetlands already being impacted by existing quarry operations? High water table may not only provide minor inputs, but also prevent surface water from infiltration, and hence, extend the wetland hydroperiod. Loss of groundwater inputs can also have an impact on wetland water temperature and have impact on the amphibian breeding in the ponds. Has this been assessed?	Pages 23 and 24 Executive summary	Conservation Halton		
74.	It is reported the West Extension is next to a locally significant groundwater discharge area, which helps to mitigate the local effects of the excavation. Although it can limit the propagation of the drawdown away from the extraction, lowering of the groundwater levels due to extraction would reduce the amount of discharge in the	Page 24 Executive summary	Conservation Halton		

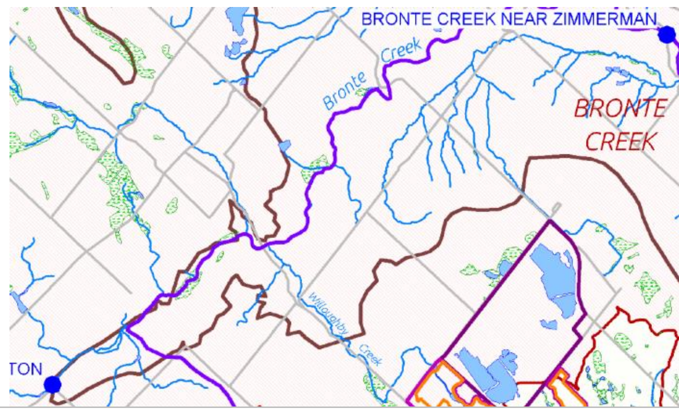
	locally significant groundwater discharge area and hence can be deemed a negative impact. Please address these potential negative impacts in the report.				
75.	The Level 1 and 2 Natural Environment Report states (page 22) "The numerical simulations confirm that the majority of the wetlands and streams 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.	Page 24	Daryl W. Cowell & Associates Inc.		
76.	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).	Page 24	Daryl W. Cowell & Associates Inc.		
77.	'The quarry has been in existence since 1953 and has been operated by Nelson since 1983.' The report does not address the long history of the quarry specifically the existing operating conditions, environmental requirements including on-going monitoring, conditions of operations, and recognition of the existing impacts of the quarry operations on the pre-quarry conditions. This should be included in the report.	Page 27 Introduction Section 1.1. Objectives, 1st Paragraph	Norbert M. Woerns		
78.	'A key aspect of this integrated model approach is that it evaluates the effects of the quarry extension on continuous multi-year basis, spanning a range of climate conditions.' The analysis does not identify the existing conditions as being impacted by the long operating quarry or whether the existing quarry operations are in compliance with environmental impact mitigation requirements that may exist. There is no cumulative impact assessment of the existing operations and the proposed quarry extensions. Cumulative impact analysis should be included in the report.	Page 30 Section 1.2. Study Approach, 2nd Paragraph	Norbert M. Woerns		
79.	Although, this section states this hydrogeological assessment has been completed in accordance with Terms of Reference for the Level 1 and 2 Hydrogeological and Hydrologic Impact Assessment of the Proposed Burlington Quarry Extension (February 2020), the TOR states that a 25-year baseline period would be simulated including dry year 2007, wet year 2008 and average conditions year 2009. It seems only 10-year period was simulated as baseline, which does not include the specified period 2007-2009. Please include a 25-year baseline period as proposed in the TOR.	Page 30 Section 1.3. Level 1/ Level 2 Study Components and Methodology	Conservation Halton		
80.	'In addition, this hydrogeological assessment has been completed in accordance with the Terms of Reference for the Level 1 and Level 2 Hydrogeological and Hydrologic Impact Assessment of the proposed Burlington Quarry Extension (February 2020).' The terms of reference were dated 2020, at about the same time as the hydrogeological report was issued. Studies in support of the hydrogeological report were initiated well in advance of issuing the Terms of reference. Typically, studies are based upon the terms of reference which are normally produced in advance of the studies being undertaken. The terms of reference appear to have been created from the completed studies. Due to the timing of the completion of the terms of reference, it appears as though the hydrogeological assessment could not have been competed in	Page 30 Section 1.3. Level 1/Level 2 Study Components and Methodology, 1st Paragraph	Norbert M. Woerns		

	accordance with terms of reference which do not appear to have existed prior to completion of the assessment. This process did not allow for an opportunity for meaningful input and modification too the studies by review agencies.				
81.	This section describes elements of previous investigations and the time period over which they were undertaken. There is no description of the period of monitoring available for this study and for the existing quarry or the periods of data gaps that may exist. This should be included within this section of the report. Some of the data gaps are discussed elsewhere in the text.	Pages 30-31 Section 1.3.1. Field Investigations	Norbert M. Woerns		
82.	To complete a surface water and groundwater impact assessment on the natural environment and private water supplies the baseline conditions scenario should represent unaltered conditions in terms of groundwater and surface water. The modelled current/ baseline scenario (2010 onwards) does not account for quarry impacts to date, i.e. what was the extent and impact of groundwater cone of depression, what were the changes to groundwater levels and vertical gradients, changes to surface water pattern and flows and surface and groundwater interactions?	Page 31 Section 1.3.2. Site Characterization and Baseline Scenario Analysis	Conservation Halton		
83.	'Section 7 of the report presents a numerical simulation of the current or "Baseline" conditions at the site. A continuous transient (time-dependent) assessment is presented, illustrating how the surface water and groundwater systems behave on a daily basis over the last 10 years. Included in this assessment time period is a severe Provincial Low Water Response Level 2 drought (2016) and an above average wet year (2017). This baseline provides a realistic long-term frame of reference for comparison and assessment of the proposed quarry extension and rehabilitation phases.' Current conditions may be appropriate for assessing impact of the proposed extensions to the existing quarry. This does not however address the impact of the existing quarry operations. The cumulative impact of the existing quarry and the proposed quarry extensions should be considered for purposes of evaluating impacts on private wells, natural heritage features and rehabilitation options.	Page 31 Section 1.3.2. Site Characterization and Baseline Conditions Analysis, 3rd Paragraph	Norbert M. Woerns		
84.	'This report, the companion documents, the integrated model, and the detailed field investigations and analyses represent an exceptionally comprehensive assessment of the proposed development' The computer model analysis is focussed on quantifying the water resources and the interaction between surface water and groundwater. Groundwater quality assessment is limited to characterizing the groundwater quality with respect to possible source waters, i.e. either groundwater or surface water. Water quality assessment is incomplete with respect to characterizing water quality with respect to drinking water objectives and potential sources of contamination. Groundwater quality thresholds as well as potential mitigation measures are also missing. An analysis of water quality threshold levels is missing and should be included in the report. There is also a limited period of water quality data with periods of record missing. The assessment is therefore not considered to be comprehensive.	Page 33 Section 1.3.7. Level 1/Level 2 Methodology Summary	Norbert M. Woerns		
85.	It is reported in this section that data collected for previous studies (see below), have been incorporated into this assessment: • Investigation by Golder in support of a previously south quarry extension (Golder, 2004) • Additional hydrogeologic field studies of wetland/groundwater interaction (Golder, 2006) • An assessment of water budgets for individual wetlands in south extension area (Golder, 2007), and • A study of the shallow overburden (Golder, 2007)	Page 36 Section 2.1. Previous Studies	Conservation Halton		

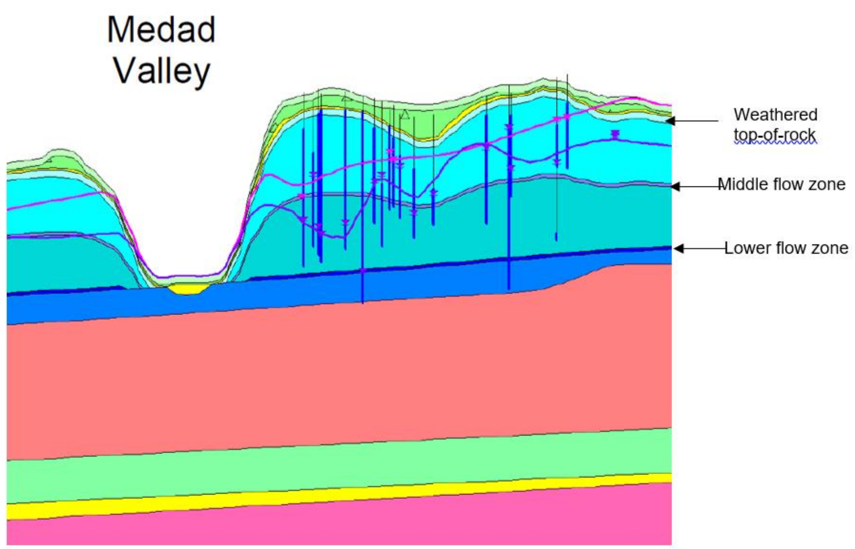
	However, it seems limited data from these studies have been included in this report for the reviewer to understand quarry expansion impacts on the surface water and groundwater regimes and their interactions within the natural features. Please expand and clarify how previous data have been used in the report conclusions.				
86.	'Local monitoring data and site characterization information collected for the Golder studies, as well as ongoing monitoring data, were obtained from Nelson and complied into a relational database for this study.' The period of record and data gaps should be identified.	Page 36 Section 2.2. Long Term Monitoring Network, 1st Paragraph	Norbert M. Woerns		
87.	'The effects of this quarry excavation and expanded dewatering have been observed in the monitoring data collected since 2005; ' It is not clear what changes in dewatering have occurred since 2005. It is also not clear whether the impacts of the changes in quarry dewatering have stabilized. This should be addressed in the report.	Page 45 Section 3.3.3. Site Development History, 1st Paragraph	Norbert M. Woerns		
88.	It is impossible to depict some of the monitors on Figure 3.4. Please provide a larger scale map clearly showing all the monitoring location.	Page 46 Figure 3.4. Well Locations – South Extension Area	Conservation Halton		
89.	Typo. Location BS-063 should be BS-03. Also note that BS-06 is missing on this figure.	Page 48 Figure 3.6. Well Locations: West Extension Area	Norbert M. Woerns		
90.	Model layers should be labelled on this figure for correlation to hydraulic conductivity results from packer testing.	Page 49 Figure 3.7. Sample Borehole Log from West Extension Area (BS-04)	Norbert M. Woerns		
91.	The control points for mapping the elevations of the top of the Cabot Head Formation are shown in Figure 3.13. What control points were used to map the thickness of the Cabot Head Formation shown in Figure 3.14?	Figures 3.13 and 3.14	S.S. Papadopulos & Associates, Inc.		
92.	It is indicated in the text that "while Brunton (2008) was able to subdivide the Reynales, these units are hydrogeologically similar (dolostone with shale partings) and are un-subdivided in the Golder and MECP logs; for simplicity, the Rockway and Merritton unit is referred to herein as the Reynales Formation." The retained consultant has checked with Mr. Brunton, and he writes, "There is no Reynales at this quarry. In fact the greenish unit below Merritton or upper Fossil Hill Fm may in fact be a thin Grimsby Formation unit" (written communication, October 15, 2020).	Page 58	S.S. Papadopulos & Associates, Inc.		

					
93.	The control points for mapping the elevations of the top of the Reynales Formation are shown in Figure 3.15. What control points were used to map the thickness of the Reynales Formation shown in Figure 3.16?	Figures 3.15 and 3.16	S.S. Papadopulos & Associates, Inc.		
94.	Figure 3.22 West-East Section shows existing Burlington Quarry up-gradient of wells adjacent to Medad Valley. This illustrates that the upgradient source water area of these wells has to a large extent been excavated by the existing quarry. These wells therefore rely to a large extent upon on up-gradient infiltration including sump discharge via upgradient irrigation/infiltration ponds to replenish groundwater levels for down-gradient wells. Much of the up-gradient bedrock remaining between the existing quarry and the private wells along the Medad valley is to be excavated in the proposed west extension. This creates further reliance on the infiltration ponds for maintenance of down-gradient well water supplies. Please provide field data to confirm that the proposed infiltration pond will function as required.	Page 66 Figure 3.22. West-East Quarry Cross Section	Norbert M. Woerns		
95.	What is the basis for the indication that the Irondequoit, Gasport and Goat Island formations are hydrogeologically similar? The retained consultant's experience elsewhere in southern Ontario suggests that their hydrogeologic characteristics are distinct. Has any attempt been made at the site to conduct hydraulic tests on the separate units? Referring to Figure 3.25, no packer test results are shown for the Goat Island Formation, and substantially lower values of hydraulic conductivity are estimated for the rocks between the Gasport Formation and the Cabot Head Formation.	Page 67 and Figure 3.35	S.S. Papadopulos & Associates, Inc.		
96.	What control points were specified to support the mapping of the elevations of the top of bedrock? Does the mapping shown in Figure 3.23 lump high-quality data from site monitoring wells and the information from the MECP water well record database?	Figure 3.23	S.S. Papadopulos & Associates, Inc.		
97.	What control points were specified to support the mapping of the thickness of the Amabel Formation in Figure 3.24 [Goat Island Formation + Gasport Formation + Irondequoit/Merritton/Rockway]?	Figure 3.24	S.S. Papadopulos & Associates, Inc.		
98.	The model layers should be shown on the borehole log to allow comparison of the Packer Hydraulic Conductivity (K) values to those used in the computer model.	Page 70 Figure 3.25. BS-01 Borehole Log Showing the Goat Island Formation	Norbert M. Woerns		
99.	'The till forms an effective aquitard where present. --- Golder (2006, p. 6) found that the presence of silty clay in the sediments effectively limited the interaction between the surface and groundwater systems.' There is some doubt as to the effectiveness of the Halton Till as an aquitard from pump test information provided by Golder (2010) where overburden monitor OW03-22C responded to a 2006 pump test of the deeper bedrock zones (See Figure 18, S.	Page 71 Section 3.5.1. Halton Till, 2nd Paragraph	Norbert M. Woerns		

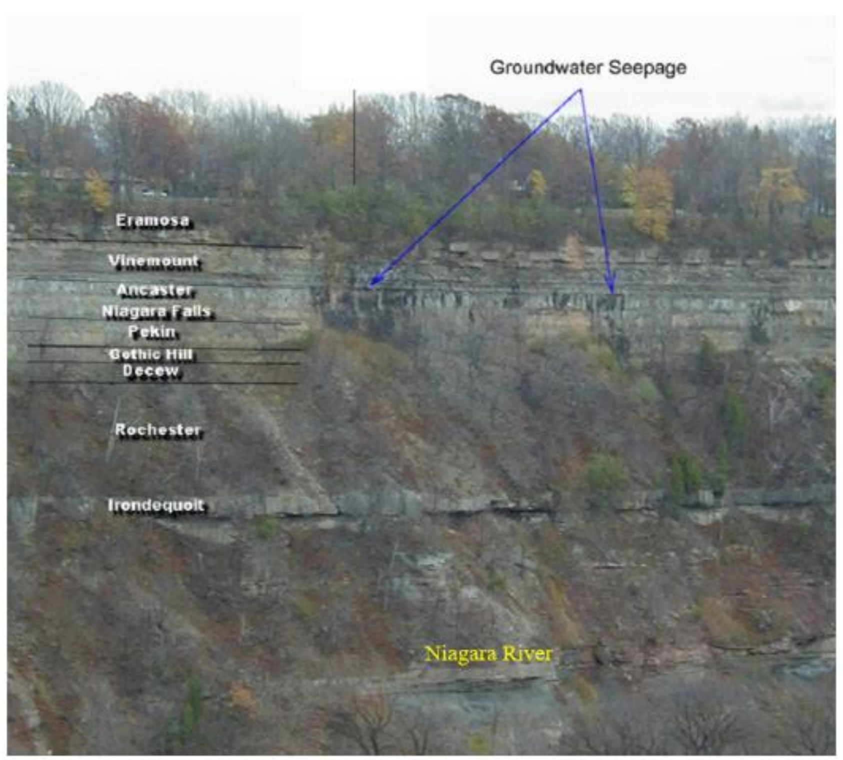
	McFarland Witness Statement, 2010, PDF page 1429). During a 2004 pump test completed by Golder on the same well, a number of shallow overburden monitors responded to a five day pump test. This included monitors; MW03-5A, MW03-04C, OW03-22C, OW03-23C, OW03-24C, and OW03-27C. Although these monitors were constructed as overburden monitors, they have been described as overburden /bedrock interface monitors. The response of these overburden monitors to pumping of the underlying bedrock raises the question of the ability of the shallow water table to respond to bedrock water levels and the interconnection between surface water and groundwater. Golder (2006), page 8, 2nd paragraph states in reference to the background monitoring results of OW03-22, MP-5 and SG-2 (Cluster2) 'These results indicate a strong degree of hydraulic connection between groundwater levels in the bedrock and the surface water levels outside of the wetland area.' It should be noted that MP5 is within the wetland area. The borehole log for MP5 shows 1.35m of clayey silt, presumably Halton Till. This information is contradictory to the Earthfx conclusion that the till forms an effective aquitard where present. This contradiction needs to be addressed.				
100.	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 $5.0x10.0^{-7}$ (Table 18-4 and Figure 18-12).	Page 71 Section 3.5.1, Table 18.4, and Figure 18.12	Daryl W. Cowell & Associates Inc.		
101.	What control points were specified to support the mapping of the thickness of the Halton Till in Figure 3.27?	Figure 3.27	S.S. Papadopulos & Associates, Inc.		
102.	What control points were specified to support the mapping of the thickness of the MIS sands and ORAC in Figure 3.28?	Figure 3.28	S.S. Papadopulos & Associates, Inc.		
103.	There is only one station within the study area below the escarpment at the edge of the study area as shown on Figure 4.1, page 77. There is no climate station in the vicinity of the Burlington Quarry nor is there a climate station representative of climatic conditions on top of the escarpment at Mount Nemo. It is noted that Mount Nemo is referenced in the report however there is no figure showing its location. The average annual precipitation of 853.0 millimetres/year varies from 655.0 and 1172.0 millimetres/year. The range in precipitation represents an increase of about 80.0% over minimum annual precipitation. Is this reflected in modeling scenarios and what impact does this have on the reliability of the integrated model predictions in representing site conditions at the Burlington Quarry?	Page 76 Section 4.4.1. Precipitation and Temperature	Norbert M. Woerns		
104.	No indication is provided in the report that a distinction has been made between data from climate stations above and below the Niagara Escarpment. The retained consultant's experience suggests that this distinction is important, affecting whether a station provides data that is or is not representative of conditions on Mount Nemo. The expectation is that the climate data from Millgrove and Mountsberg are likely to be most representative. However, referring to Figure 4.2, there are no recent data from either station. The Millgrove station is about 9.3 kilometres from the quarry.	Figure 4.2	S.S. Papadopulos & Associates, Inc.		
105.	The references for the SOLRIS land use mapping are not consistent. In the text, reference is made to SOLRIS v.3 (2019) (pages 82, 132, 446, Figures 4.8, 6.11,	Pages 82, 132, and 446 and	S.S. Papadopulos & Associates, Inc.		

	17.12). However, the citation in the list of references is to MNRF (2014), accessed August 2015.	Figures 4.8, 6.11, 17.12			
106.	Are the lime coloured areas on this figure clay loam? It is not clear from the legend that these colours are the same?	Page 84 Figure 4.9. Surficial Soil Complex Mapping	Norbert M. Woerns		
107.	Referring to Figure 4.10, there are only three WSC stream gauges in the model area, with two of the stations close to each other on Grindstone Creek (above Highway 403 and near Aldershot). None of the three WSC stations are located on Mount Nemo.	Figure 4.10	S.S. Papadopulos & Associates, Inc.		
108.	Referring to Figure 4.10, is it correct in understanding that Willoughby Creek is almost perpendicular to Bronte Creek where it discharges to Bronte Creek?  	Page 86 and Figure 4.10	S.S. Papadopulos & Associates, Inc.		
109.	Is there a record of flows in Willoughby Creek?	Page 86	S.S. Papadopulos & Associates, Inc.		
110.	'Many other small un-named natural and man-made features also exist in the study area, including a series of golf course ponds in the western extension lands' What role do the man-made irrigation ponds in the west extension area play in the maintenance of discharge to down gradient springs/seeps? What evidence is there to support this role?	Page 87 Section 4.3.3 Lakes and Ponds, 2nd Paragraph	Norbert M. Woerns		
111.	It is indicated that the discrepancy between the Ontario Hydro Network (OHN) mapping and the observed golf course and quarry pond is due to the time period during which the OHN mapping was conducted. Documentation of the OHN mapping is not cited in the list of references. What was time period for the OHN mapping?	Page 87	S.S. Papadopulos & Associates, Inc.		
112.	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).	Pages 90 and 155 and Figure 6.31	Daryl W. Cowell & Associates Inc.		
113.	Precipitation data is the key driver for the PRMS analyses. It is indicated on page 92 that measured precipitation is added to the top of the model. It is important to note from the outset that no measurements of precipitation are available within the study area. Referring to Figure 4.1, there are no climate stations close to Mount Nemo.	Page 92 and Figure 4.1	S.S. Papadopulos & Associates, Inc.		
114.	It is indicated on page 92 that the layers of the MODFLOW and GSFLOW models must be continuous across the model domain. This requirement has been interpreted in a way that is considered to be non-physical. The results close to the deep cutting	Page 92 and Figures 5.2-5.4 and 19.18-19.20	S.S. Papadopulos & Associates, Inc.		

features, including the Medad Valley and the existing quarry are not realistic. An excerpt from a cross-section through the model along 2nd Side Road is reproduced below (Figure 5.2), As shown in the figure, the model layers are “pushed down” below the base of the Medad Valley.

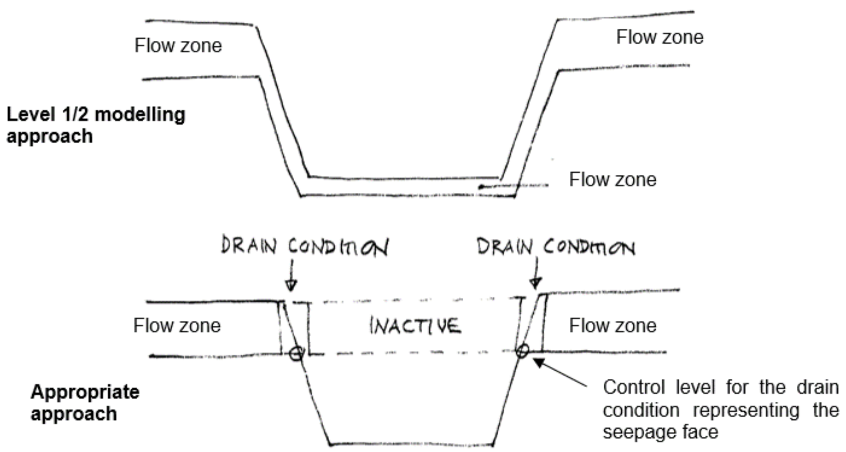


This is not a realistic representation of the bedrock flow zones in the rocks of the Niagara Escarpment. For example, a view across the gorge of the Niagara River downstream from Niagara Falls is shown on the next page. Rather than diving down below the Niagara River, the bedrock flow zones daylight at the gorge. Groundwater exits at the base of each flow zone, forming stacked seepage faces.

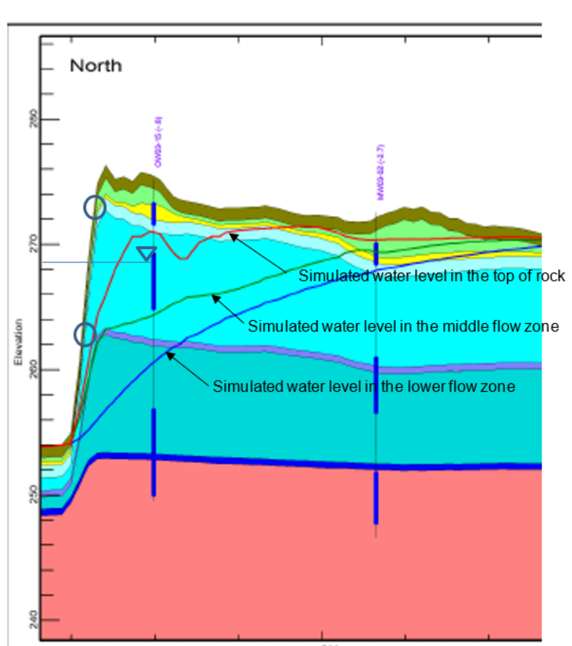


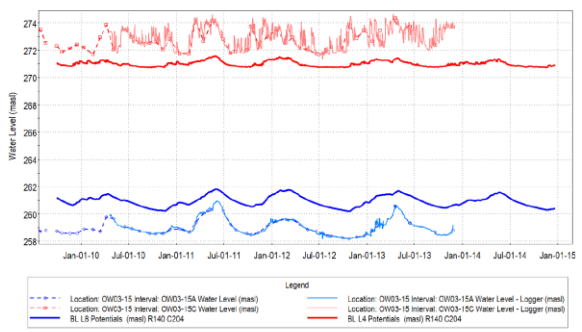
Photograph of the gorge of the Niagara River across from the Hyde Park Landfill site [Photograph by C. Neville]

A physically realistic approach for representing this situation is shown schematically below.



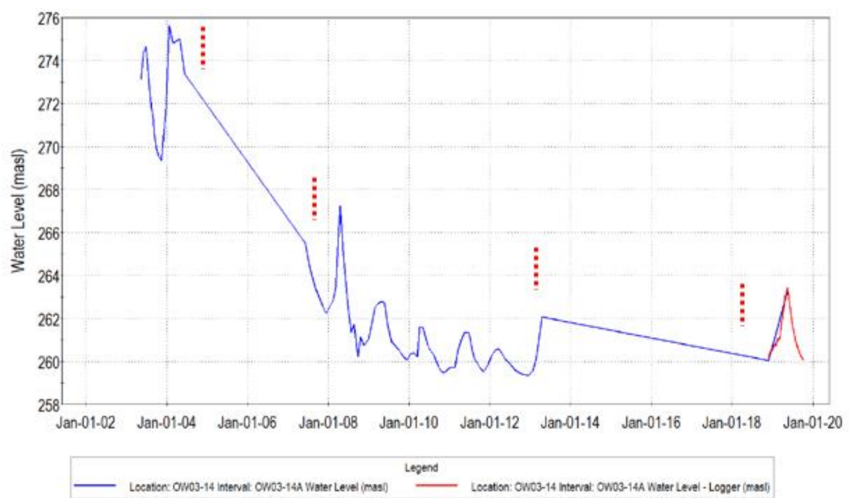
The results shown in Figures 5.2-5.4 and 19.18-19.20 of the report illustrate why the representation of conditions along the Medad Valley and Niagara Escarpment and around the existing quarry is important. A portion of Figure 19.18 is reproduced below. There is no evidence to suggest that the water levels in the weathered top-of-rock and in the middle flow zone decline steeply as predicted with the model. Hydrographs for observation well OW03-15 between April 2003 and July 2010 and between July 2009 and January 2015 are reproduced here on page 9. The long-term average water levels in the shallow "C" and deeper "B" and "A" monitoring intervals are about 273.0 metres, 269.0 metres and 259.0 metres amsl, respectively. Since 2003, the water levels have varied by only about ± 1.0 metre with respect to the average levels. The water levels are controlled by the elevations at which the flow zones daylight at the quarry, indicated by the circles added to the excerpt from Figure 19.18.The non-physical simulation approach that has been adopted compromises severely the reliability of predictions of potential impacts of the quarry extension.

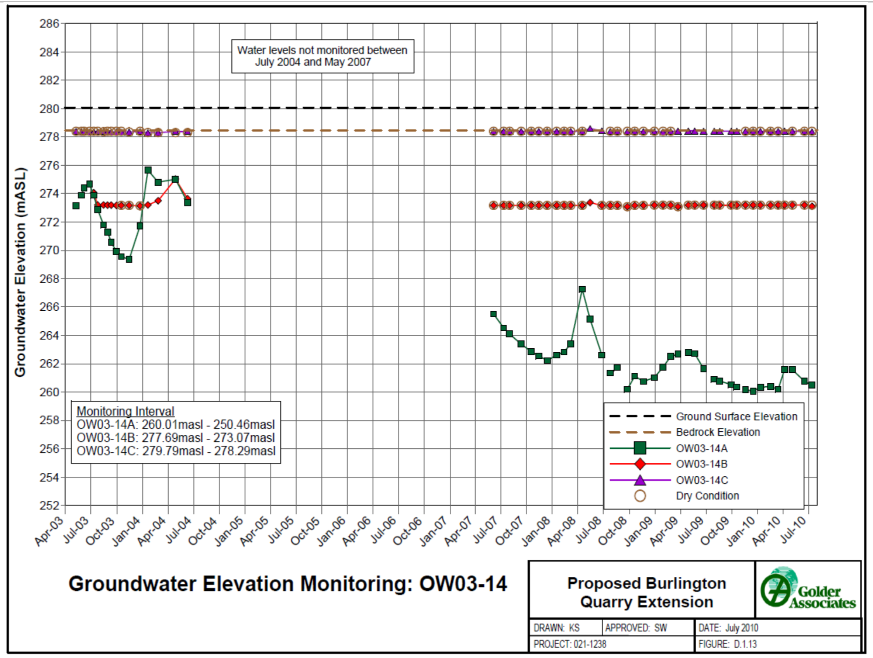


	 Figure 19.22: Comparison of observed and simulated water levels at monitor OW03-15.				
115.	'The till is of low permeability and serves to limit recharge and/or leakage to the underlying aquifers.' Is Halton Till located beneath the existing irrigation ponds or the proposed infiltration pond? If so, what effect does this have on infiltration of quarry discharge water on groundwater levels? Has this been taken into account in the modeling? Is the Halton Till weathered anywhere in the study area and has fracturing been accounted for in assigning hydraulic conductivity to fine grained overburden deposits?	Page 93 Section 5.2.2. Halton Till Aquitard, 1st Paragraph	Norbert M. Woerns		
116.	Quarry excavation in the western extension is to 252.5 mASL which will effectively remove most of the Amabel Formation up-gradient of the private wells along Cedar Springs Road. Maintenance of groundwater levels within the bedrock wells will, to a large extent, be dependent upon recharge of quarry discharge water through the proposed infiltration pond. Most of the primary aquifer within the source water area for these wells will have been removed with the completion of quarry excavation. What field investigations have been completed to demonstrate the effectiveness of the existing irrigation ponds and the proposed infiltration pond in recharging the underlying aquifer? Under the model assumptions, it is anticipated that the infiltrated water from the infiltration pond will be intercepted in Model Layer 4 and will not be available to the downgradient wells. The viability of the proposed infiltration pond should be confirmed with supporting field data.	Page 97 Figure 5.4. Cedar Springs Road Section	Norbert M. Woerns		
117.	It is noted on page 103, last paragraph, that 'Packer test results in the west area illustrate an increase in hydraulic conductivity in the Middle Amabel (Figure 5.6), but the evidence is less clear in the Golder packer test data (Figure 5.7 and Figure 5.8).' An explanation is required for this discrepancy. Clarification is required whether this has been accounted for in the integrated model. The source of the packer data should be indicated on the figures. The higher conductive lower fracture zone, of the lower Amabel, layer 8 of the model, is not reflected in the packer test results for the South Expansion Sections. This layer is also not clearly reflected in the packer results in the West Expansion Section. An explanation is required.	Pages 100-101 Figures 5.7 and 5.8. South Expansion Packer Section 1 and 2 Respectively	Norbert M. Woerns		
118.	Is this bedding plane fracture shown in Figure 5.9 at an elevation close to the elevations assigned for the middle flow zone in the model (model layer 6)?	Page 102 and Figure 5.9	S.S. Papadopulos & Associates, Inc.		
119.	'Karst sinks were represented in the model as disappearing stream segments, where streams flowing across layer 1 drop down into layer 4. In layer 4, the karst flow is represented as a subsurface conduit that leaks or picks up flow' How does the retained consultant know that Layer 4 is the only layer that transmits karstic water? Could deeper layers not also contribute to surface discharge via springs/seeps?	Page 103 Section 5.2.4. Layer 4: Weathered Bedrock/ Overburden Interface	Norbert M. Woerns		

		Aquifer, 4th Paragraph			
120.	How was the subsurface conduit to model the disappearing stream segment represented in the model?	Page 103 Section 5.2.4. Weathered Bedrock/ Overburden Interface Aquifer	Conservation Halton		
121.	It is indicated that Layer 4 has a minimum thickness of 1.0 metre. However, on page 103 it is indicated that an assumed depth of weathering equal to 0.3 metre was applied across the model, extending down from the top of bedrock. What is the correct thickness of model layer 4? Do the available hydraulic testing data support an inference of the depth of weathering in the rock?	Pages 103, 140, and 141	S.S. Papadopulos & Associates, Inc.		
122.	It is noted that low and high limits of bulk hydraulic conductivities for Amabel Formation used in the model as presented in Table 5.1 are some of the lowest values reported by others. How do hydraulic conductivities used in the model compare to the on-site field investigation derived data? The use of a uniform hydraulic conductivity data may work well for the overall system response, but please confirm if it is suited to represent local groundwater and surface water interactions? Although a lot of field testing to obtain hydraulic conductivity data was done on and in vicinity of the site, instead of using them to refine the model and to represent local conditions, a uniform hydraulic conductivity values are used, please explain.	Page 104 Section 5.2.5.1. Amabel Formation hydraulic Conductivity	Conservation Halton		
123.	The representation of vertical fractures to connect the shallow and deeper systems by adjusting Kh/Kv anisotropy value to 1:1 of model Layer 5 and Layer 7 in 5.0% of model cells maybe a good fit for the overall regional groundwater conditions. This approach suggests that areas not underlain by the model cells where Kv/Kh anisotropy was not adjusted may be subject to reduced groundwater flux than areas where the adjustment was made. Considering the above, this approach may misrepresent groundwater and surface water interactions within streams and wetlands depending on the location of the zones with adjusted parameters. Please reconsider this approach.	Pages 104 and 105 Section 5.2.5.2. Anisotropy and Vertical Flow Patterns	Conservation Halton		
124.	Typographical error? Reference to Worthington Groundwater (2019). Should this be Worthington Groundwater (2020)?	Page 105 Section 5.2.5.2. Anisotropy and Vertical Flow Patterns, 2nd Paragraph	Norbert M. Woerns		
125.	‘the bulk anisotrophy of Layer 5 (upper bulk Amabel) was estimated to be 500:1 (Kh/Kv) and Layer 7(lower bulk Amabel) to be 1000:1 (Kh/Kv).’ The above statement is in contradiction to the last paragraph of page 104 which reads as follows: ‘It is widely recognized that the dolostones of the Niagara Escarpment have a high degree of vertical to horizontal anisotrophy. Maslia and Johnston (1984) studied the “effectiveness of horizontal (bedding) joints versus vertical joints as water transmitting openings”. They concluded that vertical hydraulic conductivity (Kv) to horizontal conductivity (Kh) anisotropy of 100:1 to 1000:1 was typical of Lockport (Amabel) Formation.’ These are contradictory statements therefore one of the above statements must contain a typographical error. Please correct.	Page 105 Section 5.2.5.2. Anisotropy and Vertical Flow Patterns, 3rd Paragraph	Norbert M. Woerns		
126.	As per Figure 18.20 it appears that the cells with increased vertical hydraulic conductivity are not present within some 100.0 metres of the edge of escarpment and	Page 105	Conservation Halton		

	within the Medad valley – please explain. Based on the retained consultant's experience the distribution of vertical fractures near the escarpment tends to be higher (halo effect).	Figures 18.20 and 18.21 Section 5.2.5.2. Anisotropy and vertical Flow Patterns			
127.	It is indicated that downward leakage tends to minimize the differences in the head between the shallow and deeper bedrock layers. This seems to be in direct conflict with the water level data shown in Figure 5.11. There is a substantial difference in the water levels between the "A" and "B" intervals (~10.0 metres), and it may only be possible to sustain this head difference if the intervening rock has relatively low vertical hydraulic conductivity at this location.	Page 105 and Figure 5.11	S.S. Papadopulos & Associates, Inc.		
128.	It is indicated that municipal supply wells FDF01 and FDF03 "have been interpreted to intersect the highly permeable fractured zone in the middle of the Gasport Formation." Who has made this interpretation?	Page 105	S.S. Papadopulos & Associates, Inc.		
129.	It is suggested in the second paragraph of this section, based on Figure 5.12 which presents water levels in OW03-14C that quarry influence is less than 200.0 metres from the quarry face. Based on other monitoring well results it seems that this may be true for this location only suggesting that the aquifer is not uniform, and which puts in question the use of uniform hydraulic conductivity values in model layers. Please reconsider the use of uniform hydraulic conductivity values in the model.	Page 106 Section 5.2.8. Layer 8: Lower Fracture Zone	Conservation Halton		
130.	'A hydrograph from monitoring location OW03-15, south of the 2nd Side Road (see Figure 3.4) is shown in Figure 5.11. Water levels in the deepest monitor (OW03-15A) at this location are over 13 m below those of the water table (OW03-15C), clearly indicating that the lower system is connected to the quarry by a permeable lower fracture.' The above statement suggests that the existing quarry is draining the lower flow zone. What is the extent of the quarry influence on this flow zone?	Page 106 Section 5.2.8. Lower Flow Zone, 1st Paragraph	Norbert M. Woerns		
131.	'A hydrograph from monitoring location OW03-15, south of the 2nd Side Road (see Figure 3.4) is shown in Figure 5.11. Water levels in the deepest monitor (OW03-15A) at this location are over 13 m below those of the water table (OW03-15C), clearly indicating that the lower system is connected to the quarry by a permeable lower fracture.' A similar pattern is observed in monitor nest OW03-14 (Figure 5.12). When the monitor was installed in 2004, the quarry face was 175 m from the monitor (Figure 3.8). Between 2004 and 2009 the quarry face advanced to within 40 m of the monitor, and during that time the heads in the lower system dropped 14 m. This provides particularly useful information, for it suggests that the quarry influence is less than 200 m from the active face.' A much larger zone of influence of up to about 1000.0 metre is indicated in East Calibration Section, Figure 6.2.3 page 148. Have the impacts of the existing quarry stabilized or are the drawdowns continuing? A figure showing the cone of influence and drawdown from the existing quarry should be provided.	Page 106 Section 5.2.8. Lower Flow Zone, 1st and 2nd Paragraph	Norbert M. Woerns		
132.	The hydrographs for monitoring location a OW03-14 and OW03-15 indicate data gaps between January 2004 and Jan 2008 as well as between January 2014 and late 2018. The data gaps include the drought period (2015/2016) and the wet period (2017) included in the model simulations as noted on page 31, Section 1.3.2. What impact does this have on the reliability of the model calibration?	Page 107 Section 5.2.8. Lower Flow Zone,	Norbert M. Woerns		

		Figure 5.11. Water Levels Recorded in Monitoring Well OW03-15 (50m from Quarry Face), and Figure 5.12. Water Levels Recorded in Monitoring Well OW03-14 (175m to 40m from Quarry Face)			
133.	The connecting of the hydrographs across time long gaps provides a misleading impression. The lines connecting the gaps are in effect speculations regarding what might have happened during the gaps. Alternate hydrographs have been reproduced for OW-3-14 to illustrate objections to the presentation and to illustrate an appropriate approach.  Figure 5.12: Water levels recorded in Monitoring Well OW03-14 (175 m to 40 m from Quarry face).	Figures 5.11, 5.12, 19.6, 19.12, and 19.15	S.S. Papadopulos & Associates, Inc.		

					
134.	It is indicated that a horizontal hydraulic conductivity of 1.0×10.0^{-7} metres/second (1.0×10.0^{-8} metres/second, vertical) was selected for the Lower Aquitard (collectively the Lower Gasport through Manitoulin formations). What is the basis for this selection? Are the model results sensitive to the value of the hydraulic conductivity assigned to Layer 9?	Page 108	S.S. Papadopulos & Associates, Inc.		
135.	Monthly water level data were collected by Golder starting in 2003, and continuous data were collected in most wells from 2007 to 2013 and only starting again in October of 2018. Considering that the longest transient water level dataset is 2007 to 2013 why does the transient model run start at WY2010? It should be noted that the Level 1 and 2 Hydrologic and Hydrogeologic Assessment Terms of Reference proposes a 25 year simulation, and it specifically mentions years 2007, 2008 and 2009 as representative of dry, wet and average climate conditions, respectively.	Page 109 Section 5.3.1.2. Transient Water Level Data	Conservation Halton		
136.	Are the water level maps developed exclusively from levels reported in the MECP WWIS database? If yes, how do maps compare with the high-reliability data from dedicated Site monitoring wells? If no, how were the data of very different reliability synthesized?	Page 109 and Figures 5.13 and 5.14	S.S. Papadopulos & Associates, Inc.		
137.	When presenting water levels and interpretations, it is important to note from the outset the important differences in the reliability of the levels in the MECP WWIS database and the average water levels inferred from the records for the Site monitoring wells.	Page 109	S.S. Papadopulos & Associates, Inc.		
138.	How do the water level maps compare with the interpreted hydrostratigraphy? For example, are the levels for wells with completion depths less than 15.0 metre representative of the weathered top of rock, the "middle Amabel flow zone", or some synthesis of both? Are the levels for wells with completion depths greater than 15.0 metre representative of the "middle Amabel flow zone", the "lower Amabel flow zone", or again some kind of average for both intervals?	Page 109 and Figures 5.13 and 5.14	S.S. Papadopulos & Associates, Inc.		
139.	'There are nearby Provincial Groundwater Monitoring Network (PGMN) wells; however, all are located outside the study area.' Were the PMGM wells used to correlate climate data to ambient groundwater levels?	Page 109 Section 5.3.1. Water Level Data Sources and Monitoring Record, 1st Paragraph	Norbert M. Woerns		

140.	'Although there are gaps, the data provide useful insight into how the wells respond to rainfall events and to seasonal and inter-annual climate variability.' It appears as though there were no on-site climate data to correlate water levels to climatic events. Reliance on off-site climatic stations and composite climatic records from different climate stations as described in Section 4.1.1, page 76, and water level data gaps, limit correlation between simulated water levels and the range of climatic conditions. Please explain the impact of this on the reliability of the computer model.	Page 109 Section 5.3.1.2. Transient Water Level Data	Norbert M. Woerns		
141.	Area west of the quarry between the quarry and the Medad Valley is depicted on Figure 5.15 as having downward gradients, which suggests recharge conditions. Same figure identifies upward gradients within the Medad valley discharge conditions. If the west quarry is approved what would be the mechanism to guarantee the pre-extraction quantity of water is directed to support groundwater discharge function in Medad Valley and associated natural features?	Page 110 Figure 5.15 Section 5.3.2.1. Vertical Head Differences	Conservation Halton		
142.	What is the sign convention adopted for the mapping of the head differences in Figure 5.15? Is the following interpretation correct (with h denoting hydraulic head)? • Negative values: h(<15.0 metres) > h(>15.0 metres) ⟶ downward flow • Positive values: h(<15.0 metres) < h(>15.0 metres) ⟶ upward flow	Page 110 and Figure 5.15	S.S. Papadopulos & Associates, Inc.		
143.	This figure shows areas of upward and downward vertical hydraulic gradients. Two areas of downward gradients (in blue) are show near the edge of the Niagara Escarpment east of the subject property. These areas are located where there are few or no wells. How were these areas of downward hydraulic gradients determined? Earthfx has acknowledged that: 'While there are some clear patterns of downward gradients near the Escarpment face (shown in blue), the limitations in the MECP water well record data and spatial distribution result in limited usefulness.' (Page 110, Section5.3.2.1) Clarification is required of the information shown on Figure 5.15.	Page 113 Figure 5.15. Vertical Head Differences	Norbert M. Woerns		
144.	Figure 5.16 presents a 9 month water level hydrograph for OW03-30B, which is most likely impacted by the quarry operation in 2018/2019. Discussion of a long-term natural seasonal water level fluctuations should be supported by a long-term water level monitoring dataset for wells not impacted by the quarry operation.	Page 114 Section 5.3.3.1. Seasonal and Inter-annual Pattern	Conservation Halton		
145.	'Figure 5.16 presents a hydrograph for monitoring well MW03-30B, which shows typical seasonal water level patterns.' Figure 5.16 shows water levels for the period between November 2018 and August 2019. Does this period represent typical climatic conditions expected for this area? In other words, how typical is this period of time?	Page 114 Section 5.3.3.1. Seasonal and Inter-annual Patterns, 2nd Paragraph	Norbert M. Woerns		
146.	A relationship between the distance of the extraction face and groundwater levels in the shallow bedrock and deep bedrock is documented in this section. Even at 1000 metres away from the extraction face the groundwater levels are not at pre-extraction levels ("nearly identical"). This summary is based on a discussion of groundwater levels at four locations only (OW03-15, OW03-21, MW03-09 and OW03-17). All available groundwater level data should be provided for this assessment.	Page 115 Section 5.3.3.2. Quarry Water Level Patterns	Conservation Halton		
147.	It is clearly seen on the provided hydrographs that in the end of 2009 groundwater levels were already impacted by the quarry operation at 50, 300, 650 and 1050 metres away from the quarry face. The end of 2009 clearly cannot be used as the beginning of the transient model simulation used as a baseline scenario as it already shows impacts in groundwater conditions.	Page 115 Section 5.3.3.2. Quarry Water Level Patterns	Conservation Halton		

	Please update the baseline period.				
148.	‘Wells in close proximity to the quarry (e.g., OW03-15, which is 50 m from the face) exhibit more than 14 m of vertical head difference between the Layer 4 shallow bedrock and Layer 8 deep fracture zone, as illustrated in Figure 5.11’. The above suggests that layer 8 is drained by the adjacent existing quarry and that the horizontal hydraulic conductivity (Kh) is likely much higher that the vertical hydraulic conductivity (Kv) resulting in under draining of the overlying layers. (2nd paragraph) ‘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 (Figure 5.18),’ (4th paragraph) ‘at 1000 m from the quarry, the spring freshet provides an excess of water to the water table and, with minimal deep system drainage to the quarry, the water levels in the shallow and deep system are nearly identical.’ The above observations suggest that the existing quarry has resulted in under draining of the shallow bedrock and overburden in proximity to the quarry. It is not clear what impacts the existing quarry has had on the hydroperiod of the nearby wetlands or whether these impacts have stabilized or are expanding. Clarification is required. Earthfx considers the current conditions to represent baseline conditions. The assessed impacts are based upon simulated changes from the proposed quarry expansion compared to current conditions. The simulation of impacts of the quarry expansion do not identify the cumulative impacts of the existing quarry and the proposed expansion. Cumulative impacts including the existing quarry should be identified.	Page 115 Section 5.3.3.2. Quarry Water Level Patterns, 1st Paragraph	Norbert M. Woerns		
149.	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)	Page 115	Daryl W. Cowell & Associates Inc.		
150.	Why has a distance of 500.0 metres from the proposed extraction area been selected for particular focus? Is it expected that beyond this distance the potential impacts to private wells will be negligible? Does the calibrated model support this expectation?	Page 118	S.S. Papadopulos & Associates, Inc.		
151.	‘The actual amount of water consumed at the Burlington Quarry is relatively small. Well over 90% of the water handled is returned to the local watershed.’ How is the amount of water consumed at the quarry measured and what does it consist of?	Page 118 Section 5.4. Groundwater Use, 1st Paragraph	Norbert M. Woerns		
152.	‘Some discharge from Quarry Sump 0100 is diverted, via gravity flow, to the Burlington Springs Golf course for use as irrigation under a separate permit.’ How much water is diverted to the golf course and how much is diverted to the tributary to Willoughby Creek?	Page 118 Section 5.4. Groundwater Use, 2nd Paragraph	Norbert M. Woerns		
153.	Considering that groundwater zone of influence extends beyond 1000.0 metres away from the quarry face, if the ARA license is issued a follow up water well survey within at least 1000.0 metres of the quarry face should be carried out.	Page 118	Conservation Halton		

		Section 5.4.1. Private Water Wells			
154.	'Of the 156 homes visited, only eleven homeowners indicated that they were interested in participating in the monitoring program. Seven of the eleven private domestic water wells were accessible and, as a result, have been added to the current groundwater monitoring program (Figure 10.1)' A summary of results of the door to door well survey should be included as supporting information in the report. Copies of 26 well forms were provided in a separate information package received September 29, 2020. It is not clear whether these are all of the well survey results.	Page 118 Section 5.4.1. Private Water Wells, 3rd Paragraph	Norbert M. Woerns		
155.	It seems that total well depth was used to calculate available drawdown for private wells as presented in Table 5.3. At least 1.5 metres should be deducted from the well total depth to allow for pump setting and avoid pumping sediment. Also, private water well survey results are needed for this assessment as pump type (single jet, double jet vs submersible) may alter the available drawdown for a particular well.	Page 119 Section 5.4.1. Private Water Wells	Conservation Halton		
156.	Streamflow monitoring stations included in the GSFLOW calibration – Referring to Earthfx (2020; Sections 6 and 19), results from the calibration of the GSFLOW model are presented for 7 stream monitoring stations plus the Water Survey of Canada gauge at Grindstone Creek near Aldershot. 1. Grindstone Creek near Aldershot (02HB012): WY2010-WY2013 [Figure 6.18, 19.1] 2. SW01 (Main quarry discharge [north sump]): 2014-2019 [Figure 19.10] 3. SW02: WY2015-WY2019 [Figure 19.13]; 2017 [Figure 19.14]; 2018 [Figure 19.15] 4. SW06 (South quarry discharge [south sump]): WY2015-WY2019 [Figure 19.11]; 2017 [Figure 19.12] 5. SW09: WY2017-WY2019 [Figure 19.7]; 2019 [Figures 6.20 and 19.8] 6. SW10[B]: WY2019 [Figure 6.19]; WY2017-WY2019 [Figure 19.5]; 2019 [Figure 19.6] 7. SW29: WY2017-WY2019 [Figure 19.9] It has been left with the impression that selective use has been made of the available data in the GSFLOW calibration. • Results from the GSFLOW calibration analyses are presented for 6 of the 20 existing streamflow monitoring locations. No explanations are provided regarding why calibration results were not presented for the other 14 streamflow monitoring locations. • The understanding is that the GSFLOW calibration period extends from WY2015 to WY2019 (i.e., 5 years); however, matches to the observations are reported only for varying intervals within this period. Referring to Earthfx (2020; Section 7), GSFLOW model results for baseline conditions are presented for only 6 on-site stream monitoring stations. 1. SW07: Figures 7.14 and 7.15 2. SW09: Figures 7.4 and 7.5 3. SW10[B]: Figures 7.12 and 7.13 4. SW28: Figures 7.10 and 7.11 5. SW29: Figures 7.6 and 7.7	Sections 6, 7 and 19	S.S. Papadopulos & Associates, Inc.		

	6. SW36A: Figures 7.8 and 7.9 The results for the streamflow stations are not sufficient to confirm that the GSFLOW simulation are a reliable representation of baseline conditions. • Only three (3) of the stations selected for the representation of baseline conditions have corresponding results from the GSFLOW model calibration. • The simulation of baseline conditions with GSFLOW extends from WY2010 to WY2019 (i.e., 10 years). However, as indicated in the notes on the streamflow stations included in the GSFLOW calibration, matches to the data over the full duration of this time period are not presented. Results for a relatively small subset of the existing groundwater monitoring locations have been reported for the calibration of the GSFLOW model. Furthermore, the calibration time interval is restricted to the five (5) year period, Water Years 2010-2014. No comparisons are presented for the extensive monitoring data collected between 2003 and 2010 (Golder, 2010; Appendix D). It has been left with the impression that selective use has been made of the available data in the GSFLOW calibration. At a minimum, all locations for which water level data are available should have been considered in the calibration, for the full period for which data are available. If it was not feasible to include all the existing groundwater monitoring locations in the calibration analyses, the reporting should have at least included explanations regarding why some locations were included and others were not, and whether conditions changed between 2003 and 2015.				
157.	Does it make sense to conceive of and distinguish between Hortonian and Dunnian runoff when only daily values of precipitation are available and the PRMS analysis has 1-day time steps? Wouldn't the simulated intensity of the rainfall generally be quite different from the actual intensity?	Page 124	S.S. Papadopulos & Associates, Inc.		
158.	Should the 'Contributing Area' shown on this figure also include the up-gradient areas under Hortonian Surface Runoff and be defined by the up-gradient groundwater table?	Page 126 Section 6.3.4 Figure 6.6	Norbert M. Woerns		
159.	'Analysis of preliminary model results often pointed to gaps in the previous analyses. The gaps were addressed by obtaining additional data or re-evaluating the data analysis and assumptions made in the conceptualization phases.' What is the impact of data gaps on the accuracy/reliability of the integrated model?	Page 128 1st Paragraph, Section 6.4. GSFLOW Model Development Process	Norbert M. Woerns		
160.	How is convergence checked in the GSFLOW simulation?	Figure 6.8	S.S. Papadopulos & Associates, Inc.		
161.	Referring to Section 6.6, it is indicated that soil properties have a "significant influence on hydrological processes". However, the understanding is that tabulated look-up values are specified for many of the parameters in the analyses, rather than site-specific data. How much uncertainty should be assigned to the values assumed in the analyses? Which parameters have the most important influence on the predictions of potential impacts? As one example, refer to the estimation of potential evapotranspiration, an important component of the water budget. It is indicated on page 443 that the modified Jensen-Haise method only requires values for daily temperature, incoming global solar radiation, and "two other user-specified parameters." Based on the reading of Table A1-14 of the GSFLOW documentation, these parameters are jh_coef and jh_coef_hru, the "monthly air temperature coefficient" and the "air temperature	Section 6.6 and Page 443	S.S. Papadopulos & Associates, Inc.		

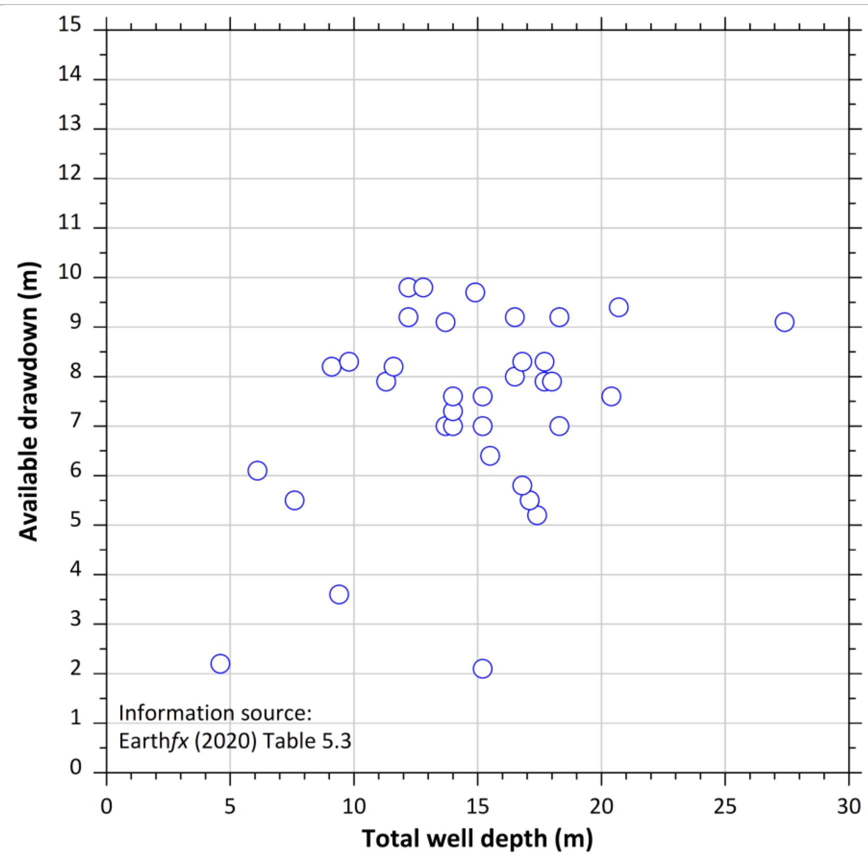
	coefficient for each HRU". There is no indication in the reporting of what these values are, what data have been considered in their assignment, and how significant they are with respect to the model results.				
162.	Topography-related Properties – The accuracy and extent of the drone survey data in the vicinity of the Quarry and expansion lands should be included within the document. LiDAR data with a +/- 0.1 metre accuracy is available for purchase from Conservation Halton to improve the accuracy of the results, if necessary.	Page 129 Section 6.6. Parameter Assignment	Conservation Halton		
163.	Reference in the text is made to MNR Soil Survey Complex (2013). However, the date of reference in Section 14 is 2003, accessed in October 2014. What is the correct date for this mapping?	Page 129	S.S. Papadopulos & Associates, Inc.		
164.	It is indicated that parameters that controlled the partitioning of flow between interflow and percolation to the water table were also specified as soil-type properties. What parameters are referred to here, and what are the bases for the specification of their values?	Page 129	S.S. Papadopulos & Associates, Inc.		
165.	The hydraulic conductivities shown on this figure are significantly higher than show on table 17.1. It is assumed this represents model layer 1. What impact do the higher hydraulic conductivities have on the model?	Page 131 Figure 6.10. Surficial Soil Hydraulic Conductivity	Norbert M. Woerns		
166.	'Parameters values were estimated for many of the submodel processes, such as snowpack accumulation, snowmelt, and potential ET (PET) calculation. These were generally estimated from "book values" or the results of previous Earthfx investigations in the Halton/Hamilton area.' What effect does parameter estimation have on the model predictions?	Page 132 2nd Paragraph Section 6.6. Hydraulic Processes Parameters	Norbert M. Woerns		
167.	It is indicated that an "acceptable" Nash-Sutcliffe efficiency of 0.44 was achieved with PRMS-only analysis of the Aldershot gauge, and an efficiency of 0.67 was achieved with the GSFLOW analysis. Chiew and McMahon (1993) is cited for the consideration of 0.6 as "a reasonable calibration value". It is worthwhile to consider exactly what Chiew and McMahon (1993) wrote. For typical hydrology and water resources studies (in particular, reservoir and catchment yield analyses), a flow estimate can generally be considered to be PERFECT if $E \geq 0.93$ or $R^2 \geq 0.97$ or $R^2 \geq 0.93$ with mean estimated flow within 10% of mean recorded flow. ACCEPTABLE if $E \geq 0.80$ or $R^2 \geq 0.90$ or $R^2 \geq 0.77$ with mean estimated flow within 10% of mean recorded flow. Simulations with $E \geq 0.60$ are generally satisfactory (inspection of graphical plots would be useful) and can be used to at least provide approximate flow volumes and for preliminary investigative studies. Generally satisfactory results for approximate flow volumes and preliminary investigative studies is not the same as "reasonable".	Page 132	S.S. Papadopulos & Associates, Inc.		
168.	Paragraph five of this section explains that white areas on Figure 6.17 represent areas where groundwater discharge exceeds groundwater recharge. It should be noted that these areas coincide with wetland locations surrounding the proposed southern extension and south of the western extension area (wetland 13201), and abut the West Branch of Mount Nemo the tributary to Grindstone Creek. Considering that the baseline scenario represents partially impacted groundwater conditions the amount of groundwater discharge in these areas was potentially higher. How would groundwater discharge function be restored and maintained during extraction face moving closer to those features resulting in additional groundwater lowering?	Page 135 Section 6.9. PRMS Submodel Outputs, Figure 6.17. Simulated annual net average groundwater recharge in mm/yr	Conservation Halton		

169.	Referring to Figure 6.4, what are the capillary and drainage reservoirs?	Page 135 and Figure 6.4	S.S. Papadopulos & Associates, Inc.		
170.	Based on the recharge map the area which is proposed for west quarry extension provides recharge which supports a number of downstream private water supplies and discharge within Medad Valley. This is also supported by provided cross sections on Figures 5.3 and 5.4. How would these conditions be maintained during and after extraction?	Page 139 Figure 6.17. Annual Net groundwater Recharge (mm/yr)	Conservation Halton		
171.	'A visual comparison of the observed and simulated values shows that a good match was achieved although, as noted in Section 5.3, there is considerable scatter in the static water level data because of the fractured nature of the bedrock; deviations are less prevalent below the Niagara Escarpment. A good match was also achieved across the model with the key study area groundwater flow patterns.' The 'considerable scatter in the static water level data' suggests local variation in the bedrock hydrogeology. The matching of water levels over the large study area suggests that the model is a good representation of area wide or regional conditions but is lacking in its ability to characterize local variations. See Section 19.5.7 Groundwater Calibration Conclusions, 5th paragraph, page 546. A discussion is required in the report on the significance of the 'considerable scatter in static water level data'.	Page 142 Section 6.10.1. Model Construction, Model Parameters, 3rd Paragraph	Norbert M. Woerns		
172.	The report should document which and how parameters in the PRMS sub-model were adjusted to calibrate the GSFLOW model.	Page 143 Section 6.11.1. GSFLOW Surface Water Streamflow Calibration	Conservation Halton		
173.	Figure 6.19, Simulated and observed flow at SW10B for WY2019 - While the match of observed streamflow to the GSFLOW simulated flows is very good for 2019, the match for Fall 2018 is weak. Further discussion is required and refinements to the calibration may be required.	Pages 143-144 Section 6.11.1. GSFLOW Surface Water Streamflow Calibration	Conservation Halton		
174.	To validate the GSFLOW model, hydrographs illustrating simulated and observed flows should be presented at a surface water monitoring location on each tributary.	Pages 143-144 Section 6.11.1. GSFLOW Surface Water Streamflow Calibration	Conservation Halton		
175.	'Additional calibration analysis was focused on matching transient responses at individual local wells, and in particular, the observed patterns in water levels between the upper and lower units and their influence on wetlands and water supply wells.' Was this additional calibration analysis extended over the study area or confined to the immediate area of the proposed quarry extensions?	Page 145 Section 6.11.3. Calibration to Transient Water Level Data, 1st Paragraph	Norbert M. Woerns		
176.	Please include OW03-15B observed and simulated water levels on Figure 6.24. The model overestimates deep groundwater conditions by some 1.0-2.0 metres and at the same time underestimates the shallow groundwater levels by some 0.5-2.0 metres without an explanation why and what it means in terms of surface and groundwater interactions. Please provide an explanation of surface and groundwater interactions at this location and any other location where the model does not simulate the observed data.	Page 149 Section 6.11.3.1. Well within 100 m of the Quarry face	Conservation Halton		

177.	Please provide a borehole logs for well nests OW03-21 and OW03-31. If well nest OW03-31 has a shallow installation, please provide the data. Please include OW03-21C simulated water levels on Figure 6.25. As presented on Figure 6.26, while the observed data in OW03-31A (deep bedrock) is consistently higher than OW03-31B (shallow bedrock), suggesting upward gradients, while the simulated water levels show consistently downward gradients. Considering OW03-31 is located next to a wetland and the model does not represent local conditions it poses a question if the model can be used to predict impacts on the wetland.	Page 150 Section 6.11.3.2. Well between 100 m and 800 m of the Quarry Face	Conservation Halton		
178.	Please include OW03-29C observed and simulated water levels on Figure 6.27. Based on observed water level data in Figure 6.27 there is a reversal of vertical gradients to upwards in the fall, this is not represented in the model as the simulated water levels are consistently 0.5 to 1.0 metre higher in the shallow bedrock – please explain.	Page 150 Section 6.11.3.3. Wells greater than 800 m from the Quarry Face	Conservation Halton		
179.	It appears that there is a two to three-month lag between the observed and simulated data as presented on Figures 6.29 and 6.30 – please explain. It appears that MP16 is constructed in MNRF wetland 13037. As per Provincially Significant Grindstone Creek Headwaters Wetland Complex assessment, February 2007, Ontario Ministry of Natural Resources Aurora District this wetland also known as No. 12 was identified to be seepage-fed and contributing baseflows to Grindstone Creek.	Page 152 Section 6.11.4. Shallow Groundwater Calibration	Conservation Halton		
180.	'Numerous additional examples of each of these water level patterns are included in Section 19. The numerical model universally replicates the patterns, indicating an excellent calibration to the observed effect of the existing quarry. The close calibration to these commonly observed patterns confirms that the model can accurately predict the future effects of the quarry extension.' The model appears to generally match the observed hydrograph patterns although the computer simulations often either under estimate or over estimate the water levels compared to observed water levels. See Figure 6.24, page 149. What is the significance of this?	Page 152 Section 6.11.3.4. Quarry Effects Calibration Conclusions	Norbert M. Woerns		
181.	The predicted water levels in shallow monitors MP16 and MP6 show similar seasonal patterns although there is a time phase shift from the observed water levels. What is the significance of this time shift?	Page 154 Figures 6.29 and 6.30	Norbert M. Woerns		
182.	Please explain a two to four-month lag between observed and simulated water level results for MP5 and what it means in terms of using the model for predictive analysis.	Page 155 Section 6.11.5. Wetland and Pond Calibration	Conservation Halton		
183.	'Water levels in this wetland are always higher than the water table (shown as the Layer 2 potentials in Figure 6.33).' Figure 6.33 appears to show hydrographs of measured and simulated water levels of the water table at MP33. Wetland water levels, for comparison, should be shown on this figure.	Page 156 Section 6.11.6.1. MNRF Wetland 13025	Norbert M. Woerns		
184.	Typographic error, 'MNRF Wetland 1301' should read 'MNRF Wetland 13031'	Page 157 Section 6.11.6.2. MNRF Wetland 13031, 1st Paragraph	Norbert M. Woerns		

185.	'The observed water levels in the wetland pond are nearly 10 m above the measured water table in monitor OW03-19C (Figure 6.34), confirming that this a highly perched wetland'. This location is elevated with an overburden thickness of 9.9 metres which is largely responsible for the perched wetland condition. A discussion is required whether this is typical of the majority of wetlands within the study area.	Page 157 Section 6.11.6.2. MNRF Wetland 13031, 1st Paragraph	Norbert M. Woerns		
186.	The GSFLOW calibration section is lacking calibration to transient groundwater level data outside of the existing quarry zone of influence, especially to the west of the quarry. Please update the calibration accordingly.	Page 161 Section 6.11.8. GSFLOW Calibration Conclusions	Conservation Halton		
187.	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).	Figure 6.37	Daryl W. Cowell & Associates Inc.		
188.	Figure 6.39 is confusing. It shows a loss of groundwater on annual basis at a rate of some 1000-2000m3/d, and groundwater ET losses in winter months at rates which are comparable to summer months – please clarify.	Page 164 Figure 6.39. Average monthly groundwater budget for the study area	Conservation Halton		
189.	The color scheme in Figure 6.39 and Figures 19.48 is confusing. In a copy of the report, the terms "Net outflow from storage" and "Net boundary flow in" have identical colors. Is it correct in understanding that the positive blue quantities denote the "Net boundary flow in" and the negative blue quantities denote the "Net outflow from storage"? The term "Net outflow from storage" is also confusing. If this is indeed a negative quantity, shouldn't it correspond to sink for the groundwater system, with water going into storage, as MODFLOW would simulate during months of rising groundwater levels? And wouldn't there be months during which groundwater levels declined and the changes in storage would be interpreted as sources in the groundwater budget?	Figures 6.39 and 19.48	S.S. Papadopulos & Associates, Inc.		
190.	'The model was run for a ten-year period (WY2010 to 2019) and calibrated to regional and local observation data collected during this time.' Were there actual measured water level data from the property throughout this period and especially during periods of drought and wet conditions from which simulations were made? Does this baseline analysis incorporate the impacts of the existing quarry? A discussion is required on how appropriate calibration to local and regional water well data may be for purposes of capturing the impacts of the existing quarry even though the quarry has existed since 1953. Well record data would span this time frame. How would these data be representative of impacts of the existing quarry which was slowly expanding over this period of time? Would the well data be representative of the modeled climatic period of 2010 to 2019?	Page 165 Section 7.1. Baseline conditions Analysis, Introduction, 2nd Paragraph	Norbert M. Woerns		
191.	'The exceptionally long model run times and model stability challenges required practical model management solutions. In some cases, the long model runs were completed as two simulations spanning the 10-year assessment time period. For example, the first 5 years of the baseline scenario was completed as one continuous simulation, with an emphasis on the assessment of the Golder monitoring data. The second part of the baseline assessment started in October 2014 and covered:	Page 166 Section 7.2.2. Scenario Summary and Nomenclature	Norbert M. Woerns		

	• the WY2015-WY2016 drought period (including a Level 2 Low Water Advisory), • the WY2017 wet period, and finally, • the WY2018-WY2019 new data collection period.' What impact does the on-site data gap have on the computer model simulations?				
192.	The proposed set of groundwater assessment points for "the Baseline and Scenario comparative analyses" at locations without observed data seems questionable. Please provide a justification of why these assessment points are representative of baseline conditions and why would it be appropriate to use them for comparative analyses.	Page 167 Section 7.2.4. Seasonal and Inter-annual Groundwater Levels	Conservation Halton		
193.	'At any location in the vicinity of the quarry a private water well could be drilled to the Layer 8 fracture zone and would have up to 22 m of available drawdown' Available drawdown has been used as a potential measure of possible available groundwater. This does not take into consideration the aquifer yield or water quality. Flow profiling completed by Golder in 2004 indicates that the Amabel aquifer has diminishing flow with depth (See Figure A8 and A9 page 434 and 435 respectively of Earthfx hydrogeological report). This suggests that despite available drawdown, little or no additional groundwater supplies may be available at deeper levels within portions of the Amabel Aquifer. Deepening wells may therefore not be a viable option for restoring water supplies to private wells. Private residences along Cedar Springs Road near the northwest portion of the western extension are located at surface elevations of about 254.0 and 545.0 mASL compared to the base of the proposed quarry excavation of 252.5 mASL which represents the lowermost portions of the Amabel Formation. What impact would this have on available drawdown from the Amabel Formation?	Page 167 Section 7.2.4. Seasonal and Inter-annual Groundwater Levels, 4th Paragraph	Norbert M. Woerns		
194.	The next-to-last paragraph on page 167 of the Earthfx report reads: Figure 7.3 presents a summary of the groundwater supply conditions in the study area. This figure shows the available groundwater drawdown in the Amabel Formation. At any location in the vicinity of the quarry a private water well could be drilled to the Layer 8 fracture zone and would have up to 22 m of available drawdown. Near the existing quarry that drawdown is reduced by the effects of the quarry dewatering, but many wells are both shallow, and in close proximity to the quarry, and yet have had suitable water supply for many years. It is not clear why model Layer 8 [Amabel Lower Fracture Zone] has been selected for the assessment of the available drawdown for baseline conditions. The depths of private wells within 500.0 metres of the extraction boundary are reported on Table 5.3 of the Earthfx report. As shown in the plot of these data below, it is likely that private wells extend only into the weathered top of rock (model Layer 4) or model Layer 6 [Amabel Middle Fracture Zone].	Page 167 and 481, Table 5.3, and Figures 3.25, 5.6, 5.7, 5.8, 7.3, 7.17, 18.3, 19.22-19.33	S.S. Papadopulos & Associates, Inc.		



The impression is that it has been assumed in the modelling that the lower portion of the Amabel Formation is a productive aquifer. This assumption does not appear to be consistent with the results of packer testing (Figure 5.6), which does not show an interval of consistently higher productivity at the bottom of the Amabel (i.e., relatively higher hydraulic conductivity). It appears that the greatest weight has been placed on the results of the testing of BS-01 (Figure 3.25), a location that does not seem to be typical of the bottom of the Amabel Formation as shown on the profiles of packer testing (Figures 5.6, 5.7 and 5.8).

Figure 7.3 shows a map of calculated values derived from two other maps of calculated values that are not provided. It appears that what is shown is the difference between (1) the simulated average water level in Layer 8 of the model (Lower Fracture Zone) for the period of WY2010-WY2019, and (2) the assumed elevation of the top of Layer 8. It is not possible to assess the reliability of this figure with the information provided in the report. No map of simulated water levels in Layer 8 is included in the report. The interpretation of the time period may not be correct. The description of Figure 7.17 in the preceding paragraph refers to a time period of WY2015-WY2019. The retained consultant could also be wrong about the assumed elevation for calculating the available drawdown. It might be the middle or the bottom of Layer 8. The reporting of the thickness for layer 8 could not be found. It is described as ‘representing a thin lower fracture zone’ (page 481 second last paragraph).

More important than simply checking the reliability of the calculation of the values of the available drawdown shown in Figure 7.3, it is not possible to assess the reliability of the simulated groundwater levels used in the calculations. In Figures 18.3 and 19.3, simulated average water levels are compared with water levels reported in the well

	records for the private wells beyond the site boundary. The results shown in these two figures suggest that the likely mismatch at the location of an individual well is relatively large, on the order of ±10.0 metres. No comparable assessment of the match to the average water levels for on-site monitoring intervals in the Amabel Lower Fracture Zone is presented in the report. Observed and simulated hydrographs for 12 observation wells are presented in Figures 19.22 through 19.33; however, there is no indication of the average levels, nor is it indicated which of the wells are open across only the Lower Fracture Zone. It is noted that there is a phase shift in these hydrographs resulting in a difference of 0.5 to 1.0 metre at the south end of the southern extension between measured and simulated water levels of the lower Amabel (OW03-17A, 18A, 19A, 29A -Figures 19-30, 19-31, 19-33, and 19-32, respectively). A similar difference is noted along the west side of the southern extension at MW03-01 (Figure 19-29). This difference increases to several metres closer to the existing quarry at MW03-02 (Figure 19-28).				
195.	'The Medad Valley is an interesting setting, for Figure 7.20 shows that there is groundwater discharge to the soil zone along the flanks of the valley, yet the main stream in the centerline of the valley is leaking water to the groundwater system (Figure 7.21). This demonstrates that the incised Medad wetlands and streams are somewhat isolated from, and functionally different than, the streams and wetlands of the upland plateau (where the quarry is located).' What measured field data are there to support the conclusion that the main stream in the Medad Valley is losing water?	Page 179 Section 7.2.5.4. Stream Leakage (Hyporheic Exchange), 2nd Paragraph	Norbert M. Woerns		
196.	Please provide digital, daily water levels, presented graphically (to depict the wetland hydroperiod) and summarize daily water balance analyses as average monthly water volumes presented in tabular format integrated in the report. Compare driest year, average and wettest year monthly water volumes to assess potential impact.	Page 179 Section 7.2.6. Wetland Water Budgets	Conservation Halton		
197.	'There are 24 wetlands within the study area (locations are shown in Figure 7.22). Detailed feature- based water budgets were calculated to analyze the inflows and outflows to 22 of these local wetlands.' Of the 22 wetlands within the study area, there appears to be groundwater shallow instrumentation only at five wetlands SW5, SW11, SW12, SW13, and SW16 for purposes of water budget analysis. How were water budgets completed for the remaining wetlands where there was no shallow groundwater instrumentation? Do the water budgets represent average, conditions or were drought and wet conditions considered?	Page 179 Section 7.2.6. Wetland Water Budgets, 1st Paragraph	Norbert M. Woerns		
198.	Figures 7.20 and 7.21 show groundwater discharge to the soil zone under wetlands and streams and discharge to streams, respectively. Some of these areas are within less than 200.0 metres of the proposed south extraction. How would these functions be maintained during and after extraction?	Pages 183-184 Figures 7.20 and 7.21	Conservation Halton		
199.	How was the level of detail generated for this figure where there are widely dispersed data control points or monitoring locations?	Page 184 Figure 7.21. Average Simulated Streamflow Loss to Groundwater (blue) or Groundwater Discharge to Streams (red)	Norbert M. Woerns		

		(m^3/d) under Baseline Conditions			
200.	Wetland 9 (13014) water balance summary shows no groundwater discharge, however based on Figure 6.26, at OW03-21 there are documented upward gradients between the deep and shallow bedrock. Please provide hydrograph of all available monitoring data for OW03-30, OW03-31, MW03-08, MW03-10 and MW03-11 located in and around Wetland 9.	Page 186 Figure 7.23	Conservation Halton		
201.	The water budget inputs do not appear to match the outputs. Please clarify.	Pages 186-188 Figures 7.23-7.28. Wetland Water Budgets	Norbert M. Woerns		
202.	To evaluate the results of the wetland water balance results please submit all available water level monitoring data in and around the wetlands.	Pages 186-189 Figures 7.24-7.30	Conservation Halton		
203.	'The Baseline surface water analysis demonstrates that, while there are some interactions between the surface and groundwater systems, they are frequently limited by the regionally extensive, and low permeability, Halton Till.' The Halton Till is recognized as consisting of relatively fine grained materials. However, no consideration has been given to the pump test results completed by Golder (2010) showing a response in the overburden materials presumably consisting of Halton Till to pumping test of the underlying Amabel bedrock. The field program completed for this investigation has not addressed the evidence from the Golder pump test results. An explanation of the Golder data and test results should be provided.	Page 190 Section 7.3. Baseline Conditions, 2nd Paragraph	Norbert M. Woerns		
204.	''None of the wetlands in the immediate vicinity of the quarry receive significant groundwater inflows.' How can this be determined with any certainty without instrumentation and monitoring of both groundwater and surface at each of the wetlands? Only five of the 22 wetlands have groundwater instrumentation installed for this investigation. Clarification is required.	Page 190 Section 7.3. Baseline Conditions, 2nd Paragraph	Norbert M. Woerns		
205.	'Near the existing quarry that available drawdown is reduced, but many existing wells are in close proximity to the quarry, and yet have been providing suitable water supply for many years.' Evidence to support the conclusion regarding suitable water supply for wells in close proximity to the existing quarry should be provided.	Page 190 Section 7.3. Baseline Conditions, 3rd Paragraph	Norbert M. Woerns		
206.	'However, the off-site discharge will continue as per the conditions of Nelson's PTTW and ECA.' There is a recommendation to increase the discharge volume for Sump 100. Tatham page 92 last paragraph. This is contradictory to the above statement. No assessment of the impact of this increase in pumping on downstream areas has been completed to support this increase in pumping. An assessment of the impact of the increase in pumping on downstream areas is required to support this increase in pumping.	Page 191 Section 8.1. Proposed Extraction, 1st Paragraph	Norbert M. Woerns		
207.	'For the western extraction area, the existing sump (0100) will continue to operate and discharge water to the Collins Road roadside ditch and into the Weir Pond. The existing golf course irrigation ditch and pond will be relocated to an area outside of the extraction area but inside of the license boundary to replicate the artificial groundwater mound they currently create.'	Page 191 Section 8.1. Proposed Extraction, 2nd Paragraph	Norbert M. Woerns		

	Has the groundwater mound beneath the existing irrigation ditch and pond been confirmed with field data or is it only assumed to exist? If the Halton Till limits surface and groundwater interaction as postulated above, the proposed infiltration pond may not provide significant recharge to the underlying aquifer. Please clarify				
208.	'The Level 2 Assessment surface and groundwater issues are fully addressed by the integrated model.' The Level 2 assessment has not addressed water quality issues with respect to potential impact of the quarry on water quality discharge as surface water and potentially being recharged back into the aquifer through an infiltration pond(s). The drinking water quality implications of this have not been addressed in the assessment. Potential sources of contamination affecting surface and groundwater quality have also not been addressed in this assessment. The nearby high pressure oil pipeline along the southern side of Collins Road and partially beneath the wetland adjacent to SW1 and the weir to control quarry discharge water, presents a potential water quality risk to the quarry operations. (see Site Plan Sheet 1 of 4 and Explotech Blasting Report page 19). A more complete analysis of water quality issues is required.	Page 191 Section 8.3. Level 2 Assessment Overview, 1st Paragraph	Norbert M. Woerns		
209.	It is stated that from a hydrogeological perspective the proposed west quarry extension is located in a favorable area due to the Medad Valley which is "a locally significant groundwater discharge area" which reduces the amount of inter-seasonal water level fluctuations. The Medad Valley is downstream of the proposed extension and although it is a hydraulic boundary which reduces the amount of water level fluctuations, a reduction of flow towards it would be considered a direct negative impact on this feature. Furthermore, most of the proposed west quarry extension is upgradient of numerous private water supplies, an area which provides recharge to the underlying aquifer. Since most of this area would be extracted causing groundwater lowering due to quarry cone of influence and reducing the upgradient area providing recharge for the private water supplies, an infiltration pond had to be proposed to mitigate the impacts, feasibility of which is uncertain (please see comments below, re: Page 226, Section 8.6.1 Infiltration Pond).	Pages 191-192 Section 8.3. Level 2 Assessment Overview	Conservation Halton		
210.	Right Hand Column - Level 2 Assessment Needed?, 3rd row 'Limited potential for water quality effects as groundwater dewatering will maintain flow directions into the quarry.' There is no information provided in the hydrogeological report to support the above statement. Clarification is required.	Page 192 Table 8.1. Evaluation for Need for Level 2 Hydrogeological Assessment	Norbert M. Woerns		
211.	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."	Section 8 Page 192, 1st Paragraph, and Table 8.1	Daryl W. Cowell & Associates Inc.		
212.	The Medad Valley Wetland Complex is within 120.0 metres 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 120.0 metres (but within the 240.0 metres 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.	Table 8.1	Daryl W. Cowell & Associates Inc.		
213.	A more robust discussion of the anticipated changes in stream flows should be provided. At a minimum, the analysis should include:	Pages 193-302	Conservation Halton		

	• Maximum changes in stream flow rates for each tributary/flow node (in addition to the change in average stream flow rates provided). • Percentage change in average and maximum stream flow rates. • Any change in the duration of no flow or baseflow periods. • Simulated stream hydrographs and analysis for Willoughby Tributary immediately downstream of Collings Road.	Section 8.4. Model Evaluation of Extraction Phases			
214.	Detailed water budget for wetland figures should include baseline and proposed values to facilitate reviews.	Pages 193-302 Section 8.4. Model Evaluation of Extraction Phases	Conservation Halton		
215.	Table 8.3, Scenario Summary – The climate data periods used to analyse extraction scenarios are not consistent. Explanation and justification for the start and end dates should be provided.	Page 196 Section 8.4.1. Model Evaluation of Extraction Phases, Scenario Summary	Conservation Halton		
216.	Up to 14 m or more drawdown predicted using equivalent porous media assumptions in model. Pumping tests (west extension area Well BS-07 and BS06) and well flow profiling in south extension area (S. McFarland Witness Statement Sept. 2010 PDF pages 284-286) show significantly different hydraulic conditions within short distances. These results question the reliability of the model to predict local conditions. Please explain how the site variability impacts the model assumptions and the reliability of the model predictions.	Page 200 Figure 8.5. Average Simulated Drawdown in Model Layer 6 (m) and Increase/ Decrease in Streamflow	Norbert M. Woerns		
217.	'The transient simulations through 2015-2016 provide insight into the effects of P12 during seasonal and interannual variation, including a Level 2 drought.' These simulations lack comparison (calibration) of predicted drawdowns to sites with measured groundwater levels during this time period. What is the impact of the lack of data for calibration of the model and on predictions of the model?	Page 204 Section 8.5.2. P12 Seasonal and Inter-annual Groundwater Levels, 1st Paragraph	Norbert M. Woerns		
218.	'Under drought conditions there will, however, continue to be up to 20 m of available drawdown in the Amabel Aquifer. (Figure 8.21)' No consideration is given well productivity in assessing interference potential and groundwater availability. Available drawdown alone does not guarantee adequate water supplies. Well productivity and water quality should be considered in quarry impacts on private wells and the assessment of groundwater availability.	Page 204 Section 8.5.2. P12 Seasonal and Inter-annual Groundwater Levels, Last Paragraph	Norbert M. Woerns		
219.	'Figure 8.24 presents the average simulated streamflow loss to groundwater (blue areas) and the areas of groundwater discharge to streams (red areas). Little change is seen compared to the Baseline Conditions (Figure 7.21), except in the small streams in the wetland complex to the west of P12.' What is the explanation for change in stream flow in the small streams in the wetland complex to the west of P12? Has this analysis taken into consideration increased potential loss of water through the Halton Till due to till fracturing?	Page 211 Section 8.5.3. P12 Surface Water/ Groundwater Interaction, 2nd Paragraph	Norbert M. Woerns		

220.	'Under P12 conditions, water levels have declined by up to 5 m under Wetland 17. What is the impact of lowering groundwater levels by 5 metres on the hydroperiod of this wetland?	Page 211 Section 8.5.3. P12 Surface Water/ Groundwater Interaction, 2nd Paragraph	Norbert M. Woerns		
221.	'Water budgets were completed to analyze inflows and outflows to 22 local wetlands (locations shown in Figure 7.22).' Only five wetlands have shallow groundwater monitors installed for this study. How can water budgets completed without groundwater monitoring data and surface water monitoring data at each wetland be considered reliable?	Page 211 Section 8.5.4. P12 Wetland Water Budgets,1st paragraph	Norbert M. Woerns		
222.	Wetland 21 (13201) is considered compromised due to the road and culvert, and its water budget is not considered representative of future conditions. There is also minor groundwater discharge to the wetland. Please confirm how changes to this wetland will be assessed and mitigated. The NETR identifies this wetland as adjacent to a rare vegetation community and this should be considered when assessing impacts.	Page 212 Section 8.5.4. P12 Wetland Water Budgets	Conservation Halton		
223.	The baseline conditions are compared to the Phase12 conditions in this figure for layer 2 (Halton Till overburden) and Layer 8 (Lower Fracture Zone). The section line extends in a northwest-southeast direction parallel to a series of wetlands east of the southern extension. The baseline conditions show water levels in layer 2 at or slightly above surface at Wetland #17 with progressively lower levels toward the northwest as one approaches the existing quarry. The layer 8 water levels follow a similar pattern with relatively high groundwater levels at wetland #17 with progressively lower levels to the northwest as one approaches the quarry. The drop in water levels closer to the quarry are likely the result of the existing quarry dewatering. (See Section 5.3.3.2 Quarry Water Level Patterns). Consequently, the current hydrogeologic conditions beneath the wetlands between wetland #17 and the quarry appear to represent altered groundwater conditions. It is also possible that wetland #17 has been impacted by the existing quarry. The current or baseline conditions of these wetlands are being used to measure the impact of the quarry expansion. The simulated Phase12 conditions show a similar pattern of decreasing water levels toward the northwest with water levels in both Layer 2 and Layer 8 being lower than baseline conditions. Please explain the appropriateness of using impacted wetland conditions as a baseline for purposes of site rehabilitation.	Page 218 Figure 8.27. Wetland Cross Section	Norbert M. Woerns		
224.	The water budget inputs do not appear to match the outputs. It would be useful to illustrate water budget inputs and outputs in a table format for comparison. It is not clear how GW Outflows and Inflows as a percentage of Total outflows were calculated. Please clarify.	Page 221-224 Wetland Water Budget Figures 8.30-8.37	Norbert M. Woerns		
225.	Phases P34, P3456, RHB1 - The report suggests that water is not discharged to the tributary of Mt. Nemo Creek during these phases, while other reports indicate the discharge from Quarry Sump Q200 will continue through these phases and will potentially increase. Analysis should be consistent with proposed mitigation plan and the modeling updated as necessary.	Page 225 Section 8.6. Scenario P34; Page 230 Scenario P3456; Page 260 Section 8.8, Scenario RHB1	Conservation Halton		
226.	Scenario P34 assumes that extraction in Phase 1 and 2 is complete and the water levels filled to the natural conditions. How long will it take for P12 to fill to the natural conditions? Unless P12 is filled before extraction commences in P34 the proposed approach does not represent cumulative impacts.	Page 225 Section 8.6. Scenario P34	Conservation Halton		

227.	'The wetland water budgets confirm that the wetlands will leak a small amount more to the groundwater system under P12 conditions, but the effect of this change is so small that it cannot be measured in the field and will not change the overall water budget of the wetland.' Leakage of water from the wetlands into the groundwater system can only be confirmed for those wetlands with shallow groundwater monitoring data along with surface water monitors. What effect is this loss of water from the wetlands expected to have on the wetlands?	Page 225 Section 8.5.5. P12 Level 2 Conclusions, 4th Paragraph	Norbert M. Woerns		
228.	The proposed infiltration pond (as shown on Figure 8.38) does not match the pond shape on the submitted site plans. The pond on the site plans does not have a spur parallel to Cedar Springs Road in the northwest corner of the site. The grades on the site plans suggest that the spur cannot be constructed as shown on Figure 8.38. Please clarify.	Page 226 Section 8.6.1. Infiltration Pond	Conservation Halton		
229.	Is the proposed infiltration pond an appropriate measure to mitigate impacts on private water supplies? The proposed infiltration pond would make most, if not all downstream wells, categorized as groundwater under direct influence of surface water (GUDI wells). Although, the proposed infiltration pond could be used as a measure to mitigate impacts on the NHS (Medad Valley), assuming that the pre-extraction groundwater heads could be maintained, considering private water supplies exist downstream of the proposed pond, how would the construction of the ponds be carried out to ensure ample and good quality of water is available for downgradient groundwater users? What measures would be implemented to ensure that water quality meets ODWQS? How would the pond be constructed to ensure continued infiltration: it is stated in the report that wetlands are perched, what would be done to ensure that the infiltration pond does not lose its intended functionality with time? How would water be prevented to flow back into the extraction zone? Monitoring, mitigation and contingency details should be provided to ensure that there is no water quantity and quality impacts on the downstream groundwater users in this area.	Page 226 Section 8.6.1. Infiltration Pond	Conservation Halton		
230.	'Water is currently routinely diverted from the north quarry discharge pond, through golf course ditches, to the golf course ponds. This water is used for irrigation and a portion also likely infiltrates directly to the groundwater system. The proposed infiltration pond is intended to function in a similar manner to the irrigation ditches and golf course ponds, so as to help maintain the current surface and groundwater system patterns. In addition, based on the findings of this report, Tatham (2020), and Savanta (2020), pumping to the north and south (Quarry discharge locations Sump 0100 and 0200), must be maintained.' The infiltration capability of the irrigation pond is assumed and has not been confirmed with field instrumentation. A compelling case for the maintenance of pumping to the north and south (Quarry discharge locations Sump 0100 and 0200) is not supported with the analysis. A more complete analysis of the impact of the rehabilitation scenarios should be completed considering not only individual stream reaches but the sub-watershed as a whole.	Page 226 Section 8.6.1. Infiltration Pond, 1st Paragraph	Norbert M. Woerns		
231.	'Figure 8.40 also shows the average simulated change in streamflow. Increases in simulated flow occur at the Northwest sump (and in new quarry floor drains and the conduits carrying flow to the infiltration pond). Decreases in simulated flow occur in the Medad Valley, reaching a maximum of approximately $1.0x10.0^{-3}$ m3/s (1.0 litre/second) in the Medad creek immediately west of the P34 excavation.'	Page 226 Section 8.6.2. P34 Drawdowns and Surface Water Flows, 2nd Paragraph	Norbert M. Woerns		

	What accounts for the decrease in flow to Medad Valley given the increase in flow of quarry discharge and subsequent discharge into the proposed infiltration pond?				
232.	Scenario P3456 assumes that extraction in Phase 1 and 2 is complete and the water levels filled to the natural conditions. How long will it take for P12 to fill to the natural conditions? Unless P12 is filled before extraction commences in P3456 the proposed approached does not represent cumulative impacts.	Page 230 Section 8.7. Scenario P3456	Conservation Halton		
233.	'Figure 8.42 shows the average simulated heads in Model Layer 6, representing the middle fracture zone in the Amabel aquifer and average simulated streamflow for the same period under Scenario P3456. Figure 8.43 shows the average simulated drawdown in Model Layer 6. The water levels rise rapidly with distance from the excavation, and exhibit less than 2.0 m of drawdown at a distance of 500 m from the active face.' The depth of excavation will extend to 252.5 mASL to near the bottom of Model Layer 7 almost to the top of Model Layer 8. Are the existing quarry sumps excavated into Model Layer 8? Will there be a need for additional sumps into model layer 8 to keep the proposed excavation dry and what impact will this have on groundwater levels in Model Layer 8 and local wells?	Page 230 Section 8.7.1. P3456 Drawdowns and Surface Water Flows, 1st Paragraph	Norbert M. Woerns		
234.	No changes to the water budget for Wetland 22 (13200) are suggested, as the wetland is perched and there is no change to its contributing area, however as noted in the Surface Water Assessment drawings DP-1 and DP-2, it appears that there will be changes to the catchment area of the wetland. Please discuss if these changes will impact the water budget for this wetland.	Page 242 Section 8.7.4. P3456 Wetland Water Budgets	Conservation Halton		
235.	'Wetland 22 is located between the P3456 extraction area and the existing quarry. This wetland had no change in the water budget compared to baseline conditions because it is perched year-round and there was no change in the contributing area.' This wetland is located relatively close to the existing quarry within about 100.0 metres, and appears to be perched, likely due to the impacts of the existing quarry. It is reasonable to assume that the proposed western expansion will not substantially change the conditions beneath Wetland #22 as quarry impacts on the groundwater system have already occurred. There is no water level data from the overburden in this area to confirm shallow groundwater table. The nearest monitors BS-03A and BS-03B are completed into the underlying bedrock. The hydrograph for BS-03A and BS-03B shown on the lower figure on page 395 (no figure no.) indicated very slight downward gradient from data logger data. It is unclear what the red line and red symbol on the hydrograph for BS-03 represents. Is this BS-03A or BS-03B? Water level data in the wetland and underlying overburden along with the underlying bedrock is required to asses the water budget and potential impact of the proposed expansion.	Page 242 Section 8.7.4. P3456 Wetland Water Budgets, 2nd Paragraph	Norbert M. Woerns		
236.	It is not clear from water budget figures 8.62 to 8.69, how the percent groundwater outflow and inflow was determined. Please clarify.	Page 243 Section 8.7.4. P3456 Wetland Water Budgets Table 8.6	Norbert M. Woerns		
237.	'Under P3456 conditions, current levels of quarry discharge will continue to pass through this pond. Diversions for golf course operations will no longer be necessary, however a portion of flow will be diverted to the newly constructed infiltration pond, which will locally support groundwater levels in a similar manner to the current golf course ditch and pond system.' The degree to which the existing irrigation pond is contributing to the groundwater system is questionable since Earthfx has concluded 'while there are some interactions between the surface and groundwater systems, they are frequently limited by the	Page 243 Section 8.7.5. P3456 North Quarry Discharge and Infiltration Pond, 2nd Paragraph	Norbert M. Woerns		

	regionally extensive, and low permeability, Halton Till.' What is the impact of low permeability Halton Till on the proposed infiltration pond? What is the potential for infiltrated water from the proposed infiltration pond to be intercepted by the underlying sand layer and the karst layer, Model Layer 4 and not reach the wells?				
238.	It is not clear from these figures how the percentage of groundwater inflow and out flow were determined. Please clarify.	Page 248-251 Figures 8.62-8.69. Detailed water budget for wetlands	Norbert M. Woerns		
239.	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."	Section 8.7.6	Daryl W. Cowell & Associates Inc.		
240.	'The effects of P3456 development on the Medad Valley is distributed across this elongated feature. Figure 8.70 shows the areas where changes in groundwater discharge to the soil zone (seepage) will occur between the baseline and P3456 scenarios. (Values are presented on a cell-by-cell basis in m3/d). Summing those values from the start-of-flow-of Medad Creek to SW07 yields a net average decrease in seepage of 2.1 L/s at SW07. The hydrograph for SW07 (Figure 8.49) shows that the change is primarily a minor reduction in winter and spring peak flows.' Tatham measured average baseflow at SW7 at 4.0 litres/second (Tatham page 10 Monitoring Location SW7, 2nd paragraph, 1st sentence). SW7 is located on Willoughby Creek immediately downstream of the confluence with the unnamed tributary to Willoughby Creek. As per the above, modeled net average decrease in seepage is 2.1 litres/second or just over 50.0% of the average baseflow measured at SW7. The significance of this reduction in baseflow should be addressed.	Page 252 Section 8.7.6. P3456 Effects on Medad Valley, 1st Paragraph	Norbert M. Woerns		
241.	'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.' Tatham measured average baseflow at SW7 as 4.0 litres/second. The reduction in seepage is calculated to be 2.1 litres/second at SW7. This is about 50.0% reduction in average baseflow. The significance of this should be addressed.	Page 252 Section 8.7.6. P3456 Effects on Medad Valley, 5th Paragraph	Norbert M. Woerns		
242.	'The water levels rise rapidly with distance from the excavation, and exhibit less than 2.0 m of drawdown at a distance of 500 m from the active face.' Most of the homes along Cedar Springs Road directly down-gradient of the proposed quarry expansion are within 300.0 metres of the limit of extraction. What is the risk of interference to these wells from the quarry expansion and what is the potential for deepening wells on these properties to maintain well productivity and water quality? Please address this issue.	Page 256 Section 8.7.7. P3456 Level 2 Conclusions, 1st Paragraph	Norbert M. Woerns		
243.	'The basal Layer 8 lower fracture will maintain, on average, between 6 and 20 m of available drawdown in the aquifer (Figure 8.75). As a result, private domestic water wells, some of which are partially penetrate the Amabel Formation, could be deepened if necessary. The proposed groundwater monitoring program has been designed to ensure that there are no changes to the quantity or quality of private water supplies (Section 9.3).' What is proposed for existing private wells that do not have 5 metres of available drawdown to support their water supply or for wells that are poorly productive and cannot supply adequate supplies of water? Please address this.	Page 256 Section 8.7.7. P3456 Level 2 Conclusions, 2nd Paragraph	Norbert M. Woerns		

244.	'Under baseline conditions, none of the wetlands receive more than 3% of their total inflows from the groundwater system (Table 8.6). Under P3456 conditions, the P12 excavation has been filled with water and the water table has recovered to a new level consistent with the P12 lake. This recovery has restored a degree of groundwater discharge to the wetlands near P12.' How was groundwater inflow determined for wetlands under baseline conditions?	Page 256 Section 8.7.7. P3456 Level 2 Conclusions, 5th Paragraph	Norbert M. Woerns		
245.	'The effects of the quarry extension are small and distributed across the long Medad Valley wetland. SW07, in the northern section of the Medad, shows some gains and losses in baseflow (Figure 8.43), but the largest change in flows at SW07 are a loss in peak flows, due to the increased buffering effect of the west extension (Figure 8.49). The changes in SW07 flows are so small that they will not be measurable in the field.' Tatham (p.10) measured average baseflow at 4 litres/second in Willoughby Creek at SW7. The model predicts a loss of seepage of 2.1 itres/second. This suggest a significant loss of stream baseflow. It is reasonable to assume that restoration of groundwater levels would restore most if not all of the loss in baseflow. This would be the case with Rehabilitation Scenario 2 (RHB2) whereas Rehabilitation Scenario 1 (RHB1) would continue to maintain lower groundwater levels. Please address this.	Page 257 1st Paragraph Section 8.7.7. P3456 Level 2 Conclusions	Norbert M. Woerns		
246.	'Scenario RHB1 represents a managed rehabilitation and it is assumed that discharge from the Sump 0100 will be ongoing to maintain dry conditions in the rest of the quarry area and to keep the P5 lake at the specified elevation of 255.5 masl.' How does RHB1 conform to the rehabilitation plan for the adjacent existing quarry?	Page 260 Section 8.8. Scenario RHB1, 2nd Paragraph	Norbert M. Woerns		
247.	How does the retained consultant know that the infiltration pond will provide groundwater discharge to the deeper bedrock (Model Layers 6 to 8) and not short circuit groundwater discharge only to the shallow bedrock system (Model Layers 4&5 weathered/fractured Amabel) and Upper Bulk Amabel) before discharging at surface along the Medad Valley? Note the upper bulk Amabel (Model Layer 5) has Kh/Kv of 500:1 as indicated on page 105, which would favour horizontal flow over vertical flow. Has the model adequately accounted for this possibility?	Page 263 Figure 8.79. Average Simulated Drawdown in Model Layer 6(m) and Increase /Decrease in Stream Flow (m^3/s) for WY2010 to Y2012 under Scenario RHB1	Norbert M. Woerns		
248.	'There are general decreases in flows within the existing quarry footprint and an overall decrease in the discharge from the Northwest sump. Decreases in simulated flow occur in the Medad Valley as a result, reaching a maximum of 5.2x10 -3 m3/s (5.2 L/s) compared to 3.6x10 -3 m3/s under Scenario P3456. Other streams in the east show small decreases in average flow compared to Baseline Conditions. Decreases in streamflow have been moderated compared to Scenario P12 due to the cessation of quarry dewatering at P12.' Why is there a decrease in flow in Medad valley of 5.2 litres/second under RHB1 when decrease in flow at SW7 is 2.1 litres/second under Scenario P3456 extraction? Why is there a larger decrease in flow in the Medad Valley as a result of rehabilitation Scenario 1 (RHB1) after extraction? Are these flows measured at different points?	Page 264 1st Paragraph Section 8.8.1. RHB1 Drawdowns and Surface Water Flows	Norbert M. Woerns		
249.	'SW07 in the Medad valley shows some gains and losses in baseflow, most likely due to changes in discharge from the Northwest sump that recharges the groundwater system as it flows through the karst feature.'	Page 264 2nd Paragraph	Norbert M. Woerns		

	SW7 gains and losses. How does this compare to decreases reported in Medad Valley above i.e., maximum 5.2 litres/second.	Section 8.8.1. RHB1 Drawdowns and Surface Water Flows			
250.	'The wetlands are located at various distances from the existing quarry and the extension areas. Wetland 22 is located between the P3456 extraction area and the existing quarry. This wetland had no change in the water budget compared to baseline conditions because it is perched year-round and there was no change in the contributing area. Most of the other wetland areas are slightly more similar to baseline conditions than P3456 because of internal quarry configuration changes.' For wetland 22, the simulated water budget appears to rely upon model calibrations for validity without actual data collected from this wetland. Little is known of Wetland 22 (MNRF wetland #13200) due to a lack of monitoring data. Tatham indicated that surface water monitoring of this wetland will be established in the spring of 2020 with monitoring station SW 37 (Tatham, 2020, Table 39, page 81). No surface water monitoring data for this location are included in the Tatham report. The nearest groundwater monitor to wetland 22 is BS-03 which is about 100.0 metres from this wetland. A similar situation exists for wetland 21 located adjacent the north side of No. 2 Side Road. The nearest groundwater monitor location, BS-04, is about 150.0 metres from wetland 21. Quarterly surface water flow monitoring data was recorded at M33 at wetland 21. How does the lack of monitoring data for wetland 22 affect the reliability of the computer simulations of the water budget?	Page 272 Section 8.8.4. RHB1 Wetland Water Budgets, 2nd Paragraph	Norbert M. Woerns		
251.	It is not clear how the percent of groundwater inflow and outflow have been determined. Please clarify.	Page 277-279 Wetland Water Budgets, Figures 8.98-8.103	Norbert M. Woerns		
252.	'From a groundwater perspective, the differences between P3456 and the RHB1 scenario are minor. Under RHB1, a small rise in the water levels in the modified quarry ponds has a minor but positive effect on the water levels in the vicinity of the private wells near the Medad Valley. Quarry discharge and operations are similar. In summary, the Level 2 analysis of available drawdown and wetland function conclusions, presented for P3456 (Section 8.7.7) is essentially the same for RHB1.' This indicated that the preferred rehabilitation option, RHB1, will have very similar impacts on the groundwater and surface water system as the phase 3 to 6 proposed western quarry extension. This condition is proposed to be maintained in perpetuity. The rational for maintaining pumping and the low groundwater levels is based upon perceived fish habitat impacts on two stream reaches currently artificially maintained by pumping. There is no analysis of overall impact on the local sub-watershed. A broader analysis of the impacts on the sub-watershed should be completed.	Page 280 Section 8.8.5. RHB1 Level 2 Conclusions	Norbert M. Woerns		
253.	'Figure 8.106 shows the simulated change in average head in Model Layer 6. Only a very small area west of Phase 5 had a drawdown greater than 2 m, which was due to the elimination of quarry discharge and leakage to groundwater. Some residual drawdowns, less than 1.3 m, are noted in the P12 area, due to the flattening of the water table in the vicinity of the P12 lake. Most of the quarry vicinity showed a significant increase in heads ranging from 0 to 12 m, with the 2 m rise extending out up to 630 m from the west side of the existing quarry.'	Pages 280-281 Section 8.9.1. RHB2 Drawdowns and Surface Water Flows, 2nd Paragraph	Norbert M. Woerns		

	The predicted increase in groundwater levels should result in restoration of groundwater conditions. The overall impact of this on surface water and on local wells should be assessed and factored into the rehabilitation scenario assessment.				
254.	'Surface water flow in the upper reaches of a tributary of Willoughby Creek and the West Arm of the West Branch of Mount Nemo Creek will cease when the quarry discharge is discontinued, resulting in an adverse impact to downstream fish habitat compared to baseline conditions (See Savanta, 2020 and Tatham, 2020 for details).' Model simulation results in flows deceasing in upper reaches of Willoughby Creek and the West Arm of the west branch of Mount Nemo Tributary of Grindstone Creek when quarry discharge is discontinued. Model simulation shown on Figure 8.105 (page 283) indicate that stream flows within these stream reaches continues but at a reduced rate compared to baseline conditions as shown on Figure 8.106 (page 284). The model shows an increase in stream flows of most of the other streams in the area (Figure 8.106). The stream flow increases have been quantified in the next two paragraphs on page 285. An overall analysis should be completed weighing the benefits of the stream flow increases against the disadvantages of reduced streamflow in selected areas. (Note: The impact of these changes in streamflow is a fish habitat issue and requires fisheries expert input.)	Page 281 Section 8.9.1. RHB2 Drawdowns and Surface Water Flows, 2nd Paragraph	Norbert M. Woerns		
255.	'SW07 in the Medad valley shows very small gains in baseflow, most likely due to cessation of discharge from the Northwest Sump that served to recharge the groundwater system as it flowed through the karst feature. Decreases in event flows reach a maximum value of 0.05 m3/s.' The simulated loss of seepage within Willoughby Creek down stream of the western expansion area was simulated to be 2.1 litres/second under the Phase 3456 extraction compared to current baseline conditions. Under RHB2 the quarry dewatering will cease and groundwater levels will increase up to 12.0 metres closest to the excavation. Given the large projected increase or rebound in groundwater levels under RHB2, it is not clear why there would not be a proportional increase or restoration of seepage in the Medad Valley as opposed to 'very small gains in baseflow' at SW7 downstream of the proposed western expansion as shown on Figure 8.112, page 288. Please clarify.	Page 285 2nd Paragraph Section 8.9.1. RHB2 Drawdowns and Surface Water Flows	Norbert M. Woerns		
256.	The surface elevation should be shown on each of these hydrograph figures representing each of the eight assessment points.	Page 289-292 Figures 8.113-8.120	Norbert M. Woerns		
257.	'Leakage below the final quarry lake contributes to the groundwater flow system and contributes to the higher heads outside of the quarry.' It is not clear how higher heads will be contributed to by the final quarry lake assuming that the lake levels will be slightly below the surrounding ground surface. As long as the water levels in the lake are maintained below the surrounding ground level, the quarry will act as a groundwater sink lowering groundwater levels in adjacent areas that occur above the lake level. Please clarify.	Page 293 Section 8.9.3 RHB2 Surface Water/ Groundwater Interaction, 1st Paragraph	Norbert M. Woerns		
258.	'Surface water flow in the upper reaches of a tributary of Willoughby Creek and the West Arm of the West Branch of Mount Nemo Creek will cease when the quarry discharge is discontinued, resulting in an adverse impact to downstream fish habitat compared to baseline conditions (See Savanta, 2020 and Tatham, 2020 for details).' Figure 8.105 shows simulated flows within these stream reaches although reduced flow as shown on Figure 8.106. The model results therefore indicate that these stream reaches will continue to have stream flow albeit reduced flow and not cease totally as suggested in the above statement. It is acknowledged that these stream reaches will	Page 293, Section 8.9.5 RHB2 Level 2 Conclusions, 3rd paragraph	Norbert M. Woerns		

	likely have periods of no flow during dry periods as was likely the case prior to quarry discharge being directed to these stream reaches. A more detailed assessment of changes to the sub-watershed should be completed to asses changes in the surface and groundwater flow regime and their impacts on natural heritage features and habitats.				
259.	It is unclear how the groundwater outflows and inflows as a percent of total flows were determined from these figures. No wetland water budget was shown for wetland no.19 for comparison to previous scenarios for wetland no. 19. Please clarify.	Page 298-300 Figures 8.125-8.130. Water Budget for Wetlands	Norbert M. Woerns		
260.	The impact assessment was done using a background scenario which represents altered conditions. As summarized in section 8.10.2, there is 2.0 metres of drawdown predicted up to 1000.0 metres from the excavation, which suggest that the baseline conditions scenario does not document natural functions within surrounding wetlands and watercourses - please clarify.	Page 301 Section 8.10. Level 2 Impact Assessment Conclusions	Conservation Halton		
261.	'The Level 2 impact assessment scenarios present a detailed and exhaustive comparison of the proposed developments to the baseline conditions. All pertinent aspects of the surface water and ground water system have been compared across a wide range of climate conditions.' The assessment scenarios provide a detailed comparison of water quantity issues. They do not address groundwater quality issues and therefore this should not be considered a complete assessment of quarry impacts. Water quality should be addressed in more detail.	Page 301 Section 8.10. Level 2 Impact Assessment Conclusions, 1st Paragraph	Norbert M. Woerns		
262.	'The long-term monitoring (including the monitoring of the 2005-2019 advancement of the south extraction face) provides a clear groundwater response that has been accurately simulated by the transient integrated model. The detailed field investigations, together with the simulation of this large-scale response, provides significant confidence in the assessment.' Although ground water monitoring data have been collected in the vicinity of the southern expansion area there are significant data gaps in the groundwater monitoring data. There is limited groundwater monitoring data for the western expansion area since boreholes were drilled between June 2016 and May 2019 and monitors installed between January 2019 and August 2019. Groundwater thresholds (i.e., quantity and quality) have not been established or discussed due to insufficient monitoring data to establish baseline conditions (see Page 315, Section 9.6.3 Groundwater Thresholds, 1st paragraph). The existing off-site irrigation ponds are thought to infiltrate water that originates to a large extent from the existing quarry discharge from the existing sump no. 100 and result in a groundwater mound beneath the ponds. There is no field data to support this conclusion. The feasibility of the proposed recharge pond should be confirmed with supporting field data.	Page 301 Section 8.10.1. System Understanding, 1st Paragraph	Norbert M. Woerns		
263.	'Similarly, the extensive record of stream flow and wetland monitoring produces an unprecedented level of understanding of the shallow surface water and ground water system.' Although there are several years of monitoring data for surface water features including wetlands in the vicinity of the southern expansion area, wetlands near and within the western expansion area were not monitored for this analysis. Two wetlands in the area of the western extension MNRF wetland no. 13201 (Earthfx wetland no. 21), and MNRF wetland no. 13200 (Earthfx wetland no. 21) are proposed to be monitored in future as monitoring locations SW36 and SW 37 respectively). Karst springs in the area have been identified but have very limited monitoring data. For	Page 301 Section 8.10.1. System Understanding, 2nd Paragraph	Norbert M. Woerns		

	example, there is only one recorded flow for these springs taken in late March and early April 2006. There remains uncertainty with respect to the hydraulic conductivity of the overburden deposits and the interconnectivity of surface water and groundwater within the study area. Conflicting information regarding the hydraulic interconnectivity of the overburden and bedrock from pump tests completed by Golder Associates in 2004 and 2006 in the southern expansion area has not been resolved. In addition, only five of the 22 wetlands in the area have been instrumented for this assessment with both surface water and groundwater monitors to support water budget analysis. Additional field investigations are required to address the above noted data gaps to confirm site conditions.				
264.	'The 2.0 m drawdown cone associated with P3456 extends 330 m to 450 m from the excavation. P3456 is next to a locally significant groundwater discharge area, so water levels are relatively stable and less subject to drought, seasonal fluctuations and the effects of excavation.' There are a number of private wells along Cedar Springs Road that are within 330m and directly down gradient of the proposed west expansion area excavation limit. Private wells along Cedar Springs Road are therefore considered to be at high risk of impacts from the proposed quarry expansion. The proposed west Extension area will be removed along with the underlying aquifer that contributes to the maintenance of private wells along Cedar Springs Road. Threshold values should be established for these wells especially those with less than 5.0 metres of assumed available drawdown.	Page 301 Section 8.10.2. Drawdowns, 3rd Paragraph	Norbert M. Woerns		
265.	'The analysis confirms that there is between 5 and 23 m of available drawdown across the study area, confirming that there is ample groundwater available for current and future private water supply use.' According to the model analysis (Figure 8-75, Average available drawdown under P3456 conditions) a number of wells along Cedar Springs Road west of the western extension have simulated available drawdowns of 10m or less during phase 3456. A number of these have less than 5.0 metres of available drawdown. The analysis has not considered evidence provided in previous studies by Golder that deepening of wells completed within the Amabel Formation may not be a viable option for increasing well yields. A number of wells along Cedar Springs Road may in fact be completed into bedrock units below the Amabel Formation due to their low elevation. These lower bedrock units are not recognized as significant aquifers. Please clarify how private wells with less than 5.0 metres of projected available drawdown will be treated with respect to quarry impacts and how wells occurring near or below the bottom of the Amabel Formation will have their water supply protected with respect to quantity and quality.	Page 301 Section 8.10.3. Water Supply, 1st Paragraph	Norbert M. Woerns		
266.	'The wide distribution of low permeability Halton Till in and round the quarry is the dominant feature controlling surface and groundwater interaction. The wetlands and streams are generally perched above the water table and isolated from the groundwater system by the low permeability till. None of the wetlands receive significant groundwater inflow, and are thus isolated from any changes in the water table due to quarry development.' MNRF wetland no. 13027 (Earthfx wetland no. 17) has shown ground water levels at or above surface and this wetland, at least seasonally, does not exhibit perched groundwater conditions. A number of other wetlands closer to the existing quarry occur within areas that have been influenced by historical dewatering of the existing quarry and as such have altered hydrogeological conditions which historically may have not exhibited perched conditions beneath the wetlands. It has not been	Page 302 Section 8.10.4. Stream and Wetland Function, 1st Paragraph	Norbert M. Woerns		

	demonstrated with certainty that none of the wetlands receive significant groundwater inflow. Please clarify.				
267.	The groundwater monitoring program must include shallow monitoring wells including wells completed in overburden to understand full impact of the proposed extraction.	Page 303 Section 9.2. On-Site Monitoring Wells	Conservation Halton		
268.	Staff support using private water wells to supplement monitoring and impact assessment, however, the efficacy of this monitoring "to act as an early warning system" as said in the first paragraph on page 304 is questionable. Especially, for the south extension area, where most of the proposed private wells for monitoring are more than 1.0 kilometre from the extraction zone (Figure 9.1). Monitoring wells between the extraction zone and groundwater receptors should be proposed to proactively assess impacts.	Page 303 Section 9.3. Off-Site Domestic Water Wells	Conservation Halton		
269.	'The intent of the groundwater monitoring program is to serve four (4) primary purposes: These are listed as: 1. to determine the background quality and seasonal groundwater level fluctuations in the vicinity of the extraction activities; 2. to assess and characterize the quality and seasonal groundwater level fluctuations throughout the quarry operations and upon closure of the Burlington Quarry; 3. to evaluate whether unforeseen changes within the groundwater regime is occurring from the extraction of aggregate and quarry dewatering; and if they are 4. to determine the presence of, and risk to, private well receptors of the unforeseen changes and if the implementation of mitigation measures is required to off-set the unexpected changes in the groundwater regime.' The above objectives do not address potential for water quality impacts of quarry operations and impacts on water uses. Water quality objectives should be clearly stated and threshold levels and mitigation measures should be identified.	Page 303 Section 9.1. Development and Monitoring Program, Objectives, 1st Paragraph	Norbert M. Woerns		
270.	'Based on the findings of the impact assessment, key sentry groundwater monitoring wells have been selected and incorporated into the long-term groundwater monitoring program. The groundwater monitoring program consists of water level and water quality monitoring. Water levels will be collected manually on a monthly basis as well as continuously with automatic water level transducers. The manual measurements are used to calibrate the continuous data, which allows for a comprehensive assessment of the water level responses and trends.' Threshold levels should be identified for water quality in addition to water levels and should include monitoring stations for all phases of quarry expansion.	Page 303 Section 9.2. On-site Monitoring Wells, 1st Paragraph	Norbert M. Woerns		
271.	Typographical errors in this paragraph: W03-1A should be MW03-1A and M03-1B should be MW03-1B.	Page 303 Section 9.2. On-site Monitoring Wells, 2nd Paragraph	Norbert M. Woerns		
272.	'Water quality sampling will be completed on a semi-annual basis. Parameters will include general water quality parameters, metals, major and minor ions and cations, and hydrocarbons (F1-F4 and VOCs).' It is not clear what the rationale for water quality monitoring is in the absence of threshold levels and a spills management plan. Given that the operations plan relies upon recharge of quarry discharge water into a recharge pond, it is not clear that semi-	Page 303 Section 9.2. On-site Monitoring Wells, 3rd Paragraph	Norbert M. Woerns		

	annual water quality monitoring will be adequate to ensure protection of down-gradient private well water quality. Site Plan Drawing 2 of 4, Site Plan Note O, Report Recommendations, 7B Natural Environment, there is reference to 'the Burlington Quarry Spills Prevention and Response Plan (2020).' This document has not been made available for this review and should be provided.				
273.	It is reported that the south extension area has been monitored extensively for 7 years. Considering most of the monitors were most likely impacted by present quarry operation during that time, how reliable is the data to establish baseline conditions?	Page 304 Section 9.4. Groundwater Impact Assessment Methodology	Conservation Halton		
274.	'The Level 1 and 2 Hydrogeological Assessment must identify potential receptors, outline the compliance monitoring program, as well as identify threshold values to assess and mitigate the potential impact to those receptors that may be impacted by the quarry development.' There are no threshold levels for groundwater quality. These should be identified for all monitoring stations.	Page 304 Section 9.4. Groundwater Impact Assessment Methodology, 1st Paragraph	Norbert M. Woerns		
275.	'The impact assessment methodology has been developed for the initial five (5) years of quarry operation. During these five (5) years, Nelson will have only operated in the south extension and will have completed extraction from Phase 1 and will have partially extracted Phase 2. The area surrounding the south extension area has been monitored extensively for over seven (7) years. As a result, the awareness of how the groundwater regime behaves is enough to develop the assessment tools, such as threshold values and threshold trend analysis for the south extension.' The Phase 12 area has been monitored for the past 7 years. Over this period of time extraction has continued in the existing quarry and has resulted in increased drawdowns in monitoring wells over this period indicating that groundwater conditions have been in flux over this period of time and are probably still changing in response into the quarry operations. The threshold values based upon simulated water levels of drought conditions in 2016 do not fully account for the progressively changing conditions within this area from existing quarry operations since the model assessment points are located some distance away for the areas of greatest flux in groundwater conditions. The analysis also does not address the cumulative impacts of the existing quarry particularly as it relates to the evaluation of rehabilitation scenarios. The model simulations include quarry conditions at the time of full excavation of the various Phases of the quarry operations described in Table 8.3 and illustrated in Figures 8.3 (P12), 8.38 (P34) and 8.41 (P3456). These model scenarios do not represent the initial five years of quarry operation. Please clarify.	Page 304 Section 9.4. Groundwater Impact Assessment Methodology, 2nd Paragraph	Norbert M. Woerns		
276.	'The impact assessment methodology proposed for the Burlington Quarry extension involves both an evidence-based and a predicted-based approach to ensure that the complexity of fractured rock hydrogeology is addressed. The evidence-based approach requires a comprehensive understanding of the natural variability of groundwater elevations at key monitoring locations. This understanding requires several years of monitoring data that shows the groundwater systems natural response to varying climatic conditions, including how the aquifer responds during and following dry/drought conditions. The baseline conditions allow for an improved ability to identify unforeseen trends in water level data, which could be a result of the quarry operations.' The groundwater monitoring data available for the southern extension has data gaps that occur between 2004 and 2007 and again between 2013 and 2018 (Earthfx	Page 304 Section 9.4. Groundwater Impact Assessment Methodology, 2nd Paragraph	Norbert M. Woerns		

	Section 5.3.1.2, Transient Water Level Data, page 109). The missing data included the drought period of 2015-2016 as well as 2017 the wet period (Earthfx, section 7.2.2 Scenario Summary and Nomenclature, page 166). Calibration of the model against actual on-site water level conditions during this period of time was therefore not possible. Please clarify the validity of the computer model calibration against extreme wet and dry conditions.				
277.	'A key component of the evidence-based groundwater monitoring program is the availability of background water level data that reports the natural conditions during quarry extraction.' The analysis has not considered the cumulative effect of the existing quarry and the proposed expansion in establishing background water level data. Cumulative impacts of the existing quarry should be included in the impact assessment.	Page 304 Section 9.4. Groundwater Impact Assessment Methodology, 4th Paragraph	Norbert M. Woerns		
278.	Considering that private well referred to as DW2 is located within the present quarry zone of influence, it may not represent the natural variability of the groundwater elevation fluctuations as stated. How many years of DW2 monitoring data is available to date?	Page 305 Section 9.4.1. Monitoring of Background groundwater Conditions	Conservation Halton		
279.	Please provide an example of the trend analysis. How often would this analysis be repeated based on actual measurements rather than simulated levels?	Page 305 Section 9.4.2. Comprehensive Groundwater Elevation Trend Analysis	Conservation Halton		
280.	'To assist in the evaluation of the water levels measured as part of the groundwater monitoring program, a background monitoring well has been incorporated to the program. The background monitoring well is a domestic water well located north of the existing quarry at 2377 Collins Road (referred to as DW2; Figure 9.1). The purpose of this background monitoring well is to document the natural variability of the groundwater elevation fluctuations and trends under various future climatic conditions. This background monitoring well has shown to have no drawdown from the proposed quarry extension.' Please provide evidence to support the conclusion that background monitor DW-2 has no drawdown impacts from the proposed quarry. Is this from computer simulations or actual measurements over time? Has this monitoring well been impacted from the existing quarry?	Page 305 Section 9.4.1. Monitoring of Background Groundwater Conditions, 1st Paragraph	Norbert M. Woerns		
281.	'Trigger values set based on the traditional approach have caused numerous false positive trigger exceedances. The reasons for these exceedances include the oversimplification of the methodology to setting trigger values in a fractured rock environment (fundamental principles of how aquifers respond to abstraction), and more importantly the neglect to account for the full impact of climate change. Seasonal variability in groundwater level as well as season creep, which refers to observed changes in the timing of the seasons, have been widely observed in Ontario.' The influence of climate on groundwater levels is acknowledged, however the analysis relies upon remote climatic stations for data. Given the importance of climate, why is there no recommendation for an on-site climate station for purposes of monitoring and evaluating groundwater levels?	Page 305 Section 9.4.2. Comprehensive Groundwater Elevation Trend Analysis, 2nd Paragraph	Norbert M. Woerns		
282.	What groundwater mitigation measures would be implemented to mitigate impacts (if identified through monitoring) on the natural environment features? e.g. groundwater discharge to Medad Valley, wetlands and streams.	Page 307 Section 9.4.4. Proposed	Conservation Halton		

		Groundwater Mitigation Measures			
283.	'The Seasonal Mann-Kendall Test considers the seasonality of the data series. This means that for monthly data with seasonality of 12 months, one will not try to find a trend in the overall series, but a trend from one of January to another, and from one February and another, and so on.' The Mann-Kendall test may be useful in assessing natural groundwater level trends but are limited in assessing quarry impacts without taking into account variations in on-site climatic conditions. How does the Mann-Kendall test compare season data from different years and relate that to a trend analysis? How will climatic factors be considered in this analysis without on-site climatic data?	Page 307 1st Paragraph Section 9.4.2. Comprehensive Groundwater Elevation Trend Analysis	Norbert M. Woerns		
284.	'The proposed thresholds have been calculated from the simulated water level elevations from the difference between the simulated average baseline water levels and the simulated drought water levels with Phase 1 and 2 extracted during a drought period. If the 0th percentile equals the minimum water level simulated, the 10th and 5th percentile values will be relied upon for the threshold values. Level 1 Threshold conditions occur when the measured water level falls below the Threshold 1 value (10th percentile) for a 15-day period. Level 2 conditions occur when the water level falls below the Threshold 2 value (5th percentile) for a 15-day period. This statistical approach to reviewing and assessing the impacts associated with the quarry development meets the objectives of the AMP, which is to implement a system that allows for a comprehensive evaluation of how the groundwater regime behaves with quarry development and to identify unforeseen changes in this system that provides time to implement appropriate mitigation strategies to protect local water use.' Method for calculating thresholds requires clarification. The simulated average baseline and simulated drought water levels represent a discrete and limited time interval, a portion of which has no monitoring data for model calibration purposes. Average and drought conditions are expected to change with an increasing record of data, rather than the limited discrete time interval and climatic conditions represented in the model simulations. How are existing climatic conditions factored into the threshold determination? Does the threshold level need to be met consistently over a 15 day period for any action to be taken? There is uncertainty whether the method proposed will provide early warning of quarry impacts where worst case drought conditions compared against average baseline conditions are used to define threshold levels. No thresholds exist for intermediate and shallow depth monitoring wells. Threshold levels for the intermediate and shallow depth monitoring wells should be identified.	Page 307 Section 9.4.3. Proposed Groundwater Thresholds Levels, 2nd Paragraph	Norbert M. Woerns		
285.	'A key finding of the Level 1 and 2 Hydrogeological Assessment and Numerical Modelling (Earthfx et. al., 2020), is that the drawdown associated with the extension of the Burlington Quarry does not adversely impact the available drawdown in the regional bedrock aquifer found at an elevation beneath 252 masl (elevation of the quarry floor). ----It is generally accepted that 5 m of available drawdown is a safe available drawdown for domestic water wells constructed in bedrock aquifers.' It is assumed that available drawdown estimates in each private well was determined from static water level recorded on the well record at the time of well completion. This is not a reliable measure of the available drawdown as the accuracy of these measurements is questionable.	Pages 307-308 Section 9.4.4. Proposed Groundwater Mitigation Measures, 2nd Paragraph	Norbert M. Woerns		

	What is the source of this generally accepted available drawdown of 5.0 metres as a 'safe available drawdown'? It is not clear what is meant as a 'safe available drawdown'. This does not take into consideration the productivity of the well or water quality considerations.				
286.	A number of important monitors are not included in the monitoring program, e.g.: MW03-02, OW03-16 and MW next to it (based on Figure 3.4 cannot decipher what the MW number is), OW03-32, MW03-03, OW03-31, MW03-08, MW03-10. All monitoring well intervals should be monitored (including shallow either bedrock or overburden installations, which are usually designated C).	Page 308 Section 9.5.1. Groundwater Monitoring Program	Conservation Halton		
287.	'Data collected from existing domestic water wells along No. 2 Sideroad, which are within 80 m of the quarry, show that wells constructed in the hydrostratigraphy layer beneath the quarry floor (Layer 8) can meet peak domestic water demands with between 2 and 5 m of available drawdown.' Please provide data from existing domestic wells in this area to support this assertion?	Page 308 2nd Paragraph Section 9.4.4. Proposed Mitigation Measures	Norbert M. Woerns		
288.	'Nelson will commence with planning the required compensation if unforeseen trends suggest off-site impacts will be greater than predicted and threaten the available drawdown in private wells. Compensation must be acceptable to the homeowner and the quarry operator and could include all or part of the costs associated with drilling of a new well, deepening a well, and abandonment of the old well.' What contingencies are proposed if well replacement /deepening are not adequate? It is not clear how 'Nelson will commence planning the required compensation' will be implemented. Please clarify.	Page 308 3rd Paragraph Section 9.4.4. Proposed Mitigation Measures	Norbert M. Woerns		
289.	'Upon completion of the well construction, a comprehensive water quality analysis will be completed to characterize the water supply. If it is shown that the water quality has deteriorated from intercepting poor water quality at depth (for example increased chlorides and sulphates), the appropriate water treatment system will be purchased and installed.' Although not stated, it is assumed that water quality sampling and analysis will be completed within the well in question prior to deepening or replacing the well. Please confirm. Who pays for the maintenance of the water treatment system? There is no discussion of potential for water quality impacts on private wells and monitoring data necessary to establish baseline water quality data and thresholds for specific water quality parameters. Water quality thresholds should be identified for monitoring stations.	Page 308 4th Paragraph, Section 9.4.4. Proposed Mitigation Measures	Norbert M. Woerns		
290.	'The integrated surface water/groundwater model results predict groundwater mounding beneath the existing irrigation ponds in the West Extension. --- To replicate the existing artificial groundwater mounding produced by the irrigation ponds, a pond will be constructed outside the extraction area within the licence boundary between the extraction limit and Cedar Springs Road. To replicate the existing artificial groundwater mounding produced by the irrigation ponds, a pond will be constructed outside the extraction area within the licence boundary between the extraction limit and Cedar Springs Road' The report concludes that the regionally extensive and low permeability Halton Till limits interaction between surface water and groundwater systems (Page 190, Section 7.3, 2nd paragraph). This brings into question the effectiveness of the existing irrigation ponds and the proposed infiltration pond in maintaining groundwater levels. Please provide field data to confirm the recharge capability of the existing irrigation ponds and the proposed recharge pond.	Page 308 5th Paragraph. Section 9.4.4. Proposed Mitigation Measures	Norbert M. Woerns		

291.	'Interference will be in part masked or, coupled by local climatic conditions. Key groundwater monitoring locations that have over 7 years of water level data have been selected to act as the long-term sentry wells to ensure the influence on the groundwater regime is consistent with the predicted influence from quarry operations (Figure 9.2). The monitoring locations, well construction details, and predicted drawdown conditions during a drought period (expressed as water level elevation, simulated drawdown, and simulated available drawdown), are provided on Table 9.1.' Climatic conditions are acknowledged to play a role in masking interference by quarry operations. It is not clear how the method for identifying threshold levels will take into account ongoing on-site climatic conditions. There is a need to monitor climatic data on-site to effectively evaluate quarry impacts versus climatic impacts on groundwater levels. Please clarify.	Page 309 1st Paragraph Section 9.5.1. Groundwater Monitoring Program	Norbert M. Woerns		
292.	Typographical errors; M03-9 and M03-14 should be MW03-9 and MW03-14.	Page 311 2nd Paragraph, Section 9.5.1. Groundwater Monitoring Program	Norbert M. Woerns		
293.	'The closest receptor (private water well) is located approximately 120 m to the west of MW03-15, and currently has 4.6 m of available drawdown.' Will existing private wells that currently have less than 5 metres of available drawdown receive mitigation measures? A number of wells having less than 5.0 metres of available drawdown are shown on Figure 9.3 and 9.5, (Minimum available drawdown in Layer 8, P12, Drought Conditions, page 312 and minimum available drawdown in Layer 8, P3456, Drought Conditions, Page 317).	Page 311 2nd Paragraph, Section 9.5.1. Groundwater Monitoring Program	Norbert M. Woerns		
294.	Provided thresholds in Table 9.2 assume that there are no impacts to the shallow zone. It seems, if the Level 1 and 2 Threshold conditions are met, a very similar response is proposed and there is no action proposed after reaching Threshold 1 to avoid Threshold 2. There is no action proposed to avoid reaching a minimum water level nor any action if it is reached or exceeded. Please revise to propose appropriate actions.	Page 313 Section 9.5.2. Groundwater Thresholds	Conservation Halton		
295.	'The response to a Level 1 Threshold condition, would prompt Nelson to: • mail out a letter to all residents located within 1 km of the southern extension lands informing them of the low water levels; • notify the SLC, MECP and MNR in writing; and • post a notice on the Nelson website.' 'The process will be repeated if a Level 2 Threshold condition is met. In addition to a second mail out letter, Nelson will attempt to notify the residents in person; and post a notification of the local groundwater conditions in the local news outlets. Instructions to contact Nelson if anyone has experienced any issues with their water supply within 1 km of the quarry will be outlined.' Apart from informational purposes, it appears as though the threshold levels have limited usefulness. Threshold levels are intended to act as an early warning system of low water levels. Achieving threshold water levels at specific monitoring locations, will result in actions as proposed by Earthfx, that are primarily of an educational nature and will not result in any mitigation actions on private wells. It is not clear how useful	Page 313 Last Three Paragraph Section 9.5.2. Groundwater Thresholds	Norbert M. Woerns		

	these notifications will be when there are no specific actions required. No information will be provided to assist the individual well owners or proactive measures taken to avoid excessive use of water and aggravate low water conditions. Actions to address well issues will only be undertaken when a complaint is registered by the well owner. During drought conditions, it is expected that increased water use will result to compensate for drought conditions. This will include such items as lawn and garden watering. Will this disqualify private homeowners from compensation should threshold levels be met? Threshold levels should be established for intermediate depth ('B' series) monitoring wells, shallow depth ('C' Series) monitoring wells, and private wells.				
296.	'The extraction of the proposed West Extension (Phase 3 through to 6) is scheduled to commence approximately 10-years following the issuance of the ARA licence. No groundwater thresholds are proposed until enough groundwater monitoring data is collected to establish baseline conditions.' What are baseline conditions to represent? In the case of phases 3,4,5 and 6, the conditions forming baseline are defined during the active excavation of Phase 12. How much groundwater monitoring data is considered enough to establish groundwater thresholds? Does this include water quality thresholds? How can a valid baseline be established from an ongoing changing quarry operation condition (i.e. selected from a period of time during which Phase 1/2 is ongoing)?	Page 315 Section 9.6.3. Groundwater Thresholds, 1st Paragraph	Norbert M. Woerns		
297.	Please provide groundwater quality and quantity monitoring details. What would be the frequency of the trend analysis? Shallow monitoring wells and a number of wells listed in comment re Section 9.5.1 should be added to the monitoring program. Nitrite and nitrate should be added to water quality monitoring.	Page 319 Section 10.1.1. On-Site Groundwater Monitoring Program	Conservation Halton		
298.	Groundwater quality parameters should include parameters related to site operations including dust suppressants, explosives, fuels, any on-site stored materials, and any identified potential sources of contamination from on-site or directly adjacent areas. There is no discussion of water quality thresholds or mitigation required in the event of water quality impacts either through normal operations or an on-site spill. Note that surface water drainage areas which direct external surface water onto the property and into the sump discharges may contain potential contaminant sources. Water quality analysis should be included with threshold levels and mitigation measures.	Page 320 Table 10.2. Groundwater Quality Parameters	Norbert M. Woerns		
299.	There are no groundwater monitoring locations upgradient and to the north of the quarry operations to monitor impacts of the quarry expansion and rehabilitation scenarios. The only exception to this is one private well DW-2. Monitoring data should be presented to demonstrate that DW-2 has not been impacted by the existing quarry. It would be useful to have a corresponding figure for AMP surface water monitoring stations.	Page 321 Figure 10.1. AMP Groundwater Locations	Norbert M. Woerns		
300.	'The Private Well Monitoring Program includes the collection of water quality samples and water levels, like the on-site monitoring program outlined in Section 10.1.1. Similarly, the impact assessment on each well will include a trend analysis and threshold value.' This suggests that the trend analysis and threshold values will be established for both groundwater levels and groundwater quality for private wells. No water quality thresholds have been established for the on-site groundwater monitoring program. Semi-annual and annual water quality monitoring is suggested in Table 10.1, page 319. It is not clear that this is sufficient to protect groundwater quality of downgradient wells. Water quality thresholds should be identified along with mitigation measures.	Page 322 Section 10.1.2. Private Water Well Monitoring, 1st Paragraph	Norbert M. Woerns		

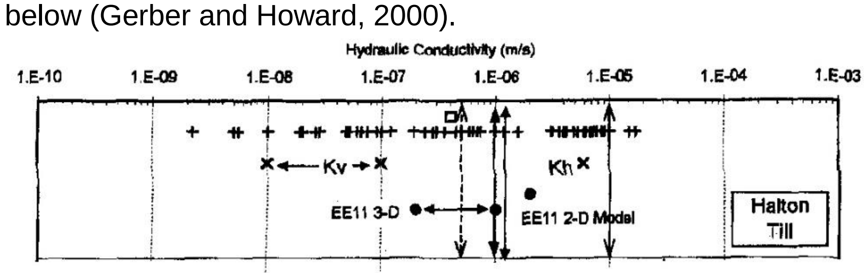
301.	Although the springs in the Medad Valley are singled out as a target of impact assessment and mitigation in Table 8.1, there is no other mention of springs in the remainder of the document other than a brief note in the summary (Section 11.2, page 324) "There are other groundwater springs (karst discharge features) in the Medad Valley, but these are masked by the wetlands that fill the valley."	Section 11.2, Page 324, and Table 8.1	Daryl W. Cowell & Associates Inc.		
302.	Permanent and intermittent streams as well as seepage areas and springs are considered key hydrologic features by the NEP. Section 11.3 of the report lacks detailed discussion on the effects on these features specifically on the western expansion lands where streams and ponds are proposed to be entirely relocated to a proposed discharge pond.	Section 11.3	Niagara Escarpment Commission		
303.	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.	Page 324	Daryl W. Cowell & Associates Inc.		
304.	'The numerical simulations confirm that the majority of the wetlands and streams are isolated from the water table by the low permeability Halton Till. A total of 5 of the 22 mapped wetlands in and around the quarry receive groundwater upwelling in the spring, however groundwater is in every case a very small percentage (less than 3%) of the overall inflows into the wetland.' The Tatham surface water investigation instrumented only five wetlands with shallow groundwater monitors in addition to surface water monitoring for water budget purposes. For the remaining wetlands the analysis relied upon simulated groundwater conditions without the benefit of having actual groundwater level data to confirm groundwater upwelling. Field data including groundwater levels for all identified wetlands should be provided to support the computer simulations.	Page 324 3rd Paragraph Section 11.2. Hydrogeologic and Hydrologic System Summary	Norbert M. Woerns		
305.	'The Level 2 impact assessment scenarios present a detailed and exhaustive comparison of the proposed developments to the baseline conditions. All pertinent aspects of the surface water and ground water system have been compared across a wide range of climate conditions. The integrated approach ensures that surface and groundwater functions and water budgets are fully reconciled.' It may be appropriate to consider existing conditions for purposes of assessing impact of the proposed expansions. The cumulative impacts of the existing quarry and the proposed expansion have not been addressed. A map showing the existing cone of influence and drawdown of the existing quarry should be provided as part of the impact assessment. The impact assessment scenarios should also address groundwater quality.	Page 324 Section 11.3.1. Baseline Conditions, 3rd Paragraph	Norbert M. Woerns		
306.	Include a summary of effects on watercourses in these sections.	Page 325 Sections 11.3.2.2 & 11.3.3.2. Wetlands and Surface Water Features	Conservation Halton		
307.	Outline proposed pumping/discharge points for Rehabilitation Scenario 1.	Page 326 Section 11.3.4. Rehabilitation and Closure	Conservation Halton		
308.	'The private wells in the vicinity of the West Extension will see a decline of approximately 2 m in available drawdown, however the majority of the wells have	Page 326	Norbert M. Woerns		

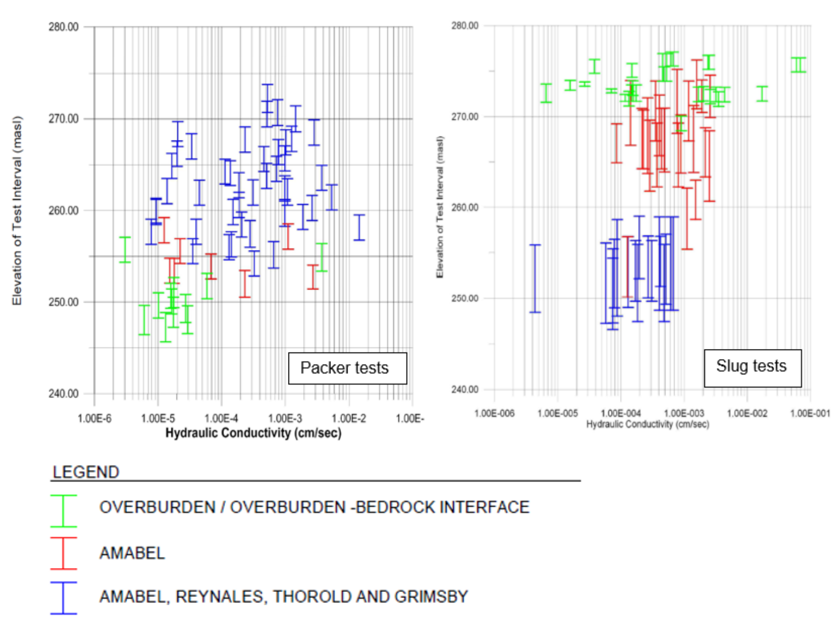
	between 10 and 16 m of Amabel Aquifer drawdown after excavation, so deepening a well is a viable mitigation measure. Near the intersection of Colling Road and Cedar Springs Road there are a few wells that will have between 5 and 10 m of available drawdown, however these are in a significant discharge area so it is likely that there will be sufficient flow to meet their private supply needs.' Numerous residences along Cedar Springs Road are located 200.0 to 300.0 metres from proposed limit of extraction. Some properties at the northwest portion of the proposed western extension are between 100.0 and 200.0 metres from the proposed limit of extraction. Wells along Cedar Springs Road are directly downgradient of the existing quarry and proposed expansion. The existing quarry has intercepted groundwater that would have flowed towards these wells under natural gradients. The groundwater seepage into the quarry as well as surface runoff from precipitation events is converted to surface water discharge via the existing quarry sumps. These wells are likely already impacted by the existing quarry and may depend to some extent upon infiltrating discharge water via a series of irrigation ponds on the upgradient golf course property much of which is to be removed through the western quarry expansion and replaced with an infiltration pond. Data provided by Golder, 2010 as well as pump tests completed in the proposed western expansion area indicate that groundwater conditions vary considerably between groundwater monitors and test wells. Available drawdown by itself is therefore not a reliable indicator of water availability for wells. The productivity of the aquifer at each well location will also be a significant determining factor of water availability. Flow profiling results (Figure A8 and A9, pages 434 and 435 respectively of the Earthfx hydrogeological Assessment Report) completed by Golder, 2004 indicate diminishing water flow with depth in existing monitoring wells in the southern extension area. This suggests that deepening wells may not be a viable solution to addressing well interference issues. A detailed analysis of this information and the implications to proposed mitigation measures should be completed and included in the report.	Section 11.3.3.3. Domestic Water Wells			
309.	'Furthermore, surface water flow in the upper reaches of a tributary of Willoughby Creek and the West Arm of the West Branch of Mount Nemo Creek will cease when the quarry discharge is discontinued resulting in an adverse impact to downstream fish habitat compared to baseline conditions (See Savanta, 2020 and Tatham, 2020 for details).' The analysis of impact of discontinuing quarry discharge does not appear to be complete. Anticipated increased seepage from higher water levels under rehabilitation scenario 2 (RHB2) and the overall benefit of this to the sub-watershed does not appear to have been given consideration in this analysis. A detailed analysis of the impacts of cessation of pumping to the sub-watershed should be completed.	Page 326 Section 11.3.4. Rehabilitation and Closure, 4th Paragraph	Norbert M. Woerns		
310.	'The final rehabilitation plan will preserve the form and function of the upper reaches of a tributary of Willoughby Creek and the West Arm of the West Branch of Mount Nemo Creek as quarry discharge will continue.' The current conditions within the unnamed tributary of Willoughby Creek and the upper reaches of the West Arm of the West Branch of Mount Nemo Creek have been altered by quarry pump discharge. Is it appropriate to preserve an artificial condition that has altered a natural system? (This requires input from a natural heritage and fisheries habitat perspective.)	Page 326 Section 11.4. Conclusions, 2nd Paragraph	Norbert M. Woerns		
311.	'The quality and quantity of groundwater needed for the natural environment and wells will be protected,'	Page 327 1st Paragraph Section 11.4. Conclusions	Norbert M. Woerns		

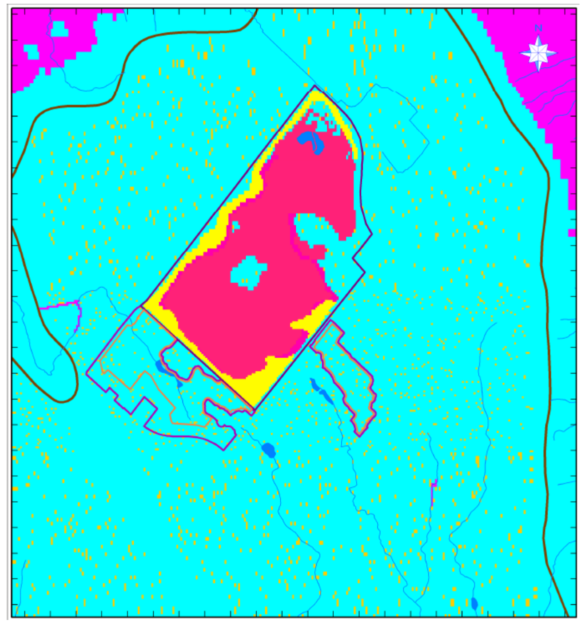
	It has not been demonstrated how water quality will be protected. Clarification is required how this will be accomplished.				
312.	'Incorporate the mitigation and monitoring requirements as outlined in this report into the Adaptive Management Plan (Earthfx and Tatham, April 2020) for the site; as outlined in Sections 9 and 10 of this report.' This report does not address potential water quality impacts from the proposed quarry extension with the identification of threshold levels and mitigation measures. This report is missing a recommendation for monitoring of climate data on-site for the duration of the proposed quarry extension and monitoring period following cessation of quarry operations. Consequently, these have not been included in the Adaptive Management Plan. Additions are required to the Adaptive Management Plan for completeness	Page 328 Section 12. Recommendations 2	Norbert M. Woerns		
313.	Typographical Error; Worthington 2019 should be Worthington 2020	Page 332 Section 14. References Cited, Last Entry	Norbert M. Woerns		
314.	Please submit all borehole logs used for the assessment (Only 50 out of 100 reported borehole logs were provided).	Page 334 Section 15.1. Drilling Program	Conservation Halton		
315.	'The Keith Lang boreholes were drilled to supplement the original HQ boreholes and expand the geological and hydrogeological coverage of the Western Lands. These boreholes are 6-inch in diameter and were constructed using a conventional rotary water well rig. As such, no core was recovered in these boreholes.' Borehole/well logs for the Keith Lang holes drilled are not included in report. These should be provided as background information within the report.	Page 334 Section 15.1. Drilling Program, 2nd Paragraph	Norbert M. Woerns		
316.	'Finally, two additional overburden monitoring wells were constructed in November 2019 at the southeast corner of the Southern Lands (MW18-1 and MW18-2).' The location of MW18-1 and MW18-2 should be shown on report figures.	Page 334 Section 15.1. Drilling Program, Last Paragraph	Norbert M. Woerns		
317.	Selected borehole logs are presented with a number of borehole logs missing. In addition, a table showing monitoring construction details is missing. Monitor details were provided in a separate submission received September 29, 2020 for the shallow groundwater monitors installed in the five wetlands noted by Tatham. No soil descriptions were included. In addition, no monitoring details or soil/bedrock descriptions were provided for test wells BS-06 and BS-07 completed by Azimuth. Monitoring details should be provided in a table format within the report and borehole logs for BS-06 and BS-07 should also be included in the report.	Pages 335-365 Borehole logs	Norbert M. Woerns		
318.	Monitoring well packer test and slug test results for all tested wells should be provided (please provide location of MW18-1 and MW18-2 monitoring wells). On page 367, last paragraph of section 15.2.1 it is reported that the packer testing results are in section 11.1, but section 11.1 is an introduction to Summary and Conclusions. Borehole logs in section 15.1 for reported in section 15.2 packer tested wells do not show the information either.	Page 367 Section 15.2.1. Downhole Packer Testing	Conservation Halton		
319.	In addition to reporting elevations of the packer testing zones, the corresponding bedrock or model layer zones for the reported packer test results should be identified.	Pages 367-368 Sections 15.2.1.1-15.2.1.4. Packer Test Interpretation	Norbert M. Woerns		
320.	Typographic error; 1615 Cedar Springs Road should be 5161 Cedar Springs Road as referenced in text at top of page 371.	Page 372	Norbert M. Woerns		

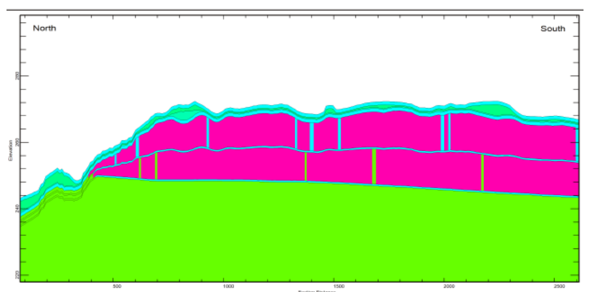
		BS-06 Pump Test Hydrograph			
321.	'In fact, BS-07 was to originally be used as the pumped well. However, the water level in this well drew down too quickly and therefore the test was abandoned and the pump moved to the BS- 06 well which proved to be more conductive than BS-07.' What is the significance of the difference in hydraulic response between BS-07 and BS-06 within the bedrock? How has this variability been accounted for in the computer model?	Page 374 4th Paragraph Section 15.2.2.2. Pumping Test Interpretation	Norbert M. Woerns		
322.	'The test response for the Westerns Lands is unique in terms of the unconfined response and is attributed to the local setting at the pumping well. This is stated since the bedrock profile at the pumping well is overridden by a thickness of sand which has not been seen elsewhere on the Western Lands and the Southern Lands. This delayed response (i.e., late-time unconfined response) is attributed to the overlying sand sequence as opposed to the larger interconnected fractured rock network. This also accounts for the fact that the same response was not observed during the former Golder pumping test sequences (Golder, 2006). The clay till overburden evident over the regional setting has no capacity to yield any significant response. ' The pump test was able to assess the hydraulic conductivity of the bedrock aquifer. No borehole logs of the test wells BS-06 and BS-07 were provided to confirm the bedrock intervals that were tested. The lack of groundwater monitors within the overburden shallow water table prevented an assessment of the degree of leakage from surface and the degree of interconnection between surface water features such as wetlands and the underlying bedrock. Pumping test of the bedrock should include a groundwater monitor completed within the overburden to assess the interconnection between the overburden and bedrock. Monitoring of nearby surface water features should also be conducted during the pumping test. The pumping test should be of sufficient length to determine the degree to which there is hydraulic connection between the overburden and bedrock.	Page 378 2nd Paragraph Section 15.2.2.2. Pumping Test Interpretation	Norbert M. Woerns		
323.	'For the three HQ (4-inch diameter) boreholes (BS-01, BS-02, & BS-03), the borehole diameter limited the installation of two formal monitoring well instrumentations, both of which were standard one-inch (25 mm) diameter PVC construction, while BS-01 and BS-02 had the upper part of the boreholes left open such that they targeted the upper saturated fractures and could be monitored and sampled similar to the deeper well constructions. The larger diameter 6-inch water wells (BS-04 & BS-05) were able to have three formal monitoring well installations with 1.25-inch (32 mm) diameter PVC construction. All these wells were constructed with either a 1.5 m or 3 m machine slotted well screen with standard monitoring well sand pack. The intervening borehole spacing was sealed with bentonite holeplug to ensure proper vertical sealing between monitoring wells within each borehole.' How can be sure the bentonite seals between the multi level monitors within one borehole were not leaking to explain the similar water level response in each monitor?	Page 378 Section 15.3. Monitoring Well Construction, 2nd Paragraph	Norbert M. Woerns		
324.	Downhole geophysical results for all tested wells should be provided. Section 15.4 presents a summary of how the testing was carried out. Does section 15.4 include all results of geophysical logging?	Page 379 Section 15.4. Geophysical Logging	Conservation Halton		
325.	Groundwater Level Monitoring – The groundwater monitoring stations considered in the Level 1/2 Hydrogeological and Hydrological Impact Assessment are shown in Figure 2.1 of the Earthfx (2020) report. Three different types of monitoring locations are indicated in the figure: • "GW Monitoring Nests";	Section 15.5 and Figure 2.1	S.S. Papadopulos & Associates, Inc.		

	• "Minipiezometers"; and • "MECP Wells". A listing of the wells shown in Figure 2.1 is not presented in the report. It is indicated in Earthfx (2020) Section 15.5 that between November 2018 and October 2019, a total of 100 monitoring wells were monitored at 39 locations. An extensive compilation of earlier water level records (hydrographs) is presented In Golder (2010; Appendix D). Many of the records extend from April 2003 through August 2010. Hydrographs are presented for 133 monitoring intervals at 81 locations: • 31 nests of the "MW" series, with 85 monitoring intervals; • 6 wells of the "GP" series; • 2 wells "Pump well 1" and PW-2; • 6 on-site quarry wells; • 35 minipiezometers of the "MP" series; and • 1 staff gauge, SG-4.				
326.	Only hydrographs for monitoring wells proposed for the long-term monitoring are provided. All available groundwater level monitoring data should be included in the submission to help understand local conditions and measured progression of groundwater lowering due to quarry operations.	Page 389 Section 15.5. Groundwater Monitoring Program	Conservation Halton		
327.	'In total, 100 monitoring wells were monitored at 39 locations (nested locations) with dataloggers targeting 34 monitoring wells for at least part of the monitoring period of November 2018 to October 2019. It is also noted that a single domestic well located at 5161 Cedar Springs Road was also included in this monitoring program and had a datalogger installed for continuous monitoring.' Need a figure to show which monitors were monitored. Were manual water level readings taken and available drawdown assessed in these wells? If so, these data should be provided as background information to the report. Shallow overburden wells need to be monitored to assess impacts to wetlands. Note that water level data was subsequently provided in a excel spreadsheet in a separate information package received September 29, 2020. The data was transcribed from the original files into a computer input file for computer model purposes and was of limited usefulness for peer review purposes.	Page 389 Section 15.5. Groundwater Monitoring Program, 2nd Paragraph	Norbert M. Woerns		
328.	OW03-20 documented groundwater levels suggest upward gradients at this location suggesting groundwater discharge conditions. Please provide simulated data for all OW03-20 (A, B and C) intervals.	Page 392 Section 15.5	Conservation Halton		
329.	OW03-28 documented groundwater levels suggest upward gradients at this location suggesting groundwater discharge conditions. Please provide simulated data for all OW03-28 (A, B and C) intervals.	Page 393 Section 15.5	Conservation Halton		
330.	BS-01 through BS-05 reported groundwater level monitoring period is less than 1 year. Please extend the monitoring period to include the most recent data. Please include BS-06 and BS7 groundwater level data, borehole logs and location of these two wells.	Page 394-396 Section 15.5	Conservation Halton		
331.	'During the field program completed by Azimuth in 2019, 24 ground water samples were collected from 13 locations, while eight additional samples were collected from the Southern Lands to complement the previous geochemical sampling completed by Golder in 2003. This previous sampling of the Southern Lands included 22 water quality samples collected from 21 locations.' Laboratory results should be provided as background information to the report. Copies of laboratory data results were provided in a separate information package received September 29, 2020. A summary and analysis of these data with respect to water	Page 397 Section 15.6. Hydrogeochemical Testing, 1st Paragraph	Norbert M. Woerns		

	quality characterization has not been provided and should be included in the assessment report.				
332.	'Of the 156 homes visited, only eleven (11) homeowners indicated that they were interested in participating in the monitoring program. Seven (7) of the eleven (11) private domestic water wells were accessible and, as a result, have been added to the current groundwater monitoring program ' A summary of the well survey results should be provided as background to the report and there should be a discussion of findings from the well survey. All of the locations included in the well survey should be identified on a figure. Copies of 26 well forms were provided in a separate information package received September 29, 2020. It is not clear whether these are all of the well survey results and the remainder of the 156 homes visited as part of the well survey did not have a response. Threshold levels should be established for the private wells.	Page 400 Section 15.7. Residential Well Survey, 2nd Paragraph	Norbert M. Woerns		
333.	The northing coordinate for the model lower left-hand corner cannot be 4,794,585,500 metres. Although no coordinates are indicated in Figure 18.4, the coordinate must be wrong by a factor of 1,000.	Page 481 and Figure 18.4	S.S. Papadopulos & Associates, Inc.		
334.	The right side of Equation (18.4) is missing an area term.	Page 483	S.S. Papadopulos & Associates, Inc.		
335.	Please clarify for which wetlands field surveyed bathymetry data was used.	Page 486 Section 18.3.2. Lake and Wetland Representation	Conservation Halton		
336.	It is indicated that the model does not include the "many" constructed in-line and off-line ponds in the Medad Valley. On page 486 it is indicated that the final model included 40 MODFLOW "lakes" and the inspection of Figures 6.21 and 18.9 suggests that this includes many small features elsewhere. Why were small ponds included in some areas but not others?	Pages 486 and 523 and Figures 6.21 and 18.19	S.S. Papadopulos & Associates, Inc.		
337.	Please explain why specific yield values for weathered and fractured zone hydrostratigraphic layers are so low (Weathered Amabel, Middle Amabel bedding plane fracture zone and Lower fracture zone)? They are an order of magnitude smaller than respective competent bedrock layers. As per section 5.2.4 Layer 4 may act as unconfined aquifer when specific yield rather than storage is used. It should be noted that this is also possible in lower layers closer to the extraction where water table drops significantly.	Page 492 Table 18.4. Final calibrated model parameter values	Conservation Halton		
338.	The expectation is that the horizontal and vertical hydraulic conductivity of the Halton Till is a critical parameter in the analyses, particularly the vertical hydraulic conductivity. Are the values of the horizontal and vertical hydraulic conductivities inferred through calibration, 5.0×10.0^{-7} metres/second and 2.0×10.0^{-7} metres/second (Table 18.4) consistent with estimates reported for other sites? A compilation of hydraulic conductivity estimates for the Halton Till is reproduced below (Gerber and Howard, 2000). 	Table 18.4	S.S. Papadopulos & Associates, Inc.		

	Gerber (2010) has suggested the following representative average values for the Halton Till (Gerber, 2010): • Weathered Halton Till: K_H ~5.0×10.0^{-6} metres/second; $K_V = K_H$; and • Unweathered Halton Till: K_H ~5.0×10.0^{-7} metres/second; $K_V = 0.1\ K_H$. Sharpe et al. (2013; Table 4) suggest a value of 2.0×10.0^{-5} metres/second for the vertical hydraulic conductivity of the weathered Halton Till. The value of the vertical hydraulic conductivity of the Halton Till inferred through calibration appears to be substantially smaller than literature values. This is not to imply that the values specified in the groundwater model are inappropriate. However, there is no discussion of how the values were inferred through calibration. How sensitive is the match of the calibration targets to the values of the vertical hydraulic conductivity of the Halton Till that are specified? How sensitive are the predictions to the vertical hydraulic conductivity of the Halton Till, in particular the predicted impacts to shallow features such as wetlands?				
339.	Final calibrated values of the hydraulic conductivities for each model layer are listed on Table 18.4. There is no indication as to whether the inferred uniform values for each hydrostratigraphic unit are consisent with the results of independent testing. This is an essential check for model acceptance. Previous summaries of hydraulic testing presented are reproduced below (Golder, 2010; Figures C.2 and C.3). These compilations should be updated, with the values inferred through calibration superimposed. A well-by-well, or test-by-test review is not expected. Rather, some general appraisal of whether the hydraulic conductivity values inferred through calibration are consistent with the bulk of the available estimates from site hydraulic testing is expected. 	Table 18.4	S.S. Papadopulos & Associates, Inc.		
340.	The approach that has been adopted to incorporate hydraulic connections between the weathered top of rock and the middle flow zone, and between the middle and lower flow zones is shown in Figures 18.20, 18.21 and 18.7 of the report. The approach is illustrated below. The approach that has been adopted to incorporate the vertical hydraulic connections is not physically based	Figures 18.7. 18.20, and 18.21	S.S. Papadopulos & Associates, Inc.		

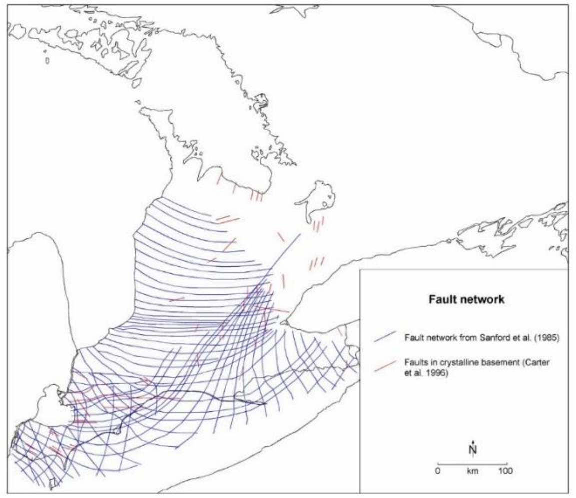


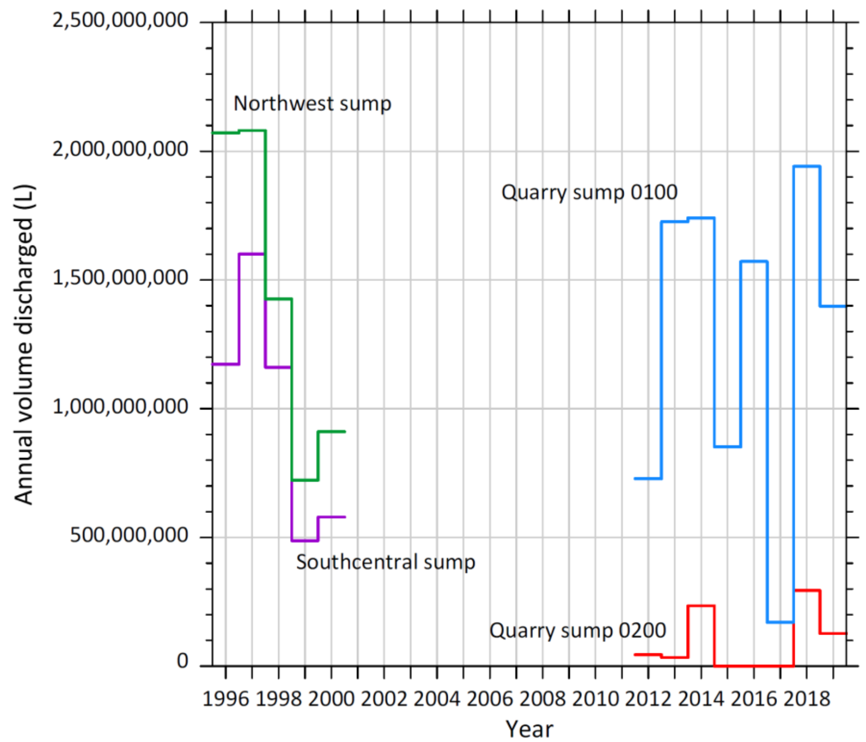


The approach does not provide either an improved representation of the fractures in the bedrock system, or the hydraulic connections between the flow zones. The approach that has been adopted is not internally consistent. Finally, the approach compromises the reliability of the predictions of potential impacts of the quarry expansion.

Although reference is made in the reporting to “fractures”, the features incorporated in the model are in fact a random distribution of “chimneys”. In the area of the model with a refined grid, the chimneys are prisms with areas of 15.0 metres by 15.0 metres. In the retained consultant’s experience, we have yet to encounter a site where such chimneys are encountered.

There are no data to constrain the assumed distribution or properties of the chimneys. At a minimum, the fractures to follow the jointing patterns in the underlying rock is expected. As shown below, the distribution of the chimneys bears no relation to regional joint patterns interpreted by Mazurek (2004) [based on the work of Sanford et al. (1985) and Carter et al. (1996)].

	 Regional faulting in southern Ontario (from Mazurek, 2004) The bedrock in the study area has been simulated using the equivalent porous medium (EPM) approach. Bulk-average hydraulic conductivities are assigned to the bedrock units, the weathered top-of-rock zone and the middle and lower flow zones. This approach is appropriate given the scale of the potential impacts of the development, and recognition that the results of the model are not predictions of what is likely to happen at discrete locations but what is likely to happen on average. However, the introduction of the chimneys runs counter to the EPM approach. A consistent approach involves specifying bulk-average vertical hydraulic conductivities, rather than introducing discrete artificial features. The bulk-average vertical hydraulic conductivities would account, in an average sense, for the presence of discontinuities that might give rise to enhanced connections between the horizontal flow zones. The introduction of the chimneys compromises the reliability of the predictions of potential impacts of the quarry expansion. The predictions of the model at particular locations will depend on the proximity to one of the simulated chimneys, about which nothing is known. The simulation approach introduces an impression of exactitude that is not supported by any data.				
341.	A key result for any model calibration is the match to observed groundwater discharges. The understanding is that the North Quarry discharge corresponds to the flows measured at SW1, and that the final model results are compared against the observations in Figure 19.10. Why is the discharge shown for only 5 years? The impression is that the model results do not approximate the observations. It is further understood that the South Quarry discharge corresponds to the flows measured at SW6, and that the final model results are compared against the observations in Figure 19.11? Why is the discharge shown for only 7 years? The impression is that again the model results do not approximate the observations. The annual quarry discharges from 2012-2019 are listed in Tatham (2020; Table 1). In the following figure the values reported by Tatham are supplemented with sump pump between 1996 and 2003 (Golder, 2010; Table E-8). The impression is that there have been important variations in the quarry discharges. How have these variations been considered in the analyses?	Figure 19.10	S.S. Papadopulos & Associates, Inc.		

					
342.	Simulation results are presented for stream gauge SW2 in the Medad Valley. Referring to Figure 19.4, were results also obtained for the other stream gauges in the Medad Valley, SW14 and SW7? The impression is that the reach between SW14 and SW7 will be critical with respect to an appreciation of potential impacts to streamflows of the proposed extension.	Page 523 and Figure 19.14	S.S. Papadopulos & Associates, Inc.		
343.	Please include simulated and observed water levels for OW03-14B. It should be noted OW03-14A water levels are also constantly overestimated by some 1-2 m.	Page 533 Section 19.5.3. Wells within 100m of the Quarry Face	Conservation Halton		
344.	Contrary to wells within 100.0 metres of the extraction the model underestimates deep system groundwater levels by some 1.0-2.5 metres, moreover, simulated water levels from model layer 7 or 8 should be presented and compared to MW03-09A. Shallow zone observed and simulated groundwater levels should be also included on this figure.	Page 535 Figure 5.25. Comparison of observed and simulated water levels at monitor MW03-09	Conservation Halton		
345.	OW03-30 – observed groundwater levels in the deep and middle zones seem to be higher than simulated water levels. Simulated water levels from model layer 7 should be presented and compared to OW03-30A. Shallow zone groundwater OW03-30C observed and simulated water level data should be included.	Page 535 Figure 19.26. Comparison of observed and simulated water levels at monitor OW03-30	Conservation Halton		
346.	It is indicated that the simulated deep water levels at MW03-2 is “somewhat higher than the observed values.” The inspection of Figure 19.28 suggests that the simulated average water level is about 267.5 metres amsl, substantially higher than the observed average of 259.5 metres amsl. It is also noted that the match shown to MW03-01A levels is also relatively poor, capturing none of the significant declines that	Page 536 and Figure 19.28	S.S. Papadopulos & Associates, Inc.		

	are observed through time. The observed levels range from 271.5 to 267.0 metres amsl, compared with the simulated range of 271.0 to 269.0 metres amsl.				
347.	The large difference between simulated and observed water levels in MW03-02 as presented on Figure 19.28 puts in question using the model to predict local conditions. Perhaps the difference between the observed and simulated water levels can be explained by heterogeneity of the bedrock aquifer. Has there been any hydraulic testing done on MW03-02 to identify local hydraulic properties of the aquifer? Please provide a borehole log for MW03-02. Please include MW03-02B observed and simulated data.	Page 537 Figure 19.28. Comparison of observed and simulated water levels at monitor MW03-02	Conservation Halton		
348.	Considering MW03-01C is a shallow well (about 2.0 metre deep), simulated water levels from an appropriate layer should be presented on Figure 19.28. Please include MW03-01B observed and simulated data.	Page 537 Figure 19.28. Comparison of observed and simulated water levels at monitor MW03-01	Conservation Halton		
349.	Please explain a 2-3-month lag between the observed and simulated water levels at monitor OW03-17.	Page 538 Figure 19.30. Comparison of observed and simulated water levels at monitor OW03-17	Conservation Halton		
350.	Please explain a couple month lag between observed and simulated water levels as visible on Figures 19.35, 19.38, 19.39, 19.40 and implications of using the model for predictive analysis. Please provide construction details of the mini-piezometers used in the assessment.	Page 540 Section 19.5.6. Shallow System Calibration (Mini-piezometers)	Conservation Halton		
351.	Referring to Table 19.1, the "inflow" reported for evaporation from interception represents 125.0% of the precipitation. If the correct percentage of the precipitation is indeed 12.8%, the correct value must be 26,070.0 cubic metres/day.	Page 554 and Table 19.1	S.S. Papadopulos & Associates, Inc.		
352.	It is not possible to reproduce the reported overall discrepancy in the GSFLOW groundwater budget for WY2010-WY2014 (Table 19.1). The components of the budget are reproduced below.	Page 554 and Table 19.1	S.S. Papadopulos & Associates, Inc.		

Item	Volumetric rate (m^3/d)
INFLOWS	
Recharge	28,155
Stream leakage	2,885
Lake leakage	2,103
Total inflows	**33,143**
OUTFLOWS	
Evapotranspiration from the water table	-2,817
Discharge to the soil zone (rejected recharge?)	-28,482
Net boundary outflows	-84.3
Groundwater discharge to streams	-2,498
Groundwater discharge to lakes	-1,229
Total outflows	**-35,110.3**

	Assuming that “net outflow from storage” represents a source of water to the groundwater system from a net decline in groundwater levels, the overall water budget discrepancy is written as: $$\% \text{ Discrepancy} = 100 \times \frac{(\text{Total inflows} + \text{Net outflow from storage}) - \text{Total outflows}}{\frac{1}{2}[(\text{Total inflows} + \text{Net outflow from storage}) + \text{Total outflows}]}$$ $$= 100 \times \frac{(33{,}143 + 852) - 35{,}110.3}{\frac{1}{2}[(33{,}143 + 852) + 35{,}110.3]} = \mathbf{-3.2\%}$$ In contrast, the reported % Discrepancy is -0.6%.				
353.	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).	Appendix A and Figure 4.2.3	Daryl W. Cowell & Associates Inc.		
354.	The final calibration of the GSFLOW model is presented in Appendix E (Section 19). It is not clear from the presentation what the targets for the calibration were (apart from the total streamflow at Aldershot), what parameters were varied during the calibration, and how the ranges were established over which the parameter values would be adjusted to match the calibration targets. Upon review of this section, these were left: Which parameters make a real difference in the calibration, and are there data to constrain the most important parameters?	Section 19. Appendix E	S.S. Papadopulos & Associates, Inc.		