HALTON CONSERVATION COMMENTS

Proposed Burlington Quarry Expansion
Interim JART COMMENT SUMMARY TABLE – Hydrogeology

Please accept the following as interim 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. **These interim comments will be finalized following the breakout meetings between JART and Nelson and any changes will be marked using "track changes". 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)	Applicant Response	Interim JART Response (February 2022)	Applicant Response (June 2022)
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.	Agreed. Our integrated modelling approach was meant to help facilitate the exchange of information across disciplines. A package of interdisciplinary tables addressing both wetland and watercourse characterization and impact analysis has been prepared and provided as Schedules B and C.	Not addressed. The wetland characterization summaries only provide an annual water budget analysis, and the impact assessment and mitigation sections do not include the requested ecological interpretation for existing (as per the TOR with proposed 25 year baseline), interim (for each identified extraction phase) and both post extraction scenarios (rehabilitation scenario 1 and rehabilitation scenario 2). Please revise, present, and summarize daily water balance analyses as average monthly water volumes in tabular format, showing existing, interim and post extraction (as outlined above) with and without mitigation to establish and confirm seasonal variations and include an ecological interpretation for the results. This will set targets/thresholds required to ensure no negative impacts. The watercourse characterization summaries only provide groundwater interactions and proposed reductions, however do not include surface water flow analysis, impact assessment or mitigation sections for existing, interim and post extraction scenarios (as outlined above). Update to integrate surface water analysis, revise to present and summarize with and without mitigation to establish seasonal variations and include ecological interpretation of the results. This will set targets/thresholds required to ensure no negative impacts.	Our study, and the follow-up response to comments, has been highly integrated. In this response, the reviewer brings up a second issue regarding monthly water budgets. The lack of monthly water budgets in the original report is not a reflection on the level of integration of this study. Hydrographs of daily flows, stage, and groundwater levels and other water budget components were provided to the other team members during the course of the project and were provided in a submission to MNDMNRF and JART. Average monthly water budgets are inferior to our submission of annual summaries and graphs of daily components. Monthly average water budgets smear the effects of wetland function because of changes in the timing of the arrival of the spring freshet and lagged changes in surface and groundwater storage. For example, the spring freshet may occur entirely in one month, or span a month boundary. Further, surface water and groundwater storage response are also lagged. The water course summaries were in response to a request by MNDMNRF to provide information on available data and model prediction on a feature-by-feature basis to ease review. The package was meant to provide the granular data (i.e., daily values) to supplement the original report which provides more general discussions of overall impact of existing, interim and post extraction conditions.
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.	The roadside ditch along Colling Rd. currently flows into the quarry at Blind Line. The diversion is to carry ditch further along to discharge to the unnamed tributary to Willoughby Creek. An approval for the diversion will be required. As noted by Tatham, the Colling Road diversion is not central to the management of quarry water. If the diversion is not approved, the surface runoff from north of Colling Road will continue to drain through the quarry as it currently does. Accordingly, we simulated the ditch as it is currently configured in the remedial scenarios.	Not addressed. To approve the diversion the proposed external catchment diversion along Colling Road should be discussed within the Impact Assessment, with modeling updated if necessary.	As noted, the roadside ditch along Colling Rd. was simulated as it is currently constructed. Diverting the ditch would only reduce the amount of water needed to be pumped to dewater the quarry. The water is not needed for operations and natural discharge of this water -- rather than as pumped discharge -- would not alter the water budget for the tributary to Willoughby Creek.
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?	Please see response to comment 5, and our detailed response to MNRF wetland questions. The statement was based on model results based on averaging over the simulation period for the baseline (model calibration) scenario. This statement relates to simulations of 2004 to 2015 conditions, a period which was felt to reasonably represent current conditions. The quarry extent and quarry water management were representative of that period. The position of the water table is an important factor in the wetland water balance, controlling the rate of leakage into and out of the wetlands as well as controlling runoff and interflow. Changes in groundwater discharge to the wetlands have been assessed in all the quarry development phase simulations.	It is our understanding that the impact assessment and calculation of the water balance components for wetlands was completed using the WY2010-2019 not 2004-2015 GS Flow simulation, please explain. Based on recent modelling meetings and additional discussions it is understood that the reported groundwater inflows are averages based on WY2010-2019 GS Flow model results, which represent conditions potentially impacted by existing quarry operation.	This was a typo. The text should have read WY 2010-2019.
4.	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 locally significant groundwater discharge area and hence can be deemed a negative impact. Please address these potential negative impacts in the report.	The main body of the report provides more detailed discussions of the simulations used to assess changes in groundwater levels and the changes in groundwater discharge and streamflow due to reductions in groundwater levels. The model demonstrates that the west extension will intercept a portion of recharge that currently infiltrates through the golf course before discharging into the Medad Valley. The proposed infiltration pond system will mitigate that effect, but any remaining water that is intercepted will simply be discharged through the north discharge point and into the Medad Valley to the north of the current discharge. Please refer to the MNRF Comment Response figure titled "Wetland 13204 – Graph 5" on page 161 (PDF page 292) and the associated discussion for an assessment of the change in soil moisture that will occur due to this change.	This is an assumption that the proposed infiltration pond will function as modelled. It is one thing to make it work in the model and another thing to ensure that it works as designed in reality. What would be the monitoring, mitigation and contingency mechanism to ensure that the recharge/infiltration is constant and sufficient to maintain the pre-extraction groundwater levels?	The infiltration pond was simulated in a very conservative manner as a shallow pond sitting on the Halton Till (similar to the Golf Course ponds it replaces. Simulations requested by MNDMNRF considered a deeper lake excavated to the top of the weathered bedrock which would have higher infiltration rates. Please refer to Schedule 1 and 2 for additional details about the infiltration pond and effects on the Medad Valley. Regardless, the updated Adaptive Management Plan addresses any uncertainty that may come out of the work completed by Earthfx and Tatham.

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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.	The selected period includes the Ontario Low Water Response Level 2 Drought condition that was posted by Conservation Halton on August 10, 2016. Monitoring data from prior to 2004 was limited, reducing the value of simulations prior to that time.	This is a major deviation from the TOR. Contrary to 2007 drought there is limited monitoring data for the Level 2 Drought condition in 2016.	The reasons for the selected time period were clearly discussed at our JART modelling meeting in November, 2021. These include an advancing quarry face and a more limited monitoring network. As we noted herein and in subsequent meetings with JART, long run times and model stability issues created practical limitations for the model run times. (The stability issues were not related to the quarry but rather to conditions at Mt. Nemo, where the Escarpment is very steep) As well, there was a benefit to running the model for a period for which some observational data were available. The model simulation started in 2009 (WY2010) and extend to 2019. As was noted, there are dry periods and wet periods within that span.
	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.	Long run times and model stability issues created practical limitations for the model run times. The stability issues were not related to the quarry but rather to conditions at Mt. Nemo, where the Escarpment is very steep. One option to improve stability and reduce model run times was to remove the lower escarpment area from the simulations. This would have prevented any analysis of headwater tributaries below the escarpment. The decision was made to use a 10-year period and maintain a larger model area.	Why was this not consulted with the agencies?	This was felt to be mainly a technical issue related to model stability. Given that we were able to simulate the period with logger data, we did not feel that additional insight would be gained by simulating the full 25-years to cover periods with either no data or monthly data only. A 20-year PRMS simulation was completed. The evaluation of potential effects on headwater streams at the base of the escarpment was considered important.
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?	Please refer to Response 15, above. Again, the study scope was directed to assessing the impact of the proposed quarry extension. There was a recognition that the expansion could impact nearby wetlands and private wells, and the study was undertaken to quantify the likely effects.	Currently, Nelson quarry operates under interim conditions. We disagree with the premise that the impacts created by the existing quarry should be overlooked and only an assessment of the additional impact of the proposed quarry extension carried out. As per the response to this comment the Nelson study team recognizes potential impact by the proposed extension. Following the same logic the existing quarry impacts should be recognized and quantified. The proposed rehabilitation of the quarry would preserve any impacts from the existing operation in perpetuity.	The model does assess the "cumulative effects" of all existing and proposed stages of quarry excavation. Results were presented in terms of absolute water levels and streamflows, not just in terms of change, so the cumulative impacts were fully taken into consideration. We also present incremental drawdowns from a fully transient 10-year baseline condition. It should be noted that the existing quarry is near full buildout and additional drawdowns due to ongoing operations are not expected. Similarly, our simulations of quarry rehabilitation analyzed the cumulative effects of rehabilitating both the existing and expanded site.
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) • A study of the shallow overburden (Golder, 2007) 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.	The Golder data and reports were **fully** integrated into the database and analysis. The Golder data are high quality and clearly presented in the previous reports, so simply replicating the data in a new format would have limited value. Please also refer to Response 10 and 11, above. The key aspect of the Earthfx approach was to fully integrate the Golder data, plus the extended long- term measurements, into a fully transient 10-year assessment. Geologic data were used in site characterization and construction of the hydrostratigraphic model. Groundwater level data, aquifer test data, and streamflow data were used in site characterization, model construction, and model calibration. Comparative assessments of updated water budgets were compared against previous to check that model assessment was reasonable. We did not replicate the previous data reports within our reports. We believe that the data were made public through the previous application and that all parties have access to this information.	Not addressed. This is a new application, and all supporting data should be included in the reports as appendices and be appropriately referenced. Please update the reports to include this data.	Work completed by other professionals is commonly referenced in technical studies. This work has already been reviewed and we did not believe it necessary to pad out our report with previously submitted data. However, we did present all available data as hydrographs in our meeting with JART team members.
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.	The map below shows the well distribution where they are tightly clustered.	Addressed	RESOLVED
12o	How was the subsurface conduit to model the disappearing stream segment represented in the model?	The SFR2 stream segment was assumed to interact (i.e., gain or lose flow to the weathered bedrock) with Layer 4. The stream had a relatively narrow section (same as a Strahler Class 2) and a bed hydraulic conductivity of 1x10-4 m/s compared to normal streams in Layer 1 (5x10-7 m/s).	Addressed.	RESOLVED

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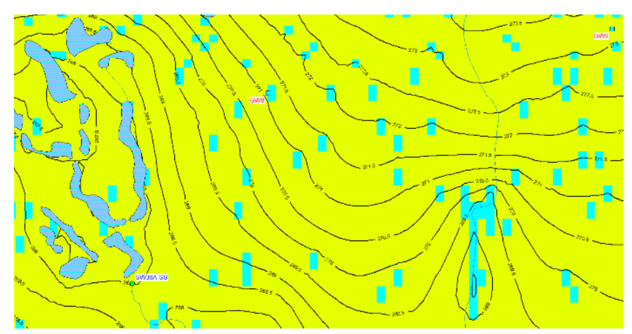
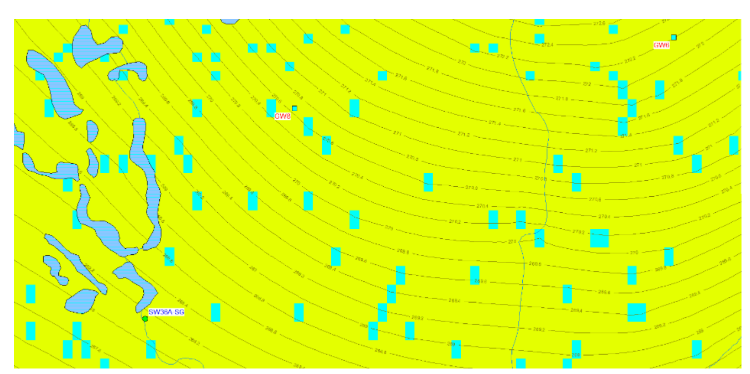
122.	It is noted that low and high limits of bulk hydraulic conductivities for Amabel Formation used in the model as presented in Table 5.1 are some of the lowest values reported by others. How do hydraulic conductivities used in the model compare to the on-site field investigation derived data? The 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.	It should be noted that the range in values cited was relatively small, so being in the lower range is not that significant. Early in the study, we used the model to replicate the aquifer testing results and ultimately selected values that were comparable. The packer test data vary over a large range and our value is within the range of reported results. We analyzed the water level data and tested to see if there was any consistent pattern to assign spatial variability to the model parameters. In particular, early in the study we used the pilot point technique in conjunction with PEST to create an interpolated hydraulic conductivity field. In the end, we found no consistent pattern and went back to uniform property assignment.	How is this representative of the field derived data? The model starts with an assumption that all wetlands interact with groundwater irrespective of the underlying soils properties. The report should clearly recognize that using uniform hydraulic conductivity values may be detrimental to local hydrologic responses.	Assuming that the measured values vary randomly about the mean hydraulic conductivity and based on the lack of clear spatial trends in the data, the assumption of stationarity is not unreasonable. Further, the regional scale advance of the Halton ice sheet would suggest that the depositional process is similarly regional and relatively uniform. The model match to the large seasonal fluctuations in the bedrock suggests that the many surface and shallow till processes are creating an accurate system behavior. As we have noted, we also adapted a hybrid approach in which horizontal fracture zones and the random occurrence of vertical fractures were represented explicitly. This was done specifically to better represent local response to stress in the immediate quarry vicinity.
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.	Adding vertical fractures to connect the shallow and deeper systems by adjusting the Kh/Kv anisotropy values was done more to fit local response in the vicinity of the quarry face rather than improving regional groundwater heads. In general, the simulated heads (Layer 4 average heads shown with a 0.5 m contour interval overlying the Layer 5 VKA assignment) show small localized breaks in slope in the vicinity of the fracture zones (indicative of groundwater moving down to deeper zones) but much larger changes in the vicinity of surface water features. Layer 7 heads (second figure) show little change in the vicinity of the fracture zones and the only break in slope occurring near the karst stream segment. There is likely little impact in the vicinity of the streams.  	The figures provided in the response are for an area where quarry impact is most likely small (small head differences between the model layers). The north-west corner seems to capture Camile golf course ponds which are at similar distance as the tip of the proposed extension some 1 km away from the existing quarry. What are the impacts closer to the quarry face especially where wetlands are located?	As was noted, we added vertical fractures connecting the shallow and deeper systems specifically to fit local response in the vicinity of the quarry. The vertical fractures are likely randomly distributed about the study area and we attempted to represent their frequency and hydraulic effect, but there is no way to know their exact locations. In our response to MNDMNRF (Earthfx, March 2021) we provided extensive observational proof that the quarry has not impacted wetlands in close proximity to the advancing face (see Section 4, and Wetland 10/13015 and Wetland 3 discussion, among others).
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 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).	Each cell in the model was assigned a random number from 0 to 1. Five percent of the cells (those with a random number between 0.95 and 1, for example) were assigned a different VKA value. There was no consideration of proximity to the Niagara Escarpment so some cells must have higher VKA in proximity to the Escarpment. Incorporation of an enhanced fracturing halo zone was tested early in the model development but was not found to improve results.	Neither Figure 18.20 or 18.21 show any cells within at least 100 m along the east boundary of the escarpment. Higher hydraulic conductivities along the fringe of the escarpment may have impact on the groundwater levels, shift the groundwater divide closer to the quarry, etc. The last statement about testing the halo zone which resulted in no improvement of the results is rather subjective. To represent groundwater conditions, the model should be built using available data to a maximum extent possible.	The cells were distributed randomly. It is not subjective; we compared results to interpolated maps of water levels and did not achieve a better match with the halo, indicating that the halo effect, if present, is not as pronounced as in other study areas.
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.	This area is the most monitored in the study area and it seemed reasonable that, without observations to the contrary, relatively consistent aquifer properties should be adopted. As noted earlier, as part of model development we used the pilot point technique in conjunction with PEST to create an interpolated hydraulic conductivity field. In the end, we found no consistent pattern and went back to uniform property assignment.	As identified on various other figures, the quarry impacts are identified farther away from quarry face. The response in OW03-14 (Figure 5.12) suggests that the aquifer is not uniform.	The quarry impact, in that particular section of the report, was related to the dropping of heads to close to the elevation of the quarry floor. In more generalized discussions of the extent of impacts (elsewhere in the report), the effects refer to o a noticeable decline in water levels, and that occurs over larger distances (about 800 m). It is not related to local hydraulic conductivity variations.

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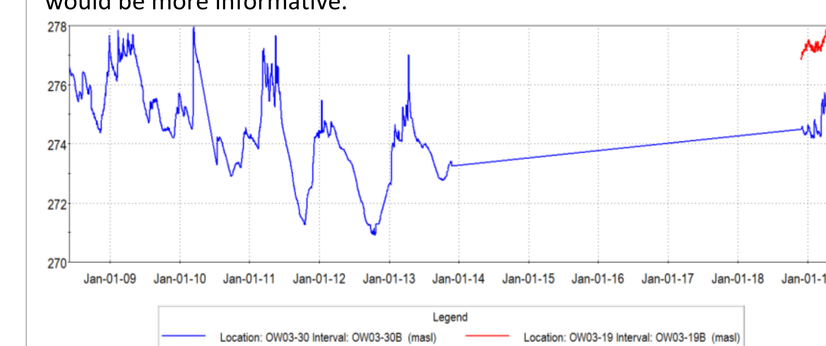
135.	Monthly water level data were collected by Golder starting in 2003, and continuous data were collected in most wells from 2007 to 2013 and only starting again in October of 2018. Considering that the longest transient water level dataset is 2007 to 2013 why does the transient model run start at 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.	The monitoring network was developing over the period of 2004 to 2008, and the most complete dataset for calibration was near the end of that period. Also please refer to Response 79 Model stability issues and long-run times forced the use of a 10-year simulation period (the stability issues were not related to the quarry but rather to conditions at Mt. Nemo, where the Escarpment is very steep). Working back from 2019 to ensure that recent data for the west was included, gave us a model start time in WY2009. There were drought periods in 2015 and 2016, so the need to simulate drought conditions was covered.	The development of the monitoring network began in 2003. There are no groundwater monitoring data available for 2015 and 2016, just model results, which reduces the confidence of relying on the model results for impact and predictive analysis during drought years.	Of the wells with continuous (logger data), only one well cluster (MW03-04) was recording data between 2004 and 2005. These loggers were discontinued in January 2006. All other wells began recording after May 24, 2007.
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?	Care should be used in interpreting the water level maps especially in areas of sparse data. In general, the map shows that there is little difference between the deep and shallow layers along the stream in the Medad (Willoughby Creek) but higher heads to either side, indicating a discharge zone. This is based on few data points, however, as access and data from within the valley is limited. Much of the area contributing to the upper reaches of Willoughby Creek (before the confluence with the tributary carrying quarry discharge) will be unaffected by the west quarry extension. The infiltration feature is intended to mitigate the drawdowns that will likely occur near the quarry footprint.	We agree that there are sparse data in the proposed west extension area, which makes it difficult to rely on model results which was built using sparse data. It has not been demonstrated that in case the proposed infiltration pond does not mitigate quarry extension impacts, the groundwater discharge within the Medad valley would be maintained. Furthermore, it was stated to JART reviewers multiple times in recent meetings and during the site visit on November 9, 2021 that the proposed infiltration pond function is not to infiltrate water and is not necessary to maintain groundwater levels. What is the mechanism to guarantee the pre-extraction quantity of water is directed to support groundwater discharge function in Medad Valley and associated natural features?	The model was built based on and to supplement the available data. Additional modelling analyses were presented to JART and MNDMNRF to demonstrate the effectiveness of the infiltration feature in replacing and exceeding the function of the Golf Course ponds (See Schedule 1 and 2). It is noted above that the infiltration pond was simulated in a very conservative manner as a shallow pond sitting on the Halton Till, similar to the Golf Course ponds it replaces. Simulations requested by MNDMNRF considered a deeper lake excavated to the top of the weathered bedrock which would have higher infiltration rates, resulting in higher heads and more groundwater discharge.
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.	The figure below shows a hydrograph for OW03-19B, located 1000 m from the quarry face or 750 m further than OW03-30B. They both show a similar seasonal response patterns. 	Not addressed. As identified on the figure in the response, portion of the two hydrographs overlap but OW03-19B is cut short and deviates from OW03-30B significantly and again it is not a long-term dataset.	Perhaps this graph, showing the full period of record and at similar scales would be more informative. 
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.	The point of this section is that extraction at the quarry face caused a relatively sharp drop in water levels in the deeper bedrock. The decrease in heads is maintained because local leakage from above (between 0 and 50 m) cannot match the drainage at the lower fracture zone outcrop. Further away from the quarry, the net leakage between the well and the quarry face (0 to 1000 m) balances the lateral outflow and there is no further decrease in water levels. At that point, the difference between the shallow and deeper bedrock is small, but not zero, since there is still vertical movement to the deeper system due to natural recharge from above. Water level data have been provided in two tables in Schedule E. There are 36373 manual measurements in the table and 128371 logger values. The logger data represents daily averages. We did not export the over 6.3 million sub-daily logger values.	The point of this comment was to present more data to support the discussion. It is rather a standard practice to present large datasets in graphical form. This is a new application, and all supporting data should be included in the reports as appendices and be appropriately referenced. Please update the reports to include this data.	We presented all available data as hydrographs in our meeting with JART team members.
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. Please update the baseline period.	By 2009, the quarry footprint had reached the quarry boundary and the effects of this change had been expressed in the water level data. 2009 is an intended baseline for comparison of the simulated response under a succession of quarry expansion/rehabilitation phases to the current baseline conditions. Rather than doing a series of punctuated steady-state simulations, we intended to capture the full range of daily responses under a 10-year range of daily climate inputs.	Not addressed. As stated, quarry impacts are already visible in presented hydrographs in 2009 so the model results show only additional impacts since 2009 as the quarry kept expanding in the southeast direction.	The analysis looked at the cumulative impacts of all future quarry operations and water use. As the quarry has expanded to occupy its full footprint, no significant drawdowns from current conditions are expected due to continued quarrying in the existing site. The impacts are due to the proposed expansion. The future rehabilitation looked at changes due to modification of the existing site and proposed extensions.
253	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.	The AMP states that a follow up well survey will be completed for wells within 1km. The assumption was that most wells would be able to handle the 2-m average drawdown at 500 m. Drawdowns at 1000 m are less than 0.25 m, well below normal seasonal fluctuations.	Addressed providing well survey within 1km is completed.	RESOLVED

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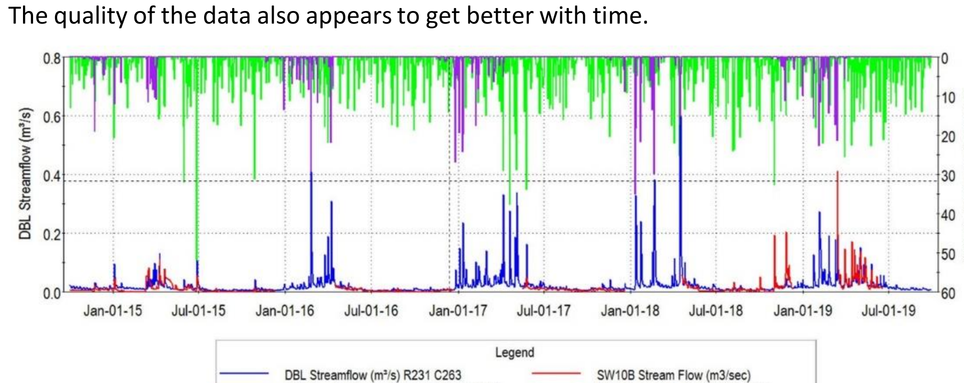
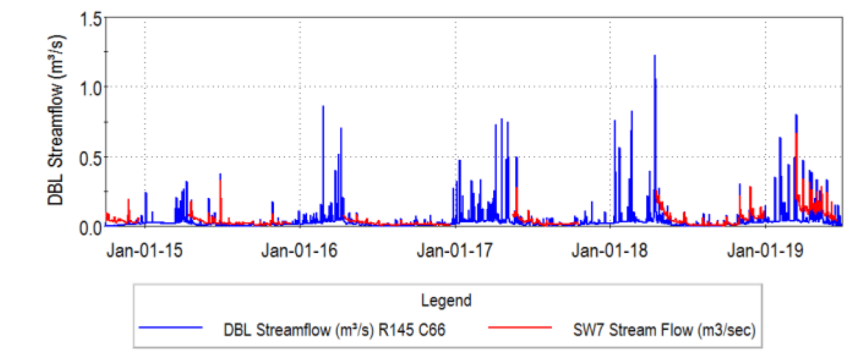
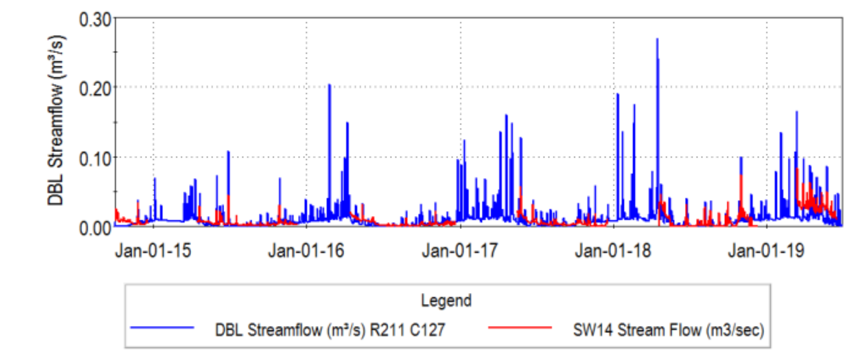
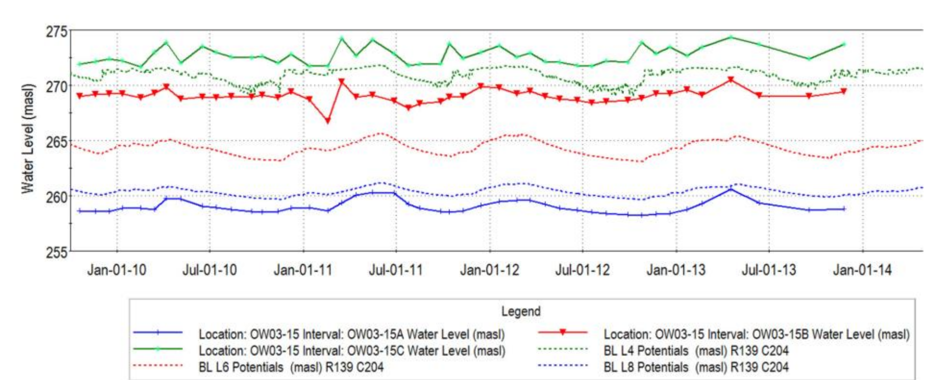
155.	It seems that total well depth was used to calculate available drawdown for private wells as presented in Table 5.3. At least 1.5 metres should be deducted from the well total depth to allow for pump setting and avoid pumping sediment. Also, private water well survey results are needed for this assessment as pump type (single jet, double jet vs submersible) may alter the available drawdown for a particular well.	Many of the cross sections (including that shown in Response 117) indicate that some private wells are completed through the aquifer, possibly to provide the extra depth for pump installation. Given this possible solution, reporting the available aquifer drawdown is clear and sufficient for contingency planning.	Partially addressed. Have all private wells in the predicted impact zone been assessed to see if they were constructed below the bottom of the aquifer?	The wells were assessed with respect to their available drawdown as well as the available drawdown in the aquifer. For example Figure 8.76 shows the Layer 4 and Layer 6 wells with <5 m of available drawdown. More important was the total available drawdown in the aquifer, as individual well construction issues are addressed in the AMP.
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.	It would have been useful to have this at the outset of the study. We had to develop our own coverages. LIDAR data is increasingly available and we are using it where available	Addressed. Accuracy of drone survey data stated in surface water comment table and is considered acceptable.	RESOLVED
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?	Areas of groundwater discharge typically occur in the vicinity of the groundwater-fed wetlands and in riparian areas of streams. This is shown more clearly in Figure 7.20	Not addressed. The second part of the comment is totally disregarded, specifically: How would groundwater discharge function be restored and maintained during extraction face moving closer to those features resulting in additional groundwater lowering?	Groundwater upwelling contributes to baseflow in the GSFLOW model. We reported on expected changes in streamflow based on simulations of theP12, P3456, and rehabilitation scenarios. In general, streamflow changes were small for P12. The changes under P3456 and RHB1 were minimized due to the infiltration feature. Additional simulations with a modified infiltration feature were conducted at the request of MNDMNRF to further reduce the impact on groundwater discharge to the soil zone. Please refer to Schedule 1 and 2 for more details.
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?	Recharge would still occur in the area between the quarry face and Cedar Springs Road. This would be augmented by the infiltration feature which would accept part of the quarry discharge.	The response provided relies on the assumption that the proposed infiltration pond will work as in the model. Similarly, to previous comments (74, 141), this has not been demonstrated and there are no monitoring and mitigation measures proposed to ensure its functionality.	Additional modelling analyses were presented to JART and MNDMNRF to demonstrate the effectiveness of the infiltration feature in replacing and exceeding the function of the Golf Course ponds. It was noted above that the infiltration pond was simulated in a very conservative manner as a shallow pond sitting on the Halton Till, similar to the Golf Course ponds it replaces. Simulations requested by MNDMNRF considered a deeper lake excavated to the top of the weathered bedrock which would have higher infiltration rates, resulting in higher heads and more groundwater discharge. Please refer to Schedule 1 and 2 for more details.
172.	The report should document which and how parameters in the PRMS sub-model were adjusted to calibrate the GSFLOW model.	There are numerous parameters in the PRMS model, most of which can be varied on a HRU, monthly, or HRU and monthly basis. We have presented the parameter values that we used and highlighted the key ones in the property tables. Calibration entailed a combination of automated (Monte Carlo) parameter estimation and manual adjustment processes in which the soil property and land use property values were refined. Visual inspection of hydrographs at gauge locations was the primary tool for evaluating the goodness of fit during the manual calibration process, adjusting parameters as needed to better match peaks and baseflow recession.	Not addressed. CH has concerns with adjusting land use property values as part of the calibration as those values can be directly measured.	The land use classification was not adjusted during calibration, but the associated hydrologic properties associated with each class were adjusted. The PRMS inputs were assigned by soil, land use, and vegetation class recognizing that there will be local variation in the properties within each class. The calibration adjusted the assigned property values within reasonable ranges to improve the match to the observed flows at all gauges.
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.	Over the longer period of record, the model performs well, although there is not much winter/early spring data for comparison other than 2019. We have noticed a bit of a lag in the fall recovery. This is likely due to the need to bring soils up to field capacity before groundwater discharge or Dunnian flow occurs. In the field, the values of soil storage capacity will likely vary, with some areas contributing flow earlier than others. Randomizing the storage capacity values within each class might help but was not implemented in this model. The quality of the data also appears to get better with time. 	Not addressed It appears that the soil layer in the model does not best fit the natural data and that field capacity and soil capacity should be revisited.	We believe that we have achieved a good match except to mechanisms that allow for contribution to groundwater recharge and overland flow before the entire soil reservoir has reached field capacity. In our response to MNDMNRF (Earthfx, March 2021) we provided extensive comparison between observed and simulated shallow model response. Overall, the calibration to the minipiezometers was excellent, in both response timing and to monitors across the wide study area.

HALTON CONSERVATION COMMENTS

174.	To validate the GSFLOW model, hydrographs illustrating simulated and observed flows should be presented at a surface water monitoring location on each tributary.	Of the 20 surface water gauges available for GSFLOW calibration, 10 were located more than 3.5 km from the site, had data only for 2018 and 2019, and, of these, seven were outside the model boundary. We found that no change in simulated flow occurs at or close to these locations. SW15 is on the opposite (north) side of the quarry and far from the expansion areas. SW7 and SW14 were discussed in great detail, so it was only SW2 which was omitted and the effects of the quarry extension were better seen in the upstream gauges.	Not addressed, comment stands. SW7 and SW14 are not discussed in this section, only SW9 and SW10 are. Further, graphs are not provided in Appendix E for SW7 or SW14. Graphs are provided for SW9, SW10B, SW29, and SW2. SW2 was not omitted, but shows poor correlation and must be included as the only gauge downstream of the karst feature on Willoughby Tributary. Please provide hydrographs for all flow monitoring stations shown on Figure 19.4 in Appendix E.	We presented all available data as hydrographs in our meeting with JART team members. The two hydrographs below were part of the presentation.   SW7 and SW14 are in the Medad Valley and separate sections were devoted to illustrating change from baseline conditions. SW2 is affected by numerous in-line ponds along Cedar Spring Road downstream of the karst feature on Willoughby Tributary.
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.	OW03-15 is adjacent to the south quarry discharge location, and water levels in the area are affected by leakage from the stream. While this is represented in the integrated model, the pumping records from the south quarry are limited during this period.  The model is high in the deep bedrock, low in the middle zone, and low in the upper zone. As noted, the discrepancies here are smallest for the upper flow zone which is more closely linked to GW/SW interaction.	Not addressed. We agree that leakage from the stream is most likely responsible for the higher water levels in overburden (OW03-15C) and shallow bedrock (OW03-15B) than simulated data. The model results do not replicate this and suggest that the hydraulic conductivity of the till layer is too low in that location.	As noted earlier, we adopted a hydraulic conductivity for the unweathered till that was on the high side.
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.	Borehole logs are included in Schedule E. Monitor OW03-31 does not have a shallow C monitor. Simulated water levels at OW03-21 for Layer 1 and 2 were very similar to those for Layer 4. There are a number of possible reasons for this local anomaly, including well construction, survey error, local shallow topographic/drainage effects and others.	Partially addressed. The simplest explanation would be that the measured data represents local conditions, which the model does not replicate and as originally stated it poses a question if the model can be used to predict wetland impacts in that location.	Local variability does exist, but more important, the model matches the bedrock response patterns in the near (dewatered deep system), intermediate (seasonal variability up to 10 m) and far (no significant vertical gradient) distance from the quarry face. This was discussed in detail in our report and in our Nov. 2021 JART Modelling meetings. As far as we are aware, this is the first model in Ontario that replicates both this transient bedrock response pattern, and the shallow wetland soil moisture hydroperiod and leakage that drives this dramatic seasonal variability.
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.	Comparing monthly water levels to logger data is a bit iffy, but there does seem to be a reversal with water levels slightly higher in the deep system for a short period in the fall. A possible explanation is the deeper system, with low storage, responds quicker to increased recharge even if it occurs outside the immediate area. The local recovery of heads may be lagged. Also see Response 177.	Not addressed. Model does not replicate the measured data very well. There is a similar lag in water level as in the shallow installations. OW03-29C data are outstanding.	An extensive discussion of the shallow system match and lag is included in our response to MNDMNRF dated March, 2021. Most important, the model also matches the dramatic seasonal change in the bedrock head as discussed in detail at our Nov. 2021 modelling meetings.

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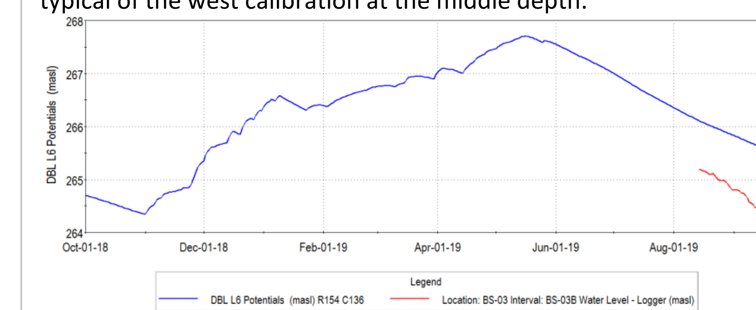
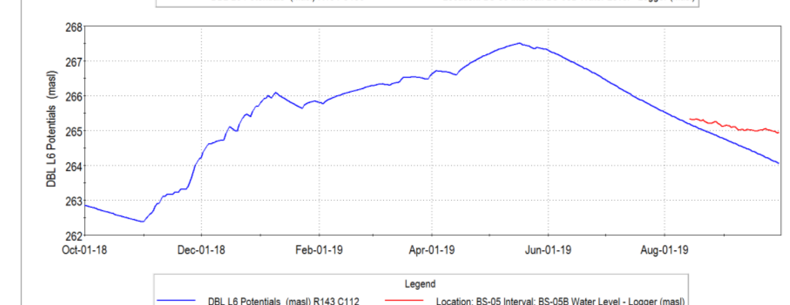
179.	It appears that there is a two to three-month lag between the observed and simulated data as presented on Figures 6.29 and 6.30 – please explain. It appears that MP16 is constructed in MNRF wetland 13037. As per Provincially Significant Grindstone Creek Headwaters Wetland Complex assessment, February 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.	The issue of response lag is discussed in great detail in our response to MNRF comments included in Schedule D. The heads in the unweathered Halton Till (Layer 2) take longer to respond than the soil zone. This can be seen in plots of soil moisture included in Schedule D. As noted in an earlier response, the soil moisture capacity and other factors may not be uniform but be distributed in a more random way within the range of values. That would allow some parts of the system to respond more rapidly than others. The figure shows that at times simulated heads are above the base of the monitor parts of the year.	Not addressed. There is a difference between physical measured data and the model results. If the model does not replicate the measured data it does not replicate local conditions and cannot be used for impact assessment or predictive analyses. If the heads in Layer 2 take longer to respond potentially the hydraulic conductivity of this layer are too low. It should be added that the lag between measured and simulated groundwater levels is also present in the bedrock wells e.g.: Fig. 6.26 and 6.27 of the Level 1 and 2 Hydrogeological Assessment report. Also, groundwater levels in these wells do not replicate short term responses (spikes in water levels) as presented in logger data (Figure 6.26 and 6.27) which suggest that the model underestimates surface and groundwater interactions. Second part of the comment (re wetland 123) is completely disregarded.	An extensive discussion of the shallow system match and lag is included in our response to MNDMNRF dated March, 2021. Most important, the model also matches the dramatic seasonal change in the bedrock head as discussed in detail at our Nov. 2021 modelling meetings.
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.	See Response 179	Not addressed. See response to Comment No. 179.	MP5 is a 1 m deep minipiezometer with a 10 cm screen and as such is responding to the soil zone. Please see response 179
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.	Long term monitoring wells with data loggers are not routinely found in the MECP water well record database. The PGMN network is growing slowly. We focused our calibration efforts on matching data wells in the vicinity of the quarry as they had an extended period of record. These well were installed for earlier south quarry studies. There are a several wells on the west side with short periods of record. The data from these sites were mainly used for comparing with the calibrated model predictions.	Not addressed. The observed and simulated data for the wells installed on the west side of the quarry should be provided in graphical form.	We presented all available data as hydrographs in our meeting with JART team members. The two hydrographs, for wells closest to the quarry, are typical of the west calibration at the middle depth.  
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.	Yes, there is a bit of background needed to better understand the figure. In a typical MODFLOW model, ET losses from groundwater are simulated by specifying a value for ETmax, the maximum ET loss rate which occurs when the water table is at or above land surface and ExtDepth, the extinction depth below which no ET occurs. ET losses linearly decrease with depth to the water table. In GSFLOW, ETmax is not specified. Rather, the PRMS model calculates the daily potential ET and then attempts to satisfy this demand first through evaporation from canopy storage and then through evaporation and ET from the soil zone. Any leftover ET demand is passed on to MODFLOW as the daily value for ETmax. In the spring, PET is usually met by available water in the soil zone. As PET demand increases in the summer months, upland areas (which receive limited run-on from upslope cells) dry out and cannot meet the ET demand and the rate of potential GWET increases. Because the upland areas have greater depth to water, some of this GWET demand will not be met and AET will be less than PET. Ironically, GWET will not be that high in the lowland areas, despite the shallow water table, because the soil zone, which is replenished from below, will be able to meet the ET demand through soil zone ET. As a consequence, even though technically it the ET is ET from groundwater, it is included with GW discharge to the soil zone (surface leakage) rather than GWET in the MODFLOW GW balance). In the winter months, there is still some PET calculated on warm days. Because the canopy coverage is reduced and because transpiration processes are shut down, a bigger percentage of this winter PET is passed to the MODFLOW model and is labelled as GWET.	Partially addressed. Thanks for the ET clarification. What about the 1000-2000m3/d loss of groundwater as visible on Figure 6.39?	The value (2000 m^3/d) translates to about 0.8 mm in a month averaged over the 83 km^2 study area, which is a very small number. January recharge, by comparison, is about 19 mm.
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.	GW-8 is located near OW03-17. The assessment points were selected not for model calibration, but to provide coverage of a wide area away from the wetlands which were addressed separately. GW6 and GW8 are near P12 on inter-stream divides which would be more sensitive to change than points adjacent to wetlands or streams. GW1, GW2, GW3, and GW4 are along the west side along roads with private wells that could be affected by P3456. Similarly, GW5 and GW 7 cover roads with housing on the east that might be affected by P12	Not addressed. Please present data collected to date at the proposed set of groundwater assessment points for "the Baseline and Scenario comparative analyses".	The model provides results at each of over 1.24 million cells. As we noted, we wanted to present results that portrayed the groundwater system response at locations other than just in the wetlands to provide a measure of the possible impact to private wells and other features.

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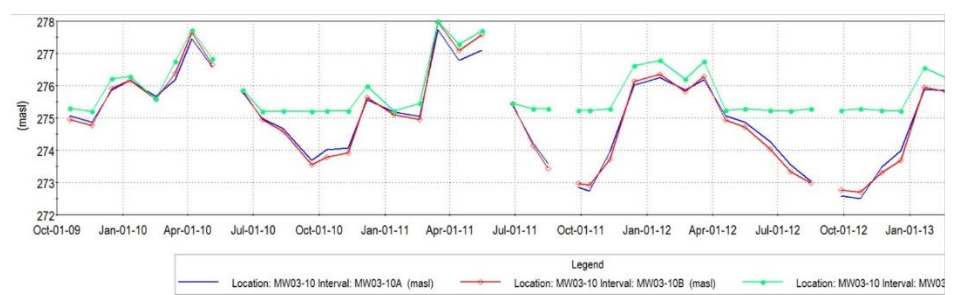
196.	Please provide digital, daily water levels, presented graphically (to depict the wetland hydroperiod) and summarize daily water balance analyses as average monthly water volumes presented in tabular format integrated in the report. Compare driest year, average and wettest year monthly water volumes to assess potential impact.	Extensive additional information related to the wetlands was provided in response to MNRF for more information regarding the wetlands. This has been provided in Schedules B and C.	Not addressed. Monthly wetland water balance summaries are still outstanding. Please also refer to response to Comment No. 1 above.	Please refer to response to Comment 1, above.
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?	The model was used to evaluate the magnitude of likely change in groundwater/surface water interaction as a result of quarry expansion by comparing baseline conditions and conditions under the various scenarios. Because of the drawdown created by dewatering P12, there are small changes in groundwater discharge to streams and streamflow, generally restricted to within the 2 m drawdown zone. The magnitude of the changes are reduced significantly when levels in P!2 recover and a lake is formed.	Not addressed. What are the mitigation measures to maintain groundwater discharge function to the soil zone under wetlands and streams?	As discussed in the report, the nearby wetlands are mostly perched and not significantly affected under P12. Changes in streamflow, as noted, are small.
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.	A hydrograph for MW03-10 is presented below as it is closer to the wetland than OW03-21 and also has a shallow (C) well. There is some crossover between the B and A wells, but the shallow well consistently shows downward gradients between the overburden and the deep bedrock. Similar conditions exist in all nearby wells It is important to note that simulated heads in Layer 1 were below land surface while stage was close to land surface the entire simulation period. The water budget shown summed up the stream leakage for all cells within the wetland polygon as discharge to groundwater. 	Partially addressed. There was a typo in our comment, Figure 6.26 shows the observed and simulated results for well OW03-31, which is located in proximity to Wetland (13014). Hydrographs for OW03-30, OW03-31, MW03-08 and MW03-11 outstanding.	We presented all available data as hydrographs in our meeting with JART team members.
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).	The baseline simulation indicates that heads would be elevated in the vicinity of the golf course ponds, Under Scenario P3456, the mound would be shifted to underneath the infiltration pond (see figures in response 207).	Not addressed. The feasibility of the infiltration pond has not been demonstrated. Also, there is conflicting messaging about the infiltration pond based on recent discussions. Is it required as a mitigation measure or is it not? If it is not, demonstration of no impact must be provided. It should also be noted that there are no monitoring, mitigation and contingency measures proposed in relation to the infiltration pond.	Additional modelling analyses were presented to JART and MNDMNRF to demonstrate the effectiveness of the infiltration feature in replacing and exceeding the function of the Golf Course ponds. (Please see Schedule 1 and 2). It was noted above that the infiltration pond was simulated in a very conservative manner as a shallow pond sitting on the Halton Till, similar to the Golf Course ponds it replaces. Simulations requested by MNDMNRF considered a deeper lake excavated to the top of the weathered bedrock which would have higher infiltration rates, resulting in higher heads and more groundwater discharge.

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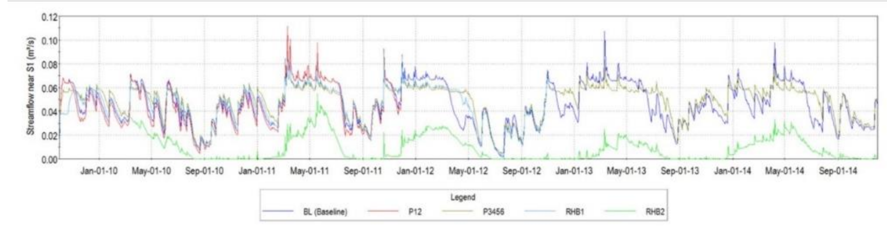
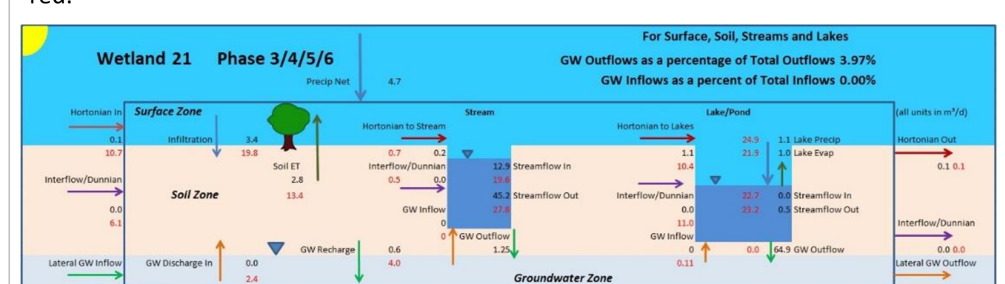
<table>
<tr>
<td>213.</td>
<td>A more robust discussion of the anticipated changes in stream flows should be provided. At a minimum, the analysis should include:

- 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.</td>
<td>The hydrograph below compares flows for Willoughby Tributary immediately downstream of Collings Road for the baseline and four scenarios. Flow statistics are provided in the accompanying table. In general, flows under P12 are generally similar to the baseline. Flows under P3456 and RHB1 are similar to each other but are generally lower in the winter and early spring compared to baseline but higher in the late spring. Flows do not differ much in the summer and fall. Flows under RHB2 are significantly lower due to cessation of pumping to dewater the quarry.



<table>
<tr><td>Station Near S1</td><td>Baseline</td><td>P12</td><td>P3456</td><td>RHB1</td><td>RHB2</td></tr>
<tr><td>Average Flow</td><td>0.044</td><td>0.042</td><td>0.046</td><td>0.045</td><td>0.008</td></tr>
<tr><td>Maximum Flow</td><td>0.122</td><td>0.120</td><td>0.091</td><td>0.088</td><td>0.055</td></tr>
<tr><td>Minimum Flow</td><td>0.005</td><td>0.002</td><td>0.000</td><td>0.003</td><td>0.000</td></tr>
<tr><td>Q50</td><td>0.043</td><td>0.040</td><td>0.053</td><td>0.048</td><td>0.004</td></tr>
<tr><td>Q95</td><td>0.015</td><td>0.012</td><td>0.015</td><td>0.013</td><td>0.000</td></tr>
<tr><td>Change in Flow by Volume</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Average Decrease (m³/s)</td><td></td><td>0.003</td><td>-0.001</td><td>0.000</td><td>0.038</td></tr>
<tr><td>Maximum Decrease (m³/s)</td><td></td><td>0.016</td><td>0.085</td><td>0.030</td><td>0.082</td></tr>
<tr><td>Maximum Increase (m³/s)</td><td></td><td>-0.034</td><td>-0.032</td><td>-0.028</td><td>0.002</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Change in Flow by PerCent</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Average Decrease (%)</td><td></td><td>7.504</td><td>-7.862</td><td>-2.113</td><td>85.132</td></tr>
<tr><td>Maximum Decrease (%)</td><td></td><td>55.919</td><td>99.954</td><td>43.332</td><td>100.000</td></tr>
<tr><td>Maximum Increase (%)</td><td></td><td>-119.872</td><td>-220.597</td><td>-105.933</td><td>37.005</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>% of Days below Q50BL</td><td>50.019</td><td>55.105</td><td>42.745</td><td>50.000</td><td>99.888</td></tr>
<tr><td>% of Days below Q95BL</td><td>5.010</td><td>7.419</td><td>5.233</td><td>6.119</td><td>78.795</td></tr>
</table>
</td>
<td>Partially addressed. Only addressed for Willoughby Tributary and not for other tributaries / nodes.</td>
<td>Please refer to the watercourse characterization tables.</td>
</tr>
<tr>
<td>214.</td>
<td>Detailed water budget for wetland figures should include baseline and proposed values to facilitate reviews.</td>
<td>Baseline water budgets were provided in figures 7.23 to Figure 7.30 for 8 key wetlands. Wetland water budgets for the four scenarios are provided in subsequent sections of the report. If you are asking for the baseline values to be posted on the scenario results figures, it can be done but would take some effort and would not provide any new information. An example for Wetland 21 is shown below with baseline values posted in red.



</td>
<td>Not addressed. Please provide baseline values based on the TOR with proposed 25-year baseline.</td>
<td>The 25-year question has been addressed earlier.</td>
</tr>
<tr>
<td>215.</td>
<td>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.</td>
<td>As noted earlier, there were model stability issues related to modelling the Niagara Escarpment near Mt. Nemo. The periods posted in the table denote the successful run times. For key scenarios, we were able to cover most or all of the 10-year period; sometimes requiring a separate drought period restart. The rehabilitation scenarios were run long enough to derive key information, such as lake stage and quarry discharge under the each rehabilitation scenarios. This information provided useful feedback and was incorporated into design modifications.</td>
<td>Not addressed. This response does not explain why there is a variation in the length of model period (ranging from a total of 2 to 10 years for various scenarios). Stability alone would not account for missing run time.

We note that not all the scenarios were run for a full 10 years and none were run for the length of time proposed within the TOR.</td>
<td>The model crashed at random points in the run. If a sufficiently long run was obtained, we analyzed the model results. Long-term conditions were assessed with the 20-year PRMS simulation and the corresponding steady state model simulation.

The stability and time frame were discussed in our Nov. 2021 Modelling meetings. Please let us know what other factors we should investigate to account for the stability issues. We have only been using GSFLOW extensively for 14 years and welcome any suggestions.</td>
</tr>
<tr>
<td>222.</td>
<td>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.</td>
<td>An extensive package of interdisciplinary tables integrating wetland and watercourse characterization and analysis has been prepared and provided in Schedules B and C. Wetland 1

As noted, there are small changes in groundwater inflows to Wetland 21. Also noted is that further review of the wetland is planned and inflows may be supplemented. The model did not consider possible flow augmentation, so the effects of the water budget, if any, will likely be smaller than predicted.
3201 is discussed in detail.</td>
<td>Not addressed. Please refer to response to Comment No. 1 above.</td>
<td>This wetland will be supported via flow from the infiltration ponds, as outlined in the AMP. Please refer to our updated response to Comment 1.</td>
</tr>
</table>

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.	Discharge from Quarry Sump Q200 to dewater the existing quarry would continue through phases P34, P3456, and RHB1. The increased discharge from the sump during Phase 12 would be discontinued and the South Quarry Extension would be allowed to fill.	Addressed.	RESOLVED
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.	The simulations of P34 assumed that the P12 quarry would fill in a relatively short amount of time (assumed to be several years) with a high rate initially and tapering off over time. It was also assumed that P34 would be fully excavated at the start of the simulation, so that a conservative analysis of impacts could be conducted. There will likely be a period where some of the P34 area has been partly excavated and the P12 not fully recovered, but we do not believe that this will represent a worst condition than the two end-members.	Addressed.	RESOLVED
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.	The graphical presentation may be slightly different, but the function is consistent.	Not addressed. Has the "spur" been incorporated in the model? This is a location where the proposed extraction is the closest to Medad Valley and there are downstream private water supplies and potential groundwater discharge areas within the Medad valley. Groundwater monitoring and mitigation must be proposed.	It was assumed that the diversion pipe would provide perforated for this segment.
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.	1) Wells were already affected by the golf course irrigation ponds 2) Many private wells are already close to ditches and streams The water quality is monitored and fit for discharge to surface water (i.e. to the unnamed tributary to Willoughby Creek. A discussion of surface water quality is presented in Response 7 and 8 The pond is to be excavated to the top of the weathered bedrock. Significantly higher infiltration rates (than from the golf course irrigation ponds) would be expected. Some infiltrated water is likely to discharge to the quarry and be recirculated.	Not addressed. The proposed infiltration pond would be significantly closer to most private wells than the existing golf course ponds, the existing golf course ponds were most likely built to retain water rather than infiltrate it, which provides for time and extra filtration of infiltrated surface water. Discharge monitoring to surface water is to ensure protection of downgradient private water supplies in terms of water quality.	The water quality data for the quarry discharge and for wells near the Golf Course ponds did not have any water quality issues. Water quality is monitored routinely at the discharge point. Additional monitoring is planned as per the AMP.
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	See response 226	Addressed.	RESOLVED
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.	Our assessment did not find significant changes to the area directly contributing to the wetlands and, therefore, no significant change to the water budget.	Not addressed. This is inconsistent with information provided during the November 9th, 2021 site visit, when mitigation measures were mentioned for this wetland. Please explain.	The model did not show significant impact. Regardless, provisions will be made to augment flows if needed.

HALTON CONSERVATION COMMENTS

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.	This has been previously addressed.	Not addressed. See response to Comment Nos. 15, 73, 79, 82, and 147.	See earlier responses. As was noted, the model considered the cumulative effects of all future development and water use. The quarry currently is at its limits and no further change due to the existing operations is expected until the rehabilitation phase.
267.	The groundwater monitoring program must include shallow monitoring wells including wells completed in overburden to understand full impact of the proposed extraction.	A detailed discussion of the monitoring program and AMP is presented in our response to comments from the MECP (Schedule A). We will take this comment under consideration as the monitoring program and AMP are finalized.	Not addressed. Subject to AMP review when available.	The AMP has been provided to JART.
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.	A detailed discussion of the monitoring program and AMP is presented in our response to comments from MECP (A copy is provided in Schedule A). We will take this comment under consideration as the monitoring program and AMP are finalized.	Not addressed. Subject to AMP review when available.	The AMP has been provided to JART.
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?	Please refer to Response 3, 15 and 78 for a discussion of cumulative impact and what is considered baseline	Not addressed, the question is not about cumulative impacts, but rather if monitoring data which documented most likely impacted conditions can be used as baseline to complete impact assessment.	As discussed in our report, the past monitoring data were analyzed extensively to determine what the likely range of groundwater level change and the lateral extents of zone of impact would be. This informed our modelling effort to further quantify the likely impacts.
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?	Well DW2 has been continuously monitored since August 2019. Also refer to Response 280, below.	Not addressed. We disagree that a private water supply well, with a very limited baseline data, can be used to show natural variability of the groundwater elevation fluctuations and trends under various future pumping and climatic conditions.	Given that there are no other upgradient wells with data; an upgradient well with 2 years of record is extremely useful.
279	Please provide an example of the trend analysis. How often would this analysis be repeated based on actual measurements rather than simulated levels?	Please see: https://www.nvca.on.ca/Shared%20Documents/NVCA%20Groundwater%20Trend%20Analysis%20Using%20the%20PGMN%20May%202013.pdf For a discussion of seasonal trend analysis.	Addressed.	RESOLVED
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.	The change in soil moisture conditions in the Medad Valley is discussed in our Wetland characterization table included in the MNRF comment response. These changes are small and are broadly distributed along the valley wall. The water intercepted by the western extension (and not infiltrated through the infiltration pond) will be ultimately be discharged to the Medad Valley slightly to the north, so no downstream impacts are likely.	Not addressed. If the groundwater levels cannot be maintained as suggested based on the model results, mitigation measures might be needed.	MNDMNRF expressed similar concerns regarding the Medad Valley. As per the updated AMP, additional monitoring is planned as well as changes to the operation of the infiltration feature to raise heads and increase infiltration.
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).	A key component of the monitoring for the AMP is to assess the extent of possible impacts in areas more distant from the quarry. A number of the wells suggested by the reviewer are located in closer proximity to the proposed quarry extension. Others are near already proposed monitoring nests. The AMP, however, is currently under review and finalization.	Not addressed. Subject to AMP review when available.	The AMP has been provided to JART.
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.	The shallow bedrock is not used as a water supply aquifer, and shallow seasonal variability is larger (some shallow monitors go dry). The deeper monitors provide a more representative measurement that is less susceptible to false alarms.	Not addressed. It is agreed that the deeper monitors may be less susceptible to false alarms; however, considering there are potentially shallow private wells and natural environment which rely on shallow groundwater zone, threshold values for shallow wells should be also developed. Considering, the response to comment 20 mentions mitigation to potential impact to shallow wells (deepening) threshold values for shallow wells are needed.	The AMP has been provided to JART.
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.	Further information about the quantity and quality monitoring program and AMP is presented in our response to comments from MECP (see Schedule A). The issues with shallow monitors are discussed in Response 294.	Not addressed. Subject to AMP review when available. No response to nitrite and nitrate monitoring request provided.	The AMP has been provided to JART.

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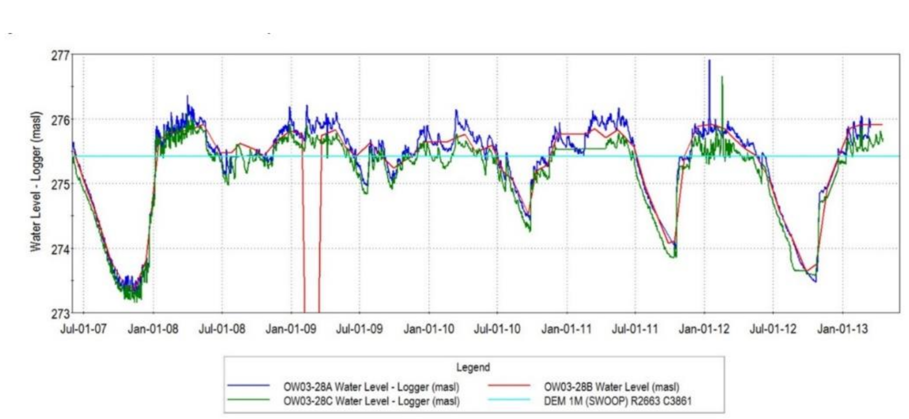
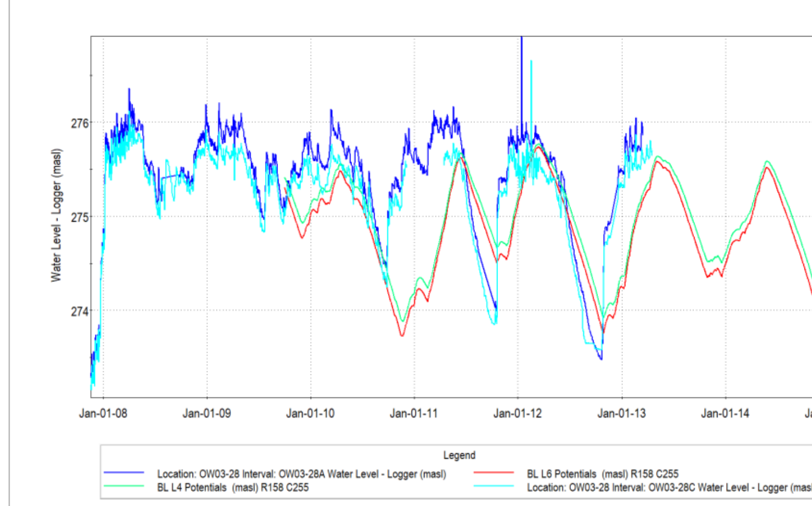
306.	Include a summary of effects on watercourses in these sections.	An extensive summary of the effects on wetlands and streams has been compiled for MNRF and has been provided in Schedules B and C.	Not addressed. Please provide written analysis of the effects on the watercourses within the Watercourse Characterization Summaries. The effects on flow are not summarized in the tables in the summaries and the provided charts are difficult to read as several charts are labeled the same and the legends are not clear as to what each line is. It is also confusing that the summaries appear to be talking about groundwater as opposed to surface water (groundwater, water budget) please clarify that surface flows are being compared.	Hydrographs comparing flows at all significant gauges were presented for each scenario. The overall impacts on streamflows were summarized in a summary section at the end of each scenario (e.g., Section 8.5.5 for P12). These summaries could have been brought forward to Chapter 11, but the focus at the time of reporting seemed to be on wetlands and domestic water supply. A summary of watercourse data was compiled for MNDMNRF to consolidate the monitoring data and model assessments for each watercourse into a single section, rather than across the various scenarios, specifically to ease the review of effects.
307	Outline proposed pumping/discharge points for Rehabilitation Scenario 1.	These will remain as before at Sump 001 and Sump 002	Addressed.	RESOLVED
314.	Please submit all borehole logs used for the assessment (Only 50 out of 100 reported borehole logs were provided). - 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.	An extensive suite of logs and monitoring details has been provided in our response the MNRF (see Schedule D). Available borehole logs have been provided, as per the request, in schedules B and C and additional information is also provided in Schedule E.	Partially addressed. Only three extra borehole logs were provided in Schedule D and two in Schedule E.	Specific requests were made by other reviewers for logs of wells drilled for this study. The wells referred to in this comment were installed by Golder and the logs are in the previous Golder submissions.
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.	A spreadsheet with packer test data has been provided in Schedule E. The information has also been presented in a table in a MS-Word document. Figures showing the packer test locations are also provided.	Addressed.	RESOLVED
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.	The wells are located next to a ditch and therefore may intermittently receive groundwater discharge. The remainder of the wetland may be perched. A spreadsheet with the observed and simulated groundwater levels has been provided in Schedule E.  	Not addressed. We cannot locate the simulated water level data in Appendix E. Groundwater levels in the deep bedrock aquifer are constantly higher than the middle and shallow aquifer, which does not support provided response.	The well is on the side of a sloping area, and local conditions and vertical interconnection may account for the generally small gradient. Nearby location MW03-08 exhibits downward gradients from the shallow to deep system.
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.	The wells are located in a low-lying area and therefore may intermittently receive groundwater discharge. The remainder of the wetland is likely perched. A spreadsheet with the observed and simulated groundwater levels has been provided in Schedule E.  	Not addressed. We cannot locate the spreadsheet with simulated data. An OW03-28 hydrograph should be presented showing simulated and observed data.	The requested hydrograph is attached. 

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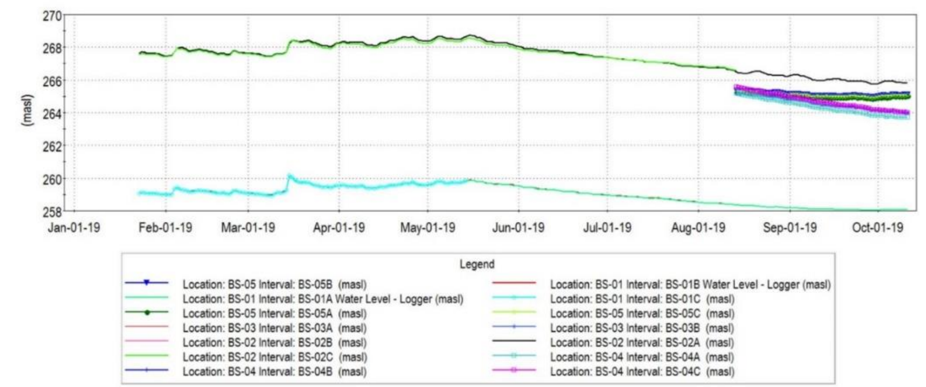
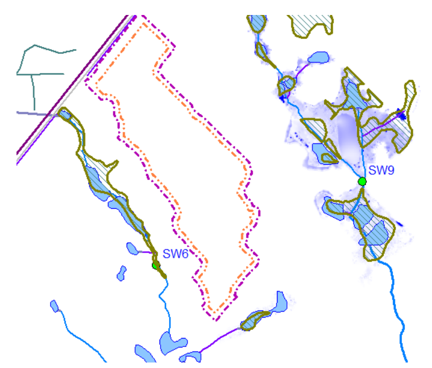
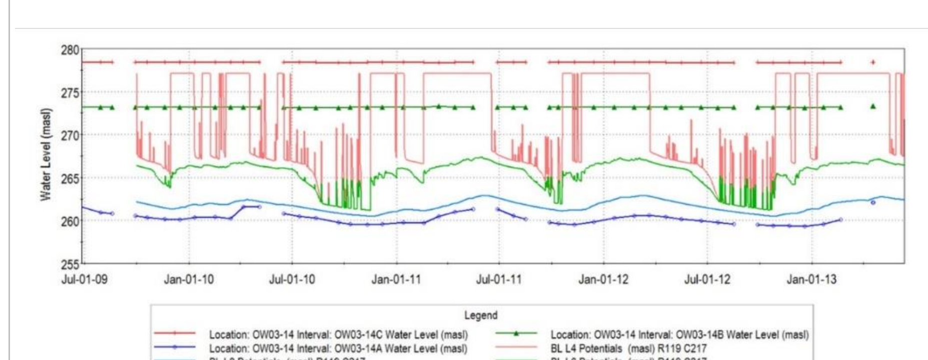
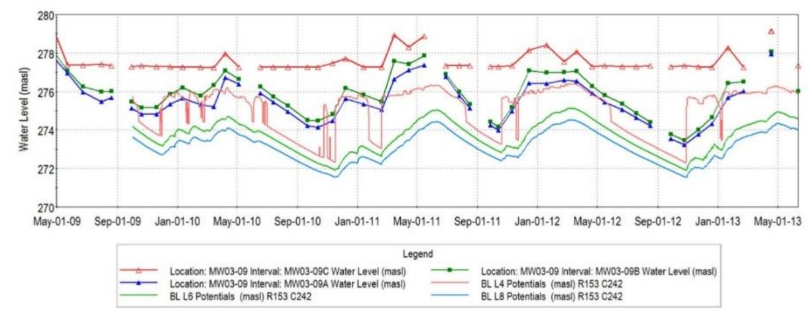
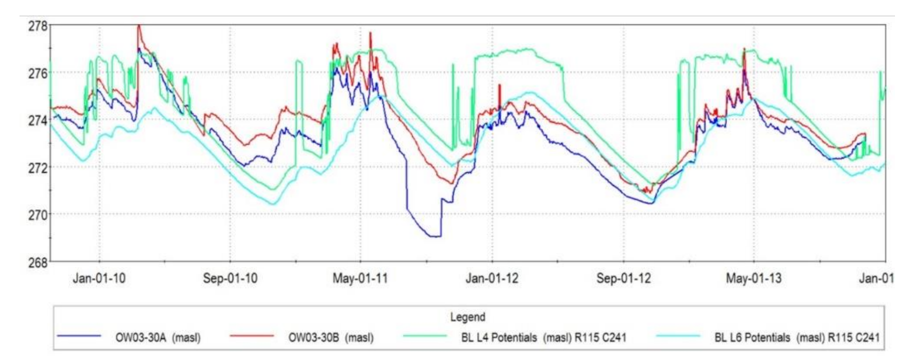
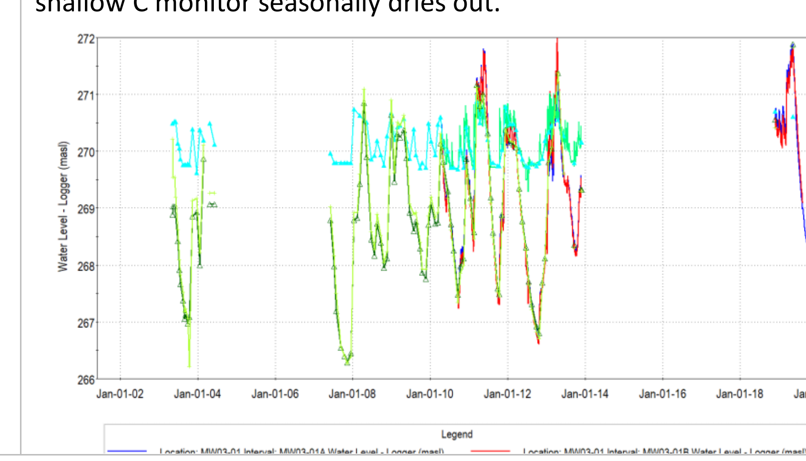
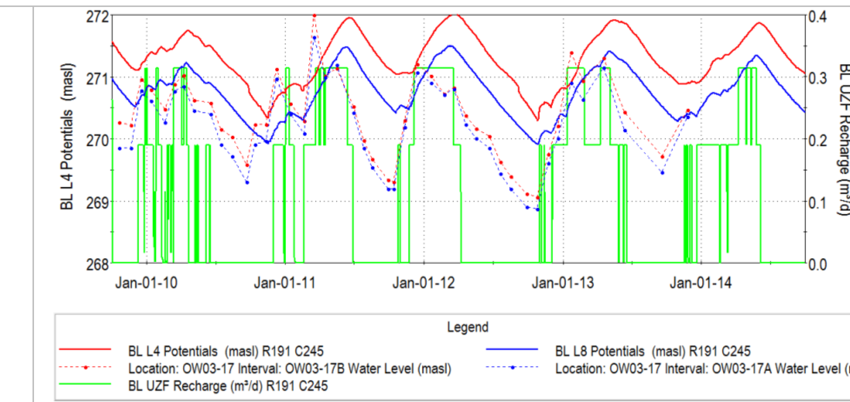
330.	BS-01 through BS-05 reported groundwater level monitoring period is less than 1 year. Please extend the monitoring period to include the most recent data. Please include BS-06 and BS7 groundwater level data, borehole logs and location of these two wells.	The analyses were completed using the available data. Data for the BS series wells starts in January 2019 for some of the wells and in August 2019 for the remainder. Observations were provided until mid- October 2019. Monitoring has continued since that time to assist with the development of the AMP. We did not have water levels for BS-06 or BS-07. Well locations are shown below. 	Not addressed. Recent monitoring data still outstanding.	No data were provided past the study cutoff time of October 2019.
335	Please clarify for which wetlands field surveyed bathymetry data was used	Bathymetry data were available for the golf course ponds and wetlands to the south and east of P12. 	Addressed.	RESOLVED
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.	In general, the pump test and responses to recharge all indicated that storage is very low in the bedrock system. The assumption was that if the bulk layers were dewatered, they would exhibit a higher storage than the fracture zones, so a higher value was assigned.	Not addressed. The question was about the specific yield rather than storage. It seems questionable to assign a lower specific yield value (drainable porosity) to weathered Amabel, and middle and lower fracture zones, which can be drained close to the extraction zone.	The original response is correct. A low value was assigned to layers specifically representing fracture zones. Higher values were assigned to the bulk rock zones assuming they had drainable primary porosity.
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.	OW03-14C and OW14B are nonresponsive and are either plugged or dry. The simulated water levels for all well are shown on the figure below for the overlapping observation/simulation period. 	Addressed.	RESOLVED

HALTON CONSERVATION COMMENTS

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.	It is difficult to match water levels exactly, given that we are trying to simulate heads close to a quarry face with a large-scale model where the local quarry geometry 10 years ago is not the same as now (further, some main quarry rehab has already taken place along the south wall). The figure shows simulated water levels in Layer 8 and observations in MW03-09A in blue. 	Addressed.	RESOLVED
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.	Hydrographs for OW03-30 A and B are provided. There is no shallow well OW03-30C. Groundwater level data and the hydrograph have been provided in Schedule E. Simulated water levels at OW03-21 for Layer 1 and 2 were very similar to those for Layer 4. There are a number of possible reasons for this anomaly, including well construction, survey error, local shallow topographic/drainage effects and others.	Upward gradients are reported in numerous monitoring wells east of the southern extension (OW03-31, OW03-20, OW03-28). Does the model replicate these conditions?	Similarly, downward gradients are observed at OW03-29 and MW03-09. Overall, the vertical gradients are typically small (10's of cm) compared to the seasonal fluctuations of several metres that are observed. The small vertical gradients reflect local surface topographic variation, while the larger seasonal fluctuations are consistent with our overall conclusions describing the near, intermediate and far scale water level response to leakage from above. The minor gradients are not significant relative to the seasonal fluctuations
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.	See response 346 	Not addressed. The response to comment 346 suggests that the model cannot be used for local impact and predictive analysis. In addition, in response to comment 123 the argument is quite opposite to response to comment 346. The response to 123 states: "Layer 7 heads (second figure) show little change in the vicinity of the fracture zones and the only break in slope occurring near the karst stream segment. There is likely little impact in the vicinity of the streams". Please explain the inconsistency.	[Comment 346: As noted above, this monitor is adjacent to the stream carrying the south quarry discharge. The monitor is also immediately beside a randomly placed vertical fracture; that is also under a wetland cell fed by the south quarry discharge. In summary, this cell probably receives too much leakage from above, explaining the high simulated water level. This is expected given the placement of the random vertical features and does not raise any alarms about the model] There is a subtle difference between being able to predict local affects and the ability to predict the effects at a particular observation point. Observed response is affected by the presence and absence of fractures, where the presence and absence and properties of these features are unknowable. The model uses randomly placed fractures to mimic the aggregate response of the local system in the vicinity of the quarry. Thus, the placement of a fracture may degrade the ability to match the response at an observation point where no fracture exists, but without the placement of the random fractures, the model would not be able to match the general pattern of drawdowns (as seen by examining the response of multiple wells).
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.	MW03-01C data does not appear on Figure 19.28.	Not addressed. Considering MW03-01C is a shallow well (about 2.0 metre deep), simulated water levels from an appropriate layer should be presented on Figure 19.29, which is on the same page as Figure 19.28. Please include MW03-01B observed and simulated data.	MW03-01 is directly influenced by the intermittent south quarry discharge, which has not been closely monitored, so simulations and conclusions are difficult. MW03-01A and B have nearly identical response, while the shallow C monitor seasonally dries out. 

HALTON CONSERVATION COMMENTS

349.	Please explain a 2-3-month lag between the observed and simulated water levels at monitor OW03-17.	See Comment 173. As we noted, there is a bit of a lag in the fall recovery. This is likely due to the need to bring soils up to field capacity before groundwater discharge or Dunnian flow occurs. In the field, the values of soil storage capacity will likely vary, with some areas contributing flow earlier than others. Randomizing the storage capacity values within each class might help but was not implemented in this model.	Not addressed. Figure 19.30 shows deep and middle bedrock aquifer water levels. The provided response is inadequate to explain the lag.	 The figure, similar to Figure 19. 30 (the focus of the comment) now shows the simulated recharge. The shallow and deep bedrock both respond to the presence/absence of recharge. That is why our original response relates the lag in groundwater levels to the lag in recharge. As can be seen, our match to the timing of recharge events is good but not perfect. The events should start a bit earlier and be should be peakier (higher maximum but shorter duration) to match the peakiness of the response. Aquifer storage may also be too high, but we are already at the lower end of reasonable values. The local variation in vertical fracturing within the Halton Till is a more likely suspect for the peaky response.
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.	See Comment 173. As we noted, there is a bit of a lag in the fall recovery. This is likely due to the need to bring soils up to field capacity before groundwater discharge or Dunnian flow occurs. In the field, the values of soil storage capacity will likely vary, with some areas contributing flow earlier than others. Randomizing the storage capacity values within each class might help but was not implemented in this model. Minipiezometer data have been provided.	Not addressed. Simulated vs. observed lag commented in Comment No. 179. There are three locations where the minipiezometer data is presented: Wetland Characterization Summaries tables, MNRF Response Table 2, and MNRF Response Appendix B: Borehole Logs. The data reported in all three locations are different. Either ground surface elevations or depths are different for most of the installations, which makes the report difficult to understand and undermines the confidence of the model results.	See above.

CHRIS NEVILLE COMMENTS

Proposed Burlington Quarry Expansion
Interim JART COMMENT SUMMARY TABLE – Hydrogeology

Please accept the following as interim 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. **These interim comments will be finalized following the breakout meetings between JART and Nelson and any changes will be marked using "track changes". 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)	Applicant Response	Interim JART Response (February 2022)	Applicant Response (June 2022)
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	The **reviewer** states in his comment overview: ***Our 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.*** **If the model can replicate the transient response in shallow and deep monitors both near and far from the existing quarry, it is, by logical extension, capable of predicting the effects of an extension to the quarry.** In Chapter 7 of this report we present a detailed modeling analysis of the baseline conditions regarding groundwater levels and streamflow and wetland conditions with comparisons to observations. In Chapter 8, we present a highly detailed analysis of likely changes to these conditions for a range of stages in the quarry extension and under a range of climate conditions (as represented using historic climate data). We know of no other quarry impact assessment with this level of detail and comprehensive analysis of groundwater, streamflow, and wetland response These two chapters are a critical part of Level 1 and 2 Hydrogeologic and Hydrologic Impact Assessment. We strongly feel the reviewer has shirked his responsibility by not reviewing the predictions of the potential effects of the proposed extension. The statement that "It has not been demonstrated that the modelling that has been conducted provides an adequate basis for making such predictions" is a disingenuous comment as it is impossible to determine that the model does not provide an adequate basis for predicting impacts without considering how the model was applied to compare the scenario predications and the type of results produced The reviewer later acknowledges that there is an entire section (Section 19 – Appendix E) discussing the calibration of the GSFLOW model, with 46 pages including sections on calibration strategy, region calibration to streamflow and regional groundwater levels, local-scale calibration to 8 streamflow gauges, calibration to quarry discharge, calibration to groundwater levels at the quarry face and the need to adjust hydraulic conductivities to match the observations along with discussions, tables, maps, and hydrographs of model results. This follows Section 17 and 18 of the report which provide another 93 pages of text, maps, and hydrographs describing the development and preliminary calibration of the hydrologic and groundwater submodels. The model was developed specifically to cover the large study area extending to below the Niagara Escarpment while still providing the high level of detail needed to assess the likely effect of the proposed quarry extension on groundwater levels, streamflow, and the water balance in nearby wetlands. The calibration was done over a two-year period with multiple revisions, innovations, and improvements to derive a good match to the observations (particularly in the shallow subsurface), and reasonably constrained parameter values. The model was calibrated by comparison to regional groundwater flow patterns and streamflow as well as local behaviour of water levels at the quarry face and during aquifer testing. The model response was checked over a wide range of climate conditions that occurred over a 10-year period which included wet and dry years. Post-analysis checks, such as that provided in Response 41, further verify that the calibrated model captured key features of the hydrologic and hydrogeologic conditions in the study area. This was all accomplished using a highly advanced integrated model, despite long run times and instabilities related to the Niagara Escarpment, in a fractured rock/till environment, and with highly complex GW/SW interaction between headwater streams and shallow wetlands. We do not believe that there has ever been such a complex integrated transient analysis ever done in Ontario to analyze a proposed quarry extension. We believe that we accomplished the goal of producing a model that can successfully predict the likely changes in streamflow, groundwater levels, and wetland stage under the quarry extension scenarios considered. Results from this model provided useful input to other team members evaluating the impact to hydrologic and natural heritage features.	The response does not address our central concern. The model appears to be capable of simulating variations in water levels due to fluctuation climatic conditions. However, no results are presented to confirm that the model is there is capable of matching changes in water levels caused by an advancing quarry face. No results are presented that confirm the predictive capabilities of the model for the proposed quarry extensions.	A great deal of effort was expended in analyzing the historic behaviour of groundwater levels in the vicinity of the quarry as the quarry face advanced, as discussed in the report. After a general calibration to regional water levels, the model calibration was re-analyzed specifically to match the unique patterns of response observed: specifically, drawdowns that extended out to about 800-1000 m from the face, a perched upper bedrock with a well-drained lower bedrock, and a highly responsive zone that seasonally dewatered. Matching this response also took a great deal of effort, and we believe it provides great confidence in the model's ability to predict response due to quarry expansion. Matching an advancing quarry face is not significantly different than matching an existing quarry face at different distances from that face. We are unaware of any quarry application model that simulated a dynamically advancing face in a fully integrated transient model. To date, the majority of approved applications have used steady state groundwater-only simulations with no dynamically advancing quarry face. This was discussed at length in our Nov. 2021 JART meetings.

CHRIS NEVILLE COMMENTS

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.	Comment noted.	No further comments.	RESOLVED
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 o parameter values, and whether the parameter values inferred through calibration are consistent with the available data.	No basis for this comment is presented by the reviewer. See the opening statement in Response 61. **General comments:** **"Everything should be made as simple as possible, but no simpler."** Attributed to Albert Einstein **"It seems that perfection is reached not when there is nothing more to add, but when nothing more can be removed."** Terre des Hommes [Land of People] by Antoine de Saint Exupéry, 1939 **Simplicity is the final achievement. After one has played a vast quantity of notes and more notes, it is simplicity that emerges as the crowning reward of art.** (Frédéric Chopin, a musician and composer, quoted in If Not God, Then What? by Fost, 2007) **Specific comments about simplicity and complexity in groundwater models:** ***Guideline 1: Apply the principle of parsimony*** *Using the principle of parsimony, the model is kept as simple as possible while still accounting for the system processes and characteristics evident in the observations and while respecting other information about the system.* From: Hill, M.C., 1998, Methods and Guidelines for Effective Model Calibration: USGS Open File Report 98-4005, Reston, VA. *An important contribution of Freyberg (1988) was* ***identifying and highlighting that a model that fits the observations best may not forecast best****. This* ***concern is of primary importance when calibrating highly parameterized models (especially those using pilot points).*** *The highly parameterized approach often achieves an excellent fit but can also "overfit," where the parameter estimation chases noise in the observations and yields unrealistic parameter values and distributions (e.g., parameter "bullseyes," or hotspots).* From: Revisiting "An Exercise in Groundwater Model Calibration and Prediction" After 30 Years: Insights and New Directions" Randall J. Hunt, Michael N. Fienen, and Jeremy T. White The reviewer has touched an important part of our approach to modelling. Earthfx has completed more than 25 Source Water Protection, land development, watershed management, and quarry/mining studies using an integrated modelling approach. The experience has shown us that it is extremely important to account for the physical processes that control runoff and groundwater recharge. That is not to say that spatial variability in material properties is not important, but, in many cases, these variations are unknown except at a few points and the extrapolation of these data to the rest of the model comes with a high level of uncertainty. Our experience has been that the use of simpler models with average material properties can provide all the information needed to assess the likely magnitude of changes to the system due to imposed stresses even though it may not be possible to accurately predict the exact response at a particular point in space. We have spent a great deal of effort to determine regional values for material properties that best match regional groundwater flow patterns and streamflow as well as local behaviour of water levels at the quarry face. The model response was checked over a wide range of climate conditions that occurred over a 10- year period which included wet and dry years. The ability to match observations over this extended period means that the values selected are consistent with the available data.	While we appreciate the quotes on simplicity and the principle of parsimony, the response does not address our general concern. We recognize that "process complexity" must be addressed, at least with respect to simulating the effects of climate variations on shallow water levels. Our motivation has not been to encourage "parameterization complexity". Rather, it has been to seek understanding. To be clear, we repeat our fundamental concern. It is not clear what parameters have the greatest influence on 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. The response does not address the questions in our review comments. • Which parameters make a real difference in the calibration? • Are there data to constrain the most important parameters? • How were the ranges established over which the parameter values would be adjusted to match the calibration targets?	We found the model response, specifically in the quarry vicinity, sensitive to the property values (hydraulic conductivity, anisotropy, and specific yield/specific storage) assigned to the fracture zones, the properties assigned to the intervening bulk bedrock units, the vertical fracture properties, and their density (in the order listed). It was relatively straight-forward to do the regional calibration to MECP observations.The values selected are constrained within tight ranges of the selected values, and are consistent with the available data. By using measured precipitation and calibrating to observed total streamflow and water levels, with a fully transient approach across a range of climate stress conditions (seasonal and inter-annual variability, including a Level 2 drought) the model has been tested across a wide range of conditions. In addition, the complex transient surface water and groundwater storage effects have been fully evaluated. This demonstrates that there is no single parameter that controls the system behavior. Hydraulic conductivity is important, but so is recharge variation. Topography and layer geometry are also important. Overall, our findings are that full transient process representation is key.

CHRIS NEVILLE COMMENTS

<table>
<tr>
<td>64.</td>
<td>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 GSFLOW model was capable of yielding acceptable matches to observed declines in groundwater levels arising from ongoing quarry operations.</td>
<td>The first statement confirms that the model is capable of matching the fluctuations in the data.

The reviewer has, however, failed to understand that the complex seasonal fluctuations in water levels are amplified in areas of quarry influence, and that our successful simulation of the full range of observed fluctuations is proof that the model is able to predict the influence of the quarry.

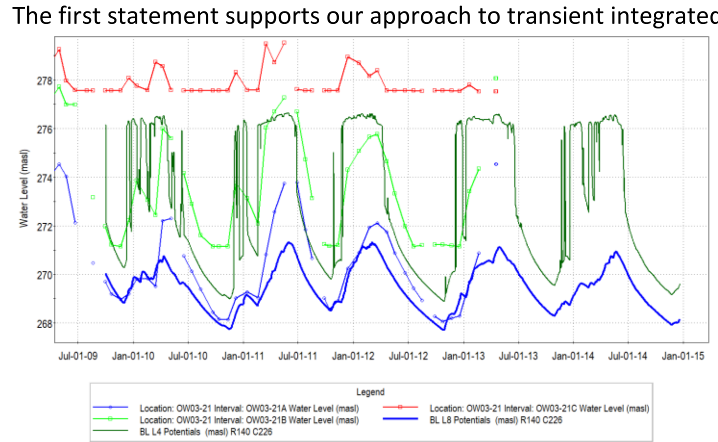
The following is a brief description of how seasonal processes interact with the quarry drainage in the range of 100 m to 800 m from the face (See Section 19.5.4):

During wet seasons, the rate of vertical replenishment (recharge to the shallow bedrock) exceeds the rate of lateral seepage (under drainage) into the quarry. The fractures rapidly fill, and water levels rise significantly (nearly 7 m as observed in Figure 19.24, below) In late spring, recharge to the bedrock dramatically falls, and aquifer levels rapidly drop via leakage (drainage) into the quarry.

As one moves beyond 800 m from the face, the effect of drainage into the quarry is negligible, water levels in the shallow and deep system broadly equilibrate, and seasonal fluctuations of 1-2 m are observed in all monitors.

In summary, large seasonal fluctuations in monitoring levels are a key indicator of quarry influence. The reviewer, in stating "the calibrated model is capable of matching variations in water levels arising from seasonal climate fluctuations" has thus confirmed that the model is effectively simulating the interaction of natural processes and quarry influence.

It is clear that the failure of the reviewer to understand these complex integrated model processes has resulted in his inability to complete the review as stated in Comment 61. Further, it is also apparent that the reviewer does not appreciate that representing the complex interaction of integrated model processes ("Process complexity" mentioned in Comment 63) is more important than an approach "where the parameter estimation chases noise in the observations" ("Parameterization complexity") (Hunt et al., as above). There is likely no amount of model K field parameterization and parameter estimation that will recreate the interaction of climate, soil zone processes, Halton till leakage and quarry drainage processes. Processes matter.

The first statement supports our approach to transient integrated modelling.


There is no basis for the second statement. The report (see Section 19.5) describes the efforts made to matching the water levels at the quarry face and incorporate information obtained from a set of historic observations of drawdowns as mining within the existing footprint approached the observation wells.

Significant revisions were made to the model after a good regional calibration was achieved, to better match the unique conditions that occur in the vicinity of the quarry face. Additional comments made by the reviewer question the methods used, but a good local calibration could not be achieved without the approach taken. This is discussed further on.</td>
<td><u>Part 1</u>

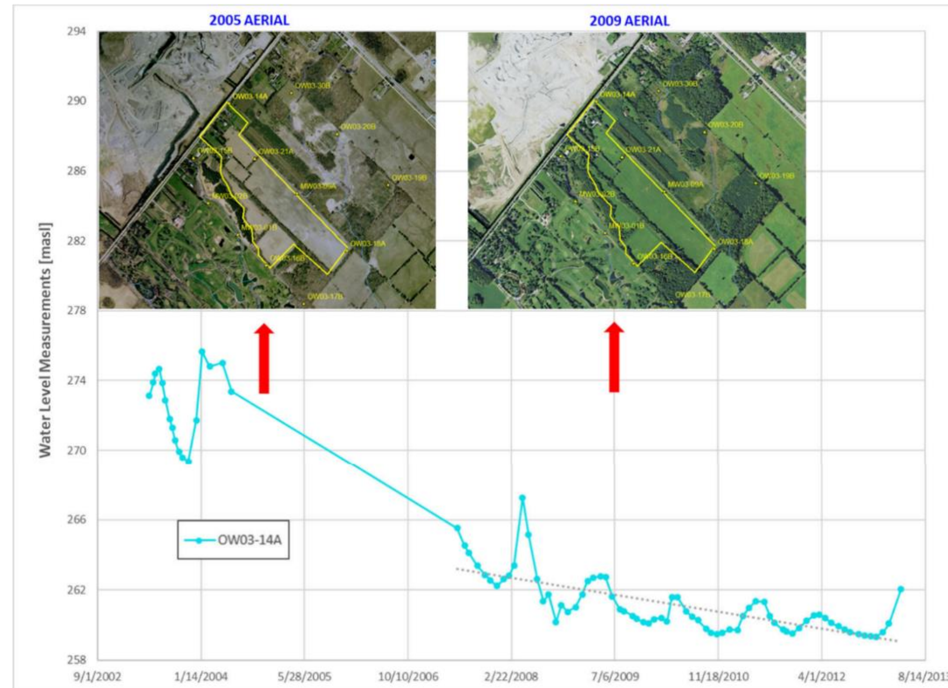
The response is correct to note that the reviewer has failed to understand how the simulation of the full range of observed fluctuations is proof that the model is able to predict the influence of the quarry. It is not clear how the ability to match seasonal fluctuations caused by climate fluctuations constitutes "proof' that the model is capable of simulation conditions for which it was not calibrated, in particular, for expansion of the quarry.

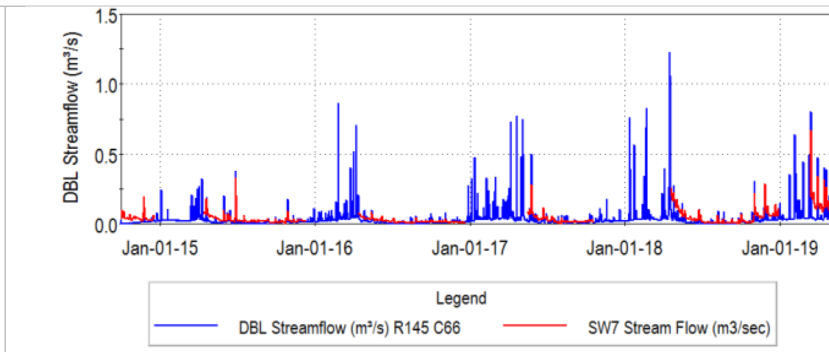
<u>Part 2</u>

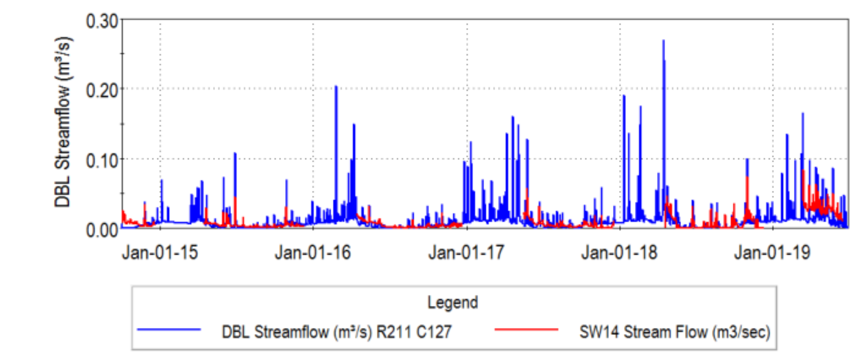
The response refers to seasonal processes interacting with the quarry drainage in the range of 100 m to 800 m from the face. Has a comparison been made between conditions observed in the shallow and deep groundwater systems between 2004 and 2021 to assess whether the effects of drainage into the quarry are negligible beyond a distance of 800 m from the quarry face?</td>
<td>As noted above, the model calibration was re-analyzed specifically to match the unique patterns of response observed at the quarry face: specifically, drawdowns that extended out to about 800-1000 m from the face, a perched upper bedrock with a well-drained lower bedrock, and a highly responsive zone that seasonally dewatered. The ability to match this behaviour is the same needed to predict the groundwater response to the expansion of the quarry. That said, the model does much more in terms of closely matching observed streamflow, the seasonal behaviour of groundwater levels, the general timing of runoff and recharge events, etc.

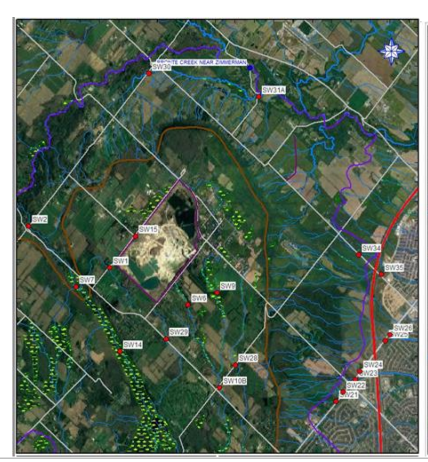
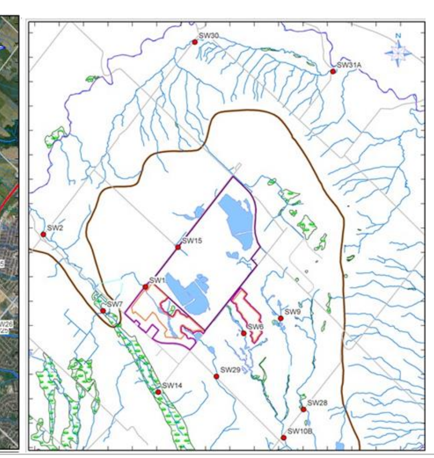
Yes, there was a significant discussion in the report regarding our analysis of historic quarry response.

It should be noted that this and the previous questions related to the analysis of historical quarry response and baseline model results in the quarry vicinity were the subject of a detailed technical meeting with Dr. Neville and the Conservation Halton reviewer in Nov. 2021.</td>
</tr>
<tr>
<td>65</td>
<td>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</td>
<td>See above. It appears the reviewer did not read the section of the report describing local calibration. Section 5.3.3.2, 6.11, and 19.5 of the report specifically address the effects of the quarry that have been observed in the South Quarry Extension area monitoring network for many years. Although limited due to gaps in the monitoring data, this particular set of observation data, related to the movement of the quarry face and changes in water levels, was analyzed early on in the study to determine the effect of quarry development on water levels and to ensure that model properties were consistent with these observations.</td>
<td>The hydrograph presented in the response to Comment 65 provides an excellent illustration of both the long-term and short-term changes in groundwater levels observed at OW03-14A. Please indicate the corresponding figure that shows the results from the groundwater model over the</td>
<td>We did not simulate the movement of the quarry face. Our simulation of baseline conditions starts after the quarry had fully expanded to its limits. However, the model calibration was refined to match the unique patterns of response observed: specifically, drawdowns that extended out to about 800-</td>
</tr>
</table>

	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).		same time interval. Please also indicate where similar figures are presented for OW03-15A and the onsite quarry wells 5, Goodchild and Starrett	1000 m from the face, a perched upper bedrock with a well-drained lower bedrock, and a highly responsive zone that seasonally dewatered.
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).	Much time and effort was spent early in the study digitize the Golder test data, verify the transmissivity estimates Golder obtained from the tests, and then set up transient model runs (MODFLOW only) to replicate test results. This was done with early versions of the model to aid in the pre-calibration, but is not discussed in great detail within the report. Model values for hydraulic properties did vary during the course of the GSFLOW calibration. Generally, K values for the lower Amabel increased from the early values assumed and are much closer to the Golder pump test derived K's.	The response indicates that a substantial effort was made to "replicate" the results of the pumping tests conducted previously at the site. It is precisely the documentation of the results of these efforts that is required to assess the model.	The pump test results provided initial estimates and practical constraints for the bedrock properties. The analyses were done with a temporary transient version of the MODFLOW-NWT model and the current GSFLOW model superseded this version.
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	All streamflow monitoring locations within the model boundaries were considered in the modelling analyses to see if the model produced reasonable matches to observed flows. Figure 19.4 shows the location of stations discussed in the report. As you note, not every flow monitoring station is discussed, but the locations discussed provide a good sampling of close and far stations, of stations affected/not affected by quarry discharge, and cover the reaches of streams likely to be affected by quarry expansion. It should be noted that data for all stream reaches were produced and saved for all simulations. We have post-processed these data to produce detailed water budgets for a set water courses to address a request by MNRF in their review. These have been provided in Schedules B and C.	The response to Comment 342 refers to simulation results for SW14 and SW7 are shown in Figures 8.72 and 8.73. These figures are reproduced below. Are any observations available for these stations, which would allow us to assess the match of the model to the observations?	We presented all available data as hydrographs in our meeting with JART team members. The two hydrographs below were part of the presentation.

<table>
<tr><td></td><td>documentation should include explanations regarding why some stations are included and others are not</td><td></td><td></td><td>



SW7 and SW14 are in the Medad Valley and separate sections were devoted to illustrating change from baseline conditions. SW2 is affected by numerous in-line ponds along Cedar Spring Road downstream of the karst feature on Willoughby Tributary.</td></tr>
<tr><td>68</td><td>Existing Streamflow Monitoring Locations – Referring to Tatham Engineering (2020; Table 2), there are 20 existing streamflow monitoring locations.
<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></td><td>The first figure shows the location of the 20 Tatham stations, while the second is from Figure 19.4 showing stations used for comparisons. The stations not shown in the second figure are all below the Escarpment and outside the model boundary. Simulated flows near the model boundary were compared against the closest gauge for consistency during model development.

</td><td>The response to Comment 342 refers to simulation results for SW14 and SW7 are shown in Figures 8.72 and 8.73. These figures are reproduced below. Are any observations available for these stations, which would allow us to assess the match of the model to the observations?</td><td>See above</td></tr>
<tr><td>69</td><td>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</td><td>The model was calibrated over a 10-year period, WY2010-WY2019. Unfortunately, the "excellent" data from 2003 for model calibration that the reviewer refers to mostly falls within WY2008 to WY2013 as shown by the data for OW03-29. The 2003 data are mostly manual monthly measurements with a large gap between May 2004 and August 2007. There is another large gap from WY2014 to August 2018. Most wells show similar data distributions but there is variation. OW03-15 and OW03-30, for example, are part of a group of wells that did not have logger data until 2010. The period selected had the best logger data coverage.</td><td>We acknowledge the correction in the duration of the model calibration. As indicated in the presentation materials accompanying a meeting held on November 11, 2021, the quarry face did not advance substantially over the period of the model calibration. Referring to Comment #61, we still contend that by limiting the calibration to this period, data are excluded that could have been matched to demonstrate</td><td>For the purposes of the cumulative impact analysis, the modelling focused on the relatively stable period from 2009 onward. While it might have been interesting to create a model that simulated the development of the quarry between 2003 and 2009, the effort to obtain monthly air photos (if available), map the incremental changes, modify the model surfaces on a monthly basis, incorporate all other changes such as construction/movement of ponds and</td></tr>
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- 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

<table>
<tr><th>Well recommended for long-term monitoring</th><th>Well included in reportin[g] GSFLOW calibration resu[lts]</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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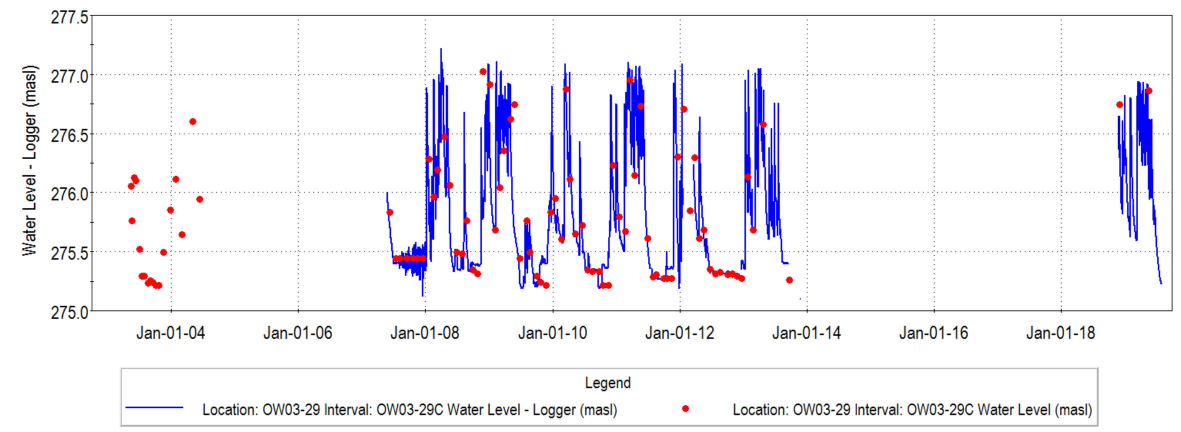

We tried to present a comprehensive but not exhaustive comparison of results. As with the streamflow stations, the locations selected provided a good sampling of close and far stations and covers the area where groundwater is likely to be affected by the quarry expansion.

</td>
<td>the capability of the calibrated model to match observations of the effects of an advancing quarry face.</td>
<td>

sumps, would have been enormous. We know of no other modelling study that has incorporated a moving quarry face.

As noted, instead we analyzed the observed historic response and used the insights gained to inform the model calibration to better represent local response in the quarry vicinity.

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<td>

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

</td>
<td>As above, we tried to present a comprehensive but not exhaustive comparison of results. As with the streamflow stations, the locations selected provided a good sampling of close and far stations and covers the area where groundwater is likely to be affected by the quarry expansion.</td>
<td>We still maintain that a complete set of results be provided.</td>
<td>Hydrographs for all wells and stream stations were presented in a meeting with the JART team.</td>
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</table>

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

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, Figur
10	OW03-15 C	Figure 6.24, Figur
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, Figur
17	OW03-21 A	Figure 6.25, Figur
18	OW03-21 B	Figure 6.25, Figur
19	OW03-21 C	Figure 6.25, Figur
20	OW03-29 A	Figure 6.27, Figur
21	OW03-29 B	Figure 6.27, Figur
22	OW03-30 A	Figure 19.26
23	OW03-30 B	Figure 19.26
24	OW03-31 A	Figure 6.26, Figur
25	OW03-31 B	Figure 6.26, Figur
26	MP6	Figure 6.30, Figur
27	MP16	Figure 6.29, Figur
28	SG-2 (SG2)	Figure 6.31; Figur
29	MP5	Figure 6.31, Figur
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

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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.
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

Comment noted. This does not change the conclusions of the report. Key missing references are provided below.
Barnett, P.J., 1992, Quaternary geology of Ontario; in Geology of Ontario, Ontario Geological Survey, Special Volume 4, p.1011-1088.
Brunton, F.R., Belanger, D., DiBiase, S., and Yungwirth, G., 2007, Caprock Carbonate Stratigraphy and
Bedrock Aquifer Character of the Niagara Escarpment – City of Guelph Region, Southern Ontario, paper presented at the 60th Canadian Geotechnical Conference/8th Joint CGS/IAH- CNC Groundwater Conf., Oct. 2007, Ottawa, Ontario.
Brunton, F. R., 2008, Preliminary revisions to the Early Silurian stratigraphy of Niagara Escarpment - Integration of sequence stratigraphy, sedimentology and hydrogeology to delineate hydrogeologic units: in Summary of Field Work and Other Activities, 2008, Ontario Geological
Survey, Open File Report 6226, p.31-1 to 31-18.
Brunton, F. R., 2009, Update of revisions to the Early Silurian stratigraphy of the Niagara Escarpment - Integration of Sequence Stratigraphy, Sedimentology and Hydrogeology to delineate Hydrogeologic Units: in Summary of Field Work and Other Activities 2009, Ontario Geological Survey, Open File Report 6240, p.25-1 to 25-20.
Chapman, L.J. and Putnam, D.F., 1984, The physiography of southern Ontario: Ontario Geologic
Survey, Special Volume 2, 270p.
SNC-Lavalin Engineers and Constructors Inc. and Charlesworth and Associates, 2006, Hamilton groundwater resources characterization and wellhead protection partnership study: report to the City of Hamilton, February, 2006
Chiew, F.H.S. and McMahon,T.A., 1993 Assessing the Adequacy of Catchment Streamflow Yield
Estimates, Australian Journal of Soil Research, v.31, p.665-680.
Dillon (2008) Dillon Consulting, 2008, Hydrogeological Study of the New Freelton Well: March 2008. Earthfx, 2010, Tier 1 water budget and water quantity stress assessment of the Black-Severn River
watershed: 124 pp. Earthfx (2020) – This *report*
Ely, D.M., and Kahle, S.C., 2012, Simulation of groundwater and surface-water resources and evaluation of water-management alternatives for the Chamokane Creek basin, Stevens County, Washington: U.S. Geological Survey Scientific Investigations Report 2012–5224, 74 p.
Gartner Lee (2005) Gartner Lee Limited, 2005, Proposed Dolostone Quarry, Hamilton Volume 1:
Hydrogeological Level 2 Report: June 2005.
Hargreaves, G.H. and Samani, Z.A. (1982) Estimating potential evapotranspiration: Journal of Irrigation and Drainage Engineering, v.108, 223-230.
Hunt, R.J., Walker, J.F., Selbig, W.R., Westenbroek, S.M., and Regan, R.S., 2013, Simulation of climate-change effects on streamflow, lake water budgets, and stream temperature using GSFLOW and SNTEMP, Trout Lake Watershed, Wisconsin: U.S. Geological Survey Scientific Investigations Report 2013–5159, 118 p., http://pubs.usgs.gov/sir/2013/5159/.
Huntington, J.L. and Niswonger R.G., 2012,
Role of surface-water and groundwater interactions on projected summertime streamflow in snow dominated regions - An integrated modeling approach: Water Resources Research, v.48, .11
Johnson M.D., Armstrong, D.K., Sanford, B.V., Telford P.G., and Rutka, M.A., 1992, Paleozoic and
Mesozoic Geology of Ontario: in Geology of Ontario, Ontario Geological Survey, Special Volume
4, Part 2, p.907-1010.Page 57: Brett et al., 1995
Karrow, P.F., 1987, Quaternary geology of the Hamilton-Cambridge area, southern Ontario: Ontario
Geological Survey Geoscience Report 255, 94p (accompanies Map 2508).
Karrow, P.F., 2005, Quaternary geology of the Brampton area, southern Ontario: Ontario Geological
Survey Geoscience Report 257, 59p.
Kassenaar, J.D.C. and E.J. Wexler, 2006, Groundwater modelling of the Oak Ridges Moraine area: YPDT-CAMC Technical Report #01-06: Available at http://www.ypdt-camc.ca. Page 121:
Liberty, B.A., Bond, I.J., and Telford, P.G., 1976, Paleozoic geology of the Hamilton area, southern
Ontario: Ontario Geological Survey. Map 2336, scale 1:50 000.
Niswonger R.G., Allander K.K., and Jeton A.E., 2014, Collaborative modelling and integrated decision support system analysis of a developed terminal lake basin Journal of Hydrology. 517: 521-537. DOI: 10.1016/J.Jhydrol.2014.05.043 Page 71:
Ontario Geological Survey, 2010, Surficial geology of southern Ontario; Ontario Geological Survey, Miscellaneous Release— Data 128 – Revised.
Tanvir Hassan, S.M., M, Niswonger, R.G., and Zhongbo Su, 2014 Role of surface-water and

The response does not include an answer to our question on page 142. Is the reference to Golder Associates (2007) a reference to Golder Associates (2007a) or Golder Associates (2007b) in the list of references?

Golder Associates (2007b)

CHRIS NEVILLE COMMENTS

	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	groundwater interactions on projected summertime streamflow in snow dominated regions - An integrated modeling approach: paper presented at the 41st IAH International Congress, September 2014, Marrakech, Morocco Vos, M.A., 1969, Stone resources of the Niagara Escarpment: Ontario Dept. Mines, IMR31, 68p, accompanied by 6 maps. White, O.L., 1975, Quaternary Geology of the Bolton Area, Southern Ontario; Ontario Division of Mines, Geological Report 117, 119p, with Map 2275 and Map 2276, scale 1:63.360. Wood Environment & Infrastructure Solutions, 2018, Freelton Well FDF01 Increased Water Taking Assessment – Phase 3 Community of Freelton, Ontario: September 2018 Worthington Groundwater, 2020, Appendix B – Karst Investigation: in Level 1 and Level 2 Hydrogeological Assessment Proposed Burlington Quarry Extension – Appendix A and B, report prepared by Earthfx Inc. for the Nelson Aggregates Co., November 2019, 41 p.		
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.	Comment noted.	No further comments.	RESOLVED
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?	The thickness of the Cabot Head was calculated using the top of Queenston, thickness of the Manitoulin and Queenston, and then checking the surface against the top of bedrock, which captures the incision of the Medad Valley.	The response does not address our question. We did not ask how the thickness of the Cabot Head Formation was estimated. Rather, we asked what control points were used to map its thickness shown in Figure 3.14.	There was a typo, the response should have stated "…the thickness of the Manitoulin and Whirlpool. The top of the Cabot Head was mapped by interpolating the data points indicated. Similarly, the top of the Queenston was mapped by interpolating the data points for the top of the Queenston Fm (including MECP water wells, Oil and Gas wells and outcrops at Kerncliff Park and Smokey Hollow Waterfall). The thickness of the Whirlpool and Manitoulin were mapped by interpolating the data points for thickness of each respective unit. The interpolated thicknesses were added using grid arithmetic to the interpolated top of Queenston to get the top of Manitoulin. The resultant surfaces were checked for consistency then checking against the top of bedrock, which captures the incision of the Medad Valley. Finally, the thickness of the Cabot Head was computed by subtracting the Top of Manitoulin from the Top of Cabot Head. All the log analysis, formation picking, variance analysis, interpolation of surfaces using kriging, application of rules for surface checking, grid arithmetic to derive secondary surfaces, posting of data, and preparation of maps and cross-sections was done within the VIEWLOG environment.

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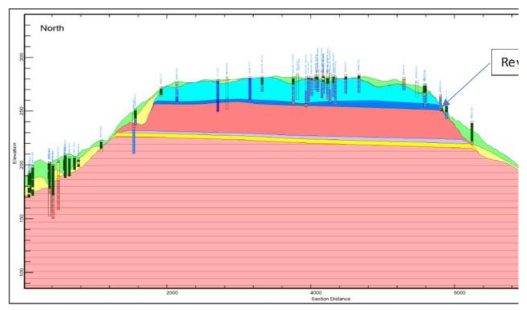
92.	It is indicated in the text that "while Brunton (2008) was able to subdivide the Reynales, these units are hydrogeologically similar (dolostone with shale partings) and are un-subdivided in the Golder and MECP logs; for simplicity, the Rockway and Merritton unit is referred to herein as the Reynales 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). 	The purpose of this statement is unclear. Brunton did not identify the Grimsby formation in any of borehole data that we provided to him for review. Are you implying that Brunton is inconsistent or unreliable by noting that there ***may*** be a thin Grimsby unit at the site? The significance of subdividing a thin unit formerly referred to as the Reynales Formation into 2 or possibly three units is unclear. Golder could not justify subdividing the unit despite mentioning the work by Brett. The 2004 Golder core is no longer available. Finally, the unit cannot be subdivided based on MECP wells.	No, we are not implying that Brunton is either inconsistent or unreliable. Rather, we are indicating for the record that Brunton did not identify the Reynales Formation at this site. No further comments.	RESOLVED
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?	The thickness of the Reynales is created by subtracting interpolated top of Reynales from the interpolated Top of Cabot Head. This is the preferred approach as not all wells penetrate the formation	The response does not address our question. We did not ask how the thickness of the Reynales Formation was estimated. Rather, we asked what control points were used to map its thickness shown in Figure 3.16. As with Comments 97, 101 and 102, our question is directed at assessing the distribution of high-reliability points for gridding the surfaces. By "high-reliability" we mean from "a surveyed borehole logged by a professional geoscientist".	As the response explained, the thickness of the Reynales is created by subtracting (using grid arithmetic) the interpolated top of Reynales (interpolated using the top of Reynales data points) from the interpolated Top of Cabot Head (interpolated using the picks for the top of Cabot Head).
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.	The extensive bedrock packer testing undertaken by both Golder and our field project partner Azimuth Environmental at this site did not identify distinct hydrogeologic formation properties for these units. Other Source Water Protection conducted in the area for Hamilton and Halton also failed to significantly differentiate the units. The lack of aquifer confinement in the study area may also be a factor. The static water level in BS01 was at a depth of 10 m when the packer testing was undertaken, limiting the ability to packer test the upper portion of the borehole.	No further comments.	RESOLVED

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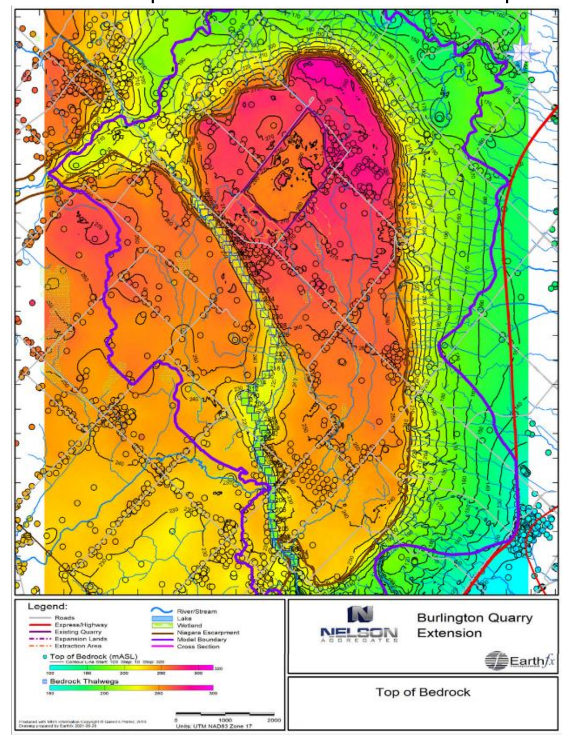
96.	What control points were specified to support the mapping of the elevations of the top of bedrock? Does the mapping shown in Figure 3.23 lump high-quality data from site monitoring wells and the information from the MECP water well record database?	The bedrock pick locations and the constraint point used to delineate the bottom of the Medad Valley are shown on the figure below.  Picking of geologic units is a labour-intensive process in which a geologist/hydrogeologist posts the boreholes on section and then "picks" the contact elevation at each selected borehole. The contact data is posted to the database. The picking typically begins with the higher quality boreholes and MECP boreholes added where ground elevation and bedrock elevation seem to be consistent with other information (i.e., on other parallel and perpendicular sections). The bedrock picks are then kriged and the surface is examined for outliers and inconsistencies.	Clarification provided and acknowledged. The map does clarify the locations of the control points. However, no distinction is made in the map between high-quality data from site monitoring wells and information from the MECP water well record database. We are left to conclude that the answer of our second question is that the two sources of picks are lumped.	RESOLVED
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]?	The thicknesses of all the units are calculated by subtracting the gridded surfaces (generated by interpolation of the borehole picks) as not all wells penetrate the entire formation.	See response to comment 90. The response does not address our question. We did not ask how the thicknesses of the units were estimated. Rather, we asked what control points were used to map the thicknesses shown in Figure 3.24.	Maybe we do not understand the question as this is the same generic question as above. The responses have spelled out the process.
101	What control points were specified to support the mapping of the thickness of the Halton Till in Figure 3.27?	The thicknesses of all the units are calculated by subtracting the gridded surfaces (generated by interpolation of the borehole picks) as not all wells penetrate the entire formation.	The response does not address our question. We did not ask how the thicknesses of the Halton Till were estimated. Rather, we asked what control points were used to map the thicknesses shown in Figure 3.27.	Same as above
102	What control points were specified to support the mapping of the thickness of the MIS sands and ORAC in Figure 3.28?	The thicknesses of all the units are calculated by subtracting the gridded surfaces (generated by interpolation of the borehole picks) as not all wells penetrate the entire formation.	The response does not address our question. We did not ask how the thicknesses of the HMIS sands and ORAC were estimated. Rather, we asked what control points were used to map the thicknesses shown in Figure 3.28.	Same as above

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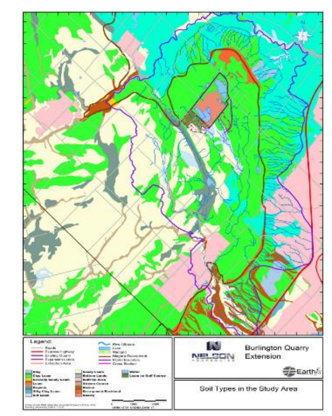
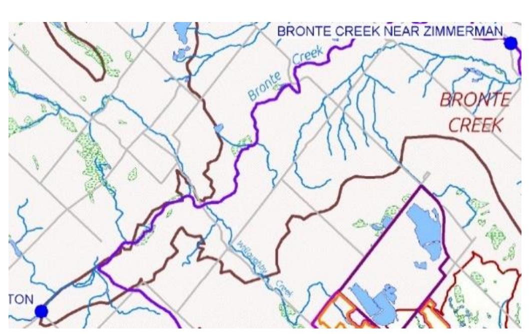
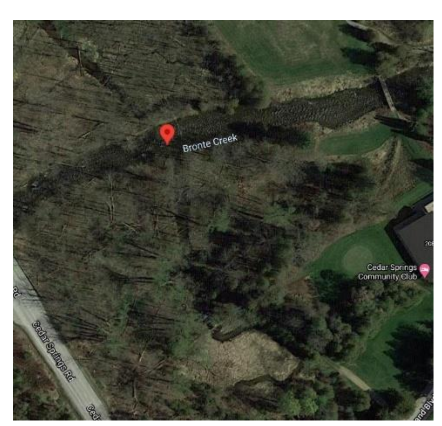
104	No indication is provided in the report that a distinction has been made between data from climate stations above and below the Niagara Escarpment. The retained consultant's experience suggests that this distinction is important, affecting whether a station provides data that is or is not representative 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.	We noted that the interpolated precipitation data showed a decreasing trend from west to east and speculated that this might be related to the presence of the Niagara Escarpment. It could also be related to proximity to Lake Ontario, degree of urbanization, or other factors. We therefore did not split the data into two populations above and below the Escarpment and interpolate the data separately.	No further comments.	RESOLVED
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, 17.12). However, the citation in the list of references is to MNRF (2014), accessed August 2015.	Comment noted. Correct reference is: Ontario Ministry of Natural Resources and Forestry (MNRF), 2019, Southern Ontario Land Resource Information System (SOLRIS) Version 3.0 [Computer File], Peterborough, ON (Accessed August 2019).	No further comments.	RESOLVED
106	Are the lime coloured areas on this figure clay loam? It is not clear from the legend that these colours are the same?	A figure with improved colour scale is provided below. 	Enhanced Figure noted. It appears that the lime coloured areas represent clay loam. The colour figures provide striking visualizations but may be difficult to interpret for individuals who may have difficulty in distinguishing colours of similar shades.	RESOLVED
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.	We did not select the locations for the WSC stations. The gauge data were useful for the PRMS model pre-calibration because of the long-term record available. There were many additional gauges placed on streams above and below the Escarpment but the period of record is shorter and the data have gaps.	No further comments.	RESOLVED
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? 	The map appears accurate and the angle may be closer to 80°. 	No further comments.	RESOLVED

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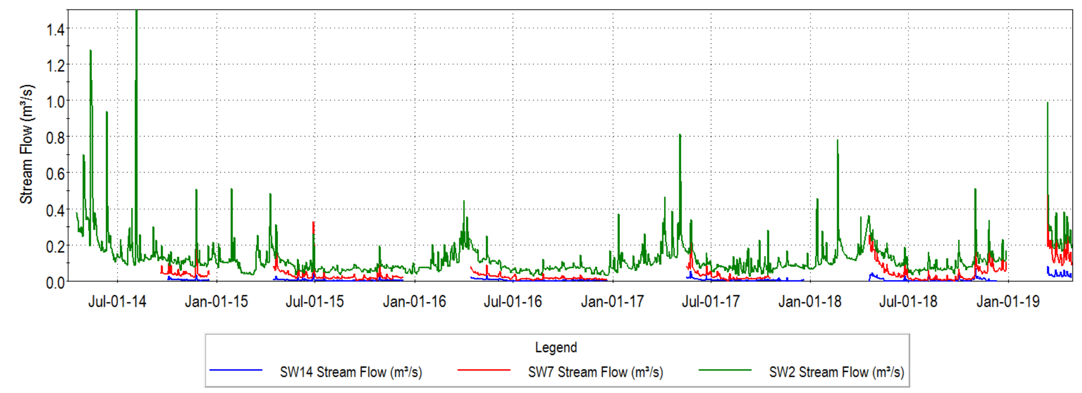
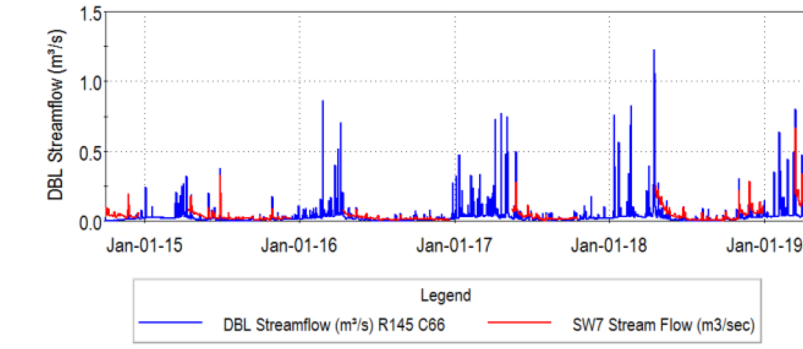
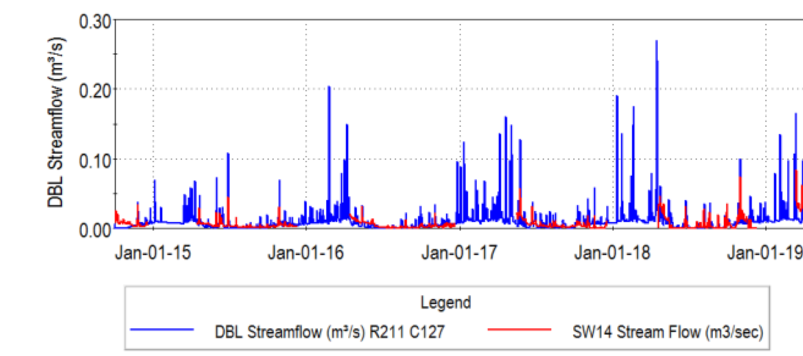
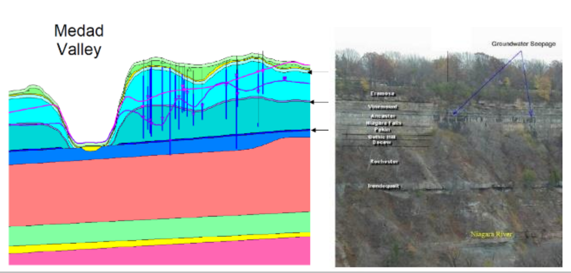
109	Is there a record of flows in Willoughby Creek?	There were three stations established on Willoughby Creek (Figure 4.14). Flow was measured from 2014 to 2019, with gaps in the record for SW7 and SW14 during the winter of each year. These flows were discussed in the chapters of the report the reviewer declined to review. 	Is the plot of the flow records included in the response presented elsewhere in the report? Referring to Comment 67 and 68, as far as we could tell there are no comparisons between observed and simulated flows at stations SW7 and SW14. In what sections of the report that we declined to review are the observed flows discussed?	We presented all available data as hydrographs in our meeting with JART team members. The two hydrographs below were part of the presentation.   SW7 and SW14 are in the Medad Valley and separate sections were devoted to illustrating change from baseline conditions. SW2 is affected by numerous in-line ponds along Cedar Spring Road downstream of the karst feature on Willoughby Tributary.
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?	We obtained the stream coverage early in the study. Most of the files were dated 4/2018 or 6/2018. https://geohub.lio.gov.on.ca/datasets/mnrf::ontario-hydro-network-ohn-watercourse\	No further comments.	RESOLVED
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.	This is a general problem in southern Ontario as the number of active stations continues to drop. Our best option was to interpolate the available data for the study period.	No further comments.	RESOLVED
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 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	We agree that representing groundwater discharge at the quarry face is important. We have used the method suggested by the reviewer in numerous older quarry and Escarpment area studies that we conducted. Draping the layers into the valley allows groundwater discharge to land surface (surface leakage) to occur at or near the multiple seepage faces. This flow is conveyed overland to the nearest quarry drain or stream reach. This alternative approach is needed because of the requirement that the layers remain continuous. Its effect on the flow system is similar and easier to implement than the older one of truncating layers and assigning a drain conductance and control elevation (usually calibrated values) in the last active cell next to the outcrop.	We appreciate the constraints of the model being required to have continuous layers. Does the approach of replacing the explicit representation of a seepage face with MODFLOW Drains with surface leakage and overland flow yield similar results? In the response it is indicated that the water levels shown in Figure 19.18 are in fact controlled by the elevations at which	We believe that the methodology produces similar results and allows better routing of flow from the sides of the excavation to the floor drains and to the sump for discharge. The figure shows a section through the quarry face near OW03-15. As can be seen, the average heads in Layer 8 are controlled by leakage at the base of the quarry (254 masl). The heads in Layer 6 are controlled by the base of the middle fracture zone (once you get a cell or two into the wall) at 264 masl. The heads

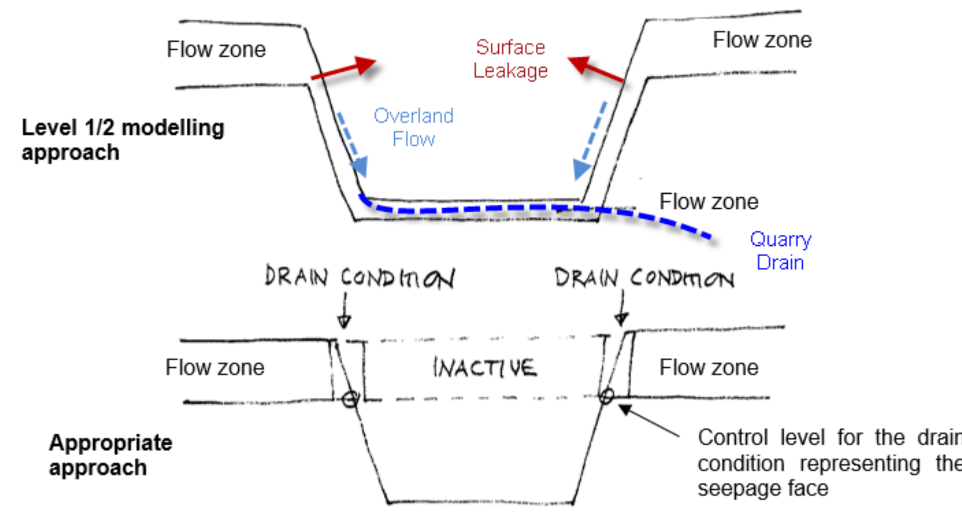
(Figure 5.2), As shown in the figure, the model layers are "pushed down" below the base of the Medad Valley.

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.

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.





the flow zones would daylight at the quarry. It appears we may be missing something. Our expectations are that at the escarpment:

- The groundwater level in the top of rock is likely close to the base of this unit, an elevation of 273 m, rather than diving down to an elevation of about 254 m; and

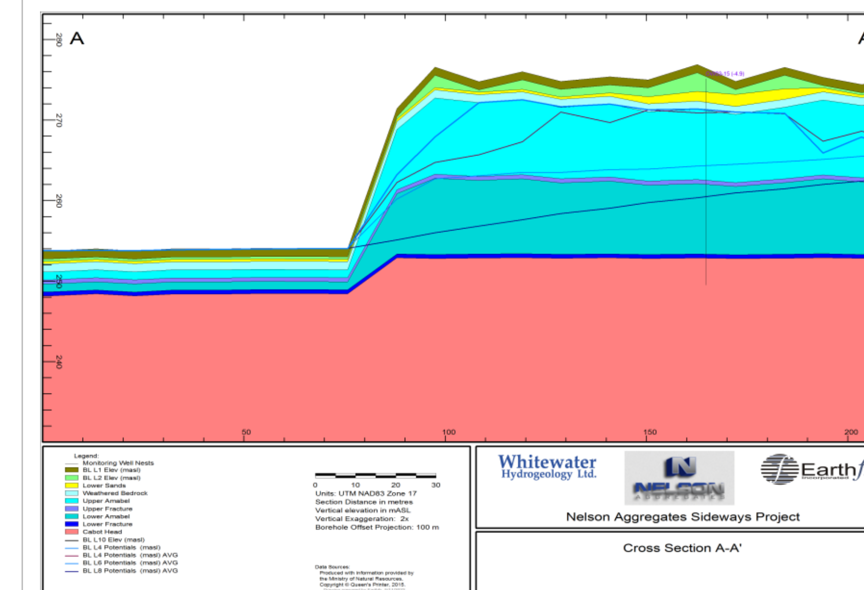
- The groundwater level in the middle flow zone to be about 263 m, not 254 m.

Referring to the hydrographs for OW03-15, it appears that the simulated water levels are about 2 m below the average observed levels in the C and A monitoring intervals.

Do the simulated water levels at the face of the escarpment not influence the calculated discharges from the units?

Page 6

in these layers due not change dramatically due to seasonal recharge. The heads in Layer 4 are much more variable, as the layer is partially saturated most of the time. The fourth line shows the heads in Layer 4 on October 31, 2012 and they are near the top of the layer (273 m) but above the average heads in the layer. **It should be noted that the response at the monitoring wells may have been affected by placement of fill against the slope and other operational factors.**



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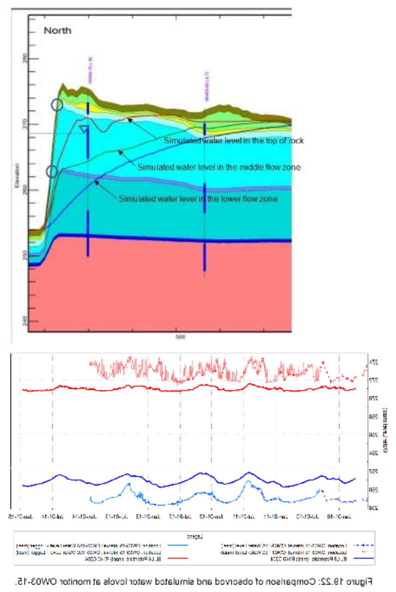
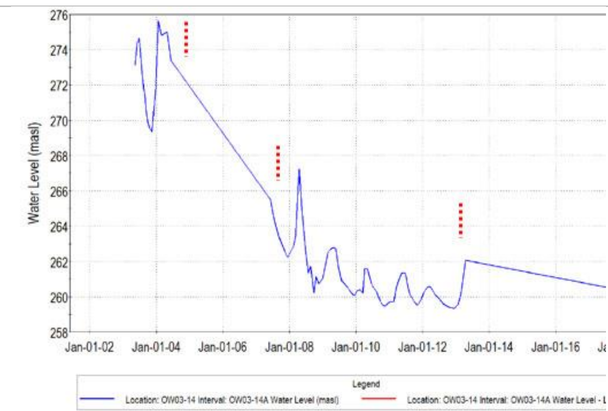
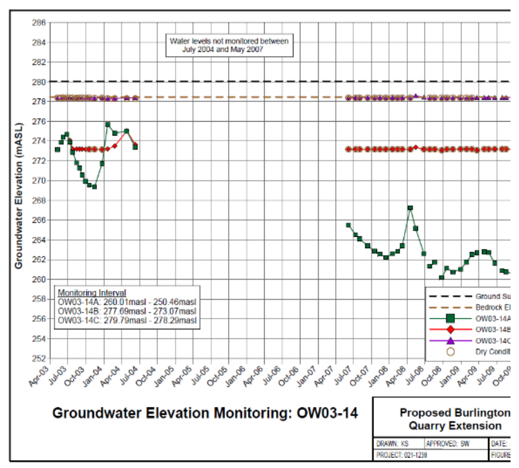
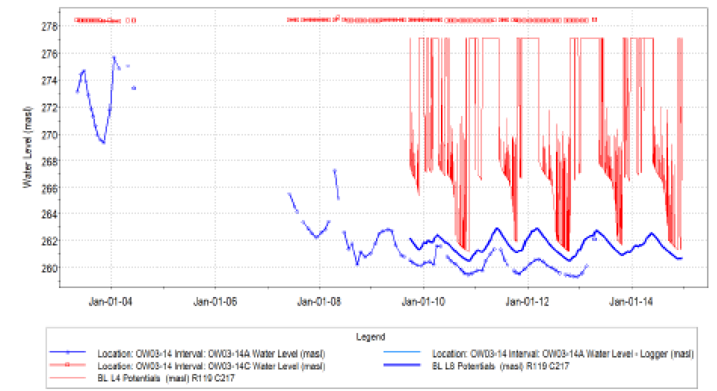
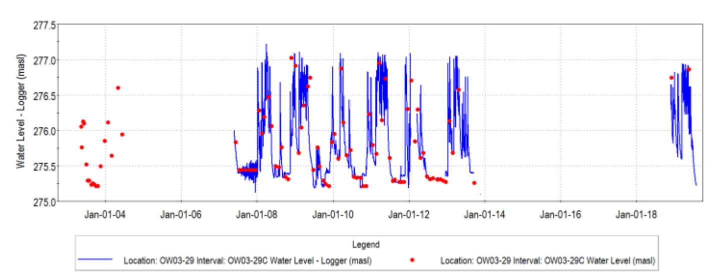
				
118	Is this bedding plane fracture shown in Figure 5.9 at an elevation close to the elevations assigned for the middle flow zone in the model (model layer 6)?	Yes, the bedding plane fracture is near that elevation. Also see response 117, above. We expect that the elevation of the middle flow zone will vary from place to place but generally following the regional dip of the unit.	No further comments.	RESOLVED
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?	The upper weathered fracture zone had a minimum thickness of 1 m. The 0.3 is a typo. Packer testing by Golder and Azimuth was generally done more than 2 m below the bedrock contact (likely because the zone was sealed off by the surface casing). Packer test data are provided in Schedule E.	No further comments.	RESOLVED
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.	The point of this whole discussion was that the differences in head between shallow and deep bedrock layers decrease with distance from the quarry face. This is essentially the "quarry face paradox". As the reviewer noted, it is only possible to sustain this head difference if the intervening rock has relatively low vertical hydraulic conductivity. However, the hydrograph also shows that there is response in the deep system that is not lagged or attenuated, which is only possible if there is a relatively high vertical hydraulic conductivity. The random placement of vertical fracture zones offered a reasonable solution to the paradox.	Our only additional comment is that it is possible to have a response in the deep system that is neither lagged or attenuated without there being a relatively high vertical hydraulic conductivity. The observations may reflect a geomechanical response to surface loading.	RESOLVED
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?	Earthfx hydrogeologists.	No further comments.	RESOLVED
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.	There are many ways to present the data. In Figure 19.23, the same data are presented with the gaps shown. Here, the figures were drawn to highlight the decrease in head.	No further comments.	RESOLVED

	 Figure 5.12: Water levels recorded in Monitoring Well OW03-14 (175 m to 40 m fro 			
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?	Typo: Sentence should read; For the simulations in this study, a collective transmissivity of $1x10^{-7}$ m^2/s was selected. For model stability, Layer 9 was treated as a constant transmissivity layer. Assuming that flow mostly takes place in the upper 5 m, that given a Kh of about $2x10^{-8}$ m/s. Relatively little flow occurs in this zone and model results should not be overly sensitive to the K of this zone within reasonable upper bounds.	No further comments.	RESOLVED
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?	Developing water level maps was a multi-step process. We started with a database query to get average water levels for all wells within the study area. The query automatically averaged the observations for wells with multiple measurements and retrieved the single static water level measurements for the MECP wells. Wells were posted in VIEWLOG with gradient colours so that likely outliers could be easily spotted. Follow-up investigations (looking at paper records, comparison of reported ground elevations with the DEM) were done to see if the errors were positional, due to errors in the units, or ground elevation). It should be noted that many of the potential outliers could not be discarded as the data seemed reasonably accurate and the differences could be more likely attributed to the fractured nature of the bedrock. The remaining wells were flagged as outliers and removed from subsequent queries. Wells were partitioned into shallow and deep subsets and further partitioned into above and below the Escarpment subsets. Variography was completed on each subset to determine the best variogram shape and estimate of nugget, range, and sill. The data were then kriged to the model grid and the above/below Escarpment maps were merged. The site monitoring data and MECP wells form two mostly non-overlapping data sets. Interpolation to a grid cell was done by selecting the nearest eight wells in each quadrant. Thus, within the vicinity of the quarry, the site wells dominate the interpolation, while outside the site vicinity, the MECP wells are generally the only data source used.	No further comments.	RESOLVED
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	See above	There is no recognition in the mapping of the very different reliabilities of the sources of water levels for the mapping.	RESOLVED

	average water levels inferred from the records for the Site monitoring wells.			
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?	It should be noted that most MECP wells are open hole and may be screened across the Upper and Middle zones, the Middle and Lower zones, or all three. The maps were intended to show general magnitudes and flow patterns in the groundwater data. General comparisons between these and model results were made on a study area scale. Detailed comparisons with particular wells in the site vicinity are also discussed.	The detailed questions of the comment are not addressed in the response. However, it is now understood that the maps were intended to show only general magnitudes and flow patterns in the groundwater data.	RESOLVED
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	There is a typo in the caption; it should read: Vertical head differences (deep minus shallow groundwater levels, in m). We subtracted the shallow water levels from the deep ones. The vertical head differences are colour contoured where red-shaded values (negative) indicate higher heads in the shallow system (downward flow) while blue shading (positive) indicates higher heads in the deeper system and upward flow.	No further comments.	RESOLVED
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?	The simulated 2-m average drawdown extends a maximum of about 500 m. It is expected that most wells would have more than 2-m of available drawdown and would not be adversely affected. This is consistent with Source Water Protection water budget analysis, which also considers natural seasonal variability in the identification of the WHPA-Q	No further comments.	RESOLVED
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	We tried to present a comprehensive but not exhaustive comparison of results. Still, it should be noted that although the reviewer states that selective use has been made of the available data in the GSFLOW calibration, of the 20 gauges, 10 were located more than 3.5 km from the site and, *of these, seven were outside the model boundary*. We found that no change in simulated flow occurs at or close to these locations. SW15 is on the opposite (north) side of the quarry and far from the expansion areas. SW7 and SW14 were discussed in great detail, so it was only SW2 which was omitted and the effects of the quarry extension were better seen in the upstream gauges. With regards to the Golder wells, the question was asked multiple times. Essentially, the model was calibrated over a 10-year period, WY2010-WY2019. Unfortunately, the Golder data mostly falls within WY2008 to WY2013 as shown by the data for OW03-29. The 2003 data are mostly manual monthly measurements with a large gap between May 2004 and August 2007. There is another gap from WY2014 to August 2018. Most wells show similar patterns but there is variation. OW03-15 and OW03-30, for example, are part of a group of wells that do not have logger data until 2010. The period selected had the best coverage and extended to the recent 2019 study period. 	An extensive response to Comment 156 has been provided. Our understanding is that the model was calibrated over a 10-year period, WY2010-WY2019. However, the Golder data mostly falls within WY2008 to WY2013 as shown by the data for OW03-29. It is not clear why the calibration period was not extended to include at least WY2008?	Again, we had difficulties getting a continuous 10-yr run under some of the scenarios. We wanted to include the most recent data and worked back from that. The issues related to the selection of the time period were discussed at length in the Nov. 2021 JART meeting.

	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 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?	Without going into a long discussion of the differences between Hortonian and Dunnian flow and why the integrated model needs to separate them, there is a point to the question regarding intensity. By representing the rainfall as a 24-hr storm, the CN method will tend to generate less Hortonian runoff. We experimented with monthly intensity modification factors (e.g., to assume that the average January storm was a six-hour event while the average August storm was a two-hour event) but this did not substantially improve the model calibration and was not pursued further.	No further comments.	RESOLVED

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160.	How is convergence checked in the GSFLOW simulation?	The model checks the standard specified closure criterion for changes in groundwater head and volumetric flow rate in MODFLOW-NWT. A specified closure criterion is checked for changes in storage in soil zone of PRMS.	No further comments.	RESOLVED
161.	Referring to Section 6.6, it is indicated that soil properties have a "significant influence on hydrological	While we started with book values for our first PRMS/GSFLOW analyses, the parameter values have been refined through close to 20 studies done in southern Ontario. Many of the studies were done in	No further comments.	RESOLVED
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?	Comment noted. It is a bit confusing but both references are correct. The digital data was based on soil mapping compiled in 2003. The digital data keeps being updated. We had downloaded a version (in 2014) that was updated in 2013. The Ontario Land Information system now only provides access to the 2016 version but still based on the 2003 mapping.	No further comments.	RESOLVED
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?	There is a first-order slow interflow coefficient that can be specified for each HRU. We found that assigning the slow interflow coefficient by land use class helped improve the calibration. In short, because interflow is taken first, increasing the interflow rate decreases the amount of flow available for groundwater recharge and discharge to streams as baseflow. Decreasing the coefficient results in a decrease in the peak flows and an increase in baseflow.	Reference in the report is made to parameters that controlled the partitioning of flow between interflow and percolation to the water table were also specified as soil-type properties. However, the response refers only to "a first-order slow interflow coefficient that can be specified for each HRU". Is this the only parameter that is referred to?	There is a second order term that was set to zero, there are also fast interflow terms that were not used.
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 analyses), a flow estimate can generally be considered to be PERFECT if $E \geq 0{\cdot}93$ or $R^2 \geq 0{\cdot}97$ or $R^2 \geq 0{\cdot}93$ with mean estimated flow within recorded flow. ACCEPTABLE if $E \geq 0{\cdot}80$ or $R^2 \geq 0{\cdot}90$ or $R^2 \geq 0{\cdot}77$ with mean estimated flow within recorded flow. Simulations with $E \geq 0{\cdot}60$ are generally satisfactory (inspection of graphical useful) and can be used to at least provide approximate flow volumes and investigative studies. Generally satisfactory results for approximate flow volumes and preliminary investigative studies is not the same as "reasonable".	It should be noted that the Chiew and McMahon (1993) is based on matching **monthly** flows, a much easier task than matching daily flows. There is a much higher degree of difficulty associated with a distributed integrated hydrologic model that is not encountered in typical catchment modelling. The long run times (2 weeks versus 3-11 seconds per run for the model used by Chiew and McMahon), data limitations, and our parsimonious approach make it difficult to achieve the high NSEs level of calibrations more typical of that lumped-parameter catchment models. Lumped parameter catchment models, calibrated on a monthly basis, have limited predictive capability for engineering scale impact assessment.	No further comments.	RESOLVED

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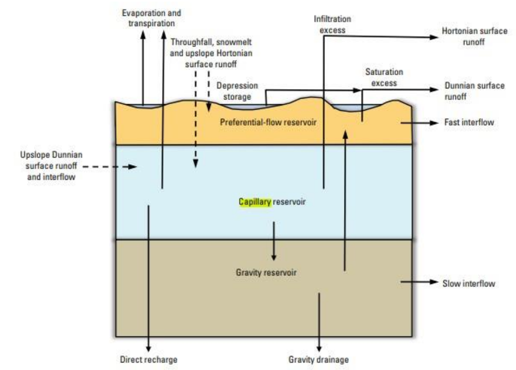
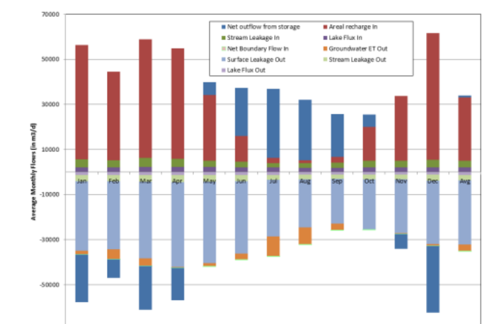
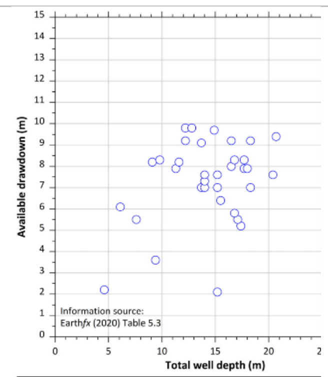
169	Referring to Figure 6.4, what are the capillary and drainage reservoirs?	Here is a schematic from the PRMS v4 manual. The capillary reservoir accepts infiltration (after canopy interception and Hortonian runoff) and loses water to soil ET. Excess water above the storage capacity of the capillary reservoir (equivalent to above field capacity) goes to the gravity reservoir where flow is portioned into interflow and GW recharge.  **Figure 2.** Details of the Precipitation-Runoff Modeling System Soil Zone.	No further comments.	RESOLVED
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?	The colours can be identified by their order in the legend. In the figure below, we changed the colour for Net boundary Inflow to lime green. Net boundary inflow is a very small term and, for this model is always negative. The term "Net outflow from storage" is meant to show that, from a MODFLOW point of view, outflow from storage constitutes an inflow to the aquifer similar to recharge. Thus it shows up in the summer months where water comes out of storage to balance other losses from the aquifer. In the spring, water is "removed" from the aquifer and goes into aquifer storage. 	No further comments.	RESOLVED
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].	Wells closer to the Medad Valley are frequently completed in the lower fracture zone. While wells further from the valley, including monitoring wells, are less frequent in the deep system, there are enough wells to conclude that it is a productive regional aquifer. It was chosen as wells can be deepened to that zone. The Golder testing was done for a south expansion. The private wells are located closer to the west expansion and, if replacement or deepening of wells is ultimately necessary, the presence of a lower flow zone and available drawdown, as indicted by the west boreholes (e.g., BS-01), is of critical importance. Please refer to Section 5.2.8 for a discussion of all the evidence related to the lower fracture zone, including Figure 5.10 and the observed effects discussed in Figure 5.11 and Figure 5.12, which clearly drain into the quarry, and yet continue to response to annual recharge event patterns.	In effect, relatively little of this substantial commentary is addressed in the response. Have the results of packer testing conducted for this study (expansion in a different direction) and data from wells closer to the Medad Valley confirmed that the lower fracture zone is a productive regional aquifer?	The interpretation was based on packer tests, private well response patterns (including water found, etc.) and photos showing discharge to the quarry (including winter ice on the quarry face). We have stated that there are enough wells to conclude that it is a productive regional aquifer.



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

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	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).			
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"; • "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.	A spreadsheet providing data for of all monitoring wells is provided in Schedule E. The data is also presented in an MS-Word table along with figures showing well locations. The wells include many of the Golder wells plus additional wells drilled for this study and several private wells. Wells are classed as active or inactive and wells that are part of wells nests are identified. Information about the type of measurement (manual, logger, or both) is shown along with the period of record for each monitor and average water level. Schedule B and C contain borehole data for wells in the vicinity of the wetlands and water courses. Additional long-term hydrographs have also been included.	Are the following documents provided with the table of responses to comments? A spreadsheet providing data for of all monitoring wells (Schedule E). Data is presented in an MS-Word table along with figures showing well locations. Borehole data for wells in the vicinity of the wetlands and water courses (Schedules B and C). Additional long-term hydrographs have also been included.	Comment noted. If there is an outstanding question, could you please clarify.
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.	Typo. The ",500" should have been deleted.	No further comments.	RESOLVED
334.	The right side of Equation (18.4) is missing an area term.	There is an area term, A_L. The second part of the equation (= - Kdh/dx) is a typo and does not belong there.	No further comments.	RESOLVED
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?	We made sure to simulate the lakes, ponds, and inundated portions of wetlands above the Escarpment especially if they were close to the quarry. We did not expect significant changes below the Escarpment so there are about 5 ponds that are mapped in the Ontario Hydrologic Network (OHN) waterbody coverage that we did not include. There are also many small ponds along Cedar Springs Road, for example, that are not mapped in the OHN coverage but are visible in Google maps. We did not include these.	No further comments.	RESOLVED
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	Yes. The values are consistent with the literature that you cited. The values are also within the range of packer testing by Golder which varied several orders of magnitude. The values worked well in terms of matching observed responses in the wetlands and were felt to be conservative. In earlier responses, we discussed the fact that because the till is fractured, there are likely to be areas with more vertical fractures and areas with less. The location of these areas is unmapped and generally unknowable.	No further comments.	RESOLVED

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	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). 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?	An extensive discussion of the testing, analysis and simulation of the Halton Till is included in our response to the MNRF comments. Copies are provided in Schedules B and C. The calibration to more than 20 minipiezometers is included.		
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	We looked at the packer test, slug test, and pump test results and the range of values they encompass. These helped us select reasonable initial estimates for aquifer properties. As per earlier responses, we did replicate the aquifer tests at an early point in model development as well as applying PEST with pilot points to try and determine larger–scale spatial variability in bedrock and overburden properties. In the end, we felt the spatial variability was a result of variable fracture properties at a smaller scale that could not be reliably determined. Therefore, we used reasonably conservative uniform values for the properties that produced good but not perfect matches to the observations.	No further comments.	RESOLVED

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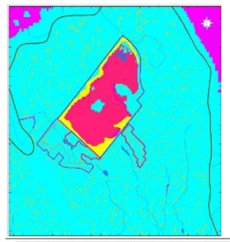
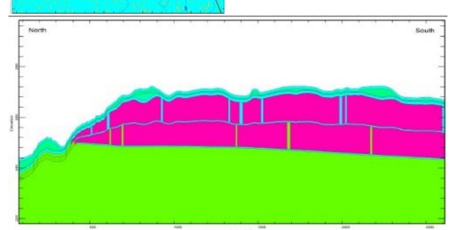
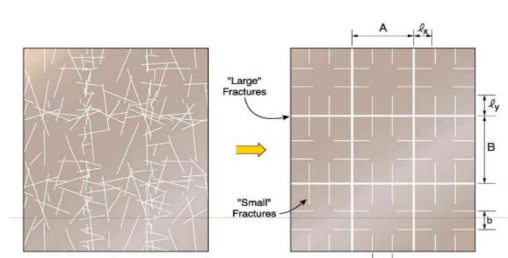
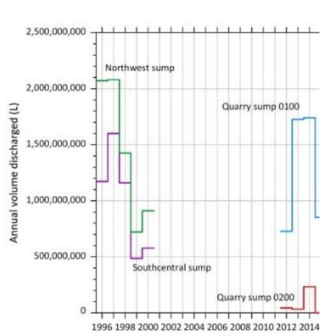
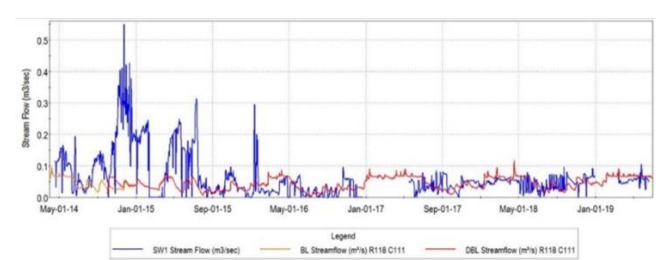
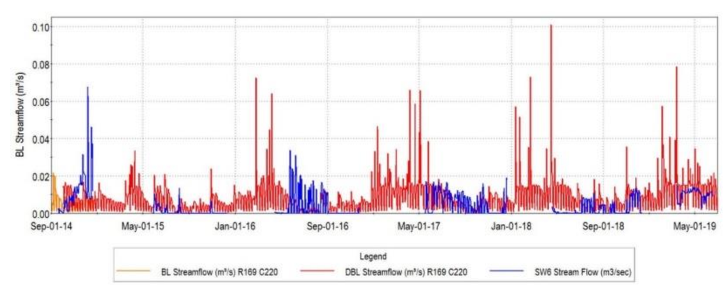
340	The approach that has been adopted to incorporate hydraulic connections between the weathered top of rock and the middle flow zone, and between the middle and lower flow zones is shown in Figures 18.20, 18.21 and 18.7 of the report. The approach is illustrated below. The approach that has been adopted to incorporate the vertical hydraulic connections is not physically based.   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)]. 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	We strongly disagree with the assertions that the approach does not provide either an improved representation of the fractures in the bedrock system, or the hydraulic connections between the flow zones, that the approach that has been adopted is not internally consistent, and that the approach compromises the reliability of the predictions of potential impacts of the quarry expansion. No quantitative proof was provided with these statements; while, on the other hand, we have shown the improved calibration to response in the deep system and at the quarry face. We agree that the size of the higher hydraulic conductivity connections are not ideal to represent individual fractures but are more representative of small zones with higher frequency of vertical fractures. Both would likely give identical response at distances within 2 to 3 times the aquifer thickness. As locations of fractures or fracture zones are unknowable, the calibration focussed on the frequency of these occurrences. This is how we settled on the 5% occurrence. This is your figure compared to the model extent and scale. Other than noting that there may be a fault in the underlying Precambrian, I am not sure how we could incorporate this information We disagree that this is counter to an EPM approach. For example, the dual-continuum approach has been extended into a triple-continuum approach in a similar manner to our representation. Wu et al. (2004) recognized that there is a network of larger and smaller fractures that are important to represent in the simulations of the Yucca Mountain site. Wu, Y.S., H.H. Liu, and G.S. Bodvarsson. “A triple-continuum approach for modeling flow and transport processes in fractured rock,” Journal of Contaminant Hydrology, 73: 145-179 (2004). In Response 123, we provided maps showing that there are small differences in heads locally due to proximity of the fracture zones, more so in Layer 6 than Layer 8. If anything, the presence of a fracture zone in the vicinity of a wetland or stream feature would magnify the effect of quarry dewatering rather than minimizing it, thus yielding a more conservative analysis of possible impacts. We did not imply any knowledge of locations of vertical fracture zones, but noted that these were placed randomly to mimic the random, unknowable occurrence of vertical fracture zones in the study area.   Fig. 5. Basic conceptualization for triple-continuum approximation of two-dimensional large-fracture, small-fracture, and rock matrix systems.	It is indicated that "fractures" are included in the model to mimic the physical response of the groundwater system to randomly occurring vertical fractures, specifically, to increase the vertical connection between units without compromising the semi-confining nature of the bulk units. Although repeated reference is made to "fractures", these features as represented in the model are vertical prisms (i.e., chimneys) that have dimensions of the grid blocks in which they are located (15.0 m x15.o m). It is indicated in the response that the "fractures" do not appreciably affect head distributions or flow patterns. This response does not appear to be consistent with the response to Comment 346. In the response it is noted that at MW03-2 the difference between the observed average water level at this location (about 259.5 m amsl) and the simulated average level (267.5 m amsl) may be related to its location immediately beside a randomly placed vertical fracture. Contrary to what is suggested in the response, in our opinion the sensitivity of model results to the location of a randomly placed chimney <u>does</u> raise concerns regarding the predictive capabilities of the model. We appreciate the effort that has been made in the response to Comment 346 to highlight the differences in scales between the Site and the regional interpretations of joint patterns. Golder (2010) included a site-scale analysis of rock structure (Appendix A; Section A5.0). Was the assignment of the random fractures informed by the inferred trends of the vertical features shown in Golder (2010; Figure A. 10 and Attachment A.3)? October 28, 2021 Page 9	There is a subtle difference between being able to predict local affects and the ability to predict the effects at a particular observation point. Observed response is affected by the presence and absence of fractures, where the presence and absence and properties of these features is unknowable. The model uses randomly placed fractures to mimic the aggregate response of the local system in the vicinity of the quarry. Thus, the placement of a fracture may degrade the ability to match the response at an observation point where no fracture exists, but without the placement of the random fractures, the model would not be able to match the general pattern of drawdowns (as seen by examining the response of multiple wells). What is important is that the model matches the levels and seasonal fluctuations in the near, intermediate and far field from the existing quarry, including the large seasonal fluctuations observed in the intermediate distance, as these define the extent of the quarry influence. Replicating these patterns are key to understanding the effects on wetlands, streams and private wells.

	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? 	The available discharge data starts in April 2014. The restarted baseline (drought period) started in August 2015. We assumed that there would be enough overlap to show the correspondence. The figure below shows the results of the first baseline run for April to December 2014 (in orange) covering the missing simulation results. Quarry discharge is lower than observed in 2014 and early 2015 but settles down and the match is good over the rest of the five year simulation and seems consistent with current quarry operating procedures. A revised hydrograph for SW6 is shown with the missing baseline data in orange. Again, the match improves in the last 5 years as we get closer to current operations.  	Referring to the plot shown in the response to the comment, it is indicated that quarry discharge is lower than observed in 2014 and early 2015 but settles down and the match is good over the rest of the five-year simulation and seems consistent with current quarry operating procedures. Is the implication that an acceptable match to the observations is achieved only to periods representing current conditions? Would a similar mismatch be expected with the opening of the proposed extension	There are two components to the quarry discharge. The first is a specified flow that is based on current operations (a constant discharge for the NW sump and a weekday-only discharge for the South sump). For the second component, all quarry inflows under the different scenarios are picked up in a series of floor drains and routed to the sumps. A control elevation was specified for the sump and any volume of water above the elevation is also routed to the discharge ponds. This allows for the model to compute an increase in discharge under the P12, P3456, and RHB1 scenarios. Significant losses can occur between the sump and SW1, especially during the summer months, so the full amount of the pumped volumes does not reach the gauge. Also, operations of the sumps were more on an ad-hoc basis in the early years of the simulation period, while in the later years, the discharge has been more consistent.
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	These were shown in Figure 8.72 and 8.73	The response to Comment 342 refers to simulation results for SW14 and SW7 are shown in Figures 8.72 and 8.73. These figures are reproduced below. Are any observations available for these stations, which would allow us to assess the match of the model to the observations?	See follow-up response to Comment 109

<table>
<tr><td></td><td>of potential impacts to streamflows of the proposed extension.</td><td></td><td></td><td></td></tr>
<tr><td>346</td><td>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 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.</td><td>As noted above, this monitor is adjacent to the stream carrying the south quarry discharge. The monitor is also immediately beside a randomly placed vertical fracture; that is also under a wetland cell fed by the south quarry discharge. In summary, this cell probably receives too much leakage from above, explaining the high simulated water level. This is expected given the placement of the random vertical features and does not raise any alarms about the model.</td><td>It is not clear why there be a substantial difference between observed and simulated groundwater levels at a monitor adjacent to the stream that carries the South Quarry discharge. Is there something fundamentally problematic in the representation in the model of the interaction between the stream and the groundwater flow system?

October 28, 2021 Page 10</td><td>No, it is just that a high rate of continual discharge to a stream that naturally had lower flows and that varied seasonally will have higher stage, greater wetted perimeter, and more leakage than other similar nearby streams.

The south quarry discharge is more intermittent than the main north quarry discharge and has not been historically tracked with a high degree of accuracy, making it difficult to quantify the effects of this leakage.</td></tr>
<tr><td>351.</td><td>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.</td><td>Typo during round-off. Should be 26071</td><td>No further comments.</td><td>RESOLVED</td></tr>
<tr><td>352.</td><td>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.

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

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:

In contrast, the reported % Discrepancy is -0.6%.</td><td>Your analysis is correct, but the table was reporting the discrepancy in the last column, that is, as percent of precipitation.</td><td>No further comments.</td><td>RESOLVED</td></tr>
<tr><td>354</td><td>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?</td><td>The basis for this comment is unclear. The reviewer acknowledges that there is an entire section discussing the calibration of the GSFLOW model, with 46 pages including sections on calibration strategy, region calibration to streamflow (the Aldershot gauge mentioned) and regional groundwater levels, local-scale calibration to 8 streamflow gauges, calibration to quarry discharge, calibration to groundwater levels at the quarry face and the need to adjust hydraulic conductivities to match the observations along with discussions, tables, maps, and hydrographs of model results. This section follows two other sections providing detailed discussions on the input data and preliminary calibration of the hydrologic and groundwater submodels.

The calibration was done over a two-year period with multiple revisions, innovations, improvements to derive a good match to the observations (particularly in the shallow subsurface), and reasonably constrained parameter values. This was all accomplished using a highly advanced integrated model, despite long run times and instabilities related to the Niagara Escarpment, in a fractured rock/till</td><td>The response does not address the questions asked:

What parameters were varied during the calibration?

How were the ranges established over which the parameter values would be adjusted to match the calibration targets?

Referring to Comment #61, we did not see in the documentation support for the belief that the model can provide reliable predictions of the likely changes in</td><td>We stand by our original response. Please also refer to earlier comments including Comment 61.</td></tr>
</table>

		environment, and with highly complex GW/SW interaction between headwater streams and shallow wetlands. We do not believe that there has ever been such a complex integrated transient analysis ever done in Ontario to analyze a proposed quarry extension. We believe that we accomplished the goal of producing a model that can successfully predict the likely changes in streamflow, groundwater levels, and wetland stage under the quarry extension scenarios considered. Results from this model provided useful input to other team members evaluating the impact to hydrologic and natural heritage features. Please refer to Response 61 and 63 for additional discussion.	streamflow, groundwater levels, and wetland stage under the quarry extension scenarios.	

DARYL W. COWELL COMMENTS

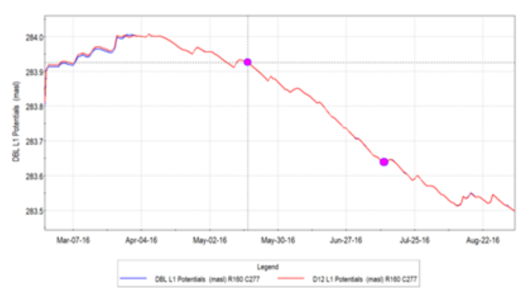
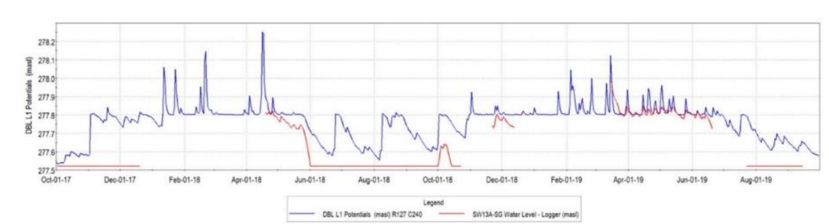
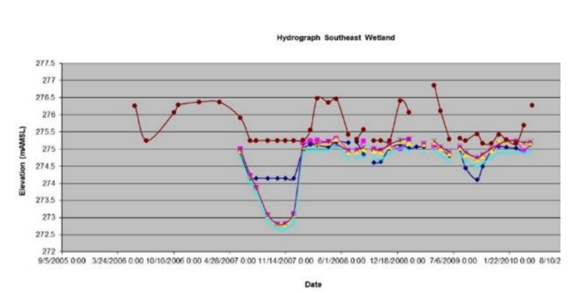
Proposed Burlington Quarry Expansion
Interim JART COMMENT SUMMARY TABLE – Hydrogeology

Please accept the following as interim 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. **These interim comments will be finalized following the breakout meetings between JART and Nelson and any changes will be marked using "track changes". 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)	Applicant Response	Interim JART Response (February 2022)	Applicant Response (June 2022)
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. Earthfx separated their responses to MNRF between an overview covering "common points" as well as separate point-by-point responses. B.l Section 1.4 Long-Term Observations of Wetland and Quarry Interaction. The overview discussion section 1.4, page 962 (also section 4.2, Figure 30, page 998) discusses observations of the effects of quarry development on individual wetlands. I had commented that I do not believe that the Halton Till was an aquiclude/impermeable and that there is a hydraulic connection between at least some wetlands and the bedrock aquifer (my JART comments #21 through 25). Figure 5 on page 962 of the MNRF response shows Golder MP 13 logger data and bedrock well levels for wetland 10 (13105). The wetland water levels appear to be unaffected by the approaching face of the quarry despite continuously declining bedrock water levels. These data are considered to be "observational proof' that the quarry will have no impact on wetlands. However, this figure shows a totally different story. Note the 'lock-step' declines in both wetland levels and bedrock levels during 2007 — a noted drought year. Then notice that the wetland levels remained high during 2009, again in 'lock-step' with high bedrock groundwater levels. A late year drop in wetland levels during 2009 is also mirrored by a decline in the wetland water level. These are clearly hydraulically connected. The fact that wetland levels don't decline further as the quarry face advances is misleading. The wetland piezometer is at the bottom (can't go lower) and the wetland is dry every year (except 2009). It doesn't matter how low the bedrock groundwater levels go, the wetland can only go to Apparent filling of the wetland in fall and spring are simply short-term responses to wet periods including rain and snowmelt. The soils are silty clays so there is some capacity to refill each year, just not for any significant period as long as bedrock water levels are below the base of the wetland	The unweathered Halton Till has a low primary hydraulic conductivity and acts as a regional aquitard. The till is likely to have some vertical fracturing that fully penetrates the unit's thickness. These fractures are sparse and randomly distributed, so their locations are unknowable. We used a conservative estimate of the hydraulic conductivity of the Halton Till based on geometric means of the available testing data. (Conservative in this sense means that we allowed for more interaction with wetlands and streams than if we had assumed a lower value for the hydraulic conductivity)	The primary point of my comment #21 focuses on wetlands not modelling. We seem to agree that there are deep vertical fractures penetrating the unit's thickness. Where these occur beneath wetlands, there is a high probability that there willl be a direct connection between the wetland water level and the underlying bedrock aquifer. The presence of direct wetland – bedrock hydraulic connections is demonstrated by the hydrographs provided by Golder (see comment #29). This results in a direct and significant impact to the wetland during excavation which needs to be documented as part of an impact assessment.	We respectfully agree to disagree that vertical fractures beneath wetlands will result in a significant impact to wetlands. This is because the sparse fractures allow heads to equalize and response in similar manner over time (as noted in the original comment) but the volume of water transmitted by small, sparse fractures is small. Our conservative modelling analysis assumed greater connection than is likely and, therefore, generally over-estimated the degree of impact of quarry expansion on the perched wetlands. Regardless, the monitoring, threshold, and mitigation plan has been designed to protect these features. Please see the updated AMP.
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.	It was assumed that the upper part of the till was weathered and densely fractured and likely has higher hydraulic conductivity than the unweathered, less fractured portion. See previous response regarding the unweathered till.	See responses to Comment #21 (above) and #23 (below).	We acknowledged that there are likely to be sparse, vertical fractures. Even though the fracture has higher permeability, the sparsity of fully-penetrating fractures yields a lower effective vertical hydraulic conductivity and volume of flow. It should be noted that desiccation fracturing is likely to be higher in upland areas which dry out quicker than the low-lying wetland areas. Deposition of wetland sediments will also limit vertical flow through the fractured till. See responses to Comment #21 (above) and #23 (below).

DARYL W. COWELL COMMENTS

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) 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…" The MNRF comment requests "wetland-specific" hydraulic conductivities for the Halton Till. I have already made the point that the although the model treats the unweathered till as one layer, it does not account for the presence of fractures. Earthfx's response to MNRF is totally inadequate, referring to the model layer and stating that "no patterns of lateral spatial variation have been observed" and because it is a glacial ("regional scale") deposit, none is to be expected. There is no glacial geological basis for this statement. As I noted, the fracturing of glacial tills is well documented (my comment and response #23). These deposits are flexed downward by glacial loading then upwards by isostatic rebound. Also, what is meant by not observing lateral spatial variation? What have they done to support this statement? No assessments of field-scale tests of hydraulic conductivities of the Halton Till have been provided. These comments are wetland specific but in each case request specific hydraulic conductivity data from beneath the wetland. See my comment #B3 above	Freed (1993) was quoting a study by Keller (et al.) of low permeability clay tills in Saskatchewan. These tills had laboratory K's of 10^{-11} m/s and bulk values closer to 10^{-9}. The Halton Till in the study area is much thinner and is likely to be slightly more fractured at depth (the calibrated model has a bulk K of 10^{-7} m/s. The assumed value is more conservative in that it allows for a greater connection between the overburden and bedrock.	Freed (1993) was quoting several studies, including one in Wisconsin. The point is that tills are known to be fractured and bulk hydraulic conductivities do not represent the entire deposit. Individual fractures can have much higher orders of magnitude conductivities. Freed's own studies in Michigan demonstrated this and he noted that, although the intensity of fracturing varied, all sites had deep fractures. When located beneath wetlands, the wetland water level will be affected/controlled through hydraulic connections to any underlying aquifer.	As above, the sparse fractures can transmit the pressure response but do not transmit large volumes of water. The presence of fractures may be limited beneath wetlands and the deposition of fine-grained wetland sediments may further decrease the transmission of water.
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."	Each area is different and glaciolacustrine clays are not clay-silt tills. Again, the model uses a relatively conservative value, much higher than those likely used in Smithville for competent glaciolacustrine clays.	As I had noted in my original comment, the Smithville deposits are not "competent glaciolacustrine clays". They are in fact reworked tills as demonstrated by a large component of stones and cobble. The point of my comments on the Halton Till is not that the matrix has low permeability but that every glacial deposit is fractured due to glacial loading and isostatic flexing.	See comment above.
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.	See above. No specific logs are referred to. The Golder lab and slug tests showed a wide range in values as they sampled weathered and unweathered portions of the till.	Again, there is a wide range in conductivities due to fractures whether weathered or not. See response to Comment #29.	See comments above. It should be noted that the till was simulated as a two-layered system when at surface. The upper layer was assumed to be weathered with a higher fracture density. When overlain by other materials, the unit was represented as a single layer with the relative low vertical hydraulic conductivity ($1x10^{-7}$ m/s) representing a till with sparse vertical fractures.
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.	Yes. There would be leakage over time through the low permeability sediments. This is seen in the Golder staff gauges and minipiezometers as a general recession in water levels from the late spring to fall. The behaviour is complicated by response to rainfall events that continue to occur over this period that convey overland runoff and, in many cases, streamflow. The late winter/early spring rise and late spring/early fall recession is also typical of every aquifer in the study area.	Comments 26 through 29 are all part of common narrative: wetland hydrographs are critical in defining the degree of hydraulic connection to the underlying aquifer. A direct connection has been demonstrated between wetland 17/13033 by Golder's hydrograph data covering a particularly dry year (2007). We seem to agree that a wetland with a low permeability substrate should show a pattern of very slowly declining water levels controlled primarily by evapotranspiration regardless of water levels in the underlying aquifer (Earthfx response to my comments #26 and 27).	We agree that the wetlands can show a gradually declining water level over due to a number of factors. For a wetland underlain by low permeability geologic material as well as accumulated wetland deposits, the primarily factors should be (1) evapotranspiration and (2) decreased runoff during the summer as infiltration is higher in the surrounding upland soils. Drainage through the wetland bottom is likely to be a minor factor as demonstrated in our analysis. Wetlands underlain by a sandier soil would likely show enhanced declines in water levels as under-drainage would be a more important component of the water balance.

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. 	Yes, the integrated model was capable of simulating the seasonal response of wetland stage. This is the main reason we went through the effort of building a very complex, transient, integrated model of the site vicinity.	See my response to comment #26 above.	This response is as expected. Losing 300 mm of water to ET during the late spring and summer would be normal behaviour. The response levels off at the end of August when ET processes begin to shut down.
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 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.	Some tills underlying the wetlands are thinner than others. A few are affected by seasonally high water tables. We, and other reviewers, noticed some longer lags in the fall recovery in the model while the staff gauge response shows a rapid recovery once ET processes shut down. We believe that the wetlands were likely assigned too much soil zone storage so we are not exactly mimicking the quick filling of soil zone storage and rapid increase in stage. The same problem would tend to slow the simulated recessions in the late spring. The staff gauges show very steep recession once ET processes get under way with a quick drop in stage. 	Earthfx's response to this comment appears to blame a "quick drop in stage" within the wetland as being due to the onset of ET processes. ET is not a switch – one doesn't either have or not have ET – the process is continuous and dependent on temperature/cloud cover. Increasing ET, during most years, is gradual which is shown by a gradual decline in wetland water levels, where wetland substrates have low permeabilities, with additions due mostly to rainfall (which is measurable).	ET processes, as noted by the review, are driven by temperature, solar radiation, other climate factors (humidity, wind speed), the availability of moisture in the root zone, the types of plants and growth stages, and other factors. Evaporation processes are continuous in the model. The model does have a switch related to temperature that turns on transpiration processes after a number of consecutive warm days in the spring and shuts down transpiration in the fall after consecutive cold days. This may be a somewhat simplified representation of reality. Regardless, we feel that ET processes are the dominant ones in these wetlands. One other possible explanation for the steepness (200 mm in 2 weeks) observed at one specific point in the wetland might be Internal drainage within the wetland and that the staff gauge may not be at the lowest point in the wetland.
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). Page 975 and Figure 8, page 981. I had spoke to this in my original comments on the report and responded to Earthfx's response to the JART table (my comments #29-30). Pumping a well over only 4 days draws down the well, and a portion of the pumped aquifer, it does not draw down the overlying sediments. As I notes before, the pumping test should have been conducted in the order of 30 days. The 2007 dry year was effectively a 4-month pumping test, demonstrating a hydraulic connection between wetland 13033 and the underlying aquifer. 			Hydraulic connection can ensure that the heads correlate across the units. The fact that a pressure response is transmitted does not necessarily mean significant volumes of water have been transferred.

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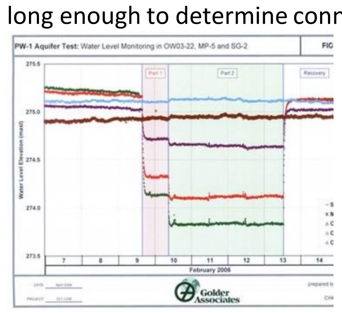
30.	Figure 3 shows the results of a 6-day pumping test in bedrock wells located near MP-5 and SG-2 during February 2006. The lack of any evident response in the mini-piezometer and staff guage (brown and blue lines, respectively) was provided as proof of the aquitard characteristic of the Halton Till. 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.  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.	No. The pumping test was a direct local stress on the aquifer. The system responded and reached equilibrium in an extremely short time with no indication of a significant impact on the wetland. Prolonging a test after equilibrium is reached makes no hydrologic sense. That both the shallow system and bedrock respond to seasonal change indicates that, on a regional scale, sparsely-spaced deep vertical fractures provide a higher degree of connectivity than would occur through an unfractured till. As in the bedrock, the occurrence of these vertical fractures is random and not mappable. A 30-day pump test would not provide any additional information in this regard.	There are two systems here – the wetland system (MP-5 and SG-2) did not respond at all during the 6-day pumping period. You will note that pumping test well (OW03-22B) did show a direct correlation of wetland and aquifer levels (yellow in preceding figure) during the dry 2007 period which was effectively a four-month pumping test. B.2 Section 2.4.2 Golder In-Situ Test and Pumping Test Page 975 and Figure 8, page 981. I had spoke to this in my original comments on the report and responded to Earthfx's response to the JART Table (my comments #29 — 30). Pumping a well over only 4 days draws down the well, it does not draw down the aquifer. As I noted before, the pumping test should have been conducted in the order of 30 days. The 2007 dry year was effectively a 4-month pumping test, demonstrating a hydraulic connection between wetland 13033 and the underlying aquifer.	We stand by our original comment. Each step of the test came to equilibrium within an hour or two. Prolonging a test after equilibrium is reached makes no hydrologic sense. The statement that "Pumping a well over only 4 days draws down the well, it does not draw down the aquifer" similarly makes no hydrologic sense as there are not 4 days of storage in the well.
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.	See previous response	A 30-day pumping test is not unreasonable when determining potential impacts to a PSW.	See previous response.
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.	The modelling and additional hydrologic assessments specifically assessed the likely changes to the perched wetlands.	The modelling assumes that the Halton Till unweathered layer has a low permeability is not based on actual data of fracture permeabilities.	The purpose of this study was to make reasonably conservative assumptions, quantify the likely changes to water levels and hydroperiod, and provide an adaptive management plan that addresses these changes. We carried out these analyses using an advanced integrated modelling approach and reported our results. No alternative method for conducting these analyses was suggested by the reviewer.
33.	Recommendation: The Halton Till layer in the hydrogeological model requires better hydraulic conductivity definition (absolute K values and spatial distribution).	Noted	Earthfx's response of "Noted" seems to agree that "better hydraulic conductivity definition" is required for the Halton Till. Although Worthington's response to my comment #47 is applied to bedrock fractures, it points out that the model does not consider flow through fractures. The same applies to fractures in till. Unless you are specifically aware of them, which you indicated in your response to comment #21 that they are "unknowable", then the model can never account of enhanced leaking through till fractures, which we know does	Testing by Golder provided a wide range of hydraulic conductivity values. We analyzed the data and found no apparent spatial pattern in the results. We were just acknowledging that it would be better if it were possible to know the absolute values of the hydraulic conductivity of the Halton Till at all locations within the 83 km^2 area, but that is clearly not possible.
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.	Karst surveys (Worthington, 2006, 2020) were conducted and identified springs, "disappearing" and re- emerging streams, and other karst features. Where data were available, these were simulated explicitly in the integrated model, including a stream reach on the east arm of the West Branch of Mt. Nemo Creek and on the unnamed tributary to Willoughby Creek, and the springs emerging in the Medad Valley. Otherwise, we believe the network of multiple short fractures and zones of moderately fractured bedrock behave as an EPM.	The model was 'verified' using a wide range of well data from throughout the entire site. I have worked my entire career along the Niagara Escarpment and it is common knowledge that there is a 1 to 2 km zone back of the scarp which has much higher secondary and tertiary permeability (e.g., Frank Brunton) due to the opening of joints and bedding planes from isostatic loading and unloading and the capture of surface waters. You will note that Worthington's karst features in the study area are exactly within that zone. It is unreasonable to assume that the model has the same efficacy across the entire site, especially nearest the escarpment including the entire proposed western expansion area.	The original comment dealt with the way the springs and karst features were characterized and we responded saying that these were represented as discrete features where we had adequate data. The response has raised a second issue related to enhanced fracturing within a short distance of the Niagara Escarpment. During model development, we added a fracture zone with experimented with a 500 m to 1 km enhanced fracture zone, but model results (i.e., matches to observed water levels) were not improved.
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".	Comment noted.	As per #36.	Refer to response to # 36.
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.	Comment noted. We extended our analysis to and beyond the Medad Valley despite it being more than 120 m from the quarry.	Earthfx's response does not address the need for an EIA as required by the PPS. Specifically, page 61 of the Natural Heritage Reference Manual which notes that "development or site alteration will not be permitted within adjacent lands [lands within 120m] unless the ecological function of the adjacent lands has been evaluated, and it has been demonstrated that there will be no negative impacts on the natural features or on their ecological functions. This critical evaluation of the adjacent lands is one of the most important parts of an EIS." (highlighting mine). Such an EIS has not been prepared	As we noted, the Medad Valley wetland is outside the 120 m buffer around the license boundary for the quarry expansion. Excavation and the infiltration pond will be outside that buffer and further from the wetland. Despite this, we felt it important to assess the magnitude of changes that would likely occur in the larger area.

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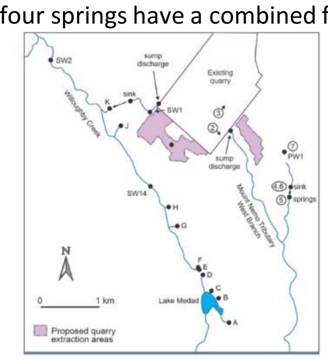
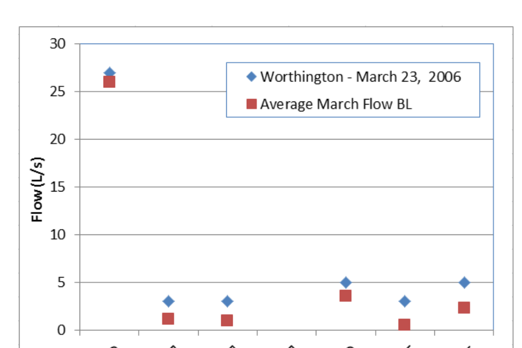
37.	Ontario Regulation 162/06 (HRCA under the *CA Act*) also prevents developments within wetlands that "could interfere with the hydrologic function of a wetland, including areas up to 120.0 meters of all provincially significant wetlands…"	See previous response	As per #36.	Refer to response #36
38.	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).	See previous response	As per #36.	Refer to response #36
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).	See previous response Our analysis was primarily focused on likely changes to streamflow which includes discharge from karst springs. Access to the Medad Valley was limited and specific information needed for more detailed modelling was also limited.	As per #36.	There have been follow-up discussions with MNDMNRF regarding the Medad Valley, changes to the wetland water balance (particularly groundwater discharge), methods to minimize the predicted impacts, and additional monitoring. See updated AMP.
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.	There is likely unmapped diffuse discharge occurring along the flanks of the Medad Valley wall and upwelling in the valley floor as well as the mapped discrete discharge points	What evidence does Earthfx have pertaining to diffuse discharge along the flanks of the Medad Valley – I have seen no prior evidence of this. Earthfx's response that groundwater upwells in the Medad Valley floor is curious. The noted (and mapped springs) are at/near the base of the carbonate sequence (my comment #42 which Earthfx appears to agree with) flowing under unconfined conditions. Hydraulically, these springs would drain fractures of the main aquifer. "Upwelling" implies artesian conditions so even if a carbonate unit extended beneath the valley (Reynales?), what is driving the head? The Reynales is not confined and any up-dip flow would likely be captured at the springs and not underflow them only to upwell in the valley. Further, the Level 1/Level 2 Report notes that "The Medad Valley is incised into the Cabot Head shale aquitard" (2nd para, page 23; page 53).	The Medad Valley was walked by Tatham and Worthington. The Medad Valley wetland is a large feature and the western part of the wetland would not likely be there if only a few discrete springs (Locations G and H) were supplying flow. Gradients are presumed to be upward in this area with groundwater discharge from the lower fracture zone that we mapped as buried beneath the valley infill sediments. Please refer to Schedule 1 and 2 for additional details.
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 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. This comment parallels my comments and responses #41 pertaining to impacts to springs in the Medad Valley and requesting flow monitoring of the springs. Earthfx's response is simply that the modeling does not show an impact. Curiously they note that "Several of the springs emanating from the face of the Medad Valley were explicitly represented in the model." They do not provide any data but this could be the one-time sampling and one-time model simulation that they had provided in response to my comment #41.	Below is a graph comparing Worthington flows against the average March flow predicted by the model under baseline conditions. The pattern in the simulated water levels appear reasonable (e.g., high simulated values match high observed values) but are consistently lower. Spring flows vary on a daily basis. It should be noted that 2006 had higher annual precipitation than any successive year. There were 47.1 mm of rain in March 2006 (30-year average for March = 43.3) prior to the Worthington measurements and January and February precipitation values were well above the monthly averages (79.1 vs. 56.8 for January and 84.1 versus 57.2 for February, respectively) so it is not unexpected that the Worthington instantaneous measurements are higher than average simulated March flows.  It should be noted that the Worthington measurements were not used as calibration targets. This post-analysis verifies that the calibrated model captured key features of the hydrologic and hydrogeologic conditions in the study area.	Where did this figure come from? What are the assumptions/data used to create it? It seems to contradict Worthington's response to my comment #55 that "EPM models do not simulate flow in individual fractures". The springs are not diffuse but are supplied by specific fractures. The springs are noted by Worthington (2006) to be "small karstic groundwater basins" (page 5) with larger conduits closer to the springs (also page 5). Simply using an area measurement (if that is what was used) will not be useful to model karst conduits using an EPM model. In part because surface and subsurface watersheds can be quite distinct in karst setting.	Worthington's comment is technically correct, it is just that we applied a hybrid approach where we simulated discrete fractures or fracture zones within the model when we had sufficient data to represent them. Otherwise, the EPM assumption was made. The March 2006 flows presented were the simulated flows in the stream segments at the point where the springs emerge. The springs all seem to be located within erosional features so the simulated streams are likely incised reasonably close to the depth of the karst conduit. A key point is that we were able to simulate the contribution of the springs to the Medad Valley reasonably well and the model indicated that upwelling was also occurring throughout the Medad Valley with the highest values close to the valley walls. This gave us the confidence to make the statements that the reviewer questioned.

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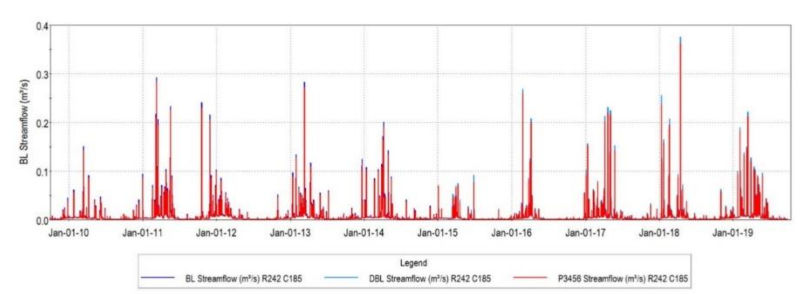
42	All springs are located at or near the base of the carbonate aquifer (Goat Island/Gasport), either at the top of the Cabot Head or more likely, at the interface of the Irondequoit – Rockway formations (F. Brunton,Ontario Geological Survey, field trip notes, September 2008).	Comment noted.	Earthfx "notes" my comment which I assume means that they agree.	RESOLVED
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.	Comment noted.	Earthfx "notes" my comment which I assume they agree with.	RESOLVED
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. This comment mirrors my comments #44 and 45 regarding a lowering and shifting of the groundwater divide between the Medad Valley and proposed western extension. Earthfx's simply states that the new divide will be beneath the infiltration pond and this will function to "maintain flow to the Medad Valley (Wetland 24)." Again, no proof is provided (see comment B.I. above).	It is over 200 m but close. Based on Layer 8 potentials for baseline, the gradient to Spring J is 0.01 not 1:25. Under P3456 it increases to 0.03. However, it is unclear what the relevance of these calculations is. We note that streamflow is slightly reduced on average at Spring J, from 1.5 L/s under baseline to 0.6 L/s under P3456. Spring K flows are a function of the quarry discharge and increase slightly from 47 to 49 L/s.	A gradient of 1:25 is 0.04 and 1.50 is 0.02 to compare to your notation. The apparent 'increase' is actually a shallowing of the gradient due to a lowering of the surface in the area of the proposed western extension. The gradient is based on rise over run from the bedrock surface where precipitation enters the aquifer. Layer 8 is a construct not a measured flow.	In follow-up discussions with JART and MNDMNRF, we presented simulations of P3456 with and without the infiltration pond to quantify the incremental change in water levels, streamflow, and upward gradients in the Medad Valley. The assumptions in representing the pond were conservative and had the Halton Till underlying the pond. Additional analyses were made at the request of MNDMNRF to determine the effects of deepening the pond by excavating through the till. Model results indicated that upward gradients would generally increase in the Medad Valley. Please refer to Schedule 1 and 2 for additional details.
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.	Yes. Changes in streamflow in the Medad (Willoughby Creek) are discussed in the report.	Figure 6.37 is the only mapping I could find that includes a potentiometric surface. However, this diagram is not sufficiently precise for this application (see my comment to response #187). Yes, changes in streamflow are discussed under scenario P3456 as you note, however, as I point in comment #301, the noted changes are an artificial construct of one simulation (post-development) over another simulation ("baseline"). Baseline is not based on actual measured data so we have no idea to what degree the noted changes are real.	The purpose of a modeling analysis is to use the best available technology to reproduce the functioning of a complex hydrologic system so as to better understand the factors that control the behaviour of the system and its responses to change. In a comparative analysis, we calibrate the model to reproduce a baseline condition and then change those conditions and analyze the subsequent response. Despite this being an "artificial construct", there is no better way to predict the likely impact of a quarry expansion without actually excavating the quarry and measuring the response.
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 currently proposed southern extension, although smaller in area than that proposed in 2004, remains within about 2.4 kilometres of spring C.	Comment noted. There are slight changes in average Spring C flow between the baseline and P3456. The changes are mostly related peak event flows while base flow shown insignificant differences. 	Again, as noted in comments #45 and 301, the simulation is artificial not based on measurements. Further, Worthington's response to my original comment #47 is that the model does not determine flow through fractures individually but collectively. I would point out that the surface watershed and bedrock aquifer watershed are seldom the same in karst settings.	See previous responses.
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."	See Earthfx Response 34. **Worthington Response** The abbreviation EPM stands for Equivalent Porous Medium, and uses for the concept that aquifers may behave as porous media at a large enough scale. EPM models do not simulate flow through all the millions of individual fractures through which water flows in the aquifer, which would not be practicable and has never been done at the scale of the Earthfx modelling. However, the model does simulate flow through the fractures collectively rather than individually.	Please define "a large enough scale" in the context of the site. I believe that Worthington's response here meant to read as "small enough" scale. Large scale represents more detailed areas than small scale (e.g., 1:10000 is a larger scale than 1:250000). Spring C has a watershed in the range of 2.5 km^2 which is a large-scale representation under any system.	Worthington is referring to the scale of analysis (e.g. on the order of kilometers rather than 10s of metres. Again, we took a hybrid approach with a mix of EPM and discrete fracture analysis.

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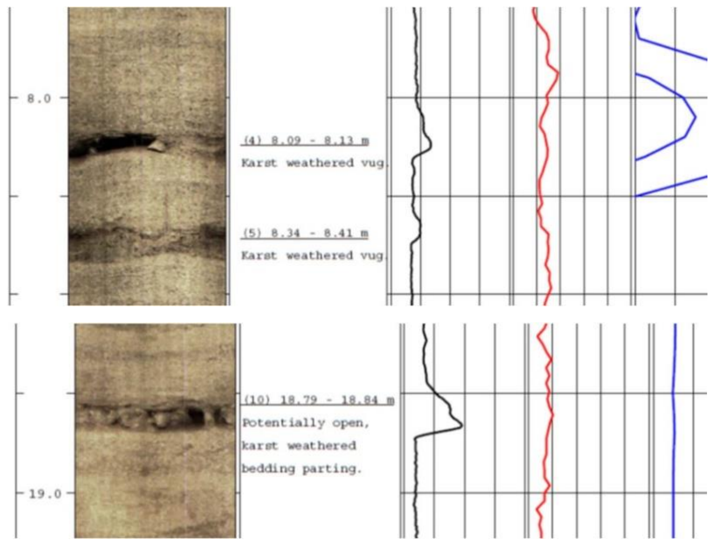
48.	Worthington (2006) mapped and traced karst conduit systems to the south (West Tributary) and north (Willoughby Creek – spring K). The latter indicates that karst conduits directly feeding the Medad Valley springs are, in fact, present. He did not observe sinkholes within the western extension area (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). 	Comment noted. Spring K was modelled explicitly. **Worthington Response** The several lines evidence on flow in the aquifer presented in the 2006 and 2020 reports consistently shows that most flow in the dolostone aquifer is through solutionally-enlarged fractures. Such flow is common and is expected to occur in dolostone and limestone aquifers. Some of that evidence is listed in Cowell’s comments (Peer Review Comments: Proposed Burlington Quarry Extension) , including: *32. Worthington (2006) mapped and traced karst conduit systems to the south (West Tributary) and north (Willoughby Creek – spring K). The latter indicates that karst conduits directly feeding the Medad Valley springs are, in fact, present. He did not observe sinkholes within the western extension area (Worthington 2020); however, his Figure A7 (partially reproduced below) indicates the presence of “Karst” weathered vugs along bedding planes in borehole BH06-1. These are found at 8.09 m, 8.34 m, and 18.79 m below ground surface adjacent to the southern extension area.* *33. The uppermost vug is particularly interesting being up 4 cm wide and open. It also shows a significantly higher specific conductivity (blue vertical line) than the remainder of the core indicating the presence of carbonate-rich water.* *34. Borehole BH06-1 is located northeast of the proposed southern extension. The continuity and extension of these “vugs” are not fully known but at least the uppermost vug provides indications of water transmission which suggests some continuity. This is confirmed by the flowmeter results from wells OW-03-30 and OW-03-31 (Worthington Figures A8 and A9) which show strong flows in the 7 to 8 mbgs depth.* *35. The final quarry floor in the western extension will be at an elevation of 252.5 m amsl which is well below the elevations of all three of the “karst-weathered” bedding planes.* *36. The Level 1 and 2 Hydrogeological Assessment also documented open fractures in boreholeslocated 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).*	The Earthfx response requires explanation. How was spring K modelled? Please provide the details of the modelling. This is curious since flow in individual fractures can not be represented in the EPM model (Worthington response to my comment #47, above. My original comment was disaggregated from my primary point which is expressed in my comments #51 and 52 regarding the elevation of these solutionally enhanced fractures being above the proposed quarry floor. The interception (or not) by these fractures of infiltration from the recharge pond as well as the elevation of the mound relative to these fractures are critical to the determination as to whether the recharge pond will in fact mitigate the shift and lowering of the groundwater divide west of the proposed extension. This has not been evaluated by Earthfx.	See previous responses regarding the approach and spring flows. We did a comparative analysis of the P3456 conditions with the infiltration feature to evaluate the effect of the quarry of water levels and streamflow. We do not understand the reviewer’s follow up comment.
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.	Comment noted.	See comment 48 above	See response to #48
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.	The model simulated upper, middle, and lower zones of enhanced permeability to represent the presence of these solution enhanced fractures within the EPM model.	See comment 48 above	See response to #48
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.	Comment noted.	Earthfx’s “notes” my comment but then seems to ignore it in their response to my comment #52.	The original comment was a statement.

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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 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. MECP had requested a "discussion of discharge water quality in relation to recharge areas, including at the new infiltration pond feature in the West Extension…" Although I did not commit on water quality, I had noted that Earthfx had not demonstrated the efficacy of the proposed infiltration pond (my comment #52/page 14) in directing groundwater toward the Medad Valley. Earthfx's response to my comment was simply, that "some" recirculated water would flow "towards the Medad". Interestingly their response to MECP pertaining to infiltration pond water quality they raised a point that water from the existing golf course ponds reaches the deeper groundwater as demonstrated by well temperature profiles provided by Dr. Worthington in his karst report (Appendix B, Level 1 and Level 2 Hydrogeological report). In fact, they suggested that temperature was actually used as a "tracer": "Dr. Worthington (Worthington Groundwater) reported a shift to higher temperatures in the groundwater at BS-07 during the aquifer testing program. This shift represents the warmer pond water entering the groundwater regime. Temperature was the only parameter that could be used as a tracer as the groundwater and pond quality are one in the same (pond water is source d from the quarry sump)." [second full paragraph, page 127] At no point did Dr. Worthington refer to temperature as a tracer and the only discussion of temperature profiles in well BS-07 is to note "changes" in temperature between 8 and 8.5 m and between 16 and 19m (Worthington's Figure A12). Both of these "changes are declining temperatures along fractures, not rising temperatures. Dr. Worthington makes no mention of any effect of the golf course ponds on deeper groundwater MNRF is requesting alternative mitigation measures to the infiltration pond in the western extension in the event the groundwater mound does not reach the intended water level. They are also requesting further demonstration that the proposed mitigation will work. This overlaps with my comment #52. Earthfx's response to MNRF is more complete that it was for mine. They note construction of the new ponds will eliminate fine grained soils allowing better infiltration and that groundwater levels will be monitored at 5 wells. However, Earthfx provides no alternative mitigation measure(s) should the designed infiltration pond fail.	The pond will create a groundwater mound with some of the infiltration returning to the quarry to be recirculated and some flowing towards the Medad.	Earthfx's response that the infiltration pond will flow to both the quarry and to the Medad Valley has not been demonstrated. There is no evidence that any flow will be directed to the Medad Valley – this will be a function of the coincidence (or not) of specific fractures which my comment #48 above suggests may be well above the groundwater mound.	Simulations indicated that water levels would rise relative to baseline in the upper bedrock but heads would decrease in the lower zones. A divide would form in the upper bedrock layer and flows would generally split between being directed to the quarry or to the Medad. Of the water directed to the Medad, some would move vertically into the lower layers. Of this water, some will be captured by the quarry (the divide is located west of the shallow bedrock divide) and some continue on to the Medad Valley. Please refer to Schedule 1 and 2 for additional details - average incremental change due to the infiltration pond is discussed (infiltration pond model simulation).
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."	Comment noted.	#53 and #54 are actually part of the same comment re. identification/naming of SW02.	Agree to disagree. Please refer to Schedule 1 and 2 for additional details.
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.]	The naming differs between Worthington 2006 and Tatham.	Response that this is a naming "difference" between Worthington and Tatham is not satisfactory. SW1 has always been SW1 going back to the original expansion studies.	Agree to disagree.

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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).	See Response 34. **Worthington Response** Agreed. EPM models do not simulate flow in individual fractures, of which there are millions in the area modelled, but that is not a drawback of the model, which is well suited for modelling flow in the aquifer under natural conditions and the changes in response to quarrying. It is not intended to model flow in the aquifer at a very local area (e.g. metres to tens of metres).	It appears Worthington agrees with my statement that flow in individual fractures can't be simulated but believes it doesn't matter as the model simulated aquifer response to quarrying. This does not exactly make sense as he seems to agree the response to quarrying can't be simulated in individual fractures (springs) or at very local scales. Springs are very local features fed by individual fractures – he seems to contradict himself that the EPM model can simulate changes due to quarrying but not for individual springs? He also seems to be contradicted by Earthfx's response to my comment # 41, page 12 which actually provides flow simulations for individual springs? Worthington's comment that the model "is not intended to model flow…at a very local area (e.g. meters to tens of meters)" is curious.	See previous response regarding our hybrid approach.
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.	Comment noted.	Earthfx "notes" my comment on continuous monitoring for springs C,G,H,J and K. I assume this means they will be undertaking such monitoring.	No. It means that a statement was made and we acknowledge that the statement was made. The AMP sets out the monitoring locations and schedule. Please refer to AMP Please refer to Schedule 1 and 2 (infiltration pond model simulation).
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.	Comment noted.	Earthfx "notes" my comment on minimum required water quality parameters for monitoring purposes – I assume this means they will incorporate into a revised AMP.	No. It means that a statement was made and we acknowledge that the statement was made. The AMP sets out the monitoring locations and schedule. Please refer to the latest AMP Version.
58.	Recommendation: • A detailed potentiometric surface should be provided.	One was provided	Earthfx responded to my request for a "detailed" potentiometric map by stating "one was provided". The only one available in the Level 1/Level 2 report (Figure 6.37) is not detailed. The scale of the map provided and groundwater level interval is much too small to be useful in a significant project such as this (see my comment re. response #187.	See response to #187

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59	Recommendation: • Dye trace(s) should be conducted between boreholes in the western extension and the same springs noted above in recommendation #1	**Worthington Response** Mr. Cowell does not explain the rationale for tracer testing between the western extension and springs in Medad Valley. Tracer tests (sometimes called dye tests because dyes are often the tracer used) are useful for (i) delineating flow paths such as checking which spring(s) are connected to a sinking stream, and (ii) for characterizing aquifer characteristics such as fracture apertures, spacing, and connectivity. Both types of test were carried out at the site and documented in the 2006 karst report. For the karst investigation documented in the 2020 report, it was decided to assess preferential flow in wells using a flowmeter and to profile electrical conductivity and temperature during a pumping test. It was decided that there was no need to do further tracer tests. Contour maps of measured and simulated water levels in wells (e.g. Figures 5.13, 5.14, 6.37, 6.38, and 7.2 in the April 2020 Earthfx report) all show that groundwater flow from the quarry area is towards the Medad valley, so tracer testing is not needed to understand the groundwater flow direction. The second reason for tracer testing would be to characterize fractures apertures, spacing, and connectivity. There has been substantial assessment of fractures in the aquifer in the 2006 and 2020 karst reports. A number of methods were used, including tracer testing, monitoring water levels at a spring for pressure pulses from quarry discharge, observation of flow from fractures in the existing quarry, profiling of flow, temperature and electrical conductivity in wells, packer testing in wells, and visual observations in wells using video and televiewer. There is no reason to suppose that fracture aperture, spacing, and connectivity is substantially different between the Western Extension and Medad valley, so tracer testing is not needed to understand flow in the aquifer. Furthermore there would be substantial challenges in carrying out such tracing, including: i) There are many domestic wells between the Western Extension and Medad valley. Consequently, it is possible that some of the dye would be intercepted by one or more of the domestic wells, which would not be desirable for aesthetic reasons (i.e. the tap water might be coloured by the dye). For this reason, it is rare for tracer testing to be carried out where there are domestic wells between an injection well and springs. ii) The distance between the wells in the Western Extension and Willoughby Creek varies from 250 m to 800 m. The distances to springs C, G, H, J, and K are even further. It is rare for tests with tracer injection into wells to be carried out over such long distances, and such tests often fail. For comparison, the 2006 karst report documents eight tracer injections into wells that were 14 - 24 m from a pumping well, with seven of the eight tests being successful. For the above reasons, the tracer testing suggested by Mr. Cowell is not recommended.	My recommendation of conducting a dye trace to the springs is withdrawn – I agree that there is a potential for domestic well interception.	RESOLVED
60.	Recommendation: • Following quarrying, the western extension should be rehabilitated to lakes.	A portion of the west extension is being rehabilitated to a shallow lake. As JART is aware, the existing approved rehabilitation plan for the Burlington Quarry requires dewatering to stop and the site to naturally flood to a lake with no off-site discharge. As part of the Burlington Quarry Extension application, Nelson agreed to modify the existing quarry rehabilitation plan to maintain off-site pumping to improve conditions for surrounding lands compared to existing approvals and maximize land area for future after uses. The proposed modification to the existing quarry rehabilitation also results in the West extension being maintained in a dewatered state.	A final lake in the western extension would ensure permanent flow to the springs in the Medad Valley and more resemble pre-development conditions.	This could result in adverse impacts to fish habitat supported by quarry discharge (as per DFO), although as noted earlier fish habitat has been impacted by the many in-line ponds and the dam between SW1 and SW2. Re: Medad Valley, please refer to Schedule 1 and 2 (infiltration pond model simulation).

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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.	Yes	My original comment #75 was not intended to be a statement of fact that I agreed with – my comment was taken out of context in the JART Response Table. Refer to my earlier comments pertaining to Halton Till permeability (especially comment #29).	RESOLVED
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).	The Executive Summary may have oversimplified a more complex observation. Dewatering for the West Quarry Expansion will direct flows to the North Discharge Pond. Some of this water is diverted to the proposed infiltration pond which will, as noted further in the summary, help preserve the current groundwater and surface water flow conditions created by this existing golf course ditch and pond system (i.e., groundwater discharge to the Medad Valley). The remaining water will be discharged to the unnamed tributary to Willoughby Creek and to the karst sink that also contributes to groundwater discharge to the Medad Valley.	Earthfx has not demonstrated that "all of its discharge [area of proposed west quarry extension] simply enters the Medad Valley in a similar manner to the current discharge." Model simulations/predictions have not been verified and Earthfx has no data on spring or stream flows within the valley.	All the groundwater is currently (baseline) intercepted and discharged to the creek or flows to the Medad Valley and discharges naturally. Under quarry expansion, different proportions of the water will be intercepted or discharge naturally. The statement is a general observation, not the specific outcome of a model simulation.
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).	See previous notes. It should also be noted that the hydraulic conductivity of the Halton Till likely varies spatially, but the variability may be random, or may be correlated with thickness, or with location (e.g., lowland versus upland). Insufficient data are available so a reasonable approach was to use a uniform value that felt close to a middle value in the wide range of reported field testing.	Earthfx agrees that Halton Till hydraulic conductivity "varies spatially" but states that the variability "may be random". This speaks to my concern that the wetlands are not universally underlain by impermeable materials ("aquitard") and thus are subject to having a hydraulic connection with the underlying bedrock aquifer. By noting the spatial variability Earthfx seems to leave the door open to such a hydraulic connection. Further, the "variability" although spatially random will be based on fundamental structural factors (roots, fractures etc.).	We concur that there are likely to be some fractures that span the till thickness and, just as likely there are areas that will have no fractures. The assumption is that the mean vertical hydraulic conductivity, taking into account the low probability of these extremes, is about $1.67x10^{-7}$ m/s, which is a reasonably high value for Halton Till. To address reviewers concerns with uncertainty, please refer to the AMP.
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).	Comment noted.	No Earthfx response. My original comment was intended to show that Earthfx's data also shows a rapid decline in wetland water levels (wetlands 13027, 13022 and 13037) which supports my contention that at lease some wetlands are hydraulically connected to the underlying bedrock aquifer.	It is inaccurate to relate the date at which some wetlands dry out to the rate at which water levels decline. Some wetlands hold little water and standing pools have limited depth and would therefore dry out sooner. Particularly if they are not being fed by groundwater.
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)	Comment noted.	No Earthfx response. My original comment was intended to point out that significant declines in head/shallow bedrock water levels are significant up to 650 m from the face of the quarry. This will impact wetlands in the proposed southern extension (that are hydraulically connected to the bedrock aquifer) as well a springs in the Medad Valley which are in the order of 200 m (or less) from the western face of the proposed western extension.	We agree to disagree. The effects of the quarry in all directions have been delineated by the integrated model. Re: Medad Valley, please refer to Schedule 1 and 2 (infiltration pond model simulation
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 is a potentiometric map of average simulated heads in March. We do not understand the question in reference to this figure.	Figure 6.37 is provided as a "potentiometric" map of average March heads. My primary point is that it is a useless Figure. To provide groundwater potential elevations at such a small scale with a 5 m interval is not acceptable. Potentiometric maps, in every groundwater report I have reviewed, are much more detailed with intervals of 1 m or even 0.5 m. Potential significant groundwater characteristics, such as groundwater troughs and precise groundwater divides can not possibly be portrayed at this small scale/imprecision.	We agree to disagree that these figures are "useless".

DARYL W. COWELL COMMENTS

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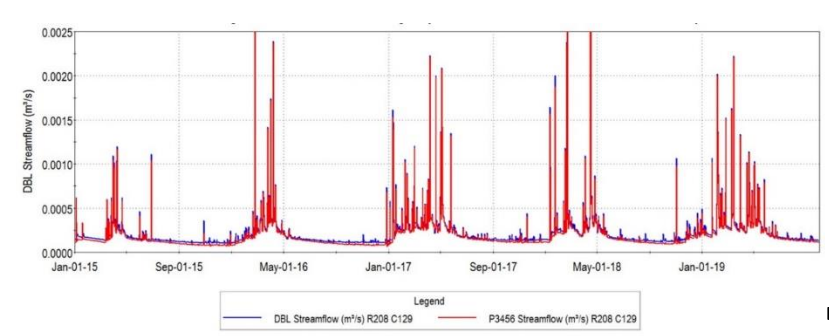
<tr><th></th><th></th><th></th><th></th><th></th></tr>
<tr><td>211.</td><td>The Level 2 Impact Assessment of the Hydrogeological Assessment report (Section 8) refers to the Medad Valley as a "significant discharge area" (Page 192, first paragraph). Table 8.1 specifically identifies the need to evaluate 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."</td><td>Comment noted.</td><td>No Earthfx response. The only "impact assessment" undertaken for Medad Valley springs in the Level 1 and Level 2 hydrogeological report are EPM model simulations of 'baseline' and post development conditions (e.g., P3456) of streamflow in the valley. There is no specific discussion of springs.

Within Earthfx's response to the original JART comment table, an upwards of 60% decline was noted at Spring J (comment #44). It is unclear how this was determined but if so would be significant and needs to be evaluated with regard to physical and biological/ecological impacts.</td><td>Please refer to Schedule 1 and 2 (infiltration pond model simulation) and the AMP.</td></tr>
<tr><td>212.</td><td>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.</td><td>Changes in groundwater and surface water flow to the Medad Valley were addressed in the simulations and analyses of model results.</td><td>The Earthfx response does not address the issue. Although there were some baseline post-development simulated flow data for Willoughby Creek, the impact assessment did not deal specifically with changes in spring flows (see comments #44 and 211). Simulations showed measured changes in post-baseline surface water flow. The PPS requires a detailed assessment of these changes on flora and fauna.

With the exception of the determination of estimated spring flows on one occasion (Worthington 2006), there is no data on spring flow either seasonally or through time.</td><td>Please refer to Schedule 1 and 2 (infiltration pond model simulation) and the AMP.</td></tr>
<tr><td>239.</td><td>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."</td><td>Comment noted.</td><td>No Earthfx response. My original comment was simply quoting Earthfx's hydrogeology Level 2 study. It is not intended as my position.</td><td>Comment Noted.</td></tr>
<tr><td>301.</td><td>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."</td><td>From a modelling perspective, we noted the presence of springs and "disappearing" streams and represented them as best as possible in the model. The representation of the subsurface flow is discussed in Response 120.



nsient measurements at these features for comparison. There are relatively small changes in the event-driven flows at the locations of the springs discharging to the Medad Valley under the different scenarios. For example, the figure shows simulated drought flows under baseline and P3456. There are small changes in the peak flows (0.1 to 0.2 L/s) and very small changes in the very small baseflows. There were no significant changes under P12. The cumulative effects of changes on flow in Willoughby Creek were discussed in the report.</td><td>My original comment remains valid – there are no data for spring flow other than Worthington's 2006 one-time survey and there are no data for Willoughby Creek flows. The figure you presented in the response, as well as Figures 8-49, 8-73, and 8-74 in the Level 1 and 2 report (and all other stream 'hydrographs') are simply two simulations compared to each other. Baseline does not include stream flow measurements in any form.

Where are the stream gauges on Willoughby Creek? Data?</td><td>Please refer to Schedule 1 and 2 for a detailed assessment of the Medad Valley.</td></tr>
<tr><td>303.</td><td>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.</td><td>Yes, there are discrete fractures that have become solution enhanced over geologic time. Where data were available, these were simulated explicitly. Otherwise, we believe the network of multiple short fractures and zones of moderately fractured bedrock behave as an EPM. There is likely diffuse discharge along the flanks of the Medad Valley wall as well as discrete discharge points.

The effects on the Medad Valley are discussed in more detail in the package of interdisciplinary tables integrating wetland and watercourse characterization and analysis that has been prepared and provided in Schedules B and C.

Worthington Response
The entire lower portion of the face would discharge groundwater if the aquifer were a porous medium. However, an EPM model explicitly assumes that an aquifer is not a porous medium, but behaves very similar to one for the purposes for which the model is used.</td><td>Which data were used to explicitly "simulate" the discrete fractures (which fractures?)?

What evidence is there for "diffuse discharge along the flanks of the Medad Valley"? What are the implications of these discharges to the existing springs which Worthington refers to as "small karst basins" (Worthington 2006, page 5).

Worthington's response is confusing. It is noted that if the aquifer were an EPM, the entire face would discharge water. It doesn't so it follows that the aquifer is not an EPM.

Worthington also notes that the EPM model "explicitly assumes that an aquifer in not a porous medium but behaves very similar to one for the purposes for which the model is used." Again, confusing is it an EPM or not? How does is explicitly assume that the aquifer in not an EPM in</td><td>Please refer to Schedule 1 and 2 for a detailed assessment of the Medad Valley.</td></tr>
</table>

DARYL W. COWELL COMMENTS

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).	Comment noted.	No Earthfx response. My original comment relates to earlier points that I made in comments #48 and 52 pertaining to the efficacy of the proposed groundwater infiltration pond proposed for the proposed western extension.	Please refer to Schedule 1 and 2 (infiltration pond results)

NORBERT WOERNS COMMENTS

Proposed Burlington Quarry Expansion
Interim JART COMMENT SUMMARY TABLE – Hydrogeology

Please accept the following as interim 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. **These interim comments will be finalized following the breakout meetings between JART and Nelson and any changes will be marked using "track changes". 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)	Applicant Response	Interim JART Response (February 2022)	Applicant Response (June 2022)
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 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.	We recognized that the bedrock in the immediate quarry vicinity (within several hundred of meters) or in the zone of influence of the pump test behaves more like a fractured rock than an EPM. The EPM approach is valid and extremely useful for predicting likely affects beyond the local zone, in this case extending from the quarry boundary to below the Niagara Escarpment. We used an innovative approach to better account for the effects of bedding plane and vertical fractures within the model by adding the extra fracture layers and the enhanced vertical connectivity in places to evoke a more fracture-like response in the quarry vicinity. The field data regarding mounding beneath the irrigation ponds are limited. Reasonable conservative estimates for the hydraulic properties of the accumulated pond sediments were made. The proposed infiltration pond will mostly be excavated to the top of the fractured bedrock and it was assumed that leakage from this feature would be higher than from the existing ponds.	It is agreed that groundwater within the area of greatest concern with respect to the influence of the existing and proposed quarry expansion (i.e., within a few hundred metres) is expected to respond as a fractured bedrock medium. The groundwater model is therefore expected to have limitations in providing accurate and reliable estimates of water level impacts from the proposed quarry expansion. More information and field data are required from the local private wells to provide more certainty with respect to the potential for impacts including water quality on local private wells.	Again, our hybrid approach was to represent discrete fracture zones and vertical fracturing to get a better match to observed response in the local area and to make the predicted assessment more accurate and reliable. The model considered and incorporated extensive field data that was more extensive and had a longer period of record than typical quarry expansion studies. The monitoring and protection of the domestic water wells is regulated by the Ministry of Environment, Conservation and Parks (MECP). As noted, upon licensing a detailed water well survey will be completed to ensure that we have accurate information on the key receptors, such as well location, well depth, historical water issues (quality and quantity), available drawdown, etc. Until residents participate in this survey, additional information cannot be obtained. . This work will be a condition of the ARA license as well as a requirement for any future ORWA applications to be submitted and reviewed by the MECP.
7	The hydrogeological analysis has failed to address the potential for groundwater and surface water contamination and is therefore incomplete.	The exiting quarry has been operating for over 70 years without contamination of surface water or groundwater resources. Private wells operate immediately adjacent to the existing quarry without impact. Quarry discharge has been used extensively for downstream golf course operation and ecological function. There is no planned change in quarry operations and therefore there are no expected impacts on groundwater and surface water quality. Water quality monitoring is discussed in the AMP, with additional data and discussions in our response to the MECP comments.	The impact on groundwater quality from the proposed use of the infiltration pond for the proposed quarry western extension has not been demonstrated. Questions remain regarding the effectiveness of this infiltration pond in maintaining water levels in downgradient private wells and potential impacts on well water quality. In addition, measures to protect groundwater quality within the quarry ponds and sumps from significant potential sources of contamination such as the adjacent Sun Oil pipeline have not been adequately addressed.	We respectfully agree to disagree. The golf course ponds have been in operation for several decades, which rely on the quarry discharge as the primary source of water. The same water will be infiltrating as currently occurs. Water quality data were re-examined in response to this comment (See Schedule 1). There were no water quality issues in monitoring and private wells close to the quarry and downgradient from the golf course ponds. The only issues identified related to water quality samples were indications of road salt contamination away from the quarry. The model was originally developed with these ponds as aesthetic features (ponds were built on existing grade with till beneath). However, since recognizing that the ponds are responsible for raising water levels in the bedrock system, the model has been updated with these ponds functioning as infiltration ponds (model now has these ponds on the weathered bedrock surface). The model was primarily updated to look at springs in the Medad Valley but can be used to look at groundwater mounding beneath the ponds. Please refer to Schedule 02. (Updated model results)
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.	See response to comment 7. Quarry discharge is currently diverted into the golf course pond system where a portion likely leaks to the groundwater system (or infiltrates as part of the irrigation operations). This discharge has been successfully used to support golf course operations for over 50 years without impact to surface water or ground water quality. The proposed infiltration pond system will function in the same manner as the golf course pond system. Water quality monitoring is discussed in the AMP, with additional data and discussions in our response to the MECP comments.	There are no groundwater quality data presented from the Golf Course lands to support the contention that there has been no impact to groundwater quality. There are also no field data to demonstrate the extent to which the existing Golf Course Pond is infiltrating the groundwater system.	We respectfully agree to disagree. Water quality results from domestic wells, the quarry discharge, the golf course ponds, etc. have been provided to JART along with our assessment (See Schedule 1). As noted above, there were no water quality issues in monitoring and private wells close to the quarry and downgradient from the golf course ponds. Furthermore, water is continuously entering the golf course ponds from the quarry sump which indicates that there are water losses beyond evaporation.
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	An extensive discussion of the testing, analysis and simulation of the Halton Till is included in our response to the MNRF comments, and provided as Schedules B and C. Included is a detailed presentation of the calibration to shallow minipiezometers. Estimating hydraulic properties of the overburden and the interconnection of the overburden with underlying bedrock was a key component of the model calibration	The wetland water levels did not show a measurable response to the Golder Pumping tests conducted in 2004 and 2006. This could be due to a number of factors including time lag, limited duration pump test, and a substantial surface water reservoir that may have buffered the pumping test impact on the wetland. A possible snow melt condition may also have influenced the wetland water levels. The possibility of return pump discharge flow cannot be discounted due to the relatively flat topography of the area. A number of the overburden monitors (i.e., C series monitors) did however show a measurable	We respectfully agree to disagree. One can propose any number of extraneous factors for a false-negative response where the monitoring shows no connection but one presumes that there a connection exists. A simpler explanation is that the monitors were installed correctly, that the pump test stressed the aquifer until equilibrium was reached, and that the wetlands are generally perched above low-permeability sediments and sparsely fractured Halton Till.

	monitor the overburden units during this pump test to determine the degree of hydraulic connectivity between overburden and the underlying bedrock.	effort. Hydraulic testing (single-well testing) of the units yielded a wide range of possible values with no recognizable pattern (as discussed in our MNRF response). The model calibration focused on obtaining appropriate mean values for these units. Previous testing by Golder work went through a number of phases, but final conclusions were that the wetlands did not respond to pumping.	response to pumping from the underlying bedrock during both the 20004 and 2006 pumping tests completed by Golder Associates (Golder). This suggests a hydraulic connection between the overburden and the underlying bedrock. Since these shallow overburden monitors were advanced to the top of the bedrock, the question remains, is the response representative of the overburden, the bedrock or both? The pump test completed by Azimuth was not able to shed light on this as no overburden monitors were included in the pump test. The Earthfx report and the wetland characterization attached to this table, points to the lack of a water level response in the wetland and the shallow mini-piezometer as evidence of hydraulic isolation of the wetland from the underlying bedrock. Alternative explanations of this lack of response are proposed. It is suggested that the hand auger hole construction of the mini-piezometers may have smeared the borehole thus muting the hydraulic response to the pumping tests. The relatively fine grained nature of the shallow soil underlying the wetlands would naturally have low hydraulic conductivity which would result in a delayed water level response from pumping the underlying bedrock. The pumping test may have been of insufficient length to provide a water level response in the mini-piezometers. The fine grained nature of the soil directly underlying the wetlands are expected to be subjected to periodic drying during seasonally dry periods. Fracturing of fine grained soil during drying is commonly observed due to shrinking clay particles. This process is expected to provide opportunities for direct hydraulic connection to the underlying overburden and bedrock. Water levels measured by Tatham in the shallow groundwater under wetlands 13027, 13022, 13016, and 13031 show groundwater levels seasonally above ground surface which indicates seasonal discharge conditions.	Our response to MNDMNRF (March 2021) provided hydrographs clearly showing wetland water levels and hydroperiod that unchanged by the advancing quarry face. Further, included model simulations hydrographs match exceptionally well. In our response to similar comments, we noted that where the wetlands are not perched, the sparse fractures allow heads to equalize and over time but the volume of water transmitted by small, sparse fractures is small. Our conservative modelling analysis assumed greater connection than is likely and, therefore, generally over-estimated the degree of impact of quarry expansion on the perched or connected wetlands. Regardless, the updated Adaptive Management Plan address any uncertainty that may come out of the work completed by Earthfx and Tatham.
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.	A package of interdisciplinary tables integrating wetland and watercourse characterization and analysis has been prepared and provided Schedules B and C. Included in those tables are additional long-term hydrographs. The groundwater level and other monitoring data from this and previous studies were assembled and uploaded into a project database to facilitate analysis and to allow data to be shared across disciplines. We can work output this data in other formats, if needed. The data from previous studies are also available in the scanned Golder reports. No data was "missing" and all was included in the database and used in the analysis. Not all data is insightful or even useful, however, and we feel "padding" the report with low value information only serves to confuse the inexperienced reader and waste the valuable time of the review team. We recommend the industry proven VIEWLOG and Sitefx Integrated modelling and data management systems if you are having difficulty managing the complex data. Virtually all the maps, cross sections, well logs, and hydrographs in the report were prepared in VIEWLOG with full integration between the relational database and transient model. We would be happy to answer any specific questions about the data.	For review purposes, it would have been useful to have included in the hydrogeological report some of the key hydrographs from the previous Golder studies, particularly those from two pumping tests, one completed in late February and early March, 2004 and the second completed in February 2006. Some of this information is provided in the attached response to MNRF.	We respectfully agree to disagree. JART reviewers have already reviewed and commented on the Golder work under a different ARA application. Work completed by other professionals is commonly referenced in technical studies. If it is known that this work has already been reviewed, it is unclear why this information needs to be presented and reviewed twice. However, we did present all available data as hydrographs in our meeting with JART team members.
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.	Additional details about the well survey are included in the AMP document (together with a map showing the locations that responded). The AMP also states that a follow-up well survey will be completed at a later date due to again invite well owners to participate. The seven wells to which access was provided in the first survey did not provide significant insight beyond the publicly available well record. Additional documentation could be provided now, however the AMP states that Nelson's website will have a page dedicated to Private Well Monitoring details once the second survey is complete.	A summary table with the well survey results along with well record information (i.e., bole log) would be useful to assess the viability of the recommended mitigation measures for private wells, specifically the deepening or replacing of impacted wells as outlined in the AMP.	See response to Comment #8
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.	Long term hydrographs illustrating the monitoring nest gradients are included in the package of interdisciplinary wetland and watercourse characterization tables that have been provided in Schedules B and C. Extensive documentation of the observed stage and minipiezometer data, in comparison to the simulated shallow wetland response, is included in our response	The response to MNRF provides additional information and a detailed discussion of hydraulic conductivity of the overburden materials. Most of this is based upon work completed by Golder and Associates. The issue of hydraulic connection between the bedrock and the wetland is discussed using the Golder pump test data. As noted in comment 9, the lack of response in the wetland water level and shallow mini-piezometers is provided as evidence of hydraulic isolation of the wetland from the underlying bedrock	We respectfully agree to disagree. Our MNDMNRF response contained hydrographs and model results that extend significantly beyond the time frame and analysis provided by Golder. The extended monitoring and modelling clearly show that the wetlands are not impacted by the advancing quarry face.

		to the MNRF comments (Schedules B and C). The results indicate that the model is very closely matching the shallow soil moisture levels that control the vertical gradient to the lower system. The numerous transient hydrographs presented in the Level 2 report indicate that model is replicating the complex seasonal and interannual water level fluctuations in the underlying bedrock. The integrated model explicitly represented the hydrologic and hydrogeologic conditions in 22 wetland areas. The model match to the observed staff gauge, minipiezometer, and well data was examined for each of the instrumented wetlands. Water budgets were formulated for the baseline conditions and compared to those formulated for each quarry extension scenario. We know of no other quarry impact assessment with this level of detail and comprehensive analysis of predicted wetland response.	during the pumping tests. It is noted that the mini-piezometers were completed by hand auger mostly into fine grained clayey silt materials. The hydraulic testing could be influenced by the method of piezometer installation and may not be representative of the in-situ hydraulic conductivity. Completion of hand auger holes in fine grained materials often result in smearing of the borehole thus restricting groundwater movement and masking the actual hydraulic response.	Driving wells into fine grained sediments can cause smearing. It was assumed that normal procedures for developing the wells were followed. It was further assumed that the lack of response in the wetland water levels and minipiezometers was due to a lack of response in the wetland.
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.	As noted, our wetland characterization tables and response to MNRF comments (Schedules B, C, and D) provide extensive additional information for each wetland. Earthfx Section 2.2.1 in that document provides details on over 62 minipiezometers, soil core boreholes, and Guelph Permeameter test locations. Table 13 lists twelve of the key wetlands that have one or more minipiezometer, including MNRF Wetland 13033, which has 5 minipiezometers. Simulations allowed us to extend the analysis to other wetlands.	It is acknowledged that a number of wetlands have been previously instrumented by Golder. Only 5 of the 22 wetlands referred to have received recent instrumentation by Tatham. The newly installed boreholes and groundwater monitors on the proposed western extension are not directly associated with wetlands. It is noted that hydrographs of the shallow groundwater monitors installed by Tatham (SW5B, SW11B, SW12B, SW13B and SW16B) all showed seasonally high groundwater levels above ground surface. This is indicative of potential seasonal groundwater discharge conditions and contradicts the conclusion that these wetlands are hydraulically isolated from the groundwater system as indicated in the attached wetland characterization tables. See comment 9, 13, and 99.	No, seasonally high water levels are consistent with enhanced runoff during the spring freshet.
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	The report does, in fact, clearly delineate the "cumulative effects" of all existing and proposed excavations in the water level maps and hydrographs presented for each development scenario phase. The results were presented in terms of absolute water levels and streamflows, not just in terms of change, so the cumulative impacts were fully taken into consideration. We also present incremental drawdowns from a fully transient 10-year baseline, and both average and minimum remaining available drawdown in the aquifers. As noted above, there is limited value in presenting the incremental drawdown from the pre-quarry 1953 conditions to current conditions because data from prior to 1953 is extremely limited. The purpose and scope of this study was to examine the likely impacts from future expansion and rehabilitation and the existing quarry effects are already approved under the existing license. Finally, our simulations of Rehab Option 2, allowing the quarry to fill as a lake, can provide some insight into the water levels and streamflow patterns under unmanaged conditions.	The existing conditions as defined in the Earthfx report includes the impacts of the existing quarry. This condition is determined by Earthfx to be the 'baseline condition' upon which the impact assessment was defined. and as such provides a quantification of the change from the current condition to the proposed quarry expansion conditions. What is not defined is the impact that the current "baseline' condition has had on pre-quarry conditions. This has relevance for the proposed preferred rehabilitation scenario which will perpetuate the current conditions. This will require a revision to the already approved closure plan for the existing quarry. It is likely that the approved rehabilitation and closure plan for the existing quarry will result in conditions that more closely align with pre-quarry conditions compared to the preferred rehabilitation scenario which is expected to perpetuate pumping from the quarry excavation and the existing surface water and groundwater impacts Calibration of the integrated surface/groundwater model to the available groundwater and surface water data, should make it possible to provide a reasonable estimate of pre-quarry conditions. Proposed rehabilitation scenarios include the existing quarry as well as the proposed expansion and should therefore be compared to pre-quarry conditions. This would provide a clearer picture of the relative merits of the proposed quarry rehabilitation scenarios.	As we noted, the baseline selected represented a stable period where the quarry has expanded to its licensed footprint and no further drawdowns due to ongoing operations are expected. The RHB1 option considered the effect of creating a new landform that would require continued dewatering. The RHB2 option considered halting dewatering and letting the quarry fill back to a new equilibrium level. The model simulated these options and presented likely groundwater levels, streamflows, and wetland water balances under the two options so that they could be compared.
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.	As noted in the report, (Section 9.4.2), the purpose of this background monitoring well at 2377 Colling Road is to document the natural variability of the groundwater elevation fluctuations and trends under various future climatic conditions. The well is located on the northwest side of the quarry, well away from the extension area. Modelling analyses showed that this background monitoring well would not likely to be affected by the proposed quarry extension. As noted in the previous comment, the quarry has been in existence since 1953. Changes in water levels may have occurred over the years in response to excavation within the quarry footprint and changes in water management operations.	Background monitors are generally considered to represent areas unaffected by an anticipated impact from proposed development. As stated in Section 9.4.1 of the Earthfx report, "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." This private well may be useful in achieving the purpose of defining seasonal variations in groundwater levels, however, without a considerable period of record of water levels, it may not be possible to determine whether this well has been impacted by the existing quarry and whether these impacts are continuing to influence water levels within this well. Such conditions could affect the usefulness of this well as a 'background monitor'. Active use of this well could also limit its usefulness as a background monitor.	Given that there are no other upgradient wells with data, an upgradient well with 2 years of record is extremely useful. Despite this, a new well will be installed. Please refer to the AMP, which recommends that the background monitoring well be installed on Conservation Halton lands.
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	It is correct that the current conditions represent baseline conditions. Predictions of absolute water levels and streamflows as well as changes in streamflow and groundwater levels (drawdowns) through the Scenario analyses were compared to current baseline conditions. (See response 15 for more discussion)	See response to comment 15.	We respectfully agree to disagree. See our reply to follow up comment 15.

	quarry and relevance to closure requirements of the existing quarry licence. This should be included in the report.			
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.	The purpose of the infiltration pond is to replace the golf course ponds that contribute to groundwater recharge in the area. The new infiltration pond will be constructed in good hydraulic contact with the bedrock surface and almost certainly will provide higher leakage than the golf course ponds that have over 50 years of accumulated sediments. The infiltration ponds were fully represented in the model scenarios, and simulate all surface water and groundwater flow paths through all layers (including interflow in the soil zone, seepage, and runoff). This full representation of surface water and groundwater flow is fundamental to an integrated model such as GSFLOW, so it was fully accounted for in the model. (Leakage and recirculation of a portion of the infiltrated water back through the excavation is fully represented in the model.) Water quality is discussed in Response 7 and 8.	The hydrogeological report states "the newly constructed infiltration pond, which will locally support groundwater levels in a similar manner to the current golf course ditch and pond system. " (Section 8.7.5, Earthfx page 243) What field data is there to support the conclusion that the existing golf course ponds support groundwater levels? It is assumed that one of the functions of the proposed infiltration ponds is to assist in maintaining groundwater levels in down gradient wells. To what extent has the model considered interception of infiltrated groundwater from the proposed infiltration ponds by granular materials overlying the bedrock? The assessment of water quality in Appendix A, Section 15.6, Hydrogeochemical Testing, is focused on identifying the source and type of water. "The water quality package is a standard package routinely utilized to characterize the water type and can be used to identify aquifer recharge areas, aquifer flow processes, and the degree of hydraulic connection between differing aquifers." Section 15.6 ,1st paragraph, page 397). The Earthfx report should consider the drinking water implications of infiltrating quarry sump water for down gradient private wells. Golder Associates (S. McFarland Witness Statement 2010, Appendix F and G) has provided an analysis of groundwater and surface water quality in the vicinity of the proposed southern quarry extension with respect to exceedances of Ontario Drinking water Quality Standards and Provincial Water Quality Standards (for surface water). Although the Hydrogeological Report by Earthfx and the AMP identify groundwater and surface water monitoring locations and water quality parameters to be monitored, a discussion of critical chemical parameters and the identification of threshold water quality levels for protection of downgradient groundwater quality in private wells are missing.	Refer to response #6. The operation of the infiltration ponds will mimic what has been in place for several decades (golf course irrigation ponds). Modelled calibration to water levels shows mounding beneath the pond system which is indicative of groundwater recharge. Water quality has been discussed several times and we believe this comment has been addressed. Specifically, water quality results from domestic wells, the quarry discharge, the golf course ponds, etc. have been provided to JART along with our assessment. There were no water quality issues in monitoring and private wells close to the quarry and downgradient from the golf course ponds. For additional discussion of the pond functions and water quality, please see the attached schedules.
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.	The restored elevations in the P12 pond are generally (1-3 m) lower than the baseline groundwater levels. Seepage into the quarry area would therefore be less than under current conditions. Seepage is fully represented in the integrated model. The northern portion of P12 is "benched" to create a step-down profile so that a beach and gradual entrance to the deeper water will occur. Similarly, rehabilitation sediments have already been placed along the south face of the existing quarry (across the road from P12). The benching and rehabilitation has created a gradational profile and support for the south wall.	The impacts of a fracture halo around the edge of the proposed southern expansion and the impact this may have on hydraulic connection and seepage between the proposed pond and the existing quarry excavation should be considered. The revised site plan for the existing quarry (MHBC Draft revisions April 2021, Sheet 3 of 4, attached to the Progressive and Final Rehabilitation Monitoring JART Summary Table) shows a vertical quarry wall adjacent to a part of the proposed Southern Extension. The potential for enhanced seepage through and long-term stability of the intervening rock mass should be evaluated as part of the site rehabilitation and closure of the aggregate operations.	Blasting technology has advanced to the point that significant blast effect hydrogeological halos are not observed or expected. The south wall of the existing quarry is already partially rehabilitated in the area of P12. This, together with the significant benching in the P12 excavation area, will limit any seepage.
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.	The question is not clear but we suspect that this refers to AMP thresholds. Please refer to the companion AMP discussions in the MECP response to comments (attached as Schedule A). Input to the model consisted of 10 years of climate data that reflect current climate conditions including drought years. The model was calibrated to match the available groundwater observations, groundwater response to quarry development, streamflow data, and soil zone response. It is expected that the range in response predicted by the model should be close to what is likely to occur under a variety of climatic conditions within the range of those observed between 2004 and 2019. It was recognized that shallow wells will be more sensitive to drawdown effects from the quarry expansion. It is expected that these wells may need to be deepened if they are impacted under drought conditions. A number of maps showing the available drawdown were included to demonstrate that shallow wells could be deepened.	The periods of missing groundwater monitoring data include the period between 2004 to 2008 and between 2013 and 2019. To what extent do these data gaps in groundwater level monitoring affect the reliability of the simulated groundwater levels or limit the simulations to represent the climatic range of conditions occurring during these data gaps? Given there are no threshold levels identified for shallow wells, it is assumed that shallow wells will be included in the mitigation measures outlined in the AMP that are triggered by the threshold levels being achieved in the bedrock monitors. Since shallow wells are recognized as being more sensitive to drawdown effects from the quarry, they should receive priority with respect to proactive well mitigation measures and water well complaints.	Level 1 and 2 Hydrogeological Assessments that are completed to support an ARA license typically only rely on one full year of monitoring data. The Burlington Quarry extension has one of the most extensive water level databases used to support an ARA application. Therefore, we disagree that the assessment contains "data gaps" that would limit the reliability of the simulated groundwater levels. In any case, the data before and after the gap are highly consistent. Please refer to the AMP with regards to the groundwater threshold values.
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.	Technically," *the assessment report must address the potential effects of the operation* (in this case, the quarry expansion) *on any groundwater and surface water features located within the zone of influence, including but not limited to:* *a) water wells (includes all types e.g. municipal, private, industrial, commercial, geothermal and agricultural)* *b) springs (e.g., place where ground water flows out of the ground)* *c) groundwater aquifers;* *d) surface water courses and bodies (e.g., lakes, rivers, brooks)*	Since the proposed rehabilitation plan for the quarry extension ties the existing quarry rehabilitation plan with the proposed expansion, the requirements of the rehabilitation plan for the existing quarry and the rational for these requirements are relevant to the proposed quarry expansion. This is particularly relevant as the approved rehabilitation plan for the existing quarry is to be changed. The implications of the proposed changes to the rehabilitation plan for the existing quarry on the groundwater system and natural environment should be evaluated against the original requirements for closure of the existing quarry. This requires an understanding of the history of the existing quarry	Agree to disagree.

		e) wetlands *The assessment must include but not be limited to the following:* *f) a description of the physical setting including local geology, hydrogeology, and surface water systems;* *g) proposed water diversion, discharge, storage and drainage facilities;* *h) water budget (e.g. how water is managed on-site);* *i) the possible positive or negative impacts that the proposed site may have on the water regime;* *The Level 2 water report must also contain:* *j) monitoring plan(s); and* *k) technical support data in the form of tables, graphs and figures, usually appended to the report."* Please refer to Response 15, above The report is a stand-alone study that focused on the impacts of the expansion that took into consideration approved impacts of the existing quarry. It was beyond the scope of the Level 1/2 study to recreate or analyze pre-development conditions. That said, the report provides estimates of predicted water levels and flows which incorporate the existing quarries effects, as opposed to just the change in flows and heads, as other quarry reports we have seen tend to do.	operations and the environmental conditions of operation and closure for the existing quarry.	
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.	See response 77, above	See comment for item 15 and 77.	This comment has been addressed multiple times and in meetings with the JART team. At this point, we respectfully agree to disagree.
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 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.	Comment noted.	The absence of meaningful input to the Terms of Reference due to the production of the terms of reference after completion of the reports has resulted in deficiencies in the scope of investigations.	We respectfully agree to disagree. It is not unusual to begin collecting field data and conducting feasibility studies for a land development or quarry expansion prior to announcing the development plans.
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.	A data gaps section could have been added; however, as the reviewer notes, the data gaps are discussed further on in the text. Additional long term hydrographs are presented in our response to the MNRF comments (Schedules B, C, and D).	Comment noted. See comment 14, 86, 132, 140, 159, 191, 217, and 235.	We respectfully agree to disagree. Reference to comment 14 is not relevant. Please refer to comment #20.
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.'	Please refer to Response 15, above.	See items 15 and 77.	We feel that the issue surround "baseline conditions" has been addressed.

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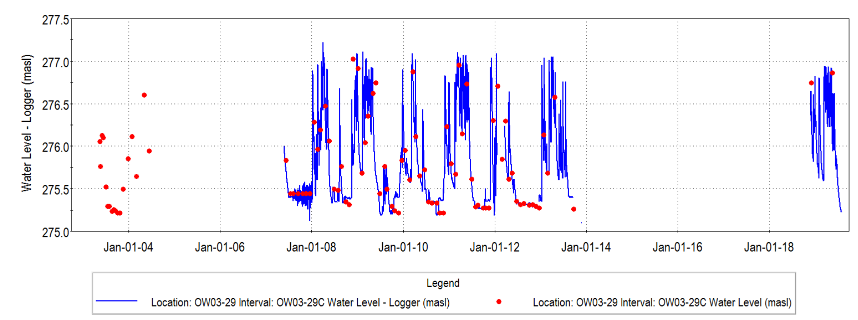
	Current conditions may be appropriate for assessing impact of the proposed extensions to the existing quarry. This does not however address the impact of the existing quarry operations. The cumulative impact of the existing quarry and the proposed quarry extensions should be considered for purposes of evaluating impacts on private wells, natural heritage features and rehabilitation options.			
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.	Please refer to our Response 7, above. As a general statement, dewatering for the quarry will result in inward gradients. This minimizes the risk of contaminants introduced into the subsurface from migrating offsite. The exception would be related to the infiltration pond which would infiltrate water discharged from the north sump. Water quality monitoring requirements for the quarry discharge would apply.	Impact assessment of the quarry expansion, especially the western expansion area, remains incomplete without addressing the groundwater quality issues associated with infiltrating quarry sump water to maintain down-gradient private well water supplies.	Water quality has been discussed several times and we believe this comment has been addressed. Specifically, water quality results from domestic wells, the quarry discharge, the golf course ponds, etc. have been provided to JART along with our assessment (Schedule 1). There were no water quality issues in monitoring and private wells close to the quarry and downgradient from the golf course ponds.
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.	Periods of record varied for each well and measuring point. A table of start and end dates for wells near the wetlands has been prepared for MNRF and are included as Schedule D. There are significant (multi- year) gaps in most of the data sets as shown below. This information was presented in the comparative hydrographs provided in the report.  The benefit of our continuous integrated modelling approach is that model results can be compared to available data even if there are gaps and non-overlapping surface water and groundwater measurement periods. Please also refer to Response 10 and 11, above.	Limitations of existing data gaps on the integrated model should be clearly stated in the reports. See comment 14, 81, 132, 140, 159, 191, 217, and 235.	We agree that there are data gaps in the data since 2003. As was noted earlier, most quarry expansion studies typically rely on 1-2 years of data. We do not feel that the data gaps adversely affect the model integrity.
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.	This is a reference to the changes that occurred as the active quarry face progressed with respect to observation wells on the south side of the quarry. Please refer to Figure 5.12 and Section 6.11.3 of Earthfx, 2020. For additional detailed discussions about quarry advancement please refer to Section 4 (Long Term Observation of Wetland and Quarry Interaction) of the Earthfx Response to MNRF comments. Little data are available for the period prior to the instrumentation in the south and gaps exist in the subsequent observations. Significant effort was made to extract useful information from this limited data set.	Figure 5.12 shows water level change in monitoring well OW03-14 between 2003 and 2012 with data gaps between May 2004 and August 2007 as well as between 2008 and August 2018. See Comment No. 69 above. The available data shows a drop in water levels of about 14 m. It remains unclear what changes in dewatering occurred historically and whether the zone of influence of the existing quarry has stabilized.	As was noted, the quarry has expanded to its licensed footprint and no further increases in dewatering or significant changes at the active face are expected. This stable baseline condition is the starting point of our analyses of changes expected due to the proposed quarry expansion and site rehabilitation.
89	Typo. Location BS-063 should be BS-03. Also note that BS-06 is missing on this figure.	BS-03 and BS-06 are so close that their labels overprinted and appeared as BS-063. The map below shows the well locations. 	Clarification provided.	RESOLVED

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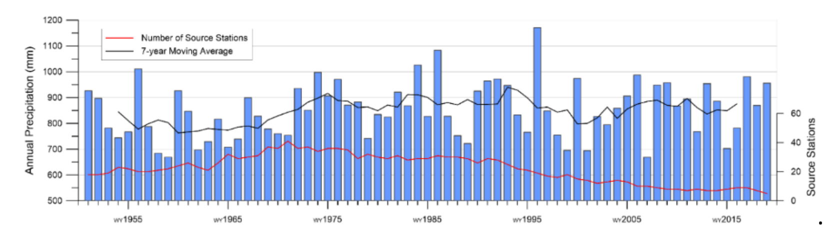
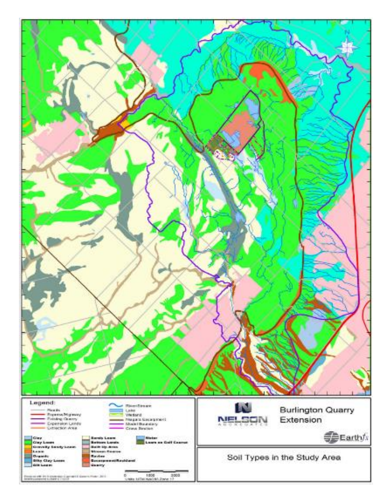
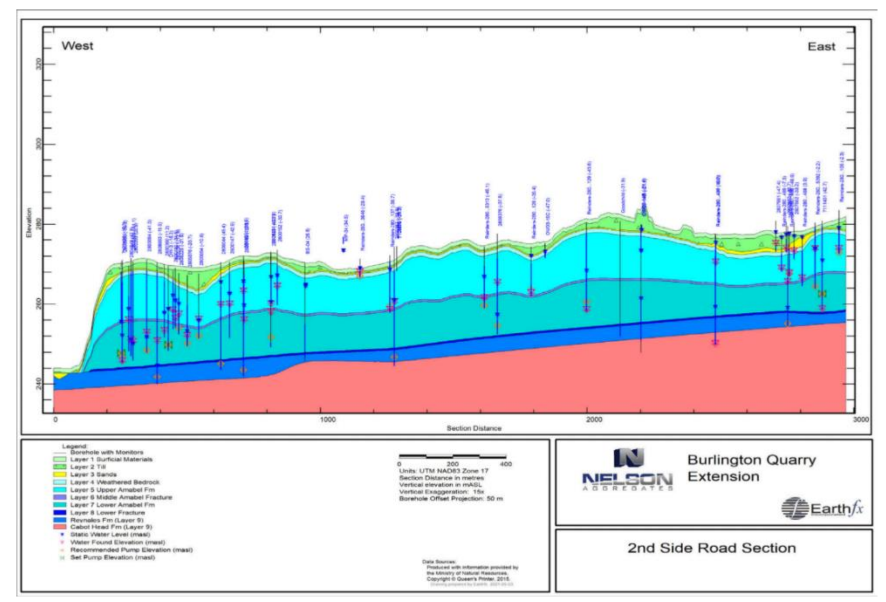
90	Model layers should be labelled on this figure for correlation to hydraulic conductivity results from packer testing.	Model layering had not been introduced at this point in the report and would have complicated the figure .	Figure 3.7 could have been modified with the packer test information and model layers added and presented at an appropriate location in the text. Reference to the model layer could have been included in the text. This would have provided a useful visualization from a peer review perspective in order to more fully understand the model layer development. The bedrock formation names presented on this figure had also not been introduced at this point in the report.	Packer test data were discussed in Section 5 and Figures 5.6 – 5.8 present packer data with respect to model layers. We feel the discussion on model and layer development was clearly communicated.
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	Please refer to Response 4, 6 and 18, above. It is unlikely that the wells, as you note, *"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".* Golf course irrigation is limited to the summer months and the 50+ year old ponds are likely infilled with silt and fines that would limit leakage. Early simulations with and without the infiltration pond showed that higher drawdowns would occur in the absence of the feature, indicating that the feature would mitigate the effects of quarry. The design of the pond was adjusted by Tatham based on feedback from the modelling results and the extents of the pond were increased. There are no field data available as the pond has not been constructed, but creating an infiltration system that is more effective than a 50-year-old pond network will not be difficult. The principal of the design was to replace the limited infiltration from ponds excavated into the Halton Till containing accumulated sediments with a pond excavated to the top of the weathered bedrock. Significantly higher infiltration rates would be expected.	As noted, no field data exists to support the assumption that the existing golf course ponds are providing infiltration to the groundwater system. Since the purpose of the golf course ponds is to provide irrigation water for the golf course, it seems reasonable to assume they were constructed to minimize water losses by leaking or infiltration to the groundwater system. The effects of the proposed infiltration ponds are simulated based upon assumed and generalized local hydrogeological conditions. Figures 5.13 and 5.14 in the Earthfx hydrogeological impact assessment report show groundwater levels in the shallow and deep groundwater wells. Water levels contours in the proposed western extension area indicate a groundwater flow direction toward Medad Valley and the various private wells along Cedar Springs Road. Groundwater flow direction has been described as "In general, groundwater flow is radially outward from Mt. Nemo; however, the flow direction is predominantly to the southwest towards the Medad Valley' in the quarry vicinity (section 5.3.2, page 109, Earthfx 2020). The highest groundwater levels are reported to be at Mount Nemo which is a topographically high area surrounded by low lying areas. Groundwater within the Amabel formation beneath Mount Nemo is therefore logically derived from infiltration of precipitation falling within this area. The Amabel formation is truncated around Mount Nemo as shown on geological cross section along 2nd Side Road, Figure 3.21. Lateral groundwater flow in the vicinity of the quarry within the Amabel Formation is therefore limited to within the Mount Nemo area and is expressed as seepages and springs around the periphery of Mount Nemo and as seepages into the existing quarry along the quarry walls. Removal of the majority of the Amabel formation in the proposed western quarry extension area will further disrupt lateral groundwater flow toward the private wells along Cedar Springs Road adjacent to the proposed quarry extension. (See Figure 3.22) This will place heavier reliance on up-gradient infiltration to support the groundwater system down-gradient of the proposed western quarry extension. Private wells along Cedar Springs Road adjacent to the proposed western quarry extension are at significant risk of disruption from the proposed western quarry extension. The lack of field data in support of an important mitigation measure intended to compensate for disruption to private well water supplies provide a high degree of uncertainty with respect to the feasibility of this mitigation measure. Reliance upon model predictions of impacts on private wells is fraught with uncertainties due to generalized assumptions of site conditions upon which the model is based. Field data of groundwater conditions including pilot testing of infiltration measures along with groundwater tracing and private well response to infiltration measures is required to provide a reasonable measure of certainty with respect to the proposed mitigation measures for down gradient wells. In addition, detailed water quality testing of local wells and quarry sump discharge would be required to assess the suitability of infiltrating quarry sump water to maintain groundwater levels in order to support water supplies for down gradient wells.	In follow-up discussions with JART and MNDMNRF, we presented simulations of P3456 with and without the infiltration pond to quantify the incremental change in water levels, streamflow, and upward gradients in the Medad Valley. The assumptions in representing the pond were conservative and had the Halton Till underlying the pond. Additional analyses were made at the request of MNDMNRF to determine the effects of deepening the pond by excavating through the till. Model results indicated that, as might be expected, upward gradients would generally increase in the Medad Valley. Please refer to Schedule 2 which discusses the infiltration pond in detail. Regardless, the updated AMP includes additional monitoring wells in the Medad Valley.
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.	See response to Comment 90	Suggested addition of model layer on Figure 3.35 would provide clarity and facilitate peer review. See response to comment 90.	See response to #90.
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. 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,	Wells that penetrate to the top of bedrock (i.e., overburden/bedrock monitors) would be more likely to reflect the effects of water level change in the bedrock than short-screen wells carefully sealed into the centre of the unweathered Halton. Golder (2006) noted that *"No water level response was observed in the piezometers completed in the shallow overburden sediments or standing water staff gauge locations at ground surface. This indicates that the hydraulic connection between standing surface water in the wetland and groundwater resources in the bedrock is weak".* That said, it is recognized that the Halton Till is an aquitard in the sense that it **limits**	There appears to be sufficient information to demonstrate a hydraulic connection between the surface wetlands and the underlying bedrock. Shallow monitors installed by Tatham including SW5B, SW11B (wetland 13027), SW12B (wetland 13022), SW13B (wetland 13016), SW16B (wetland 13027) showed shallow groundwater levels seasonally above ground surface at the corresponding wetlands. This demonstrates seasonal discharge conditions and hydraulic connection between these wetlands and the shallow groundwater system. These wetlands therefore cannot be considered hydraulically isolated from the groundwater system as described in the wetland characterization attachment to the JART Hydrogeological Table of comments and responses from Nelson. Corrections should be made to the wetland characterization tables for the above noted	We respectfully agree to disagree. In our response to similar comments, we noted that where the wetlands are not perched, the sparse fractures allow heads to equalize and over time but the volume of water transmitted by small, sparse fractures is small. Our conservative modelling analysis assumed greater connection than is likely and, therefore, generally over-estimated the degree of impact of quarry expansion on the perched or connected wetlands. Regardless, the updated and approved Adaptive Management Plan addresses any uncertainty that may come out of the work completed by Earthfx and

	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.	the degree of interaction between the shallow overburden and the bedrock. There is likely to be some vertical fractures that span the unweathered till. This is why Golder observed a general response away from the wetlands to recharge events, which occur over a wide area, but no response to local pumping. That is why a relatively high ($5x10^{-7}$ m/s) value was used and not one or two orders of magnitude lower which would be more typical of an unfractured clay till. Golder (2006) indicated that lab tests showed K values as low as of $2x10^{-10}$ m/s. Our findings generally follow those of Golders.	wetlands. See comment 9, 13, and 14.	Tatham.
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?	The review is correct in regards to the number of stations within the study area. We therefore assembled a large number of stations from outside the study area. Mt. Nemo is labeled on the earlier figures (See Figures 1.1 and 1.2). The model simulation period study period contained three years with precipitation greater than one standard deviation (> 980 mm/yr) and one with very low precipitation, close to the period of record minimum 	What is the impact on the results of the modelling, if any, of the lack of a climate station on Mount Nemo in close proximity to the subject property?	As noted, we interpolated data from a large number of stations from outside the study area.
106	Are the lime coloured areas on this figure clay loam? It is not clear from the legend that these colours are the same?	A figure with improved colour scale is provided below. 	Enhanced Figure noted. It appears that the lime coloured areas represent clay loam. The colour figures provide striking visualizations but may be difficult to interpret for individuals who may have difficulty in distinguishing colours of similar shades.	RESOLVED
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?	Average simulated seepage from the golf course irrigation ponds was about 130 m3/d. Under Phase 3456, average simulated seepage from the infiltration pond was about 777 m3/d. Some of that flow is recaptured by the quarry drains and recirculated.	What degree of error can be expected for the simulated seepage and the recaptured flow by the quarry from the golf course irrigation ponds in the absence of hydrogeological information from the area of the ponds?	The assumptions in representing the pond were conservative and had the Halton Till underlying the pond. Additional analyses were made at the request of MNDMNRF to determine the effects of deepening the pond by excavating through the till. Model results indicated that, as might be expected, outflows are higher. (see Schedule 2)
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?	Yes, we believe that Halton Till underlies most portions of the irrigation ponds. Bathymetry data were used to determine the parts of the ponds that lie on weathered bedrock. Leakage varies based on the underlying material and on pond stage. As we have noted in several responses, the upper part of the Halton Till (Layer 1) is	Clarification provided. It is unclear the extent to which areas of thin Halton Till overlies bedrock. These areas should be identified.	Please refer to Schedule 2.

	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?	assumed to be weathered. The unweathered till is still relatively thin and is assumed to have some vertical fracturing, increasing the effective permeability of the unit (i.e. K = 5x10-7, rather than what might be expected of an intact clay-silt till). The location of the fractures and any spatial pattern in the fracturing was not determined.		
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.	Please refer to Response 4, 6 18, and 92, above. This question has been asked several times. The purpose of the infiltration pond is to replace the golf course ponds that may have contributed to groundwater recharge in the area. It is assumed that the pond will be in good hydraulic contact with the bedrock surface and should provide higher leakage than the natural ponds with their accumulated sediments. Some form of long-term maintenance may be required in the final design to ensure that the infiltration pond does not become silted up. Some of the water will be picked up in the expanded excavation area and recirculated, but the main effect is to recharge the groundwater west of the quarry and maintain higher heads and prevent the private wells from going dry.	See comment 94 above.	See original response and response to #94 above.
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.	It is expected that the hydraulic conductivity of the fracture zone is likely to vary. As noted, there are multiple lines of evidence for the middle Amabel fracture zone. A cross section showing water found and well completion depth along 2nd Side Road shows a pattern consistent with the interpretation of the data from multiple sources. The question then becomes: how do you spatially distribute this information from multiple lines of evidence. For simplicity, we assumed that a uniform value, guided by the mean of the test data and refined through model testing and calibration, would serve as a reasonable approach. The evidence for the lower fracture is discussed later on in Section 5.2.8. 	The approach taken to account for variability appears to be a reasonable compromise for modelling purposes although there should be a qualifier describing the probable degree of error attached to the model results and perhaps a sensitivity analysis to account for local variability. It remains unclear why the packer testing data does not, in most boreholes tested, reflect the higher hydraulic conductivity of Layer 8, the Lower Amabel, and what evidence there is in support of the higher hydraulic conductivity.	As was stated in the report, domestic supply wells along Cedar Springs Road are drilled into this zone. It is productive there and is likely to be productive in other areas as well. The approach to sensitivity analysis is different for fully integrated, fully transient (daily time step) models. The calibration to thousands of daily measurements, with varying daily climatic stresses, and the corresponding match to observed time-varying water levels and flows, is much more exacting and insightful than numerous runs of a steady state model groundwater-only model. As noted, the packer testing is only one aspect of the evidence supporting the conceptual model.

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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?	Yes. We made the assumption that flow would likely be carried within the weathered bedrock layer, but it is possible that it could go through some deeper fractures. For an impact analysis perspective, we felt that heads in the weathered bedrock would be most sensitive to changes in flow and vice-versa, and therefore the assumption is relatively conservative.	Comment noted. What are the implications of the possibility of deeper layers contributing to seeps and springs in terms of model predictions of water level impacts from the proposed quarry expansion?	There are two sections of streams represented in this manner and for relatively short reaches. The method used was novel enough to mention, but these reaches are not critical to the overall conclusions of the impact assessment.
124.	Typographical error? Reference to Worthington Groundwater (2019). Should this be Worthington Groundwater (2020)?	Comment noted. Reference was to an initial draft. Correct reference is: Worthington Groundwater, 2020, Appendix B – Karst Investigation: in Level 1 and Level 2 Hydrogeological Assessment Proposed Burlington Quarry Extension – Appendix A and B, report prepared by Earthfx Inc. for the Nelson Aggregates Co., November 2019, 41 p.	Correction noted. Assume correction will be made.	RESOLVED
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 anisotropy. 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.	Typo on the h and v: Sentence should read: 'It is widely recognized that the dolostones of the Niagara Escarpment have a high degree of vertical to horizontal anisotropy. Maslia and Johnston (1984) studied the "effectiveness of horizontal (bedding) joints versus vertical joints as water transmitting openings". They concluded that horizontal hydraulic conductivity (Kh) to vertical conductivity (Kv) anisotropy ratios of 100:1 to 1000:1 was typical of Lockport Formation.'	Correction noted. Assume correction will be made.	RESOLVED
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?	As noted in the report, there are strong head differences between the shallow and deep system near the quarry face and, as noted, the outcrop of the lower fracture zone is likely helping to drain the deeper system. Leakage from above contributes to the inflow but at a rate that cannot bring the heads up to near shallow bedrock levels. Further from the quarry, at about 300 m of the quarry face, lateral flow towards the quarry face is better balanced by leakage from above and the head differences are much smaller. This is directly analogous to flow to a well in leaky aquifer.	What is the expected area of influence of the existing quarry excavations in the lower system?	As noted, within 800 to 1000 m from the quarry face. The figure shows a section through the quarry face near OW03-15. As can be seen, the average heads in Layer 8 are controlled by leakage at the base of the quarry (254 masl). The heads in Layer 6 are controlled by the base of the middle fracture zone (once you get a cell or two into the wall) at 264 masl. The heads in these layers do not change as dramatically due to seasonal recharge. The heads in Layer 4 are much more variable, as the layer is partially saturated most of the time. The fourth line shows the heads in Layer 4 on October 31, 2012 and they are near the top of the layer (273 m) but above the average heads in the layer. Differences in the simulated heads in the three units are getting smaller at only 150 m from the face. By 800 to 1000 m, the differences are very small.

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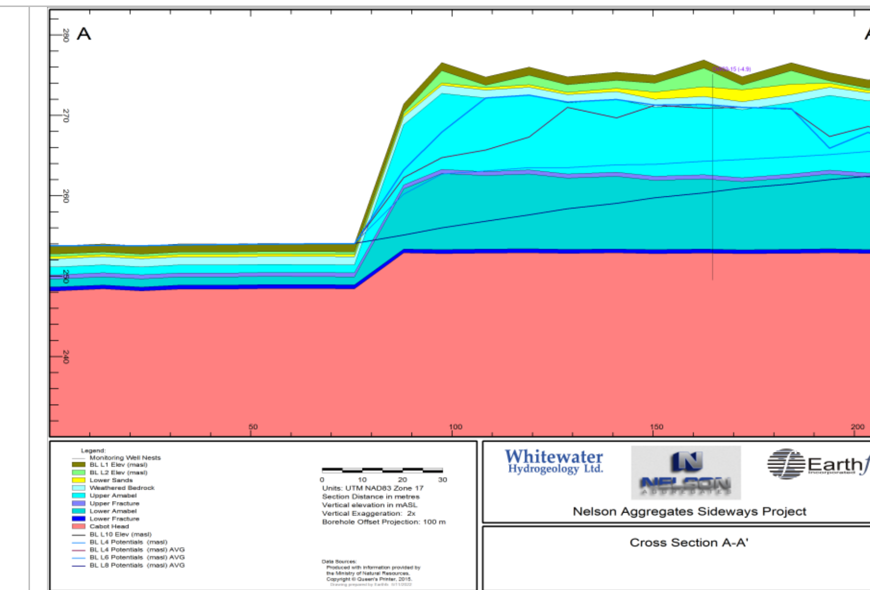
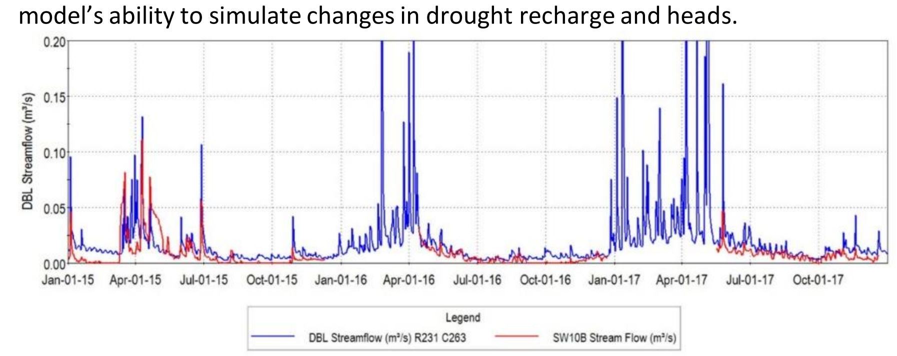
				
131	'A hydrograph from monitoring location OW03-15, south of the 2nd Side Road (see Figure 3.4) is shown in Figure 5.11. Water levels in the deepest monitor (OW03-15A) at this location are over 13 m below those of the water table (OW03-15C), clearly indicating that the lower system is connected to the 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.	Head differences decrease relatively quickly with distance from the quarry face. At the quarry face there is about a 15 m difference between Layer 4 and Layer 8 heads. This decreases to about 5 m within 300 m from the face. By 600 m there is no difference between Layer 4 and Layer 6 heads and about a 1 m difference between Layer 6 and Layer 8. By 900 m, there is no difference in the simulated water levels. This is generally consistent with the observations, but the reviewer is correct that the model shows a slightly higher degree of influence and the model would tend to over-predict the impact of quarry expansion.	The model predictions of the area of influence of about 1000m appears to be a reasonable approximation of the measured water levels within bedrock flow zones. It is unclear whether the area of influence of the existing quarry has stabilized or is still expanding.	There is significant redundancy in questioning. The heads vary seasonally, but the drawdowns due to the existing quarry expanding to its limits have been stable since before 2009. This is due to the relatively low storage in the bedrock system and leakage from above and below.
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?	There are gaps in the groundwater observations that Earthfx had no control over. With regards to the reliability of the model predictions for that period, our simulations of streamflow (along with estimated quarry dewatering) for the drought period compare well with the available observed data (see figure below for drought flows at SW10B). The integrated model shows that streamflow is reduced compared to average flows especially in the groundwater-level sensitive headwater tributaries. The ability to simulate drought streamflow gives us confidence in the model's ability to simulate changes in drought recharge and heads. 	Clarification of the limitation of the computer model simulations would be useful. See comment 14, 81, 86, 140, 159, 191, 217, and 235.	We stand by the original response.

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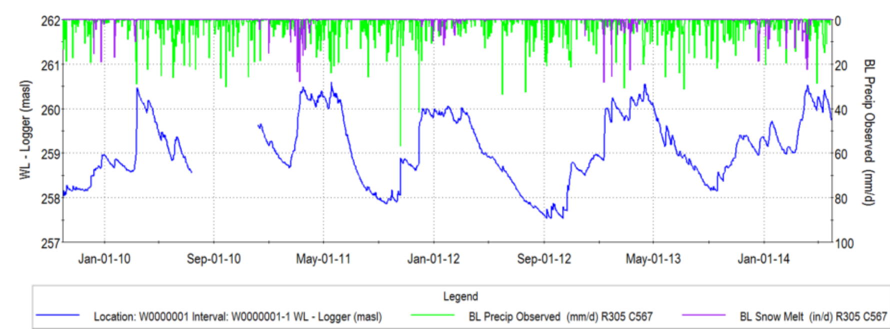
139	'There are nearby Provincial Groundwater Monitoring Network (PGMN) wells; however, all are located outside the study area.' Were the PMGM wells used to correlate climate data to ambient groundwater levels?	A discusion of the seasonal response (Nov 2018-to August 2019) at PGMN well W00005-1 was provided in Section 5.3.3. The figure below shows a longer-term hydrograph for PGMN well W00001, located in Kilbride, about 5 km NE of the site compared to interpolated precipitation and simulated snowmelt in the closest nearby active model cell. There is a very good correltation between well response and precipitation/snowmelt events, especially during the spring. The summer response is very muted, as might be expected, but the small spikes in water levels correlate well with the larger rainfall events. This indicates that although the data are not perfect and there are substantial distances between the well and the active stations, the interpolated climate data produces reasonable results.  	Clarification provided.	RESOLVED
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 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.	See above	See comment 14, 81, 86, 132, 159, 191, 217, and 235.	Climate station question was addressed earlier. We believe that the model matched event based responses well despite the lack of an on-site station.
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	The question has been answered earlier. In essence, heads differences decrease relatively quickly with distance from the quarry face. The decrease in heads is maintained because local leakage from above (between 0 and 50 m) cannot match the drainage at the lower fracture zone outcrop. Further away from the quarry, the net leakage between the well and the quarry face (0 to 1000 m) balances the lateral outflow and there is no need to further decrease water levels. At that point, the difference between the shallow and deeper bedrock is small, but not zero, since there is still vertical movement to the deeper system due to natural recharge from above. Several points can be made with regards to surface water features: (1) The steep decline is relative to the shallow bedrock heads. Heads in the weathered till, the zone in direct contact with the wetlands that are not perched is largely unaffected; (2) wetlands that are perched are obviously unaffected; (3) the impact on the deep bedrock attenuates rapidly with distance and wetlands beyond 300 m should not have been affected at all by the decrease caused by the approach of the quarry face; (4) although the change occurred in a gap period, the response was likely rapid and a new equilibrium quickly established due to relatively small storage values in the bedrock. The issue of cumulative impact is discussed in Response 3, 15 and 77	Figures 6.22 (West Calibration Section) and Figure 6.23 (East Calibration Section) in the south expansion area, show average simulated water levels within the bedrock model layer 4 (weathered bedrock), model layer 6 (Middle Amabel Fracture Zone) and model layer 8 (Lower Fracture Zone), These figures suggest an area of influence of the existing quarry to include the areas within about 1000m of the existing quarry edge. This appears to have contributed to perched groundwater conditions for wetlands within this area, particularly those closest to the existing quarry. It remains unclear whether this condition has stabilized or is still expanding. It is also unclear what impact this has had on the wetlands within the area of influence of the existing quarry. These conditions are considered 'baseline' conditions for purposes of assessing impact of the proposed quarry expansion, however they clearly represent impacts from the existing quarry which have not been specifically identified. For cumulative effects see comment 15 and 77.	We disagree that the cumulative impacts have not been addressed. The question of whether the impacts due to the existing quarry have stabilized were addressed above. The period of 2009 onward was a stable period and represented a reasonable baseline for comparison.

	identified.			
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.	Typo. The blue areas are upward gradients, that is, heads in the deeper system are higher than the shallow. They are likely an artifact of limited data at the Escarpment brow.	Typographical error acknowledged and clarification provided. Assume correction will be made.	RESOLVED
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?	The point of the figure was to show that "Groundwater levels show a muted response in the late fall and early winter as the ground freezes, precipitation decreases, and snow accumulates. Peak water levels generally occur in early to mid-April primarily due to recharge from precipitation and snowmelt events after the ground has thawed. Groundwater levels decline through the summer because few infiltration events reach the water table, and most of the water in the soil zone is lost to evapotranspiration. Groundwater levels typically recover in the early fall due to increased precipitation and decreased ET." The period was selected because it is a period of recent continuous data collection. The seasonal pattern is typical of most wells in southern Ontario. 2018 was a year with near average annual rainfall. Inter-annual variation was discussed further on in the section.	Clarification provided.	RESOLVED
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	The question has been answered earlier. In essence, heads differences decrease relatively quickly with distance from the quarry face. The decrease in heads is maintained because local leakage from above (between 0 and 50 m) cannot match the drainage at the lower fracture zone outcrop. Further away from the quarry, the net leakage between the well and the quarry face (0 to 1000 m) balances the lateral outflow and there is no need to further decrease water levels. At that point, the difference between the shallow and deeper bedrock is small, but not zero, since there is still vertical movement to the deeper system due to natural recharge from above. Several points can be made with regards to surface water features: (1) The steep decline is relative to the shallow bedrock heads. Heads in the weathered till, the zone in direct contact with the wetlands that are not perched is largely unaffected; (2) wetlands that are perched are obviously unaffected; (3) the impact on the deep bedrock attenuates rapidly with distance and wetlands beyond 300 m should not have been affected at all by the decrease caused by the approach of the quarry face; (4) although the change occurred in a gap period, the response was likely rapid and a new equilibrium quickly established due to relatively small storage values in the bedrock.	Figures 6.22 (West Calibration Section) and Figure 6.23 (East Calibration Section) in the south expansion area, show average simulated water levels within the bedrock model layer 4 (weathered bedrock), model layer 6 (Middle Amabel Fracture Zone) and model layer 8 (Lower Fracture Zone), These figures suggest an area of influence of the existing quarry to include the areas within about 1000m of the existing quarry edge. This appears to have contributed to perched groundwater conditions for wetlands within this area, particularly those closest to the existing quarry. It remains unclear whether this condition has stabilized or is still expanding. It is also unclear what impact this has had on the wetlands within the area of influence of the existing quarry. These conditions are considered 'baseline' conditions for purposes of assessing impact of the proposed quarry expansion, however they clearly represent impacts from the existing quarry which have not been specifically identified. For cumulative effects see comment 15 and 77.	Agree to disagree on the definition of baseline conditions. Baseline represents the current conditions.

	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.	The issue of cumulative impact is discussed in Response 3, 15 and 77		
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?	Water enters the quarry primarily as rainfall and groundwater seepage but there is some inflow from ditches along Colling Road to the north. The amount discharged from the two quarry sumps is recorded. Differences between inflows and quarry discharge are due to evaporation and losses to groundwater, primarily beneath the quarry ponds. This mass balance is represented in the model, allowing us to match the quarry discharge in the model rather than specifying it as a measured value. Our match to the actual flows is good and improves in the later years when pumping was done continuously rather than on an as needed basis. This gives the model predictive power to estimate quarry discharge in the impact assessment scenarios.	Clarification provided. It remains unclear how much water is consumed within the quarry including the water removed within the washed aggregate and used for dust control.	There is no washing of aggregate at the Burlington Quarry. Minimal amount of water used for dust control as there is a state-of-the-art wheel wash that recirculates water on-site.
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?	There are no measured records of water diversion for golf course irrigation. The Quarry and Golf Course have been collaboratively using water for decades. There is a weir that can be controlled to raise stage in the pond, thereby feeding the golf course ponds. Flow is measured at SW1, but it would be hard to estimate the actual losses from the available data.	Acknowledged that there is a data gap.	No response required.
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.	See response 12	See comment 12	See response to #12.

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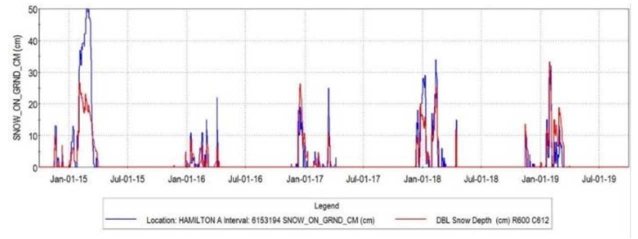
158.	Should the 'Contributing Area' shown on this figure also include the up-gradient areas under Hortonian Surface Runoff and be defined by the up-gradient groundwater table?	The figure is a schematic trying to show the concept of an increasing/decreasing contributing area (as defined by Whitely) to one type of Dunnian flow. This type of Dunnian flow occurs when the water table is near or at surface, often the case in the lowland areas. Two things occur: (1) the groundwater system can discharge to the soil zone creating saturated conditions and possible discharge to the surface; and (2) any rainfall within the "contributing area" will be lost to runoff. The position of the water table relative to land surface controls the rate of Dunnian runoff. You are correct in the sense that the Hortonian runoff shown in the figure would likely cascade downslope and reach the saturated area. At that point it would be added as run-on to the downslope cells. Some or all of that flow would be partitioned and emerge as Hortonian and Dunnian runoff. This is not to say that Dunnian runoff cannot occur in upland areas (i.e., areas with deep water table). Another type of saturation excess can occur in wet periods if sufficient infiltration has occurred and the soil is poorly drained and at saturation. Subsequent rainfall events produce Dunnian runoff.	Clarification provided.	RESOLVED
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?	See Response 132. We acknowledge that there are gaps in the groundwater observations that Earthfx had no control over. Where we were able to obtain additional data, we did. For example, we went further afield to get precipitation. With regards to the calibration, the hydrologic model was calibrated against gauges with longer term data. The strength of the continuous integrated modelling approach is that the intermittent records available at other stations could still be compared against model output to verify the predictive capability of the model.	The remote locations of the climate stations do not add to the accuracy of defining on-site conditions. The data gaps for on-site monitors would likely pose further limitations to the accuracy of the model predictions. See comment 14, 81, 86, 132, 140, 191, 217, and 235.	The climate station question was addressed earlier. We believe that the model matched event based responses well despite the lack of an on-site station.
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?	Generally, it was assumed that the fine-grained soils would be slightly more permeable than the parent material due to weathering. The values are used in the model to define the maximum amount of water that can infiltrate per day. Variations in hydraulic conductivity values above $3x10^{-7}$ (equivalent to 25.4 mm/d) have little influence on recharge and interflow since it is rare to infiltrate more than that amount on any given day (except along a cascade flowpath or during snow melt events). The model is more sensitive to the lower values. Lower values will allow water to remain in the soil zone over several days and subsequent events can saturate the soil leading to Dunnian runoff. More soil water is also available for ET, leading to higher actual ET rates in the summer compared to more permeable soils.	Clarification provided.	RESOLVED
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?	The parameters mainly control the depth of the snowpack and, more importantly, snowmelt timing. There was not a lot of data to calibrate to and we did not do any comparisons for the report. The figure below, however, compares predicted snow depth in the south of the study area versus the "snow on ground" measurements at Hamilton Airport, 23.5 km to the south. The timing of the snowmelt is dead-on. Calibration of snow compaction factors may have produced a better match to the observed depth for the larger snow packs, although the match after 2015 is still very good. A similar figure compares the predicted snow depth in the north of the study area versus the "snow on ground" measurements at Mono Centre, 68.5 km to the north. 	Clarification provided.	RESOLVED

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		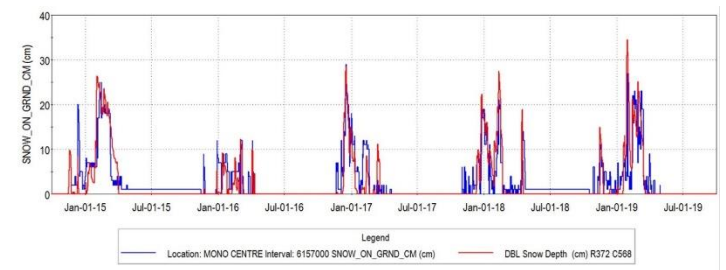		
171	'A visual comparison of the observed and simulated values shows that a good match was achieved although, as noted in Section 5.3, there is considerable scatter in the static water level data because of the fractured nature of the bedrock; deviations are less prevalent below the Niagara Escarpment. 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'.	The local variations are likely due to proximity (or distance from) discrete vertical and bedding plane fractures. We tried to represent the overall effect of these features, but the exact location and properties of the fractures are unknowable. Overall, our goal was to represent the likely impact of the quarry expansion across the area, including kilometers of streams, wetland complexes, and multiple bedrock and overburden units; we did not attempt to predict the response at individual fracture locations.	The difficulty of predicting response in individual fractures is acknowledged. The impact of this on model predictions should be identified with respect to the reliability and/or the representativeness of the computer model simulations of actual site conditions.	The local response in a single vertical fracture is of less importance than the water level response patterns observed with distance from the quarry face as discussed in detail in our Nov. 2021 JART meetings.
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?	As was noted in earlier answers, the exposure of the lower fracture zone at the quarry face causes a unique condition that enhances the head differences between the shallow and deep system. Matching this local response required modification of hydraulic conductivity values used in early versions of the model and the addition of vertical fracture zones. Away from the quarry face, the head differences are small and various combinations of vertical and horizontal hydraulic conductivity values would produce reasonably similar heads. Matching the head profile with distance from the quarry face illustrates that the model is closely matching the observed and expected effects.	Clarification provided.	RESOLVED
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 underestimate or overestimate the water levels compared to observed water levels. See Figure 6.24, page 149. What is the significance of this?	"Excellent" calibration should be taken in context of the difficulty in creating and calibrating an integrated transient model that produced a good representation of shallow surface conditions in a fractured bedrock environment overlain by a variably fractured till using interpolated climate data. We are unaware of any similar level of integrated quarry modelling in Canada.	It would be useful to put into context the limitations of the model simulations.	As far as we are aware, this is the first model in Ontario to replicate the seasonality in the water level response with distance from the quarry face. The match to this complex response is excellent.

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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?	See Response 179	Comment referred to Comment 179 which refers to Schedule D, response to MNRF. It remains unclear where Scheduled D is as it is not labelled as such in the accompanying material to the JART Hydrogeology Table. It is speculated that Schedule D is Wetland Characterization Summaries. Clarification is required.	Correct.
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.	The potentials in Layer 1 at this location represent the simulated water levels in the shallow MODFLOW lake used to represent the portion of the wetland assumed to have standing water. These levels should be comparable to MP33. The heads in Layer 2 are assumed to represent the water table.	Water levels within MP33 have not been confirmed to represent wetland (pond) water levels. The hydrograph for MP33, as provided in S. McFarland Witness Statement, 2010 (Attachment D.1, pdf page 787) shows water levels in MP33 below ground level. It is therefore presumed that the water levels within MP33 represent the groundwater table. The simulated water levels of Layer 2 on Figure 6.33 representing the water table, do not correlate well with measured water level for MP33. Clarification is required.	As discussed in our MNDMNRF response (March 2021), the minipiezometers are all approximately 1 m deep and therefore straddle the soil zone and weathered till. This is a higher elevation than the center of Layer 1, and will respond differently.
184	Typographic error, 'MNRF Wetland 1301' should read 'MNRF Wetland 13031'	Comment noted.	Typographical error noted. It is assumed that a correction will be made.	RESOLVED
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.	MNRF Wetlands 13031 and 13032 are a bit unique because they are located in depressions on top of topographic highs associated with the Waterdown Moraine. Other wetlands are located in the lower lying areas between the ridges. The topography shown in Figures 6.28 and the section through the wetlands (Figure 6.32) were meant to highlight this. An extensive discussion of the shallow wetland response is included in our response to the MNRF comments. Copies are provided in Schedules B, C, and D.	Clarification provided. It is not clear that the wetlands with shallow groundwater instrumentation installed by Tatham are perched as indicated in the Wetland Summaries. Examination of hydrographs of the shallow groundwater monitors installed by Tatham provide evidence contrary to the wetland descriptions as perched and isolated from the groundwater system. Schedules B, C, and D referred to are not labelled in the materials provided with the JART Table. Clarification is required.	The following schedules were noted: Schedule A: MECP response matrix Schedule B: Wetland Characterization Schedule C: Watercourse Characterization Schedule D: Earthfx response to MNDMNRF

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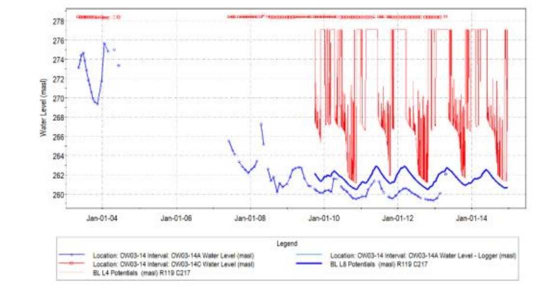
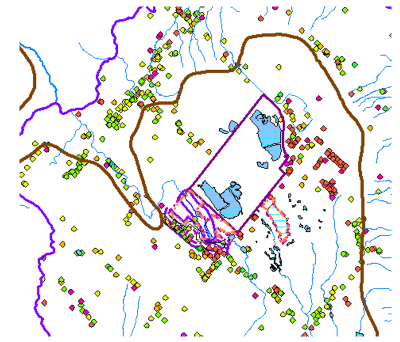
190	The model was run for a ten-year period (WY2010 to 2019) and calibrated to regional and local observation data collected during this time.' Were there actual measured water level data from the property throughout this period and especially during periods of drought and wet conditions from which simulations 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?	We have discussed the gaps in data in previous answers. Figure 19.23 presents a typical observation hydrograph with gaps in the measurement periods. The 2017 drought was missed.   Yes, the baseline analysis incorporates the impacts of the existing quarry. We started the model assuming the topography, quarry pond configuration, and water management consistent with current conditions. As noted in earlier responses, the site data and MECP data sets are generally non-overlapping. That said, early on in the study, we tried separating populations of wells by time period to see if any patterns could be discerned. This exercise was generally unsuccessful because (1) general noise in the data (e.g., natural seasonal and inter-annual variation), (2) the lack of sufficient number of wells and good spatial coverage within decadal grouping (see figure) needed to interpolate regional surfaces for comparison.	The water well record information spans a large time frame well beyond the period of time that was simulated with the model. Since the model predictions were calibrated against the water well data set, it is important to put the model predictions for the regional characterization in this context with a qualifier regarding the reliability and accuracy of the model predictions.	This question is redundant as it has been asked and answered several times. The steady state calibration demonstrated the model response on a long term regional basis and the level of calibration is consistent with similar models.
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: • 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?	The advantage of our continuous modelling approach, using multi-year simulations with a daily time step, is that we can compare model results with the available streamflow and water level data even if the data cover short periods and there are gaps. Obviously, it would be better to have long, gap-free data, but we can make good use of what we have. The continuous model can be compared to continuous or intermittent manual or logger levels.	The continuous modelling approach cannot compare model results to groundwater data that is missing. What impact does the on-site groundwater data gaps have on the computer model simulations? See comment 14, 81, 86, 132, 140, 159, 217, and 235.	We respectfully agree to disagree. Please refer to comment #20.
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?	MECP wells are completed across a range of depths indicating that water is broadly available. It is expected that the lower part of the formation will yield groundwater of good quality water and sufficient quantity for domestic supply.	The Earthfx report has not acknowledged evidence which suggests that deepening of private wells in some areas may not necessarily provide significant addition well yields. Water quality information from the lower portions of the Amabel formation and the underlying Reynales and Cabot Head formations is lacking. This is critical in determining suitability of groundwater from these zones for drinking water purposes if deepening of wells is to be considered a viable option for mitigating the impacts of the proposed quarry extension. The Earthfx report has also not acknowledged the fact that a number of wells along Cedar Springs Road are obtaining water from bedrock zones near or below the base of the proposed quarry extension. It is quite possible that a number of these wells are obtaining water from a near surface intervals that rely upon up-gradient water percolating though the bedrock intervals that are to be excavated.	Please refer to response #6.

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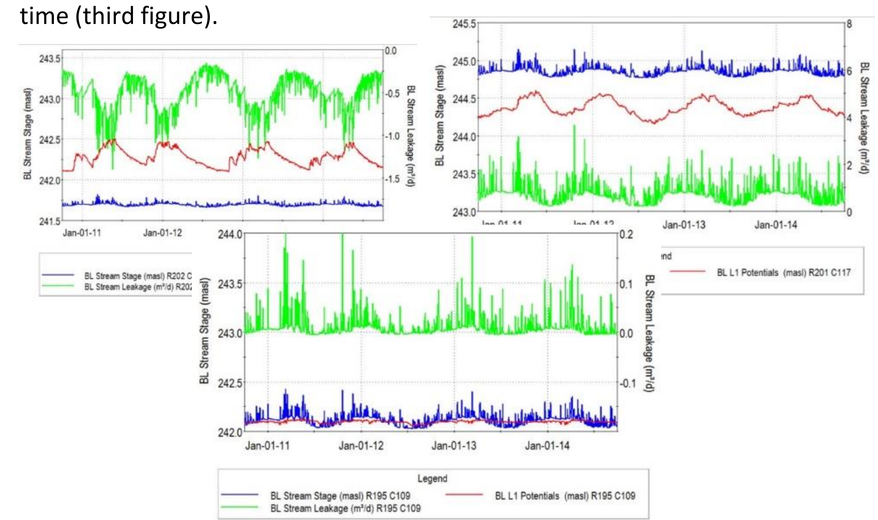
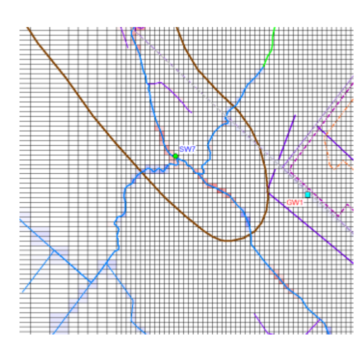
195.	'The Medad Valley is an interesting setting, for Figure 7.20 shows that there is groundwater discharge to the soil zone along the flanks of the valley, yet the main stream in the centerline of the valley is leaking water to the groundwater system (Figure 7.21). This demonstrates that the incised 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?	Access to the Medad Valley was limited, so there are only flow measurements at the gauges for comparison. The map needs a bit of explanation, since it portrays the average of stream leakage over the simulation period. Areas of dark red on the map tend to exhibit heads that are always higher than stream stage and net leakage is from the aquifer into the stream (first figure below). Areas of dark blue on the map exhibit heads that are always lower than stream stage and net leakage is from the stream to the aquifer (second figure). Reaches with lighter shades of reds and blues are areas where heads and stage reverse over the simulation period and leakage in or out varies over time (third figure). 	Clarification provided.	RESOLVED
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?	The water budgets were prepared using simulation period averages of all PRMS and MODFLOW inflows and outflows. The flows were averaged over all cells falling within the polygons defined by the wetland area. The purpose was to compare the flow terms under each scenario to see how they change and re- balance under the different conditions. Water budgets for the instrumented wetlands are presented in the Tatham report. Please also refer to Response 5 and 14	See comment 14.	See response to #14.
199.	How was the level of detail generated for this figure where there are widely dispersed data control points or monitoring locations?	As noted in the caption these are average <u>simulated</u> values. The model computes stream leakage, surface discharge, overland runoff, and groundwater leakage at every cell in the model grid. The daily cell-by-cell values were averaged over the simulation period. You are probably more used to model results presented as coloured rectangular cell values (see below); we used a new VIEWLOG option to colour the stream segment crossing the cell based on the cell value. 	Clarification provided.	RESOLVED

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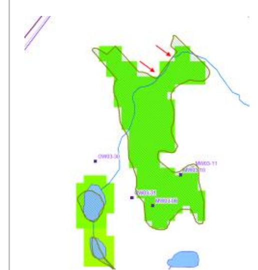
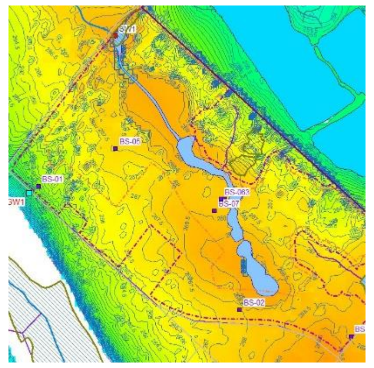
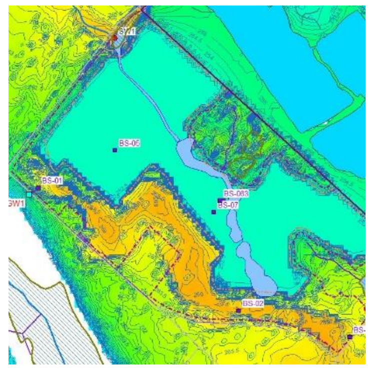
201	The water budget inputs do not appear to match the outputs. Please clarify	The wetland water budgets should nearly close. There are round-off errors due to: Change in storage. The lake or soil zone may have more or less water remaining in it at the end of the assessment period Mass balance error. There can be a small mass balance error (2-3%) over the simulation Precipitation and ET directly in/out of streams calculated but not tabulated here (usually small) The SW and GW models are solved iteratively, with the surface water system solved first and then the GW model, so there is potential for small discrepancies Internal transfers between processes After further investigation, the key problem turns out to be the way the polygon was drawn and the cells selected. For example, the polygon for Wetland 9 missed two cells that the stream touched but were not included in the summation. Hortonian and Interflow to streams was underreported by 10% because of this. This would account for the difference between those terms and stream pickup through the wetland. We tried hard to be careful not to miss any cells (see the selected cells versus the polygons for the two small wetlands (10 and 11) but may have missed some. 	A summary table showing water inputs compared to outputs would be useful in assessing the water budget analysis.	Earthfx feels that the presentation of the water balance parameters was adequately presented.
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.	Golder (2006) states that "As shown on Figure 18, no water level response is observed in the shallow overburden sediments and pockets of standing water. This indicates that there is essentially no hydraulic connection between surface water in the wetland and groundwater in the underlying bedrock during the testing period. This assessment is further supported by observed monitoring data from Cluster I and 3 which are presented in Figure C-3 and C-4 respectively in Appendix C. Some of the C series wells responded to the pumping tests. These wells are drilled to top of bedrock and therefore would respond differently than wells screened solely within the overburden. Most of the C wells showed no response. As in the bedrock, there are likely some vertical fractures penetrating the till. This would allow heads to respond to recharge events, but it does not mean that there is significant flow across the unit.	See comments to response 9, 13, 29, 30, and 99.	The reviewer noted in comment #13 that "the lack of response in the wetland water level and shallow mini-piezometers is provided as evidence of hydraulic isolation of the wetland from the underlying bedrock during the pumping tests." The reviewer blames inadequate well construction for the lack of response" Earthfx continues to disagree with the reviewers position.
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.	This section is summarizing the results of the simulations which used property information from testing and monitoring at the five instrumented wetlands.	This comment should be qualified to include 'based on the results of computer simulations'.	Comment noted.
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.	The observation being made here is simply that adequate water quantity has not been a problem in the quarry vicinity despite ongoing operations at the quarry and climate variability. It is recognized that additional drawdowns will likely occur as a result of the quarry extensions. This is discussed in Chapter 8. Please refer to the well survey discussion for more information on local water supply.	This appears to be anecdotal as opposed to evidence in the form of examples of successful well deepening and/or replacement.	We agree to disagree.
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	The model simulated the discharge volumes for the expanded quarry in a similar manner as the baseline conditions where discharge was triggered based on the elevations of the water in the sumps. Thus, discharge was increased automatically in the model due to expansion of the quarry and the assumed drainage of water (precipitation and groundwater inflow). Accordingly, the assessment of the impact of the increase in pumping on downstream areas has been completed.	The statement in question is misleading as it implies that the sump discharge will continue as in the past.	Please note that the regulatory agency is the MECP and Nelson will be required to obtain MECP approval (amendments to the active PTTW and ECA) prior to increasing pumping rates. The expansion does not require amendments to the existing approvals, but Nelson believes that amendments will improve the pumping conditions of downgradient systems (mimic natural conditions)

	increase in pumping.			
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.' 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	The baseline simulation indicates that heads would be elevated in the vicinity of the golf course ponds, Under Scenario P3456, the mound would be shifted to underneath the infiltration pond (see figures below). The observation data covered a limited period and wells were not positioned to detect mounding. Seepage out of the infiltration pond is higher because it is excavated to the weathered bedrock. The model simulates higher average seepage by about a factor of 6.  	See comment 94.	See Comment 94.
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.	Please refer to Response 7 and 8.	See comments to response 7 and 8. The specific issue of a potential high pressure oil pipeline leak into the quarry and the nearby Sump1 has not been addressed.	Any leaks from the oil pipeline is not the responsibility of Nelson. If the sumps contained oil from an oil pipeline leak it would be very evident in the sumps and Nelson would be required to cease pumping. Please consult with the pipeline operator for their emergency response plans.
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.	Please refer to Response 7 and 8. Water quality monitoring is discussed in the AMP. As noted, the quarry forms a local groundwater sink and the general direction of flow in the quarry vicinity is inward into the quarry. Accordingly, contaminant spills within the quarry or close to the quarry face will be drawn in to the quarry.	It is acknowledged that the quarry will form a local groundwater sink. It is anticipated that contaminant spills will be contained within the quarry. It is not clear how contaminants from spills or introduced from surface runoff will be prevented from being discharged through the quarry sumps.	The quarry is currently a local groundwater sink. As per the existing ECA, Nelson complies with the Operations Manual (Spill Contingency and Pollution Prevention Plan, revised February 6, 2019) which includes the contingency plans and procedures for dealing with potential spill, bypasses and any other abnormal situations.
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.	The 14 m drawdowns within the quarry footprint are a result of dewatering the P12 quarry extension and are to be expected. The point of the figure is to show how far the drawdowns would extend outside of the quarry footprint. The question has been answered multiple times. There are unknowable local variations in hydraulic conductivity because of the fractured nature of the bedrock. What we did is use a reasonably conservative EPM assumption with mean values to represent he entire study area. We believe that in this way, the model was able to produce reasonably conservative estimates of the likely time-dependent drawdowns across the study area.	It is acknowledged that the model provides estimates of drawdown on local wells. Due to differences between actual site conditions and assumed conditions for purposes of computer modelling, qualifiers should be provided on the accuracy and applicability of the model predictions.	The monitoring and protection of the domestic water wells is regulated by the Ministry of Environment, Conservation and Parks (MECP). As noted, upon licensing a detailed water well survey will be completed to ensure that we have accurate information on the key receptors, such as well location, well depth, historical water issues (quality and quantity), available drawdown, etc. Until residents participate in this survey, additional information cannot be obtained. This work will be a condition of the ARA license as well as a requirement for any future ORWA applications to be submitted and reviewed by the MECP.

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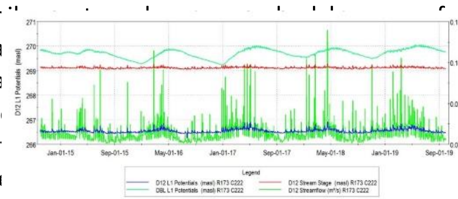
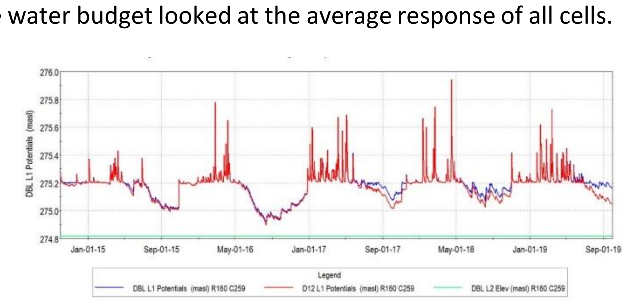
217.	'The transient simulations through 2015-2016 provide insight into the effects of P12 during seasonal and interannual variation, including a Level 2 drought.' These simulations lack comparison (calibration) of predicted drawdowns to sites with measured groundwater levels during this time period. What is the impact of the lack of data for calibration of the model and on predictions of the model?	This question has been asked multiple times. The model was calibrated to streamflow, regional groundwater levels, and local response to pump tests and quarry advancement. The transient baseline heads were compared to Golder wells with observation data for earlier time periods. Although there were gaps in the observation data, the results for earlier periods demonstrate the predictive capability of the model. As an example, the figure below shows a hydrograph for Wetland 17 and Golder SG3. There is reasonably good agreement between the monthly staff gauge measurements and the daily stage. (This area is discussed further in Comment 220)	See comment 14, 81, 86, 132, 140, 159, 191, and 235.	Redundancy in questioning. We respectfully agree to disagree. Please refer to comment #20.
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.	This has been asked multiple times. The point is that there is adequate available drawdown and deeper wells should not be affected. Affected shallow wells could be deepened to address those that go dry due to quarry impacts. There may be individual wells with construction-related issues or areas where well yield proves inadequate. Well operation issues can be mitigated.	See comment 193.	See response to #6 and #193.
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?	Wh... tions in topography, some rea... nditions (i.e. heads are higher tha... aph near SW6 versus red line). Du... 2 (see blue line), these reaches shi... harge from the quarry raises str... sing leakage out of the perched reaches. 	Clarification provided.	RESOLVED
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?	As discussed in the report, groundwater inflow into Wetland 17 comprises about 1.3% of the overall water budget, on average, under baseline conditions. The reduction in water levels will eliminate this inflow. The hydrograph shows simulated wetland stage during the drought period under baseline and P12 conditions at SG-3 (see Comment 217). The model indicates that wetland stage will drop in the summer in most years as much as 10 cm; however the stage in this wetland cell remains above the wetland base (green line). Each cells within the wetland complex will behave differently, this one is located in the centre. The water budget looked at the average response of all cells. 	Clarification provided.	RESOLVED
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?	This question has been asked multiple times. These are water budgets based on model simulations. Most items in a typical water budget including runoff, infiltration, canopy capture, ET, cannot be measured directly with simple instrumentation such as staff gages and piezometers. Instead, the model was calibrated to match water levels (stage and head) and streamflow and checked against other secondary indicators such as soil moisture. The assumption is that if measurable outputs are matched over a wide range of conditions, the partitioning of flows within the water budget is reasonable. The extension of this assumption is that if reasonable parameter values are used to represent processes in the monitored catchment, they can be used with reasonable confidence in the unmonitored catchments.	See comment 197.	See response to #197.

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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.	This question has been asked multiple times. The analysis focussed on how streamflow, groundwater levels, and wetland stage and related measures would be affected by quarry expansion.	See comment 148.	See response to #148.
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.	See Response 201. In general, the matches between inputs and outputs are close. We recognize some problems where a stream crossed the edge of a wetland cell but was not accounted for. We divided the sum of all the outflows to groundwater by the sum of all the wetland area outflows and multiplied by 100. GW outflow terms included GW recharge, GW discharge to streams, and GW discharge to lakes. The other outflows included Soil ET, streamflow out, lake evaporation, Hortonian runoff out, and interflow/Dunnian runoff out. GW inflow terms included GW discharge (surface leakage), GW inflow from streams, and GW inflow from lakes. The other outflows included Net Precipitation, streamflow in, lake precipitation, Hortonian runoff in, and interflow/Dunnian runoff in.	See comment 201.	See response #201.
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?	See Response 220. The response discusses Wetland 17 which is typical of wetlands close to the P12 quarry extension. The responses at all other wetlands were evaluated and formed the basis of our statement.	Comment noted. See comment 220.	RESOLVED
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.	Modelling analysis showed that leakage from the infiltration pond, presumed to be in contact with the weathered bedrock, would be much higher than for the golf course ponds. Pumping to the sumps would continue in order to: (1) dewater the existing quarry and the quarry extensions, and (2) to help maintain hydrologic and biologic features that have adapted to the higher flows. Predicted changes in discharge from the sumps were analyzed in each scenario. The comprehensive analysis of the rehabilitation scenarios (RHB1 and RHB2) considered potential impacts to groundwater and streamflow across the entire study area including the Willoughby Creek sub-watershed.	The computer modelling results are based upon a number of assumptions that have not been supported with field data. The results of the computer modelling are questionable and should therefore be considered as approximations and may not be reflective of actual impacts of the proposed quarry expansions. Qualifiers should be provided on the accuracy of the model predictions and the expected variation from local conditions.	We respectfully agree to disagree.

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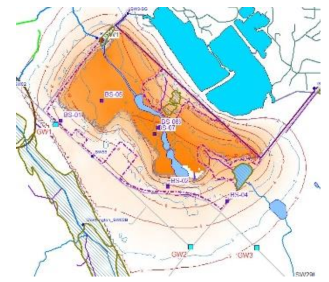
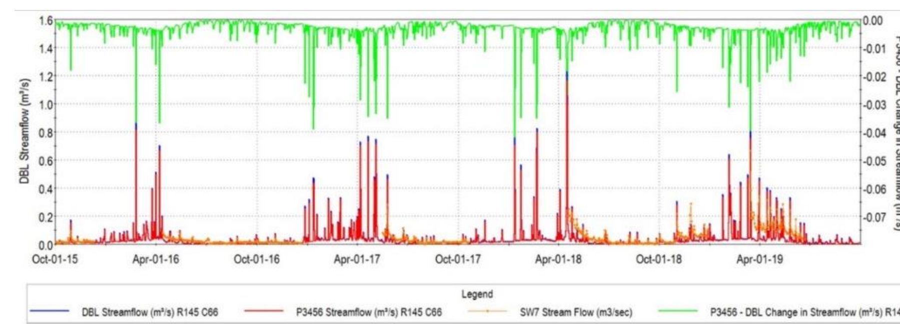
231.	'Figure 8.40 also shows the average simulated change in streamflow. Increases in simulated flow occur at the Northwest sump (and in new quarry floor drains and the conduits carrying flow to the infiltration pond). Decreases in simulated flow occur in the Medad Valley, reaching a maximum of approximately $1.0x10.0^{-3}$ m3/s (1.0 litre/second) in the Medad creek immediately west of the P34 excavation.' 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?	The infiltration pond is intended to mitigate the effects of the quarry expansion as best as possible. Small changes in flows, groundwater levels, and groundwater discharge still occur across the study area despite the infiltration pond and are reflected in the small changes in flow in the Medad Valley.	It remains unclear what is responsible for the simulated decrease in flow to Medad Valley.	Please refer to Schedule 2. (Updated model results).
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?	The sumps were assumed to be at the elevation of the quarry floor. Water levels will decrease in Layer 8 as well as Layer 6. The drawdowns extend out a bit (< 100 m) further in Layer 8 (red contours) compared to Layer 6. 	If sumps within the existing quarry are constructed with the bottom of the sump coincident with the quarry floor of 252.5 masl, it would be expected that drawdowns resulting from the quarry expansions would extend beyond the excavation limit in a similar fashion to the existing quarry which is shown on the East and West Calibration Sections for the south extension as shown on Figures 6.23 and 6.24 respectively. Figures 8.42. and 8.43 show average simulated heads and drawdown respectively for Layer 6 (Middle Amabel Fracture Zone). There are no hydrostratigraphic sections showing simulated drawdowns for Layer 8 (Lower Fracture Zone) in the area of the west extension. Figures 8.42 and 8.43 suggest that the proposed infiltration ponds are largely responsible for maintaining groundwater levels and mitigating the drawdown effects of the proposed western extension on downgradient private wells. There is no field data such as infiltration field testing to support the computer simulations that the infiltration ponds will provide such mitigation effects. The simulated drawdowns in Layer 6 as shown on Figure 8.43, extend into an area of the Medad Valley in which Layer 6 does not likely occur.	Please refer to the new pond simulations presented in Schedule 2.
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.	For a discussion of this specific wetland please refer to the package of interdisciplinary tables integrating wetland and watercourse characterization and analysis has been prepared and provided in Schedules B and C. Additional water level data are being collected at this site.	Field data is lacking for water levels in this wetland and in the directly underlying overburden to support the conclusions of impacts from the proposed western expansion. SW37, was installed by Tatham April 22, 2020. The Tatham Surface Water report was issued in April 2020 and did not include any field data for SW37 located in Earthfx wetland 22 (MNRF Wetland 13200). See comment 14, 81, 86, 132, 140, 159, 191, 217.	Please refer to the updated AMP.
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.	We divided the sum of all the outflows to groundwater by the sum of all the wetland area outflows and multiplied by 100. GW outflow terms included GW recharge, GW discharge to streams, and GW discharge to lakes. The other outflows included Soil ET, streamflow out, lake evaporation, Hortonian runoff out, and interflow/Dunnian runoff out. GW inflow terms included GW discharge (surface leakage), GW inflow from streams, and GW inflow from lakes. The other outflows included Net Precipitation, streamflow in, lake precipitation, Hortonian runoff in, and interflow/Dunnian runoff in.	Clarification provided.	RESOLVED
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 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	This question has been asked multiple times. The purpose of the infiltration pond is to replace the golf course ponds that may have contributed to groundwater recharge in the area. It is assumed that the pond will be in good hydraulic contact with the bedrock surface and should provide higher leakage than the natural ponds with their accumulated sediments.	See comments 207, 116, 94, 18 and 6.	Please refer to Schedule 2. (Updated model results).

	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	See Response 236	Clarification provided.	RESOLVED
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.	It should be noted that, except in 2019, Tatham pulled their loggers in December and replaced them in May, thereby missing much of the high flows. Our model was continuous. As we state, the larger change is in the winter and early spring. There is much less change in the summer flows. 	The projected reduction in baseflow would have the most impact during periods of low flow within the summer months as stream flows are generally at their lowest during this period. Comment is required with respect to the significance of reduction in baseflow during the seasonally low flow periods.	Please refer to Schedule 2. (Updated model results).
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.	See Response 240 The effects on this wetland are discussed in more detail in the package of interdisciplinary tables integrating wetland and watercourse characterization and analysis that has been prepared and provided in Schedules B and C.	See comment 240.	Please refer to Schedule 2. (Updated model results).
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.	As noted, this is a groundwater discharge area and is not significantly sensitive to change.	The computer model does not appear to take into account the stratigraphic intervals providing water to the downgradient wells. Some of these wells appear to be located in areas of groundwater discharge from the lower Amabel. The possibility of deepening these wells and obtaining suitable additional water supplies is questionable. How will loss of water to these wells be addressed?	The protection of domestic water wells falls under the site's PTTW. Any amendments to the PTTW will require the approval of the MECP that no adverse impacts will occur as a result of the quarry operations.
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.	This question has been asked and answered multiple times	See comment 242.	See response #24.2

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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?	As per Response 236, we divided the sum of all the outflows to groundwater by the sum of all the wetland area outflows and multiplied by 100. GW outflow terms included GW recharge, GW discharge to streams, and GW discharge to lakes. The other outflows included Soil ET, streamflow out, lake evaporation, Hortonian runoff out, and interflow/Dunnian runoff out. GW inflow terms included GW discharge (surface leakage), GW inflow from streams, and GW inflow from lakes. The other outflows included Net Precipitation, streamflow in, lake precipitation, Hortonian runoff in, and interflow/Dunnian runoff in. Specifically, water budgets were conducted using an Earthfx GSFLOW post-processor to analyze the daily flows produced as outputs from the PRMS and MODFLOW models. MODFLOW fluxes were analyzed with an Earthfx version of the USGS ZoneBudget tool. It processes all the direct cell-by-cell flow terms (e.g. groundwater recharge or stream leakage). Lateral flows are summed for all cells on the wetland boundary. Direct PRMS flows are also summed on a cell-by cell basis. Overland runoff and interflow required analyzing the cascade flow map to determine which cells have runoff leaving the wetland boundary and which cells receive runoff and interflow from upslope cells. Streams crossing the wetland boundaries were detected by analyzing the SFR2 input to locate stream segments entering and leaving the cells. Lake water budgets were saved on a daily basis and used to determine Lake precipitation, evaporation, and GW and streamflow inputs and outputs. The post-processor output was produced as a CSV file and pasted into an Excel spreadsheet to tabulate and combine flows to create the wetland water budget figures.	Same comment as comment 236.	Please refer to the updated AMP.
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.	See Responses 240 and 241. The loss is on an annual basis. Again, the model showed that flows would be affected mainly in the winter and spring not summer.	How does rehabilitation Scenario RHB1 address the loss of baseflow to the Medad Valley? Also see comment 240.	Please refer to Schedule 2. (Updated model results).
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?	RHB1 is a plan for the entire quarry and would replace existing rehab plans	No response provided	RESOLVED
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?	As previously explained, water leaks out of the infiltration pond and forms a groundwater mound. As indicated in the model, heads rise in all layers.	It is implied that there is no preferential flow accounted for in the computer model to address this concern.	Please refer to Schedule 2. (Updated model results).
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	These were differences in average flows measured at SW7 (Average flows were 0.0423 m^3/s for baseline, 0.0387 for P3456, and 0.0372 for RHB1). The difference between Baseline and RHB1 is 5.1 L/s while the difference between baseline and P3456 is 3.6 L/s. The higher decrease for RHB1 is mainly because there is less quarry discharge under this scenario, therefore less leakage from the unnamed tributary and subsequent pickup in the Medad near SW7, as stated in the report (see next comment).	It seems counter intuitive that there will be decreased flow under RHB1 compared to P3456 as it is proposed to continue pumping from the northwest sump as part of RHB1. An explanation is required why the flows from the northwest sump will be decreased for RHB1 from P3456. What is the anticipated reduction in flow to the unnamed tributary to Willoughby Creek from the Northwest Sump for RHB1? The reported decrease in flow in the Medad Valley of 3.6x10 -3 m3/s (3.6 L/sec) appears to contradict the modelled reduction in flow of 2.1 L/sec. See comment 240. Clarification is required.	Please refer to Schedule 2. (Updated model results).

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	different points?			
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.' SW7 gains and losses. How does this compare to decreases reported in Medad Valley above i.e., maximum 5.2 litres/second.	The 5.2 L/s is an average value. Figure 8.84 shows that there are decreases in the peak flows but baseflows actually increase slightly. The small increase is due to the higher head in the RHB1 lake and added leakage to groundwater but the peak flows decrease due to less quarry discharge. This demonstrates why a model is needed because there are a number of opposing factors affecting flow in the Medad and it is impossible to intuit which is likely to dominate.	See comment 248.	Please refer to Schedule 2. (Updated model results).
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?	As previously discussed, the model calibrated model was checked and found to produce reasonable results at instrumented wetlands. Assuming that underlying conditions are similar, the response at the remaining wetlands was felt to be predictable.	The subsurface stratigraphy is shown to be variable and somewhat different in the vicinity of wetland 22 (Wetland 13200). The borehole log for nearby borehole BS-03 shows a sand and gravel layer underlying a surficial silty clay till. The sand and gravel layer is absent in other boreholes completed in the western extension area with the exception of BS-06. The soil stratigraphy of BS-07 in unknown as the drillers log has not been provided. Water level data from wetland 22 and the underlying overburden and bedrock is lacking. The computer simulations therefore rely on data removed from the wetland. The modelling results may therefore not provide a reasonable representation of wetland 22. A comment is required on the degree of reliability of the model predictions for wetland 22	Please refer to the updated AMP.
251.	It is not clear how the percent of groundwater inflow and outflow have been determined. Please clarify.	See Response 244.	See comment 236, and 244.	See response to #244.
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.	This report discusses groundwater conditions. There are a number of factors that make RHB1 a preferred alternative that are not discussed here. From a hydrologic/ecologic point of view, this is the preferred alternative because the flows to the fisheries are maintained. The distributed integrated model fully addresses overall impact on a sub-watershed scale. We specifically assess both local and distant surface water monitoring.	The main rational for maintaining the quarry discharge and pumping appears to be based upon perceived fish habitat benefit. The benefits of restoration of stream baseflows to conditions more closely aligned to pre-quarry conditions does not appear to have been given consideration in the comparison of rehabilitation scenarios.	The rationale is based on recommendations from Thatham and GEI. The watershed and associated features have become dependent on water being discharged from the existing quarry and it is recommended that the current pumping regime be maintained.
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 2m rise extending out up to 630 m from the west side of the existing quarry. The predicted increase in groundwater levels should result in restoration of groundwater conditions. The overall impact of this on surface water and on local	Yes, from a groundwater perspective, this may be a better alternative. As noted previously, there are concerns related to cessation of pumping at the existing quarry and therefore the preferred alternative was RHB1. We evaluated both scenarios with the integrated model.	The benefits of increasing groundwater levels from RHB2 doe not appear to have been considered in relation to the impacts of the existing quarry and the existing approved rehabilitation plan. The rationale for selecting RHB1 appears to be based primarily upon perceived impacts on fish habitat including unconfirmed fish habitat along the tributary to Willoughby Creek. The groundwater benefits and resulting improvements in stream baseflow from RHB2 do not appear to have been given appropriate consideration when evaluating alternative rehabilitation scenarios.	Nelson will not be removing the weir at SW1.

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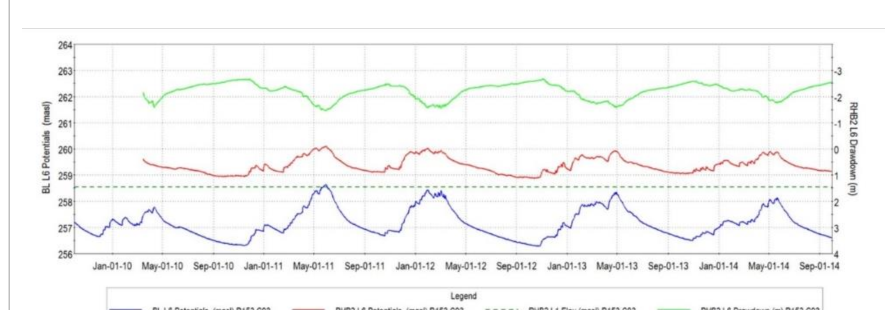
	wells should be assessed and factored into the rehabilitation scenario assessment.'		Clarification is required whether the RHB2 modelled streamflow scenario as shown on Figure 8.106 (PDF page 284) takes into consideration the removal of the weir at SW1 which controls the flow into the tributary to Willoughby Creek as well as the proposal by Tatham to redirect of external drainage from entering the existing quarry from north of the existing quarry to the drainage ditch along Collins Road ultimately feeding the tributary to Willoughby Creek. See comment 252	
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.)	Typo, you are correct, the text should have said decrease not cease.	Typographical error acknowledged. Assume correction to be made. Suggestion of an analysis of anticipated streamflow changes remains unanswered. See comment 253.	See response #253.
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.	This sentence is a bit unclear. With quarry discharge ceasing, there is no inflow into the infiltration pond. The lack of infiltration from the pond though is offset by leakage from the filled quarry lake so overall there is a very small increase in baseflow. The event flows decrease because there is no quarry discharge and to SW1 and leakage from the karst feature.	The response suggests that model predictions show that leakage from the filled quarry under RHB2 provide slightly more benefits to groundwater recharge than the predictions of infiltration from the infiltration ponds. See comment 253.	See Schedule 2 for updated pond simulations.
256.	The surface elevation should be shown on each of these hydrograph figures representing each of the eight assessment points.	With the exception of GW1 (below) all heads are below land surface. 	Ground surface elevations on these figures would be helpful in visualizing and understanding the hydrogeological simulations.	Information has been adequately presented.

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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.	The comment is unclear from a hydrologic sense. Ground surface has nothing to do with groundwater levels. The quarry lake will be allowed to refill. It will reach an equilibrium where seepage in from the north, precipitation, lake evaporation, runoff in, and seepage to the south will balance. The lake becomes the local high point for the groundwater system across from Cedar Springs Road and heads slope down from the lake to the Medad Valley as per Figure 8.105.	Clarification provided. It is acknowledged that the lake will contribute to maintain groundwater levels down-gradient of the lake. Groundwater levels in up-gradient adjacent areas would likely not be affected by lake levels except perhaps directly adjacent the lake. This assumes that up-gradient areas of the lake are upland areas contributing groundwater inflow to the quarry lake.	RESOLVED
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 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.	Same as Comment 254.	See comment 253 and 254.	We are confident and can defend our assessment of potential impacts as simulated. We do not believe additional simulations are required.
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.	This has been previously addressed.	See comment 236 and 244.	Clarification has been provided.
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.	A discussion of surface water quality is presented in Response 7 and 8	See comment 7, and 8.	See response #7 and #8
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.	This point has been raised multiple times and answered. There was a substantial effort to collect data in the vicinity of the proposed western and southern extensions. The southern extension benefitted from historic data collected as part of a previous quarry expansion study. We took advantage of the data to develop a very detailed model of the study area. The lack of a long period of record in the west does not detract the understanding of baseline conditions developed for the site. The infiltration ponds are discussed in numerous comments, above.	Acknowledged data gaps.	RESOLVED

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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 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.	An extensive package of interdisciplinary tables integrating wetland and watercourse characterization and analysis has been prepared and provided in Schedules B and C. Wetland monitoring is discussed in Response 14	Inconsistencies and conflicting data persist and remain unresolved. See comment 14 and 262.	We respectfully agree to disagree.
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.	The point is raised here and in a number of previous and succeeding comments. We recognized that drawdowns due to dewatering the west expansion could impact private wells on Cedar Springs Road. This was the main point of adding an infiltration pond is to replace the golf course ponds that may have contributed to groundwater recharge in the area. It is assumed that the infiltration pond will be in good hydraulic contact with the bedrock surface and should provide higher leakage than the natural ponds with their accumulated sediments. Some of the water will be picked up in the expanded excavation area and recirculated, but the main effect is to recharge the groundwater west of the quarry and maintain higher heads and prevent the private wells from going dry. Other provisions for the private wells are discussed in the report.	Concerns remain with respect to impacts on down-gradient private wells. Insufficient information is available to support proposed mitigation measures for private wells. See comment 293, 285, 242, and 243.	See response #6.
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.	This has been previously addressed.	See comment 264	See response to #6.
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	Yes, Wetland 17 was noted to have higher rates of groundwater inflows than the other features under current conditions. Pre-development conditions may have been altered over the 70 year life of the existing quarry. However, the scope of this work was to analyze the likely impact of quarry expansion. The effects on this wetland are discussed in more detail in the package of interdisciplinary tables integrating wetland and watercourse characterization and analysis that has been prepared and is provided in Schedules B and C.	Hydrographs provided by Tatham for wetland 13027 (SW11B), wetland 13022 (SW12B), wetland 13016 (SW13B), wetland 13031 (SW5B) and wetland 13037 (SW16B) all show seasonally high shallow groundwater levels above ground surface. This indicates that these wetlands are not perched above the shallow groundwater table. These wetlands therefore would potentially receive groundwater inputs on a seasonal basis and would be potentially impacted by changes and lowering of groundwater levels from quarry operations.	Inputs are less than 3% as presented in the water balances. We stand by the assessment that indicates that wetlands are surface driven features.

	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 demonstrated with certainty that none of the wetlands receive significant groundwater inflow. Please clarify.			
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.	A detailed discussion of the monitoring program and AMP is presented in our response to comments from the MECP (see Schedule A). We will take this comment under consideration as the monitoring program and AMP are finalized. Additional water quality data and discussions are presented in our response to the MECP comments.	Water quality objectives remain absent from the documentation. The water quality information presented in the Earthfx report completed by Azimuth Environmental Consulting Inc. (Azimuth) was focused upon determining the water quality type with the perspective of determining the origin of the water and differentiation between surface water and groundwater. No groundwater quality targets were provided in the Earthfx report or the response to MECP attached to this table. Water quality limits were provided in the Environmental Certificate of Approval (ECA) for sump discharges for the existing quarry. It was proposed to maintain those limits with the proposed rehabilitation Scenario RHB1 where sump discharge would continue as part of the rehabilitation plan. Water quality limits stipulated within the existing ECA include only three parameters including Total Suspended Solids, Oil and Grease and PH. No reference is made to drinking water quality limits as the discharge water is proposed to be infiltrated by proposed infiltration ponds to maintain groundwater levels in down-gradient private wells.	This has been addressed several times. Please refer to the updated AMP.
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.	A detailed discussion of the monitoring program and AMP is presented in our response to comments from MECP (see Schedule A). We will take this comment under consideration as the monitoring program and AMP are finalized.	See comment 269.	See response #269.
271	Typographical errors in this paragraph: W03-1A should be MW03-1A and M03-1B should be MW03- 1B.	Comment noted.	Typographical error noted. Assume this will be corrected.	RESOLVED
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-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.	A detailed discussion of the monitoring program and AMP is presented in our response to comments from MECP (see Schedule A). We will take this comment under consideration as the monitoring program and AMP are finalized. Additional discussions of the water quality are presented in our response to the MECP comments (see Schedule A).	See comment 269. Spill Contingency and Pollution Prevention Plan, revised February 6, 2019 is Attachment 3 to the Natural Heritage JART Comment Summary Table. This document provides a description of the mechanics of spill reporting and cleanup, also outlining roles and responsibilities of individuals with respect to spill detection, reporting and cleanup. Absent from this document are monitoring requirements to determine effectiveness of spill cleanup and measures to protect the quarry sumps from discharging contaminants in the sump discharge.	This plan was developed in consultation with MECP as part of the ECA. The document is complete and meets MECP requirements.
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.	A detailed discussion of the monitoring program and AMP is presented in our response to comments from MECP (see Schedule A). We will take this comment under consideration as the monitoring program and AMP are finalized. Our response to MECP Comment 7 discusses the use of data trends as part of the AMP.	See comment 269.	Please refer to the updated AMP.

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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.	A detailed discussion of the monitoring program and AMP is presented in our response to comments from MECP (see Schedule A). We will take this comment under consideration as the monitoring program and AMP are finalized. Our response to MECP Comment 7 discusses the use of data trends as part of the AMP.	The impacts of the existing quarry are not recognized in the computer modelling. The existing quarry impact appears to be in flux. It has not been demonstrated that these conditions present a stable baseline of conditions from which to evaluate the impact of the proposed quarry expansion.	We agree to disagree.
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 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.	The close calibration to seasonal fluctuations in water levels (that vary, in the near vicinity to the quarry, by more than 7 m) suggests that the model is able to replicate and respond to significant climate variation.	The computer model calibrate is limited due to the absence of on-site data between 2013 and 2019 which described by Earthfx Section 7.2.2, includes a wet period (2017) and a drought period (2015-2016). The model therefore relies upon projections. This provides uncertainty with respect to the model's ability to simulate varying climatic conditions. The impact of data gaps/limitations on model predictions should be clarified.	We agree to disagree. The ARA only requires 1 year of monitoring and Earthfx has calibrated to an extensive water level database that spans several years. The purpose of a model is to project.
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.	Please refer to Response 3, 15 and 78 for a discussion of cumulative impact	Earthfx has incorporated the 'existing impacts' into the impact analysis as 'baseline conditions' and had not acknowledged existing conditions as including impacts from the existing quarry. The proposed preferred rehabilitation option RHB1appears to enshrine the impacts of the existing quarry and the proposed expansion in perpetuity. Site restoration implications of the proposed site rehabilitation plan with respect to mitigation of the impacts of the existing quarry should be identified. See comment 15, 77, 78,148, and 223.	We respectfully agree to disagree.
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	Historical air photos show that the north quarry face wall has been largely remediated (with sloping backfill) since 1979. MP35, located in Wetland 3 near DW2, has shown a consistent seasonal water level pattern in data recorded since 2010. Please refer to our MNRF Comment Response (Earthfx Section 4.3) for maps and hydrographs.	It is apparent that the hydrograph (Figure 34) for MP35 located about 50m from the quarry face is similar to the hydrograph for MP9 (Figure 35) located 820m from the quarry face. The hydrographs extend over a period between May 2010 and September 2013. This suggests that the water levels have not dropped perceptively over this relatively short time period in both of these monitors. It is not clear whether Wetland 3 at MP35 has received surface water inputs that would contribute to the maintenance of water levels within the wetland at MP 35. In the absence of long term groundwater level trends within the shallow and deep groundwater systems northwest of the existing quarry there remains doubt on the suitability of DW2 as a background groundwater monitor.	Please refer to the updated AMP.

	simulations or actual measurements over time? Has this monitoring well been impacted from the existing quarry?			
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?	A detailed discussion of the monitoring program and AMP is presented in our response to comments from MECP (see Schedule A). Our response to MECP Comment 7 discusses the use of data trends as part of the AMP. There are a number of climate stations in the area. Our calibration match to numerous minipiezometers, presented in our response to MNRF comments, illustrates that the model is very closely matching local soil moisture conditions. This indicates that the climate data available for the calibration is more than adequate.	It is commonly acknowledged that weather systems can provide dramatically different conditions locally from the same weather system. For example, some local areas can experience significantly different amount of rainfall than nearby adjacent areas. Local impacts of climate are therefore not likely to be recorded by climate stations that are located kilometers away. Although the existing climate stations may be suitable for establishing average conditions for purposes of calibrating computer modelling, they are considered to be inadequate for purposes of monitoring local groundwater conditions especially in areas with contrasting landforms such as Mount Nemo. An on-site climate station should be part of the surface and groundwater monitoring system for the proposed quarry extensions.	The Burlington Quarry has a weather station (recently installed). Please refer to the updated AMP.
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?	Interannual fluctuations in climate could be compared to the variability observed in the 10 year model simulations. Additional refinement of the AMP approach is open to discussion. Fortunately, the site has an extensive network and history of monitoring, and a proven and highly advanced predictive tool (the GSFLOW Model) that are available for monitoring and analysis.	See comment 281.	Please refer to the updated AMP.
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.	Additional refinement of the AMP approach is open to discussion. Fortunately, the site has an extensive network and history of monitoring, and a proven and highly advanced predictive tool (the GSFLOW Model) that are available for monitoring and analysis.	Issues remain unaddressed. See comment 14, 81, 86, 132, 140, 159, 191. 217, and 235 regarding data gaps.	Please refer to the updated AMP.

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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. 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.	The overall available drawdown at each well was calculated using the simulated water levels and the elevation of the base of the Amabel. Wells may be deepened and operationally treated and restored as necessary.	Issues remain unaddressed. See comment 193, 242, 243, 264, 285, and 293.	We respectfully agree to disagree.
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?'	Long term monitoring data from the private wells is not available, but no well complaints or issues have been noted in this area. The extensive network of monitors in the P12 extension area demonstrates that water levels recover quickly with distance from the existing quarry.	Water levels within the bedrock have been lowered significantly by the existing quarry operations. It has not been demonstrated that deepening of private wells alone has been sufficient to provide adequate water supplies to affected private wells.	This has been addressed several times. We agree to disagree.
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.	Additional refinement of the AMP response is open to discussion. Given the long history of compatible coexistence between the quarry and the home owners and the extensive and productive Amabel aquifer, it is highly unlikely that the proposed solution will not be sufficient.	See comment 287.	Please refer to the updated AMP.
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.	Additional refinement of the AMP approach is open to discussion.	Issues remain unresolved.	Please refer to the updated AMP.
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.	Please refer to Response 116	The effectiveness of the proposed infiltration ponds is based upon assumptions and not supported by field data. See comment 116 and 94.	Please refer to Schedule 2 (model of infiltration ponds).

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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.	Please refer to Response 284.	See comment 140, 281, 283, and 284.	Please refer to the updated AMP.
292	Typographical errors; M03-9 and M03-14 should be MW03-9 and MW03-14.	Comment noted.	Typographical error noted. Assume error will be corrected.	RESOLVED
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).	Nelson is committed to addressing water supply issues as outlined in the AMP. The model has been comprehensively used to identify both average and the minimum available drawdown (under drought conditions) which demonstrates a commitment to understanding of the full range of response.	The proposed percentile statistical method for establishing groundwater level thresholds as outlined in the AMP requires sufficient monitoring data to include a drought period as the drought related groundwater levels are taken to represent the 0th percentile water level. Groundwater level monitoring may not be possible in all nearby private wells due to restricted access. It is not clear how this method will be useful in evaluating water well complaints in nearby private wells where access to the well not possible. Nelson proposes to investigate each water well complaint by engaging a licensed water well technician to perform an investigation on any wells within one kilometer of the quarry where a change has been reported. No guidance is provided with regard to this investigation especially where no background data exists on the well in question. It is not clear whether existing wells that have less than 5 m of available drawdown will be provided with mitigation measures to ensure adequate water supplies.	Please refer to the updated AMP.
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 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.	The purpose to the thresholds is to actively monitor the system before action is required. That makes them useful. The commitments to mitigation are clearly defined. is what	Details are lacking on how the well complaint investigations are to be conducted especially where access to wells for monitoring purposes is not possible and background data on private wells is not available. See comment 293.	Please refer to the updated AMP.

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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)?	The site already has an extensive network and history of monitoring, and a proven and highly advanced predictive tool (the GSFLOW Model) could be used for further assessment. The 10 year period of monitoring will provide an excellent extension to the baseline data already available.	It is questionable how representative the (water level) thresholds will be of background or baseline conditions. It is proposed that monitoring data will be collected during a 10 year period of transient conditions resulting from the excavation of Phase 12. Thresholds should be established prior to commencement of extraction until enough groundwater monitoring data is collected to establish stable baseline conditions.	Please refer to the updated AMP.
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.	Further information on the monitoring program and AMP is presented in our response to comments from MECP (see Schedule A). We will take this comment under consideration as the monitoring program and AMP are finalized. A discussion of water quality is presented in Response 7 and 8	Identification of possible source of contamination to the quarry sumps should be identified. Water quality threshold levels should be established for potential contaminants from on-site and off-site sources. Groundwater quality monitoring should be expanded to include potential sources of contamination. Mitigation and contaminant containment/treatment measures should address all potential contaminants entering the quarry sumps.	Please refer to the updated AMP.
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.	The north discharge has been shown to support (recharge) the shallow water levels. This will be ongoing, in the future so no impacts are expected.	No data has been provided for the north discharge to demonstrate that it supports shallow groundwater levels. Earthfx contends that an extensive layer of Halton Till acts to isolate wetlands from the groundwater system. See comment 280.	Please refer to the updated AMP.
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.	Further information on the monitoring program and AMP is presented in our response to comments from MECP (see Schedule A). We will take this comment under consideration as the monitoring program and AMP are finalized. A discussion of water quality is presented in Response 7 and 8.	The proposed water quality monitoring and mitigation measures are not considered sufficiently thorough to protect private wells. See comment 7, 8, and 298.	Please refer to the updated AMP.
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.	As noted, our wetland characterization tables and response to MNRF comments provide extensive additional information for each wetland. Earthfx Section 2.2.1 in that document provides details on over 62 minipiezometers, soil core boreholes, and Guelph Permeameter test locations. Table 13 lists twelve of the key wetlands that have one or more minipiezometer, including MNRF Wetland 13033, which has 5 minipiezometers. The key larger wetlands, Wetland 17 in particular, were instrumented. Matching the dynamics of these features gave us confidence in our ability to represent the remaining ones.	It is agreed that a number of wetlands have both surface water and groundwater instrumentation. most of which were previously installed for studies completed by Golder Associates within and adjacent to the proposed southern expansion area. These monitors have data gaps that extend over a number of years between the completion of the Golder studies and the current investigations. The western expansion area was instrumented more recently by Azimuth for the Earthfx investigation and computer modelling. The western extension has limited monitoring data upon which to base the computer model projections. A number of wetlands are lacking key instrumentation required for the water budget purposes. Only five wetlands have recent instrumentation installed by Tatham for establishing a water budget analysis. Without groundwater and surface water monitoring data the model predictions cannot be verified for specific locations through a calibration process for those wetlands lacking adequate monitoring data. In the absence of data at a particular wetland, calibration must be made with the available data from surrounding areas. In this way local variations in site conditions cannot be detected. This suggests a degree of uncertainty with respect to model predictions for those wetlands. The uncertainties associated with the model predictions should be quantified.	The number of monitors and period of record is exceptionally large, considering only 1 year of monitoring is necessary for an ARA license application. The transient integrated simulation and comparison to the large monitoring network provides the reader with a detailed view of the model response across a range of climate and groundwater stress conditions both near and far from the existing site. This is far superior to a traditional steady state simulation with sensitivity bracketing, because we are actually simulating all of the processes and their interactions.
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	This has been previously addressed.	See comment 15, 77, 78, 148, 223, and 277 regarding baseline conditions and cumulative impacts. See comment 7, 8, 18, 193, 208, 269, and 298 for water quality.	We respectfully agree to disagree.

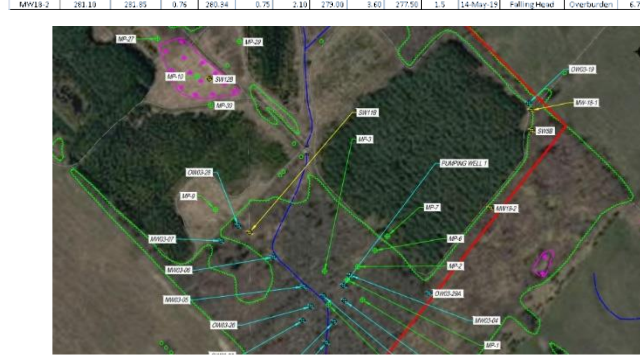
	are fully reconciled.' It may be appropriate to consider existing conditions for purposes of assessing impact of the proposed expansions. The cumulative impacts of the existing quarry and the proposed expansion have not been addressed. A map showing the existing cone of influence and drawdown of the existing quarry should be provided as part of the impact assessment. The impact assessment scenarios should also address groundwater quality.			
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 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 ofextraction. 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.	Please see Response 285 and 293.	See comment 193, 242, 243, 264. 285 and 293 for issues relating to down gradient wells.	This question has been asked and addressed several times. Please note responses regarding the MECP and their requirements under future PTTW and ECA amendments as well as the AMP.
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.	We have analyzed the likely flows in Willoughby Creek and its tributaries under RHB2 conditions. These results were transmitted to other team members to analyze potential impact on hydrologic and natural heritage features.	See comment 230, 245, 252, and 253.	See responses to #230, 245, 252, and 253.
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	We have analyzed the likely flows in Willoughby Creek and its tributaries under RHB1 conditions. These results were transmitted to other team members to analyze potential impact on hydrologic and natural heritage features. We recognize that quarry discharge has modified the pre-development conditions, but there may now be ecological features (e.g., fish populations) that developed over the 70 years of operations that have adapted to or require these flow conditions.	It appears as though the hydrological benefits of scenario RHB2 have not been given sufficient consideration. See comment 230, 245, 252, and 253.	We agree to disagree.

<table>
<tr><td></td><td>condition that has altered a natural system? (This requires input from a natural heritage and fisheries habitat perspective.)</td><td></td><td></td><td></td></tr>
<tr><td>311.</td><td>‘The quality and quantity of groundwater needed for the natural environment and wells will be protected,’

It has not been demonstrated how water quality will be protected. Clarification is required how this will be accomplished.</td><td>A discussion of water quality is presented in Response 7 and 8 and discussed in our response to the MECP AMP questions (see Schedule A).</td><td>The documentation is missing a discussion of the necessity of meeting drinking water quality standards for the infiltration ponds and the establishment of groundwater quality thresholds for the protection of downgradient private wells. See comment 7, 8, 18, 193, 208, 269, and 298.</td><td>This comment is redundant and has been addressed. See responses #8, 18, 193, 208, 269, and 298.</td></tr>
<tr><td>312.</td><td>‘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</td><td>A discussion of water quality is presented in Response 7 and 8 and discussed in our response to the MECP AMP questions (see Schedule A).</td><td>See comment 311.</td><td>See response #311</td></tr>
<tr><td>313</td><td>Typographical Error; Worthington 2019 should be Worthington 2020</td><td>Comment noted.</td><td>Typographical error noted. Assume error will be corrected.</td><td>RESOLVED</td></tr>
<tr><td>315.</td><td>‘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.</td><td>See response to Comment 11. It should be noted that the Keith Lang boreholes are BS-04 to BS-07 and data have been provided for these wells in the report. The original MECP drillers logs are provided in Schedule E</td><td>It would be helpful if the corresponding assigned borehole numbers are indicated on the MECP drillers log provided in Schedule E. It is not possible to correlate with certainty, the MECP drillers record with the assigned borehole numbers. See comment 317.</td><td>Keith Lang records were requested and provided.</td></tr>
<tr><td>316.</td><td>‘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.</td><td>Well construction and location data are provided below. Slug test data for the wells are provided in Schedule E. Well locations are shown below.
<table>
<tr><th>Well ID</th><th>Ground Elevation</th><th>Reference Elevation</th><th>Static WL</th><th></th><th>Stick up</th><th>Top of Sand Pack*</th><th></th><th>Bottom of Sand Pack *</th><th></th><th>Length of Screen</th><th>Test Date</th><th>Test method</th><th>Formation</th><th>Hydraulic Conductivity Analysis</th><th>Interval Transmissivity</th></tr>
<tr><td></td><td>(masl)</td><td>(masl)</td><td>(mbgs)</td><td>(masl)</td><td>(m)</td><td>(mbgs)</td><td>(masl)</td><td>(mbgs)</td><td>(masl)</td><td>(m)</td><td></td><td></td><td></td><td>(m/s)</td><td>(m2/s)</td></tr>
<tr><td>MW18-1</td><td>284.60</td><td>285.40</td><td>1.55</td><td>283.05</td><td>0.80</td><td>3.00</td><td>281.60</td><td>6.00</td><td>278.60</td><td>3.0</td><td>14-May-19</td><td>Rising Head</td><td>Overburden</td><td>1.6E-08</td><td>4.8E-08</td></tr>
<tr><td>MW18-2</td><td>281.10</td><td>281.85</td><td>0.76</td><td>280.34</td><td>0.75</td><td>2.10</td><td>279.00</td><td>3.60</td><td>277.50</td><td>1.5</td><td>14-May-19</td><td>Falling Head</td><td>Overburden</td><td>6.7E-08</td><td>1.0E-07</td></tr>
</table>
</td><td>It is not clear for what the purpose monitor MW-18-1 and MW-18-2 were installed.</td><td>To monitor water levels in the overburden at the property boundary.</td></tr>
<tr><td>317.</td><td>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.</td><td>As per the response to Comment 11 and 315, drillers logs for BS-06 and 07 are provided in Schedule E. As indicated in the report: “The Keith Lang boreholes [including BS-06 and BS-07] 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”.

Spinner logs were recorded in BS-06 and BS-07 and these are also included in Schedule E. For additional details refer to Borehole Log BS-03, (Earthfx, 2020, Page 361) which is less than 10 m from BS-06. The borehole log for BS-03 shows that the</td><td>MECP drillers records were provided for the Lang monitoring wells BS-06 (Tag no. A235621) along with Tag no. A235624, assumed to be BS-04 and Tag no. A235628 assumed to be BS-05. Azimuth provided borehole logs with their report for BS-01, BS-02, BS-03, BS-04, BS-05, BH18-1 and BH18-2. The borehole and/or drillers log for BS-07 appears to be missing. Soil descriptions for the Tatham boreholes are also missing. It is noted that ground elevation is missing for BS-04, BS-05, BS-06 and BS-07.</td><td>Noted.</td></tr>
</table>

		water table was at the bedrock surface contact at the time of drilling so no monitor was installed above the water table.		
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.	A spreadsheet with pack test data has been provided in Schedule E. The packer test depth intervals are listed in the table. The information has also been presented in a table in a MS-Word document. Figures showing the packer test locations are also provided.	Comment noted. Model layers corresponding to packer test intervals on the provided tables would be helpful for peer review purposes.	RESOLVED
320.	Typographic error; 1615 Cedar Springs Road should be 5161 Cedar Springs Road as referenced in text at top of page 371.	Comment noted.	Typographical error noted. Assume error will be corrected.	RESOLVED
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?	As demonstrated by these two close wells, some locations will be proximal to a well-connected fracture, some locations will not. There distribution of fracture connectivity is likely random and not mappable. Reasonable EPM aquifer properties were adopted in the model, but there will not be a match to K variation at specific locations.	Clarification provided.	RESOLVED
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.	As per the response to Comment 11 and 315, drillers logs for BS-06 and 07 are provided in Schedule E. As indicated in the report: "The Keith Lang boreholes [including BS-06 and BS-07] 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". Spinner logs were recorded in BS-06 and BS-07 and these are also included in Schedule E. For additional details refer to Borehole Log BS-03, (Earthfx, 2020, Page 361) which is less than 10 m from BS-06. The borehole log for BS-03 shows that the water table was at the bedrock surface contact at the time of drilling so no monitor was installed above the water table.	Borehole logs were provided as per comment 11. Confirmation of the unsaturated overburden with the construction of a groundwater monitor within the overburden would have been helpful in assessing the interconnectivity between the overburden and the bedrock. The lack of water within the overburden may have been due to the conventional rotary drilling techniques used to drill the borehole. A bentonite mud is typically used in conventional rotary drilling techniques to lubricate the drill bit while completing the borehole. This may also create a temporary barrier to formation water entering the borehole. Water levels measured within the underlying bedrock zones as shown on the borehole log for BS-03 would support the conclusion of unsaturated conditions within the overlying overburden at this location although this is not conclusive without instrumenting the overburden for groundwater level measurements.	Please refer to the updated AMP.
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?	Monitors were constructed by experienced staff so there should be little chance of interconnection. BS-01 to BS-05 contain multi-level monitors. Similar water levels between screened aquifer units were expected at these wells due to the findings presented by Golder on the south lands (MW03-04, MW03-28, and MW03-32) along with the aquifer testing results on the western expansion land wells. There is also a constant supply of recharge water from the golf course irrigation ponds which influence the aquifer systems. The vertical gradients are also discussed in Section 5.3.3.2 where it is noted that that with increasing distance from the quarry, the difference in head between the shallow and deep system is reduced and when the quarry no longer influences the lower system, the water levels in the shallow and deep system are nearly identical.	It is acknowledged that testing the integrity of bentonite seals may be problematic. Slug testing with the removal from or adding of water to one monitor while measuring water level response in the other monitors within the same borehole could provide evidence of the integrity of the bentonite seals within the same borehole. Completion of separate boreholes with individual monitors in each borehole would greatly reduce uncertainty regarding leakage through bentonite seals within the borehole.	Your preferred way to construct monitoring wells is noted however we are confident that the multi-level monitors within each borehole have adequate seals.

NORBERT WOERNS COMMENTS

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.	As noted in Comment 325, a spreadsheet providing data for of all monitoring wells is provided in Schedule E. The data is also presented in an MS-Word table along with figures showing well locations. Average water levels are provided in the table along with ground surface and monitor top and bottom elevations so that depth to water and available drawdown can be determined.	Monitoring well water level data provided.	RESOLVED
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 quality characterization has not been provided and should be included in the assessment report.	Additional water quality information has been compiled and supplied in the response to the MECP comments and AMP discussion included in Schedule A.	Some additional water quality data was provided for the Goodchild well in the response to MECP Table comment 4. It is not clear whether the water quality data presented represents average water quality. It is also not clear when or how the well water samples were taken. Water quality data is provided from the sump discharges as part of the 2019 and 2020 Groundwater and Surface Water Compliance Reports, provided as attachments to the JART Natural Heritage Summary Table. Water quality laboratory data sheets are included in these reports but are missing for groundwater data collected by Azimuth. A discussion is lacking regarding the potential for water quality impacts on the groundwater system and down-gradient wells from the proposed infiltration ponds. As it is proposed to infiltrate quarry sump discharge, a water quality analysis of the sump discharge with respect to the Ontario Drinking Water Standards is required.	This has been asked and answered. Therefore we can agree to disagree.
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 the156 homes visited as part of the well survey did not have a response. Threshold levels should be established for the private wells.	Additional details about the well survey are included in the AMP document (together with a map showing the locations that responded). The AMP also states that a follow-up well survey will be completed at a later date due to again invite well owners to participate. The seven wells to which access was provided in the first survey did not provide significant insight beyond the publicly available well record. Additional documentation could be provided now, however the AMP states that Nelson's website will have a page dedicated to Private Well Monitoring details once the second survey is complete.	All wells/residences included in the survey, whether responding or not, should be indicated on a map. Having private well information is important to providing an effective assessment of potential well interference complaints.	All wells within 1 km were surveyed however resident participation was limited. As noted, upon licensing a detailed water well survey will be completed again to ensure that we have accurate information on the key receptors, such as well location, well depth, historical water issues (quality and quantity), available drawdown, etc. Until residents participate in this survey, additional information cannot be obtained. This work will be a condition of the ARA license as well as a requirement for any future ORWA applications to be submitted and reviewed by the MECP.

NIAGARA ESCARPMENT COMMISSION COMMENTS

Proposed Burlington Quarry Expansion
Interim JART COMMENT SUMMARY TABLE – Hydrogeology

Please accept the following as interim 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. **These interim comments will be finalized following the breakout meetings between JART and Nelson and any changes will be marked using "track changes". 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)	Applicant Response	Interim JART Response (February 2022)	Applicant Response June 2022
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.	The report does in fact, clearly delineate the "cumulative effects" of all existing and proposed excavations in the water level maps and hydrographs presented for each development scenario phase. The results were presented in terms of absolute water levels and streamflows, not just in terms of change, so the cumulative impacts were fully taken into consideration. We also present incremental drawdowns from a fully transient 10-year baseline, and both average and minimum remaining available drawdown in the aquifers. As part of the report, extensive use of observations of change in groundwater levels due to excavation within the quarry footprint was utilized (See Section 6.11.3). This information was extremely useful for the transient calibration and for developing an understanding of the magnitude of the likely future changes due to quarry expansion. This work resulted in a recommendation to revise the rehabilitation plan for the existing quarry to mitigate impacts from the existing approved quarry. As JART is aware the existing approved rehabilitation plan for the Burlington Quarry requires dewatering to stop and the site to naturally flood to a lake with no off-site discharge. As part of the Burlington Quarry Extension application, Nelson has agreed to modify the existing quarry rehabilitation plan to maintain off-site pumping to improve conditions for surrounding lands compared to existing approvals and maximize land area for future after uses. We did not attempt to recreate pre-1950s conditions, as this would have limited relevance to assessing the impact of future expansion, which was the focus of this study. Pre-1950's data is extremely limited, so attempts to estimate flows and levels at that time would be of little value.	Not addressed. Restoration and enhancement with regard to development that has occurred or may occur is not predicated on recreation of pre-1950s conditions but can refer to historical data available for surface conditions, and this report details that absent perpetual pumping the resulting lake will be at a level conforming to the water table. Potential "long-term" impacts to the downstream fish habitats are relative, given the life of the existing quarry and pumping regime versus the age of the overall landscape.	As we noted, the model analyses and report looked at the cumulative impacts of all activities in an 83 km2 area surrounding the quarry site during the excavation periods of the proposed quarry expansion and post-rehabilitation. The analyses assumed that the current quarry footprint represented the maximum for the existing site and no further impacts from current conditions were expected. The rehabilitation analyses included rehabilitation for both the existing quarry and expansion areas. This covers the lifespan of the proposed excavation, as required, with the added analysis of the existing site under current and future (rehabilitated) conditions. The response raised a second issue related to potential "long-term" impacts to downstream fish habitat. As we noted in discussions with MNDMNRF, fish habitat has been significantly altered due to factors other than quarry discharge including construction of a dam at the confluence of Willoughby and Bronte Creek (SW2) and numerous in line ponds between SW7 and SW2. There is no fish habitat in the Medad Valley upstream of SW7.
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.	The rehabilitation objectives and designs are discussed in further detail in the other companion reports (i.e. MHBC 2020). Considerable thought and analysis went into the preparation of the design and it reflected factors including the requirements of the NEP (2017). The integrated modelling rehabilitation analysis indicates that the proposed scenarios will preserve and restore streamflow, groundwater levels, wetland stage, and wetland hydroperiod to conditions similar to those currently observed at the site. The phrase "the overall hydrogeologic and hydrologic conditions will be similar to the final extraction phase" was referring to the groundwater levels and water management features from a modelling context. Considerable site rehabilitation will be done to create and enhance recreational features and enhance natural features on the site. Pumping will be required in Scenario RHB1 to manage groundwater inflows into the site, maintain the recreational features and enhanced natural features on site. Discharge from the site will have the added benefit of helping maintain current flows in the tributaries to Willoughby and Mount Nemo Creeks and to sustain the fisheries that have adapted to these long established rates of flow. Future operations will no longer be driven by golf course irrigation needs and can be optimized for ecological and fisheries benefits as there is considerable water storage in the quarry. The proposed infiltration pond in RHB1 is both larger than the current golf course pond system and closer to the Medad Valley and can also be operated in a manner beneficial to the natural features of the valley. Scenario 2 allows the groundwater levels within the excavated areas to recover. This will also allow groundwater levels outside the site to recover. Flows in the tributaries to Willoughby and Mt Nemo Creeks will decrease because of the cessation of pumping, but a new, more natural equilibrium would be restored with increased groundwater discharge to the Medad Valley. Taking into consideration both rehabilitation scenarios, the water resources and natural environment team recommend rehabilitation scenario RHB1.	Partially addressed. As with comment 3, the "long established" quarry discharge rates of flow to the Willoughby and Mount Nemo Creeks tributaries are relatively brief given the life of the quarry vs. the extant landscape. Estimates of quarry discharge contributions in proportion to overall flow where fish habitat occurs in these watersheds would be informative, in addition to background information on whether fish habitat was present prior to establishment of the quarry operations.	As we noted in our response, two scenarios were investigated: RHB1 which required ongoing pumping to continue to provide water to off-site features; and RHB2 which allows the groundwater levels within the excavated areas to recover but would result in decreased discharge, with flows at more natural (pre-dewatering) levels. The response raised other questions related to fish habitat. As noted above, fish habitat has been significantly altered due to factors other than quarry discharge including construction of a dam at the confluence of Willoughby and Bronte Creek (SW2) and numerous in line ponds between SW7 and SW2. With regards to historic flows, existing quarry operations started in the 1950s and pre-date the start of monitoring in 2003. Data on flow conditions and habitat prior to that time are unavailable. The Bronte Creek Watershed Study (Conservation Halton, 2002), notes that fish habitat has been significantly altered due the dam at the confluence of Willoughby and Bronte Creek (SW2) and more than 12 private in line ponds (visible in new LIDAR data) between the quarry and SW2. Significant additional insight, including new LIDAR data detailing Willoughby Creek and the Medad Valley, is provided in Earthfx Schedule 1 and 2.

NIAGARA ESCARPMENT COMMISSION COMMENTS

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)?	A package of interdisciplinary tables integrating wetland and watercourse characterization and analysis has been prepared and provided in Schedules B and C. Included in those tables are additional hydrographs illustrating the timing and volume of groundwater seepage change that is predicted to occur. The simulations are consistent with long term observations at Wetland 10 and 3 which demonstrate that nearby quarry excavations have no measurable effects on the perched wetlands (see companion MNRF response and discussion). There are wetlands close to 120 m from the proposed extraction areas. Most of the wetlands are perched and thus receive no groundwater inflow. Lowering the water table in the vicinity of these features will not have an impact on the features. Other wetlands receive groundwater inflows for all or part of the year when the water table rises above the base of the wetland. The amount of groundwater exchanged between the aquifer and the wetland at these times strongly depends on the hydraulic conductivity of the material beneath the wetland. The wetlands in the site vicinity are underlain by Halton Till, which has been found to have generally low hydraulic conductivity, thereby limiting the volumes of water exchanged. Groundwater inflow into these wetlands forms a small part of their water budget, therefore, decreases in these volumes are expected to have limited negative impact on the hydrologic function of the feature, water quantity and quality, natural streams or drainage pattern, and the overall water budget for the watershed.	Partially addressed. The review may be better informed by more granular data presentation and analysis. Confirmation that some wetlands receive groundwater flows for all or part of the year indicates that a 3% loss of inflow is acknowledged and evaluation of cumulative impacts based on a short sampling span is limited in scope.	Our study has been highly integrated, both during the original work and in formulating responses to the review comments. The lack of monthly water budgets in the original report is not a reflection on the level of integration. In fact, hydrographs and tables of daily flows, stage, and groundwater levels and other water budget components were provided to the other team members during the course of the project as aids in their analyses. These daily data were as granular as possible with the integrated model and showed the seasonality and year-to-year variation in wetland behaviour. Additional granular results, integrated with new LIDAR data detailing Willoughby Creek and the Medad Valley, is provided in Earthfx Schedule 1 and 2. As noted, monthly water budgets are inferior to our submission of annual summaries and graphs of daily components. Monthly average water budgets smear the effects of wetland function because of changes in the timing of the arrival of the spring freshet and lagged changes in surface and groundwater storage. For example, the spring freshet may occur entirely in one month, or span a month boundary. Further, surface water and groundwater storage response is also lagged.
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 is a summary of the findings. There are detailed discussions on predicted changes in the groundwater levels, streamflow, and wetland stage for each scenario. In particular, Section 8.5 and 8.6 discuss the effects of P12 excavation and refilling on western streams and wetlands.	Partially addressed. 8.5 details extraction of areas 1A, 1B and 2 (south extension). 8.6 and 8.7 provide information on extraction of areas 3, 4, 5 and 6 (west extension). These further details are acknowledged, but impacts on NEP key hydrological features are confirmed in this analysis.	Correct, sections 8.6 and 8.7 provide the detailed discussions on predicted changes in the groundwater levels, streamflow, and wetland stage for the effects of P3456 excavation and P12 refilling on the western streams and wetlands. The streams and ponds to be redirected under that scenario, mentioned in the original comment, are artificially created golf course ponds and the interconnecting channels (originally drainage ditches) that are fed by quarry discharge. These will be removed. An infiltration pond, discussed in the report, is intended to replace the groundwater recharge function, of the removed golf course ponds. For additional information please refer to Schedule 1 and 2.

Schedule 1

MEMORANDUM

To: JART Review Team

From: Earthfx Incorporated

Date: April 19, 2022

Subject: Response to JART comments and follow up to Feb. 16, 2022 meeting.

Introduction

This technical memorandum is intended to address remaining concerns expressed in the February 16, 2022 meeting with the JART hydrogeology technical team. The meeting was convened to address the following outstanding items related to the infiltration feature that will be constructed prior to Phase 3 excavation in the proposed West Quarry extension.

1. Clarification of purpose(s) for the infiltration pond.
    1. What is the mitigation purpose?
    2. Are they required or are they proposed for aesthetic purposes?
    3. Have there been any changes/updates?
    4. Should the modelling be updated to exclude the infiltration pond?
2. It would be good to understand how the infiltration from the new ponds will benefit the receiving waters (Willoughby Tributary, Willoughby Creek, and reaches along the Medad Valley) from a habitat perspective.
3. What are the anticipated changes to streamflow in receiving waters with and without the infiltration pond?
4. Lack of field data to support or confirm the feasibility /effectiveness of the proposed infiltration (refer to comments 6, 18, 94, 110, 116, 207, 230, 231, 237, and 247).
5. Water Quality discussion

The February 16 meeting slides have been previously provided to the JART team.

1 Infiltration Pond Purpose

1.1 What is the mitigation purpose

A short presentation was provided at the outset of the meeting in an attempt to address the list of questions. The slides have been provided to the JART team. The first slides reviewed the site history and purpose of the infiltration feature and noted that the primary intent was to replace infiltration that currently occurs due to losses from the golf course irrigation ponds. These ponds are fed by quarry discharge from the Northwest sump.

As per the slides, the purpose is as follows:

- Purpose is to replicate the function of the existing golf course irrigation ponds
- Would be fed by same diversion of quarry discharge.
- Not required, but purpose is to maintain heads and flow divide between quarry and Cedar Springs Road

1.2 Pond Requirement

The infiltration ponds will be excavated down to the bedrock surface and will also be fed by quarry discharge. Infiltration of water from the feature will raise heads in the immediate surrounding area and re-establish a groundwater mound between the West Quarry extension and Cedar Springs Road. The intent is to minimize the likely drawdowns (change in groundwater levels) due to the quarry but is not a required mitigation feature. The golf course ponds and irrigation system may provide some limited aesthetic benefit to the surrounding private ponds and properties.

1.3 Changes/Updates

There have been no changes to the original design and no changes are foreseen. The modelling results provided in the report represented the infiltration feature as it was designed.

1.4 Model Analysis without infiltration ponds

Additional simulations have been conducted (as discussed in the presentation and below) with and without the feature strictly for the purpose of quantifying the incremental effect of the feature on groundwater levels and surface water flows. The results of the simulations are discussed below.

2 Benefits to Receiving Waters

In the slide show, Earthfx presented results of two simulations conducted to isolate and quantify the effects of the golf course irrigation ponds and the infiltration feature. First, a model run was set up in which the golf course ponds were eliminated. Comparison of these results with the baseline conditions showed that infiltration from the golf course ponds accounted for about a 1.5

to 2.5 m increase in the water levels (Figure 1). Net seepage from the ponds was estimated at 130 m3/d (about 20 igpm).

A similar analysis was conducted with the infiltration ponds removed from the P3456 conditions simulation. Drawdowns show that the feature contributes to an increase of 4.5 to 5.5 m beneath the ponds and about 1.5 to 4.5 m along Cedar Springs Road. Net seepage from the feature was estimated at 780 m3/d (about 120 igpm). It should be noted that the infiltration ponds were simulated in a very conservative manner, assuming that the feature could clog over time due to runoff from the surrounding area and accumulation of organic material. The total suspended solids in the quarry discharge are low and would not contribute to clogging. Clogging would be prevented by periodic maintenance of the feature.

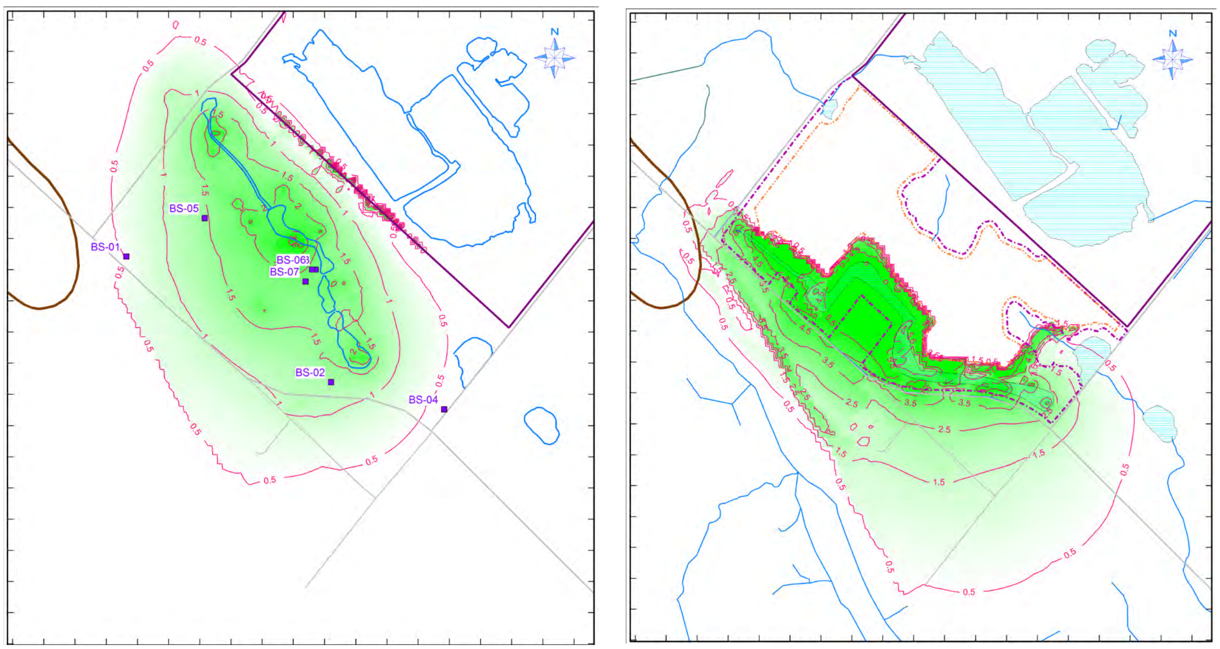


Figure 1: Simulated drawdowns in model Layer 6 due to (a) removal of the golf course irrigation ponds from the baseline conditions simulation and (b) removal of the infiltration feature from the P3456 conditions simulation.

3 Changes to Streamflow with and without infiltration pond

Earthfx presented a hydrograph of simulated streamflow in Willoughby Creek with and without the infiltration feature to address concerns related to impacts on groundwater-dependent habitat in the Medad Valley. The hydrograph shows that the decrease in baseflow in Willoughby Creek without the feature is very small (a decrease of about 0.002 L/s) and thus the feature has little influence on groundwater discharge. With regards to change in peak flows, the simulations indicated that there is some reduction in peak flows, but generally less than 0.01 L/s. Reductions in peak flows are generally considered beneficial as they tend to reduce potential for channel erosion. The changes here are insignificant.

In the meeting, Norbert Woerns acknowledged that the modelling was done with great effort and a high level of detail. Chris Neville indicated that that he was also willing to “sign-off” on the model. Both indicated that there are limitations in the ability of the model to predict exact response of the groundwater at specific locations. These arise from data limitations and the variable properties of fractured rock. However, Earthfx maintains that through model calibration, we are able to represent current groundwater levels and streamflow response very well and, therefore, the prediction of future response under quarry expansion is expected to have relatively low uncertainty.

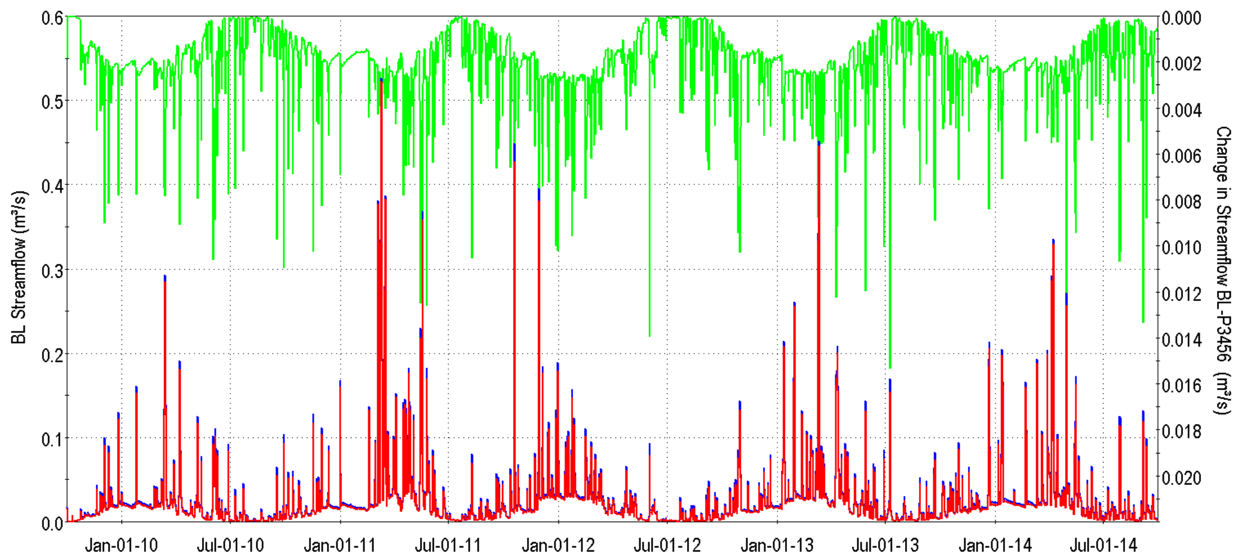


Figure 2: Simulated streamflow in Willoughby Creek upstream of SW7 with(blue) and without (red) the infiltration feature.

3.1 Additional details on Groundwater discharge to the Medad Valley

Earthfx, 2020, includes Dr. Worthington's map of groundwater seeps into the Medad Valley. It is important to note that no seeps are mapped immediately adjacent to the proposed infiltration system. Recently collected LIDAR data provides useful insight, particularly when combined with the numerical model results, to illustrate how and where groundwater discharge currently occurs in the Medad Valley. The LIDAR data is able to see through the tree canopy and better illustrate the Medad valley wetland conditions.

The LIDAR DSM (digital uppermost surface model, including treetops, Figure 3) shows that the tree canopy masks the wetland and stream channels configuration. The LIDAR DTM (digital *terrain* model, Figure 4), however, can see through the canopy to show the bare ground topography as extracted from the LIDAR point cloud data. This data clearly shows the steep walls of the valley and the exceptionally flat topography of the valley fill wetlands. No discernable channel features are visible in the flat wetland even in this high-resolution imagery (enlargement shown in Figure 5). The MNDMNRF "mapped" stream (blue line) is a series of straight-line segments, also reflecting the lack of a visible stream channel. This suggests that, in the absence of a defined stream channel, flow in Willoughby Creek may behave more like sheet flow than channel flow, due to the lack of an incised channel. Without an incised channel, most of the groundwater discharge will enter the wetland as surface leakage along the valley wall.

Figure 5, in particular, confirms that there are no discernible seeps and stream channels emanating from the east valley wall and joining Willoughby Creek.

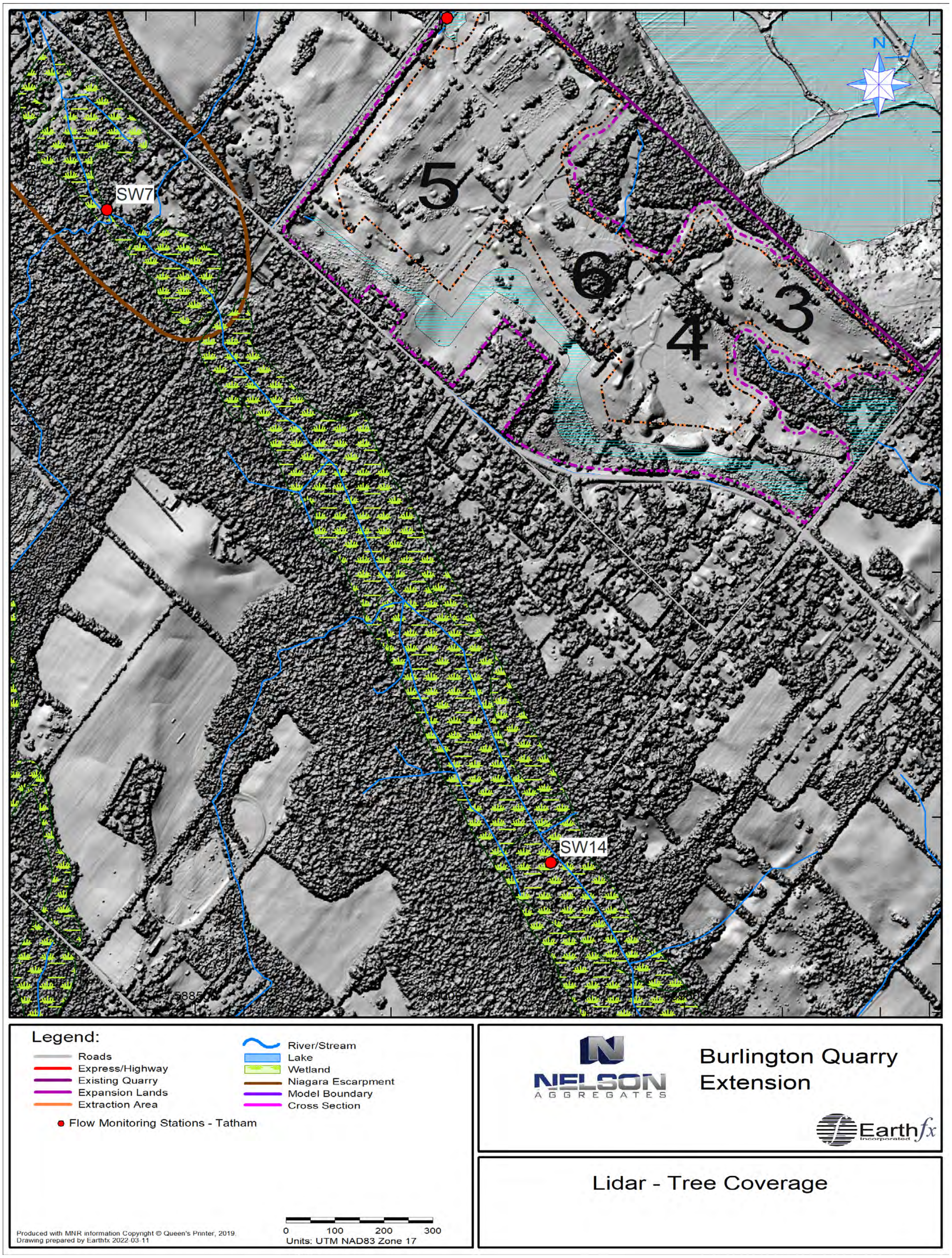


Figure 3: Land surface elevation based on LIDAR data (no correction for tree cover).

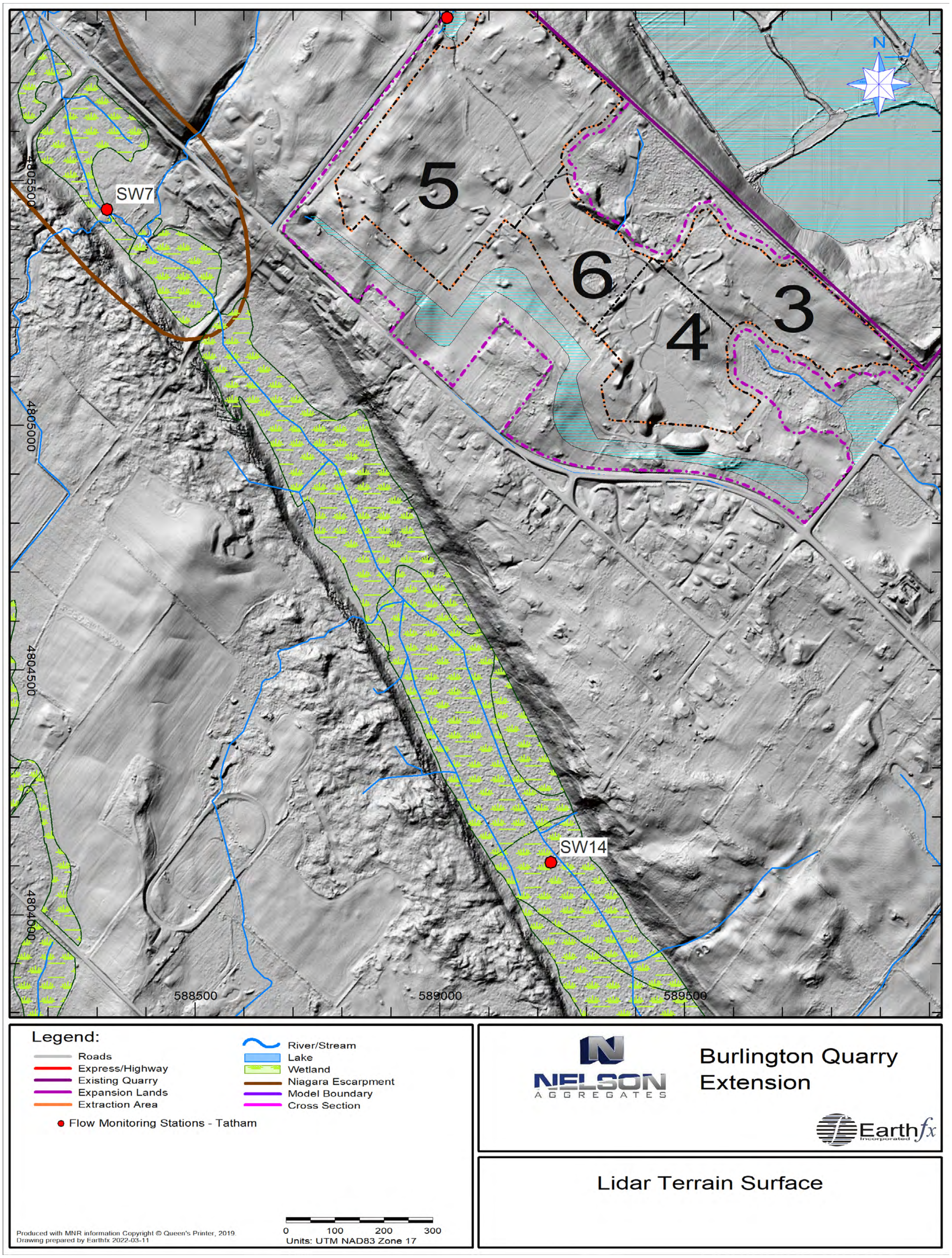


Figure 4: Land surface elevation based on bare-earth LIDAR data

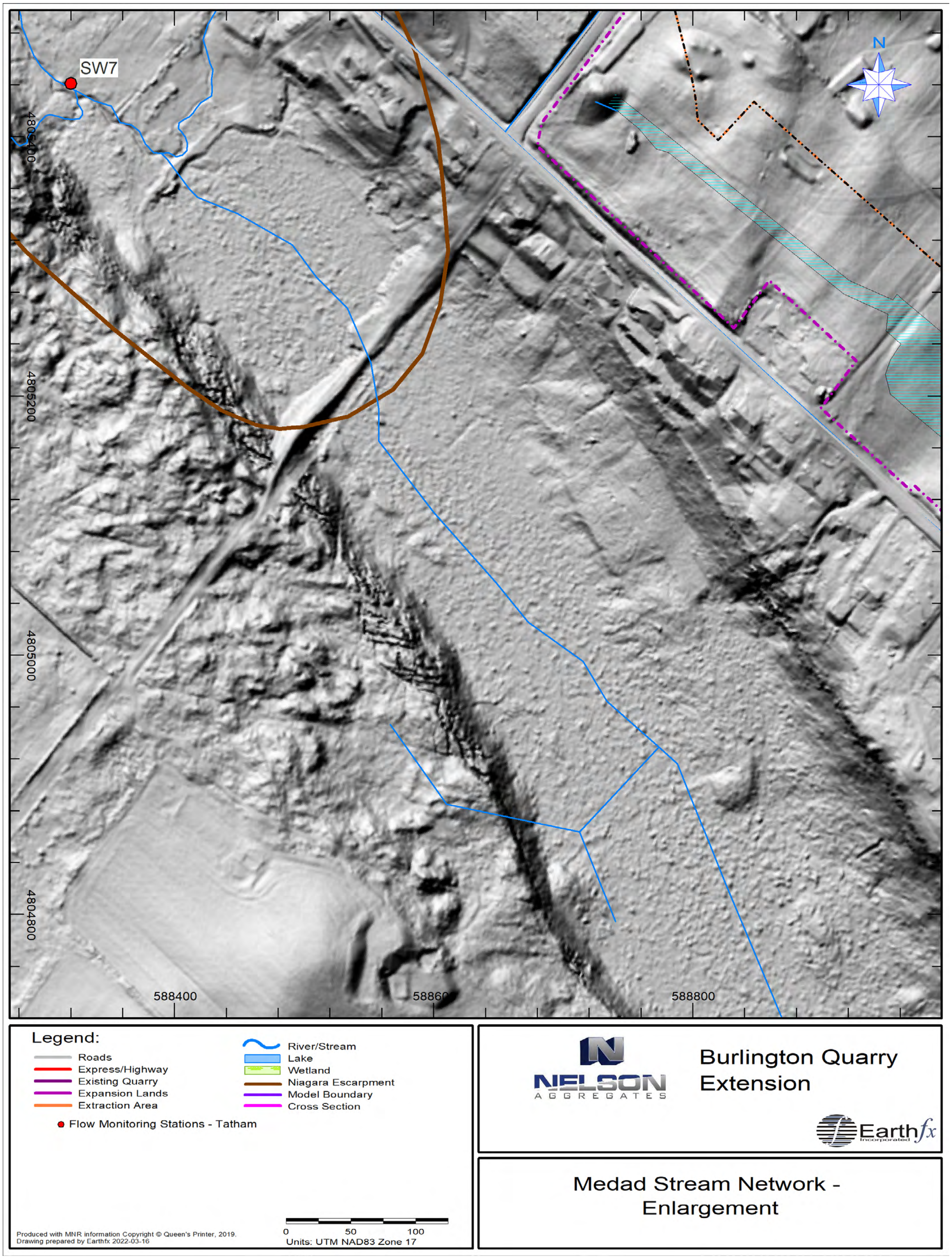


Figure 5: Medad Stream Network Mapping – Enlargement showing lack of defined stream channel

Earthfx, 2020, Figure 8.70 presented and discussed change in distributed groundwater discharge to the Medad Valley. The report compared current baseline and P3456 conditions with the infiltration ponds. The following discussion presents those simulation results in conjunction with the new LIDAR data to illustrate the limited and distributed nature of the effects of the quarry development.

Figure 6 shows the average surface leakage in the Medad Valley vicinity under baseline (current) conditions. As can be seen, the highest rates occur in model cells adjacent to the valley walls on both sides of the valley. Pickup in streamflow (shown as blue shading along the stream lines) is relatively small and losses through the streambed occur in areas with larger influx of runoff related to surface leakage.

An overlay of the simulated *change in groundwater discharge* to the Medad valley (Figure 7) shows that the change in discharge between baseline and P3456 conditions occurs primarily along the eastern valley wall at the edge of the wetland (Note that the model results shown in Figure 7 were previously presented the Earthfx 2020 Level 1 / 2 Hydrogeologic Report, Figure 8.70).

In summary, the LIDAR data shows that there is no incised stream channel within the broad, flat wetland that fills the valley. This is consistent with the water budget that shows that the majority of the groundwater discharge to the Medad Valley enters along the edge of the wetlands as distributed surface leakage. The model results are consistent with the new LIDAR data, and shows that the modest change in groundwater discharge will occur in a distributed manner along the eastern edge of the valley.

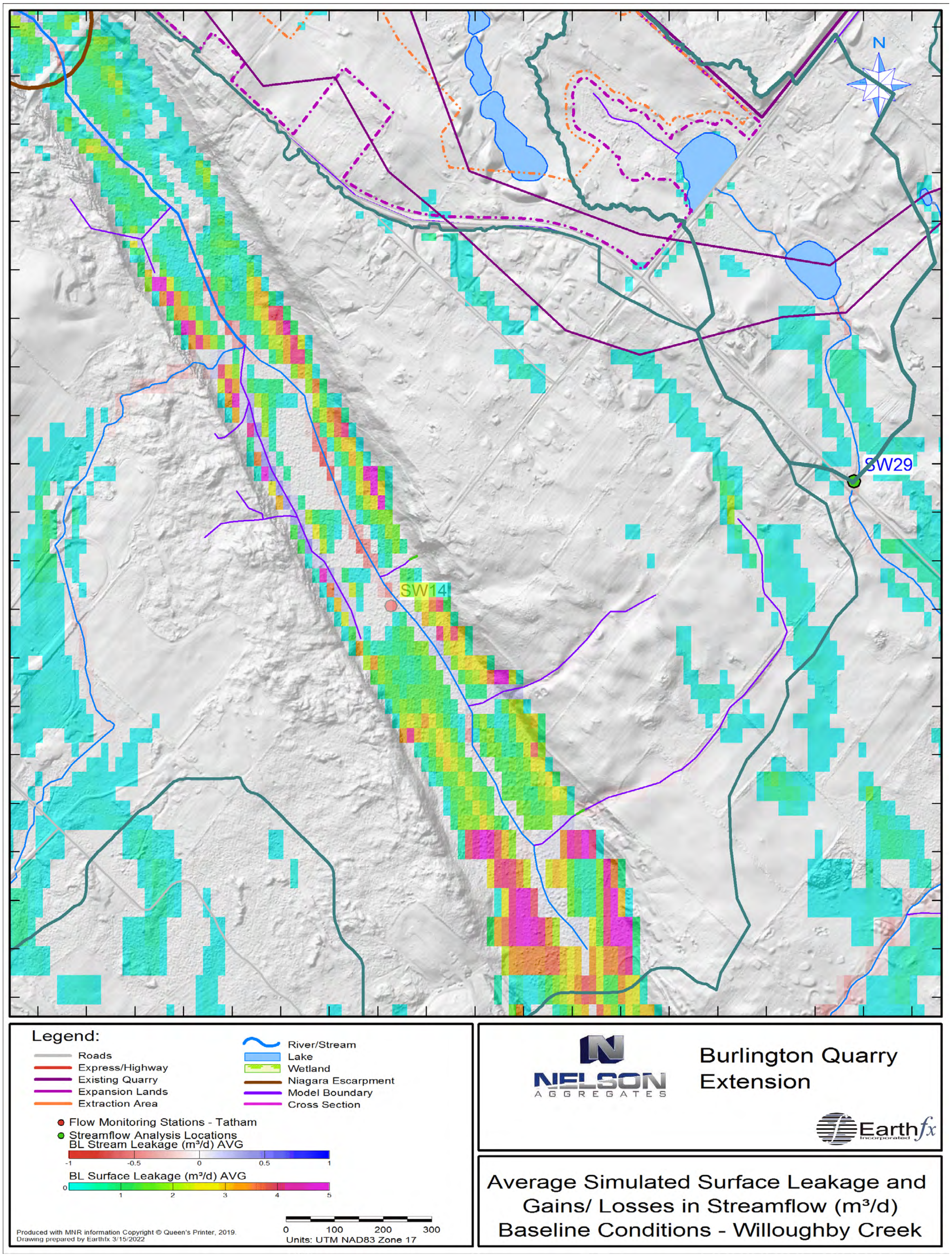


Figure 6: Simulated average stream leakage and surface leakage in the Medad Valley under baseline conditions.

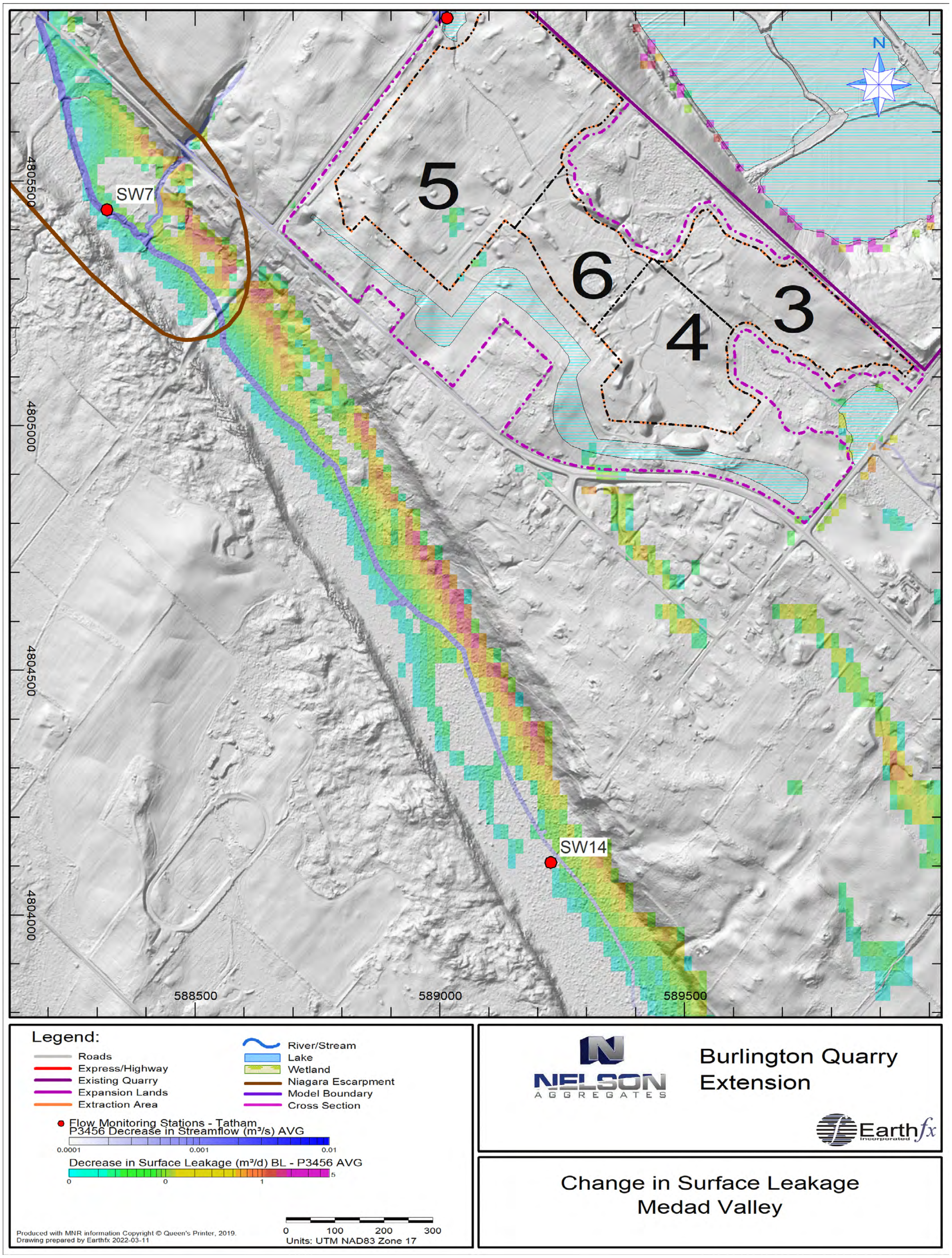


Figure 7: Change in groundwater discharge to the soil zone and predicted decrease in streamflow (Model results taken from Earthfx, 2020, Figure 8.70)

4 Field Data and Infiltration Pond Feasibility and Effectiveness

Most of the outstanding comments referred to in Item 4 (excluding Comment 6 and 231) questioned the assumption that the golf-course irrigation ponds are infiltrating water and that the infiltration feature will recharge the aquifer as designed. The lack of field data was cited in several of the comments.

Earthfx noted the leaky response observed during the BS-06 pump test as evidence of leakage from the nearby irrigation ponds. Further, we noted the temperature increase in the profile recorded in BS-07 before, during and after the pump test as strong evidence that surface water can leak downward and recharge into the aquifer system (Figure 8).

Earthfx relied on results of model simulations, including those presented, to quantify the likely volumes of water discharged from the ponds. The volumes lost from the ponds are small and it would be difficult to design a field program, other than the temperature test (as completed and noted above) or tracer test, to detect these volumes. In theory, the ponds might be disconnected and drained for a period of time to determine if there was a groundwater level decrease but it would be (1) impractical and inconvenient to the golf course and (2) it would still be difficult to separate the response out from other natural variation.

Similarly, Earthfx relied on field tests results and model simulations to aid in designing the infiltration feature and to quantify the likely volumes of water discharged. As noted earlier, very conservative assumptions were made so as to not overestimate the effectiveness. This was done even though the feature will be excavated to the top of or into the weathered bedrock and clogging with low TSS water should not occur.

Field testing the infiltration feature would require the actual construction of a part of the feature and installing monitoring wells. Construction would not be permitted without a prior site approval. Brian Zeman of MHBC Planning indicated that a site condition could be added to the approval requiring testing of the infiltration feature prior to start of Phase 3 extraction. This would provide a ten-year period in which to demonstrate its effectiveness.

4.1 Response to Water Supply Problems at Domestic Wells

The review team indicated that the concern was not so much related to the ability to “get water into the ground” but rather if the increased heads due to the recharged water would benefit all well owners in the area. Norbert Woerns expressed concerns that, due to the fractured nature of the formation, there could be individual well owners that would still be impacted by quarry development.

While there is natural variation in the rock properties in the area, there are no documented cases where there is insufficient available drawdown in the Amabel Aquifer (a widely recognized bedrock aquifer resource) for a private well supply. As discussed, natural variability is observed when comparing the higher response observed in BS-06 versus BS-07, however BS-07 would still be a suitable well for private water supply, even if it was not selected for the much higher capacity pumping test.

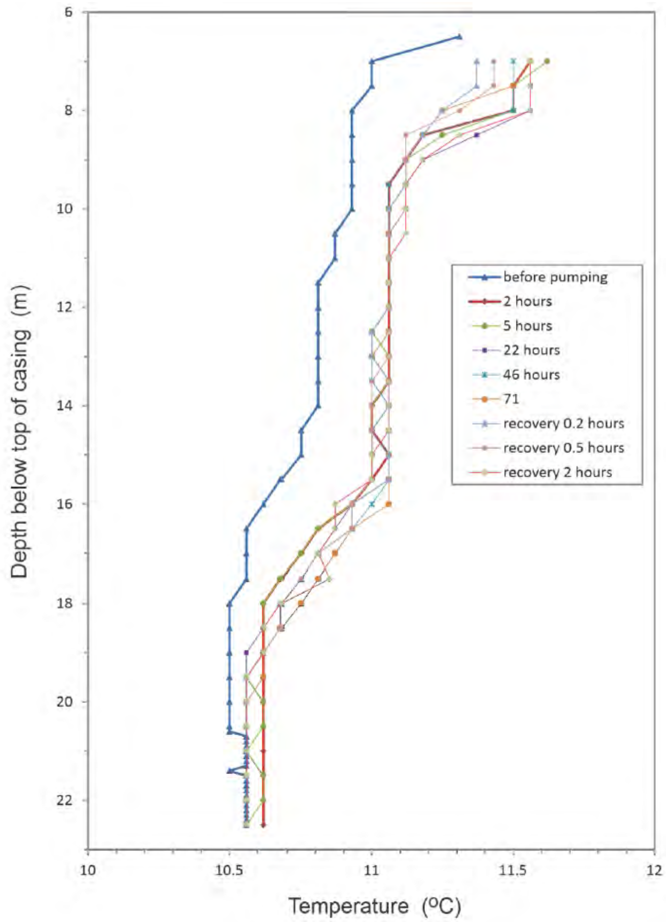


Figure 8: Temperature profile at well BS07 before, during and after the pumping test at BS-06 (From Earthfx, 2020, Page 439)

4.1.1 Available Drawdown

The report discussed possible effects of decreased heads due to quarry expansion on private wells. The report noted that “The private wells in the vicinity of the West Extension will see a decline of approximately 2 m in available drawdown [during the Phase 3, 4, 5, and 6 operations], however the majority of the wells have 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.” Furthermore, “If the ARA licence is issued, Nelson will complete a follow-up door-to-door water well survey to inform residents that they are still able to participate in the [monitoring] program if interested. Particular focus will be on wells located within 500 m of the proposed extraction area and wells that have an available drawdown of less than 10 m. Based on the information obtained from the MECP database, there are 36 water wells that meet this requirement...” As well, “Under worst case drought conditions, such during the Level 2 Provincial Low Water Advisory that was issued in 2016, water levels in the vicinity of P3456 will be an additional 1 m lower than average extraction conditions. There will, however, continue to be between 5 and 20 m of available drawdown in the Amabel Aquifer”.

The JART team then expressed concerns that having sufficient available drawdown may not be enough to prevent well problems for low yielding wells. There are no records of significant existing issues in private wells, and the proposed AMP includes a detailed approach to mitigate any potential issues.

5 Water Quality

Questions related to water quality were mainly focussed on the lack of water quality information with respect to Ontario drinking water objectives (ODWO). Our opinion is that sufficient data is available to clearly show that the local water quality is generally excellent, and that the long-term discharge to the golf course ponds and south quarry discharge stream show no ill effects.

Our response centers on three areas: (1) Historic monitoring of quarry discharge to meet ECA requirements; (2) historic information related to groundwater quality in the South expansion area; (3) and water quality sampling from 2019 and 2021, covering both the south and west expansion areas.

5.1 Environmental Compliance Approval (ECA) Data

Environment, Conservation and Parks (MECP) issued Nelson Aggregate Company an Ontario Water Resources Act Section 53 Environmental Compliance Approval for Industrial Sewage Works (ECA No.: 5203-AN6NGV). The ECA allows the site to discharge incidental water that enters the quarry footprint. As a condition of the ECA, Nelson is required to complete an annual compliance report that contains, among other information, data on water quality of the effluent. The sampling details are provided in Table 1.

Quarry discharge is monitored completed at two sampling locations: the North Discharge pipe located along Collins Road which conveys water from the northwest sump; and the South Discharge pipe, located along 2nd line.

Table 1: List of Parameters and Sampling Frequency for Quarry Discharge Sampling.

Monthly	Quarterly
pH (field), temperature (field), conductivity (field), dissolved oxygen (field), total suspended solids (TSS), total dissolved solids (TDS), Alkalinity, Hardness Total Ammonia, unionized Ammonia (calculated), Oil, and Grease	Chloride, Sulphate, Total Kjeldahl Nitrogen (TKN), Dissolved Organic Carbon, Total Phosphorus, Nitrate, Nitrite, Phenols, PAHs, Metals (Total Aluminum, Antimony, Arsenic, Barium, Boron, Cadmium, Chromium, Copper, Iron, Lead, Manganese, Mercury, Selenium, Silver, and Zinc) temperature (field)

The ECA reports confirm that the Burlington Quarry discharge complied with the requirements stipulated in ECA No.: 5203-AN6NGV. The quarry discharge water is safe and in compliance.

Additional discharge water sampling was conducted in 2021, and is discussed in more detail below.

5.2 Groundwater Quality Data

Golder collected groundwater quality data from numerous wells starting in 2003 in the South expansion area. A summary table, compiled by Golder, is presented Table 2. As can be seen, water quality is generally good with exceedances of some Aesthetic Objectives including iron, manganese, and total dissolved solids. The high alkalinity and hardness values are typical of groundwater in carbonate aquifers. The elevated arsenic, just above the ODWO limit, is a common, naturally-occurring problem in this area. High turbidity and TSS results are not representative of groundwater quality because sediments in the well were likely disturbed during sampling.

Additional sampling was conducted by Azimuth in 2019 for well clusters in both the west extension area and in the south extension area (Table 3). In a similar manner to the Golder results, exceedances are seen in the samples for hardness, TDS, iron, and manganese. The water chemistry at location MW03-01A (Figure 9, Table 3), immediately beneath the stream containing the south quarry discharge, is very similar to the chemistry at background location MW03-04A (Figure 9), which is located distant from the quarry and south quarry discharge. This data indicates that the south quarry discharge is not impacting the water quality relative to the background levels at the site. Complete results are shown in Table 4 and Table 5.

A similar comparison can be made between the water quality at the BS-01 and the background water quality at MW03-04A. The sodium and chloride levels at BS-01 are slightly elevated, but this is not unexpected give that the well is less than 30 m from the road salt applied to Cedar Spring Road. A stronger road salt impact is noted at BS-02A and BS-02B, located west of the quarry.

Background water quality in the west extension (without road salt impact) is better illustrated by the sampling at well DW1 (Figure 9). A number of domestic wells, the northwest quarry sump, and the golf course ponds were sampled in March and May of 2021 and analyzed for compliance with ODWO (Table 4). The samples for the sump and pond provide the most direct evidence that the quarry discharge is compliant with OWDO and should not be a concern for future infiltration. The Aesthetic Objectives for hardness and TDS are exceeded by all samples, with the sump and pond having the lowest values (The lower values are reflective of the mixing of groundwater inflows with direct precipitation into the quarry). DW1, located west of the golf course ponds, shows no effect of the ponds and good water quality. (DW3, located east of the quarry, appears to have been impacted by road salt.)

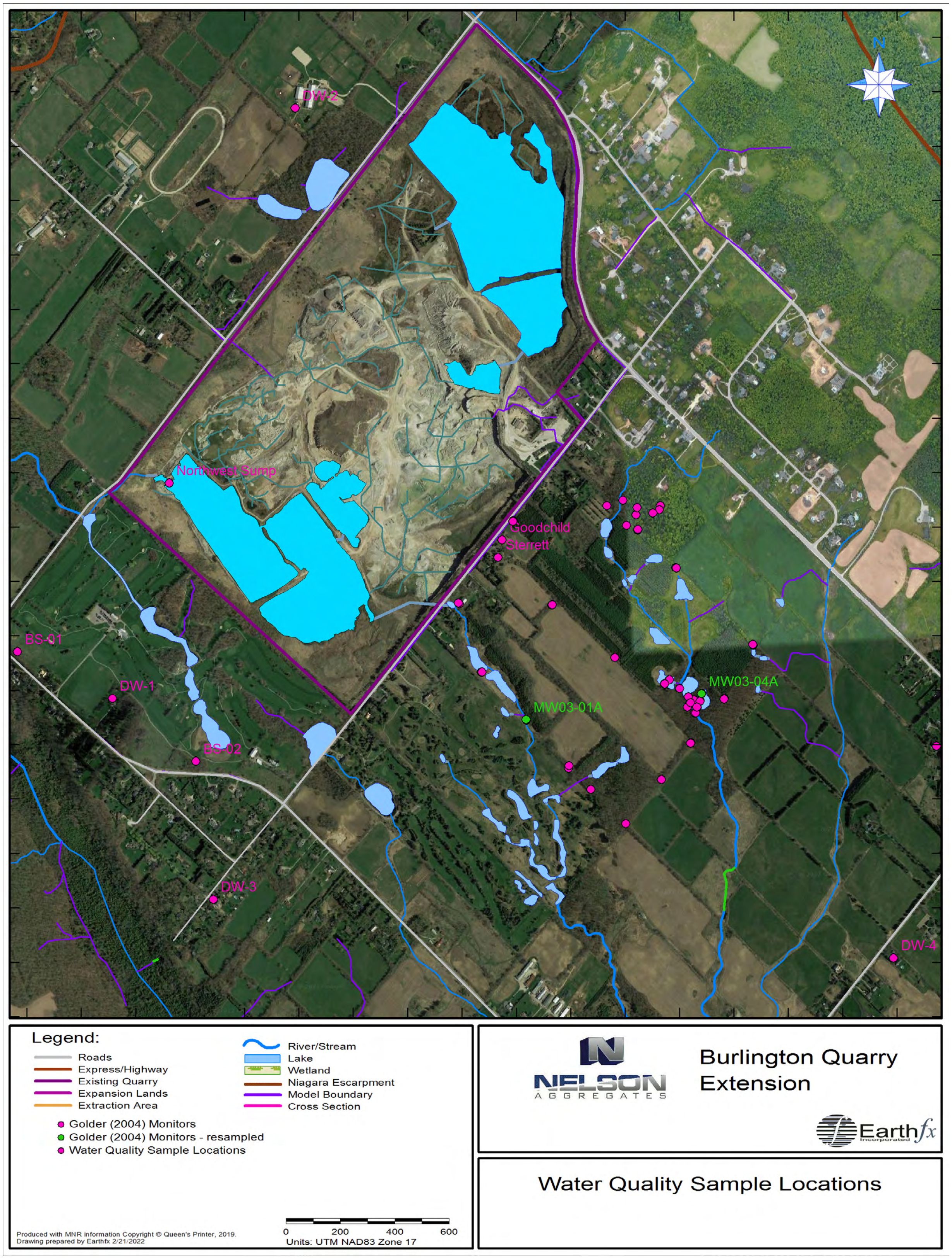


Figure 9: Location of water quality sampling points.

Table 2: Summary of water quality samples from Golder wells.

Parameter	MDL	ODWO	Units	Overburden/Upper Bedrock			Upper Amabel			Lower Amabel			Amabel/Lower Units		
				Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg
Alkalinity ($CaCO_3$)	1.0	30-500[2]	mg/L	300	730	432	220	1200	411	170	310	260	230	310	263
Conductivity	4.2		µS/cm	640	1100	788	460	790	630	490	820	690	680	1200	893
DOC	0.20	5.0[1]	mg/L	1.1	6.5	3.1	0.4	1.3	0.8	<	4.0	1.8	0.4	1.6	0.8
Hardness ($CaCO_3$)	1.0	80-100[2]	mg/L	280	550	378	260	450	331	230	370	314	260	500	393
pH (20 °C)				7.69	8.39	8.11	8.01	8.21	8.14	7.54	8.22	7.94	7.62	8.24	7.99
TDS (180 °C)	11	500[1]	mg/L	420	800	540	240	560	400	260	580	446	460	870	618
TKN (as N)	0.16		mg/L	<	0.62	0.47	<	0.58	0.43	0.16	0.91	0.38	<	1.20	0.57
TSS[3]	2.0		mg/L	1500	8000	3850	<	18000	11750	<	4200	1615	800	800	800
Turbidity[3]	0.10	5.0[1]	ntu	1100	3800	2100	0.27	9800	3701	1	3200	922	7	390	104
Aluminum	0.010	0.10[2]	mg/L	0.03	0.32	0.09	0.02	0.21	0.06	0.02	0.11	0.04	0.02	0.19	0.11
Ammonia (N)	0.02		mg/L	<	0.12	0.09	<	0.15	0.07	<	0.18	0.09	0.04	0.66	0.22
Antimony	0.002	0.006	mg/L	<	<	<	<	0.004	0.003	<	0.002	0.002	<	<	<
Arsenic	0.002	0.01	mg/L	0.002	0.007	0.005	<	0.005	0.003	0.003	0.023	0.014	0.002	0.011	0.005
Barium	0.005	1.0	mg/L	0.02	0.07	0.05	0.05	0.13	0.08	0.03	0.18	0.07	0.01	0.08	0.04
Beryllium	0.001		mg/L	<	<	<	<	<	<	<	<	<	<	<	<
Bismuth	0.002		mg/L	<	<	<	<	<	<	<	<	<	<	<	<
Boron	0.005	5.0	mg/L	0.016	0.061	0.033	0.014	0.120	0.033	0.026	0.060	0.036	0.041	1.200	0.365
Bromide	0.10		mg/L	<	<	<	<	<	<	<	<	<	<	0.41	0.41
Cadmium	0.00007	0.005	mg/L	<	0.00007	0.00007	<	0.00008	0.00008	<	<	<	<	<	<
Calcium	0.20		mg/L	73	110	91	71	120	86	61	110	85	68	150	116
Chloride	0.05	250[1]	mg/L	3	27	9	3	32	11	4	19	10	5	38	15
Chromium	0.002	0.05	mg/L	<	<	<	<	0.008	0.008	<	<	<	<	<	<
Cobalt	0.0005		mg/L	<	0.001	0.0009	0.0005	0.002	0.001	<	0.0006	0.0006	<	0.0007	0.0006
Copper	0.002	1.0[1]	mg/L	<	0.010	0.006	0.002	0.008	0.004	<	0.008	0.005	<	0.004	0.003
Cyanide free	0.002	0.02	mg/L	<	<	<	<	<	<	<	<	<	<	<	<
Fluoride (probe)	0.030	1.5	mg/L	0.15	0.22	0.18	0.13	0.28	0.18	0.18	0.24	0.22	0.20	0.69	0.35

Parameter	MDL	ODWO	Units	Overburden/Upper Bedrock			Upper Amabel			Lower Amabel			Amabel/Lower Units		
				Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg
Iron (Total)	0.010	0.3[1]	mg/L	0.03	6.70	1.54	<	0.36	0.12	0.08	0.51	0.23	<	0.35	0.23
Iron (Dissolved)	0.020	0.3[1]	mg/L	<	<	<	<	0.07	0.05	0.40	0.40	0.40	<	0.23	0.20
Lead	0.0005	0.010	mg/L	<	0.012	0.012	0.0008	0.0034	0.0018	<	0.0005	0.0005	<	0.0061	0.0027
Magnesium	0.40		mg/L	23	67	37	19	40	28	19	33	25	23	30	26
Manganese	0.002	0.05[1]	mg/L	0.047	0.620	0.258	0.007	0.038	0.022	0.014	0.043	0.025	0.026	0.044	0.035
Mercury	0.05	0.001	µg/L	<	<	<	<	<	<	<	<	<	<	<	<
Molybdenum	0.002		mg/L	0.002	0.026	0.011	<	0.023	0.009	0.003	0.023	0.009	0.002	0.010	0.006
Nickel	0.002		mg/L	<	0.002	0.002	<	0.009	0.004	<	0.002	0.002	<	0.002	0.002
Nitrate (N)	0.050	10.0	mg/L	<	0.93	0.61	<	2.2	1.29	<	<	<	<	0.74	0.74
Nitrite (N)	0.010	1.0	mg/L	0.013	0.018	0.016	<	0.150	0.048	<	0.015	0.015	<	0.018	0.018
Orthophosphate	0.50		mg/L	<	<	<	<	<	<	<	<	<	<	<	<
Phenolic compounds	0.0010		mg/L	<	0.001	0.001	<	<	<	<	<	<	<	<	<
Phosphorus	0.06		mg/L	<	<	<	<	<	<	<	<	<	<	0.06	0.06
Total Phosphorus	0.010		mg/L	0.73	2.10	1.26	<	1.40	0.57	0.01	2.10	0.68	0.01	0.60	0.16
Potassium	1.0		mg/L	1.7	5.8	3	<	1.7	1.5	<	2.2	1.825	1.2	14	4.7
Selenium	0.002	0.01	mg/L	<	<	<	<	<	<	<	<	<	<	0.002	0.002
Silver	0.0001		mg/L	<	0.0001	0.0001	<	<	<	<	<	<	<	<	<
Sodium	0.10	200	mg/L	4.9	73	25	3	18	7.88	4.7	20	10.66	11	98	45
Strontium	0.002		mg/L	0.18	0.86	0.39	0.11	3.30	0.85	0.23	11.00	4.81	2.30	10.00	6.53
Sulphate (SO_4)	0.10	500	mg/L	41	230	99	23	150	66	33	150	81	66	460	242
Sulphide	0.020		mg/L	0.02	0.03	0.025	<	0.48	0.128	<	0.02	0.02	<	0.02	0.02
Sulphur	0.060		mg/L	14	94	40	8	51	23	12	51	29	24	150	78
Thallium	0.0002		mg/L	<	<	<	<	<	<	<	<	<	<	<	<
Tin	0.002		mg/L	<	<	<	<	<	<	<	<	<	<	<	<
Titanium	0.001		mg/L	0.001	0.017	0.004	0.001	0.010	0.003	<	0.002	0.001	0.001	0.010	0.005
Uranium	0.0002	0.02	mg/L	0.0012	0.012	0.0048	0.0002	0.0020	0.0013	0.0003	0.0056	0.0017	0.0003	0.0018	0.0012
Vanadium	0.002		mg/L	<	0.003	0.003	<	<	<	<	<	<	<	0.002	0.002
Zinc	0.003	5[1]	mg/L	0.008	0.026	0.018	0.012	0.110	0.051	0.004	0.022	0.015	0.017	0.042	0.027

Notes: [1] Ontario Drinking Water Aesthetic Objective, [2] Ontario Drinking Water Operational Guideline, [3] High values likely due to disturbance of well sediments

Table 3: 2019 Water quality data from BS-01, BS-02, and two Golder well clusters.

Parameter	ODWO	Units	BS-01A 5/15/19	BS-01B 5/15/19	BS-01C 5/15/19	BS-02A 5/15/19	BS-02B 5/15/19	BS-02C 5/15/19	MW03-01A 5/15/19	MW03-04A 5/15/19
Alkalinity ($CaCO_3$)	30-500[2]	mg/L	260	264	264	309	312	264	167	245
Conductivity		µS/cm	865	811	538	2280	1780	1110	626	595
DOC	5.0[1]	mg/L	2.8	2.4	2.4	1.6	1.3	2.1	3.2	4.4
Hardness ($CaCO_3$)	80-100[2]	mg/L	344	325	261	447	427	396	320	247
pH			7.89	7.93	8.03	7.8	7.84	7.85	8.0	8.0
TDS (180 °C)	500[1]	mg/L	476	430	257	1184	938	584	376	306
Turbidity[3]	5.0[1]	ntu	5540	18300	596	6840	8150	342	533	6520
Aluminum	0.10[2]	mg/L	0.07	0.05	0.05	0.08	0.07	0.06	0.050	0.050
Ammonia (N)		mg/L	0.21	0.2	0.13	0.3	0.24	0.09	0.24	0.26
Arsenic	0.01	mg/L	0.0006	0.0002	<0.0001	0.0088	0.007	0.0103	0.0015	0.0096
Barium	1.0	mg/L	0.049	0.045	0.012	0.256	0.206	0.177	0.01	0.08
Boron	5.0	mg/L	0.02	0.019	< 0.005	0.027	0.026	0.034	0.062	0.071
Bromide		mg/L	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4
Cadmium	0.005	mg/L	0.000173	0.000039	0.00002	< 0.000015	< 0.000015	0.000047	<0.000015	0.0000
Calcium		mg/L	94.1	87.1	67.8	117	109	97.1	90	64
Chloride	250[1]	mg/L	39.3	44.9	2.8	459	321	137	7	6
Chromium	0.05	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	< 0.001	0.0010	0.0010
Copper	1.0[1]	mg/L	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Fluoride	1.5	mg/L	<0.1	<0.1	<0.1	<0.1	0.3	<0.1	<0.1	0.40
Iron (Dissolved)	0.3[1]	mg/L	0.047	< 0.005	0.011	1.37	1.16	1.12	0.84	0.63
Lead	0.010	mg/L	0.00044	0.00009	0.00008	0.00113	0.00079	0.00048	0.0001	0.0003
Magnesium		mg/L	26.5	26.2	22.3	37.6	37.7	37.4	23	21
Manganese	0.05[1]	mg/L	0.038	0.002	0.001	0.083	0.103	0.105	0.054	0.014
Molybdenum		mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Nickel		mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrate (N)	10.0	mg/L	1.9	3.1	0.3	0.2	< 0.1	0.2	0.2	0.3
Nitrite (N)	1.0	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Orthophosphate		mg/L	2.26	0.063	0.152	1.41	0.01	0.087	0.15	6.71
Total Phosphorus		mg/L	4.88	4.42	0.2	2.68	1.9	0.25	0.27	7.85
Potassium		mg/L	2.3	2	0.1	1.8	1.7	1.9	2.4	2.4
Selenium	0.01	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Silver		mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

Parameter	ODWO	Units	BS-01A 5/15/19	BS-01B 5/15/19	BS-01C 5/15/19	BS-02A 5/15/19	BS-02B 5/15/19	BS-02C 5/15/19	MW03-01A 5/15/19	MW03-04A 5/15/19
Sodium	200	mg/L	31.3	33	2.1	277	183	60.5	11	16
Strontium		mg/L	0.389	0.185	0.08	0.666	0.602	0.545	1.3	13.5
Sulphate (SO_4)	500	mg/L	118	65	3	104	97	90	140	47
Thallium		mg/L	0.00007	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Tin		mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Titanium		mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Uranium	0.02	mg/L	0.00093	0.0005	0.00019	0.0004	0.00034	0.00044	<0.00005	0.0006
Vanadium		mg/L	0.0002	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Zinc	5[1]	mg/L	0.03	0.023	0.033	0.047	0.096	0.219	0.073	0.383

Table 4: Water chemistry results 2003-2019 - Part 1

	PARAMETER			Alkalinity	Conductivity @25°C	Dissolved Organic Carbon	Hardness	pH	Total Dissolved Solids	Total Kjeldahl Nitrogen	Total Suspended Solids	Turbidity	Aluminum	Ammonia, total	Antimony	Arsenic	Barium	Beryllium	Bismuth	Boron	Bromide	Cadmium	Calcium	Chloride	Chromium	Cobalt	Copper	Ctanide free
		UNITS		mg/L	µS/cm	mg/L	mg/L	pH Units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
		ODWQS		500	-	5	100	6.5-8.5	500	-	-	1	0.100	-	0.006	0.0250	1.00	-		5.000	-	0.0050	-	250	0.0500	-	1.0000	0.2000
				OG			OG	OG	AO				OG		IMAC	IMAC	MAC			IMAC		MAC		AO	MAC		AO	
1	MW03-01A	30-May-03		230	940	2	480	8	640	0	<2	14	0	0	<0.002	0	0	<0.001	<0.002	0	<0.1	<0.00007	150	5	<0.002	0	0	<0.002
2	MW03-01A	15-May-19		167	626	3	320	8	376			533	0	0		0	0			0	<0.4	< 0.000015	90	7	0		< 0.002	
3	MW03-01B	30-May-03		260	560	1	320	8	300	<0.16	<2	1	0	<0.02	0	<0.002	0	<0.001	<0.002	0	<0.1	<0.00007	88	5	<0.002	0	0	<0.002
4	MW03-01C	21-Aug-03	Dry																									
5	MW03-02A	30-May-03		240	1,200	0	500	8	870	<0.16	<2	7	0	1	<0.002	<0.002	0	<0.001	<0.002	1	0	<0.00007	150	38	<0.002	0	0	<0.002
6	MW03-02A	15-May-19		224	1,830	3	619	8	1,321			14,000	0	5		0	0			2	1	< 0.000029	184	74	< 0.001		< 0.002	
7	MW03-02B	30-May-03		310	790	1	450	8	560	<0.16	<2	3	0	<0.02	<0.002	0	0	<0.001	<0.002	0	<0.1	<0.00007	120	32	<0.002	0	0	<0.002
8	MW03-02C	21-Aug-03	Dry																									
9	MW03-03A	30-May-03		270	680	1	330	8	460	<0.16	<2	7	0	0	<0.002	0	0	<0.001	<0.002	0	<0.1	<0.00007	96	7	<0.002	0	0	<0.002
10	MW03-03B	30-May-03		260	590	1	320	8	350	0	<2	0	0	<0.02	0	<0.002	0	<0.001	<0.002	0	<0.1	<0.00007	85	6	<0.002	0	0	<0.002
11	MW03-03C	21-Aug-03	Dry																									
12	MW03-04A	30-May-03		310	750	0	260	8	500	0	800	390	0	0	<0.002	0	0	<0.001	<0.002	0	<0.1	<0.00007	68	11	<0.002	<0.0005	<0.002	<0.002
13	MW03-04A	15-May-19		245	595	4	247	8	306			6,520	0	0		0	0			0	<0.4	0	64	6	0		< 0.002	
14	MW03-04B	30-May-03		1,200	670	1	290	8	440	0	14,000	8,000	0	0	<0.002	0	0	<0.001	<0.002	0	<0.1	<0.00007	77	3	<0.002	<0.0005	<0.002	<0.002
15	MW03-04B	15-May-19		263	598	2	285	8	309			7,490	0	0		0	0			0	<0.4	0	75	3	0		< 0.002	
16	MW03-04C	30-May-03		430	640	1	300	8	430	0	1,500	1,200	0	<0.02	<0.002	<0.002	0	<0.001	<0.002	0	<0.1	0	78	3	<0.002	0	0	<0.002
17	MW03-04C	30-May-03	Dup	730	640	1	280	8	420	0	1,500	1,400	0	<0.02	<0.002	<0.002	0	<0.001	<0.002	0	<0.1	<0.00007	75	3	<0.002	0	0	<0.002
18	MW03-05A	30-May-03		380	650	2	280	8	430	<0.16	4,900	2,900	0	0	<0.002	0	0	<0.001	<0.002	0	<0.1	<0.00007	73	3	<0.002	<0.0005	0	<0.002
19	MW03-05B	21-Aug-03	Dry																									
20	MW03-06A	21-Aug-03	Dry																									
21	MW03-06B	21-Aug-03	Dry																									
22	MW03-07A	20-Aug-03		270	820	<0.2	370	8	580	0	970	580	0	0	<0.002	0	0	<0.001	<0.002	0	<0.1	<0.00007	110	4	<0.002	<0.0005	<0.002	<0.002
23	MW03-07A	20-Aug-03	Dup	260	820	0	370	8	530	0	960	640	0	0	<0.002	0	0	<0.001	<0.002	0	<0.1	<0.00007	110	4	<0.002	<0.0005	0	<0.002
24	MW03-07B	20-Aug-03		460	700	0	300	8	480	1	18,000	9,800	0	0	<0.002	<0.002	0	<0.001	<0.002	0	<0.1	0	78	7	<0.002	0	0	<0.002
25	MW03-07C	30-May-03		300	920	5	380	8	610	1	3,200	1,100	0	0	<0.002	0	0	<0.001	<0.002	0	<0.1	<0.00007	100	8	<0.002	<0.0005	0	<0.002
26	MW03-08A	30-May-03		310	600	1	320	8	380	0	4,200	3,200	0	0	<0.002	0	0	<0.001	<0.002	0	<0.1	<0.00007	74	8	<0.002	<0.0005	<0.002	<0.002
27	MW03-08B	30-May-03		290	630	1	340	8	410	1	9,100	7,000	0	<0.02	<0.002	<0.002	0	<0.001	<0.002	0	<0.1	<0.00007	86	14	0	<0.0005	<0.002	<0.002
28	MW03-08C	30-May-03		330	780	3	480	8	550	0	4,000	2,200	0	0	<0.002	0	0	<0.001	<0.002	0	<0.1	<0.00007	110	27	<0.002	0	<0.002	<0.002
29	MW03-09A	30-May-03		170	490	4	230	8	260	0	<2	1	0	<0.02	0	0	0	<0.001	<0.002	0	<0.1	<0.00007	61	14	<0.002	<0.0005	0	<0.002
30	MW03-09B	30-May-03		220	460	1	260	8	240	<0.16	<2	4	0	<0.02	<0.002	<0.002	0	<0.001	<0.002	0	<0.1	<0.00007	71	7	<0.002	<0.0005	<0.002	<0.002
31	MW03-09C	21-Aug-03	Dry																									
32	MW03-10A	21-Aug-03		290	720	2	280	8	480	1	330	190	0	0	<0.002	0	0	<0.001	<0.002	0	<0.1	<0.00007	70	19	<0.002	0	0	<0.002
33	MW03-10B	30-May-03		290	640	1	370	8	420	1	5,900	4,800	0	0	0	0	0	<0.001	<0.002	0	<0.1	<0.00007	84	15	<0.002	0	0	<0.002
34	MW03-10C	30-May-03		420	1,100	7	550	8	800	1	8,000	3,800	0	0	<0.002	0	0	<0.001	<0.002	0	<0.1	<0.00007	110	11	<0.002	<0.0005	<0.002	<0.002
35	MW03-11A	21-Aug-03	Dry																									
36	MW03-11B	21-Aug-03	Dry																									
37	MW03-12	21-Aug-03	Dry																									
38	BS01-A	15-May-19		260	865	3	344	8	476			5,540	0	0		0	0			0	<0.4	0	94	39	< 0.001		< 0.002	
39	BS01-B	15-May-19		264	811	2	325	8	430			18,300	0	0		0	0			0	<0.4	0	87	45	< 0.001		< 0.002	
40	BS01-C	15-May-19		264	538	2	261	8	257			596	0	0		< 0.0001	0			< 0.005	<0.4	0	68	3	< 0.001		< 0.002	
41	BS02-A	15-May-19		309	2,280	2	447	8	1,184			6,840	0	0		0	0			0	<0.4	< 0.000015	117	459	< 0.001		< 0.002	
42	BS02-B	15-May-19		312	1,780	1	427	8	938			8,150	0	0		0	0			0	<0.4	< 0.000015	109	321	< 0.001		< 0.002	
43	BS02-C	15-May-19		264	1,110	2	396	8	584			342	0	0		0	0			0	<0.4	0	97	137	< 0.001		< 0.002	

Table 5: Water chemistry results 2003-2019 - Part 2

	PARAMETER			Fluoride	Iron	Iron (dissolved)	Lead	Magnesium	Manganese	Mercury	Molybdenum	Nickel	Nitrate (N)	Nitrite (N)	ortho-Phosphate (P)	Phenolics	Phosphorus	Phosphorus-Total	Potassium	Selenium	Silver	Sodium	Strontium	Sulphate	Sulphide	Sulphur	Thallium	Tin	Titanium	Uranium	Vanadium	Zinc
	UNITS			mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
	ODWQS			2.40	0.30	0.30	0.0100	-	0.050	1.00000	-	-	10.0	1.00				-	-	0.010	-	200	-	500	0.05		-			0.1000	-	5.000
				MAC	AO	AO	MAC		AO	MAC			MAC	MAC						MAC		AO		AO								AO
1	W03-01A	30-May-03		0	0	0	0	26	0	<0.05	0	0	<0.05	0	<0.5	<0.001	<0.06	0	2	<0.002	<0.0001	38	2	310	<0.02	100	<0.0002	<0.002	0	0	<0.002	0
2	W03-01A	15-May-19		<0.1		1	0	23	0		< 0.01	< 0.01	0	<0.1	0			0	2	< 0.001	< 0.0001	11	1	140			< 0.00005	< 0.05	< 0.005	< 0.00005	< 0.0001	0
3	W03-01B	30-May-03		0	0	<0.02	<0.0005	24	0	<0.05	0	0	1	0	<0.5	<0.001	<0.06	<0.01	<1.0	<0.002	<0.0001	3	0	59	0	23	<0.0002	<0.002	0	0	<0.002	0
4	W03-01C	21-Aug-03	Dry																													
5	W03-02A	30-May-03		1	0	<0.02	<0.0005	30	0	<0.05	0	<0.002	<0.05	<0.01	<0.5	<0.001	<0.06	0	14	0	<0.0001	98	4	460	<0.02	150	<0.0002	<0.002	0	0	0	0
6	W03-02A	15-May-19		1		< 0.005	0	39	0		0	0	0	<0.1	2			2	21	< 0.001	< 0.0001	166	6	694			< 0.00005	< 0.05	< 0.005	0	< 0.0004	0
7	W03-02B	30-May-03		0	0	0	0	40	0	<0.05	0	0	<0.05	<0.01	<0.5	<0.001	<0.06	0	2	<0.002	<0.0001	18	0	150	<0.02	51	<0.0002	<0.002	0	0	<0.002	0
8	W03-02C	21-Aug-03	Dry																													
9	W03-03A	30-May-03		0	<0.01	<0.02	0	23	0	<0.05	0	<0.002	<0.05	<0.01	<0.5	<0.001	0	0	1	<0.002	<0.0001	11	10	130	0	36	<0.0002	<0.002	0	0	<0.002	0
10	W03-03B	30-May-03		0	0	0	0	27	0	<0.05	0	<0.002	<0.05	<0.01	<0.5	<0.001	<0.06	<0.01	<1.0	<0.002	<0.0001	7	3	76	<0.02	26	<0.0002	<0.002	0	0	<0.002	0
11	W03-03C	21-Aug-03	Dry																													
12	W03-04A	30-May-03		0	0		0	23	0	<0.05	0	<0.002	1	<0.01	<0.5	<0.001	<0.06	1	2	<0.002	<0.0001	33	10	66	<0.02	24	<0.0002	<0.002	0	0	<0.002	0
13	W03-04A	15-May-19		0		1	0	21	0		< 0.01	< 0.01	0	<0.1	7			8	2	< 0.001	< 0.0001	16	14	47			< 0.00005	< 0.05	< 0.005	0	< 0.0001	0
14	W03-04B	30-May-03		0	0		0	24	0	<0.05	0	0	0	0	<0.5	<0.001	<0.06	1	2	<0.002	<0.0001	6	1	48	0	16	<0.0002	<0.002	0	0	<0.002	0
15	W03-04B	15-May-19		<0.1		0	0	24	0		< 0.01	< 0.01	0	<0.1	0			9	1	< 0.001	< 0.0001	4	1	44			< 0.00005	< 0.05	< 0.005	0	< 0.0001	0
16	W03-04C	30-May-03		0	0		<0.0005	24	0	<0.05	0	0	0	0	<0.5	<0.001	<0.06	1	2	<0.002	<0.0001	5	0	41	0	15	<0.0002	<0.002	0	0	<0.002	0
17	W03-04C	30-May-03	Dup	0	0		<0.0005	23	0	<0.05	0	0	0	0	<0.5	<0.001	<0.06	1	2	<0.002	<0.0001	5	0	41	0	14	<0.0002	<0.002	0	0	<0.002	0
18	W03-05A	30-May-03		0	0		<0.0005	25	0	<0.05	0	<0.002	<0.05	<0.01	<0.5	0	<0.06	2	2	<0.002	<0.0001	19	1	57	<0.02	22	<0.0002	<0.002	0	0	<0.002	0
19	W03-05B	21-Aug-03	Dry																													
20	W03-06A	21-Aug-03	Dry																													
21	W03-06B	21-Aug-03	Dry																													
22	W03-07A	20-Aug-03		0	0		<0.0005	24	0	<0.05	0	<0.002	<0.05	<0.01	<0.5	<0.001	<0.06	1	2	<0.002	<0.0001	7	11	150	<0.02	51	<0.0002	<0.002	<0.001	0	<0.002	0
23	W03-07A	20-Aug-03	Dup	0	0		<0.0005	24	0	<0.05	0	<0.002	<0.05	<0.01	<0.5	<0.001	<0.06	1	2	<0.002	<0.0001	7	11	130	<0.02	51	<0.0002	<0.002	<0.001	0	<0.002	0
24	W03-07B	20-Aug-03		0	0		<0.0005	25	0	<0.05	0	0	2	0	<0.5	<0.001	<0.06	0	<1.0	<0.002	<0.0001	15	1	73	0	26	<0.0002	<0.002	0	0	<0.002	0
25	W03-07C	30-May-03		0	7		0	31	0	<0.05	0	<0.002	<0.05	0	<0.5	<0.001	<0.06	1	4	<0.002	0	29	0	150	<0.02	54	<0.0002	<0.002	0	0	<0.002	0
26	W03-08A	30-May-03		0	0		<0.0005	33	0	<0.05	0	<0.002	<0.05	<0.01	<0.5	<0.001	<0.06	2	1	<0.002	<0.0001	5	1	33	<0.02	12	<0.0002	<0.002	0	0	<0.002	0
27	W03-08B	30-May-03		0	<0.01		0	30	0	<0.05	0	0	1	0	<0.5	<0.001	<0.06	0	1	<0.002	<0.0001	5	0	48	0	15	<0.0002	<0.002	<0.001	0	<0.002	0
28	W03-08C	30-May-03		0	1		<0.0005	51	1	<0.05	0	<0.002	1	<0.01	<0.5	<0.001	<0.06	1	3	<0.002	<0.0001	19	0	74	0	41	<0.0002	<0.002	0	0	<0.002	0
29	W03-09A	30-May-03		0	1	0	0	19	0	<0.05	0	0	<0.05	0	<0.5	<0.001	<0.06	0	<1.0	<0.002	<0.0001	14	0	43	0	16	<0.0002	<0.002	0	0	<0.002	0
30	W03-09B	30-May-03		0	0	<0.02	<0.0005	19	0	<0.05	,0.002	<0.002	2	<0.01	<0.5	<0.001	<0.06	0	<1.0	<0.002	<0.0001	3	0	23	0	8	<0.0002	<0.002	0	0	<0.002	0
31	W03-09C	21-Aug-03	Dry																													
32	W03-10A	21-Aug-03		0	0		<0.0005	26	0	<0.05	0	<0.002	<0.05	<0.01	<0.5	<0.001	<0.06	0	2	<0.002	<0.0001	20	1	51	<0.02	15	<0.0002	<0.002	0	0	<0.002	0
33	W03-10B	30-May-03		0	0		0	38	0	<0.05	0	0	<0.05	<0.01	<0.5	<0.001	<0.06	1	<1.0	<0.002	<0.0001	6	0	49	<0.02	17	<0.0002	<0.002	0	0	<0.002	0
34	W03-10C	30-May-03		0	1		<0.0005	67	1	<0.05	0	<0.002	<0.05	<0.01	<0.5	<0.001	<0.06	3	6	<0.002	<0.0001	73	0	230	0	94	<0.0002	<0.002	0	0	0	<0.003
35	W03-11A	21-Aug-03	Dry																													
36	W03-11B	21-Aug-03	Dry																													
37	MW03-12	21-Aug-03	Dry																													
38	BS01-A	15-May-19		<0.1		0	0	27	0		< 0.01	< 0.01	2	<0.1	2			5	2	< 0.001	< 0.0001	31	0	118			0	< 0.05	< 0.005	0	0	0
39	BS01-B	15-May-19		<0.1		< 0.005	0	26	0		< 0.01	< 0.01	3	<0.1	0			4	2	< 0.001	< 0.0001	33	0	65			< 0.00005	< 0.05	< 0.005	0	< 0.0001	0
40	BS01-C	15-May-19		<0.1		0	0	22	0		< 0.01	< 0.01	0	<0.1	0			0	0	< 0.001	< 0.0001	2	0	3			< 0.00005	< 0.05	< 0.005	0	< 0.0001	0
41	BS02-A	15-May-19		<0.1		1	0	38	0		< 0.01	< 0.01	0	<0.1	1			3	2	< 0.001	< 0.0001	277	1	104			< 0.00005	< 0.05	< 0.005	0	< 0.0001	0
42	BS02-B	15-May-19		0		1	0	38	0		< 0.01	< 0.01	< 0.1	<0.1	0			2	2	< 0.001	< 0.0001	183	1	97			< 0.00005	< 0.05	< 0.005	0	< 0.0001	0
43	BS02-C	15-May-19		<0.1		1	0	37	0		< 0.01	< 0.01	0	<0.1	0			0	2	< 0.001	< 0.0001	61	1	90			< 0.00005	< 0.05	< 0.005	0	< 0.0001	0

Table 6: 2021 Water quality data from the Northwest Sump, golf course ponds, and nearby domestic wells.

Parameter	ODWO	Units	NW Sump 5/12/21	Golf Pond 5/12/21	Sterrett 5/12/21	Goodchild 5/12/21	Goodchild 3/16/21	Sterrett 3/16/21	Golf Pond 3/16/21	NW Sump 3/16/21	DW1 3/16/21	DW2 3/16/21	DW3 3/16/21	DW4 3/16/21
Alkalinity ($CaCO_3$)	30-500[2]	mg/L	136	145	285	363	330	312	121	206	313	265	384	310
Conductivity		µS/cm	974	839	817	983	904	885	711	1110	775	624	1430	715
DOC	5.0[1]	mg/L	3.2	4.1	0.9	1	0.8	0.6	4.5	3.2	0.8	1.9	1.6	0.9
Hardness ($CaCO_3$)	80-100[2]	mg/L	347	310	178	466	477	450	245	428	426	291	478	362
pH			8.2	8.1	7.79	7.73	7.71	7.82			7.85	7.74	7.77	7.96
TDS (180 °C)	500[1]	mg/L	580	540	495	614	595	595	459	787	509	369	819	433
TKN (as N)		mg/L					2.8	2.8	3.1	6	3.9	3.3	2.9	3
Turbidity[3]	5.0[1]	ntu	0.7	1.5	0.2	1.1	0.1	0.9			0.8	5.8	3.1	0.7
Colour	5	TCU	3	6	2	2	<1	<1			<1	8	4	4
Aluminum	0.10[2]	mg/L	0.006	0.02	<0.001	<0.001								
Ammonia (N)		mg/L	<0.01	0.02	0.03	<0.01								
Antimony	0.006	mg/L	<0.0005	<0.0005	<0.0005	<0.0005								
Arsenic	0.01	mg/L	0.002	0.002	<0.001	<0.001								
Barium	1.0	mg/L	0.034	0.036	0.016	0.038								
Beryllium		mg/L	<0.0005	<0.0005	<0.0005	<0.0005								
Bicarbonate($CaCO_3$)			134	143	283	361	328	310	120	204	311	264	382	307
Bismuth		mg/L	<0.001	<0.001	<0.001	<0.001								
Boron	5.0	mg/L	0.113	0.09	0.021	0.026								
Bromide		mg/L	0.2	<0.1	<0.1	<0.1								
Cadmium	0.005	mg/L	<0.0001	<0.0001	<0.0001	0.0001								
Calcium		mg/L	75.4	69.7	46.5	136	131	120	54.4	106	115	80.9	142	86.3
Carbonate		mg/L	2	2	2	2	2	2	1	2	2	1	2	3
Cerium			<0.001	<0.001	<0.001	<0.001								
Cesium			<0.001	<0.001	<0.001	<0.001								
Chloride	250[1]	mg/L	80.7	70	9.6	34.7	31.1	27.3	64.9	86	16.2	27.8	193	19.5
Chromium	0.05	mg/L	0.001	0.002	0.004	0.004								
Cobalt		mg/L	0.0001	0.0001	<0.0001	0.0004								

Parameter	ODWO	Units	NW Sump 5/12/21	Golf Pond 5/12/21	Sterrett 5/12/21	Goodchild 5/12/21	Goodchild 3/16/21	Sterrett 3/16/21	Golf Pond 3/16/21	NW Sump 3/16/21	DW1 3/16/21	DW2 3/16/21	DW3 3/16/21	DW4 3/16/21
Copper	1.0[1]	mg/L	0.002	0.002	0.023	0.012								
Europium	0.02	mg/L	<0.001	<0.001	<0.001	<0.001								
Fluoride	1.5	mg/L	0.16	0.17	0.1	0.07	0.09	<0.06			<0.06	0.07	0.06	0.09
Gallium		mg/L	<0.001	<0.001	<0.001	<0.001								
Hydroxide (NaOH)		mg/L	0.0269	0.0214	0.0105	0.00913								
Iron	0.3[1]	mg/L	0.25	0.24	0.14	0.4								
Lanthium		mg/L	<0.001	<0.001	<0.001	<0.001								
Lead	0.010	mg/L	<0.0001	<0.0001	0.0002	0.001								
Lithium		mg/L	0.011	0.009	0.005	<0.005								
Magnesium		mg/L	38.6	32.9	15.1	30.8	36.4	36.6	26.4	39.7	33.8	21.5	29.9	35.6
Manganese	0.05[1]	mg/L	0.007	0.007	<0.001	0.022								
Mercury	0.001	µg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Molybdenum		mg/L	0.002	0.002	0.002	0.005								
Nickel		mg/L	0.003	0.003	0.002	0.01								
Nobium		mg/L	<0.001	<0.001	<0.001	<0.001								
Nitrate (N)	10.0	mg/L	<0.05	<0.05	1.9	0.19	0.11	0.48	<0.05	<0.05	4.73	1.34	0.06	<0.05
Nitrite (N)	1.0	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Orthophosphate		mg/L	<0.005	<0.005	0.005	<0.005								
Phosphorus		mg/L	<0.05	<0.05	<0.05	<0.05								
Total Phenols		mg/L					<0.0004	0.0007	0.0018	0.0022	<0.0004	0.001	0.0006	0.0015
Total Phosphorus		mg/L	0.02	0.017	0.012	0.012	<0.002	0.002	0.008	0.009	0.004	0.04	0.027	0.003
Potassium		mg/L	4.52	4.62	17.5	1.23	1.31	3.21	4.62	5.08	1.72	6.48	1.78	1.88
Reactive Silica		mg/L	0.49	0.11	7.06	7.82								
Rubidium		mg/L	0.002	0.001	0.008	0.001								
Scandium			0.001	<0.001	0.002	0.002								
Selenium	0.01	mg/L	0.0009	<0.0005	<0.0005	<0.0005								
Silicon		mg/L	0.629	0.482	4.11	4.26								
Silver		mg/L	<0.0001	<0.0001	<0.0001	<0.0001								
Sodium	200	mg/L	43	38	88	17.8	20.2	17.3	37	47	8.7	12.6	123	10.7
Strontium		mg/L	1.09	0.846	0.136	0.317								

Parameter	ODWO	Units	NW Sump 5/12/21	Golf Pond 5/12/21	Sterrett 5/12/21	Goodchild 5/12/21	Goodchild 3/16/21	Sterrett 3/16/21	Golf Pond 3/16/21	NW Sump 3/16/21	DW1 3/16/21	DW2 3/16/21	DW3 3/16/21	DW4 3/16/21
Sulphate (SO_4)	500	mg/L	222	177	113	141	123	151	130	244	84.6	21	78.1	56.3
Sulphur		mg/L	80.3	62.9	39.7	48.3								
Tellurium		mg/L	<0.001	<0.001	<0.001	<0.001								
Thallium		mg/L	<0.0001	<0.0001	0.0002	<0.0001								
Thorium		mg/L	<0.001	<0.001	<0.001	<0.001								
Tin		mg/L	<0.001	<0.001	<0.001	<0.001								
Titanium		mg/L	<0.001	<0.001	<0.001	0.001								
Tungsten		mg/L	<0.001	<0.001	<0.001	<0.001								
Uranium	0.02	mg/L	0.0012	0.012	0.0048	0.0002								
Vanadium		mg/L	<0.001	<0.001	<0.001	<0.001								
Yttrium		mg/L	0.004	0.002	0.095	0.2								
Zinc	5[1]	mg/L	<0.001	<0.001	<0.001	<0.001								

Notes: [1] Ontario Drinking Water Aesthetic Objective, [2] Ontario Drinking Water Operational Guideline, [3] High values likely due to disturbance of well sediments

5.3 Water Quality Summary

In summary, water quality data has been collected, both historically and in the past few years, to characterize the groundwater in the quarry vicinity and at nearby domestic wells. There has been continuous ECA data collection from the North quarry discharge to characterize this water for surface water criteria and a more limited set of analysis for comparative analysis against ODWO parameters. In general, the natural groundwater quality is good except for elevated levels of hardness and total dissolved solids. Some domestic wells near roads appear to have been have been impacted by road salting. The quarry water has generally better quality that the nearby domestic well DW-1, due to the mixing of groundwater and precipitation in the discharge, and therefore should not present a water quality problem is used in an infiltration system. Quarry water has been discharged to the golf course ponds for over 50 years and infiltration from the ponds does not seem to have adversely affected water quality in the downgradient domestic well.

Yours truly
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Schedule 2

MEMORANDUM

To: Nelson Review Team

From: Earthfx Incorporated

Date: May 29, 2022

Subject: Documentation of Deep Pond Simulation Results presented at May 20, 2022 NDMNRF Meeting

1 Introduction

This technical memorandum provides information on the simulation of a new infiltration pond design as discussed at the project meeting on May 20, 2022.

2 Simulation Objectives

The objectives of the new simulation were to determine the effects of modifying the proposed infiltration ponds, as presented in Earthfx, 2020, Scenario P3456, to increase infiltration to the bedrock.

3 P3456 Scenario Summary

Earthfx (2020, Section 8.7) reporting on the likely impact of extracting aggregate from Phases 3 through Phase 6 in the proposed West Extension of the Burlington Quarry. For the purposes of those analysis, referred to as Scenario P3456, it was assumed that extraction was at its maximum depth and dewatering was ongoing in all four extraction areas. The final elevation of the quarry floor is 252.5 masl in the P3456 footprint. Quarry discharge was directed to the existing quarry lakes and eventually discharged from the Northwest sump. Figure 1 shows the topography and drainage in the quarry vicinity in the P3456 scenario.

Results of the analysis were compared against baseline (current) conditions and showed the likely change in groundwater levels, stream flows, and discharge of groundwater to land surface within the

Medad Valley west of the quarry site. These were discussed in detail in Earthfx (2020) and several key figures are reproduced here. Figure 2 shows the average simulated drawdown (decrease in groundwater levels compared to Baseline) in Model Layer 6. The drawdowns decrease 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. Figure 2 also shows the average simulated change in streamflow. Increases in simulated flow occur within the P3456 area, at the Northwest sump, and in the conduits carrying flow to the infiltration pond. Slight decreases in average simulated flow occur in the Medad Valley compared to Baseline Conditions.

Figure 3 shows a hydrograph comparing simulated daily streamflow under Scenario P3456 to Baseline Conditions for SW07 in the Medad Valley. Changes in streamflow are shown (inverted) on the secondary y-axis. Results show very small decreases in baseflow and small losses in peak flows during storm or snowmelt events.

A feature of the P3456 Scenario was the addition of an infiltration pond in the West Extension area between Cedar Springs Road and the extraction area (see Figure 1) for the purpose of replicating existing golf course ponds. Under current conditions, water is routinely diverted from the north quarry discharge pond and conveyed through ditches to the golf course ponds. This water is used for irrigation (a portion of which likely recharges the groundwater system), and in addition the standing water in the ponds also directly leak to the groundwater system. The pond leakage was investigated during a pumping test reported in Earthfx (2020). Figure A12 on page 439 of that report, shows the increase in temperature in borehole BS-06 due to leakage from warmer pond water.

The P3456 infiltration pond was designed intended to function in a similar manner to the irrigation ditches and golf course ponds, and help maintain the existing surface and groundwater system. Water from quarry discharge at the northwest sump will be continuously diverted to the infiltration pond. The proposed infiltration pond was assumed to be shallow, occupying model Layer 1, and underlain by unweathered Halton Till. The proposed P3456 infiltration ponds were not optimized to maximize infiltration, but simply to replicate the existing system. The lake average seepage under this scenario is shown in Figure 4.

Simulations of the P3456 scenario were run with and without the infiltration pond to determine the incremental benefit of the shallow layer 1 pond. Results showed that the infiltration pond raised the groundwater levels in Layer 6 (middle of the Amabel aquifer) by 5.5 m at the pond location1.5 to 3.5 m along Cedar Springs Road, and 0.5 m along the edge of the Medad Valley, when compared to a scenario without the infiltration pond (Figure 5).

The effects on the water levels and gradients in the Medad Valley under P3456 were evaluated by identifying areas where there was a change in water level gradient. Water levels decline modestly in the valley during P3456. One measure of that decline are areas where, on average, water levels in the Layer 4 bedrock will no longer be above ground surface. (Seasonally, water levels may still be above ground surface, however). These areas, shown as purple squares in Figure 6, are generally located along the easter wall of the Medad Valley.

In summary, the original P3456 pond design is effective at generally replicating the effects of the golf course ponds. The effects of the design P3456, including the proposed shallow infiltration ponds, result in minimal impact on water levels in the Medad Valley.

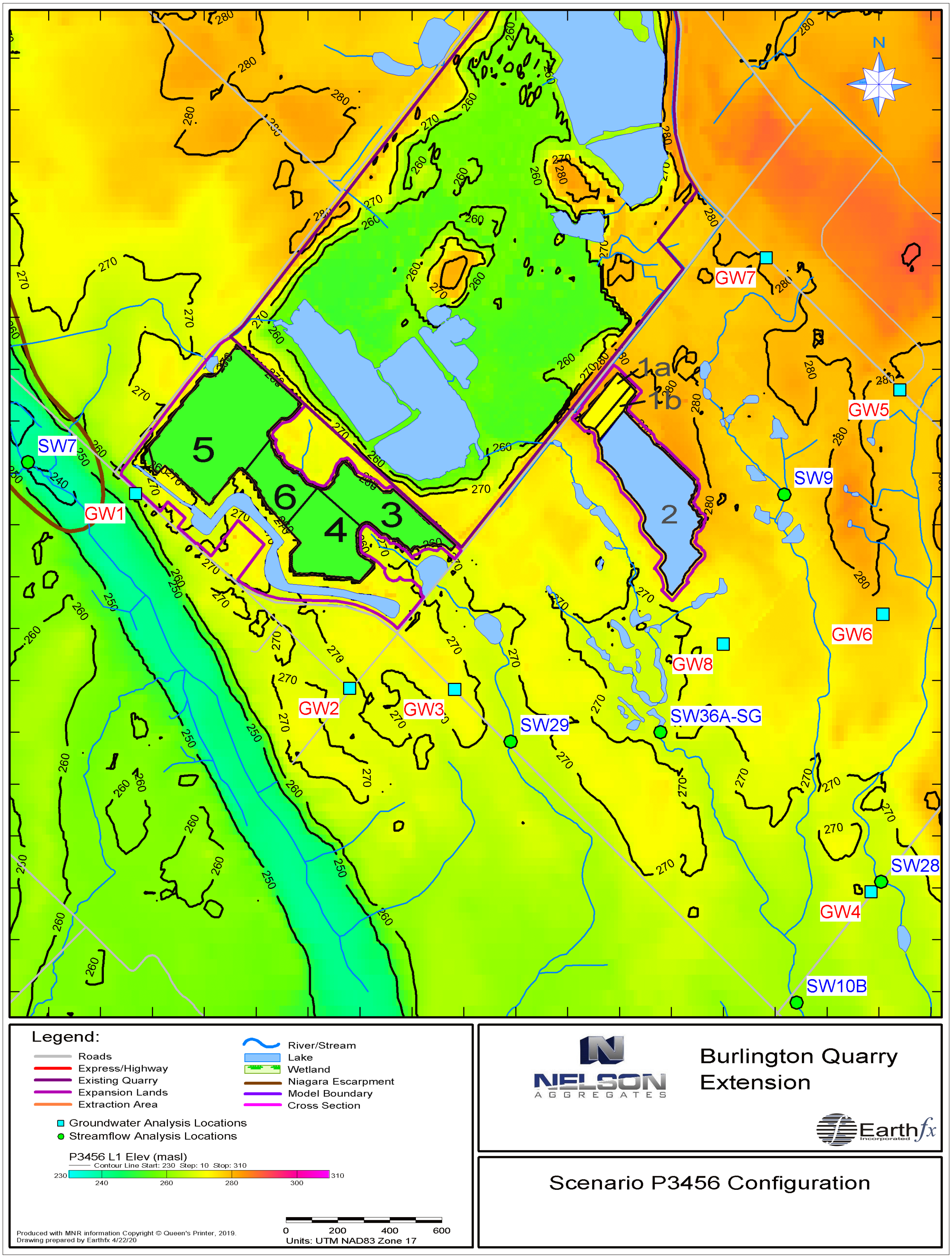

Figure 1: Scenario P3456 and Deep Pond Scenario configurations.

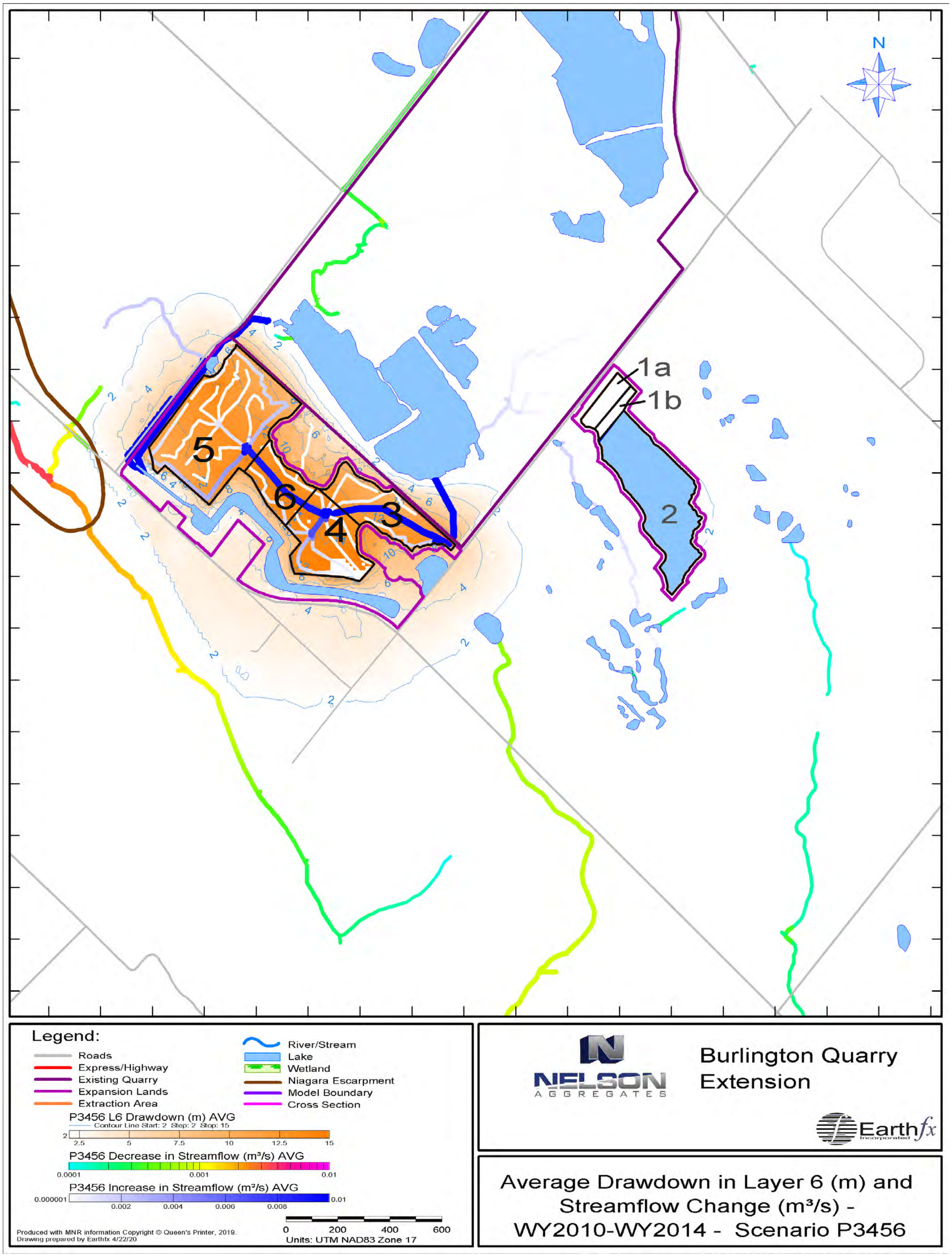

Figure 2: Average simulated drawdown in Model Layer 6 (m) and increase/decrease in streamflow (m3/s) for WY2010 to WY2014 under Scenario P3456.

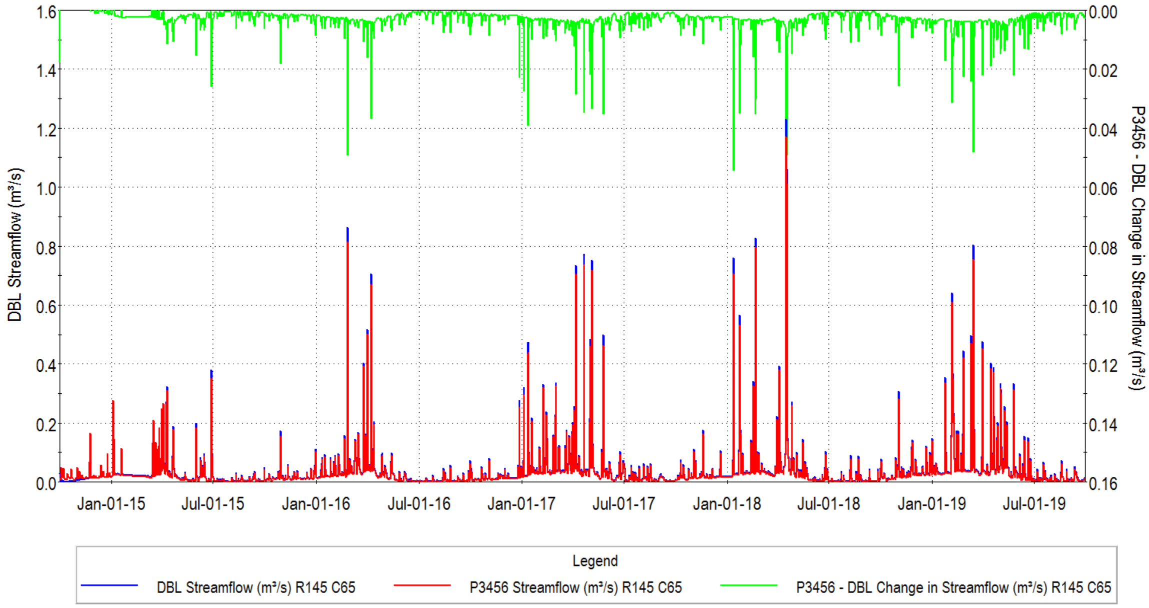

Figure 3: Simulated streamflow at SW07 for WY 2014-2019 – P3456 and Baseline Conditions.

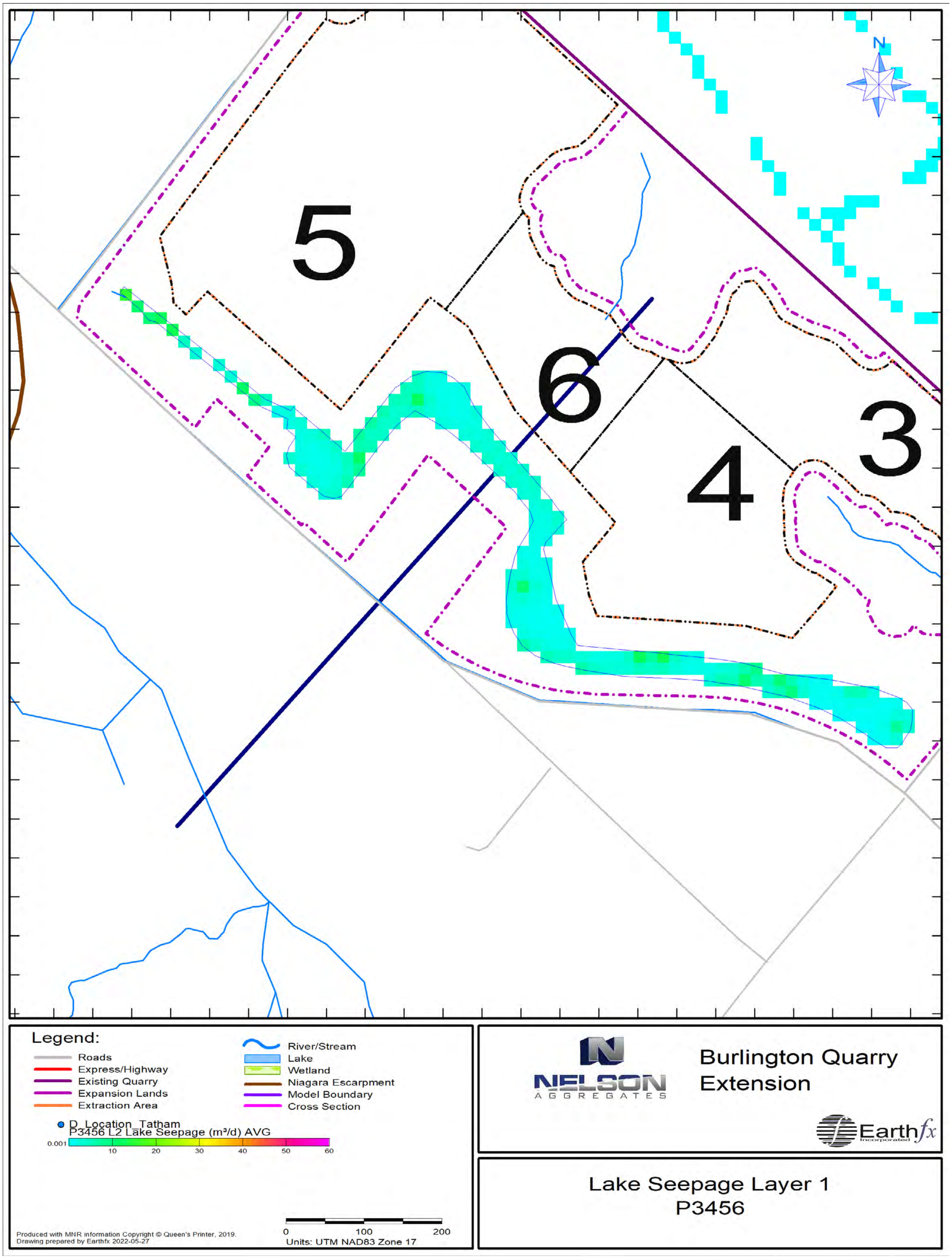

Figure 4: Lake seepage in Layer 1 P3456 Scenario

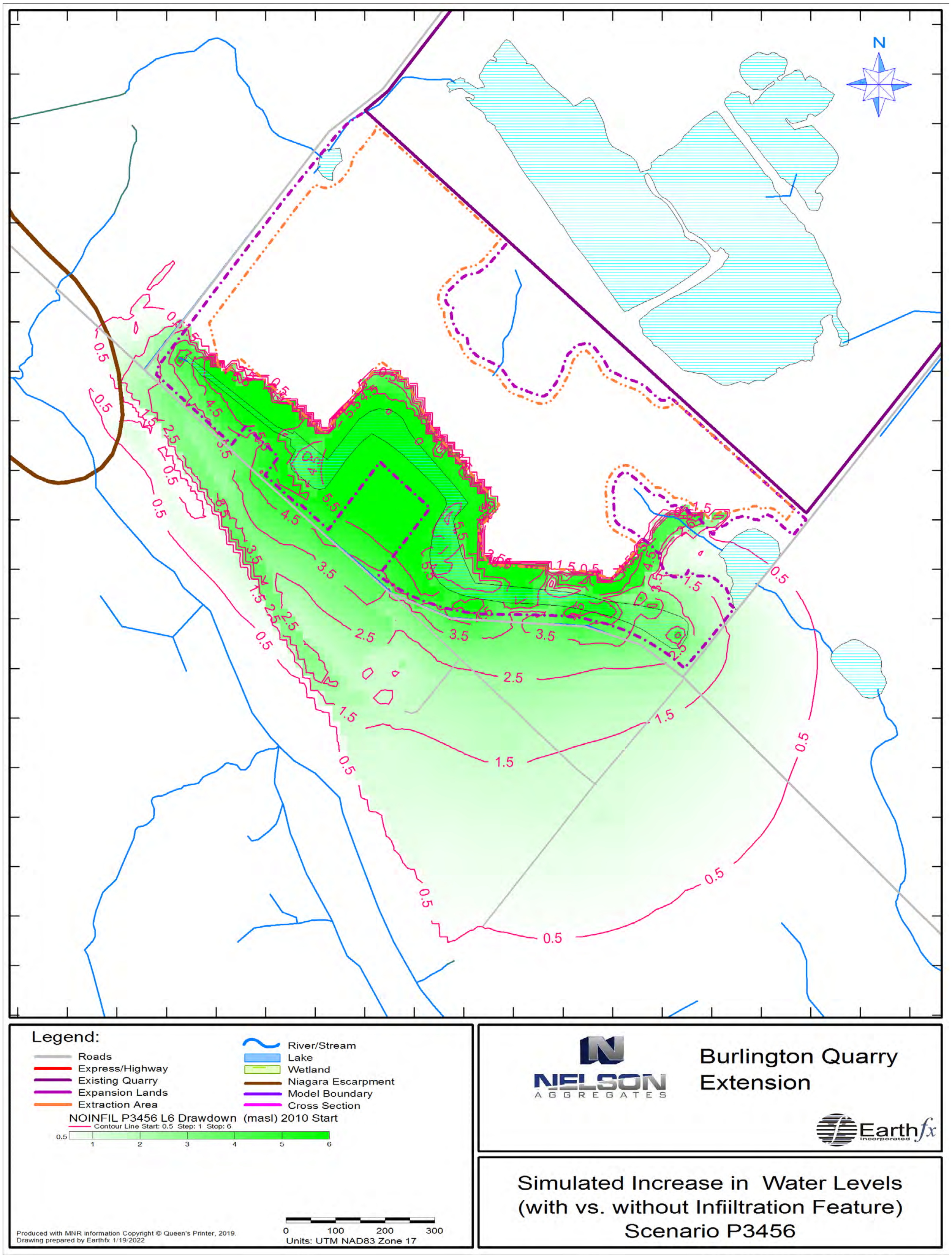

Figure 5: Simulated increase in water levels due to P3456 shallow infiltration ponds

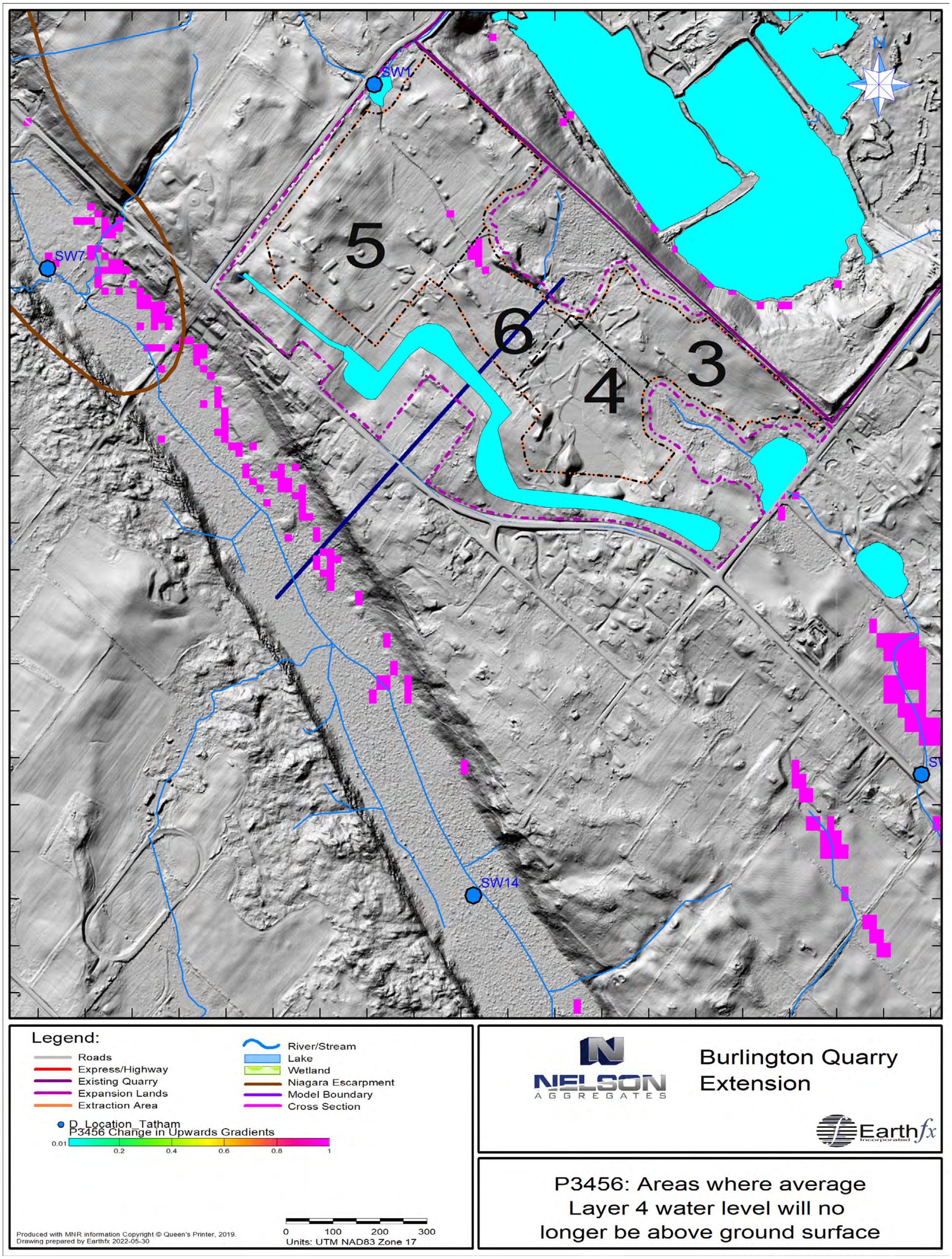

Figure 6: P3456 Areas where average Layer 4 water levels will no longer be above ground surface

4 Modified Scenario P3456: Deep Pond Scenario

The P3456 infiltration pond was not specifically designed to maximize infiltration. During discussions in April, 2022, MNDMNRF reviewers requested that additional simulations be undertaken to determine whether simple changes could be made to the operation and configuration of the infiltration pond to further reduce the impacts of the quarry on the Medad Valley.

A modified Scenario P3456 was run to assess the effects of changes to the infiltration pond. For this scenario the infiltration pond is fully excavated through the Halton till to the bedrock (base of Layer 3). This will provide more opportunity for infiltration compared to the previous P3456 scenario where the ponds were constructed only to the top of the unweathered till (base on Layer 1). To further enhance leakage, the proposed operating water level in the pond was raised from 269.05 masl to 270.05 masl to provide a higher driving head for infiltration.

While a direct excavated connection to the bedrock is proposed, there remains the possibility that some fine-grained sediments may remain (or accumulate) over time on the bedrock surface. This may limit leakage. As a conservative assumption, the hydraulic conductance of the lake bottom sediments was assigned a hydraulic conductivity one-half an order of magnitude lower than that of the Layer 4 weathered bedrock.

As in the previous P3456 simulation, extraction is assumed to be at its maximum depth and dewatering is ongoing in all four extraction areas. The final elevation of the quarry floor is 252.5 masl in the P3456 footprint. Quarry discharge is directed to the existing quarry lakes and eventually discharged from the Northwest sump.

The GSFLOW model was run with the updated inputs. This scenario is referred to as the “Deep Pond Scenario” and model results were post-processed and compared to the original P3456 Design Conditions.

Figure 7 shows the increase in average water levels between the P3456 and new Deep Pond scenario. The increased leakage causes water levels rise locally up to 4 m, and as much as 0.5 m in the eastern portion of the Medad Valley.

Figure 8 shows the average leakage to bedrock under the Deep Pond Scenario. Compared to P3456 (Figure 4), the leakage to bedrock doubles from an average of 778 m^3/d to 1405 m^3/d. As noted above, this is under a conservative assumption of lake bed conductance. Leakage would be still higher if no fine-grained sediments remain or accumulate. Strict settlement and discharge water quality monitoring will be implemented to prevent fine grained sediments from entering the ponds.

As in the previous scenario, the effects on the water levels and gradients in the Medad Valley were evaluated by identifying areas where there was a change in water level gradient. Areas where, on average, water levels in the Layer 4 bedrock will no longer be above ground surface are shown in Figure 9. These areas, shown as purple squares in Figure 9, are generally located along the easter wall of the Medad Valley. Compared to the P3456 conditions shown in Figure 6, the affected area is reduced by over 50% and is now sporadically distributed along the eastern portion of the Medad valley (in areas of slightly higher local relief). Figure 10 compares the P3456 results to those of the Deep Pond scenario, showing the difference as green cells.

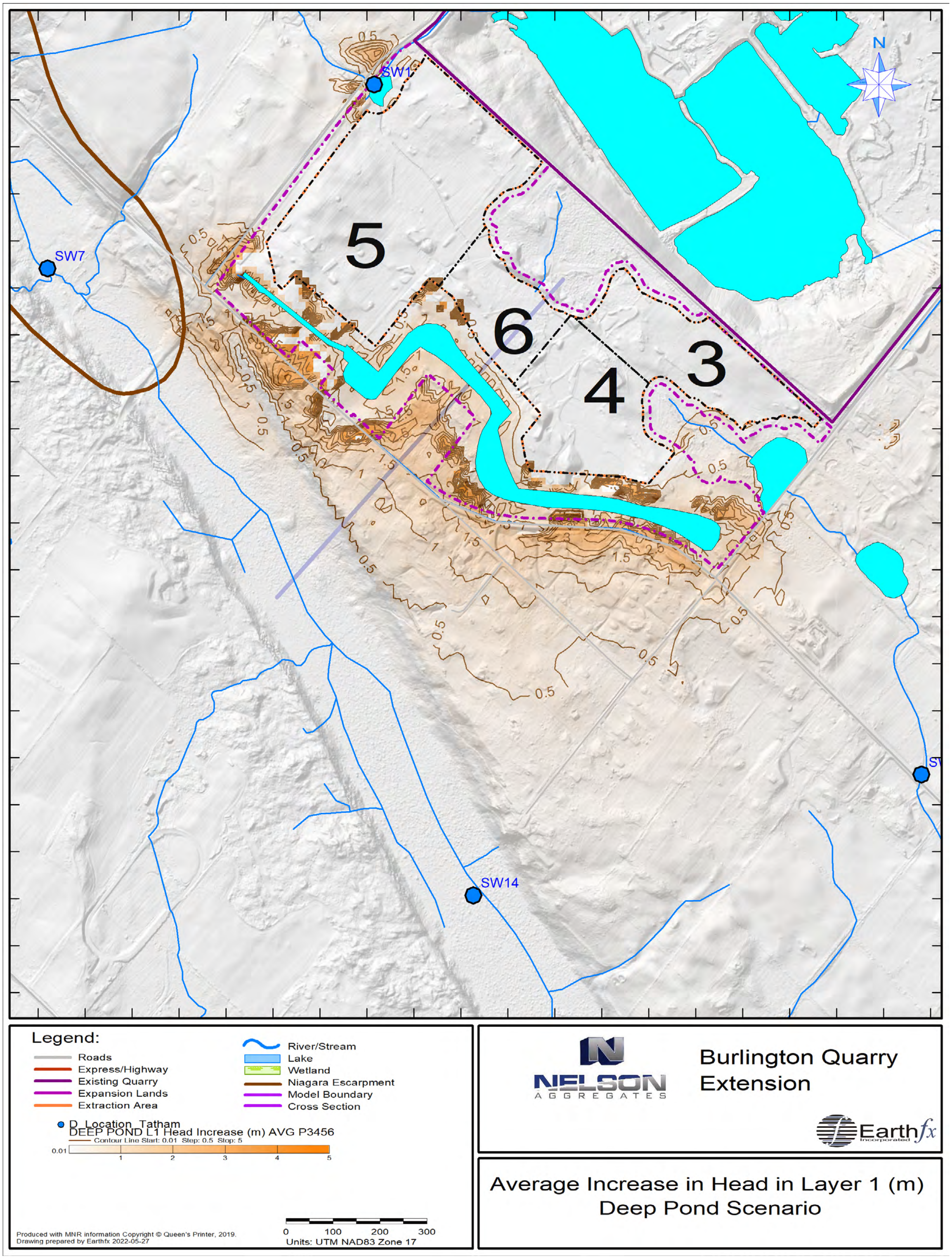

Figure 7: Average increase in Layer 1 water levels between P3456 and Deep Pond Scenario

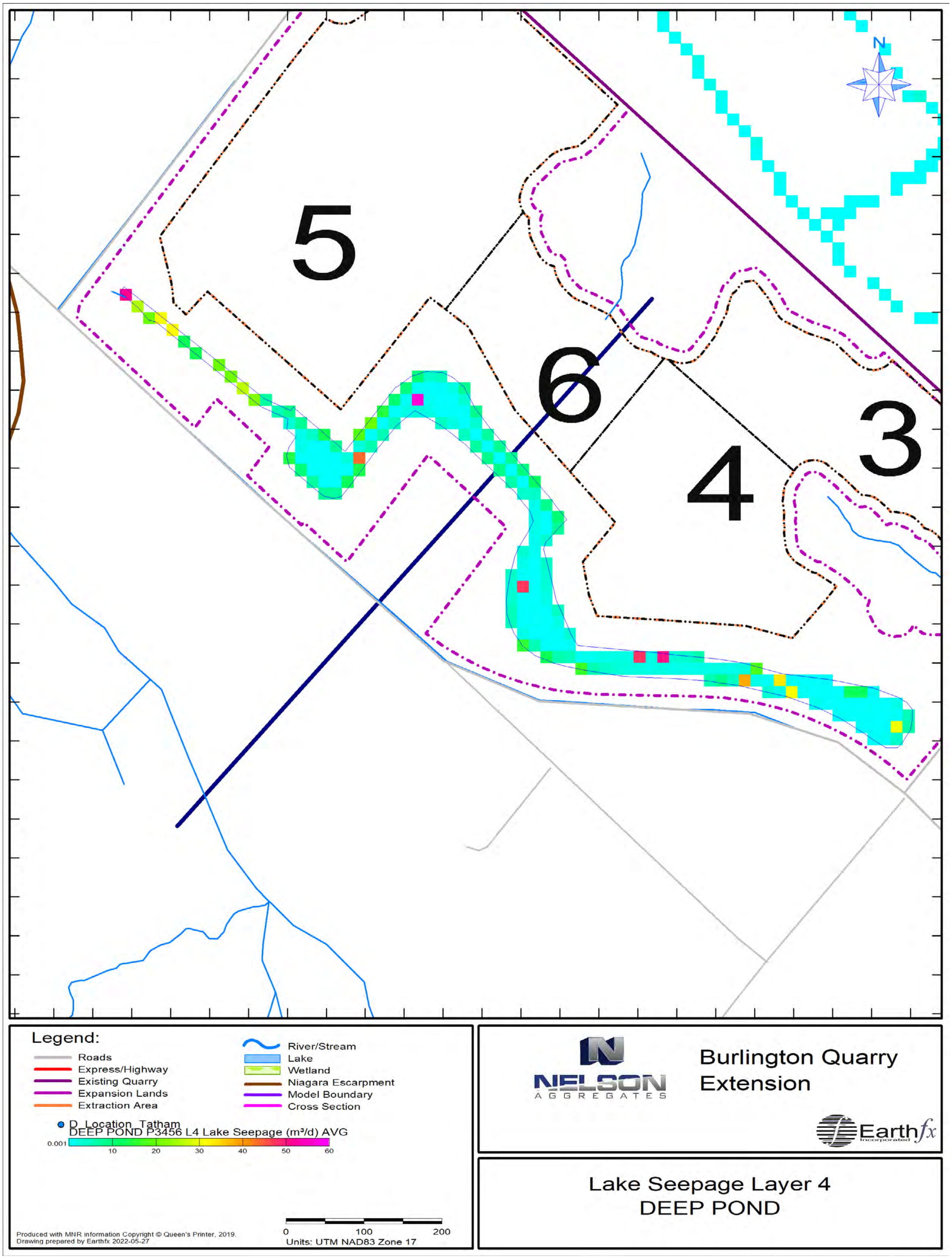

Figure 8: Lake seepage under the Deep Pond Scenario

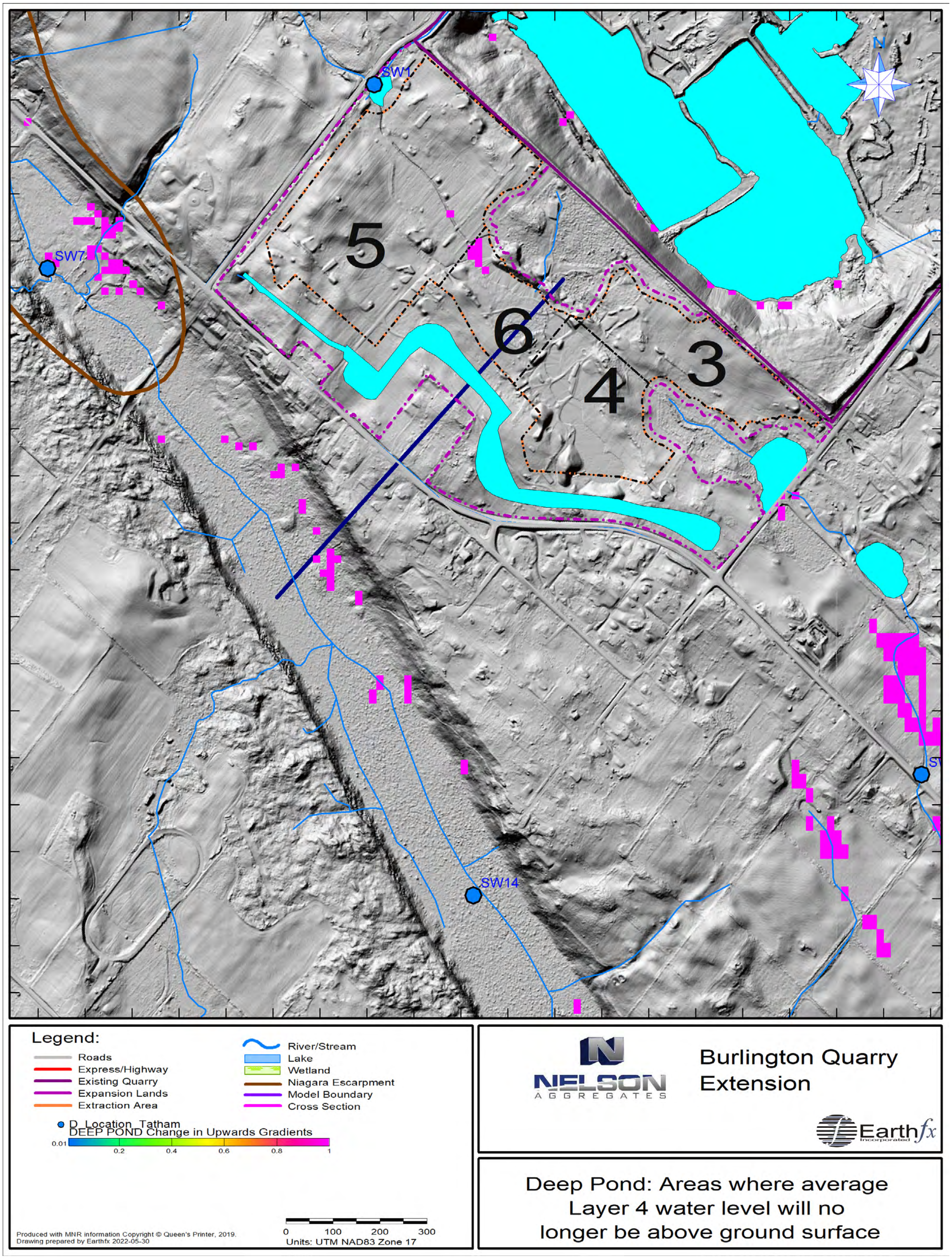

Figure 9: Deep Pond Scenario areas where average Layer 4 water levels will no longer be above ground surface

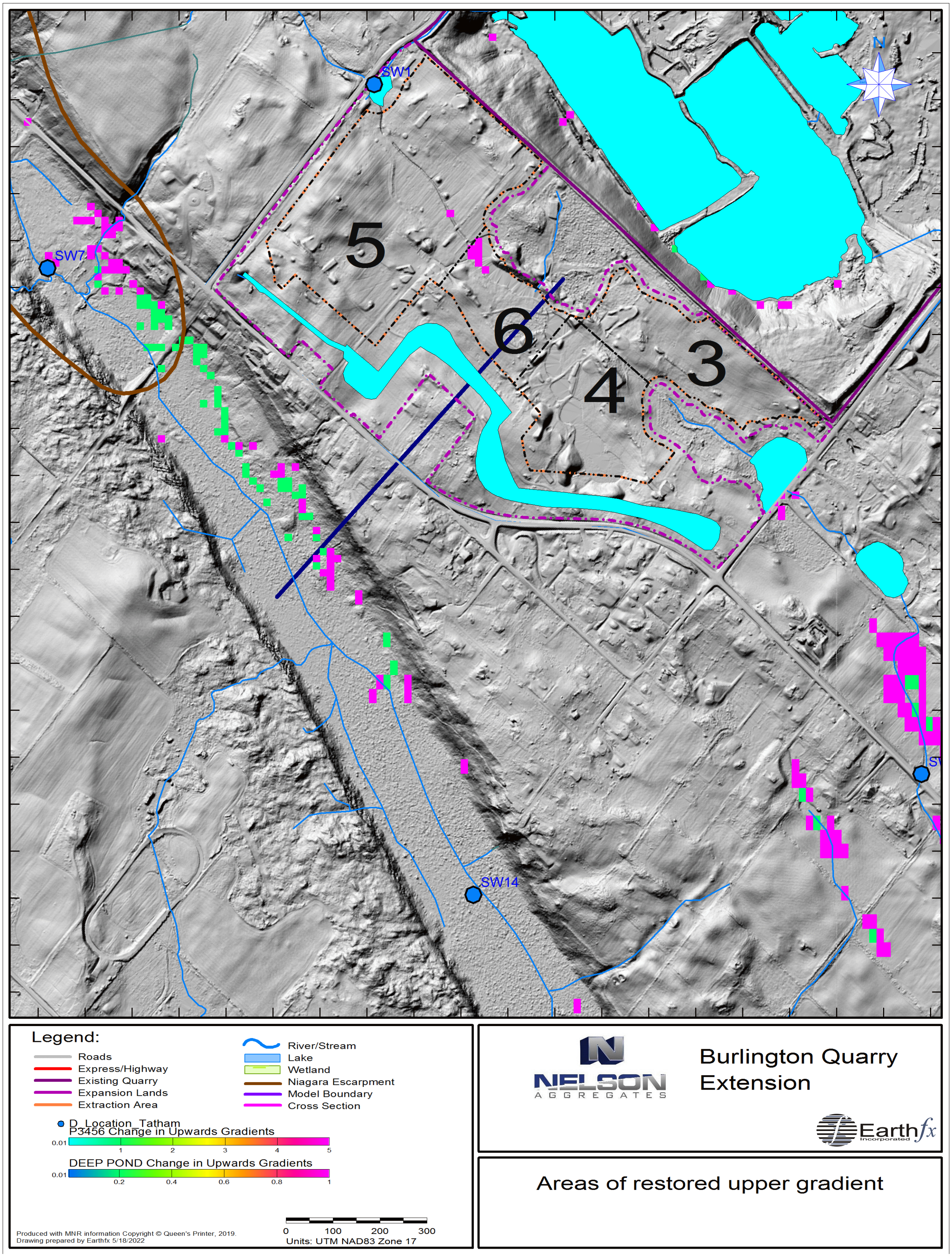

Figure 10: Areas where average water levels will be restored (green cells) between P3456 and Deep Pond scenario. Remaining affected cells are shown in purple.

To conclude, the new Deep Pond scenario demonstrates that modest improvements in the pond design can significantly improve water levels both locally and in the Medad Valley. Conservative assumptions were used to represent the deeper infiltration pond. Under the new design, the effects on the Medad Valley will be very limited and highly dispersed across the extensive wetland feature that occupies the valley.

Yours truly
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