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MEMORANDUM

To: David Germain, Thomson, Rogers

Re: Initial Hydrogeological Peer Review: Burlington Quarry, Hydrogeology Report/Surface Water Report/AMP/Rehabilitation Plan/Site Plan/Progressive and Final Rehabilitation Monitoring Study

Prepared By: Norbert M. Woerns

Date: December 18, 2020

Cc: Joe Nethery

1.0 Introduction

Hydrogeological peer review has been undertaken for the Burlington Quarry Expansion Application by Nelson Aggregates Co. on behalf of Halton Region. The following reports were examined in support of the hydrogeological peer review:

a) Level 1 and Level 2 Hydrogeological and Hydrological Impact Assessment Report of the Proposed Burlington Quarry Extension, Nelson Aggregates Co. prepared by Earthfx Incorporated, (April 2020).
b) Burlington Quarry Extension, Surface Water Assessment, Nelson Aggregate Co., prepared by Tatham Engineering (April 2020).
c) Adaptive Management Plan, Proposed Burlington Quarry Extension (AMP) prepared by Earthfx Incorporated, Savanta Inc., Tatham Engineering, (April 2020).
d) Progressive and Final Rehabilitation Monitoring Study, Burlington Quarry Extension, prepared by MHBC Planning, Urban Design and Landscape Architecture, (MHBC) (April 2020).
e) Site Plan, Four Sheets, Burlington Quarry Extension, prepared by MHBC, (April 2020).
f) Level 1and Level 2 Natural Environment Technical Report, proposed Burlington Quarry Extension. Nelson Aggregates Co., prepared by Savanta Inc., (April 2020).
g) Blast Impact Analysis, Burlington Quarry Extension, Concession 2, Part lot 1, 2, 17 &18, Township of Burlington, prepared by Explotech Engineering Limited, (March 2020).

In addition to the above documents, previous investigations completed by Golder Associates Ltd. (Golder) on behalf of the previous Nelson Aggregate Company (Nelson) quarry extension application have been referred to. Additional information was provided by the applicant in response to questions from Halton Region resulting from a preliminary initial examination of the documentation. Responses were received September 29, 2020 via email and consisted of Excel spreadsheets as well as PDF files. Reference to the information provided is included in the following review comments.

The hydrogeological analysis completed by Earthfx Incorporated (Earthfx) is presented through an integrated groundwater and surface water model. The following review comments take into account the inter-relationship of surface and groundwater and the potential of the proposed quarry expansion impacts on local groundwater resources including private wells and natural heritage features such as wetlands. Detailed comments on the integrated modelling and on the Karst study were not provided. These were left to others. Summary comments are provided followed by detailed review comments.

2.0 Summary Comments

1) Hydrogeology (Earthfx, 2020)
    a) 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.
    b) The hydrogeological analysis has failed to address the potential for groundwater and surface water contamination and is therefore incomplete.
    c) 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.

d) The hydrogeological investigations have failed to clarify the issue of overburden hydraulic conductivity and interconnection of the overburden with under lying bedrock. Previous pump test conducted in 2004 by Golder Associates (Golder), (Golder, September 2010) demonstrated apparent hydraulic connectivity between overburden and underlying bedrock underlying wetlands adjacent to previously proposed Nelson Quarry Extension. The pump test completed by Azimuth in the Western Extension lands monitored a nearby surface water level but did not monitor the overburden units during this pump test to determine the degree of hydraulic connectivity between overburden and the underlying bedrock.

e) 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.

f) Borehole logs are provided in Appendix A which includes some boreholes completed by Golder as well as most borehole logs of holes completed as part of the Azimuth Environmental Consulting Inc. (Azimuth). A number of Golder borehole logs are not included. In addition, borehole logs for shallow groundwater monitors installed by Tatham and the logs for boreholes/wells drilled by Keith Lang on the western extension have also not been included in the documentation. Partial monitor detail information on the previously installed Golder groundwater monitors is provided in Table 9.1, page 311. A complete list of borehole logs and information included in the hydrogeological analysis with monitor completion details including piezometers installed near or in wetland features should be included in the documentation. Some of the requested borehole information was subsequently provided and received September 29, 2020. This information was provided in computer model input file formats and was not readily useful for peer review purposes.

g) 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.

h) 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.

i) 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.

j) 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.

k) 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.

l) The hydrogeological analysis is based upon the assumption that current conditions represent baseline conditions. Predicted changes in groundwater levels are compared to current baseline conditions. There is no discussion of the impacts from the historical operation of the existing quarry and relevance to closure requirements of the existing quarry licence. This should be included in the report.

m) With respect to Rehabilitation Scenario 1 (RHB1), how do we 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.

n) 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.

o) 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.

2) Surface Water Report (Tatham Engineering, 2020)

a) Water quality results are presented in Appendix H, however there is no discussion of water quality in the report with respect to drinking water quality standards. Infiltration of surface water is proposed to maintain down-gradient private well water supplies. Emphasis is focussed upon the threshold values of selected parameters included in the Environmental Compliance Approval (ECA) for the existing quarry.

b) Preliminary baseflow and temperature thresholds are recommended. Water quality thresholds for total suspended solids, pH, and oil and grease for discharge waters are part of the existing quarry Environmental Compliance Approval (ECA). Tatham recommended that these be maintained for the proposed expansion.

   No threshold or target water quality levels for the remaining water quality parameters included in the monitoring program, currently exist. *'Its recommended that the water quality thresholds be established from the results of the historic water quality sampling completed in support of the proposed quarry extension. Specifically, maximum and minimum concentration limits should be established from the sample results collected while considering the Provincial Water Quality Objectives (PWQO) and role water quality plays in the Natural Heritage Features.'* (Tatham, page 88, 3rd paragraph.)
   No such recommendation has been made for groundwater quality parameters.

c) Lacking details on groundwater monitor construction in or near surface water features. No monitor details or borehole logs in Appendices. Subsequent drive point information has been provided with no information on the soil units encountered.
d) Only five wetlands of the 22 wetlands in the vicinity were instrumented with piezometers to assess vertical hydraulic gradients for water budget purposes. Water budget conclusions regarding the wetlands that have not been instrumented by Tatham therefore cannot be verified against measured data.
e) Manual water level readings are shown on hydrographs in Appendix G. Appendix F summarizes manual shallow groundwater levels although it is not clear what the measuring point was and the significance of negative values.

3) AMP (Earthfx, Savanta, Tatham, 2020)
   a) For the southern extension groundwater levels *'Preliminary groundwater threshold values have been assigned to key Sentry Wells that are located outside of the extraction area.'* AMP page 15 section 4.4.2 1st paragraph. However, for the west extension "*No groundwater thresholds are proposed until enough groundwater monitoring data is collected to establish baseline conditions.*" AMP page 17, section 4.5.3, 1st paragraph. Groundwater level thresholds for the west extension are missing from the report.
   b) No water quality discussion or threshold levels for groundwater quality are included. See comments on surface water report.
   c) Prior to the surrender of the existing ARA licence the licence is required to provide confirmation that any long term monitoring, pumping, or mitigation will not result in a financial liability to the public. Due to the uncertainty of the proposed mitigation measures for the proposed expansion, this should be confirmed prior to the issuance of the ARA licence.

d) What options are available and what process will be followed if a suitable replacement well cannot be installed on properties where adverse well interference from quarry operations has been confirmed?
e) How will the effects of current climatic conditions on groundwater levels be evaluated?
f) No water level thresholds have been provided for shallow monitoring wells nor for existing wells shown on Figure 4 and 6 that have less than 5 metres of available drawdown.
g) The AMP should identify measures required to address the current decline in groundwater levels in the vicinity of sensitive receptors.
h) The AMP does not fully recognize the interests of local agencies and municipalities in the protection of private water supplies ecological features. Details are missing with respect to AMP implementation oversight and ongoing data access with these agencies.
i) The long-term financial implications of the recommended final site rehabilitation scenario have not been addressed.
j) The use of available drawdown as criteria for implementation mitigation measures does not consider existing well conditions such as well productivity or water quality issues and is inadequate for assessing negative impact on private wells.
k) The AMP approach to mitigation is reactive and should be proactive especially with respect to residential wells at high risk of potential well interference.

4) Rehabilitation Plan (MHBC,2020)

a) Recommended rehabilitation option RHB1, as shown on the Site Plan, requires perpetual pumping to maintain artificially low groundwater levels. An alternative (RHB2) has been proposed with resulting fish habitat impact concerns. No cost benefit analysis of impacts of the alternative rehabilitation scenario has been provided. The overall impact of the two rehabilitation scenarios on the subwatershed does not appear to have been considered in this analysis nor has the cumulative impact of the existing quarry been considered.
b) There is no discussion on how the applicant will provide *'confirmation that any long-term monitoring, pumping or mitigation will not result in a financial liability to the public.'* Rehabilitation Study, page 22 section 5.2 Final Rehabilitation, point 8. This appears to be a requirement of surrendering the ARA Aggregate Licence. Given uncertainties of the effectiveness of proposed mitigation measures this should be demonstrated prior to approval of the licence application for quarry expansion.
c) No discussion on the need to integrate the rehabilitation and closure plan of the proposed expansion with that of the existing quarry. The Progressive and Final Rehabilitation Monitoring Study provides detailed information on the rehabilitation of the proposed extension. Information is lacking on the relationship of the proposed extensions to the approved rehabilitation plan for the existing quarry.

d) There is no discussion of the maintenance requirements of the proposed land use for the preferred recommended rehabilitation option and the potential affects on surface water and groundwater quality.

5) Site Plan (MHBC, 2020)
   a) Details of an integrated rehabilitation plan including the existing quarry and proposed extensions should be shown on the site plans for the proposed expansion.
   b) No information is provided on the site plans that described how the west extension area will be integrated with the existing quarry under final rehabilitation.
   c) It is not shown on the site plans how the discharge water from surface runoff and dewatering of the west Extension will be integrated into the existing sump in the existing quarry.
   d) Details of the monitoring and mitigation should be included as part of the site plan.

Detailed Review Comments

Level 1 and Level 2 Hydrogeological and Hydrological Impact Assessment Report (Earthfx, April 2020)

Text in italics and quotation marks represent quotes for the report text. Non italicised text represents review comments.

1) Page 27, Introduction, Section 1.1 Objectives, 1st Paragraph –

   '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.

2) Page 30, Section 1.2 Study Approach, 2nd paragraph –

   '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.

3) Page 30, Section 1.3 Level 1/Level 2 Study Components and Methodology, 1st paragraph

'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.

4) Page 30/31, Section 1.3.1 Field Investigations,

   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.

5) Page 31, Section 1.3.2 Site Characterization and Baseline Conditions Analysis, 3rd paragraph

   'Section 7 of the report presents a numerical simulation of the current or "Baseline' conditions at the site. A continuous transient (time-dependent) assessment is presented, illustrating how the surface water and groundwater systems behave on a daily basis over the last 10 years. Included in this assessment time period is a severe Provincial Low Water Response Level 2 drought (2016) and an above average wet year (2017). This baseline provides a realistic long-term frame of reference for comparison and assessment of the proposed quarry extension and rehabilitation phases.'

   Current conditions may be appropriate for assessing impact of the proposed extensions to the existing quarry. This does not however address the impact of the existing quarry operations. The cumulative impact of the existing quarry and the proposed quarry extensions should be considered for purposes of evaluating impacts on private wells. natural heritage features and rehabilitation options.

6) Page 33, Section 1.3.7 Level 1/Level 2 Methodology Summary

   '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.

7) Page 36, Section 2.2 Long Term Monitoring Network, 1st paragraph

'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.

8) Page 45, Section 3.3.3, Site Development History,1st paragraph

'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

9) Page 48, Figure 3.6 Well Locations: West Extension area.

Typo. Location BS-063 should be BS-03. Also note that BS-06 is missing on this figure.

10) Page 49, Figure 3.7, Sample Borehole Log from West Extension area (BS-04)

Model layers should be labelled on this figure for correlation to hydraulic conductivity results from packer testing.

11) Page 66, Figure 3.22 West-East quarry cross section

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 up-gradient 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.

12) Page 70, Figure 3.25, BS-01 Borehole log showing the Goat Island Formation

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.

13) Page 71, Section 3.5.1, Halton Till, 2nd paragraph

'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, 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.

14) Page 76, Section 4.4.1 Precipitation and Temperature

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 mm/yr. varies from 655 and 1172 mm/yr. The range in precipitation represents an increase of about 80% 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?

15) Page 84, Figure 4.9, Surficial soil complex mapping

Are the lime coloured areas on this figure clay loam? It is not clear from the legend that these colours are the same?

16) Page 87, Section 4.3.3, Lakes and Ponds, 2nd Paragraph

‘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?

17) Page 93, Section 5.2.2: Halton Till Aquitard, 1st paragraph.

‘The till is of low permeability and serves to limit recharge and/or leakage to the underlying aquifers.’

Is Halton Till located beneath the existing irrigation ponds or the proposed infiltration pond? If so, what effect does this have on infiltration of quarry discharge water on groundwater levels? Has this been taken into account in the modeling? Is the Halton Till weathered anywhere in the study area and has fracturing been accounted for in assigning hydraulic conductivity to fine grained overburden deposits?

18) Page 97, Figure 5.4 Cedar Springs Road Section

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.

19) Page 100 & 101, Figure 5.7 and 5.8, South Expansion Packer Section 1 and 2 respectively

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.

20) Page 103, Section 5.2.4, Layer 4: Weathered Bedrock/Overburden Interface Aquifer, 4th paragraph

'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 do we know that Layer 4 is the only layer that transmits karstic water? Could deeper layers not also contribute to surface discharge via springs/seeps?

21) Page 105, Section 5.2.5.2, Anisotropy and Vertical Flow Patterns, 2nd paragraph

Typographical error? Reference to Worthington Groundwater (2019). Should this be Worthington Groundwater (2020)?

22) Page 105, Section 5.2.5.2, Anisotropy and Vertical Flow Patterns, 3rd paragraph

'the bulk anisotrophy of Layer 5 (upper bulk Amabel) was estimated to be 500:1 (Kh/Kv) and Layer 7(lower bulk Amabel) to be 1000:1 (Kh/Kv).'

The above statement is in contradiction to the last paragraph of page 104 which reads as follows:

'It is widely recognized that the dolostones of the Niagara Escarpment have a high degree of vertical to horizontal anisotrophy. Maslia and Johnston (1984) studied the "effectiveness of horizontal (bedding) joints versus vertical joints as water transmitting openings". They concluded that vertical hydraulic conductivity (Kv) to horizontal conductivity (Kh) anisotropy of 100:1 to 1000:1 was typical of Lockport (Amabel) Formation.'

These are contradictory statements therefore one of the above statements must contain a typographical error. Please correct.

23) Page 106, Section 5.2.8 Lower Flow Zone,1st paragraph

'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?

24) Page 106, Section 5.2.8 Lower Flow Zone, 1st and 2nd paragraph.

'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 m 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.

25) Page 107, Section 5.2.8 Lower Flow Zone, Figure 5.11 Water Levels recorded in Monitoring Well OW03-15 (50m from quarry face), and Figure 5.12: Water levels recorded in Monitoring Well OW03-14 (175m to 40m from Quarry face)

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?

26) Page 109.Section 5.3.1 Water Level Data Sources and Monitoring Record,1st paragraph

'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?

27) Page 109, Section 5.3.1.2 Transient Water Level Data,

'Although there are gaps, the data provide useful insight into how the wells respond to rainfall events and to seasonal and inter-annual climate variability.'

It appears as though there were no on-site climate data to correlate water levels to climatic events. Reliance on off-site climatic stations and composite climatic records from different climate stations as described in Section 4.1.1, page 76, and water level data gaps, limit correlation between simulated water levels and the range of climatic conditions. Please explain the impact of this on the reliability of the computer model.

28) Page 113, Figure 5.15 Vertical Head Differences

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

29) Page 114, Section 5.3.3.1, Seasonal and Inter-annual Patterns 2nd paragraph

'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?

30) Page 115, Section 5.3.3.2 Quarry Water Level Patterns, 1st paragraph.

'Wells in close proximity to the quarry (e.g., OW03-15, which is 50 m from the face) exhibit more than 14 m of vertical head difference between the Layer 4 shallow bedrock and Layer 8 deep fracture zone, as illustrated in Figure 5.11'.

The above suggests that layer 8 is drained by the adjacent existing quarry and that the horizontal hydraulic conductivity (Kh) is likely much higher that the vertical hydraulic conductivity (Kv) resulting in under draining of the overlying layers.
(2nd paragraph)
'With increasing distance from the quarry, the difference in head between the shallow and deep system is reduced. At 300 m from the face, the difference in head has decreased to 10 m (Figure 5.18),'
(4th paragraph)
'at 1000 m from the quarry, the spring freshet provides an excess of water to the water table and, with minimal deep system drainage to the quarry, the water levels in the shallow and deep system are nearly identical.'

The above observations suggest that the existing quarry has resulted in under draining of the shallow bedrock and overburden in proximity to the quarry. It is not clear what impacts the existing quarry has had on the hydroperiod of the nearby wetlands or whether these impacts have stabilized or are expanding. Clarification is required.

Earthfx considers the current conditions to represent baseline conditions. The assessed impacts are based upon simulated changes from the proposed quarry expansion compared to current conditions. The simulation of impacts of the quarry expansion do not identify the cumulative impacts of the existing quarry and the proposed expansion. Cumulative impacts including the existing quarry should be identified.

31) Page 118, Section 5.4, Groundwater Use, 1st paragraph

'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?

32) Page 118, Section 5.4, Groundwater Use, 2nd paragraph

'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?

33) Page 118, Section 5.4.1 Private Water Wells, 3rd paragraph

'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.

34) Page 126, Section 6.3.4, Figure 6.6

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?

35) Page 128, 1st paragraph, Section 6.4, GSFLOW Model Development Process.

'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?

36) Page 131, Figure 6.10 Surficial Soil Hydraulic Conductivity

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.

37) Page 132, 2nd paragraph, Section 6.6 Hydraulic Processes Parameters

'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?

38) Page 142, Section 6.10.1 Model Construction, Model Parameters, 3rd paragraph

'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'.

39) Page 145, Section 6.11.3 Calibration to Transient Water Level Data,1st paragraph

'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?

40) Page 152, Section 6.11.3.4 Quarry Effects Calibration Conclusions

'Numerous additional examples of each of these water level patterns are included in Section 19. The numerical model universally replicates the patterns, indicating an excellent calibration to the observed effect of the existing quarry. The close calibration to these commonly observed patterns confirms that the model can accurately predict the future effects of the quarry extension.'.

The model appears to generally match the observed hydrograph patterns although the computer simulations often either under estimate or over estimate the water levels compared to observed water levels. See Figure 6.24, page 149. What is the significance of this?

41) Page 154, Figures 6.29 and 6.30

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?

42) Page 156, Section 6.11.6.1 MNRF Wetland 13025

'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.

43) Page 157, Section 6.11.6.2, MNRF Wetland 13031, 1st paragraph

Typographic error, 'MNRF Wetland 1301' should read 'MNRF Wetland 13031'

44) Page 157, Section 6.11.6.2, MNRF Wetland 13031, 1st paragraph

'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 9.9m 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.

45) Page 165, Section 7.1Baseline conditions Analysis, Introduction, 2nd paragraph

'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?

46) Page 166, Section 7.2.2 Scenario Summary and Nomenclature

'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?

47) Page 167, Section 7.2.4, Seasonal and Inter-annual Groundwater Levels,4th paragraph

'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 and 545 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?

48) Page 179, Section 7.2.5.4 Stream Leakage (Hyporheic Exchange), 2nd Paragraph

'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?

49) Page 179, Section 7.2.6 Wetland Water Budgets, 1st paragraph

'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?

50) Page 184, Figure 7.21, Average simulated streamflow loss to groundwater (blue) or groundwater discharge to streams (red) (m^3/d) under Baseline Conditions

How was the level of detail generated for this figure where there are widely dispersed data control points or monitoring locations?

51) Page 186 -188 Figures 7.23 to 7.28 Wetland Water Budgets

The water budget inputs do not appear to match the outputs. Please clarify.

52) Page 190, Section 7.3 Baseline Conditions, 2nd paragraph

'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.

53) Page 190, Section 7.3 Baseline Conditions, 2nd paragraph

'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.

54) Page 190, Section 7.3 Baseline Conditions, 3rd paragraph

'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.

55) Page 191, Section 8.1, Proposed Extraction, 1st paragraph

'However, the off-site discharge will continue as per the conditions of Nelson's PTTW and ECA.'

There is a recommendation to increase the discharge volume for Sump 100. Tatham page 92 last paragraph. This is contradictory to the above statement. No assessment of the impact of this increase in pumping on downstream areas has been completed to support this increase in pumping. An assessment of the impact of the increase in pumping on downstream areas is required to support this increase in pumping.

56) Page 191, Section 8.1, Proposed Extraction, 2nd paragraph

'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.

57) Page 191, Section 8.3, Level 2 Assessment Overview,1st paragraph

'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.

58) Page 192, Table 8.1, Evaluation for need for Level 2 Hydrogeological Assessment

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.

59) Page 200, Figure 8.5: Average simulated drawdown in Model Layer 6 (m) and increase/decrease in streamflow

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.

60) Page 204, Section 8.5.2, P12 Seasonal and Inter-annual Groundwater Levels, 1st paragraph

'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?

61) Page 204, Section 8.5.2, P12 Seasonal and Inter-annual Groundwater Levels, last paragraph

'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.

62) Page 211, Section 8.5.3, P12 Surface Water/Groundwater Interaction, 2nd paragraph

'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?

63) Page 211, Section 8.5.3, P12 Surface Water/Groundwater Interaction, 2nd paragraph

'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?

64) Page 211, Section 8.5.4 P12 Wetland Water Budgets,1st paragraph

'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?

65) Page 218, Figure 8.27 Wetland Cross Section

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.

66) Page 221-224, Wetland Water Budget Figures 8.30 – 8.37

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

67) Page 225, Section 8.5.5 P12 Level 2 Conclusions,4th Paragraph

'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?

68) Page 226, Section 8.6.1, Infiltration Pond,1st paragraph.

'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.

69) Page 226, Section 8.6.2 P34 Drawdowns and Surface Water Flows, 2nd paragraph

'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 1x10-3 m3/s (1 L/s) 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?

70) Page 230, Section 8.7.1, P3456 Drawdowns and Surface Water Flows, 1st paragraph

'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?

71) Page 242, Section 8.7.4 P3456 Wetland Water Budgets, 2nd paragraph

'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 m, 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.

72) Page 243, Section 8.7.4, P3456 Wetland Water Budgets, Table 8.6

It is not clear from water budget figures 8.62 to 8.69, how the percent groundwater outflow and inflow was determined. Please clarify.

73) Page 243, Section 8.7.5, P3456 North Quarry Discharge and Infiltration Pond,2nd paragraph.

'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 intercepted by the underlying sand layer and the karst layer, Model Layer 4 and not reach the wells?

74) Page 248 to 251, Figures 8.62 to 8.69 Detailed water budget for wetlands

It is not clear from these figures how the percentage of groundwater inflow and out flow were determined. Please clarify.

75) Page 252, Section 8.7.6 P3456 Effects on Medad Valley, 1st paragraph

'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 4L/s (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 L/s or just over 50% of the average baseflow measured at SW7. The significance of this reduction in baseflow should be addressed.

76) Page 252, Section 8.7.6 P3456 Effects on Medad Valley, 5th paragraph

'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 L/s. The reduction in seepage is calculated to be 2.1L/s at SW7. This is about 50% reduction in average baseflow. The significance of this should be addressed.

77) Page 256, Section 8.7.7 P3456 Level 2 Conclusions, 1st paragraph

'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 300m 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.

78) Page 256, Section 8.7.7 P3456 Level 2 Conclusions, 2nd paragraph

'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.

79) Page 256, Section 8.7.7 P3456 Level 2 Conclusions, 5th paragraph

'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?

80) Page 257, 1st paragraph, Section 8.7.7 P3456 Level 2 Conclusions

'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 L/s in Willoughby Creek at SW7 (see comment 75 above). The model predicts a loss of seepage of 2.1 L/s. 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.

81) Page 260, Section 8.8, Scenario RHB1, 2nd paragraph

'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?

82) Page 263, Figure 8.79: Average simulated drawdown in Model Layer 6(m) and increase /decrease in stream flow (m^3/s) for WY2010 toY2012 under scenario RHB1

How do we 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?

83) Page 264, 1st paragraph, Section 8.8.1 RHB1 Drawdowns and Surface Water Flows

'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 L/s under RHB1 when decrease in flow at SW7 is 2.1 L/s under Scenario P3456 extraction (see comment 75 above). Why is there a larger decrease in flow in the Medad Valley as a result of rehabilitation Scenario 1 (RHB1) after extraction.. Are these flows measured at different points?

84) Page 264, 2nd paragraph, Section 8.8.1 RHB1 Drawdowns and Surface Water Flows,

'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 L/s.

85) Page 272, Section 8.8.4, RHB1 Wetland Water Budgets, 2nd paragraph

'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 100m 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 150m 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?

86) Page 277 – 279, Wetland Water Budgets, Figures 8-98 to 8-103.

It is not clear how the percent of groundwater inflow and outflow have been determined. Please clarify.

87) Page 280, Section 8.8.5 RHB1 Level 2 Conclusions

‘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.

88) Page 280/281, Section 8.9.1 RHB2 Drawdowns and Surface Water Flows,2nd paragraph

‘Figure 8.106 shows the simulated change in average head in Model Layer 6. Only a very small area west of Phase 5 had a drawdown greater than 2 m, which was due to the elimination of quarry discharge and leakage to groundwater. Some residual drawdowns, less than 1.3 m, are noted in the P12 area, due to the flattening of the water table in the vicinity of the P12 lake. Most of the quarry vicinity showed a significant increase in heads ranging from 0 to 12 m, with the 2 m rise extending out up to 630 m from the west side of the existing quarry.’

The predicted increase in groundwater levels should result in restoration of groundwater conditions. The overall impact of this on surface water and on local wells should be assessed and factored into the rehabilitation scenario assessment.

89) Page 281, Section 8.9.1 RHB2 Drawdowns and Surface Water Flows,2nd paragraph

‘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.)

90) Page 285, 2nd paragraph, Section 8.9.1 RHB2 Drawdowns and Surface Water Flows.

'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 2.1L/s under the Phase 3456 extraction compared to current baseline conditions (see comment No. 75 above). Under RHB2 the quarry dewatering will cease and groundwater levels will increase up to 12m 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.

91) Page 289 – 292, Figures 8.113 to 8.120

The surface elevation should be shown on each of these hydrograph figures representing each of the eight assessment points.

92) Page 293, Section 8.9.3 RHB2 Surface Water/Groundwater Interaction,1st paragraph.

'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.

93) Page 293, Section 8.9.5 RHB2 Level 2 Conclusions, 3rd paragraph

'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.

94) Page 298-300, Figures 8.125 – 8.130, Water Budget for Wetlands

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

95) Page 301, Section 8.10 Level 2 Impact Assessment Conclusions,1st paragraph

'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.

96) Page 301, Section 8.10.1 System Understanding,1st paragraph

'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.

97) Page 301, Section 8.10.1 System Understanding, 2nd paragraph

'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.

98) Page 301, Section 8.10.2 Drawdowns, 3rd paragraph.

'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 area 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 metres of assumed available drawdown.

99) Page 301, Section 8.10.3, Water Supply, 1st paragraph

'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 5m 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 m 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.

100) Page 302, Section 8.10.4, Stream and Wetland Function,1st paragraph.

'The wide distribution of low permeability Halton Till in and round the quarry is the dominant feature controlling surface and groundwater interaction. The wetlands and streams are generally perched above the water table and isolated from the groundwater system by the low permeability till. None of the wetlands receive significant groundwater inflow, and are thus isolated from any changes in the water table due to quarry development.'

MNRF wetland no. 13027 (Earthfx wetland no. 17) has shown ground water levels at or above surface and this wetland, at least seasonally, does not exhibit perched groundwater conditions. A number of other wetlands closer to the existing quarry occur within areas that have been influenced by historical dewatering of the existing quarry and as such have altered hydrogeological conditions which historically may have not exhibited perched conditions beneath the wetlands. It has not been demonstrated with certainty that none of the wetlands receive significant groundwater inflow. Please clarify.

101) Page 303, Section, 9.1 Development and Monitoring Program, Objectives, 1st paragraph

'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.

102) Page 303, Section 9.2 On-site Monitoring Wells, 1st paragraph

'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.

103) Page 303, Section 9.2 On-site Monitoring Wells, 2nd paragraph

Typographical errors in this paragraph: W03-1A should be MW03-1A and M03-1B should be MW03-1B.

104) Page 303, Section 9.2 On-site Monitoring Wells, 3rd paragraph

'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.

105) Page 304, Section 9.4 Groundwater Impact Assessment Methodology,1st paragraph

'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.

106) Page 304, Section 9.4 Groundwater Impact Assessment Methodology,2nd paragraph

'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

107) Page 304, Section 9.4 Groundwater Impact Assessment Methodology,2nd paragraph

'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.

108) Page 304, Section 9.4 Groundwater Impact Assessment Methodology,4th paragraph

'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.

109) Page 305, Section 9.4.1 Monitoring of Background Groundwater Conditions, 1st paragraph

'To assist in the evaluation of the water levels measured as part of the groundwater monitoring program, a background monitoring well has been incorporated to the program. The background monitoring well is a domestic water well located north of the existing quarry at 2377 Collins Road (referred to as DW2; Figure 9.1). The purpose of this background monitoring well is to document the natural variability of the groundwater elevation fluctuations and trends under various future climatic conditions. This background monitoring well has shown to have no drawdown from the proposed quarry extension.'

Please provide evidence to support the conclusion that background monitor DW-2 has no drawdown impacts from the proposed quarry. Is this from computer simulations or actual measurements over time? Has this monitoring well been impacted from the existing quarry?

110) Page 305, Section 9.4.2 Comprehensive Groundwater Elevation Trend Analysis, 2nd paragraph.

'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?

111) Page 307, 1st paragraph, Section 9.4.2, Comprehensive Groundwater Elevation Trend Analysis.

'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?

112) Page 307, Section 9.4.3 Proposed Groundwater Thresholds Levels, 2nd paragraph.

'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.

113) Page 307-308, Section 9.4.4. Proposed Groundwater Mitigation Measures, 2nd paragraph.

'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 m 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.

114) Page 308, 2nd paragraph, Section 9.4.4, Proposed Mitigation Measures.

'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

115) Page 308 3rd paragraph, Section 9.4.4, Proposed Mitigation Measures.

'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.

116) Page 308, 4th paragraph, Section 9.4.4, Proposed Mitigation Measures.

'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.

117) Page 308, 5th paragraph, Section 9.4.4, Proposed Mitigation Measures

'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.

118) Page 309, 1st paragraph, Section 9.5.1, Groundwater Monitoring Program.

'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.

119) Page 311, 2nd paragraph, Section 9.5.1, Groundwater Monitoring Program

Typographical errors; M03-9 and M03-14 should be MW03-9 and MW03-14.

120) Page 311, 2nd paragraph, Section 9.5.1, Groundwater Monitoring Program

'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 meters 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).

121) Page 313, last three paragraph, Section 9.5.2, Groundwater Thresholds.

'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.

122) Page 315, Section 9.6.3 Groundwater Thresholds, 1st paragraph.

'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)?

123) Page 320, Table 10.2, Groundwater Quality Parameters

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.

124) Page 321, Figure 10.1: AMP Groundwater Locations

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.

125) Page 322, Section 10.1.2 Private Water Well Monitoring,1st paragraph.

'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.

126) Page 324, 3rd paragraph, Section 11.2 Hydrogeologic and Hydrologic System Summary

'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.

127) Page 324, Section 11.3.1 Baseline Conditions, 3rd paragraph.

'The Level 2 impact assessment scenarios present a detailed and exhaustive comparison of the proposed developments to the baseline conditions. All pertinent aspects of the surface water and ground water system have been compared across a wide range of climate conditions. The integrated approach ensures that surface and groundwater functions and water budgets are fully reconciled.'

It may be appropriate to consider existing conditions for purposes of assessing impact of the proposed expansions. The cumulative impacts of the existing quarry and the proposed expansion have not been addressed. A map showing the existing cone of influence and drawdown of the existing quarry should be provided as part of the impact assessment. The impact assessment scenarios should also address groundwater quality.

128) Page 326, Section 11.3.3.3 Domestic Water Wells.

'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 to 300 m from proposed limit of extraction. Some properties at the northwest portion of the proposed western extension are between 100 and 200m from the proposed limit of extraction. Wells along Cedar Springs Road are directly downgradient of the existing quarry and proposed expansion. The existing quarry has intercepted groundwater that would have flowed towards these wells under natural gradients. The groundwater seepage into the quarry as well as surface runoff from precipitation events is converted to surface water discharge via the existing quarry sumps. These wells are likely already impacted by the existing quarry and may depend to some extent upon infiltrating discharge water via a series of irrigation ponds on the upgradient golf course property much of which is to be removed through the western quarry expansion and replaced with an infiltration pond. Data provided by Golder, 2010 as well as pump tests completed in the proposed western expansion area indicate that groundwater conditions vary considerably between groundwater monitors and test wells. Available drawdown by itself is therefore not a reliable indicator of water availability for wells. The productivity of the aquifer at each well location will also be a significant determining factor of water availability. Flow profiling results (Figure A8 and A9, pages 434 and 435 respectively of the Earthfx hydrogeological Assessment Report) completed by Golder, 2004 indicate diminishing water flow with depth in existing monitoring wells in the southern extension area. This suggests that deepening wells may not be a viable solution to addressing well interference issues. A detailed analysis of this information and the implications to proposed mitigation measures should be completed and included in the report.

129) Page 326, Section 11.3.4, Rehabilitation and Closure, 4th paragraph.

'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.

130) Page 326, Section 11.4 Conclusions, 2nd paragraph.

'The final rehabilitation plan will preserve the form and function of the upper reaches of a tributary of Willoughby Creek and the West Arm of the West Branch of Mount Nemo Creek as quarry discharge will continue.'

The current conditions within the unnamed tributary of Willoughby Creek and the upper reaches of the West Arm of the West Branch of Mount Nemo Creek have been altered by quarry pump discharge. Is it appropriate to preserve an artificial condition that has altered a natural system? (This requires input from a natural heritage and fisheries habitat perspective.)

131) Page 327, 1st paragraph, Section 11.4, Conclusions.

'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.

132) Page 328, Section 12 Recommendations 2.

' 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.

133) Page 332, Section 14, References Cited, last entry

Typographical Error; Worthington 2019 should be Worthington 2020.

134) Page 334, Section 15.1, Drilling Program, 2nd paragraph.

'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.

135) Page 334, Section 15.1, Drilling Program, last paragraph.

'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.

136) Page 335 - 365, Borehole logs

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.

137) Page 367, 368, Sections 15.2.1.1 to 15.2.1.4, Packer Test Interpretation.

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.

138) Page 372, BS-06 Pump Test Hydrograph

Typographic error; 1615 Cedar Springs Road should be 5161 Cedar Springs Road as referenced in text at top of page 371.

139) Page 374, 4th paragraph, Section 15.2.2.2, Pumping Test Interpretation

'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 has been accounted for in the computer model?

140) Page 378, 2nd paragraph, Section 15.2.2.2, Pumping Test Interpretation

'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.

141) Page 378, Section 15.3 Monitoring Well Construction, 2nd paragraph.

'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 you 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?

142) Page 389, Section 15.5 Groundwater Monitoring Program, 2nd paragraph.

'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.

143) Page 397, Section 15.6, Hydrogeochemical Testing, 1st paragraph.

'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.

144) Page 400, Section 15.7 Residential Well Survey, 2nd paragraph,

'Of the 156 homes visited, only eleven (11) homeowners indicated that they were interested in participating in the monitoring program. Seven (7) of the eleven (11) private domestic water wells were accessible and, as a result, have been added to the current groundwater monitoring program '

A summary of the well survey results should be provided as background to the report and there should be a discussion of findings from the well survey. All of the locations included in the well survey should be identified on a figure. Copies of 26 well forms were provided in a separate information package received September 29, 2020. It is not clear whether these are all of the well survey results and the remainder of the 156 homes visited as part of the well survey did not have a response. Threshold levels should be established for the private wells.

Burlington Quarry Extension, Surface Water Assessment, Nelson Aggregate Co., prepared by Tatham Engineering (April 2020).

145) Page 9, Monitoring Location SW1, 1st paragraph.

'Streamflow monitoring location SW1 was established in July 2015 and is located in the weir pond (wetland 13202) downstream of the Quarry Sump 0100 discharge. SW1 measures the flow through the weir structure to the tributary of Willoughby Creek

downstream. The quarry discharge occurs year-round, maintaining sufficient water depth and flow at SW1 to prevent freezing of the pressure transducer during the winter months. As such, the continuously recording pressure transducer typically remains installed year-round to capture the flows at the upstream end of the tributary of Willoughby Creek.'

Is the flow to the irrigation ponds separate from or is that included in SW1 flow to the Tributary to Willoughby Creek? Does the flow in SW1 also include the 2 L/s diversion through the head box diversion from the weir?

146) Page 39, 2nd paragraph, Section 3.3 Existing Condition Integrated Surface Water Groundwater Analysis.

'The portion of the quarry discharge assigned to Spring J is determined through numerical analysis within the integrated surface water groundwater model. The balance of the quarry discharge resurfaces at Spring K which drains to Willoughby Creek downstream of SW7.'

There are no flow measurements of Spring J and K except for one occasion April 10, 2006 by Worthington, 2006. There are no field data to confirm flow conditions from these two springs and consequently flow from the tributary of Willoughby Creek which feeds these two springs. It is known that a minimum of 2 L/s of pump discharge from quarry sump 100 is diverted to the tributary of Willoughby Creek but the total flow characteristics of quarry sump discharge into the tributary to Willoughby Creek are not known. It is also not known how much water is diverted from Sump 100 discharge to the existing irrigation ponds on the golf course property. An assessment of impact on this tributary therefore relies upon computer simulations in the absence of critical streamflow information and without the benefit of verification of existing conditions with field measurements.

147) Page 58, 2nd paragraph, Section 4.3 Proposed Condition Integrated Surface Water Groundwater Analysis.

'The Willoughby Creek watershed will be reduced in area at SW7 through extraction in the west extension. The overall watershed will be reduced by approximately 19 ha or 6% at SW7. As illustrated in the previous table, the proposed condition integrated surface water groundwater model predicts a minor reduction in Willoughby Creek average monthly streamflow through the Medad Valley due to the reduction in in watershed area, and consequently reduction in surface runoff, and the lowering of the groundwater table in the area through extraction and quarry dewatering. A reduction of 1.1 – 2.9 L/s is predicted at surface water monitoring location SW7. The reduction in streamflow is predicted to be greater in the fall, winter and spring (when more water is available in Willoughby Creek) and less during the summer months. The monitoring data collected to date shows a continuous baseflow of approximately 4 L/s in Willoughby Creek at SW7. However, the quarry discharge contributes to the baseflow at SW7 and it is expected that Willoughby Creek would run dry at SW7 if the quarry discharge were to cease. As proposed, the quarry discharge from Quarry Sump 0100 will be maintained during operations and long-term post rehabilitation. Maintaining the off-site discharge will maintain baseflows in Willoughby Creek downstream of its confluence with its tributary.'

Why is it expected that Willoughby Creek at SW7 will dry up by stopping pumping into the creek? See Earthfx, page 252, 1st paragraph where the model shows a net reduction in seepage at SW7 of 2.1 L/s from phases 3456 extraction. This represents over 50% of measured base flow of 4 L/s at SW7. By turning off the pumps in rehabilitation scenario 2 (RHB2) the model shows increased surface water flows in adjacent creeks not currently receiving sump discharge from the quarry (see Earthfx Figure 8.106, page 284)). There does not appear to be a complete cost benefit analysis with respect to the two rehabilitation scenarios.

148) Page 61, Section 5.1 Approved Rehabilitation, 3rd paragraph.

'The predicted average lake water level (269.00 m) is below the existing sill elevation (269.08 m) of the weir structure constructed by the BSGCC in the weir pond (wetland 13202) which created the weir pond (wetland 13202), maintains water levels in the wetland and controls discharge to the tributary of Willoughby Creek and consequently Willoughby Creek. When the lake water level drops below an elevation of 269.08 m, gravity discharge to the tributary of Willoughby Creek will not occur. Also, the average water level in the weir pond (wetland 13202) is 269.27 m. The wetland water level will drop in response to the lake water levels and cessation of off-site discharge.'

Have modifications to the weir been considered to maintain gravity flow to the Tributary to Willoughby Creek?

149) Page 61/62, Section 5.1 Approved Rehabilitation, 4th paragraph.

'This is an important consideration as Willoughby Creek and the West Arm have been identified as fish habitat. Baseflow and water temperature are critical to the form and function of these watercourses from a natural heritage, habitat and spawning perspective. Rehabilitating the Burlington Quarry as approved will negatively impact Willoughby Creek and the West Arm as flows will be reduced and/or eliminated. Similarly, the weir pond (wetland 13202) and the wetland 13203 (located along the West Arm adjacent to the south extension) are currently identified as natural heritage features. These features are dependent on the quarry discharge to maintain their hydroperiod and may dry out under the approved rehabilitation plan.'

Has drying out of features been established with supporting field evidence and analysis. The lack of understanding of the critical flow characteristics of the tributary of Willoughby Creek brings into question the validity of the conclusions regarding the impact from the quarry and quarry discharge on Willoughby Creek.

150) Page 89, 3rd paragraph, Section 6.5, Mitigation.

'Extraction will reduce the drainage area to wetland 13201 northwest of No. 2 Sideroad forming the headwaters of the unnamed tributary of Lake Medad. Reducing the drainage area of the wetland has the potential to adversely impact the wetlands hydroperiod. As such, a mitigation strategy has been developed to supplement the flow into the wetland during operations as required. A bottom draw outlet will be constructed in the southeast corner of the proposed replica pond and an outlet pipe complete with a control valve will be installed to discharge water into the roadside ditch along No. 2 Sideroad feeding the wetland. The wetland hydroperiod will be monitored and water will be discharged to the wetland as required to maintain the wetland hydroperiod.'

What are the threshold levels for the hydroperiod for this wetland?

151) Page 90, Section 6.5, Mitigation.

Mitigation measures are described with respect to meeting thresholds and triggering mitigation for streamflow, stream temperature, wetland hydroperiod, effluent limits, and water quality.

Changes to surface water regime can change rapidly in response to precipitation events. How will the trigger levels be responded to and mitigative measures be implemented? The current monitoring program consists of continuous data logger recordings plus monthly manual flow measurements, quarterly water quality sampling, and weekly field visits to monitor wetland hydroperiods during the seasonal wetland hydroperiod.

Adaptive Management Plan, Proposed Burlington Quarry Extension (AMP) prepared by Earthfx Incorporated, Savanta Inc., Tatham Engineering, (April 2020).

152) Page 4, Section 2.2 West Extension, 3rd paragraph.

'Prior to the surrender of the Aggregate Resources Act licence, the licencee will provide, to the satisfaction of the MNRF, confirmation that any long-term monitoring, pumping, or mitigation will not result in a financial liability to the public.'

Public financial liability. How will this be addressed? There is no discussion of how this will be addressed in this document. This should be demonstrated prior to approval of the licence application.

153) Page7, 3rd paragraph, Section 4.2, Off-Site Domestic Water Wells'

'the domestic water wells, which will be incorporated into the AMP shall

be constructed to comply with Ontario Regulation 903 (as amended).'

Does this mean only private wells meeting this requirement will be included in the AMP and monitoring program?

154) Page 7, Section 4.3 Groundwater Impact Assessment Methodology.2nd paragraph

'The impact assessment has been developed for the initial 5 years of quarry operation'

The above statement appears to contradict the modelling scenarios that were completed. Please clarify.

155) Page 7, Section 4.3 Groundwater impact assessment Methodology, 4th paragraph.

'The predictive-based approach relied upon the simulated water level drawdowns in the bedrock aquifers resulting from both climatic conditions and quarry dewatering. The predicted water levels during drought conditions represent a worst-case scenario that may be encountered during the initial phases of quarry operation (Phase 1 and 2).'

There is no discussion or predictions regarding the potential for water quality impacts.

156) Page 7, Section 4.3.1 Monitoring of Background Groundwater Conditions,1st paragraph.

'background monitoring well is a domestic water well located north of the existing quarry at 2377 Collins Road (referred to as DW2; Figure 2. This background monitoring well has shown to have no drawdown from the proposed quarry extension. '

What is the period of record available for this well? No water level or water quality data was found in the reports for this well. Has this well been impacted by the existing quarry? This well is shown on figure 7 not figure 2.

157) Page 10, 2nd paragraph, Section 4.3.4 Proposed Ground Water Mitigation Measures.

'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.'

No data was provided in the report to substantiate this conclusion.

158) Page 10, 3rd paragraph, Section 4.3.4 Proposed Ground Water Mitigation Measures.

'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.'

Does this also include a permanent supply of water if suitable well cannot be drilled on the property?

159) Page 10. Section 4.4.1 Groundwater monitoring Program, 1st paragraph.

'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 3).'

How will the effects of current climate on groundwater levels be evaluated? Will the proposed background well/monitor at 2377 Collins Road be used as baseline? Groundwater monitoring sentry wells will likely also be influenced by the quarry and the climate. How will quarry effects be distinguished for current climate conditions?

160) Page 15, Section 4.4.2 Groundwater Thresholds, 2nd paragraph.

'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. These threshold levels are set as early warning water level elevations were the cumulative influence of drought conditions and quarry dewatering have lowered the water levels to an early warning threshold, where local private wells (adjacent to or in close proximity to the quarry) may start to notice a decrease in well yield.'

If the 15 day period of simulation represents worst case drought conditions (i.e. 2015/2016 drought conditions) it may be limited as an early warning threshold of quarry impacts under normal climatic conditions.

161) Page 15, Section 4.4.2 Groundwater Thresholds, Table 2 Groundwater Threshold Values

No threshold values are assigned to intermediate level 'B'series monitoring wells or 'C'series shallow wells. This does not take into account potential interference with private wells completed into shallow bedrock zones or overburden.

162) Page 15, Section 4.4.2 Groundwater Thresholds, 2nd last bullet.

'notify the SLC, MECP and MNR in writing; '

What does SLC represent?

163) Page 16, Section 4.5.2 Groundwater monitoring Program, 1st paragraph.

'Groundwater monitoring at several monitoring wells on the West Extension commenced in 2018 and 2019. The monitoring of water levels and water quality shall continue for the duration of this AMP. Data collected will represent background conditions for as long as Phases 3-6 remain undisturbed.'

This assumes that the extraction of phase 1 and 2 will not impact background conditions around the proposed phases 3 to 6. This will represent baseline conditions affected by phase 1 and 2.

164) Page 17, Section 4.5.3 Groundwater Thresholds, 1st paragraph.

'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.'

This suggests that currently there is insufficient groundwater monitoring information to establish threshold levels. As noted in comment 163 above, the additional monitoring will represent a baseline that is affected by the Phase 1 and 2 extraction and not represent an undisturbed condition. How will the additional monitoring data affect the AMP?

165) Page 25, Section 5.3.1, Streamflow and Water Temperature Thresholds

Typographical errors. There are references to Section 6.4. These should be Section 5.4.

166) Page 26, Section 5.3.2 Wetland Hydroperiod Thresholds, 2nd paragraph.

'Its recommended that the wetland hydroperiod thresholds be established from the results of the historic surface water monitoring, existing condition water balance and integrated surface water groundwater model completed in support of the proposed quarry extension. Specifically, dates when the wetlands must remain wet should be established from the monitoring data and water balance and integrated surface water groundwater model results.'

How do we know whether the current hydro-period for the wetlands hasn't been altered from historical operations of the existing quarry and whether this represents appropriate baseline conditions for a quarry impact assessment and for determining a preferred rehabilitation option?

167) Page 28, Section Water Quality Thresholds, 3rd paragraph.

'Downstream of each quarry discharge location (SW2 and SW10), water quality thresholds will be established to identify impacts on the water quality of the surface water features resulting from the quarry discharge. Its recommended that the water quality thresholds be established from the results of the historic water quality sampling completed in support of the proposed quarry extension. Specifically, maximum and minimum concentration limits should be established from the sample results collected while considering the Provincial Water Quality Objectives (PWQO) and role water quality plays in the Natural Heritage Features.'

A portion of the discharge from Sump 100 is currently directed to the golf course irrigation ponds and is proposed to be directed to future infiltration ponds for purposes of recharging the groundwater system and the maintenance of groundwater levels for down gradient private wells. Water quality monitoring for this discharge should be evaluated against Ontario Drinking Water Standards since the infiltrated discharge is expected to ultimately impact drinking water supplies.

Rehabilitation Plan (MHBC,2020)

168) The rehabilitation plan does not explain how the West Extension area will be integrated with the existing quarry to achieve the preferred rehabilitation Scenario 1 (RHB1).

Site Plan (MHBC, 2020)

169) The Site Plan does not describe how the West Extension will be integrated into the existing quarry licence. It appears that the proposed rehabilitation of the proposed quarry extensions is subject to modification of the approved site plan for the existing quarry.

170) The site plan shows a gas line right of way along the south side of Collins Road opposite to proposed West Extension area. The Blasting report refers to this as the 'Sun Canadian High Pressure Oil Pipeline'. A correction should be made to the site plans.

171) Will Phase P12 be rehabilitated fully and filled with water prior to commencement of Phase P34 or will extraction commence in P34 while P12 is filling. Clarification is required on the phasing of extraction as this will impact the groundwater system and may require additional assessment of impacts.

Documents Referred to:

Golder Associates Ltd., 2006: Additional Hydrogeologic Field Studies at the proposed Nelson Quarry Co. Extension, April 2006

Golder Associates Ltd., 2010: Witness Statement, Mr. Sean McFarland, P. Geo., Proposed Nelson Aggregate Co. Quarry Extension, Burlington, Ontario, September 2010.

Ontario Ministry of the Environment 2006: Technical Support Document for Ontario Drinking Water Standards, Objectives and Guidelines, revised June 2006, (PIBS 4449e01).

Supplemental Information Provided by Applicant, Received via email, September 29, 2020

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