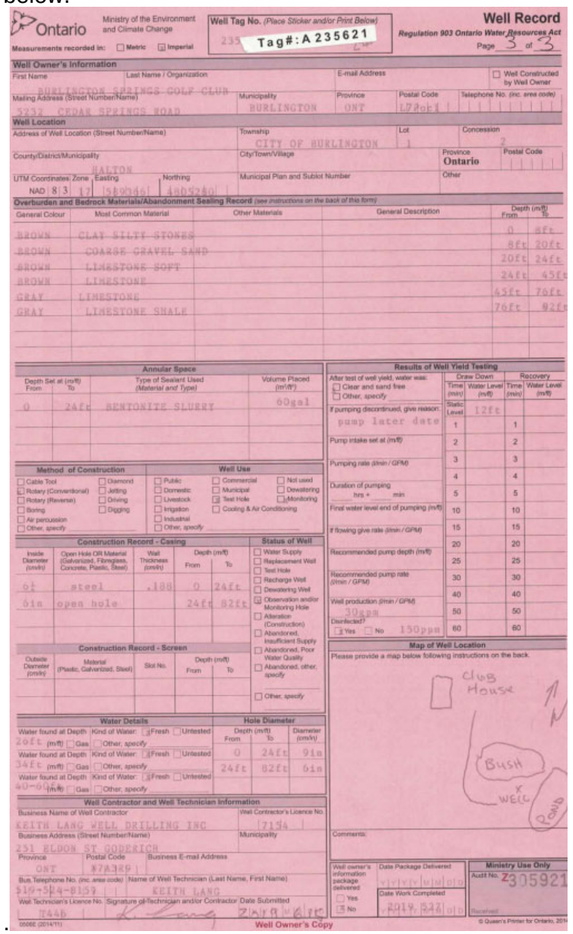
Proposed Burlington Quarry Expansion
JART COMMENT SUMMARY TABLE – Hydrogeology

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

	JART Comments (February 2021)	Reference	Source of Comment	Applicant Response	JART Response
Report/Date: Level 1 and Level 2 Hydrogeological and Hydrological Impact Assessment Report, April 2020				**Author: Earthfx Incorporated (July 2021)**	
1.	All studies should be coordinated and integrated. In particular, the findings of the Hydrogeologic and Hydrologic Impact Assessment, Surface Water Assessment and Level 1 and 2 Natural Environment Technical Report should inform each other and should be reviewed for consistency.	General	Conservation Halton	Agreed. Our integrated modelling approach was meant to help facilitate the exchange of information across disciplines. A package of interdisciplinary tables addressing both wetland and watercourse characterization and impact analysis has been prepared and provided as Schedules B and C.	
2.	The proposed external catchment diversion along Colling Road should be discussed within the Impact Assessment, with modeling updated if necessary. Identify and address any uncertainty associated with completion of these works within the analysis and report.	General	Conservation Halton	The roadside ditch along Colling Rd. currently flows into the quarry at Blind Line. The diversion is to carry ditch further along to discharge to the unnamed tributary to Willoughby Creek. An approval for the diversion will be required. As noted by Tatham, the Colling Road diversion is not central to the management of quarry water. If the diversion is not approved, the surface runoff from north of Colling Road will continue to drain through the quarry as it currently does. Accordingly, we simulated the ditch as it is currently configured in the remedial scenarios.	
3.	The report lacks discussion on the realized impact of the existing extraction operation on groundwater in the area throughout its lifespan. (Part 2.2.1 & 2.9.3 (g)). Discussion on cumulative impacts and the objective of minimizing negative impact on surrounding land uses would benefit from the inclusion of such information.	General	Niagara Escarpment Commission	The report does, in fact, clearly delineate the “cumulative effects” of all existing and proposed excavations in the water level maps and hydrographs presented for each development scenario phase. The results were presented in terms of absolute water levels and streamflows, not just in terms of change, so the cumulative impacts were fully taken into consideration. We also present incremental drawdowns from a fully transient 10-year baseline, and both average and minimum remaining available drawdown in the aquifers. As part of the report, extensive use of observations of change in groundwater levels due to excavation within the quarry footprint was utilized (See Section 6.11.3). This information was extremely useful for the transient calibration and for developing an understanding of the magnitude of the likely future changes due to quarry expansion. This work resulted in a recommendation to revise the rehabilitation plan for the existing quarry to mitigate impacts from the existing approved quarry. As JART is aware the existing approved rehabilitation plan for the Burlington Quarry requires dewatering to stop and the site to naturally flood to a lake with no off-site discharge. As part of the Burlington Quarry Extension application, Nelson has agreed to modify the existing quarry rehabilitation plan to maintain off-site pumping to improve conditions for surrounding lands compared to existing approvals and maximize land area for future after uses. We did not attempt to recreate pre-1950s conditions, as this would have limited relevance to assessing the impact of future expansion, which was the focus of this study. Pre-1950’s data is extremely limited, so attempts to estimate flows and levels at that time would be of little value.	
4.	Review of rehabilitation scenarios should better reflect the requirements of the NEP (2017). Currently there is no concrete evidence that the natural and hydrological features of either expansion sites are being restored or enhanced. • Scenario 1 describes that “the overall hydrogeologic and hydrologic conditions will be similar to the final extraction “phase". Please consider Part 2.9.11 (a) & (b) of the	General	Niagara Escarpment Commission	The rehabilitation objectives and designs are discussed in further detail in the other companion reports (i.e. MHBC 2020). Considerable thought and analysis went into the preparation of the design and it reflected factors including the requirements of the NEP (2017). The integrated modelling rehabilitation analysis indicates that the proposed scenarios will preserve and restore streamflow, groundwater levels, wetland stage, and wetland hydroperiod to conditions similar to those currently observed at the site. The phrase “the overall hydrogeologic and hydrologic conditions will be similar to the final extraction phase” was referring to the groundwater levels and water management features from a modelling context. Considerable site rehabilitation will be done to create and enhance recreational features and enhance natural features on the site.	

	NEP. • Scenario 1 will require perpetual pumping of the site to ensure appropriate water levels. More detail on how this would support other public water management needs should be provided. NEC Staff interpret this to mean supporting existing water management needs, not as a mitigation measure to achieve a proposed after-use. (Part 2.9.11 (j)). • Scenario 2 describes that the whole quarry will be allowed to fill and become a lake. Additionally, groundwater levels will be impacted as will stream segments (key hydrologic features). Please consider 2.9.11 (a) & (b) of the NEP.			Pumping will be required in Scenario RHB1 to manage groundwater inflows into the site, maintain the recreational features and enhanced natural features on site. Discharge from the site will have the added benefit of helping maintain current flows in the tributaries to Willoughby and Mount Nemo Creeks and to sustain the fisheries that have adapted to these long established rates of flow. Future operations will no longer be driven by golf course irrigation needs and can be optimized for ecological and fisheries benefits as there is considerable water storage in the quarry. The proposed infiltration pond in RHB1 is both larger than the current golf course pond system and closer to the Medad Valley and can also be operated in a manner beneficial to the natural features of the valley. Scenario 2 allows the groundwater levels within the excavated areas to recover. This will also allow groundwater levels outside the site to recover. Flows in the tributaries to Willoughby and Mt Nemo Creeks will decrease because of the cessation of pumping, but a new, more natural equilibrium would be restored with increased groundwater discharge to the Medad Valley. Taking into consideration both rehabilitation scenarios, the water resources and natural environment team recommend rehabilitation scenario RHB1.	
5.	Better integration between the findings of Hydrogeological report and the Natural Environment Technical report should be considered. • Hydro report suggests that the effects of a 3.0% loss to the inflow of groundwater to 5 of 22 wetlands is so small that “it cannot be measured in the field”. What type of effects are being measured? How does even a 3.0% loss of groundwater inflow to these key hydrologic features achieve Parts 2.6.3, 2.7.6, 2.9.3 (d & e) of the NEP (2017)?	General	Niagara Escarpment Commission	A package of interdisciplinary tables integrating wetland and watercourse characterization and analysis has been prepared and provided in Schedules B and C. Included in those tables are additional hydrographs illustrating the timing and volume of groundwater seepage change that is predicted to occur. The simulations are consistent with long term observations at Wetland 10 and 3 which demonstrate that nearby quarry excavations have no measurable effects on the perched wetlands (see companion MNRF response and discussion). There are wetlands close to 120 m from the proposed extraction areas. Most of the wetlands are perched and thus receive no groundwater inflow. Lowering the water table in the vicinity of these features will not have an impact on the features. Other wetlands receive groundwater inflows for all or part of the year when the water table rises above the base of the wetland. The amount of groundwater exchanged between the aquifer and the wetland at these times strongly depends on the hydraulic conductivity of the material beneath the wetland. The wetlands in the site vicinity are underlain by Halton Till, which has been found to have generally low hydraulic conductivity, thereby limiting the volumes of water exchanged. Groundwater inflow into these wetlands forms a small part of their water budget, therefore, decreases in these volumes are expected to have limited negative impact on the hydrologic function of the feature, water quantity and quality, natural streams or drainage pattern, and the overall water budget for the watershed.	
6.	The hydrogeological analysis and resulting conclusions rely heavily upon the results of the integrated computer modelling and simulations and does not provide due consideration to conflicting field data. For example, the assumption of the modelling that the local bedrock aquifers behave hydraulically as equivalent porous media when field testing such as pump tests and previously conducted borehole flow testing shows significant variability in hydraulic performance of the under lying bedrock layers. In addition, computer model simulations of groundwater mounding beneath the existing irrigation ponds in the Western Extension area and the proposed recharge ponds within this area are not supported with field data to confirm groundwater mounding and the recharge characteristic of these ponds.	General	Norbert M. Woerns	We recognized that the bedrock in the immediate quarry vicinity (within several hundred of meters) or in the zone of influence of the pump test behaves more like a fractured rock than an EPM. The EPM approach is valid and extremely useful for predicting likely affects beyond the local zone, in this case extending from the quarry boundary to below the Niagara Escarpment. We used an innovative approach to better account for the effects of bedding plane and vertical fractures within the model by adding the extra fracture layers and the enhanced vertical connectivity in places to evoke a more fracture-like response in the quarry vicinity. The field data regarding mounding beneath the irrigation ponds are limited. Reasonable conservative estimates for the hydraulic properties of the accumulated pond sediments were made. The proposed infiltration pond will mostly be excavated to the top of the fractured bedrock and it was assumed that leakage from this feature would be higher than from the existing ponds.	
7.	The hydrogeological analysis has failed to address the	General	Norbert M.	The exiting quarry has been operating for over 70 years without contamination of surface water or	

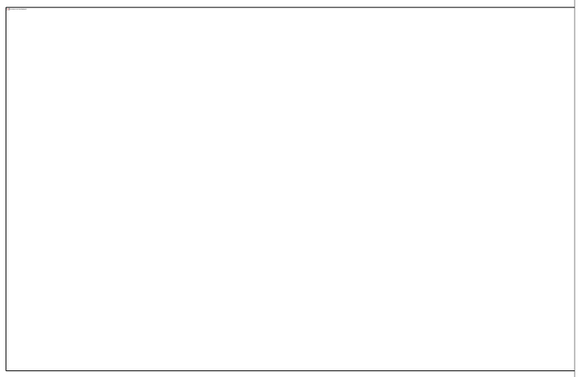
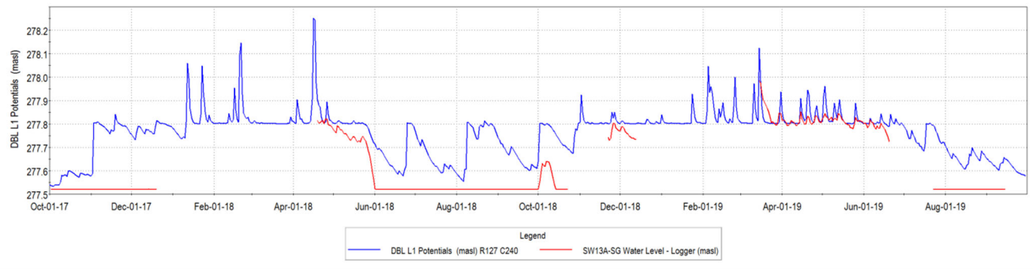
	potential for groundwater and surface water contamination and is therefore incomplete.		Woerns	groundwater resources. Private wells operate immediately adjacent to the existing quarry without impact. Quarry discharge has been used extensively for downstream golf course operation and ecological function. There is no planned change in quarry operations and therefore there are no expected impacts on groundwater and surface water quality. Water quality monitoring is discussed in the AMP, with additional data and discussions in our response to the MECP comments.	
8.	Groundwater quality monitoring is outlined in the AMP report. There is limited documentation of water quality provided in the Earthfx report. Water quality information is provided in Appendix A with a discussion of general water types. There is an incomplete analysis and discussion of ground water quality and the interrelationship of surface water discharge to groundwater quality through infiltration mitigation measures. There is no link between parameters for groundwater quality monitoring and surface water quality monitoring parameters. A discussion is lacking of groundwater water quality results with respect to Ontario Drinking Water Standards (ODWS, 2006), groundwater quality thresholds and mitigation measures. This should be included in the report.	General	Norbert M. Woerns	See response to comment 7. Quarry discharge is currently diverted into the golf course pond system where a portion likely leaks to the groundwater system (or infiltrates as part of the irrigation operations). This discharge has been successfully used to support golf course operations for over 50 years without impact to surface water or ground water quality. The proposed infiltration pond system will function in the same manner as the golf course pond system. Water quality monitoring is discussed in the AMP, with additional data and discussions in our response to the MECP comments.	
9.	The hydrogeological investigations have failed to clarify the issue of overburden hydraulic conductivity and interconnection of the overburden with under lying bedrock. Previous pump test conducted in 2004 by Golder Associates (Golder), (Golder, September 2010) demonstrated apparent hydraulic connectivity between overburden and underlying bedrock underlying wetlands adjacent to previously proposed Nelson Quarry Extension. The pump test completed by Azimuth in the Western Extension lands monitored a nearby surface water level but did not monitor the overburden units during this pump test to determine the degree of hydraulic connectivity between overburden and the underlying bedrock.	General	Norbert M. Woerns	An extensive discussion of the testing, analysis and simulation of the Halton Till is included in our response to the MNRF comments, and provided as Schedules B and C. Included is a detailed presentation of the calibration to shallow minipiezometers. Estimating hydraulic properties of the overburden and the interconnection of the overburden with underlying bedrock was a key component of the model calibration effort. Hydraulic testing (single-well testing) of the units yielded a wide range of possible values with no recognizable pattern (as discussed in our MNRF response). The model calibration focussed on obtaining appropriate mean values for these units. Previous testing by Golder work went through a number of phases, but final conclusions were that the wetlands did not respond to pumping.	
10.	Hydrographs illustrating groundwater level trends are provided in the documentation however there is incomplete documentation of monitoring data including manual water level measurement from previous studies as well as the current investigations. Some of the missing data was subsequently provided in a computer input file format some of which was not readily decipherable.	General	Norbert M. Woerns	A package of interdisciplinary tables integrating wetland and watercourse characterization and analysis has been prepared and provided Schedules B and C. Included in those tables are additional long-term hydrographs. The groundwater level and other monitoring data from this and previous studies were assembled and uploaded into a project database to facilitate analysis and to allow data to be shared across disciplines. We can work output this data in other formats, if needed. The data from previous studies are also available in the scanned Golder reports. No data was “missing” and all was included in the database and used in the analysis. Not all data is insightful or even useful, however, and we feel “padding” the report with low value information only serves to confuse the inexperienced reader and waste the valuable time of the review team. We recommend the industry proven VIEWLOG and Sitefx Integrated modelling and data management systems if you are having difficulty managing the complex data. Virtually all the maps, cross sections, well logs, and hydrographs in the report were prepared in VIEWLOG with full integration between the relational database and transient model.	

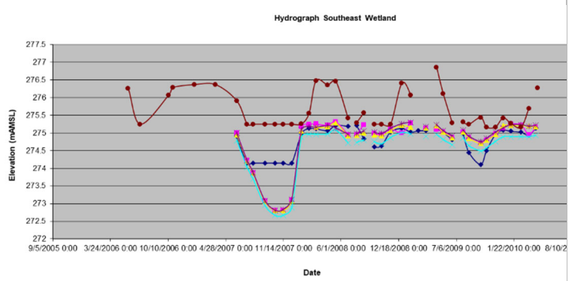
				We would be happy to answer any specific questions about the data.	
11.	Borehole logs are provided in Appendix A which includes some boreholes completed by Golder as well as most borehole logs of holes completed as part of the Azimuth Environmental Consulting Inc. (Azimuth). A number of Golder borehole logs are not included. In addition, borehole logs for shallow groundwater monitors installed by Tatham and the logs for boreholes/wells drilled by Keith Lang on the western extension have also not been included in the documentation. Partial monitor detail information on the previously installed Golder groundwater monitors is provided in Table 9.1, page 311. A complete list of borehole logs and information included in the hydrogeological analysis with monitor completion details including piezometers installed near or in wetland features should be included in the documentation. Some of the requested borehole information was subsequently provided and received September 29, 2020. This information was provided in computer model input file formats and was not readily useful for peer review purposes.	General	Norbert M. Woerns	The borehole data from previous studies were assembled and uploaded into a project database to facilitate analysis and to allow data to be shared across disciplines. If the reviewer needs paper copies of the logs, these can be obtained from the scanned copies of the Golder reports, which can be provided. An extensive package of shallow borehole logs was requested and provided to MNRF. Copies are provided in Schedules B and C. Well records from Keith Lang for the wells installed in the West Expansion area (BS-04, BS-05, BS06, and BS07) are provided as pdf files in Schedule E. The record for the pumping well (BS-06) is shown below. 	
12.	Appendix A describes the completion of a well survey however no results providing details of this well survey are included in the report. This should be provided in the documentation. Copies of 26 well survey forms were provided, September 29, 2020. Of the 156 private properties included in the well survey, it is not clear what information if any, exists on the remaining well survey properties. A summary table of well	General	Norbert M. Woerns	Additional details about the well survey are included in the AMP document (together with a map showing the locations that responded). The AMP also states that a follow-up well survey will be completed at a later date due to again invite well owners to participate. The seven wells to which access was provided in the first survey did not provide significant insight beyond the publicly available well record. Additional documentation could be provided now, however the AMP states that Nelson's website will have a page dedicated to Private Well Monitoring details once the second survey is complete.	

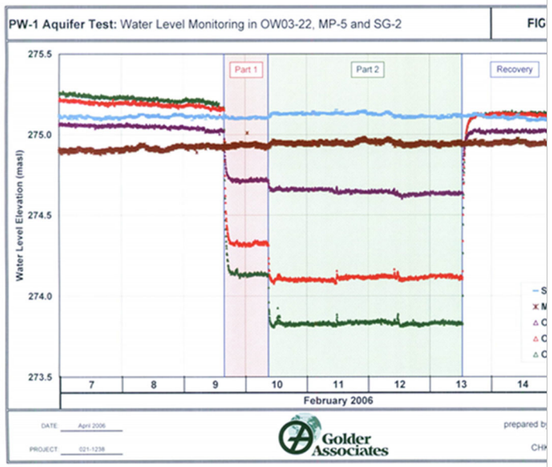
	information from the well survey should be included in the hydrogeological report. The MECP well record data base would be useful in providing information on local private wells.				
13.	The documentation is lacking a detailed and comprehensive analysis of vertical hydraulic gradients associated with wetland features and the implications to the computer modelling analysis and conclusions.	General	Norbert M. Woerns	Long term hydrographs illustrating the monitoring nest gradients are included in the package of interdisciplinary wetland and watercourse characterization tables that have been provided in Schedules B and C. Extensive documentation of the observed stage and minipiezometer data, in comparison to the simulated shallow wetland response, is included in our response to the MNRF comments (Schedules B and C). The results indicate that the model is very closely matching the shallow soil moisture levels that control the vertical gradient to the lower system. The numerous transient hydrographs presented in the Level 2 report indicate that model is replicating the complex seasonal and interannual water level fluctuations in the underlying bedrock. The integrated model explicitly represented the hydrologic and hydrogeologic conditions in 22 wetland areas. The model match to the observed staff gauge, minipiezometer, and well data was examined for each of the instrumented wetlands. Water budgets were formulated for the baseline conditions and compared to those formulated for each quarry extension scenario. We know of no other quarry impact assessment with this level of detail and comprehensive analysis of predicted wetland response.	
14.	The report states that 'A total of 5 of the 22 wetlands mapped in and around the quarry receive groundwater in the spring.' Page 23, 6th paragraph. This implies the remaining wetlands do not receive groundwater in the spring. Tatham Surface Water Report indicates only five of the wetlands appear to have been instrumented with piezometers to confirm this. Confirming shallow groundwater level measurements are missing for the remaining wetlands.	General	Norbert M. Woerns	As noted, our wetland characterization tables and response to MNRF comments (Schedules B, C, and D) provide extensive additional information for each wetland. Earthfx Section 2.2.1 in that document provides details on over 62 minipiezometers, soil core boreholes, and Guelph Permeameter test locations. Table 13 lists twelve of the key wetlands that have one or more minipiezometer, including MNRF Wetland 13033, which has 5 minipiezometers. Simulations allowed us to extend the analysis to other wetlands.	
15.	The report does not discuss cumulative effects i.e., existing impacts vs additional impacts from expansion. The report should include a map showing the existing cone of influence and drawdown resulting from the existing quarry.	General	Norbert M. Woerns	The report does, in fact, clearly delineate the "cumulative effects" of all existing and proposed excavations in the water level maps and hydrographs presented for each development scenario phase. The results were presented in terms of absolute water levels and streamflows, not just in terms of change, so the cumulative impacts were fully taken into consideration. We also present incremental drawdowns from a fully transient 10-year baseline, and both average and minimum remaining available drawdown in the aquifers. As noted above, there is limited value in presenting the incremental drawdown from the pre-quarry 1953 conditions to current conditions because data from prior to 1953 is extremely limited. The purpose and scope of this study was to examine the likely impacts from future expansion and rehabilitation and the existing quarry effects are already approved under the existing license. Finally, our simulations of Rehab Option 2, allowing the quarry to fill as a lake, can provide some insight into the water levels and streamflow patterns under unmanaged conditions.	
16.	The investigations have failed to demonstrate through on-site monitoring that the selected 'background monitoring well at 2377 Collins Road has not been affected by the existing quarry operations.	General	Norbert M. Woerns	As noted in the report, (Section 9.4.2), the purpose of this background monitoring well at 2377 Colling Road is to document the natural variability of the groundwater elevation fluctuations and trends under various future climatic conditions. The well is located on the northwest side of the quarry, well away from the extension area. Modelling analyses showed that this background monitoring well would not likely to be affected by the proposed quarry extension. As noted in the previous comment, the quarry has been in existence since 1953. Changes in water levels may have occurred over the years in response to excavation within the quarry footprint and changes in water management operations.	
17.	The hydrogeological analysis is based upon the	General	Norbert M.	It is correct that the current conditions represent baseline conditions. Predictions of absolute water levels	

	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.		Woerns	and streamflows as well as changes in streamflow and groundwater levels (drawdowns) through the Scenario analyses were compared to current baseline conditions. (See response 15 for more discussion)	
18.	With respect to Rehabilitation Scenario 1 (RHB1), how does the retained consultant know that the infiltration pond for the western extension will provide adequate supplies of water (i.e., quantity and quality) to the deep bedrock (model layers 6 &8) and not short circuit groundwater infiltration to the shallow bedrock (model layers 4&5) and the local overburden sand deposits into which the infiltration pond is to be constructed. This does not appear to have been considered or accounted for in the computer model. There is also no analysis of implications of the proposed infiltration pond to water quality of the downgradient wells. This should be included in the report.	General	Norbert M. Woerns	The purpose of the infiltration pond is to replace the golf course ponds that contribute to groundwater recharge in the area. The new infiltration pond will be constructed in good hydraulic contact with the bedrock surface and almost certainly will provide higher leakage than the golf course ponds that have over 50 years of accumulated sediments. The infiltration ponds were fully represented in the model scenarios, and simulate all surface water and groundwater flow paths through all layers (including interflow in the soil zone, seepage, and runoff). This full representation of surface water and groundwater flow is fundamental to an integrated model such as GSFLOW, so it was fully accounted for in the model. (Leakage and recirculation of a portion of the infiltrated water back through the excavation is fully represented in the model.) Water quality is discussed in Response 7 and 8.	
19.	Rehabilitation Scenario 1 (RHB1); There is no discussion of seepage into the main quarry area from the rehabilitated lake in Phase 1/2 and long term potential affects on stability of the intervening area and on No. 2 Sideroad. This should be addressed.	General	Norbert M. Woerns	The restored elevations in the P12 pond are generally (1-3 m) lower than the baseline groundwater levels. Seepage into the quarry area would therefore be less than under current conditions. Seepage is fully represented in the integrated model. The northern portion of P12 is “benched” to create a step-down profile so that a beach and gradual entrance to the deeper water will occur. Similarly, rehabilitation sediments have already been placed along the south face of the existing quarry (across the road from P12). The benching and rehabilitation has created a gradational profile and support for the south wall.	
20.	The statistical methods for establishing groundwater level trends and thresholds appear to rely solely on simulated groundwater levels calibrated against water level data with significant data gaps and simulated climatic conditions. It is not clear that simulated climatic conditions will accurately reflect current climatic data. Threshold levels have only been assigned to deep monitoring wells completed into the lower Amabel Formation. This does not recognize local wells that are completed into shallow zones and their sensitivity to drawdown affects from the proposed quarry expansion. Threshold levels for shallow and intermediate depth wells should be included in the report.	General	Norbert M. Woerns	The question is not clear but we suspect that this refers to AMP thresholds. Please refer to the companion AMP discussions in the MECP response to comments (attached as Schedule A). Input to the model consisted of 10 years of climate data that reflect current climate conditions including drought years. The model was calibrated to match the available groundwater observations, groundwater response to quarry development, streamflow data, and soil zone response. It is expected that the range in response predicted by the model should be close to what is likely to occur under a variety of climatic conditions within the range of those observed between 2004 and 2019. It was recognized that shallow wells will be more sensitive to drawdown effects from the quarry expansion. It is expected that these wells may need to be deepened if they are impacted under drought conditions. A number of maps showing the available drawdown were included to demonstrate that shallow wells could be deepened.	
21.	POSTULATE: The Halton Till does not have a uniform K; is not an aquitard; and has not been appropriately characterized with regard to wetland hydrology and model layer input.	General	Daryl W. Cowell & Associates Inc.	The unweathered Halton Till has a low primary hydraulic conductivity and acts as a regional aquitard. The till is likely to have some vertical fracturing that fully penetrates the unit’s thickness. These fractures are sparse and randomly distributed, so their locations are unknowable. We used a conservative estimate of the hydraulic conductivity of the Halton Till based on geometric means of the available testing data. (Conservative in this sense means that we allowed for more interaction with wetlands and streams than if we had assumed a lower value for the hydraulic conductivity)	
22.	The determination of matrix permeability (primary permeability) in tills is a grossly misleading	General	Daryl W. Cowell &	It was assumed that the upper part of the till was weathered and densely fractured and likely has higher hydraulic conductivity than the unweathered, less fractured portion. See previous response regarding the	

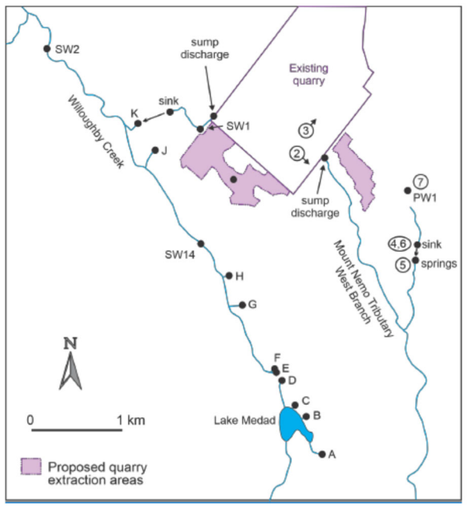
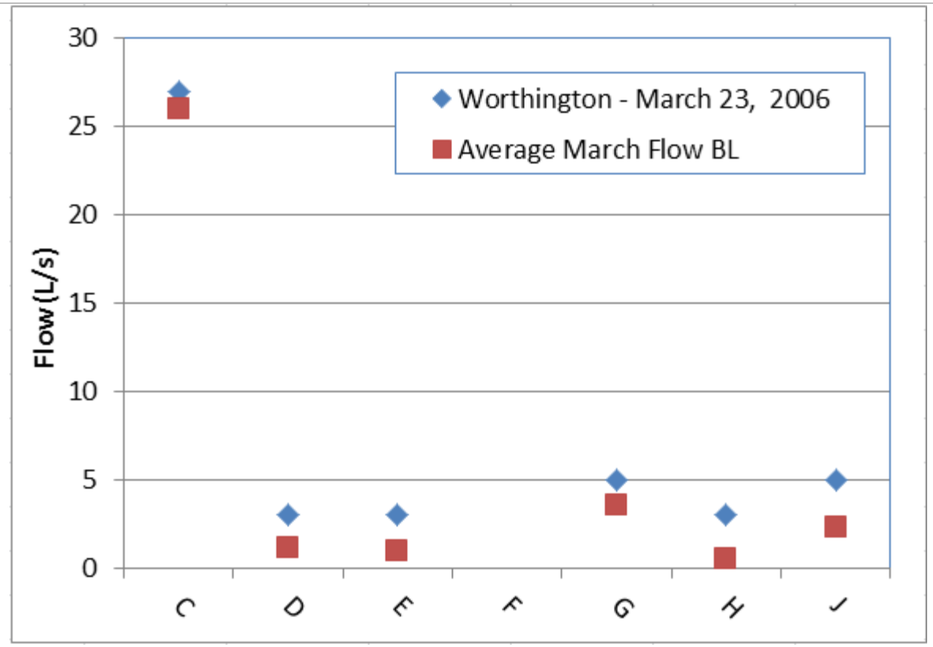
	determination of the potential for surface water to infiltrate to (in this case) the underlying bedrock. Tills are well known to have fractures, especially finer-grained materials, which create a secondary permeability that can be orders of magnitude higher that the primary permeability. Secondary permeability is achieved through drying-out and contraction over time (especially in fine grained tills); fracturing due to glacial isostatic flexing; soil pipes created by the downward suffosion of material into underlying bedrock (especially where karst is present); root channels; and animal burrowing.		Associates Inc.	unweathered till.	
23.	Till fracturing has been well documented. Freed (1993) for example, notes that: "Recent studies show (a) fractures in tills can greatly alter…hydraulic conductivity and storativity by allowing more fluids to move through the till…(b) fractures can alter the bulk permeability over the matrix permeability by several orders of magnitude…(c) isolation of surface contaminants from aquifers may not be possible due to fractures in the underlying unweathered till… and (d) fractures increase the median in-situ hydraulic conductivity by three orders of magnitude…"	General	Daryl W. Cowell & Associates Inc.	Freed (1993) was quoting a study by Keller (et al.) of low permeability clay tills in Saskatchewan. These tills had laboratory K's of 10^{-11} m/s and bulk values closer to $10^{-9.}$ The Halton Till in the study area is much thinner and is likely to be slightly more fractured at depth (the calibrated model has a bulk K of 10^{-7} m/s. The assumed value is more conservative in that it allows for a greater connection between the overburden and bedrock.	
24.	The movement of a contaminant through deep silty clay materials into underlying karstic bedrock was clearly demonstrated during studies into the Smithville Ontario PCB 'spill' during the latter part of the last century (Worthington and Ford 1998). Although not a till per se, the deposit is a 9.0 – 12.0 metre silty clay glaciolacustine deposit which, based on personal observations, may in fact be a reworked till. Worthington and Ford (1998), based on electrical conductivity measurements, indicated a double permeability with the presence of "…wide-aperture pathways through the overburden. These pathways currently allow low-EC precipitation to rapidly flow through the overburden…the open fractures would have allowed prompt contamination of the bedrock very shortly after wastes started to leak from their containers."	General	Daryl W. Cowell & Associates Inc.	Each area is different and glaciolacustrine clays are not clay-silt tills. Again, the model uses a relatively conservative value, much higher than those likely used in Smithville for competent glaciolacustrine clays.	
25.	The hydrographic data provided for the study area, originally by Golder (Golder Associates Ltd. data files, 2010), and subsequently in the current investigation's Level 1 and 2 Hydrogeological Assessment report do not support the hypothesis that the Halton Till is a single, continuous tight layer or aquitard.	General	Daryl W. Cowell & Associates Inc.	See above. No specific logs are referred to. The Golder lab and slug tests showed a wide range in values as they sampled weathered and unweathered portions of the till.	
26.	A wetland (or pond) underlain by material having a very low permeability should demonstrate a very gradually lowering water level over the course of the hydroperiod assuming the level is not directly supported by underlying aquifer(s). For example, as the till aquifer level declines following snowmelt and	General	Daryl W. Cowell & Associates Inc.	Yes. There would be leakage over time through the low permeability sediments. This is seen in the Golder staff gauges and minipiezometers as a general recession in water levels from the late spring to fall. The behaviour is complicated by response to rainfall events that continue to occur over this period that convey overland runoff and, in many cases, streamflow. The late winter/early spring rise and late spring/early fall recession is also typical of every aquifer in the study area.	

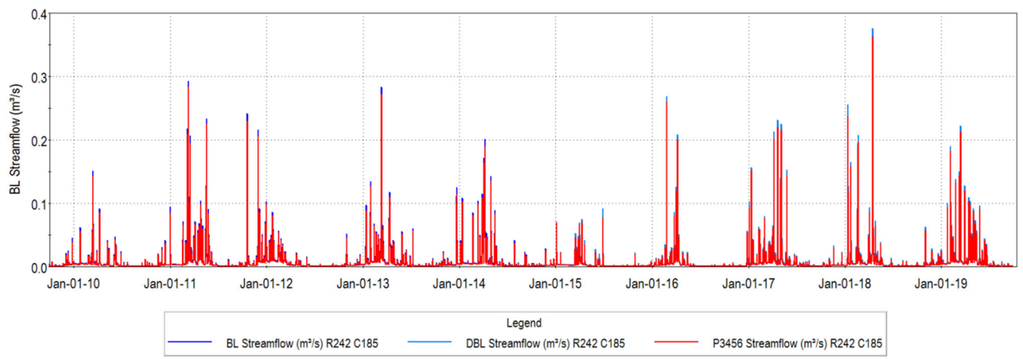
	spring precipitation, then the surface water level in the wetland should decrease very gradually over the course of the hydrological period potentially being recharged by rainfall but otherwise demonstrating a gradual but continuous decline.				
27.	This behaviour was, in fact simulated for Wetland 13032 (Figure 1). Following snowmelt and early precipitation from late March through early April, the water level gradually declines, responding only to rainfall events (as shown by each of the slight upticks) through the season reaching annual lows in late July/early August.  Figure 1. Simulated water level showing a spring recession pattern typical of wetlands underlain by low permeability materials (Figure 6.35 for Wetland 13032 in the Level 1 and 2 Hydrogeological Assessment). In this simulation, lowest wetland water levels are not achieved until August – September.	General	Daryl W. Cowell & Associates Inc.	Yes, the integrated model was capable of simulating the seasonal response of wetland stage. This is the main reason we went through the effort of building a very complex, transient, integrated model of the site vicinity.	
28.	However, this pattern is not demonstrated in all wetlands located on the site. Table 42 (page 86) in the Surface Water Assessment report indicates that levels in at least four wetlands (SW11/13027; SW12/13022; SW13/13016) and SW16/13201) all reach “0” (based on 0.0 metre reading on staff gauge) prior to late May on the 20-year monitoring and most prior to the first week of May. These indicate a pattern of snowmelt/spring precipitation fed systems immediately drying out by relatively rapid infiltration through the underlying till unlike the pattern demonstrated in Figure 1.	General	Daryl W. Cowell & Associates Inc.	Some tills underlying the wetlands are thinner than others. A few are affected by seasonally high water tables. We, and other reviewers, noticed some longer lags in the fall recovery in the model while the staff gauge response shows a rapid recovery once ET processes shut down. We believe that the wetlands were likely assigned too much soil zone storage so we are not exactly mimicking the quick filling of soil zone storage and rapid increase in stage. The same problem would tend to slow the simulated recessions in the late spring. The staff gauges show very steep recession once ET processes get under way with a quick drop in stage. 	
29.	Figure 2 indicates that surface waters in the wetland	General	Daryl W.	Correlation is not necessarily causation but in this case, the driving mechanisms for the recession in	

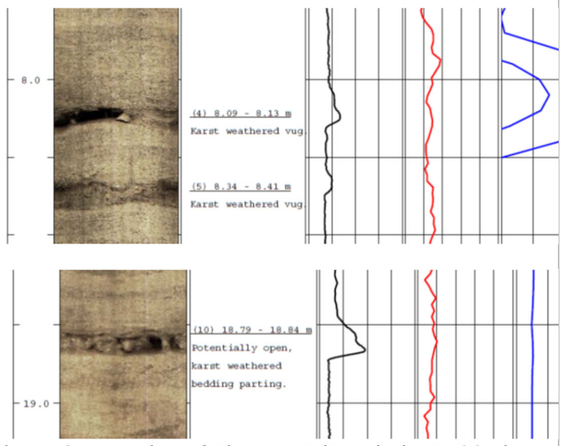
	are in fact directly connected to the underlying bedrock aquifer as shown by the precise correlation between the levels in MP-5 and all underlying wells. This behaviour is particularly well marked during the late Spring to early Winter period of 2007. The data are monthly, hence could mask some delay in response, however, such a direct correlation in levels as shown, even over monthly intervals indicate the presence of a direct hydraulic connection with the bedrock aquifer (compare to Figure 2 to Figure 1).  Figure 2. Manual water level hydrograph of MP-5, SG-4, OW3-22B as well as at three adjacent wells (OW03-24B, 27B, and MW03-04B). The “Southeast Wetland” of Golder Associates Ltd. (2006) is equivalent to Wetland 17/13033 in the Earthfx (2020) report (Figure 19-50).		Cowell & Associates Inc.	groundwater levels and in the wetlands have similar timing. The recession of regional groundwater levels, as recorded by all wells in the study area, is typically due to high ET rates in the late spring and early summer remove water from the soil zone that potentially could have provided recharge to groundwater. The groundwater system continues to lose water through discharge to streams. High ET rates in the early spring and summer also remove water from the wetlands and reduce the volume of water stored in the wetland.	
30.	Figure 3 shows the results of a 6-day pumping test in bedrock wells located near MP-5 and SG-2 during February 2006. The lack of any evident response in the mini-piezometer and staff guage (brown and blue lines, respectively) was provided as proof of the aquitard characteristic of the Halton Till. However the next year – 2007 – was a drought year and the full year hydrograph for the wells, mini-piezometer and staff guage demonstrate a direct connection (Figure 2). It is clear that a 6-day pumping test is not long enough to determine connectivity.	General	Daryl W. Cowell & Associates Inc.	No. The pumping test was a direct local stress on the aquifer. The system responded and reached equilibrium in an extremely short time with no indication of a significant impact on the wetland. Prolonging a test after equilibrium is reached makes no hydrologic sense. That both the shallow system and bedrock respond to seasonal change indicates that, on a regional scale, sparsely-spaced deep vertical fractures provide a higher degree of connectivity than would occur through an unfractured till. As in the bedrock, the occurrence of these vertical fractures is random and not mappable. A 30-day pump test would not provide any additional information in this regard.	

	 Figure 3: Aquifer pumping test results showing water levels in bedrock wells (OW03), the wetland surface (MP-5), and a staff gauge (SG-2) in the southeast wetland during February 2006 (Golder Associates Ltd. 2006).				
31.	Recommendation: • A 30-day pumping test should be conducted in at least 2 wetlands (e.g., 17/13033) to determine degree of connectivity between wetlands and the underlying aquifer.	General	Daryl W. Cowell & Associates Inc.	See previous response	
32.	Recommendation: • Wetland hydroperiods will be impacted during quarrying and prior to excavation lake filling (and potentially after filling depending on final levels). These impacts need to be assessed and potential mitigation measures should be developed.	General	Daryl W. Cowell & Associates Inc.	The modelling and additional hydrologic assessments specifically assessed the likely changes to the perched wetlands.	
33.	Recommendation: • The Halton Till layer in the hydrogeological model requires better hydraulic conductivity definition (absolute K values and spatial distribution).	General	Daryl W. Cowell & Associates Inc.	Noted	
34.	POSTULATE: Groundwater flows to the Medad Valley have not been adequately characterized; these flows involve flow through discrete karst conduits (not EPM); and impacts to the valley and its wetlands have not been adequately defined.	General	Daryl W. Cowell & Associates Inc.	Karst surveys (Worthington, 2006, 2020) were conducted and identified springs, “disappearing” and re-emerging streams, and other karst features. Where data were available, these were simulated explicitly in the integrated model, including a stream reach on the east arm of the West Branch of Mt. Nemo Creek and on the unnamed tributary to Willoughby Creek, and the springs emerging in the Medad Valley. Otherwise, we believe the network of multiple short fractures and zones of moderately fractured bedrock behave as an EPM.	
35.	The Medad Valley is a Provincially Significant Wetland (PSW) and lies within the Niagara Escarpment Planning Area. It is also designated as a Provincially Significant Earth and Life Science ANSI. The wetland complex within the valley is formally identified by	General	Daryl W. Cowell & Associates Inc.	Comment noted.	

	MNRF as the “Medad Valley Wetland Complex”. The proposed west extension is currently zoned as “Escarpment Rural Area” and the valley itself is predominantly “Escarpment Natural Area” surrounded by “Escarpment Protection Area”.				
36.	PSW’s are designated as significant natural heritage features under the Provincial Policy Statement which, as defined in the Natural Heritage Reference Manual, specifies no development within a PSW and a full impact assessment is required where developments are proposed within 120.0 metres of the PSW boundary.	General	Daryl W. Cowell & Associates Inc.	Comment noted. We extended our analysis to and beyond the Medad Valley despite it being more than 120 m from the quarry.	
37.	Ontario Regulation 162/06 (HRCA under the *CA Act*) also prevents developments within wetlands that “could interfere with the hydrologic function of a wetland, including areas up to 120.0 meters of all provincially significant wetlands…”	General	Daryl W. Cowell & Associates Inc.	See previous response	
38.	The Niagara Escarpment Commission Plan also requires a natural heritage evaluation in cases where a development is proposed within 120.0 metres of any key natural heritage feature or key hydrologic feature (Policy 2.7.6) and the evaluation should demonstrate that “the connectivity between key natural heritage features and key hydrologic features located within 240.0 meters of each other will be maintained…” (Policy 2.7.6d).	General	Daryl W. Cowell & Associates Inc.	See previous response	
39.	Although the Natural Environment Report (Savanta Inc. 2020) and Surface Water Assessment Report (Tatham Engineering 2020) provide some description of form and function of the Medad Valley Wetland Complex, wetland impact assessment is principally associated with fish habitat in creeks within the valley. There is no discussion of wetland water balance and potential impacts on hydrological (other than valley stream flows) and hydrogeological function nor impacts to flora and fauna (other than fish) due to the proposed quarry extension. Wetland water balances are provided for many wetlands but not for the Medad Valley Wetland Complex (Earthfx ID #24).	General	Daryl W. Cowell & Associates Inc.	See previous response Our analysis was primarily focussed on likely changes to streamflow which includes discharge from karst springs. Access to the Medad Valley was limited and specific information needed for more detailed modelling was also limited.	
40.	The discharges are not masked as indicated in the Level 1 and 2 Hydrogeological Assessment and have been mapped by Worthington (2006, 2020) as discrete features.	General	Daryl W. Cowell & Associates Inc.	There is likely unmapped diffuse discharge occurring along the flanks of the Medad Valley wall and upwelling in the valley floor as well as the mapped discrete discharge points	
41.	Worthington (2006 and 2020) documented the presence and location of 10 springs in the Medad Valley. He provided one-time flow estimates (March 23, 2006) that ranged between 3.0 and 32.0 litres/second at the time of observation. Springs G, H, J, and K are all within about 1.0 kilometre of the western extension and spring J is within about 500.0 metres (see Worthington Figure 1a below). These four springs have a combined flow estimated at 45.0 litres/second.	General	Daryl W. Cowell & Associates Inc.	Below is a graph comparing Worthington flows against the average March flow predicted by the model under baseline conditions. The pattern in the simulated water levels appear reasonable (e.g., high simulated values match high observed values) but are consistently lower. Spring flows vary on a daily basis. It should be noted that 2006 had higher annual precipitation than any successive year. There were 47.1 mm of rain in March 2006 (30-year average for March = 43.3) prior to the Worthington measurements and January and February precipitation values were well above the monthly averages (79.1 vs. 56.8 for January and 84.1 versus 57.2 for February, respectively) so it is not unexpected that the Worthington instantaneous measurements are higher than average simulated March flows.	

	 **Figure 1a. Location of springs A to K, sinking streams near the quarry, and locations of the photos (circled numbers) shown in Figures 2 to 7.**			 It should be noted that the Worthington measurements were not used as calibration targets. This post-analysis verifies that the calibrated model captured key features of the hydrologic and hydrogeologic conditions in the study area.	
42.	All springs are located at or near the base of the carbonate aquifer (Goat Island/Gasport), either at the top of the Cabot Head or more likely, at the interface of the Irondequoit – Rockway formations (F. Brunton, Ontario Geological Survey, field trip notes, September 2008).	General	Daryl W. Cowell & Associates Inc.	Comment noted.	
43.	In either case, they lie near the base of the valley wall. Spring elevations are not documented but are likely at about 250.0 metres amsl based on visible contour flattening (see Site Plan, Page 2) which is very close to the final quarry floor at 252.5 metres. The springs are approximately 20.0 metres below the top of bedrock at the northwest corner of the western extension but will be only a couple of meters below the proposed quarry floor.	General	Daryl W. Cowell & Associates Inc.	Comment noted.	
44.	The northwest corner of the western extension quarry is within 200.0 metres of the base of the Medad Valley wall, thus yielding a pre-development hydraulic gradient in the order of 1:10 and post-development gradient of 1:80; an approximately eight times shallowing of the groundwater surface. Spring J would have a pre-development hydraulic gradient in the order of 1:25 and spring K about 1:50: both well above the post-development condition.	General	Daryl W. Cowell & Associates Inc.	It is over 200 m but close. Based on Layer 8 potentials for baseline, the gradient to Spring J is 0.01 not 1:25. Under P3456 it increases to 0.03. However, it is unclear what the relevance of these calculations is. We note that streamflow is slightly reduced on average at Spring J, from 1.5 L/s under baseline to 0.6 L/s under P3456. Spring K flows are a function of the quarry discharge and increase slightly from 47 to 49 L/s.	
45.	The potentiometric surface is not discussed nor	General	Daryl W.	Yes. Changes in streamflow in the Medad (Willoughby Creek) are discussed in the report.	

	portrayed in the Level 1 and 2 Hydrogeological Assessment report however Figure 6-37 provides isolines of the March average simulated groundwater heads. These suggest a groundwater divide at between 265.0 and 270.0 metres amsl which lies directly within the proposed extension. The figure does not show a detailed potentiometric surface but the steep hydraulic gradients toward the escarpment face, in combination with an approximately 20.0 metre lowering of the plateau surface within the western extension will, without question, lower the divide and, by definition, reduce groundwater flows toward the Medad Valley Wetland Complex.		Cowell & Associates Inc.		
46.	Worthington (2006) estimates that spring C (27.0 litres/second) has a groundwater basin of 1 to 5.0 square kilometres (Page 5). He also notes that this spring is located 2.4 kilometres "from the closest point of the [southern] extension lands, and…it seems possible that this spring may drain part of the [southern] extension lands." The currently proposed southern extension, although smaller in area than that proposed in 2004, remains within about 2.4 kilometres of spring C.	General	Daryl W. Cowell & Associates Inc.	Comment noted. There are slight changes in average Spring C flow between the baseline and P3456. The changes are mostly related peak event flows while base flow shown insignificant differences.  	
47.	Although Worthington was relying on the former Golder model to make these area determinations, that model is also an EPM-based model and neither the Golder Model nor the Earthfx Model account for flow along fractures (secondary permeability) or karst conduits (tertiary permeability). Secondary and/or tertiary permeability pathways in simple sinkhole to spring systems along the escarpment in southern Ontario, can be much longer that 1.0 kilometre and, in the retained consultant's experience working on the Niagara Escarpment, distances from source to spring in the order of 2.0 kilometres is not uncommon. Worthington (2020) notes that given the high "bulk hydraulic conductivity of the aquifer (~10^{-}5 to 10^{-}4 m/s)…almost all the flow is through the fracture network."	General	Daryl W. Cowell & Associates Inc.	See Earthfx Response 34. **Worthington Response** The abbreviation EPM stands for Equivalent Porous Medium, and uses for the concept that aquifers may behave as porous media at a large enough scale. EPM models do not simulate flow through all the millions of individual fractures through which water flows in the aquifer, which would not be practicable and has never been done at the scale of the Earthfx modelling. However, the model does simulate flow through the fractures collectively rather than individually.	
48.	Worthington (2006) mapped and traced karst conduit systems to the south (West Tributary) and north (Willoughby Creek – spring K). The latter indicates that karst conduits directly feeding the Medad Valley springs are, in fact, present. He did not observe sinkholes within the western extension area (Worthington 2020), however, his Figure A7 (partially reproduced below) indicates the presence of "Karst"	General	Daryl W. Cowell & Associates Inc.	Comment noted. Spring K was modelled explicitly. **Worthington Response** The several lines evidence on flow in the aquifer presented in the 2006 and 2020 reports consistently shows that most flow in the dolostone aquifer is through solutionally-enlarged fractures. Such flow is common and is expected to occur in dolostone and limestone aquifers. Some of that evidence is listed in Cowell's comments (Peer Review Comments: Proposed Burlington Quarry Extension) , including:	

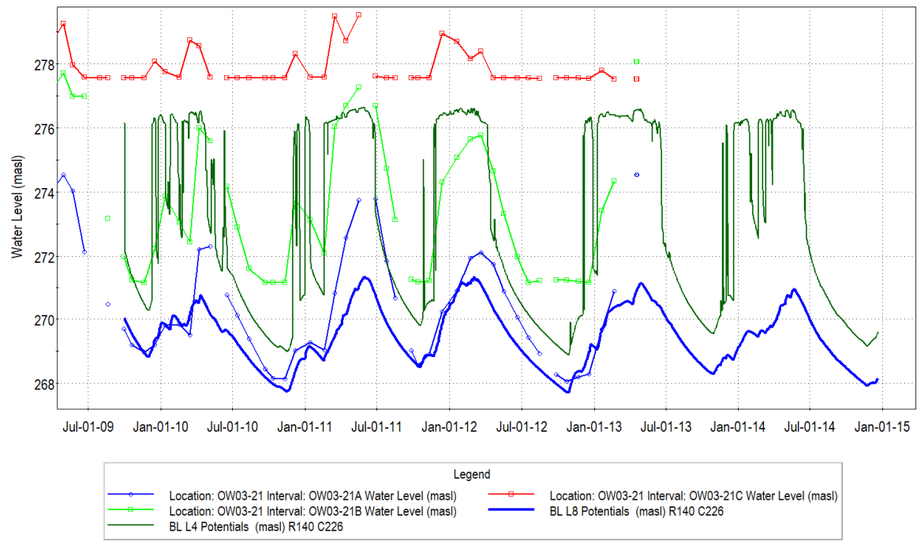
	weathered vugs along bedding planes in borehole BH06-1. These are found at 8.09 metres, 8.34 metres and 18.79 metres below ground surface adjacent to the southern extension area.  Figure 2. A portion of Figure A7 (Borehole BH06-1) from Worthington (2020).			*32. Worthington (2006) mapped and traced karst conduit systems to the south (West Tributary) and north (Willoughby Creek – spring K). The latter indicates that karst conduits directly feeding the Medad Valley springs are, in fact, present. He did not observe sinkholes within the western extension area (Worthington 2020); however, his Figure A7 (partially reproduced below) indicates the presence of "Karst" weathered vugs along bedding planes in borehole BH06-1. These are found at 8.09 m, 8.34 m, and 18.79 m below ground surface adjacent to the southern extension area.* *33. The uppermost vug is particularly interesting being up 4 cm wide and open. It also shows a significantly higher specific conductivity (blue vertical line) than the remainder of the core indicating the presence of carbonate-rich water.* *34. Borehole BH06-1 is located northeast of the proposed southern extension. The continuity and extension of these "vugs" are not fully known but at least the uppermost vug provides indications of water transmission which suggests some continuity. This is confirmed by the flowmeter results from wells OW-03-30 and OW-03-31 (Worthington Figures A8 and A9) which show strong flows in the 7 to 8 mbgs depth.* *35. The final quarry floor in the western extension will be at an elevation of 252.5 m amsl which is well below the elevations of all three of the "karst-weathered" bedding planes.* *36. The Level 1 and 2 Hydrogeological Assessment also documented open fractures in boreholes located within the western extension. This included references to the presence of "moderately open" fractures in the composite video log (Appendix A, Figure 4.2.3) and several of the borehole logs were annotated as "heavily fractured" (BS01), and "larger fractures" (BS02).*	
49.	The uppermost vug is particularly interesting being up 4.0 centimetres wide and open. It also shows a significantly higher specific conductivity (blue vertical line) than the remainder of the core indicating the presence of carbonate-rich water.	General	Daryl W. Cowell & Associates Inc.	Comment noted.	
50.	Borehole BH06-1 is located northeast of the proposed southern extension. The continuity and extension of these "vugs" are not fully known but at least the uppermost vug provides indications of water transmission which suggests some continuity. This is confirmed by the flowmeter results from wells OW-03-30 and OW-03-31 (Worthington Figures A8 and A9) which show strong flows in the 7.0 to 8.0 mbgs depth.	General	Daryl W. Cowell & Associates Inc.	The model simulated upper, middle, and lower zones of enhanced permeability to represent the presence of these solution enhanced fractures within the EPM model.	
51.	The final quarry floor in the western extension will be at an elevation of 252.5 metres amsl which is well below the elevations of all three of the "karst-weathered" bedding planes.	General	Daryl W. Cowell & Associates Inc.	Comment noted.	
52.	The Site Plan and AMP note that an "infiltration pond" will be constructed immediately west of the quarry face in the western extension. The specific role and character of this pond is not detailed in the supporting documentation but appears to serve a dual purpose of water supply for continuing sump operations and providing some form of groundwater mounding. Again, this is not quantified but the infiltration will likely be mostly directed toward the open quarry floor (which is continually drained) and will not provide any significant flow toward the escarpment face in the Medad Valley.	General	Daryl W. Cowell & Associates Inc.	The pond will create a groundwater mound with some of the infiltration returning to the quarry to be recirculated and some flowing towards the Medad.	

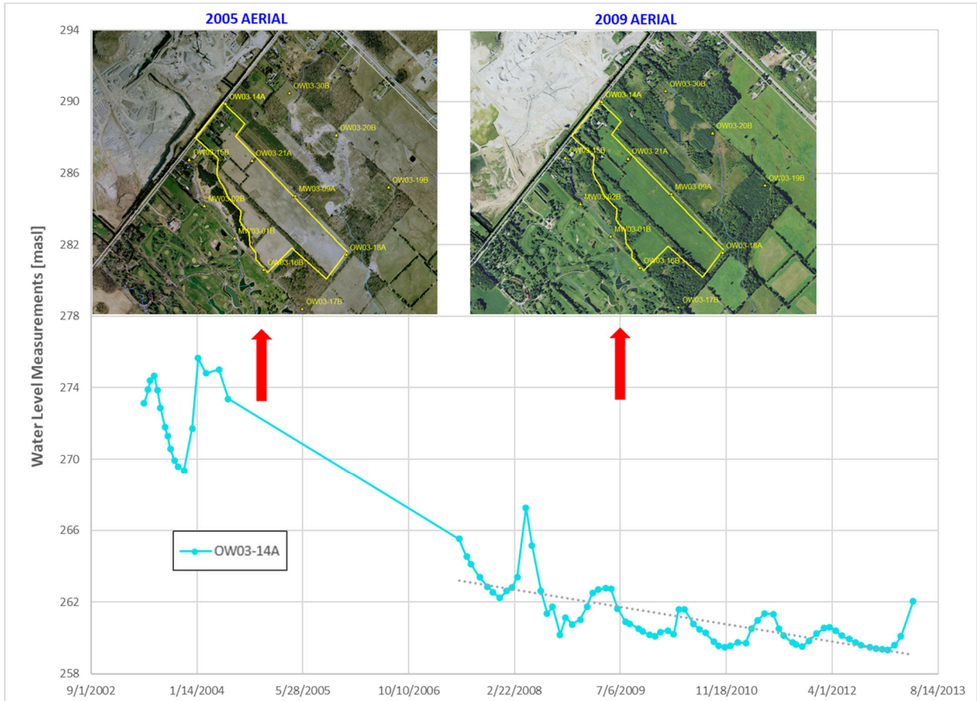
53.	These statements are based on simulated model stream flows for “baseline” (current) and post-quarrying that show net average reductions of about 2.0 litres/second in flow downstream of SW07 (Willoughby Creek below spring J) resulting in “no significant change downstream at SW1.”	General	Daryl W. Cowell & Associates Inc.	Comment noted.	
54.	[Note: SW1 is the main quarry discharge station which is located above the Medad Valley; it is likely that this is an error as the station below SW07 is SW02 located at Bronte Creek. Worthington (2006) appears to have made the same error in Table 1 although this is corrected in his 2020 karst report.]	General	Daryl W. Cowell & Associates Inc.	The naming differs between Worthington 2006 and Tatham.	
55.	These statements are based on simulations from an EPM model that can’t model flow in individual fractures, particularly if enhanced by karst solution (tertiary permeability). The presence of karst conduits is known to occur based on the presence of the sink to spring system in the Willoughby Creek headwater (spring K).	General	Daryl W. Cowell & Associates Inc.	See Response 34. **Worthington Response** Agreed. EPM models do not simulate flow in individual fractures, of which there are millions in the area modelled, but that is not a drawback of the model, which is well suited for modelling flow in the aquifer under natural conditions and the changes in response to quarrying. It is not intended to model flow in the aquifer at a very local area (e.g. metres to tens of metres).	
56.	Recommendation: • Continuous spring flow monitoring should be undertaken for (at least) Medad Valley springs C, G, H, J and K commencing at least 2 years prior to quarrying in the western extension and throughout the period of rehabilitation.	General	Daryl W. Cowell & Associates Inc.	Comment noted.	
57.	Recommendation: • Monitoring should include flow, temperature, conductivity and suspended solids, at a minimum, and be added to the AMP with designated targets and contingency triggers and response.	General	Daryl W. Cowell & Associates Inc.	Comment noted.	
58.	Recommendation: • A detailed potentiometric surface should be provided.	General	Daryl W. Cowell & Associates Inc.	One was provided	
59.	Recommendation: • Dye trace(s) should be conducted between boreholes in the western extension and the same springs noted above in recommendation #1.	General	Daryl W. Cowell & Associates Inc.	**Worthington Response** Mr. Cowell does not explain the rationale for tracer testing between the western extension and springs in Medad Valley. Tracer tests (sometimes called dye tests because dyes are often the tracer used) are useful for (i) delineating flow paths such as checking which spring(s) are connected to a sinking stream, and (ii) for characterizing aquifer characteristics such as fracture apertures, spacing, and connectivity. Both types of test were carried out at the site and documented in the 2006 karst report. For the karst investigation documented in the 2020 report, it was decided to assess preferential flow in wells using a flowmeter and to profile electrical conductivity and temperature during a pumping test. It was decided that there was no need to do further tracer tests. Contour maps of measured and simulated water levels in wells (e.g. Figures 5.13, 5.14, 6.37, 6.38, and 7.2 in the April 2020 Earthfx report) all show that groundwater flow from the quarry area is towards the Medad valley, so tracer testing is not needed to understand the groundwater flow direction. The second reason for tracer testing would be to characterize fractures apertures, spacing, and connectivity. There has been substantial assessment of	

				fractures in the aquifer in the 2006 and 2020 karst reports. A number of methods were used, including tracer testing, monitoring water levels at a spring for pressure pulses from quarry discharge, observation of flow from fractures in the existing quarry, profiling of flow, temperature and electrical conductivity in wells, packer testing in wells, and visual observations in wells using video and televiewer. There is no reason to suppose that fracture aperture, spacing, and connectivity is substantially different between the Western Extension and Medad valley, so tracer testing is not needed to understand flow in the aquifer. Furthermore there would be substantial challenges in carrying out such tracing, including: i) There are many domestic wells between the Western Extension and Medad valley. Consequently, it is possible that some of the dye would be intercepted by one or more of the domestic wells, which would not be desirable for aesthetic reasons (i.e. the tap water might be coloured by the dye). For this reason, it is rare for tracer testing to be carried out where there are domestic wells between an injection well and springs. ii) The distance between the wells in the Western Extension and Willoughby Creek varies from 250 m to 800 m. The distances to springs C, G, H, J, and K are even further. It is rare for tests with tracer injection into wells to be carried out over such long distances, and such tests often fail. For comparison, the 2006 karst report documents eight tracer injections into wells that were 14 - 24 m from a pumping well, with seven of the eight tests being successful. For the above reasons, the tracer testing suggested by Mr. Cowell is not recommended.	
60.	Recommendation: • Following quarrying, the western extension should be rehabilitated to lakes.	General	Daryl W. Cowell & Associates Inc.	A portion of the west extension is being rehabilitated to a shallow lake. As JART is aware, the existing approved rehabilitation plan for the Burlington Quarry requires dewatering to stop and the site to naturally flood to a lake with no off-site discharge. As part of the Burlington Quarry Extension application, Nelson agreed to modify the existing quarry rehabilitation plan to maintain off-site pumping to improve conditions for surrounding lands compared to existing approvals and maximize land area for future after uses. The proposed modification to the existing quarry rehabilitation also results in the West extension being maintained in a dewatered state. Rehabilitating the existing quarry and west extension to a lake with no off-site discharge does not mitigate impacts from the existing approved rehabilitation plan for the existing quarry or maximize land area for future after uses and therefore is not recommended. Both alternative rehabilitation designs were evaluated using the integrated model as described in the report.	
61.	The retained consultant has not commented on the predictions of the potential effects of the proposed extension. It has not been demonstrated that the modelling that has been conducted provides an adequate basis for making such predictions.	General	S.S. Papadopulos & Associates, Inc.	The **reviewer** states in his comment overview: ***Our review of the GSFLOW results suggests that, in general, the calibrated model is capable of matching variations in water levels arising from seasonal climate fluctuations.*** **If the model can replicate the transient response in shallow and deep monitors both near and far from the existing quarry, it is, by logical extension, capable of predicting the effects of an extension to the quarry.** In Chapter 7 of this report we present a detailed modeling analysis of the baseline conditions regarding groundwater levels and streamflow and wetland conditions with comparisons to observations. In Chapter 8, we present a highly detailed analysis of likely changes to these conditions for a range of stages in the quarry extension and under a range of climate conditions (as represented using historic climate data). We know of no other quarry impact assessment with this level of detail and comprehensive analysis of groundwater, streamflow, and wetland response	

				These two chapters are a critical part of Level 1 and 2 Hydrogeologic and Hydrologic Impact Assessment. We strongly feel the reviewer has shirked his responsibility by not reviewing the predictions of the potential effects of the proposed extension. The statement that "It has not been demonstrated that the modelling that has been conducted provides an adequate basis for making such predictions" is a disingenuous comment as it is impossible to determine that the model does not provide an adequate basis for predicting impacts without considering how the model was applied to compare the scenario predications and the type of results produced. The reviewer later acknowledges that there is an entire section (Section 19 – Appendix E) discussing the calibration of the GSFLOW model, with 46 pages including sections on calibration strategy, region calibration to streamflow and regional groundwater levels, local-scale calibration to 8 streamflow gauges, calibration to quarry discharge, calibration to groundwater levels at the quarry face and the need to adjust hydraulic conductivities to match the observations along with discussions, tables, maps, and hydrographs of model results. This follows Section 17 and 18 of the report which provide another 93 pages of text, maps, and hydrographs describing the development and preliminary calibration of the hydrologic and groundwater submodels. The model was developed specifically to cover the large study area extending to below the Niagara Escarpment while still providing the high level of detail needed to assess the likely effect of the proposed quarry extension on groundwater levels, streamflow, and the water balance in nearby wetlands. The calibration was done over a two-year period with multiple revisions, innovations, and improvements to derive a good match to the observations (particularly in the shallow subsurface), and reasonably constrained parameter values. The model was calibrated by comparison to regional groundwater flow patterns and streamflow as well as local behaviour of water levels at the quarry face and during aquifer testing. The model response was checked over a wide range of climate conditions that occurred over a 10-year period which included wet and dry years. Post-analysis checks, such as that provided in Response 41, further verify that the calibrated model captured key features of the hydrologic and hydrogeologic conditions in the study area. This was all accomplished using a highly advanced integrated model, despite long run times and instabilities related to the Niagara Escarpment, in a fractured rock/till environment, and with highly complex GW/SW interaction between headwater streams and shallow wetlands. We do not believe that there has ever been such a complex integrated transient analysis ever done in Ontario to analyze a proposed quarry extension. We believe that we accomplished the goal of producing a model that can successfully predict the likely changes in streamflow, groundwater levels, and wetland stage under the quarry extension scenarios considered. Results from this model provided useful input to other team members evaluating the impact to hydrologic and natural heritage features.	
62.	The Terms of Reference for the Level 1 and 2 Hydrogeologic and Hydrologic Impact Assessment of the Proposed Burlington Quarry Extension are dated February 2020 (Earthfx, Inc., Azimuth Environmental Consulting, Inc., Tatham Engineering, and Worthington Groundwater, February 2020). The field investigations and modelling analyses must have been largely completed by the date of the Terms of Reference.	General	S.S. Papadopulos & Associates, Inc.	Comment noted.	
63.	The modelling described in the Level 1/2 report does not achieve the objective of providing defensible predictions of the potential impacts of the proposed development. The analyses described in the Level 1/2 report are extraordinarily complex from a process perspective,	General	S.S. Papadopulos & Associates, Inc.	No basis for this comment is presented by the reviewer. See the opening statement in Response 61. **General comments:** **"Everything should be made as simple as possible, but no simpler."** Attributed to Albert Einstein	

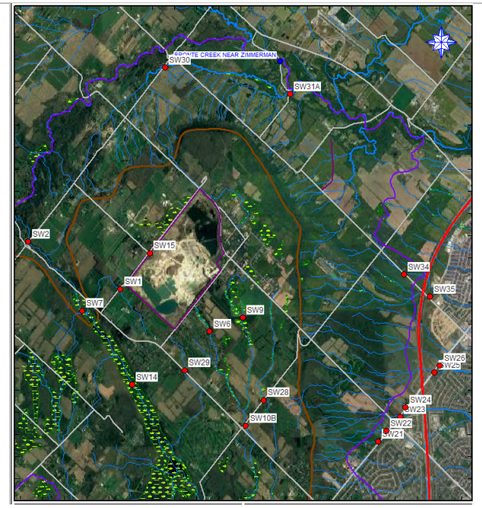
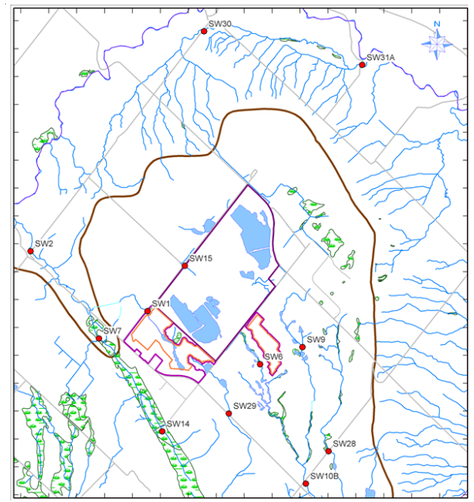
	but highly simplified with respect to the assignment of material properties. It is not clear what parameters have the greatest influence of the predictions, whether there are sufficient data to constrain the assignment of parameter values, and whether the parameter values inferred through calibration are consistent with the available data.			**"It seems that perfection is reached not when there is nothing more to add, but when nothing more can be removed."** Terre des Hommes [Land of People] by Antoine de Saint Exupéry, 1939 **Simplicity is the final achievement. After one has played a vast quantity of notes and more notes, it is simplicity that emerges as the crowning reward of art.** (Frédéric Chopin, a musician and composer, quoted in If Not God, Then What? by Fost, 2007) **<u>Specific comments about simplicity and complexity in groundwater models:</u>** ***Guideline 1: Apply the principle of parsimony*** *Using the principle of parsimony, the model is kept as simple as possible while still accounting for the system processes and characteristics evident in the observations and while respecting other information about the system.* From: Hill, M.C., 1998, Methods and Guidelines for Effective Model Calibration: USGS Open File Report 98-4005, Reston, VA. *An important contribution of Freyberg (1988) was* ***identifying and highlighting that a model that fits the observations best may not forecast best****. This* ***concern is of primary importance when calibrating highly parameterized models (especially those using pilot points).*** *The highly parameterized approach often achieves an excellent fit but can also "overfit," where the parameter estimation chases noise in the observations and yields unrealistic parameter values and distributions (e.g., parameter "bullseyes," or hotspots<u>).</u>* From: Revisiting "An Exercise in Groundwater Model Calibration and Prediction" After 30 Years: Insights and New Directions" Randall J. Hunt, Michael N. Fienen, and Jeremy T. White The reviewer has touched an important part of our approach to modelling. Earthfx has completed more than 25 Source Water Protection, land development, watershed management, and quarry/mining studies using an integrated modelling approach. The experience has shown us that it is extremely important to account for the physical processes that control runoff and groundwater recharge. That is not to say that spatial variability in material properties is not important, but, in many cases, these variations are unknown except at a few points and the extrapolation of these data to the rest of the model comes with a high level of uncertainty. Our experience has been that the use of simpler models with average material properties can provide all the information needed to assess the likely magnitude of changes to the system due to imposed stresses even though it may not be possible to accurately predict the exact response at a particular point in space. We have spent a great deal of effort to determine regional values for material properties that best match regional groundwater flow patterns and streamflow as well as local behaviour of water levels at the quarry face. The model response was checked over a wide range of climate conditions that occurred over a 10-year period which included wet and dry years. The ability to match observations over this extended period means that the values selected are consistent with the available data.	
64.	Review of the GSFLOW results suggests that, in general, the calibrated model is capable of matching variations in water levels arising from seasonal climate fluctuations.	General	S.S. Papadopulos & Associates, Inc.	The first statement confirms that the model is capable of matching the fluctuations in the data. **The reviewer has, however, failed to understand that the complex seasonal fluctuations in water levels are amplified in areas of quarry influence, and that our successful simulation of the full**	

	However, there are fundamental concerns regarding the treatment of the available data and the approaches that have been adopted for simulating groundwater flow in the bedrock. Evidence could not be found in the report that confirmed the GSFLOW model was capable of yielding acceptable matches to observed declines in groundwater levels arising from ongoing quarry operations.			**range of observed fluctuations is proof that the model is able to predict the influence of the quarry.** The following is a brief description of how seasonal processes interact with the quarry drainage in the range of 100 m to 800 m from the face (See Section 19.5.4): • During wet seasons, the rate of vertical replenishment (recharge to the shallow bedrock) exceeds the rate of lateral seepage (under drainage) into the quarry. The fractures rapidly fill, and water levels rise significantly (**nearly 7 m** as observed in Figure 19.24, below) • In late spring, recharge to the bedrock dramatically falls, and aquifer levels rapidly drop via leakage (drainage) into the quarry. As one moves beyond 800 m from the face, the effect of drainage into the quarry is negligible, water levels in the shallow and deep system broadly equilibrate, and seasonal fluctuations of 1-2 m are observed in all monitors. In summary, **large** seasonal fluctuations in monitoring levels are a key indicator of quarry influence. The reviewer, in stating *"the calibrated model is capable of matching variations in water levels arising from seasonal climate fluctuations"* has thus confirmed that the model is effectively simulating the interaction of natural processes and quarry influence. It is clear that the failure of the reviewer to understand these complex integrated model processes has resulted in his inability to complete the review as stated in Comment 61. Further, it is also apparent that the reviewer does not appreciate that representing the complex interaction of integrated model processes ("Process complexity" mentioned in Comment 63) is more important than an approach "*where the parameter estimation chases noise in the observations*" ("Parameterization complexity") (Hunt et al., as above). There is likely no amount of model K field parameterization and parameter estimation that will recreate the interaction of climate, soil zone processes, Halton till leakage and quarry drainage processes. Processes matter.  The first statement supports our approach to transient integrated modelling.	

				There is no basis for the second statement. The report (see Section 19.5) describes the efforts made to matching the water levels at the quarry face and incorporate information obtained from a set of historic observations of drawdowns as mining within the existing footprint approached the observation wells. Significant revisions were made to the model after a good regional calibration was achieved, to better match the unique conditions that occur in the vicinity of the quarry face. Additional comments made by the reviewer question the methods used, but a good local calibration could not be achieved without the approach taken. This is discussed further on.	
65.	Although the model has been developed to predict the potential impacts of the quarry expansion, the predictive capacity of the model has not been demonstrated. In general, the hydrographs presented in the report demonstrate that the model is capable of reproducing changes in water levels that are driven by seasonal variations in climate. However, no comparison is presented between observed and simulated average declines in water levels caused by the quarry operations. The quarry has been operating sufficiently long that it should be possible to identify the declines for at least some key monitoring locations. An appropriate application of the MODFLOW model would be to simulate time-averaged water levels for different positions of the quarry face. Did the position of the quarry face change 2003/2004 and 2007/2010? Has the position of the quarry face changed between 2010 and 2020? The results of time-averaged simulations of the different time periods would be important for confirming that the predicted effects of the quarry expansion on bedrock groundwater levels are within the realm of possibility. Referring the hydrographs in Golder (2010), it is estimated that for OW03-14A, the average level between April 2003 and July 2004 was about 272.0 metres amsl, and between July 2007 and July 2010 the average level was about 261.0 metre amsl. For monitoring well OW03-15A, the average level between April 2003 and July 2004 was about 260.0 metres amsl, while the average level between July 2007 and July 2010 was about 259.0 metres amsl. Substantial drawdowns were also observed at OW03-21. Golder (2010) present hydrographs for three other wells that show clear long-term declining trends and that might be used for this demonstration: Onsite quarry well 5 (Golder, 2010; Figure D.1.77); Onsite quarry well Goodchild (Golder, 2010; Figure D.1.78); and Onsite quarry well Sterrett (Golder, 2010; Figure D.1.79).	General	S.S. Papadopulos & Associates, Inc.	See above. It appears the reviewer did not read the section of the report describing local calibration. Section 5.3.3.2, 6.11, and 19.5 of the report specifically address the effects of the quarry that have been observed in the South Quarry Extension area monitoring network for many years. Although limited due to gaps in the monitoring data, this particular set of observation data, related to the movement of the quarry face and changes in water levels, was analyzed early on in the study to determine the effect of quarry development on water levels and to ensure that model properties were consistent with these observations. 	
66.	No mention is made in the report of the two well-instrumented constant-rate pumping tests that have been conducted near the quarry. These tests provide useful opportunities to test the predictive capabilities of the calibrated groundwater flow model.	General	S.S. Papadopulos & Associates, Inc.	Much time and effort was spent early in the study digitize the Golder test data, verify the transmissivity estimates Golder obtained from the tests, and then set up transient model runs (MODFLOW only) to replicate test results. This was done with early versions of the model to aid in the pre-calibration, but is not discussed in great detail within the report. Model values for hydraulic properties did vary during the course of the GSFLOW calibration. Generally, K	

<table>
<tr><td></td><td>The pumping test conducted in March 2004 is reported in Golder (2004; Appendix B). The pumping test conducted in February 2006 is reported in Golder (2006).</td><td></td><td></td><td>values for the lower Amabel increased from the early values assumed and are much closer to the Golder pump test derived K’s.</td><td></td></tr>
<tr><td>67.</td><td>Streamflow Monitoring – A relatively small subset of the existing streamflow monitoring locations has been considered in the modelling analyses. Furthermore, inconsistent sets of streamflow monitoring stations have been considered for the GSFLOW calibration and the representation of baseline conditions. It was left with the impression that selective use has been made of the available data in the GSFLOW calibration and the representation of baseline conditions. At a minimum, all stations considered for the representation of baseline conditions should have calibration records that extend across the 10-year period WY2010 to WY2019. In addition, if it is not feasible to include all the existing streamflow monitoring locations in the calibration analyses/baseline conditions simulations, the documentation should include explanations regarding why some stations are included and others are not.</td><td>General</td><td>S.S. Papadopulos & Associates, Inc.</td><td>All streamflow monitoring locations within the model boundaries were considered in the modelling analyses to see if the model produced reasonable matches to observed flows. Figure 19.4 shows the location of stations discussed in the report. As you note, not every flow monitoring station is discussed, but the locations discussed provide a good sampling of close and far stations, of stations affected/not affected by quarry discharge, and cover the reaches of streams likely to be affected by quarry expansion.

It should be noted that data for all stream reaches were produced and saved for all simulations. We have post-processed these data to produce detailed water budgets for a set water courses to address a request by MNRF in their review. These have been provided in Schedules B and C.</td><td></td></tr>
<tr><td>68.</td><td>Existing Streamflow Monitoring Locations – Referring to Tatham Engineering (2020; Table 2), there are 20 existing streamflow monitoring locations.

<table><tr><td>SW01</td><td>SW23</td></tr><tr><td>SW02</td><td>SW24</td></tr><tr><td>SW06</td><td>SW25</td></tr><tr><td>SW07</td><td>SW26</td></tr><tr><td>SW09</td><td>SW28</td></tr><tr><td>SW10</td><td>SW29</td></tr><tr><td>SW14</td><td>SW30</td></tr><tr><td>SW15</td><td>SW31</td></tr><tr><td>SW21</td><td>SW34</td></tr><tr><td>SW22</td><td>SW35</td></tr></table></td><td>General</td><td>S.S. Papadopulos & Associates, Inc.</td><td>  

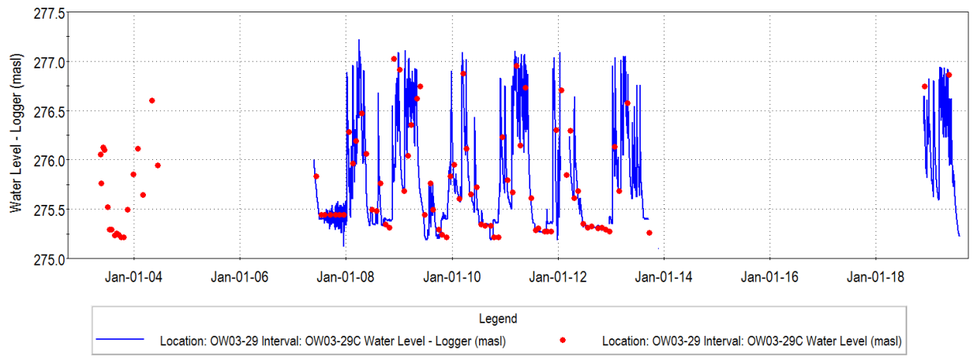
The first figure shows the location of the 20 Tatham stations, while the second is from Figure 19.4 showing stations used for comparisons. The stations not shown in the second figure are all below the Escarpment and outside the model boundary. Simulated flows near the model boundary were compared against the closest gauge for consistency during model development.</td><td></td></tr>
<tr><td>69.</td><td>Monitoring locations for which results from the GSFLOW model calibration are reported – The Level 1/2 Hydrogeological and Hydrological Impact Assessment has been reviewed and it is noted that:
• The GSFLOW model has been calibrated for the five (5) year period, WY2010-WY2014 (October 2009 to September 2014); and</td><td>General</td><td>S.S. Papadopulos & Associates, Inc.</td><td>The model was calibrated over a 10-year period, WY2010-WY2019. Unfortunately, the “excellent” data from 2003 for model calibration that the reviewer refers to mostly falls within WY2008 to WY2013 as shown by the data for OW03-29. The 2003 data are mostly manual monthly measurements with a large gap between May 2004 and August 2007. There is another large gap from WY2014 to August 2018. Most wells show similar data distributions but there is variation. OW03-15 and OW03-30, for example, are part of a group of wells that did not have logger data until 2010. The period selected had the best logger data coverage.</td><td></td></tr>
</table>

- The summary of the number of wells for which GSFLOW simulation results are reported in the Level 1/2 report is presented on Table 1. Comparisons between observations and simulation results are presented for 39 locations.

No explanation is provided for restricting the GSFLOW calibration to the five-year period 2009-2014. Excellent data are available since 2003, and at a minimum it would be expected there to be some discussion of the consistency between the model results and earlier data. This is particularly important for assessing the ability of the GSFLOW model to match long-term changes in groundwater conditions caused by the evolution of the existing quarry, in particular the 2005-2019 advancement of the south extraction face).

Any rationale could not be found for considering only 39 of the 100 monitoring wells in the GSFLOW analyses. At a minimum it would be expected there to be some explanation regarding why some results have been presented for some wells and not others.

Table 1. Reported comparisons between observations and GSFLOW simulation results



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

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

70.	Monitoring locations recommended for long-term monitoring – The wells recommended for inclusion in the long-term monitoring network are listed on Table 10.1 of the Level 1/2 report. The check marks on Table 2 denote those wells for which GSFLOW calibration results are reported. The results for the GSFLOW calibration are reported for only about half of these wells. The GSFLOW calibration should have included all of the wells recommended for inclusion in the long-term monitoring program. The GSFLOW results represent a prediction of what is likely to occur in the future, and the data from the long-term monitoring program will serve in an ongoing assessment of the realism of that prediction. As a minimum condition for reliability, it should be	General	S.S. Papadopulos & Associates, Inc.	As above, we tried to present a comprehensive but not exhaustive comparison of results. As with the streamflow stations, the locations selected provided a good sampling of close and far stations and covers the area where groundwater is likely to be affected by the quarry expansion.	

	confirmed that the GSFLOW results provide a reasonable match to data that are already available. Table 2. Wells recommended for long-term monitoring **Well recommended for long-term monitoring** / **Well included in reportin GSFLOW calibration resu** MW03-01 A: √ MW03-01 B: - MW03-07 A: - MW03-07 B: - (OW) MW03-09 A: √ (OW) MW03-09 B: √ (OW) MW03-14 A: √ (OW) MW03-14 B: √ (OW) MW03-15 A: √ (OW) MW03-15 B: √ (OW) MW03-17 A: √ (OW) MW03-17 B: √ (OW) MW03-18 A: √ (OW) MW03-18 B: √ (OW) MW03-19 A: √ (OW) MW03-19 B: √ MW03-20 A: - MW03-20 B: - (OW) MW03-21 A: √ (OW) MW03-21 B: √ MW03-28 A: - MW03-28 B: - (OW) MW03-29 A: √ (OW) MW03-29 B: √ (OW) MW03-30 A: √ (OW) MW03-30 B: √ BS-01 A: - BS-01 B: - BS-02 A: - BS-02 B: - BS-03 A: - BS-03 B: - BS-04 A: - BS-04 B: - BS-05 A: - BS-05 B: - BS-07: - P-MW-08: - P-MW-09: - P-MW-10: - P-MW-11: -				
71.	Missing References – Although the Level 1 and Level 2 report is extensive, it is not complete. Complete references for may of the documents cited in the report are missing. Missing references are listed below. Page 52: Brunton, 2008 Page 52: Brunton, 2009 Page 52: Johnson et al., 1991 Page 54: Liberty et al., 1976 Page 54: Brett et al., 1990	General	S.S. Papadopulos & Associates, Inc.	Comment noted. This does not change the conclusions of the report. Key missing references are provided below. Barnett, P.J., 1992, Quaternary geology of Ontario; in Geology of Ontario, Ontario Geological Survey, Special Volume 4, p.1011-1088. Brunton, F.R., Belanger, D., DiBiase, S., and Yungwirth, G., 2007, Caprock Carbonate Stratigraphy and Bedrock Aquifer Character of the Niagara Escarpment – City of Guelph Region, Southern Ontario, paper presented at the 60th Canadian Geotechnical Conference/8th Joint CGS/IAH-CNC Groundwater Conf., Oct. 2007, Ottawa, Ontario. Brunton, F. R., 2008, Preliminary revisions to the Early Silurian stratigraphy of Niagara Escarpment - Integration of sequence stratigraphy, sedimentology and hydrogeology to delineate hydrogeologic units: in Summary of Field Work and Other Activities, 2008, Ontario Geological	

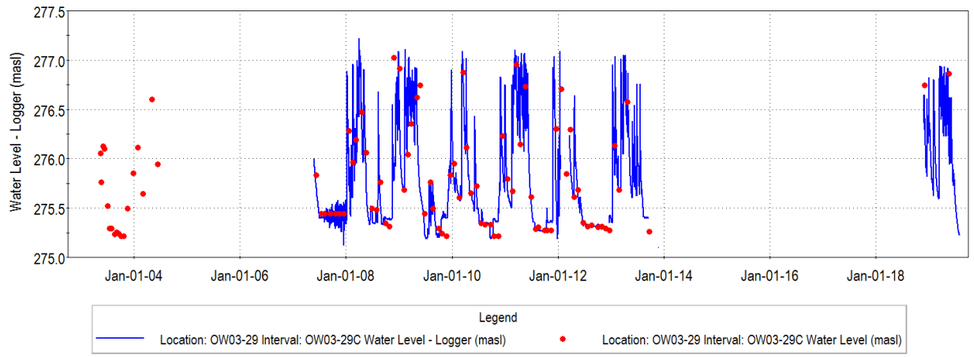
	Page 54: Bond et al., 1976 Page 54, 67: Johnson et al., 1992 Page 57: Brett et al., 1995 Page 57: Voss, 1969 Page 57, 103: Golder, 2004 (also Figure 5.9) Page 71: Karrow, 1987. In addition to including the complete citation in the list of references, the specific map sheet should be indicated, Map 2508. Page 71: OGS, 2010 [and Figure 3.26] Page 71: White, 1975 Page 71: Karrow, 2005 Page 71: Chapman and Putnam, 1984 Page 71: Barnett, 1992 Page 82, 132: Earthfx, 2010 Page 82, 132: Hargreaves and Samani, 1982 Page 82: MNRF, 2013 (also Figure 4.9) Page 86: Worthington Water, 2020 Page 86: Worthington, 2020 Page 86: Worthington Groundwater, 2020 Page 104: Golder, 2005 Page 104: Jagger Himms [sic] (2003) [should read "Hims"] Page 104: Charlesworth & Associates (2006) Page 104: Dillon (2008) Page 104: Gartner Lee (2005) Page 104: AECOM (2009) Page 104: OGS (2010) Page 104: Wood (2018a) Page 104: Earthfx (2020) Page 105: Brunton, 2007 Page 109: Kassenaar and Wexler, 2006 Page 121: Huntington and Niswonger, 2014 Page 121: Hunt et al., 2013 Page 121: Ely and Kahle, 2012 Page 121: Tanvir Hassan et al., 2014 Page 121: Niswonger et al., 2014 Page 121: Leavesly et al., 2011 [should be Leavesley] Page 142: The reference in the text of the report is to Golder Associates (2007). Is that to Golder Associates (2007a) or Golder Associates (2007b) in the list of references? Page 143, 512: Chiew and McMahon, 1993 Page 460: [Figure 17.10] MNR, 2013			Survey, Open File Report 6226, p.31-1 to 31-18. Brunton, F. R., 2009, Update of revisions to the Early Silurian stratigraphy of the Niagara Escarpment - Integration of Sequence Stratigraphy, Sedimentology and Hydrogeology to delineate Hydrogeologic Units: in Summary of Field Work and Other Activities 2009, Ontario Geological Survey, Open File Report 6240, p.25-1 to 25-20. Chapman, L.J. and Putnam, D.F., 1984, The physiography of southern Ontario: Ontario Geologic Survey, Special Volume 2, 270p. SNC-Lavalin Engineers and Constructors Inc. and Charlesworth and Associates, 2006, Hamilton groundwater resources characterization and wellhead protection partnership study: report to the City of Hamilton, February, 2006 Chiew, F.H.S. and McMahon,T.A., 1993 Assessing the Adequacy of Catchment Streamflow Yield Estimates, Australian Journal of Soil Research, v.31, p.665-680. Dillon (2008) Dillon Consulting, 2008, Hydrogeological Study of the New Freelton Well: March 2008. Earthfx, 2010, Tier 1 water budget and water quantity stress assessment of the Black-Severn River watershed: 124 pp. Earthfx (2020) – *This report* Ely, D.M., and Kahle, S.C., 2012, Simulation of groundwater and surface-water resources and evaluation of water-management alternatives for the Chamokane Creek basin, Stevens County, Washington: U.S. Geological Survey Scientific Investigations Report 2012–5224, 74 p. Gartner Lee (2005) Gartner Lee Limited, 2005, Proposed Dolostone Quarry, Hamilton Volume 1: Hydrogeological Level 2 Report: June 2005. Hargreaves, G.H. and Samani, Z.A. (1982) Estimating potential evapotranspiration: Journal of Irrigation and Drainage Engineering, v.108, 223-230. Hunt, R.J., Walker, J.F., Selbig, W.R., Westenbroek, S.M., and Regan, R.S., 2013, Simulation of climate-change effects on streamflow, lake water budgets, and stream temperature using GSFLOW and SNTEMP, Trout Lake Watershed, Wisconsin: U.S. Geological Survey Scientific Investigations Report 2013–5159, 118 p., http://pubs.usgs.gov/sir/2013/5159/. Huntington, J.L. and Niswonger R.G., 2012, Role of surface-water and groundwater interactions on projected summertime streamflow in snow dominated regions - An integrated modeling approach: Water Resources Research, v.48, .11, Johnson M.D., Armstrong, D.K., Sanford, B.V., Telford P.G., and Rutka, M.A., 1992, Paleozoic and Mesozoic Geology of Ontario: in Geology of Ontario, Ontario Geological Survey, Special Volume 4, Part 2, p.907-1010.Page 57: Brett et al., 1995 Karrow, P.F., 1987, Quaternary geology of the Hamilton-Cambridge area, southern Ontario: Ontario Geological Survey Geoscience Report 255, 94p (accompanies Map 2508). Karrow, P.F., 2005, Quaternary geology of the Brampton area, southern Ontario: Ontario Geological Survey Geoscience Report 257, 59p. Kassenaar, J.D.C. and E.J. Wexler, 2006, Groundwater modelling of the Oak Ridges Moraine area: YPDT-CAMC Technical Report #01-06: Available at http://www.ypdt-camc.ca. Page 121: Liberty, B.A., Bond, I.J., and Telford, P.G., 1976, Paleozoic geology of the Hamilton area, southern Ontario: Ontario Geological Survey. Map 2336, scale 1:50 000. Niswonger R.G., Allander K.K., and Jeton A.E., 2014, Collaborative modelling and integrated decision support system analysis of a developed terminal lake basin Journal of Hydrology. 517: 521-537. DOI: 10.1016/J.Jhydrol.2014.05.043 Page 71: Ontario Geological Survey, 2010, Surficial geology of southern Ontario; Ontario Geological Survey, Miscellaneous Release— Data 128 – Revised. Tanvir Hassan, S.M., M, Niswonger, R.G., and Zhongbo Su, 2014 Role of surface-water and groundwater interactions on projected summertime streamflow in snow dominated regions - An integrated modeling approach: paper presented at the 41st IAH International Congress, September 2014, Marrakech, Morocco Vos, M.A., 1969, Stone resources of the Niagara Escarpment: Ontario Dept. Mines, IMR31, 68p, accompanied by 6 maps. White, O.L., 1975, Quaternary Geology of the Bolton Area, Southern Ontario; Ontario Division of Mines,	

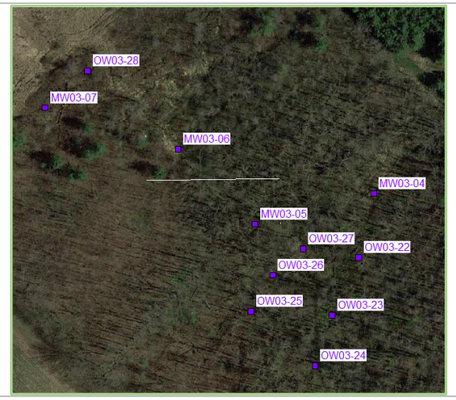
				Geological Report 117, 119p, with Map 2275 and Map 2276, scale 1:63.360. Wood Environment & Infrastructure Solutions, 2018, Freelton Well FDF01 Increased Water Taking Assessment – Phase 3 Community of Freelton, Ontario: September 2018 Worthington Groundwater, 2020, Appendix B – Karst Investigation: in Level 1 and Level 2 Hydrogeological Assessment Proposed Burlington Quarry Extension – Appendix A and B, report prepared by Earthfx Inc. for the Nelson Aggregates Co., November 2019, 41 p.	
72.	Referring to page 92, the analyses are referred to as an “integrated model-driven, quarry assessment approach”. The objectives are summarized on page 22: The objective of this Level 2 ARA investigation is to characterize the existing conditions at the Burlington quarry site, describe the development of an integrated groundwater/surface water assessment model, and predict any likely changes to the hydrologic and hydrogeologic conditions at different phases of extraction and final rehabilitation.	Pages 22 and 92	S.S. Papadopulos & Associates, Inc.	Comment noted.	
73.	It is reported 5 out of 22 wetlands receive a groundwater discharge (less than 3.0% of the total inflows). Is this based on monitoring or model results? What year does this represents? How does this relate to potentially wetlands already being impacted by existing quarry operations? High water table may not only provide minor inputs, but also prevent surface water from infiltration, and hence, extend the wetland hydroperiod. Loss of groundwater inputs can also have an impact on wetland water temperature and have impact on the amphibian breeding in the ponds. Has this been assessed?	Pages 23 and 24 Executive summary	Conservation Halton	Please see response to comment 5, and our detailed response to MNRF wetland questions. The statement was based on model results based on averaging over the simulation period for the baseline (model calibration) scenario. This statement relates to simulations of 2004 to 2015 conditions, a period which was felt to reasonably represent current conditions. The quarry extent and quarry water management were representative of that period. The position of the water table is an important factor in the wetland water balance, controlling the rate of leakage into and out of the wetlands as well as controlling runoff and interflow. Changes in groundwater discharge to the wetlands have been assessed in all the quarry development phase simulations.	
74.	It is reported the West Extension is next to a locally significant groundwater discharge area, which helps to mitigate the local effects of the excavation. Although it can limit the propagation of the drawdown away from the extraction, lowering of the groundwater levels due to extraction would reduce the amount of discharge in the locally significant groundwater discharge area and hence can be deemed a negative impact. Please address these potential negative impacts in the report.	Page 24 Executive summary	Conservation Halton	The main body of the report provides more detailed discussions of the simulations used to assess changes in groundwater levels and the changes in groundwater discharge and streamflow due to reductions in groundwater levels. The model demonstrates that the west extension will intercept a portion of recharge that currently infiltrates through the golf course before discharging into the Medad Valley. The proposed infiltration pond system will mitigate that effect, but any remaining water that is intercepted will simply be discharged through the north discharge point and into the Medad Valley to the north of the current discharge. Please refer to the MNRF Comment Response figure titled “Wetland 13204 – Graph 5” on page 161 (PDF page 292) and the associated discussion for an assessment of the change in soil moisture that will occur due to this change.	
75.	The Level 1 and 2 Natural Environment Report states (page 22) “The numerical simulations confirm that the majority of the wetlands and streams are isolated from the water table by the low permeability Halton Till.” This is echoed on page 24 of the Level 1 and 2 Hydrogeological Assessment report.	Page 24	Daryl W. Cowell & Associates Inc.	Yes	
76.	The Level 1 and 2 Hydrogeological Assessment report notes (Page 24, Executive Summary) that “The Medad Valley is a locally significant groundwater	Page 24	Daryl W. Cowell & Associates Inc.	The Executive Summary may have oversimplified a more complex observation. Dewatering for the West Quarry Expansion will direct flows to the North Discharge Pond. Some of this water is diverted to the proposed infiltration pond which will, as noted further in the summary, help preserve the current groundwater and surface water flow conditions created by this existing golf course ditch and pond system	

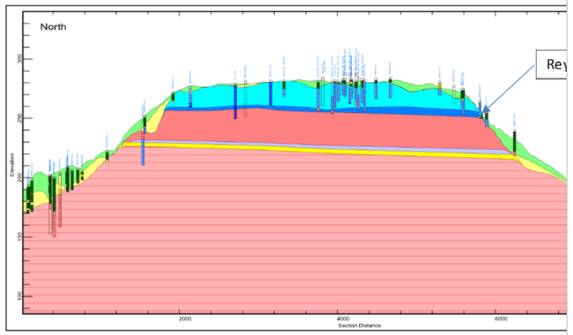
	discharge area that receives the majority of the groundwater that flows in and around the existing and proposed quarry [western extension]. The development of the West Extension will shift some of the groundwater discharge to the north, through the North Discharge pond, but ultimately all of its discharge simply enters the Medad Valley in a similar manner to the current discharge." (highlight mine).			(i.e., groundwater discharge to the Medad Valley). The remaining water will be discharged to the unnamed tributary to Willoughby Creek and to the karst sink that also contributes to groundwater discharge to the Medad Valley.	
77.	'The quarry has been in existence since 1953 and has been operated by Nelson since 1983.' The report does not address the long history of the quarry specifically the existing operating conditions, environmental requirements including on-going monitoring, conditions of operations, and recognition of the existing impacts of the quarry operations on the pre-quarry conditions. This should be included in the report.	Page 27 Introduction Section 1.1. Objectives, 1st Paragraph	Norbert M. Woerns	Technically," *the assessment report must address the potential effects of the operation* (in this case, the quarry expansion) *on any groundwater and surface water features located within the zone of influence, including but not limited to:* *a) water wells (includes all types e.g. municipal, private, industrial, commercial, geothermal and agricultural)* *b) springs (e.g., place where ground water flows out of the ground)* *c) groundwater aquifers;* *d) surface water courses and bodies (e.g., lakes, rivers, brooks)* *e) wetlands* *The assessment must include but not be limited to the following:* *f) a description of the physical setting including local geology, hydrogeology, and surface water systems;* *g) proposed water diversion, discharge, storage and drainage facilities;* *h) water budget (e.g. how water is managed on-site);* *i) the possible positive or negative impacts that the proposed site may have on the water regime;* *The Level 2 water report must also contain:* *j) monitoring plan(s); and* *k) technical support data in the form of tables, graphs and figures, usually appended to the report."* Please refer to Response 15, above The report is a stand-alone study that focussed on the impacts of the expansion that took into consideration approved impacts of the existing quarry. It was beyond the scope of the Level 1/2 study to recreate or analyze pre-development conditions. That said, the report provides estimates of predicted water levels and flows which incorporate the existing quarries effects, as opposed to just the change in flows and heads, as other quarry reports we have seen tend to do.	
78.	'A key aspect of this integrated model approach is that it evaluates the effects of the quarry extension on continuous multi-year basis, spanning a range of climate conditions.' The analysis does not identify the existing conditions as being impacted by the long operating quarry or whether the existing quarry operations are in compliance with environmental impact mitigation requirements that may exist. There is no cumulative impact assessment of the existing operations and the proposed quarry extensions. Cumulative impact analysis should be included in the report.	Page 30 Section 1.2. Study Approach, 2nd Paragraph	Norbert M. Woerns	See response 77, above	
79.	Although, this section states this hydrogeological assessment has been completed in accordance with Terms of Reference for the Level 1 and 2	Page 30 Section 1.3. Level 1/ Level	Conservation Halton	The selected period includes the Ontario Low Water Response Level 2 Drought condition that was posted by Conservation Halton on August 10, 2016. Monitoring data from prior to 2004 was limited, reducing the value of simulations prior to that time.	

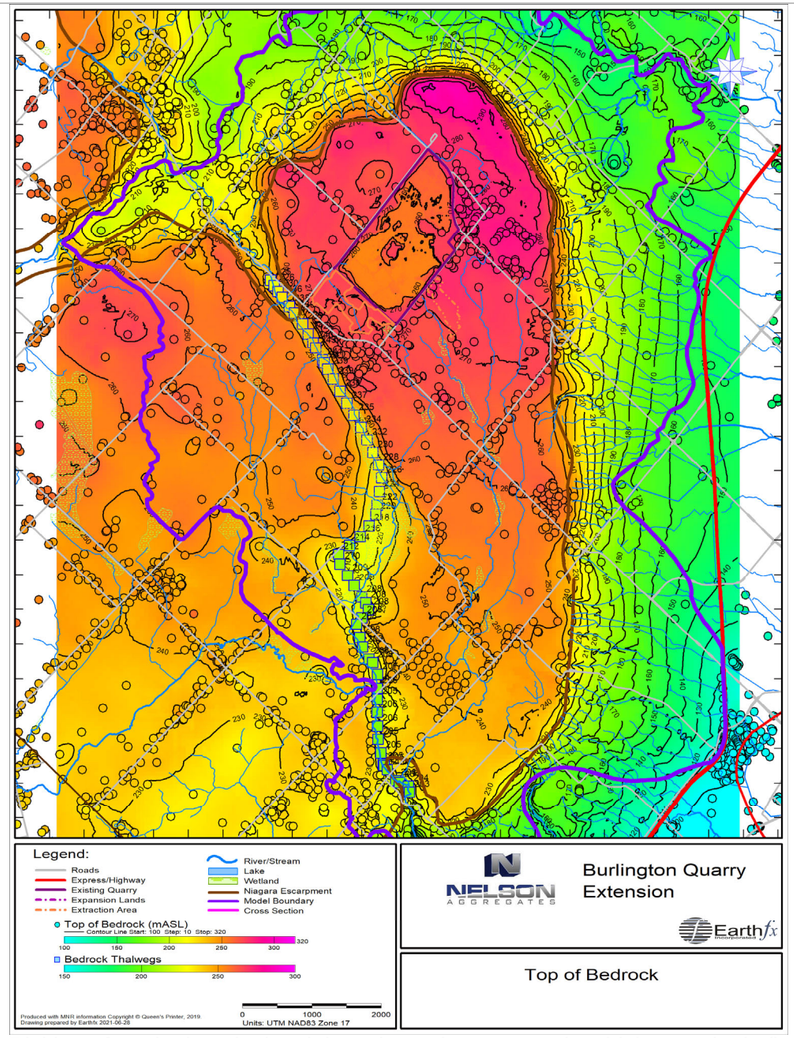
	Hydrogeological and Hydrologic Impact Assessment of the Proposed Burlington Quarry Extension (February 2020), the TOR states that a 25-year baseline period would be simulated including dry year 2007, wet year 2008 and average conditions year 2009. It seems only 10-year period was simulated as baseline, which does not include the specified period 2007-2009. Please include a 25-year baseline period as proposed in the TOR.	2 Study Components and Methodology		Long run times and model stability issues created practical limitations for the model run times. The stability issues were not related to the quarry but rather to conditions at Mt. Nemo, where the Escarpment is very steep. One option to improve stability and reduce model run times was to remove the lower escarpment area from the simulations. This would have prevented any analysis of headwater tributaries below the escarpment. The decision was made to use a 10-year period and maintain a larger model area.	
80.	'In addition, this hydrogeological assessment has been completed in accordance with the Terms of Reference for the Level 1 and Level 2 Hydrogeological and Hydrologic Impact Assessment of the proposed Burlington Quarry Extension (February 2020).' The terms of reference were dated 2020, at about the same time as the hydrogeological report was issued. Studies in support of the hydrogeological report were initiated well in advance of issuing the Terms of reference. Typically, studies are based upon the terms of reference which are normally produced in advance of the studies being undertaken. The terms of reference appear to have been created from the completed studies. Due to the timing of the completion of the terms of reference, it appears as though the hydrogeological assessment could not have been competed in accordance with terms of reference which do not appear to have existed prior to completion of the assessment. This process did not allow for an opportunity for meaningful input and modification too the studies by review agencies.	Page 30 Section 1.3. Level 1/Level 2 Study Components and Methodology, 1st Paragraph	Norbert M. Woerns	Comment noted.	
81.	This section describes elements of previous investigations and the time period over which they were undertaken. There is no description of the period of monitoring available for this study and for the existing quarry or the periods of data gaps that may exist. This should be included within this section of the report. Some of the data gaps are discussed elsewhere in the text.	Pages 30-31 Section 1.3.1. Field Investigations	Norbert M. Woerns	A data gaps section could have been added; however, as the reviewer notes, the data gaps are discussed further on in the text. Additional long term hydrographs are presented in our response to the MNRF comments (Schedules B, C, and D).	
82.	To complete a surface water and groundwater impact assessment on the natural environment and private water supplies the baseline conditions scenario should represent unaltered conditions in terms of groundwater and surface water. The modelled current/ baseline scenario (2010 onwards) does not account for quarry impacts to date, i.e. what was the extent and impact of groundwater cone of depression, what were the changes to groundwater levels and vertical gradients, changes to surface water pattern	Page 31 Section 1.3.2. Site Characterization and Baseline Scenario Analysis	Conservation Halton	Please refer to Response 15, above. Again, the study scope was directed to assessing the impact of the proposed quarry extension. There was a recognition that the expansion could impact nearby wetlands and private wells, and the study was undertaken to quantify the likely effects.	

	and flows and surface and groundwater interactions?				
83.	'Section 7 of the report presents a numerical simulation of the current or "Baseline' conditions at the site. A continuous transient (time-dependent) assessment is presented, illustrating how the surface water and groundwater systems behave on a daily basis over the last 10 years. Included in this assessment time period is a severe Provincial Low Water Response Level 2 drought (2016) and an above average wet year (2017). This baseline provides a realistic long-term frame of reference for comparison and assessment of the proposed quarry extension and rehabilitation phases.' Current conditions may be appropriate for assessing impact of the proposed extensions to the existing quarry. This does not however address the impact of the existing quarry operations. The cumulative impact of the existing quarry and the proposed quarry extensions should be considered for purposes of evaluating impacts on private wells, natural heritage features and rehabilitation options.	Page 31 Section 1.3.2. Site Characterization and Baseline Conditions Analysis, 3rd Paragraph	Norbert M. Woerns	Please refer to Response 15, above.	
84.	'This report, the companion documents, the integrated model, and the detailed field investigations and analyses represent an exceptionally comprehensive assessment of the proposed development' The computer model analysis is focussed on quantifying the water resources and the interaction between surface water and groundwater. Groundwater quality assessment is limited to characterizing the groundwater quality with respect to possible source waters, i.e. either groundwater or surface water. Water quality assessment is incomplete with respect to characterizing water quality with respect to drinking water objectives and potential sources of contamination. Groundwater quality thresholds as well as potential mitigation measures are also missing. An analysis of water quality threshold levels is missing and should be included in the report. There is also a limited period of water quality data with periods of record missing. The assessment is therefore not considered to be comprehensive.	Page 33 Section 1.3.7. Level 1/Level 2 Methodology Summary	Norbert M. Woerns	Please refer to our Response 7, above. As a general statement, dewatering for the quarry will result in inward gradients. This minimizes the risk of contaminants introduced into the subsurface from migrating offsite. The exception would be related to the infiltration pond which would infiltrate water discharged from the north sump. Water quality monitoring requirements for the quarry discharge would apply.	
85.	It is reported in this section that data collected for previous studies (see below), have been incorporated into this assessment: • Investigation by Golder in support of a previously south quarry extension (Golder, 2004) • Additional hydrogeologic field studies of wetland/groundwater interaction (Golder,	Page 36 Section 2.1. Previous Studies	Conservation Halton	The Golder data and reports were **fully** integrated into the database and analysis. The Golder data are high quality and clearly presented in the previous reports, so simply replicating the data in a new format would have limited value. Please also refer to Response 10 and 11, above. The key aspect of the Earthfx approach was to fully integrate the Golder data, plus the extended long-term measurements, into a fully transient 10-year assessment. Geologic data were used in site characterization and construction of the hydrostratigraphic model. Groundwater level data, aquifer test data, and streamflow data were used in site characterization, model	

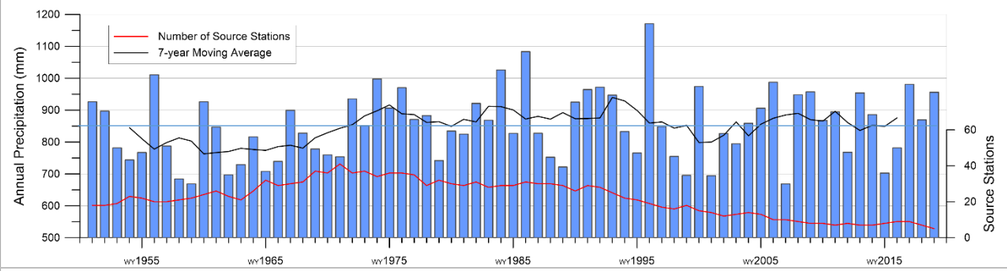
	2006) • An assessment of water budgets for individual wetlands in south extension area (Golder, 2007), and • A study of the shallow overburden (Golder, 2007) However, it seems limited data from these studies have been included in this report for the reviewer to understand quarry expansion impacts on the surface water and groundwater regimes and their interactions within the natural features. Please expand and clarify how previous data have been used in the report conclusions.			construction, and model calibration. Comparative assessments of updated water budgets were compared against previous to check that model assessment was reasonable. We did not replicate the previous data reports within our reports. We believe that the data were made public through the previous application and that all parties have access to this information.	
86.	'Local monitoring data and site characterization information collected for the Golder studies, as well as ongoing monitoring data, were obtained from Nelson and complied into a relational database for this study.' The period of record and data gaps should be identified.	Page 36 Section 2.2. Long Term Monitoring Network, 1st Paragraph	Norbert M. Woerns	Periods of record varied for each well and measuring point. A table of start and end dates for wells near the wetlands has been prepared for MNRF and are included as Schedule D. There are significant (multi-year) gaps in most of the data sets as shown below. This information was presented in the comparative hydrographs provided in the report.  The benefit of our continuous integrated modelling approach is that model results can be compared to available data even if there are gaps and non-overlapping surface water and groundwater measurement periods. Please also refer to Response 10 and 11, above.	
87.	'The effects of this quarry excavation and expanded dewatering have been observed in the monitoring data collected since 2005; ' It is not clear what changes in dewatering have occurred since 2005. It is also not clear whether the impacts of the changes in quarry dewatering have stabilized. This should be addressed in the report.	Page 45 Section 3.3.3. Site Development History, 1st Paragraph	Norbert M. Woerns	This is a reference to the changes that occurred as the active quarry face progressed with respect to observation wells on the south side of the quarry. Please refer to Figure 5.12 and Section 6.11.3 of Earthfx, 2020. For additional detailed discussions about quarry advancement please refer to Section 4 (Long Term Observation of Wetland and Quarry Interaction) of the Earthfx Response to MNRF comments. Little data are available for the period prior to the instrumentation in the south and gaps exist in the subsequent observations. Significant effort was made to extract useful information from this limited data set.	
88.	It is impossible to depict some of the monitors on Figure 3.4. Please provide a larger scale map clearly showing all the monitoring location.	Page 46 Figure 3.4. Well Locations – South	Conservation Halton	The map below shows the well distribution where they are tightly clustered.	

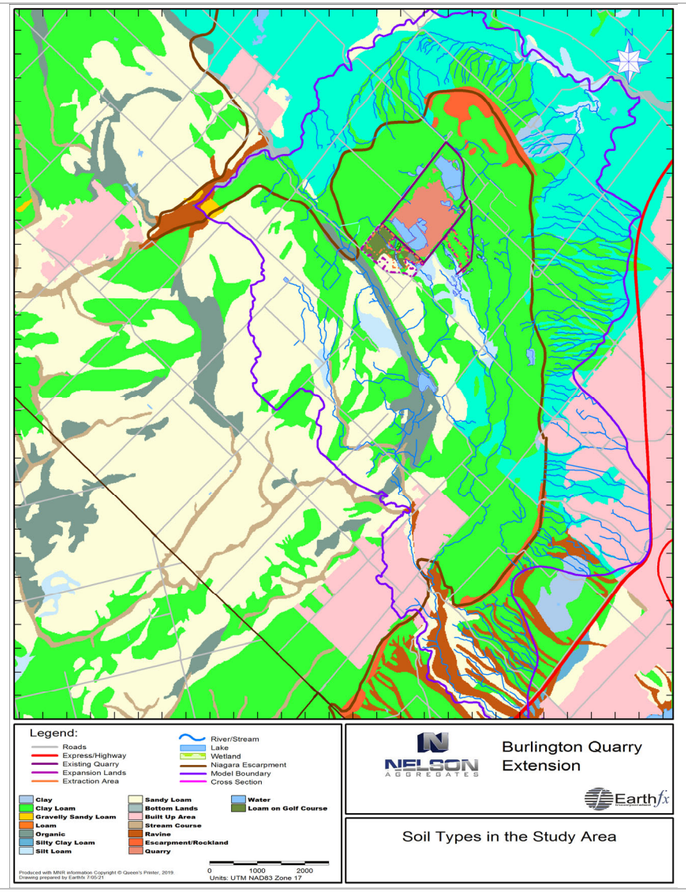
		Extension Area			
89.	Typo. Location BS-063 should be BS-03. Also note that BS-06 is missing on this figure.	Page 48 Figure 3.6. Well Locations: West Extension Area	Norbert M. Woerns	BS-03 and BS-06 are so close that their labels overprinted and appeared as BS-063. The map below shows the well locations. 	
90.	Model layers should be labelled on this figure for correlation to hydraulic conductivity results from packer testing.	Page 49 Figure 3.7. Sample Borehole Log from West Extension Area (BS-04)	Norbert M. Woerns	Model layering had not been introduced at this point in the report and would have complicated the figure.	
91.	The control points for mapping the elevations of the top of the Cabot Head Formation are shown in Figure 3.13. What control points were used to map the thickness of the Cabot Head Formation shown in Figure 3.14?	Figures 3.13 and 3.14	S.S. Papadopulos & Associates, Inc.	The thickness of the Cabot Head was calculated using the top of Queenston, thickness of the Manitoulin and Queenston, and then checking the surface against the top of bedrock, which captures the incision of the Medad Valley.	
92.	It is indicated in the text that “while Brunton (2008) was able to subdivide the Reynales, these units are hydrogeologically similar (dolostone with shale partings) and are un-subdivided in the Golder and MECP logs; for simplicity, the Rockway and Merritton unit is referred to herein as the Reynales Formation.” The retained consultant has checked with Mr. Brunton, and he writes, “There is no Reynales at this quarry. In fact the greenish unit below Merritton or upper Fossil Hill Fm may in fact be a thin Grimsby	Page 58	S.S. Papadopulos & Associates, Inc.	The purpose of this statement is unclear. Brunton did not identify the Grimsby formation in any of borehole data that we provided to him for review. Are you implying that Brunton is inconsistent or unreliable by noting that there ***may*** be a thin Grimsby unit at the site? The significance of subdividing a thin unit formerly referred to as the Reynales Formation into 2 or possibly three units is unclear. Golder could not justify subdividing the unit despite mentioning the work by Brett. The 2004 Golder core is no longer available. Finally, the unit cannot be subdivided based on MECP wells.	

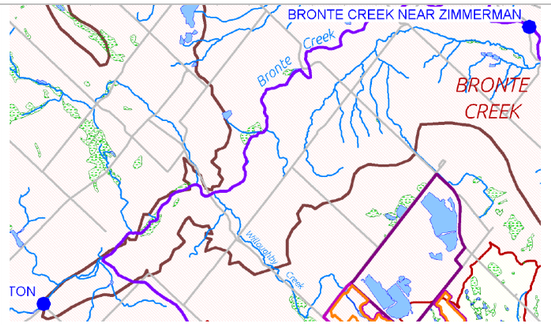
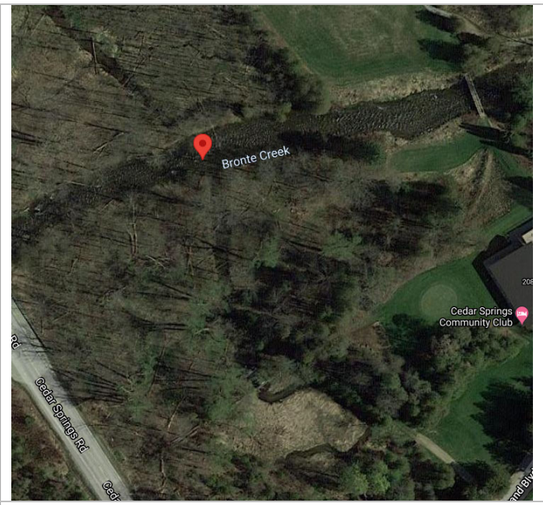
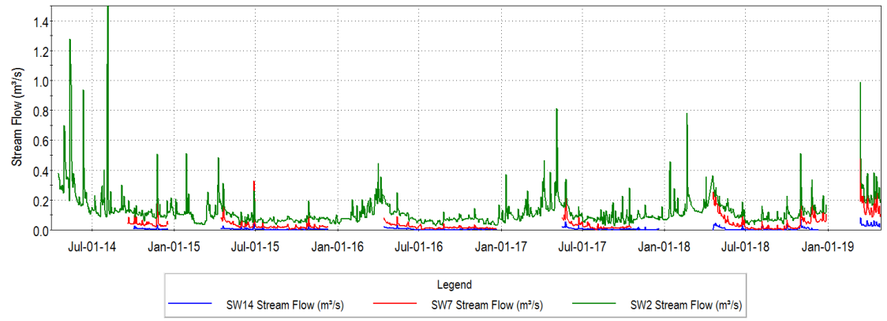
	Formation unit" (written communication, October 15, 2020).  				
93.	The control points for mapping the elevations of the top of the Reynales Formation are shown in Figure 3.15. What control points were used to map the thickness of the Reynales Formation shown in Figure 3.16?	Figures 3.15 and 3.16	S.S. Papadopulos & Associates, Inc.	The thickness of the Reynales is created by subtracting interpolated top of Reynales from the interpolated Top of Cabot Head. This is the preferred approach as not all wells penetrate the formation	
94.	Figure 3.22 West-East Section shows existing Burlington Quarry up-gradient of wells adjacent to Medad Valley. This illustrates that the upgradient source water area of these wells has to a large extent been excavated by the existing quarry. These wells therefore rely to a large extent upon on up-gradient infiltration including sump discharge via upgradient irrigation/infiltration ponds to replenish groundwater levels for down-gradient wells. Much of the up-gradient bedrock remaining between the existing quarry and the private wells along the Medad valley is to be excavated in the proposed west extension. This creates further reliance on the infiltration ponds for maintenance of down-gradient well water supplies. Please provide field data to confirm that the proposed infiltration pond will function as required.	Page 66 Figure 3.22. West-East Quarry Cross Section	Norbert M. Woerns	Please refer to Response 4, 6 and 18, above. It is unlikely that the wells, as you note, *"rely to a <u>large extent</u> upon on up-gradient infiltration including sump discharge via upgradient irrigation/infiltration ponds to replenish groundwater levels for down-gradient wells".* Golf course irrigation is limited to the summer months and the 50+ year old ponds are likely infilled with silt and fines that would limit leakage. Early simulations with and without the infiltration pond showed that higher drawdowns would occur in the absence of the feature, indicating that the feature would mitigate the effects of quarry. The design of the pond was adjusted by Tatham based on feedback from the modelling results and the extents of the pond were increased. There are no field data available as the pond has not been constructed, but creating an infiltration system that is more effective than a 50-year-old pond network will not be difficult. The principal of the design was to replace the limited infiltration from ponds excavated into the Halton Till containing accumulated sediments with a pond excavated to the top of the weathered bedrock. Significantly higher infiltration rates would be expected.	
95.	What is the basis for the indication that the Irondequoit, Gasport and Goat Island formations are hydrogeologically similar? The retained consultant's experience elsewhere in southern Ontario suggests that their hydrogeologic characteristics are distinct. Has any attempt been made at the site to conduct hydraulic tests on the separate units? Referring to Figure 3.25, no packer test results are shown for the Goat Island Formation, and substantially lower values of hydraulic conductivity are estimated for the rocks between the Gasport Formation and the Cabot Head Formation.	Page 67 and Figure 3.35	S.S. Papadopulos & Associates, Inc.	The extensive bedrock packer testing undertaken by both Golder and our field project partner Azimuth Environmental at this site did not identify distinct hydrogeologic formation properties for these units. Other Source Water Protection conducted in the area for Hamilton and Halton also failed to significantly differentiate the units. The lack of aquifer confinement in the study area may also be a factor. The static water level in BS01 was at a depth of 10 m when the packer testing was undertaken, limiting the ability to packer test the upper portion of the borehole.	
96.	What control points were specified to support the mapping of the elevations of the top of bedrock? Does the mapping shown in Figure 3.23 lump	Figure 3.23	S.S. Papadopulos & Associates, Inc.	The bedrock pick locations and the constraint point used to delineate the bottom of the Medad Valley are shown on the figure below.	

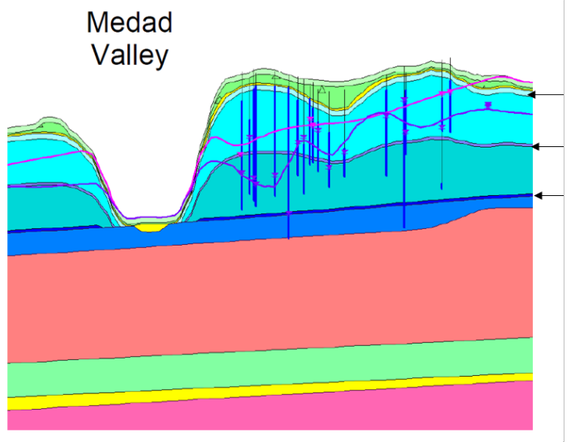
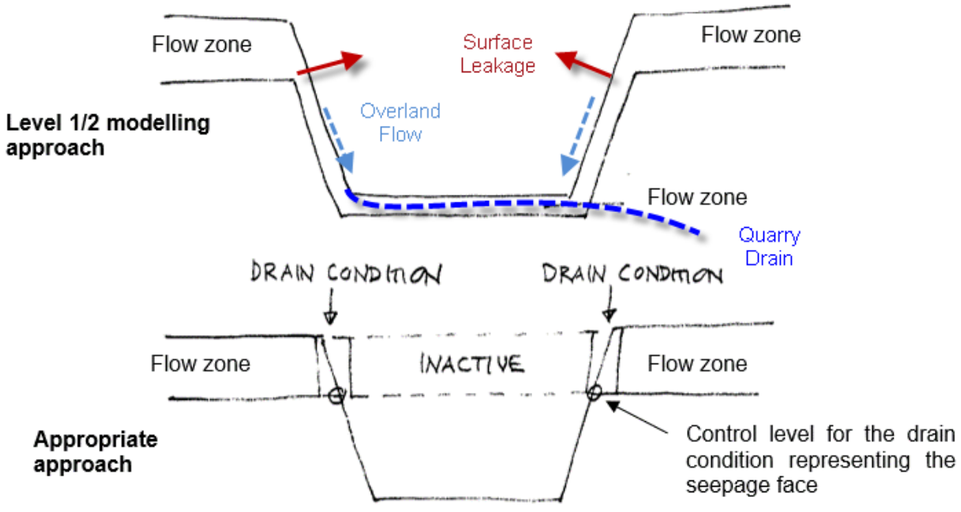
	high-quality data from site monitoring wells and the information from the MECP water well record database?			 Picking of geologic units is a labour-intensive process in which a geologist/hydrogeologist posts the boreholes on section and then “picks” the contact elevation at each selected borehole. The contact data is posted to the database. The picking typically begins with the higher quality boreholes and MECP boreholes added where ground elevation and bedrock elevation seem to be consistent with other information (i.e., on other parallel and perpendicular sections). The bedrock picks are then kriged and the surface is examined for outliers and inconsistencies.	
97.	What control points were specified to support the mapping of the thickness of the Amabel Formation in Figure 3.24 [Goat Island Formation + Gasport Formation + Irondequoit/Merritton/Rockway]?	Figure 3.24	S.S. Papadopulos & Associates, Inc.	The thicknesses of all the units are calculated by subtracting the gridded surfaces (generated by interpolation of the borehole picks) as not all wells penetrate the entire formation.	
98.	The model layers should be shown on the borehole log to allow comparison of the Packer Hydraulic Conductivity (K) values to those used in the computer	Page 70 Figure 3.25. BS-01	Norbert M. Woerns	See response to Comment 90	

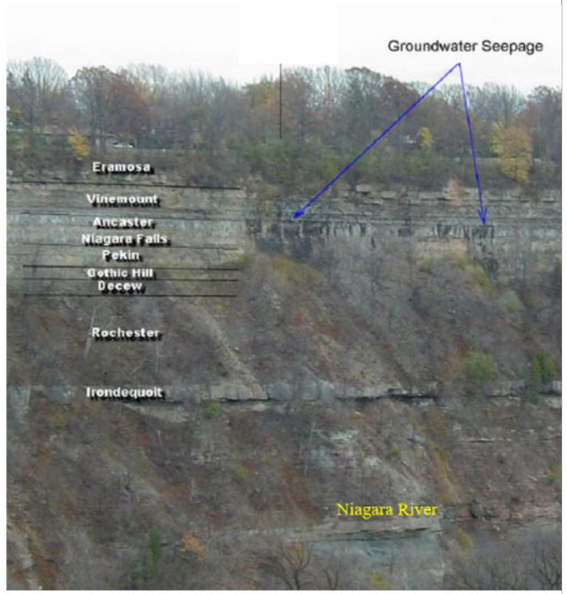
	model.	Borehole Log Showing the Goat Island Formation			
99.	'The till forms an effective aquitard where present. --- Golder (2006, p. 6) found that the presence of silty clay in the sediments effectively limited the interaction between the surface and groundwater systems.' There is some doubt as to the effectiveness of the Halton Till as an aquitard from pump test information provided by Golder (2010) where overburden monitor OW03-22C responded to a 2006 pump test of the deeper bedrock zones (See Figure 18, S. McFarland Witness Statement, 2010, PDF page 1429). During a 2004 pump test completed by Golder on the same well, a number of shallow overburden monitors responded to a five day pump test. This included monitors; MW03-5A, 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.	Page 71 Section 3.5.1. Halton Till, 2nd Paragraph	Norbert M. Woerns	Wells that penetrate to the top of bedrock (i.e., overburden/bedrock monitors) would be more likely to reflect the effects of water level change in the bedrock than short-screen wells carefully sealed into the centre of the unweathered Halton. Golder (2006) noted that "*No water level response was observed in the piezometers completed in the shallow overburden sediments or standing water staff gauge locations at ground surface. This indicates that the hydraulic connection between standing surface water in the wetland and groundwater resources in the bedrock is weak".* That said, it is recognized that the Halton Till is an aquitard in the sense that it **limits** the degree of interaction between the shallow overburden and the bedrock. There is likely to be some vertical fractures that span the unweathered till. This is why Golder observed a general response away from the wetlands to recharge events, which occur over a wide area, but no response to local pumping. That is why a relatively high ($5x10^{-7}$ m/s) value was used and not one or two orders of magnitude lower which would be more typical of an unfractured clay till. Golder (2006) indicated that lab tests showed K values as low as of $2x10^{-10}$ m/s. Our findings generally follow those of Golders.	
100.	On page 71 (Section 3.1), the hydrogeological report goes even further referring to the till as an "aquitard", limiting any interaction between surface and groundwater. During the August 10th video call, E.J. Wexler spoke about a "uniform K value for the Halton Till" (personal notes) and, in reference to Golder's MP16, suggested there may be "too much storage in the Halton Till…and [the till] may be even tighter" (personal notes). The Halton Till forms layer 2 in the	Page 71 Section 3.5.1, Table 18.4, and Figure 18.12	Daryl W. Cowell & Associates Inc.	See previous notes. It should also be noted that the hydraulic conductivity of the Halton Till likely varies spatially, but the variability may be random, or may be correlated with thickness, or with location (e.g., lowland versus upland). Insufficient data are available so a reasonable approach was to use a uniform value that felt close to a middle value in the wide range of reported field testing.	

	model and is characterized as a uniform layer having an hydraulic conductivity of 5.0x10.0^{-7} (Table 18-4 and Figure 18-12).				
101.	What control points were specified to support the mapping of the thickness of the Halton Till in Figure 3.27?	Figure 3.27	S.S. Papadopulos & Associates, Inc.	The thicknesses of all the units are calculated by subtracting the gridded surfaces (generated by interpolation of the borehole picks) as not all wells penetrate the entire formation.	
102.	What control points were specified to support the mapping of the thickness of the MIS sands and ORAC in Figure 3.28?	Figure 3.28	S.S. Papadopulos & Associates, Inc.	The thicknesses of all the units are calculated by subtracting the gridded surfaces (generated by interpolation of the borehole picks) as not all wells penetrate the entire formation.	
103.	There is only one station within the study area below the escarpment at the edge of the study area as shown on Figure 4.1, page 77. There is no climate station in the vicinity of the Burlington Quarry nor is there a climate station representative of climatic conditions on top of the escarpment at Mount Nemo. It is noted that Mount Nemo is referenced in the report however there is no figure showing its location. The average annual precipitation of 853.0 millimetres/year varies from 655.0 and 1172.0 millimetres/year. The range in precipitation represents an increase of about 80.0% over minimum annual precipitation. Is this reflected in modeling scenarios and what impact does this have on the reliability of the integrated model predictions in representing site conditions at the Burlington Quarry?	Page 76 Section 4.4.1. Precipitation and Temperature	Norbert M. Woerns	The review is correct in regards to the number of stations within the study area. We therefore assembled a large number of stations from outside the study area. Mt. Nemo is labeled on the earlier figures (See Figures 1.1 and 1.2). The model simulation period study period contained three years with precipitation greater than one standard deviation (> 980 mm/yr) and one with very low precipitation, close to the period of record minimum. 	
104.	No indication is provided in the report that a distinction has been made between data from climate stations above and below the Niagara Escarpment. The retained consultant's experience suggests that this distinction is important, affecting whether a station provides data that is or is not representative of conditions on Mount Nemo. The expectation is that the climate data from Millgrove and Mountsberg are likely to be most representative. However, referring to Figure 4.2, there are no recent data from either station. The Millgrove station is about 9.3 kilometres from the quarry.	Figure 4.2	S.S. Papadopulos & Associates, Inc.	We noted that the interpolated precipitation data showed a decreasing trend from west to east and speculated that this might be related to the presence of the Niagara Escarpment. It could also be related to proximity to Lake Ontario, degree of urbanization, or other factors. We therefore did not split the data into two populations above and below the Escarpment and interpolate the data separately.	
105.	The references for the SOLRIS land use mapping are not consistent. In the text, reference is made to SOLRIS v.3 (2019) (pages 82, 132, 446, Figures 4.8, 6.11, 17.12). However, the citation in the list of references is to MNRF (2014), accessed August 2015.	Pages 82, 132, and 446 and Figures 4.8, 6.11, 17.12	S.S. Papadopulos & Associates, Inc.	Comment noted. Correct reference is: Ontario Ministry of Natural Resources and Forestry (MNRF), 2019, Southern Ontario Land Resource Information System (SOLRIS) Version 3.0 [Computer File], Peterborough, ON (Accessed August 2019).	
106.	Are the lime coloured areas on this figure clay loam? It is not clear from the legend that these colours are the same?	Page 84 Figure 4.9. Surficial Soil Complex Mapping	Norbert M. Woerns	A figure with improved colour scale is provided below.	

					
107.	Referring to Figure 4.10, there are only three WSC stream gauges in the model area, with two of the stations close to each other on Grindstone Creek (above Highway 403 and near Aldershot). None of the three WSC stations are located on Mount Nemo.	Figure 4.10	S.S. Papadopulos & Associates, Inc.	We did not select the locations for the WSC stations. The gauge data were useful for the PRMS model pre-calibration because of the long-term record available. There were many additional gauges placed on streams above and below the Escarpment but the period of record is shorter and the data have gaps.	
108.	Referring to Figure 4.10, is it correct in understanding that Willoughby Creek is almost perpendicular to Bronte Creek where it discharges to Bronte Creek?	Page 86 and Figure 4.10	S.S. Papadopulos & Associates, Inc.	The map appears accurate and the angle may be closer to 80°.	

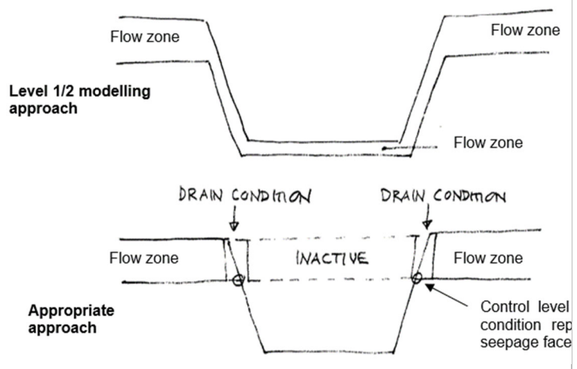
					
109.	Is there a record of flows in Willoughby Creek?	Page 86	S.S. Papadopulos & Associates, Inc.	There were three stations established on Willoughby Creek (Figure 4.14). Flow was measured from 2014 to 2019, with gaps in the record for SW7 and SW14 during the winter of each year. These flows were discussed in the chapters of the report the reviewer declined to review. 	
110.	'Many other small un-named natural and man-made features also exist in the study area, including a series of golf course ponds in the western extension lands' What role do the man-made irrigation ponds in the west extension area play in the maintenance of discharge to down gradient springs/seeps? What evidence is there to support this role?	Page 87 Section 4.3.3 Lakes and Ponds, 2nd Paragraph	Norbert M. Woerns	Average simulated seepage from the golf course irrigation ponds was about 130 m^3/d. Under Phase 3456, average simulated seepage from the infiltration pond was about 777 m^3/d. Some of that flow is recaptured by the quarry drains and recirculated.	
111.	It is indicated that the discrepancy between the Ontario Hydro Network (OHN) mapping and the observed golf course and quarry pond is due to the time period during which the OHN mapping was conducted. Documentation of the OHN mapping is not cited in the list of references. What was time period for the OHN mapping?	Page 87	S.S. Papadopulos & Associates, Inc.	We obtained the stream coverage early in the study. Most of the files were dated 4/2018 or 6/2018. https://geohub.lio.gov.on.ca/datasets/mnrf::ontario-hydro-network-ohn-watercourse\	
112.	However, on page 155 of the Level 1 and 2 Hydrogeological Assessment Report (and in Figure 6.31), in reference to Golder data (MP5), it is noted that Wetland 17 "both receives and loses to	Pages 90 and 155 and Figure 6.31	Daryl W. Cowell & Associates Inc.	Comment noted.	

	groundwater, depending on the time of year." Further, the Surface Water Assessment report notes (page 86, Table 42) that three wetlands effectively dry-out ("0.0 m water level") by late April to early May (SW11/13027; SW12/13022; and SW13/13037). These dates are identified in order to determine thresholds should impacts from quarrying result in earlier drying out (mitigation proposed on page 90, third bullet).				
113.	Precipitation data is the key driver for the PRMS analyses. It is indicated on page 92 that measured precipitation is added to the top of the model. It is important to note from the outset that no measurements of precipitation are available within the study area. Referring to Figure 4.1, there are no climate stations close to Mount Nemo.	Page 92 and Figure 4.1	S.S. Papadopulos & Associates, Inc.	This is a general problem in southern Ontario as the number of active stations continues to drop. Our best option was to interpolate the available data for the study period.	
114.	It is indicated on page 92 that the layers of the MODFLOW and GSFLOW models must be continuous across the model domain. This requirement has been interpreted in a way that is considered to be non-physical. The results close to the deep cutting features, including the Medad Valley and the existing quarry are not realistic. An excerpt from a cross-section through the model along 2nd Side Road is reproduced below (Figure 5.2), As shown in the figure, the model layers are "pushed down" below the base of the Medad Valley.  This is not a realistic representation of the bedrock flow zones in the rocks of the Niagara Escarpment. For example, a view across the gorge of the Niagara River downstream from Niagara Falls is shown on the next page. Rather than diving down below the Niagara River, the bedrock flow zones daylight at the gorge. Groundwater exits at the base of each flow zone, forming stacked seepage faces.	Page 92 and Figures 5.2-5.4 and 19.18-19.20	S.S. Papadopulos & Associates, Inc.	We agree that representing groundwater discharge at the quarry face is important. We have used the method suggested by the reviewer in numerous older quarry and Escarpment area studies that we conducted. Draping the layers into the valley allows groundwater discharge to land surface (surface leakage) to occur at or near the multiple seepage faces. This flow is conveyed overland to the nearest quarry drain or stream reach. This alternative approach is needed because of the requirement that the layers remain continuous. Its effect on the flow system is similar and easier to implement than the older one of truncating layers and assigning a drain conductance and control elevation (usually calibrated values) in the last active cell next to the outcrop. 	

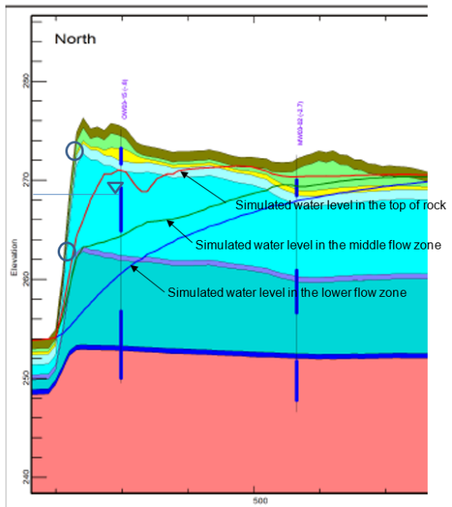
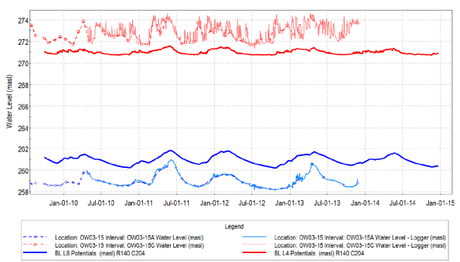


Photograph of the gorge of the Niagara River across from the Hyde Park Landfill site [Photograph by C. Neville]

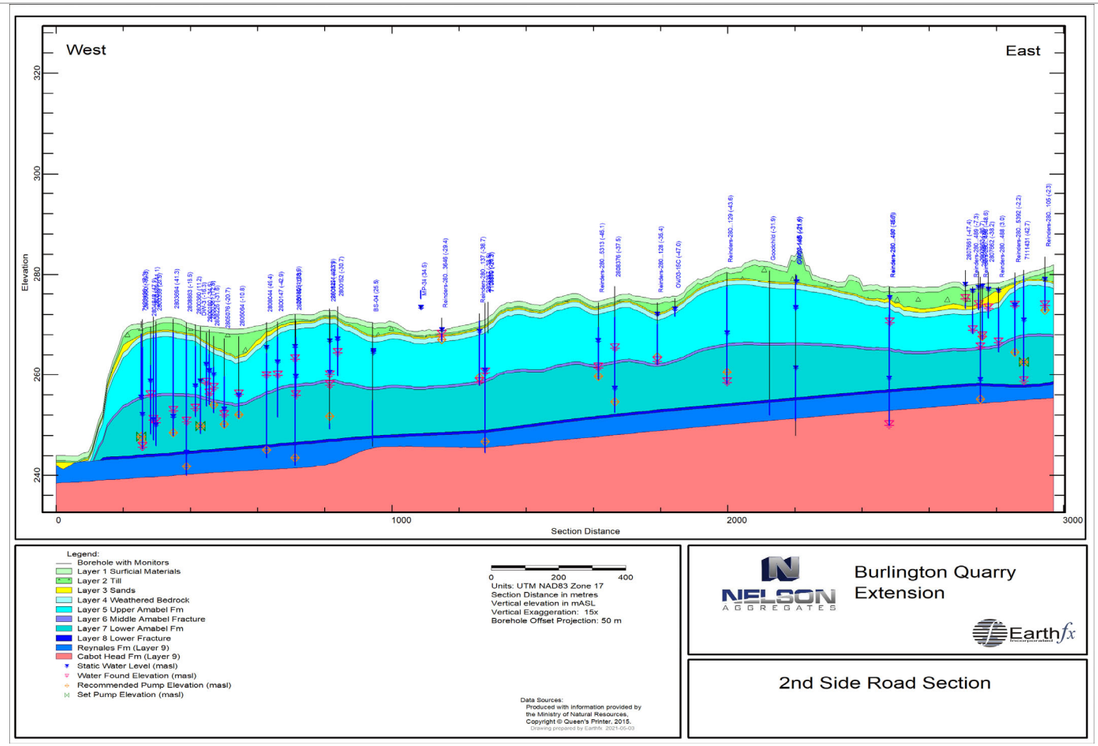
A physically realistic approach for representing this situation is shown schematically below.



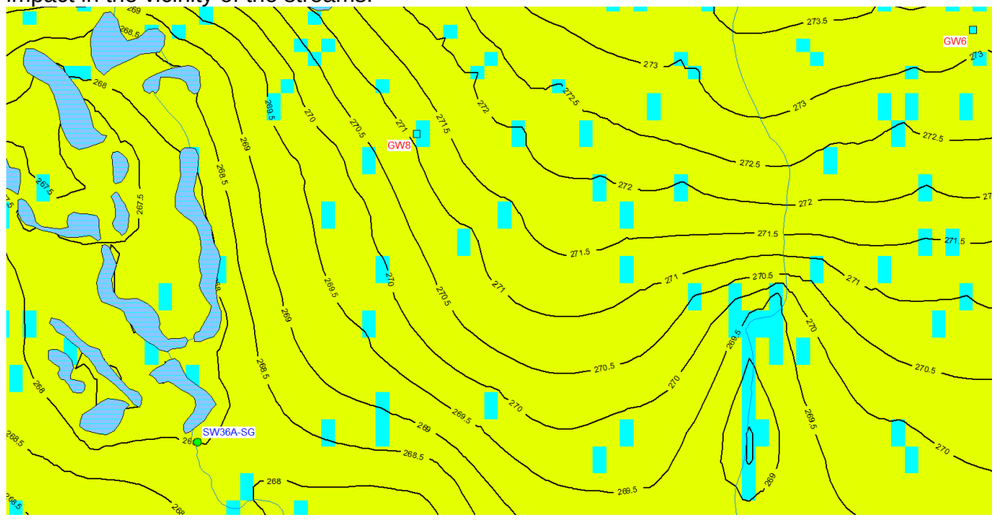
The results shown in Figures 5.2-5.4 and 19.18-19.20 of the report illustrate why the representation of conditions along the Medad Valley and Niagara Escarpment and around the existing quarry is important. A portion of Figure 19.18 is reproduced below. There is no evidence to suggest that the water levels in the weathered top-of-rock and in the middle flow zone decline steeply as predicted with the model.

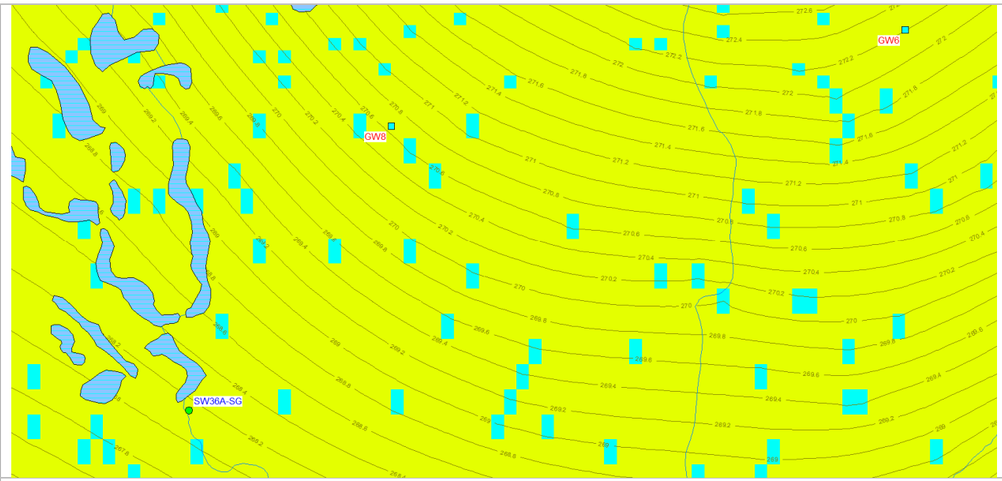
	Hydrographs for observation well OW03-15 between April 2003 and July 2010 and between July 2009 and January 2015 are reproduced here on page 9. The long-term average water levels in the shallow “C” and deeper “B” and “A” monitoring intervals are about 273.0 metres, 269.0 metres and 259.0 metres amsl, respectively. Since 2003, the water levels have varied by only about ± 1.0 metre with respect to the average levels. The water levels are controlled by the elevations at which the flow zones daylight at the quarry, indicated by the circles added to the excerpt from Figure 19.18.The non-physical simulation approach that has been adopted compromises severely the reliability of predictions of potential impacts of the quarry extension.   Figure 19.22: Comparison of observed and simulated water levels at monitor OW03-15.			If you examine Figure 19.18, you will see that the water levels are, in fact, controlled by the elevations at which the flow zones would daylight at the quarry. It should be noted that there is a zone of fill that was emplaced along the quarry face that is represented by the model. A significant effort was made to create the distribution of heads seen in Figure 19.18. The objective was to match the observations of change in head as the quarry face approached the property boundary.	
115.	‘The till is of low permeability and serves to limit recharge and/or leakage to the underlying aquifers.’ Is Halton Till located beneath the existing irrigation ponds or the proposed infiltration pond? If so, what	Page 93 Section 5.2.2. Halton Till Aquitard, 1st Paragraph	Norbert M. Woerns	Yes, we believe that Halton Till underlies most portions of the irrigation ponds. Bathymetry data were used to determine the parts of the ponds that lie on weathered bedrock. Leakage varies based on the underlying material and on pond stage. As we have noted in several responses, the upper part of the Halton Till (Layer 1) is assumed to be weathered. The unweathered till is still relatively thin and is assumed to have some vertical fracturing,	

	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?			increasing the effective permeability of the unit (i.e. K = $5x10^{-7}$, rather than what might be expected of an intact clay-silt till). The location of the fractures and any spatial pattern in the fracturing was not determined.	
116.	Quarry excavation in the western extension is to 252.5 mASL which will effectively remove most of the Amabel Formation up-gradient of the private wells along Cedar Springs Road. Maintenance of groundwater levels within the bedrock wells will, to a large extent, be dependent upon recharge of quarry discharge water through the proposed infiltration pond. Most of the primary aquifer within the source water area for these wells will have been removed with the completion of quarry excavation. What field investigations have been completed to demonstrate the effectiveness of the existing irrigation ponds and the proposed infiltration pond in recharging the underlying aquifer? Under the model assumptions, it is anticipated that the infiltrated water from the infiltration pond will be intercepted in Model Layer 4 and will not be available to the downgradient wells. The viability of the proposed infiltration pond should be confirmed with supporting field data.	Page 97 Figure 5.4. Cedar Springs Road Section	Norbert M. Woerns	Please refer to Response 4, 6 18, and 92, above. This question has been asked several times. The purpose of the infiltration pond is to replace the golf course ponds that may have contributed to groundwater recharge in the area. It is assumed that the pond will be in good hydraulic contact with the bedrock surface and should provide higher leakage than the natural ponds with their accumulated sediments. Some form of long-term maintenance may be required in the final design to ensure that the infiltration pond does not become silted up. Some of the water will be picked up in the expanded excavation area and recirculated, but the main effect is to recharge the groundwater west of the quarry and maintain higher heads and prevent the private wells from going dry.	
117.	It is noted on page 103, last paragraph, that ‘Packer test results in the west area illustrate an increase in hydraulic conductivity in the Middle Amabel (Figure 5.6), but the evidence is less clear in the Golder packer test data (Figure 5.7 and Figure 5.8).’ An explanation is required for this discrepancy. Clarification is required whether this has been accounted for in the integrated model. The source of the packer data should be indicated on the figures. The higher conductive lower fracture zone, of the lower Amabel, layer 8 of the model, is not reflected in the packer test results for the South Expansion Sections. This layer is also not clearly reflected in the packer results in the West Expansion Section. An explanation is required.	Pages 100-101 Figures 5.7 and 5.8. South Expansion Packer Section 1 and 2 Respectively	Norbert M. Woerns	It is expected that the hydraulic conductivity of the fracture zone is likely to vary. As noted, there are multiple lines of evidence for the middle Amabel fracture zone. A cross section showing water found and well completion depth along 2nd Side Road shows a pattern consistent with the interpretation of the data from multiple sources. The question then becomes: how do you spatially distribute this information from multiple lines of evidence. For simplicity, we assumed that a uniform value, guided by the mean of the test data and refined through model testing and calibration, would serve as a reasonable approach. The evidence for the lower fracture is discussed later on in Section 5.2.8.	

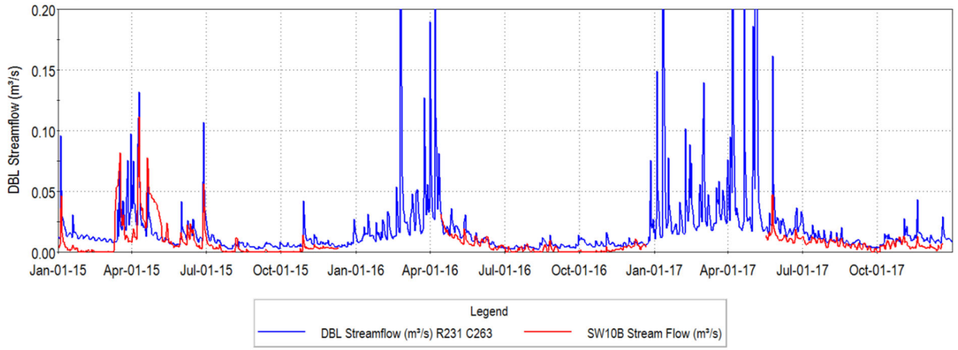
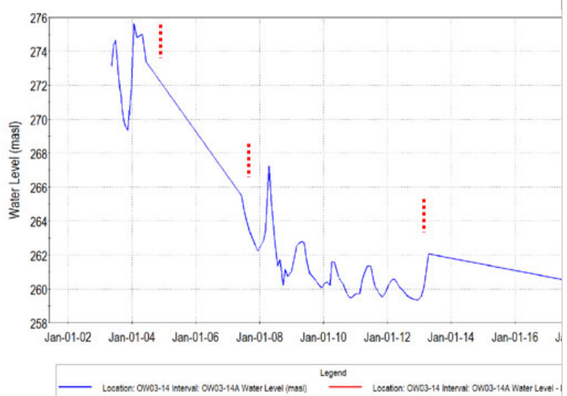
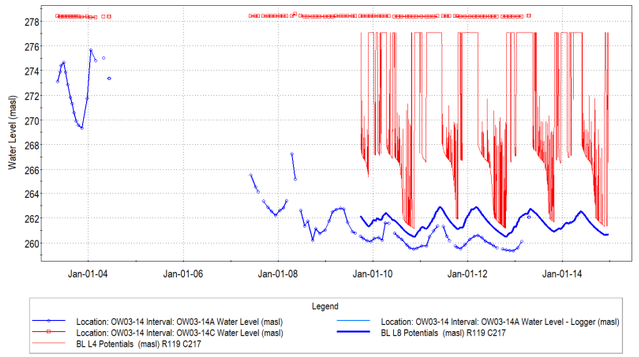


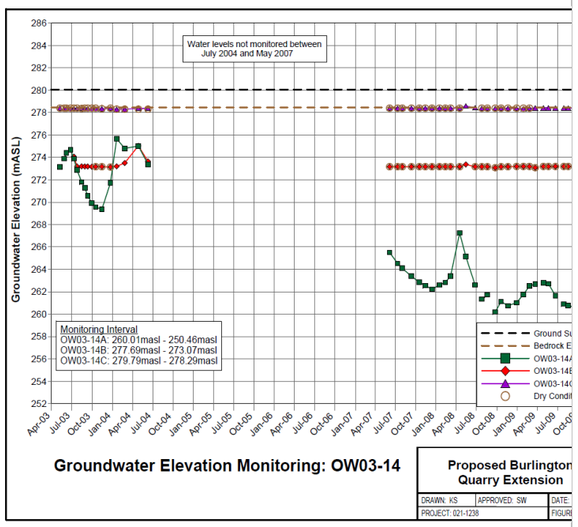
118.	Is this bedding plane fracture shown in Figure 5.9 at an elevation close to the elevations assigned for the middle flow zone in the model (model layer 6)?	Page 102 and Figure 5.9	S.S. Papadopulos & Associates, Inc.	Yes, the bedding plane fracture is near that elevation. Also see response 117, above. We expect that the elevation of the middle flow zone will vary from place to place but generally following the regional dip of the unit.	
119.	'Karst sinks were represented in the model as disappearing stream segments, where streams flowing across layer 1 drop down into layer 4. In layer 4, the karst flow is represented as a subsurface conduit that leaks or picks up flow' How does the retained consultant know that Layer 4 is the only layer that transmits karstic water? Could deeper layers not also contribute to surface discharge via springs/seeps?	Page 103 Section 5.2.4. Layer 4: Weathered Bedrock/ Overburden Interface Aquifer, 4th Paragraph	Norbert M. Woerns	Yes. We made the assumption that flow would likely be carried within the weathered bedrock layer, but it is possible that it could go through some deeper fractures. For an impact analysis perspective, we felt that heads in the weathered bedrock would be most sensitive to changes in flow and vice-versa, and therefore the assumption is relatively conservative.	
120.	How was the subsurface conduit to model the disappearing stream segment represented in the model?	Page 103 Section 5.2.4. Weathered Bedrock/ Overburden Interface Aquifer	Conservation Halton	The SFR2 stream segment was assumed to interact (i.e., gain or lose flow to the weathered bedrock) with Layer 4. The stream had a relatively narrow section (same as a Strahler Class 2) and a bed hydraulic conductivity of $1x10^{-4}$ m/s compared to normal streams in Layer 1 ($5x10^{-7}$ m/s).	
121.	It is indicated that Layer 4 has a minimum thickness of 1.0 metre. However, on page 103 it is indicated that an assumed depth of weathering equal to 0.3 metre	Pages 103, 140, and 141	S.S. Papadopulos & Associates,	The upper weathered fracture zone had a minimum thickness of 1 m. The 0.3 is a typo.	

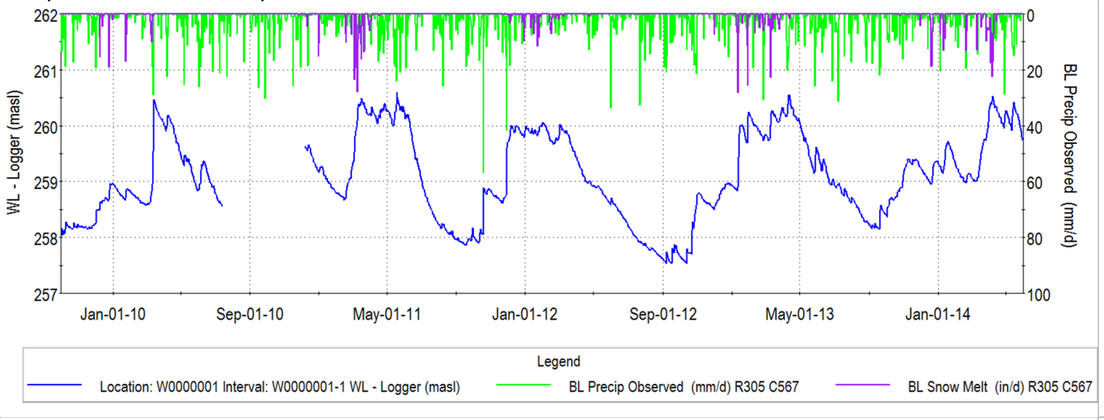
	was applied across the model, extending down from the top of bedrock. What is the correct thickness of model layer 4? Do the available hydraulic testing data support an inference of the depth of weathering in the rock?		Inc.	Packer testing by Golder and Azimuth was generally done more than 2 m below the bedrock contact (likely because the zone was sealed off by the surface casing). Packer test data are provided in Schedule E.	
122.	It is noted that low and high limits of bulk hydraulic conductivities for Amabel Formation used in the model as presented in Table 5.1 are some of the lowest values reported by others. How do hydraulic conductivities used in the model compare to the on-site field investigation derived data? The use of a uniform hydraulic conductivity data may work well for the overall system response, but please confirm if it is suited to represent local groundwater and surface water interactions? Although a lot of field testing to obtain hydraulic conductivity data was done on and in vicinity of the site, instead of using them to refine the model and to represent local conditions, a uniform hydraulic conductivity values are used, please explain.	Page 104 Section 5.2.5.1. Amabel Formation hydraulic Conductivity	Conservation Halton	It should be noted that the range in values cited was relatively small, so being in the lower range is not that significant. Early in the study, we used the model to replicate the aquifer testing results and ultimately selected values that were comparable. The packer test data vary over a large range and our value is within the range of reported results. We analyzed the water level data and tested to see if there was any consistent pattern to assign spatial variability to the model parameters. In particular, early in the study we used the pilot point technique in conjunction with PEST to create an interpolated hydraulic conductivity field. In the end, we found no consistent pattern and went back to uniform property assignment.	
123.	The representation of vertical fractures to connect the shallow and deeper systems by adjusting Kh/Kv anisotropy value to 1:1 of model Layer 5 and Layer 7 in 5.0% of model cells maybe a good fit for the overall regional groundwater conditions. This approach suggests that areas not underlain by the model cells where Kv/Kh anisotropy was not adjusted may be subject to reduced groundwater flux than areas where the adjustment was made. Considering the above, this approach may misrepresent groundwater and surface water interactions within streams and wetlands depending on the location of the zones with adjusted parameters. Please reconsider this approach.	Pages 104 and 105 Section 5.2.5.2. Anisotropy and Vertical Flow Patterns	Conservation Halton	Adding vertical fractures to connect the shallow and deeper systems by adjusting the Kh/Kv anisotropy values was done more to fit local response in the vicinity of the quarry face rather than improving regional groundwater heads. In general, the simulated heads (Layer 4 average heads shown with a 0.5 m contour interval overlying the Layer 5 VKA assignment) show small localized breaks in slope in the vicinity of the fracture zones (indicative of groundwater moving down to deeper zones) but much larger changes in the vicinity of surface water features. Layer 7 heads (second figure) show little change in the vicinity of the fracture zones and the only break in slope occurring near the karst stream segment. There is likely little impact in the vicinity of the streams. 	

					
124.	Typographical error? Reference to Worthington Groundwater (2019). Should this be Worthington Groundwater (2020)?	Page 105 Section 5.2.5.2. Anisotropy and Vertical Flow Patterns, 2nd Paragraph	Norbert M. Woerns	Comment noted. Reference was to an initial draft. Correct reference is: Worthington Groundwater, 2020, Appendix B – Karst Investigation: in Level 1 and Level 2 Hydrogeological Assessment Proposed Burlington Quarry Extension – Appendix A and B, report prepared by Earthfx Inc. for the Nelson Aggregates Co., November 2019, 41 p.	
125.	'the bulk anisotrophy of Layer 5 (upper bulk Amabel) was estimated to be 500:1 (Kh/Kv) and Layer 7(lower bulk Amabel) to be 1000:1 (Kh/Kv).' The above statement is in contradiction to the last paragraph of page 104 which reads as follows: 'It is widely recognized that the dolostones of the Niagara Escarpment have a high degree of vertical to horizontal anisotropy. Maslia and Johnston (1984) studied the "effectiveness of horizontal (bedding) joints versus vertical joints as water transmitting openings". They concluded that vertical hydraulic conductivity (Kv) to horizontal conductivity (Kh) anisotropy of 100:1 to 1000:1 was typical of Lockport (Amabel) Formation.' These are contradictory statements therefore one of the above statements must contain a typographical error. Please correct.	Page 105 Section 5.2.5.2. Anisotropy and Vertical Flow Patterns, 3rd Paragraph	Norbert M. Woerns	Typo on the h and v: Sentence should read: 'It is widely recognized that the dolostones of the Niagara Escarpment have a high degree of vertical to horizontal anisotropy. Maslia and Johnston (1984) studied the "effectiveness of horizontal (bedding) joints versus vertical joints as water transmitting openings". They concluded that horizontal hydraulic conductivity (Kh) to vertical conductivity (Kv) anisotropy ratios of 100:1 to 1000:1 was typical of Lockport Formation.'	
126.	As per Figure 18.20 it appears that the cells with increased vertical hydraulic conductivity are not present within some 100.0 metres of the edge of escarpment and within the Medad valley – please explain. Based on the retained consultant's experience the distribution of vertical fractures near the escarpment tends to be higher (halo effect).	Page 105 Figures 18.20 and 18.21 Section 5.2.5.2. Anisotropy and vertical Flow Patterns	Conservation Halton	Each cell in the model was assigned a random number from 0 to 1. Five percent of the cells (those with a random number between 0.95 and 1, for example) were assigned a different VKA value. There was no consideration of proximity to the Niagara Escarpment so some cells must have higher VKA in proximity to the Escarpment. Incorporation of an enhanced fracturing halo zone was tested early in the model development but was not found to improve results.	

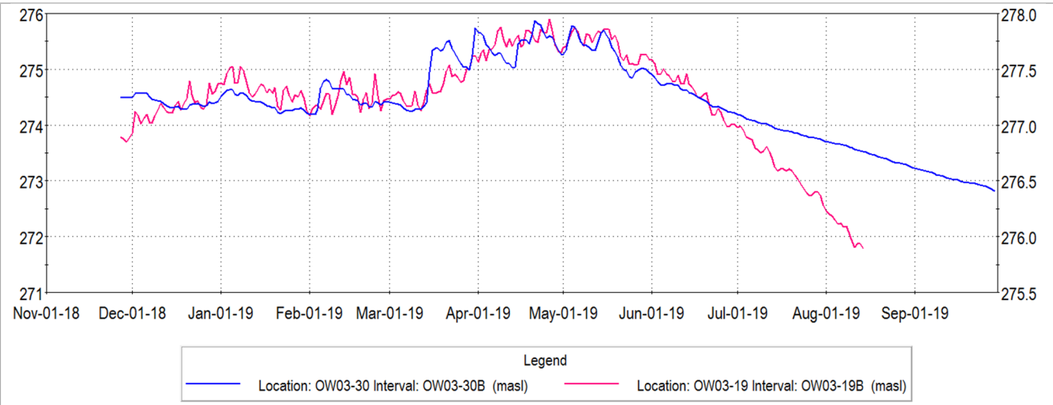
127.	It is indicated that downward leakage tends to minimize the differences in the head between the shallow and deeper bedrock layers. This seems to be in direct conflict with the water level data shown in Figure 5.11. There is a substantial difference in the water levels between the “A” and “B” intervals (~10.0 metres), and it may only be possible to sustain this head difference if the intervening rock has relatively low vertical hydraulic conductivity at this location.	Page 105 and Figure 5.11	S.S. Papadopulos & Associates, Inc.	The point of this whole discussion was that the differences in head between shallow and deep bedrock layers decrease with distance from the quarry face. This is essentially the “quarry face paradox”. As the reviewer noted, it is only possible to sustain this head difference if the intervening rock has relatively low vertical hydraulic conductivity. However, the hydrograph also shows that there is response in the deep system that is not lagged or attenuated, which is only possible if there is a relatively high vertical hydraulic conductivity. The random placement of vertical fracture zones offered a reasonable solution to the paradox.	
128.	It is indicated that municipal supply wells FDF01 and FDF03 “have been interpreted to intersect the highly permeable fractured zone in the middle of the Gasport Formation.” Who has made this interpretation?	Page 105	S.S. Papadopulos & Associates, Inc.	Earthfx hydrogeologists.	
129.	It is suggested in the second paragraph of this section, based on Figure 5.12 which presents water levels in OW03-14C that quarry influence is less than 200.0 metres from the quarry face. Based on other monitoring well results it seems that this may be true for this location only suggesting that the aquifer is not uniform, and which puts in question the use of uniform hydraulic conductivity values in model layers. Please reconsider the use of uniform hydraulic conductivity values in the model.	Page 106 Section 5.2.8. Layer 8: Lower Fracture Zone	Conservation Halton	This area is the most monitored in the study area and it seemed reasonable that, without observations to the contrary, relatively consistent aquifer properties should be adopted. As noted earlier, as part of model development we used the pilot point technique in conjunction with PEST to create an interpolated hydraulic conductivity field. In the end, we found no consistent pattern and went back to uniform property assignment.	
130.	‘A hydrograph from monitoring location OW03-15, south of the 2nd Side Road (see Figure 3.4) is shown in Figure 5.11. Water levels in the deepest monitor (OW03-15A) at this location are over 13 m below those of the water table (OW03-15C), clearly indicating that the lower system is connected to the quarry by a permeable lower fracture.’ The above statement suggests that the existing quarry is draining the lower flow zone. What is the extent of the quarry influence on this flow zone?	Page 106 Section 5.2.8. Lower Flow Zone, 1st Paragraph	Norbert M. Woerns	As noted in the report, there are strong head differences between the shallow and deep system near the quarry face and, as noted, the outcrop of the lower fracture zone is likely helping to drain the deeper system. Leakage from above contributes to the inflow but at a rate that cannot bring the heads up to near shallow bedrock levels. Further from the quarry, at about 300 m of the quarry face, lateral flow towards the quarry face is better balanced by leakage from above and the head differences are much smaller. This is directly analogous to flow to a well in leaky aquifer.	
131.	‘A hydrograph from monitoring location OW03-15, south of the 2nd Side Road (see Figure 3.4) is shown in Figure 5.11. Water levels in the deepest monitor (OW03-15A) at this location are over 13 m below those of the water table (OW03-15C), clearly indicating that the lower system is connected to the quarry by a permeable lower fracture.’ A similar pattern is observed in monitor nest OW03-14 (Figure 5.12). When the monitor was installed in 2004, the quarry face was 175 m from the monitor (Figure 3.8). Between 2004 and 2009 the quarry face advanced to within 40 m of the monitor, and during that time the heads in the lower system dropped 14 m. This provides particularly useful information, for it suggests that the quarry influence is less than 200 m	Page 106 Section 5.2.8. Lower Flow Zone, 1st and 2nd Paragraph	Norbert M. Woerns	Head differences decrease relatively quickly with distance from the quarry face. At the quarry face there is about a 15 m difference between Layer 4 and Layer 8 heads. This decreases to about 5 m within 300 m from the face. By 600 m there is no difference between Layer 4 and Layer 6 heads and about a 1 m difference between Layer 6 and Layer 8. By 900 m, there is no difference in the simulated water levels. This is generally consistent with the observations, but the reviewer is correct that the model shows a slightly higher degree of influence and the model would tend to over-predict the impact of quarry expansion.	

	from the active face.' A much larger zone of influence of up to about 1000.0 metre is indicated in East Calibration Section, Figure 6.2.3 page 148. Have the impacts of the existing quarry stabilized or are the drawdowns continuing? A figure showing the cone of influence and drawdown from the existing quarry should be provided.				
132.	The hydrographs for monitoring location a OW03-14 and OW03-15 indicate data gaps between January 2004 and Jan 2008 as well as between January 2014 and late 2018. The data gaps include the drought period (2015/2016) and the wet period (2017) included in the model simulations as noted on page 31, Section 1.3.2. What impact does this have on the reliability of the model calibration?	Page 107 Section 5.2.8. Lower Flow Zone, 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)	Norbert M. Woerns	There are gaps in the groundwater observations that Earthfx had no control over. With regards to the reliability of the model predictions for that period, our simulations of streamflow (along with estimated quarry dewatering) for the drought period compare well with the available observed data (see figure below for drought flows at SW10B). The integrated model shows that streamflow is reduced compared to average flows especially in the groundwater-level sensitive headwater tributaries. The ability to simulate drought streamflow gives us confidence in the model's ability to simulate changes in drought recharge and heads. 	
133.	The connecting of the hydrographs across time long gaps provides a misleading impression. The lines connecting the gaps are in effect speculations regarding what might have happened during the gaps. Alternate hydrographs have been reproduced for OW-3-14 to illustrate objections to the presentation and to illustrate an appropriate approach.  Figure 5.12: Water levels recorded in Monitoring Well OW03-14 (175 m to 40 m fro	Figures 5.11, 5.12, 19.6, 19.12, and 19.15	S.S. Papadopulos & Associates, Inc.	There are many ways to present the data. In Figure 19.23, the same data are presented with the gaps shown. Here, the figures were drawn to highlight the decrease in head. 	

					
134.	It is indicated that a horizontal hydraulic conductivity of 1.0×10.0^{-7} metres/second (1.0×10.0^{-8} metres/second, vertical) was selected for the Lower Aquitard (collectively the Lower Gasport through Manitoulin formations). What is the basis for this selection? Are the model results sensitive to the value of the hydraulic conductivity assigned to Layer 9?	Page 108	S.S. Papadopulos & Associates, Inc.	Typo: Sentence should read; For the simulations in this study, a collective transmissivity of $1x10^{-7}$ m^2/s was selected. For model stability, Layer 9 was treated as a constant transmissivity layer. Assuming that flow mostly takes place in the upper 5 m, that given a Kh of about $2x10^{-8}$ m/s. Relatively little flow occurs in this zone and model results should not be overly sensitive to the K of this zone within reasonable upper bounds.	
135.	Monthly water level data were collected by Golder starting in 2003, and continuous data were collected in most wells from 2007 to 2013 and only starting again in October of 2018. Considering that the longest transient water level dataset is 2007 to 2013 why does the transient model run start at WY2010? It should be noted that the Level 1 and 2 Hydrologic and Hydrogeologic Assessment Terms of Reference proposes a 25 year simulation, and it specifically mentions years 2007, 2008 and 2009 as representative of dry, wet and average climate conditions, respectively.	Page 109 Section 5.3.1.2. Transient Water Level Data	Conservation Halton	The monitoring network was developing over the period of 2004 to 2008, and the most complete dataset for calibration was near the end of that period. Also please refer to Response 79 Model stability issues and long-run times forced the use of a 10-year simulation period (the stability issues were not related to the quarry but rather to conditions at Mt. Nemo, where the Escarpment is very steep). Working back from 2019 to ensure that recent data for the west was included, gave us a model start time in WY2009. There were drought periods in 2015 and 2016, so the need to simulate drought conditions was covered.	
136.	Are the water level maps developed exclusively from levels reported in the MECP WWIS database? If yes, how do maps compare with the high-reliability data from dedicated Site monitoring wells? If no, how were the data of very different reliability synthesized?	Page 109 and Figures 5.13 and 5.14	S.S. Papadopulos & Associates, Inc.	Developing water level maps was a multi-step process. We started with a database query to get average water levels for all wells within the study area. The query automatically averaged the observations for wells with multiple measurements and retrieved the single static water level measurements for the MECP wells. Wells were posted in VIEWLOG with gradient colours so that likely outliers could be easily spotted. Follow-up investigations (looking at paper records, comparison of reported ground elevations with the DEM) were done to see if the errors were positional, due to errors in the units, or ground elevation). It should be noted that many of the potential outliers could not be discarded as the data seemed reasonably accurate and the differences could be more likely attributed to the fractured nature of the bedrock. The remaining wells were flagged as outliers and removed from subsequent queries. Wells were partitioned into shallow and deep subsets and further partitioned into above and below the Escarpment subsets. Variography was completed on each subset to determine the best variogram shape and estimate of nugget, range, and sill. The data were then kriged to the model grid and the above/below	

				Escarpment maps were merged. The site monitoring data and MECP wells form two mostly non-overlapping data sets. Interpolation to a grid cell was done by selecting the nearest eight wells in each quadrant. Thus, within the vicinity of the quarry, the site wells dominate the interpolation, while outside the site vicinity, the MECP wells are generally the only data source used.	
137.	When presenting water levels and interpretations, it is important to note from the outset the important differences in the reliability of the levels in the MECP WWIS database and the average water levels inferred from the records for the Site monitoring wells.	Page 109	S.S. Papadopulos & Associates, Inc.	See above	
138.	How do the water level maps compare with the interpreted hydrostratigraphy? For example, are the levels for wells with completion depths less than 15.0 metre representative of the weathered top of rock, the “middle Amabel flow zone”, or some synthesis of both? Are the levels for wells with completion depths greater than 15.0 metre representative of the “middle Amabel flow zone”, the “lower Amabel flow zone”, or again some kind of average for both intervals?	Page 109 and Figures 5.13 and 5.14	S.S. Papadopulos & Associates, Inc.	It should be noted that most MECP wells are open hole and may be screened across the Upper and Middle zones, the Middle and Lower zones, or all three. The maps were intended to show general magnitudes and flow patterns in the groundwater data. General comparisons between these and model results were made on a study area scale. Detailed comparisons with particular wells in the site vicinity are also discussed.	
139.	‘There are nearby Provincial Groundwater Monitoring Network (PGMN) wells; however, all are located outside the study area.’ Were the PMGM wells used to correlate climate data to ambient groundwater levels?	Page 109 Section 5.3.1. Water Level Data Sources and Monitoring Record, 1st Paragraph	Norbert M. Woerns	A discusion of the seasonal response (Nov 2018-to August 2019) at PGMN well W00005-1 was provided in Section 5.3.3. The figure below shows a longer-term hydrograph for PGMN well W00001, located in Kilbride, about 5 km NE of the site compared to interpolated precipitation and simulated snowmelt in the closest nearby active model cell. There is a very good correltation between well response and precipitation/snowmelt events, especially during the spring. The summer response is very muted, as might be expected, but the small spikes in water levels correlate well with the larger rainfall events. This indicates that although the data are not perfect and there are substantial distances between the well and the active stations, the interpolated climate data produces reasonable results.  	
140.	‘Although there are gaps, the data provide useful insight into how the wells respond to rainfall events and to seasonal and inter-annual climate variability.’ It appears as though there were no on-site climate data to correlate water levels to climatic events. Reliance on off-site climatic stations and composite climatic records from different climate stations as	Page 109 Section 5.3.1.2. Transient Water Level Data	Norbert M. Woerns	See above	

	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.				
141.	Area west of the quarry between the quarry and the Medad Valley is depicted on Figure 5.15 as having downward gradients, which suggests recharge conditions. Same figure identifies upward gradients within the Medad valley discharge conditions. If the west quarry is approved what would be the mechanism to guarantee the pre-extraction quantity of water is directed to support groundwater discharge function in Medad Valley and associated natural features?	Page 110 Figure 5.15 Section 5.3.2.1. Vertical Head Differences	Conservation Halton	Care should be used in interpreting the water level maps especially in areas of sparse data. In general, the map shows that there is little difference between the deep and shallow layers along the stream in the Medad (Willoughby Creek) but higher heads to either side, indicating a discharge zone. This is based on few data points, however, as access and data from within the valley is limited. Much of the area contributing to the upper reaches of Willoughby Creek (before the confluence with the tributary carrying quarry discharge) will be unaffected by the west quarry extension. The infiltration feature is intended to mitigate the drawdowns that will likely occur near the quarry footprint.	
142.	What is the sign convention adopted for the mapping of the head differences in Figure 5.15? Is the following interpretation correct (with h denoting hydraulic head)? • Negative values: h(<15.0 metres) > h(>15.0 metres) ⟶ downward flow • Positive values: h(<15.0 metres) < h(>15.0 metres) ⟶ upward flow	Page 110 and Figure 5.15	S.S. Papadopulos & Associates, Inc.	There is a typo in the caption; it should read: Vertical head differences (deep minus shallow groundwater levels, in m). We subtracted the shallow water levels from the deep ones. The vertical head differences are colour contoured where red-shaded values (negative) indicate higher heads in the shallow system (downward flow) while blue shading (positive) indicates higher heads in the deeper system and upward flow.	
143.	This figure shows areas of upward and downward vertical hydraulic gradients. Two areas of downward gradients (in blue) are show near the edge of the Niagara Escarpment east of the subject property. These areas are located where there are few or no wells. How were these areas of downward hydraulic gradients determined? Earthfx has acknowledged that: 'While there are some clear patterns of downward gradients near the Escarpment face (shown in blue), the limitations in the MECP water well record data and spatial distribution result in limited usefulness.' (Page 110, Section5.3.2.1) Clarification is required of the information shown on Figure 5.15.	Page 113 Figure 5.15. Vertical Head Differences	Norbert M. Woerns	Typo. The blue areas are upward gradients, that is, heads in the deeper system are higher than the shallow. They are likely an artifact of limited data at the Escarpment brow.	
144.	Figure 5.16 presents a 9 month water level hydrograph for OW03-30B, which is most likely impacted by the quarry operation in 2018/2019. Discussion of a long-term natural seasonal water level fluctuations should be supported by a long-term water level monitoring dataset for wells not impacted by the quarry operation.	Page 114 Section 5.3.3.1. Seasonal and Inter-annual Pattern	Conservation Halton	The figure below shows a hydrograph for OW03-19B, located 1000 m from the quarry face or 750 m further than OW03-30B. They both show a similar seasonal response patterns.	

					
145.	'Figure 5.16 presents a hydrograph for monitoring well MW03-30B, which shows typical seasonal water level patterns.' Figure 5.16 shows water levels for the period between November 2018 and August 2019. Does this period represent typical climatic conditions expected for this area? In other words, how typical is this period of time?	Page 114 Section 5.3.3.1. Seasonal and Inter-annual Patterns, 2nd Paragraph	Norbert M. Woerns	The point of the figure was to show that "Groundwater levels show a muted response in the late fall and early winter as the ground freezes, precipitation decreases, and snow accumulates. Peak water levels generally occur in early to mid-April primarily due to recharge from precipitation and snowmelt events after the ground has thawed. Groundwater levels decline through the summer because few infiltration events reach the water table, and most of the water in the soil zone is lost to evapotranspiration. Groundwater levels typically recover in the early fall due to increased precipitation and decreased ET." The period was selected because it is a period of recent continuous data collection. The seasonal pattern is typical of most wells in southern Ontario. 2018 was a year with near average annual rainfall. Inter-annual variation was discussed further on in the section.	
146.	A relationship between the distance of the extraction face and groundwater levels in the shallow bedrock and deep bedrock is documented in this section. Even at 1000 metres away from the extraction face the groundwater levels are not at pre-extraction levels ("nearly identical"). This summary is based on a discussion of groundwater levels at four locations only (OW03-15, OW03-21, MW03-09 and OW03-17). All available groundwater level data should be provided for this assessment.	Page 115 Section 5.3.3.2. Quarry Water Level Patterns	Conservation Halton	The point of this section is that extraction at the quarry face caused a relatively sharp drop in water levels in the deeper bedrock. The decrease in heads is maintained because local leakage from above (between 0 and 50 m) cannot match the drainage at the lower fracture zone outcrop. Further away from the quarry, the net leakage between the well and the quarry face (0 to 1000 m) balances the lateral outflow and there is no further decrease in water levels. At that point, the difference between the shallow and deeper bedrock is small, but not zero, since there is still vertical movement to the deeper system due to natural recharge from above. Water level data have been provided in two tables in Schedule E. There are 36373 manual measurements in the table and 128371 logger values. The logger data represents daily averages. We did not export the over 6.3 million sub-daily logger values.	
147.	It is clearly seen on the provided hydrographs that in the end of 2009 groundwater levels were already impacted by the quarry operation at 50, 300, 650 and 1050 metres away from the quarry face. The end of 2009 clearly cannot be used as the beginning of the transient model simulation used as a baseline scenario as it already shows impacts in groundwater conditions. Please update the baseline period.	Page 115 Section 5.3.3.2. Quarry Water Level Patterns	Conservation Halton	By 2009, the quarry footprint had reached the quarry boundary and the effects of this change had been expressed in the water level data. 2009 is an intended baseline for comparison of the simulated response under a succession of quarry expansion/rehabilitation phases to the current baseline conditions. Rather than doing a series of punctuated steady-state simulations, we intended to capture the full range of daily responses under a 10-year range of daily climate inputs.	
148.	'Wells in close proximity to the quarry (e.g., OW03-15, which is 50 m from the face) exhibit more than 14 m of vertical head difference between the Layer 4 shallow bedrock and Layer 8 deep fracture zone, as illustrated in Figure 5.11'. The above suggests that layer 8 is drained by the	Page 115 Section 5.3.3.2. Quarry Water Level Patterns, 1st Paragraph	Norbert M. Woerns	The question has been answered earlier. In essence, heads differences decrease relatively quickly with distance from the quarry face. The decrease in heads is maintained because local leakage from above (between 0 and 50 m) cannot match the drainage at the lower fracture zone outcrop. Further away from the quarry, the net leakage between the well and the quarry face (0 to 1000 m) balances the lateral outflow and there is no need to further decrease water levels. At that point, the difference between the shallow and deeper bedrock is small, but	

	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.			not zero, since there is still vertical movement to the deeper system due to natural recharge from above. Several points can be made with regards to surface water features: (1) The steep decline is relative to the shallow bedrock heads. Heads in the weathered till, the zone in direct contact with the wetlands that are not perched is largely unaffected; (2) wetlands that are perched are obviously unaffected; (3) the impact on the deep bedrock attenuates rapidly with distance and wetlands beyond 300 m should not have been affected at all by the decrease caused by the approach of the quarry face; (4) although the change occurred in a gap period, the response was likely rapid and a new equilibrium quickly established due to relatively small storage values in the bedrock. The issue of cumulative impact is discussed in Response 3, 15 and 77	
149.	The Level 1 and 2 Hydrogeological Assessment (Page 115) notes that: "With increasing distance from the quarry, the difference in head between the shallow and deep system is reduced. At 300 m from the face, the difference in head has decreased to 10 m…and the water levels in the deep system become much more variable (as much as 6 m). This variability is due to the effects of seasonal recharge that serve to replenish the lower system. During the spring freshet, higher rates of recharge and higher water table are able to fill the vertical fractures and drive flow to the lower system faster than it drains laterally to the quarry... at 650 m from the quarry face…up to 4 m in head difference." (highlighting mine)	Page 115	Daryl W. Cowell & Associates Inc.	Comment noted.	
150.	Why has a distance of 500.0 metres from the proposed extraction area been selected for particular focus? Is it expected that beyond this distance the potential impacts to private wells will be negligible? Does the calibrated model support this expectation?	Page 118	S.S. Papadopulos & Associates, Inc.	The simulated 2-m average drawdown extends a maximum of about 500 m. It is expected that most wells would have more than 2-m of available drawdown and would not be adversely affected. This is consistent with Source Water Protection water budget analysis, which also considers natural seasonal variability in the identification of the WHPA-Q	

151.	'The actual amount of water consumed at the Burlington Quarry is relatively small. Well over 90% of the water handled is returned to the local watershed.' How is the amount of water consumed at the quarry measured and what does it consist of?	Page 118 Section 5.4. Groundwater Use, 1st Paragraph	Norbert M. Woerns	Water enters the quarry primarily as rainfall and groundwater seepage but there is some inflow from ditches along Colling Road to the north. The amount discharged from the two quarry sumps is recorded. Differences between inflows and quarry discharge are due to evaporation and losses to groundwater, primarily beneath the quarry ponds. This mass balance is represented in the model, allowing us to match the quarry discharge in the model rather than specifying it as a measured value. Our match to the actual flows is good and improves in the later years when pumping was done continuously rather than on an as needed basis. This gives the model predictive power to estimate quarry discharge in the impact assessment scenarios.	
152.	'Some discharge from Quarry Sump 0100 is diverted, via gravity flow, to the Burlington Springs Golf course for use as irrigation under a separate permit.' How much water is diverted to the golf course and how much is diverted to the tributary to Willoughby Creek?	Page 118 Section 5.4. Groundwater Use, 2nd Paragraph	Norbert M. Woerns	There are no measured records of water diversion for golf course irrigation. The Quarry and Golf Course have been collaboratively using water for decades. There is a weir that can be controlled to raise stage in the pond, thereby feeding the golf course ponds. Flow is measured at SW1, but it would be hard to estimate the actual losses from the available data.	
153.	Considering that groundwater zone of influence extends beyond 1000.0 metres away from the quarry face, if the ARA license is issued a follow up water well survey within at least 1000.0 metres of the quarry face should be carried out.	Page 118 Section 5.4.1. Private Water Wells	Conservation Halton	The AMP states that a follow up well survey will be completed for wells within 1km. The assumption was that most wells would be able to handle the 2-m average drawdown at 500 m. Drawdowns at 1000 m are less than 0.25 m, well below normal seasonal fluctuations.	
154.	'Of the 156 homes visited, only eleven homeowners indicated that they were interested in participating in the monitoring program. Seven of the eleven private domestic water wells were accessible and, as a result, have been added to the current groundwater monitoring program (Figure 10.1)' A summary of results of the door to door well survey should be included as supporting information in the report. Copies of 26 well forms were provided in a separate information package received September 29, 2020. It is not clear whether these are all of the well survey results.	Page 118 Section 5.4.1. Private Water Wells, 3rd Paragraph	Norbert M. Woerns	See response 12	
155.	It seems that total well depth was used to calculate available drawdown for private wells as presented in Table 5.3. At least 1.5 metres should be deducted from the well total depth to allow for pump setting and avoid pumping sediment. Also, private water well survey results are needed for this assessment as pump type (single jet, double jet vs submersible) may alter the available drawdown for a particular well.	Page 119 Section 5.4.1. Private Water Wells	Conservation Halton	Many of the cross sections (including that shown in Response 117) indicate that some private wells are completed through the aquifer, possibly to provide the extra depth for pump installation. Given this possible solution, reporting the available aquifer drawdown is clear and sufficient for contingency planning.	
156.	Streamflow monitoring stations included in the GSFLOW calibration – Referring to Earthfx (2020; Sections 6 and 19), results from the calibration of the GSFLOW model are presented for 7 stream monitoring stations plus the Water Survey of Canada gauge at Grindstone Creek near Aldershot. 1. Grindstone Creek near Aldershot (02HB012): WY2010-WY2013 [Figure 6.18, 19.1] 2. SW01 (Main quarry discharge [north sump]): 2014-2019 [Figure 19.10] 3. SW02: WY2015-WY2019 [Figure 19.13]; 2017	Sections 6, 7 and 19	S.S. Papadopulos & Associates, Inc.	We tried to present a comprehensive but not exhaustive comparison of results. Still, it should be noted that although the reviewer states that selective use has been made of the available data in the GSFLOW calibration, of the 20 gauges, 10 were located more than 3.5 km from the site and, *of these, seven were outside the model boundary*. We found that no change in simulated flow occurs at or close to these locations. SW15 is on the opposite (north) side of the quarry and far from the expansion areas. SW7 and SW14 were discussed in great detail, so it was only SW2 which was omitted and the effects of the quarry extension were better seen in the upstream gauges.	

[Figure 19.14]; 2018 [Figure 19.15]
4. SW06 (South quarry discharge [south sump]): WY2015-WY2019 [Figure 19.11]; 2017 [Figure 19.12]
5. SW09: WY2017-WY2019 [Figure 19.7]; 2019 [Figures 6.20 and 19.8]
6. SW10[B]: WY2019 [Figure 6.19]; WY2017-WY2019 [Figure 19.5]; 2019 [Figure 19.6]
7. SW29: WY2017-WY2019 [Figure 19.9]

It has been left with the impression that selective use has been made of the available data in the GSFLOW calibration.

- Results from the GSFLOW calibration analyses are presented for 6 of the 20 existing streamflow monitoring locations. No explanations are provided regarding why calibration results were not presented for the other 14 streamflow monitoring locations.
- The understanding is that the GSFLOW calibration period extends from WY2015 to WY2019 (i.e., 5 years); however, matches to the observations are reported only for varying intervals within this period.

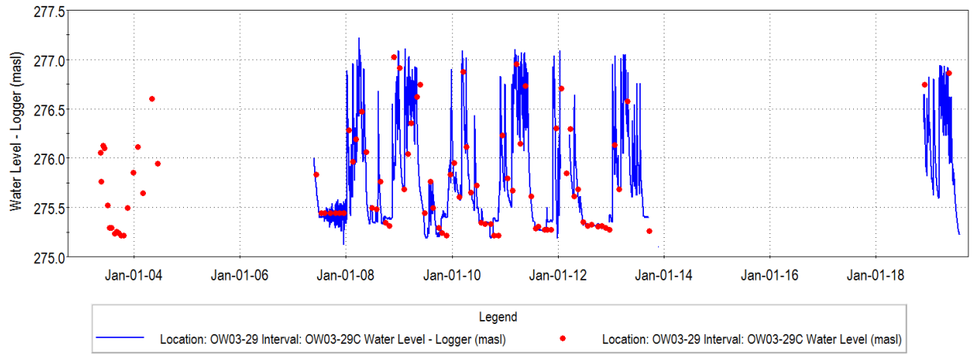
Referring to Earthfx (2020; Section 7), GSFLOW model results for baseline conditions are presented for only 6 on-site stream monitoring stations.

1. SW07: Figures 7.14 and 7.15
2. SW09: Figures 7.4 and 7.5
3. SW10[B]: Figures 7.12 and 7.13
4. SW28: Figures 7.10 and 7.11
5. SW29: Figures 7.6 and 7.7
6. SW36A: Figures 7.8 and 7.9

The results for the streamflow stations are not sufficient to confirm that the GSFLOW simulation are a reliable representation of baseline conditions.

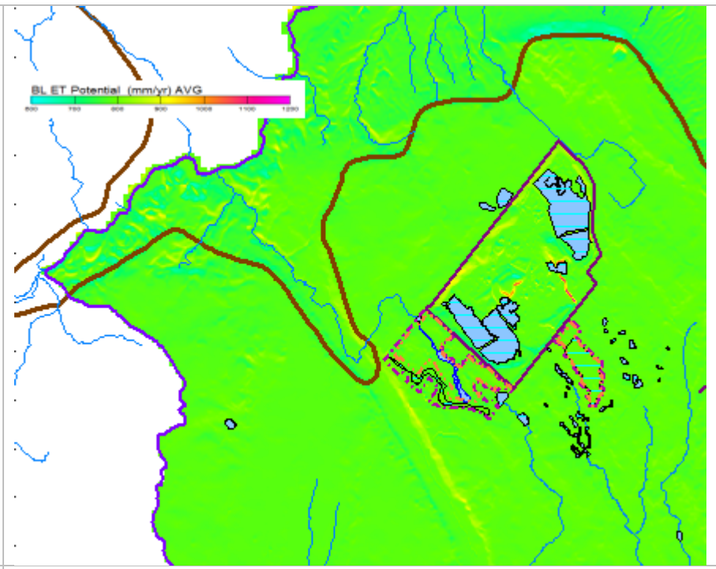
- Only three (3) of the stations selected for the representation of baseline conditions have corresponding results from the GSFLOW model calibration.
- The simulation of baseline conditions with GSFLOW extends from WY2010 to WY2019 (i.e., 10 years). However, as indicated in the notes on the streamflow stations included in the GSFLOW calibration, matches to the data over the full duration of this time period are not presented.

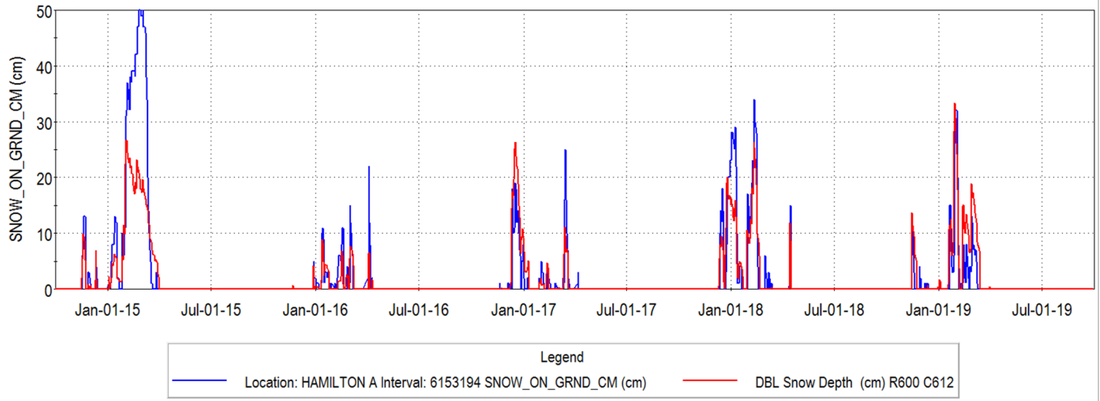
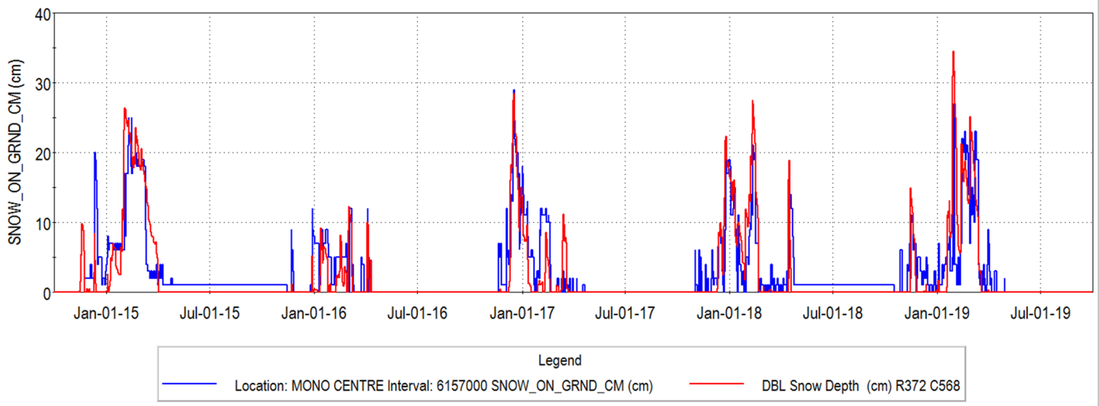
With regards to the Golder wells, the question was asked multiple times. Essentially, the model was calibrated over a 10-year period, WY2010-WY2019. Unfortunately, the Golder data mostly falls within WY2008 to WY2013 as shown by the data for OW03-29. The 2003 data are mostly manual monthly measurements with a large gap between May 2004 and August 2007. There is another gap from WY2014 to August 2018. Most wells show similar patterns but there is variation. OW03-15 and OW03-30, for example, are part of a group of wells that do not have logger data until 2010. The period selected had the best coverage and extended to the recent 2019 study period.

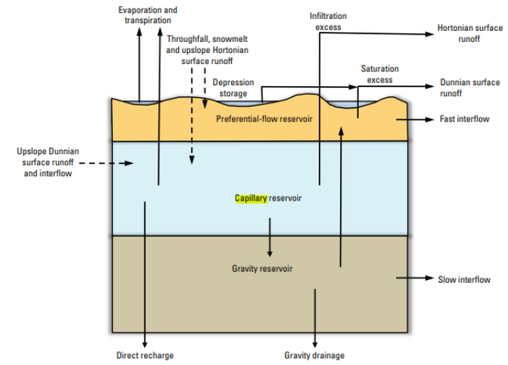


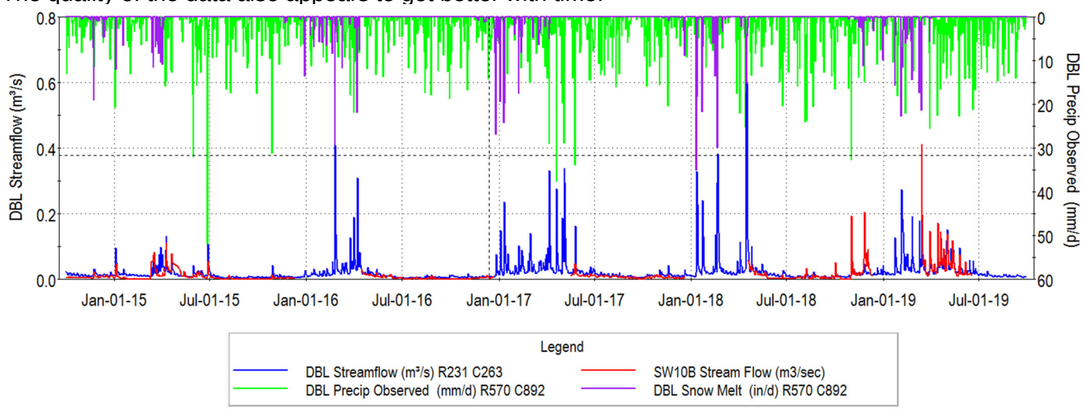
	Results for a relatively small subset of the existing groundwater monitoring locations have been reported for the calibration of the GSFLOW model. Furthermore, the calibration time interval is restricted to the five (5) year period, Water Years 2010-2014. No comparisons are presented for the extensive monitoring data collected between 2003 and 2010 (Golder, 2010; Appendix D). It has been left with the impression that selective use has been made of the available data in the GSFLOW calibration. At a minimum, all locations for which water level data are available should have been considered in the calibration, for the full period for which data are available. If it was not feasible to include all the existing groundwater monitoring locations in the calibration analyses, the reporting should have at least included explanations regarding why some locations were included and others were not, and whether conditions changed between 2003 and 2015.				
157.	Does it make sense to conceive of and distinguish between Hortonian and Dunnian runoff when only daily values of precipitation are available and the PRMS analysis has 1-day time steps? Wouldn't the simulated intensity of the rainfall generally be quite different from the actual intensity?	Page 124	S.S. Papadopulos & Associates, Inc.	Without going into a long discussion of the differences between Hortonian and Dunnian flow and why the integrated model needs to separate them, there is a point to the question regarding intensity. By representing the rainfall as a 24-hr storm, the CN method will tend to generate less Hortonian runoff. We experimented with monthly intensity modification factors (e.g., to assume that the average January storm was a six-hour event while the average August storm was a two-hour event) but this did not substantially improve the model calibration and was not pursued further.	
158.	Should the 'Contributing Area' shown on this figure also include the up-gradient areas under Hortonian Surface Runoff and be defined by the up-gradient groundwater table?	Page 126 Section 6.3.4 Figure 6.6	Norbert M. Woerns	The figure is a schematic trying to show the concept of an increasing/decreasing contributing area (as defined by Whitely) to one type of Dunnian flow. This type of Dunnian flow occurs when the water table is near or at surface, often the case in the lowland areas. Two things occur: (1) the groundwater system can discharge to the soil zone creating saturated conditions and possible discharge to the surface; and (2) any rainfall within the "contributing area" will be lost to runoff. The position of the water table relative to land surface controls the rate of Dunnian runoff. You are correct in the sense that the Hortonian runoff shown in the figure would likely cascade downslope and reach the saturated area. At that point it would be added as run-on to the downslope cells. Some or all of that flow would be partitioned and emerge as Hortonian and Dunnian runoff. This is not to say that Dunnian runoff cannot occur in upland areas (i.e., areas with deep water table). Another type of saturation excess can occur in wet periods if sufficient infiltration has occurred and the soil is poorly drained and at saturation. Subsequent rainfall events produce Dunnian runoff.	
159.	'Analysis of preliminary model results often pointed to gaps in the previous analyses. The gaps were addressed by obtaining additional data or re-evaluating the data analysis and assumptions made in the conceptualization phases.' What is the impact of data gaps on the accuracy/reliability of the integrated model?	Page 128 1st Paragraph, Section 6.4. GSFLOW Model Development Process	Norbert M. Woerns	See Response 132. We acknowledge that there are gaps in the groundwater observations that Earthfx had no control over. Where we were able to obtain additional data, we did. For example, we went further afield to get precipitation. With regards to the calibration, the hydrologic model was calibrated against gauges with longer term data. The strength of the continuous integrated modelling approach is that the intermittent records available at other stations could still be compared against model output to verify the predictive capability of the model.	
160.	How is convergence checked in the GSFLOW simulation?	Figure 6.8	S.S. Papadopulos & Associates, Inc.	The model checks the standard specified closure criterion for changes in groundwater head and volumetric flow rate in MODFLOW-NWT. A specified closure criterion is checked for changes in storage in soil zone of PRMS.	
161.	Referring to Section 6.6, it is indicated that soil properties have a "significant influence on hydrological	Section 6.6 and	S.S. Papadopulos	While we started with book values for our first PRMS/GSFLOW analyses, the parameter values have been refined through close to 20 studies done in southern Ontario. Many of the studies were done in	

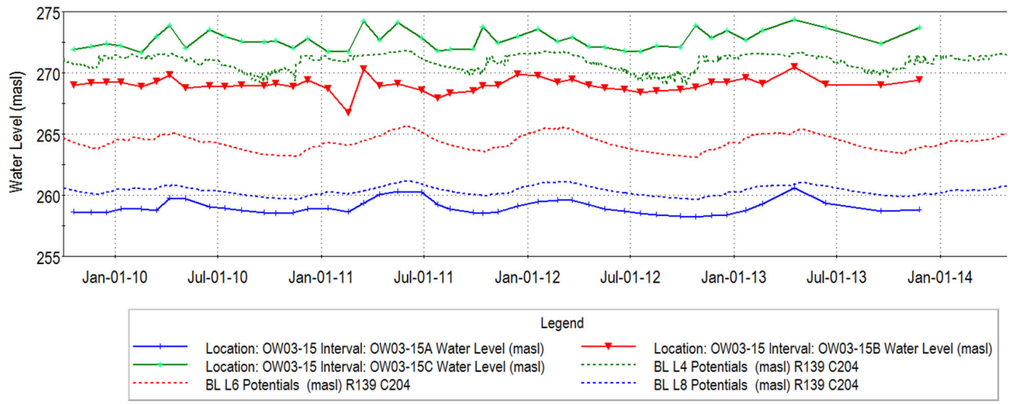
	processes". However, the understanding is that tabulated look-up values are specified for many of the parameters in the analyses, rather than site-specific data. How much uncertainty should be assigned to the values assumed in the analyses? Which parameters have the most important influence on the predictions of potential impacts? As one example, refer to the estimation of potential evapotranspiration, an important component of the water budget. It is indicated on page 443 that the modified Jensen-Haise method only requires values for daily temperature, incoming global solar radiation, and "two other user-specified parameters." Based on the reading of Table A1-14 of the GSFLOW documentation, these parameters are jh_coef and jh_coef_hru, the "monthly air temperature coefficient" and the "air temperature coefficient for each HRU". There is no indication in the reporting of what these values are, what data have been considered in their assignment, and how significant they are with respect to the model results.	Page 443	& Associates, Inc.	Halton, Hamilton, Waterloo, and Peel regions, so the soils and land cover categories are generally similar and properties assigned are generally comparable but are varied within reasonable ranges. We have generally tried to keep the model parameterization as simple as possible. With regards to soil properties, the PRMS model deals with volumes (e.g. maximum soil storage (Smax), in inches). In our preprocessor, we have tried to assign those to more physically based parameters (e.g., Smax = (field capacity – wilting point) * soil zone thickness where fc, wp, and soil thickness values are assigned through look-ups based on soil or vegetation type). With regards to sensitivity, the term (fc-wp) does not vary that much for different soil types but we have found the model more sensitive to soil zone thickness. Percent impervious is a key factor with regards to runoff and model results are sensitive to this value in urban regions but less so in this study area. The PRMS v4 manual provides insight into these parameters and provides sample calculations. $$potet_{HRU} = \mathbf{jh\_coef}_{month} \times \left(tavgf_{HRU} - \mathbf{jh\_coef\_hru}_{HRU} \right) \times \frac{swrad_{HRU}}{2.54 \times \lambda_{HRU}} \text{ and}$$ $$\lambda_{HRU} = 597.3 - \left(0.5653 \times tavgf_{HRU} \right),$$ $$\mathbf{jh\_coef\_hru}_{\mathrm{HRU}} = 27.5 - \left[0.25 \times \left(\rho_{high\_temp} - \rho_{low\_temp} \right) \right] - \frac{\mathbf{hru\_elev}_{HRU}}{1000},$$ For a rough estimate, assume r*low_temp* is 10.02 millibars and r*high_temp* is 31.67 millibars. Thus, equation 52 is simplified to: $$\mathbf{jh\_coef\_hru}_{\mathrm{HRU}} = 22 - \frac{\mathbf{hru\_elev}_{HRU}}{1000}. \quad (1\text{-}53)$$ So, jh_coef (month) is an adjustment factor which allows you to modify the calculated PET values on a monthly basis as part of the calibration. Generally, we avoided using monthly factor adjustments (there are numerous ones for climate terms) unless absolutely needed. The second factor can be seen as mainly an elevation correction factor (once you have the temperature-dependent saturation vapour values). PET values were very sensitive to this parameter in a model we did for Spokane WA where we had 1000s of feet of elevation change across the watershed. In most Ontario studies, PET was found to vary within a narrow range. The figure demonstrates this, showing that PET values are relatively uniform but with low values occurring in the shadow of Mt Nemo and higher values on south facing slopes (e.g., the Medad Valley) because slope, aspect, and cover density affect the amount of solar radiation hitting each cell.	

					
162.	Topography-related Properties – The accuracy and extent of the drone survey data in the vicinity of the Quarry and expansion lands should be included within the document. LiDAR data with a +/- 0.1 metre accuracy is available for purchase from Conservation Halton to improve the accuracy of the results, if necessary.	Page 129 Section 6.6. Parameter Assignment	Conservation Halton	It would have been useful to have this at the outset of the study. We had to develop our own coverages. LIDAR data is increasingly available and we are using it where available	
163.	Reference in the text is made to MNR Soil Survey Complex (2013). However, the date of reference in Section 14 is 2003, accessed in October 2014. What is the correct date for this mapping?	Page 129	S.S. Papadopulos & Associates, Inc.	Comment noted. It is a bit confusing but both references are correct. The digital data was based on soil mapping compiled in 2003. The digital data keeps being updated. We had downloaded a version (in 2014) that was updated in 2013. The Ontario Land Information system now only provides access to the 2016 version but still based on the 2003 mapping.	
164.	It is indicated that parameters that controlled the partitioning of flow between interflow and percolation to the water table were also specified as soil-type properties. What parameters are referred to here, and what are the bases for the specification of their values?	Page 129	S.S. Papadopulos & Associates, Inc.	There is a first-order slow interflow coefficient that can be specified for each HRU. We found that assigning the slow interflow coefficient by land use class helped improve the calibration. In short, because interflow is taken first, increasing the interflow rate decreases the amount of flow available for groundwater recharge and discharge to streams as baseflow. Decreasing the coefficient results in a decrease in the peak flows and an increase in baseflow.	
165.	The hydraulic conductivities shown on this figure are significantly higher than show on table 17.1. It is assumed this represents model layer 1. What impact do the higher hydraulic conductivities have on the model?	Page 131 Figure 6.10. Surficial Soil Hydraulic Conductivity	Norbert M. Woerns	Generally, it was assumed that the fine-grained soils would be slightly more permeable than the parent material due to weathering. The values are used in the model to define the maximum amount of water that can infiltrate per day. Variations in hydraulic conductivity values above $3x10^{-7}$ (equivalent to 25.4 mm/d) have little influence on recharge and interflow since it is rare to infiltrate more than that amount on any given day (except along a cascade flowpath or during snow melt events). The model is more sensitive to the lower values. Lower values will allow water to remain in the soil zone over several days and subsequent events can saturate the soil leading to Dunnian runoff. More soil water is also available for ET, leading to higher actual ET rates in the summer compared to more permeable soils.	
166.	‘Parameters values were estimated for many of the submodel processes, such as snowpack accumulation, snowmelt, and potential ET (PET) calculation. These were generally estimated from “book values” or the results of previous Earthfx investigations in the Halton/Hamilton area.’	Page 132 2nd Paragraph Section 6.6. Hydraulic Processes Parameters	Norbert M. Woerns	The parameters mainly control the depth of the snowpack and, more importantly, snowmelt timing. There was not a lot of data to calibrate to and we did not do any comparisons for the report. The figure below, however, compares predicted snow depth in the south of the study area versus the “snow on ground” measurements at Hamilton Airport, 23.5 km to the south. The timing of the snowmelt is dead-on. Calibration of snow compaction factors may have produced a better match to the observed depth for the larger snow packs, although the match after 2015 is still very good. A similar figure compares the predicted snow depth in the north of the study area versus the “snow on ground” measurements at Mono	

	What effect does parameter estimation have on the model predictions?			Centre, 68.5 km to the north.  	
167.	It is indicated that an “acceptable” Nash-Sutcliffe efficiency of 0.44 was achieved with PRMS-only analysis of the Aldershot gauge, and an efficiency of 0.67 was achieved with the GSFLOW analysis. Chiew and McMahon (1993) is cited for the consideration of 0.6 as “a reasonable calibration value”. It is worthwhile to consider exactly what Chiew and McMahon (1993) wrote. For typical hydrology and water resources studies (in particular, reservoir and ca analyses), a flow estimate can generally be considered to be PERFECT if $E \geq 0{\cdot}93$ or $R^2 \geq 0{\cdot}97$ or $R^2 \geq 0{\cdot}93$ with mean estimated flow within 1 recorded flow. ACCEPTABLE if $E \geq 0{\cdot}80$ or $R^2 \geq 0{\cdot}90$ or $R^2 \geq 0{\cdot}77$ with mean estimated flow within 1 recorded flow. Simulations with $E \geq 0{\cdot}60$ are generally satisfactory (inspection of graphical p useful) and can be used to at least provide approximate flow volumes and f investigative studies. Generally satisfactory results for approximate flow volumes and preliminary investigative studies is not the same as “reasonable”.	Page 132	S.S. Papadopulos & Associates, Inc.	It should be noted that the Chiew and McMahon (1993) is based on matching **monthly** flows, a much easier task than matching daily flows. There is a much higher degree of difficulty associated with a distributed integrated hydrologic model that is not encountered in typical catchment modelling. The long run times (2 weeks versus 3-11 seconds per run for the model used by Chiew and McMahon), data limitations, and our parsimonious approach make it difficult to achieve the high NSEs level of calibrations more typical of that lumped-parameter catchment models. Lumped parameter catchment models, calibrated on a monthly basis, have limited predictive capability for engineering scale impact assessment.	

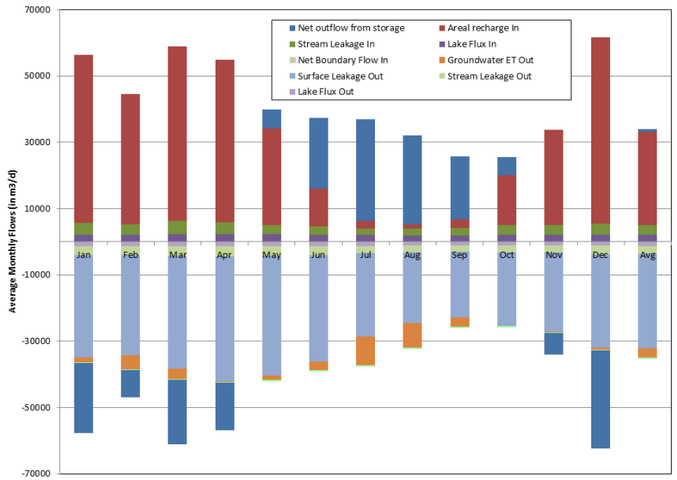
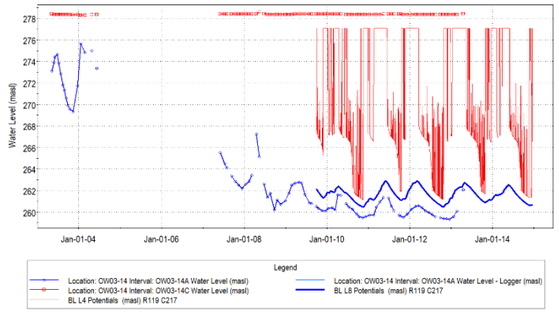
168.	Paragraph five of this section explains that white areas on Figure 6.17 represent areas where groundwater discharge exceeds groundwater recharge. It should be noted that these areas coincide with wetland locations surrounding the proposed southern extension and south of the western extension area (wetland 13201), and abut the West Branch of Mount Nemo the tributary to Grindstone Creek. Considering that the baseline scenario represents partially impacted groundwater conditions the amount of groundwater discharge in these areas was potentially higher. How would groundwater discharge function be restored and maintained during extraction face moving closer to those features resulting in additional groundwater lowering?	Page 135 Section 6.9. PRMS Submodel Outputs, Figure 6.17. Simulated annual net average groundwater recharge in mm/yr	Conservation Halton	Areas of groundwater discharge typically occur in the vicinity of the groundwater-fed wetlands and in riparian areas of streams. This is shown more clearly in Figure 7.20	
169.	Referring to Figure 6.4, what are the capillary and drainage reservoirs?	Page 135 and Figure 6.4	S.S. Papadopulos & Associates, Inc.	Here is a schematic from the PRMS v4 manual. The capillary reservoir accepts infiltration (after canopy interception and Hortonian runoff) and loses water to soil ET. Excess water above the storage capacity of the capillary reservoir (equivalent to above field capacity) goes to the gravity reservoir where flow is portioned into interflow and GW recharge.  **Figure 2.** Details of the Precipitation-Runoff Modeling System Soil Zone.	
170.	Based on the recharge map, the area which is proposed for west quarry extension provides recharge which supports a number of downstream private water supplies and discharge within Medad Valley. This is also supported by provided cross sections on Figures 5.3 and 5.4. How would these conditions be maintained during and after extraction?	Page 139 Figure 6.17. Annual Net groundwater Recharge (mm/yr)	Conservation Halton	Recharge would still occur in the area between the quarry face and Cedar Springs Road. This would be augmented by the infiltration feature which would accept part of the quarry discharge.	
171.	'A visual comparison of the observed and simulated values shows that a good match was achieved although, as noted in Section 5.3, there is considerable scatter in the static water level data because of the fractured nature of the bedrock; deviations are less prevalent below the Niagara Escarpment. A good match was also achieved across the model with the key study area groundwater flow patterns.'	Page 142 Section 6.10.1. Model Construction, Model Parameters, 3rd Paragraph	Norbert M. Woerns	The local variations are likely due to proximity (or distance from) discrete vertical and bedding plane fractures. We tried to represent the overall effect of these features, but the exact location and properties of the fractures are unknowable. Overall, our goal was to represent the likely impact of the quarry expansion across the area, including kilometers of streams, wetland complexes, and multiple bedrock and overburden units; we did not attempt to predict the response at individual fracture locations.	

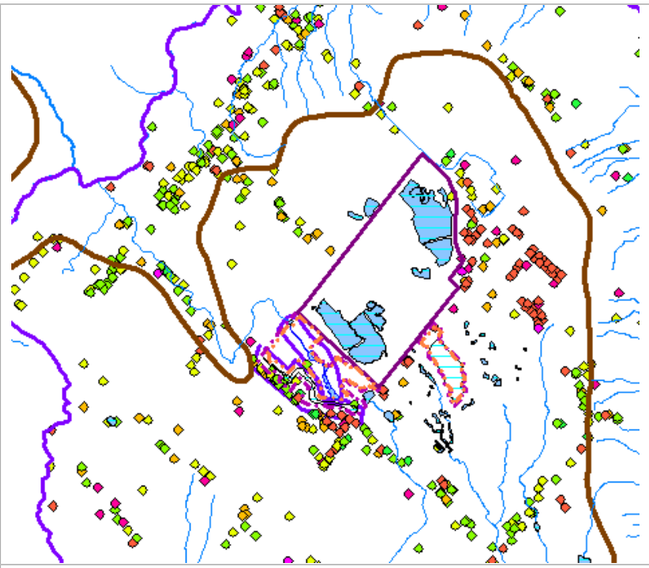
	The 'considerable scatter in the static water level data' suggests local variation in the bedrock hydrogeology. The matching of water levels over the large study area suggests that the model is a good representation of area wide or regional conditions but is lacking in its ability to characterize local 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'.				
172.	The report should document which and how parameters in the PRMS sub-model were adjusted to calibrate the GSFLOW model.	Page 143 Section 6.11.1. GSFLOW Surface Water Streamflow Calibration	Conservation Halton	There are numerous parameters in the PRMS model, most of which can be varied on a HRU, monthly, or HRU and monthly basis. We have presented the parameter values that we used and highlighted the key ones in the property tables. Calibration entailed a combination of automated (Monte Carlo) parameter estimation and manual adjustment processes in which the soil property and land use property values were refined. Visual inspection of hydrographs at gauge locations was the primary tool for evaluating the goodness of fit during the manual calibration process, adjusting parameters as needed to better match peaks and baseflow recession.	
173.	Figure 6.19, Simulated and observed flow at SW10B for WY2019 - While the match of observed streamflow to the GSFLOW simulated flows is very good for 2019, the match for Fall 2018 is weak. Further discussion is required and refinements to the calibration may be required.	Pages 143-144 Section 6.11.1. GSFLOW Surface Water Streamflow Calibration	Conservation Halton	Over the longer period of record, the model performs well, although there is not much winter/early spring data for comparison other than 2019. We have noticed a bit of a lag in the fall recovery. This is likely due to the need to bring soils up to field capacity before groundwater discharge or Dunnian flow occurs. In the field, the values of soil storage capacity will likely vary, with some areas contributing flow earlier than others. Randomizing the storage capacity values wihin each class might help but was not implemented in this model. The quality of the data also appears to get better with time. 	
174.	To validate the GSFLOW model, hydrographs illustrating simulated and observed flows should be presented at a surface water monitoring location on each tributary.	Pages 143-144 Section 6.11.1. GSFLOW Surface Water Streamflow Calibration	Conservation Halton	Of the 20 surface water gauges available for GSFLOW calibration, 10 were located more than 3.5 km from the site, had data only for 2018 and 2019, and, of these, seven were outside the model boundary. We found that no change in simulated flow occurs at or close to these locations. SW15 is on the opposite (north) side of the quarry and far from the expansion areas. SW7 and SW14 were discussed in great detail, so it was only SW2 which was omitted and the effects of the quarry extension were better seen in the upstream gauges.	
175.	'Additional calibration analysis was focused on matching transient responses at individual local wells, and in particular, the observed patterns in water levels between the upper and lower units and their influence	Page 145 Section 6.11.3. Calibration to	Norbert M. Woerns	As was noted in earlier answers, the exposure of the lower fracture zone at the quarry face causes a unique condition that enhances the head differences between the shallow and deep system. Matching this local response required modification of hydraulic conductivity values used in early versions of the model and the addition of vertical fracture zones. Away from the quarry face, the head differences are	

	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?	Transient Water Level Data, 1st Paragraph		small and various combinations of vertical and horizontal hydraulic conductivity values would produce reasonably similar heads. Matching the head profile with distance from the quarry face illustrates that the model is closely matching the observed and expected effects.	
176.	Please include OW03-15B observed and simulated water levels on Figure 6.24. The model overestimates deep groundwater conditions by some 1.0-2.0 metres and at the same time underestimates the shallow groundwater levels by some 0.5-2.0 metres without an explanation why and what it means in terms of surface and groundwater interactions. Please provide an explanation of surface and groundwater interactions at this location and any other location where the model does not simulate the observed data.	Page 149 Section 6.11.3.1. Well within 100 m of the Quarry face	Conservation Halton	OW03-15 is adjacent to the south quarry discharge location, and water levels in the area are affected by leakage from the stream. While this is represented in the integrated model, the pumping records from the south quarry are limited during this period.  The model is high in the deep bedrock, low in the middle zone, and low in the upper zone. As noted, the discrepancies here are smallest for the upper flow zone which is more closely linked to GW/SW interaction.	
177.	Please provide a borehole logs for well nests OW03-21 and OW03-31. If well nest OW03-31 has a shallow installation, please provide the data. Please include OW03-21C simulated water levels on Figure 6.25. As presented on Figure 6.26, while the observed data in OW03-31A (deep bedrock) is consistently higher than OW03-31B (shallow bedrock), suggesting upward gradients, while the simulated water levels show consistently downward gradients. Considering OW03-31 is located next to a wetland and the model does not represent local conditions it poses a question if the model can be used to predict impacts on the wetland.	Page 150 Section 6.11.3.2. Well between 100 m and 800 m of the Quarry Face	Conservation Halton	Borehole logs are included in Schedule E. Monitor OW03-31 does not have a shallow C monitor. Simulated water levels at OW03-21 for Layer 1 and 2 were very similar to those for Layer 4. There are a number of possible reasons for this local anomaly, including well construction, survey error, local shallow topographic/drainage effects and others.	
178.	Please include OW03-29C observed and simulated water levels on Figure 6.27. Based on observed water level data in Figure 6.27 there is a reversal of vertical gradients to upwards in the fall, this is not represented in the model as the simulated water levels are consistently 0.5 to 1.0 metre higher in the shallow bedrock – please explain.	Page 150 Section 6.11.3.3. Wells greater than 800 m from the Quarry Face	Conservation Halton	Comparing monthly water levels to logger data is a bit iffy, but there does seem to be a reversal with water levels slightly higher in the deep system for a short period in the fall. A possible explanation is the deeper system, with low storage, responds quicker to increased recharge even if it occurs outside the immediate area. The local recovery of heads may be lagged. Also see Response 177.	
179.	It appears that there is a two to three-month lag between the observed and simulated data as presented on Figures 6.29 and 6.30 – please explain. It appears that MP16 is constructed in MNRF wetland	Page 152 Section 6.11.4. Shallow Groundwater	Conservation Halton	The issue of response lag is discussed in great detail in our response to MNRF comments included in Schedule D. The heads in the unweathered Halton Till (Layer 2) take longer to respond than the soil zone. This can be seen in plots of soil moisture included in Schedule D. As noted in an earlier response, the soil moisture	

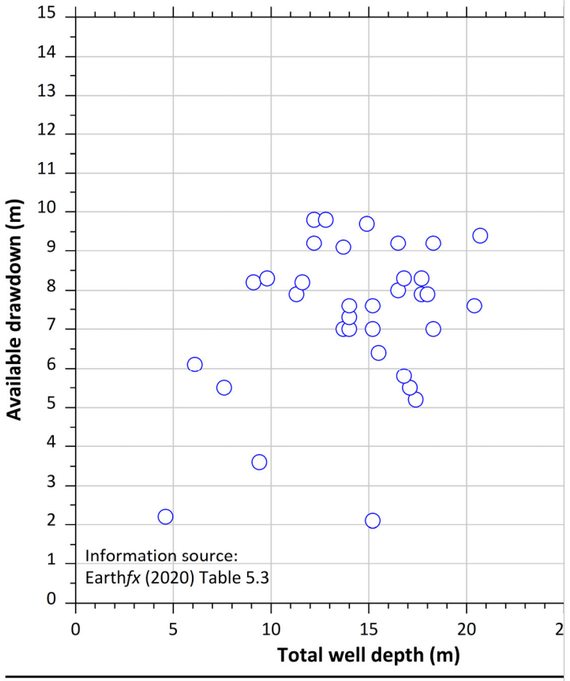
	13037. As per Provincially Significant Grindstone Creek Headwaters Wetland Complex assessment, February 2007, Ontario Ministry of Natural Resources Aurora District this wetland also known as No. 12 was identified to be seepage-fed and contributing baseflows to Grindstone Creek.	Calibration		capacity and other factors may not be uniform but be distributed in a more random way within the range of values. That would allow some parts of the system to respond more rapidly than others. The figure shows that at times simulated heads are above the base of the monitor parts of the year.	
180.	'Numerous additional examples of each of these water level patterns are included in Section 19. The numerical model universally replicates the patterns, indicating an excellent calibration to the observed effect of the existing quarry. The close calibration to these commonly observed patterns confirms that the model can accurately predict the future effects of the quarry extension.' The model appears to generally match the observed hydrograph patterns although the computer simulations often either under estimate or over estimate the water levels compared to observed water levels. See Figure 6.24, page 149. What is the significance of this?	Page 152 Section 6.11.3.4. Quarry Effects Calibration Conclusions	Norbert M. Woerns	"Excellent" calibration should be taken in context of the difficulty in creating and calibrating an integrated transient model that produced a good representation of shallow surface conditions in a fractured bedrock environment overlain by a variably fractured till using interpolated climate data. We are unaware of any similar level of integrated quarry modelling in Canada.	
181.	The predicted water levels in shallow monitors MP16 and MP6 show similar seasonal patterns although there is a time phase shift from the observed water levels. What is the significance of this time shift?	Page 154 Figures 6.29 and 6.30	Norbert M. Woerns	See Response 179	
182.	Please explain a two to four-month lag between observed and simulated water level results for MP5 and what it means in terms of using the model for predictive analysis.	Page 155 Section 6.11.5. Wetland and Pond Calibration	Conservation Halton	See Response 179	
183.	'Water levels in this wetland are always higher than the water table (shown as the Layer 2 potentials in Figure 6.33).' Figure 6.33 appears to show hydrographs of measured and simulated water levels of the water table at MP33. Wetland water levels, for comparison, should be shown on this figure.	Page 156 Section 6.11.6.1. MNRF Wetland 13025	Norbert M. Woerns	The potentials in Layer 1 at this location represent the simulated water levels in the shallow MODFLOW lake used to represent the portion of the wetland assumed to have standing water. These levels should be comparable to MP33. The heads in Layer 2 are assumed to represent the water table.	
184.	Typographic error, 'MNRF Wetland 1301' should read 'MNRF Wetland 13031'	Page 157 Section 6.11.6.2. MNRF Wetland 13031, 1st Paragraph	Norbert M. Woerns	Comment noted.	
185.	'The observed water levels in the wetland pond are nearly 10 m above the measured water table in monitor OW03-19C (Figure 6.34), confirming that this a highly perched wetland'. This location is elevated with an overburden thickness of 9.9 metres which is largely responsible for the	Page 157 Section 6.11.6.2. MNRF Wetland 13031, 1st Paragraph	Norbert M. Woerns	MNRF Wetlands 13031 and 13032 are a bit unique because they are located in depressions on top of topographic highs associated with the Waterdown Moraine. Other wetlands are located in the lower lying areas between the ridges. The topography shown in Figures 6.28 and the section through the wetlands (Figure 6.32) were meant to highlight this. An extensive discussion of the shallow wetland response is included in our response to the MNRF comments. Copies are provided in Schedules B, C, and D.	

	perched wetland condition. A discussion is required whether this is typical of the majority of wetlands within the study area.				
186.	The GSFLOW calibration section is lacking calibration to transient groundwater level data outside of the existing quarry zone of influence, especially to the west of the quarry. Please update the calibration accordingly.	Page 161 Section 6.11.8. GSFLOW Calibration Conclusions	Conservation Halton	Long term monitoring wells with data loggers are not routinely found in the MECP water well record database. The PGMN network is growing slowly. We focussed our calibration efforts on matching data wells in the vicinity of the quarry as they had an extended period of record. These well were installed for earlier south quarry studies. There are a several wells on the west side with short periods of record. The data from these sites were mainly used for comparing with the calibrated model predictions.	
187.	These estimates are based on borehole measurements around the existing quarry and EPM model simulations. They represent conditions on the upper bedrock plateau and do not represent conditions between a quarry wall and the escarpment face. The steep hydraulic gradients noted above, in combination with extensive bedrock fracturing (as well documented), creates a very steep potentiometric surface in the unconfined aquifer which drains through fractures and emerge as discrete springs at the base of the escarpment face (a discharge face).	Figure 6.37	Daryl W. Cowell & Associates Inc.	Figure 6.37 is a potentiometric map of average simulated heads in March. We do not understand the question in reference to this figure.	
188.	Figure 6.39 is confusing. It shows a loss of groundwater on annual basis at a rate of some 1000-2000m3/d, and groundwater ET losses in winter months at rates which are comparable to summer months – please clarify.	Page 164 Figure 6.39. Average monthly groundwater budget for the study area	Conservation Halton	Yes, there is a bit of background needed to better understand the figure. In a typical MODFLOW model, ET losses from groundwater are simulated by specifying a value for ETmax, the maximum ET loss rate which occurs when the water table is at or above land surface and ExtDepth, the extinction depth below which no ET occurs. ET losses linearly decrease with depth to the water table. In GSFLOW, ETmax is not specified. Rather, the PRMS model calculates the daily potential ET and then attempts to satisfy this demand first through evaporation from canopy storage and then through evaporation and ET from the soil zone. Any leftover ET demand is passed on to MODFLOW as the daily value for ETmax. In the spring, PET is usually met by available water in the soil zone. As PET demand increases in the summer months, upland areas (which receive limited run-on from upslope cells) dry out and cannot meet the ET demand and the rate of potential GWET increases. Because the upland areas have greater depth to water, some of this GWET demand will not be met and AET will be less than PET. Ironically, GWET will not be that high in the lowland areas, despite the shallow water table, because the soil zone, which is replenished from below, will be able to meet the ET demand through soil zone ET. As a consequence, even though technically it the ET is ET from groundwater, it is included with GW discharge to the soil zone (surface leakage) rather than GWET in the MODFLOW GW balance). In the winter months, there is still some PET calculated on warm days. Because the canopy coverage is reduced and because transpiration processes are shut down, a bigger percentage of this winter PET is passed to the MODFLOW model and is labelled as GWET.	
189.	The color scheme in Figure 6.39 and Figures 19.48 is confusing. In a copy of the report, the terms “Net outflow from storage” and “Net boundary flow in” have identical colors. Is it correct in understanding that the positive blue quantities denote the “Net boundary flow in” and the negative blue quantities denote the “Net outflow from storage”? The term “Net outflow from storage” is also confusing. If this is indeed a negative quantity, shouldn’t it correspond to sink for the groundwater system, with water going into storage, as MODFLOW would simulate during months of rising groundwater levels? And wouldn’t there be months during which	Figures 6.39 and 19.48	S.S. Papadopulos & Associates, Inc.	The colours can be identified by their order in the legend. In the figure below, we changed the colour for Net boundary Inflow to lime green. Net boundary inflow is a very small term and, for this model is always negative. The term “Net outflow from storage” is meant to show that, from a MODFLOW point of view, outflow from storage constitutes an inflow to the aquifer similar to recharge. Thus it shows up in the summer months where water comes out of storage to balance other losses from the aquifer. In the spring, water is “removed” from the aquifer and goes into aquifer storage.	

	groundwater levels declined and the changes in storage would be interpreted as sources in the groundwater budget?				
190.	'The model was run for a ten-year period (WY2010 to 2019) and calibrated to regional and local observation data collected during this time.' Were there actual measured water level data from the property throughout this period and especially during periods of drought and wet conditions from which simulations were made? Does this baseline analysis incorporate the impacts of the existing quarry? A discussion is required on how appropriate calibration to local and regional water well data may be for purposes of capturing the impacts of the existing quarry even though the quarry has existed since 1953. Well record data would span this time frame. How would these data be representative of impacts of the existing quarry which was slowly expanding over this period of time? Would the well data be representative of the modeled climatic period of 2010 to 2019?	Page 165 Section 7.1. Baseline conditions Analysis, Introduction, 2nd Paragraph	Norbert M. Woerns	We have discussed the gaps in data in previous answers. Figure 19.23 presents a typical observation hydrograph with gaps in the measurement periods. The 2017 drought was missed.  Yes, the baseline analysis incorporates the impacts of the existing quarry. We started the model assuming the topography, quarry pond configuration, and water management consistent with current conditions. As noted in earlier responses, the site data and MECP data sets are generally non-overlapping. That said, early on in the study, we tried separating populations of wells by time period to see if any patterns could be discerned. This exercise was generally unsuccessful because (1) general noise in the data (e.g., natural seasonal and inter-annual variation), (2) the lack of sufficient number of wells and good spatial coverage within decadal grouping (see figure) needed to interpolate regional surfaces for comparison.	

					
191.	'The exceptionally long model run times and model stability challenges required practical model management solutions. In some cases, the long model runs were completed as two simulations spanning the 10-year assessment time period. For example, the first 5 years of the baseline scenario was completed as one continuous simulation, with an emphasis on the assessment of the Golder monitoring data. The second part of the baseline assessment started in October 2014 and covered: • the WY2015-WY2016 drought period (including a Level 2 Low Water Advisory), • the WY2017 wet period, and finally, • the WY2018-WY2019 new data collection period.' What impact does the on-site data gap have on the computer model simulations?	Page 166 Section 7.2.2. Scenario Summary and Nomenclature	Norbert M. Woerns	The advantage of our continuous modelling approach, using multi-year simulations with a daily time step, is that we can compare model results with the available streamflow and water level data even if the data cover short periods and there are gaps. Obviously, it would be better to have long, gap-free data, but we can make good use of what we have. The continuous model can be compared to continuous or intermittent manual or logger levels.	
192.	The proposed set of groundwater assessment points for "the Baseline and Scenario comparative analyses" at locations without observed data seems questionable. Please provide a justification of why these assessment points are representative of baseline conditions and why would it be appropriate to use them for comparative analyses.	Page 167 Section 7.2.4. Seasonal and Inter-annual Groundwater Levels	Conservation Halton	GW-8 is located near OW03-17. The assessment points were selected not for model calibration, but to provide coverage of a wide area away from the wetlands which were addressed separately. GW6 and GW8 are near P12 on inter-stream divides which would be more sensitive to change than points adjacent to wetlands or streams. GW1, GW2, GW3, and GW4 are along the west side along roads with private wells that could be affected by P3456. Similarly, GW5 and GW 7 cover roads with housing on the east that might be affected by P12	
193.	'At any location in the vicinity of the quarry a private water well could be drilled to the Layer 8 fracture zone and would have up to 22 m of available drawdown' Available drawdown has been used as a potential measure of possible available groundwater. This does not take into consideration the aquifer yield or water	Page 167 Section 7.2.4. Seasonal and Inter-annual Groundwater Levels, 4th Paragraph	Norbert M. Woerns	MECP wells are completed across a range of depths indicating that water is broadly available. It is expected that the lower part of the formation will yield groundwater of good quality water and sufficient quantity for domestic supply.	

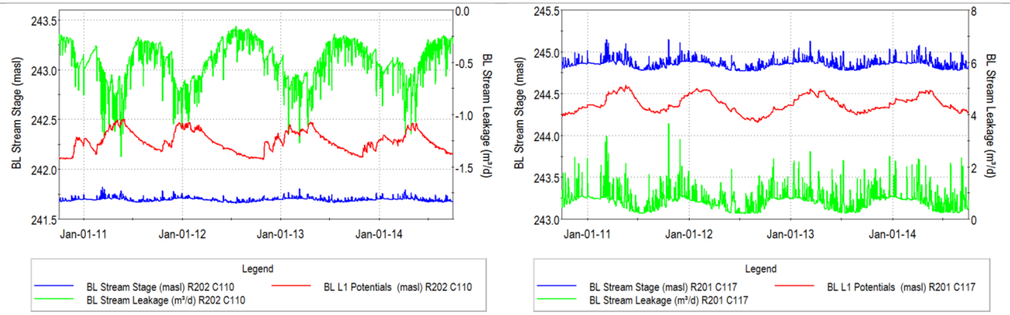
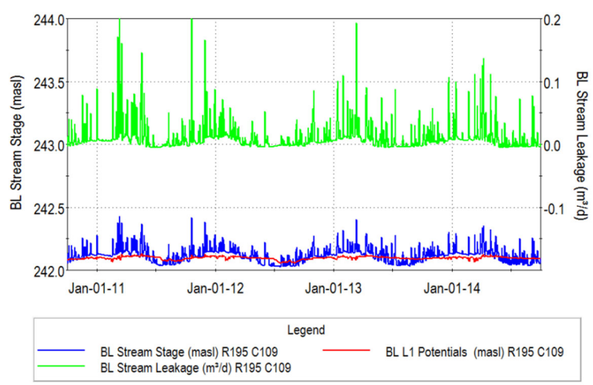
	quality. Flow profiling completed by Golder in 2004 indicates that the Amabel aquifer has diminishing flow with depth (See Figure A8 and A9 page 434 and 435 respectively of Earthfx hydrogeological report). This suggests that despite available drawdown, little or no additional groundwater supplies may be available at deeper levels within portions of the Amabel Aquifer. Deepening wells may therefore not be a viable option for restoring water supplies to private wells. Private residences along Cedar Springs Road near the northwest portion of the western extension are located at surface elevations of about 254.0 and 545.0 mASL compared to the base of the proposed quarry excavation of 252.5 mASL which represents the lowermost portions of the Amabel Formation. What impact would this have on available drawdown from the Amabel Formation?				
194.	The next-to-last paragraph on page 167 of the Earthfx report reads: Figure 7.3 presents a summary of the groundwater supply conditions in the study area. This figure shows the available groundwater drawdown in the Amabel Formation. At any location in the vicinity of the quarry a private water well could be drilled to the Layer 8 fracture zone and would have up to 22 m of available drawdown. Near the existing quarry that drawdown is reduced by the effects of the quarry dewatering, but many wells are both shallow, and in close proximity to the quarry, and yet have had suitable water supply for many years. It is not clear why model Layer 8 [Amabel Lower Fracture Zone] has been selected for the assessment of the available drawdown for baseline conditions. The depths of private wells within 500.0 metres of the extraction boundary are reported on Table 5.3 of the Earthfx report. As shown in the plot of these data below, it is likely that private wells extend only into the weathered top of rock (model Layer 4) or model Layer 6 [Amabel Middle Fracture Zone].	Page 167 and 481, Table 5.3, and Figures 3.25, 5.6, 5.7, 5.8, 7.3, 7.17, 18.3, 19.22-19.33	S.S. Papadopulos & Associates, Inc.	Wells closer to the Medad Valley are frequently completed in the lower fracture zone. While wells further from the valley, including monitoring wells, are less frequent in the deep system, there are enough wells to conclude that it is a productive regional aquifer. It was chosen as wells can be deepened to that zone. The Golder testing was done for a south expansion. The private wells are located closer to the west expansion and, if replacement or deepening of wells is ultimately necessary, the presence of a lower flow zone and available drawdown, as indicted by the west boreholes (e.g., BS-01), is of critical importance. Please refer to Section 5.2.8 for a discussion of all the evidence related to the lower fracture zone, including Figure 5.10 and the observed effects discussed in Figure 5.11 and Figure 5.12, which clearly drain into the quarry, and yet continue to response to annual recharge event patterns.	

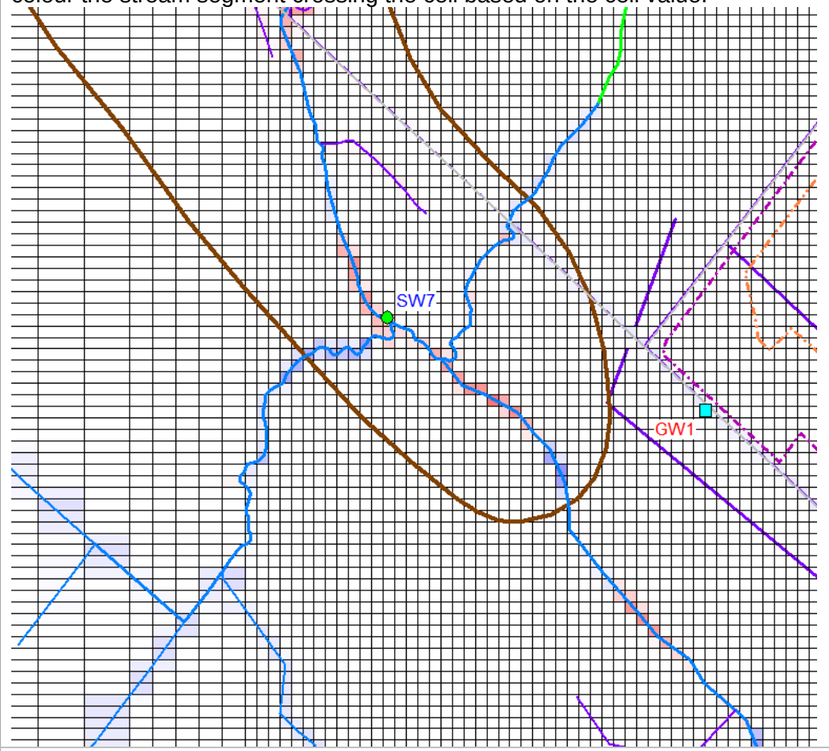


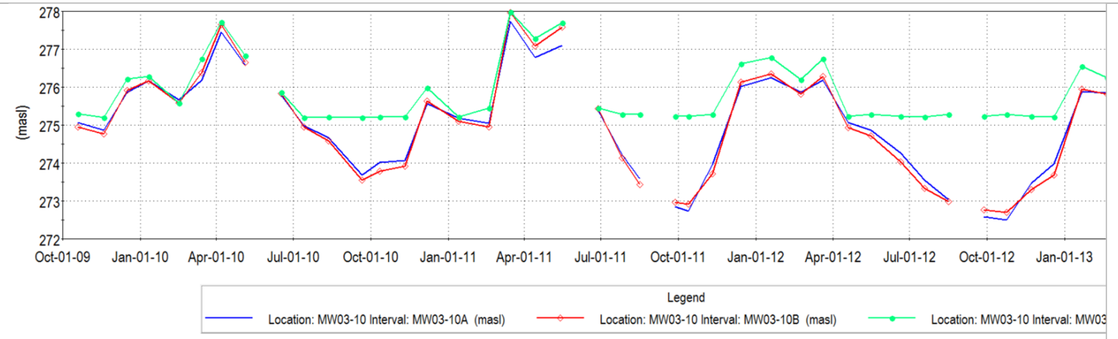
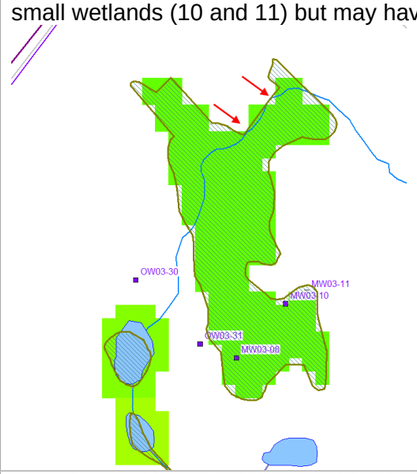
The impression is that it has been assumed in the modelling that the lower portion of the Amabel Formation is a productive aquifer. This assumption does not appear to be consistent with the results of packer testing (Figure 5.6), which does not show an interval of consistently higher productivity at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

Figure 7.3 shows a map of calculated values derived from two other maps of calculated values that are not provided. It appears that what is shown is the difference between (1) the simulated average water level in Layer 8 of the model (Lower Fracture Zone) for the period of WY2010-WY2019, and (2) the assumed elevation of the top of Layer 8. It is not possible to assess the reliability of this figure with the information provided in the report. No map of simulated water levels in Layer 8 is included in the report. The interpretation of the time period may not be correct. The description of Figure 7.17 in the

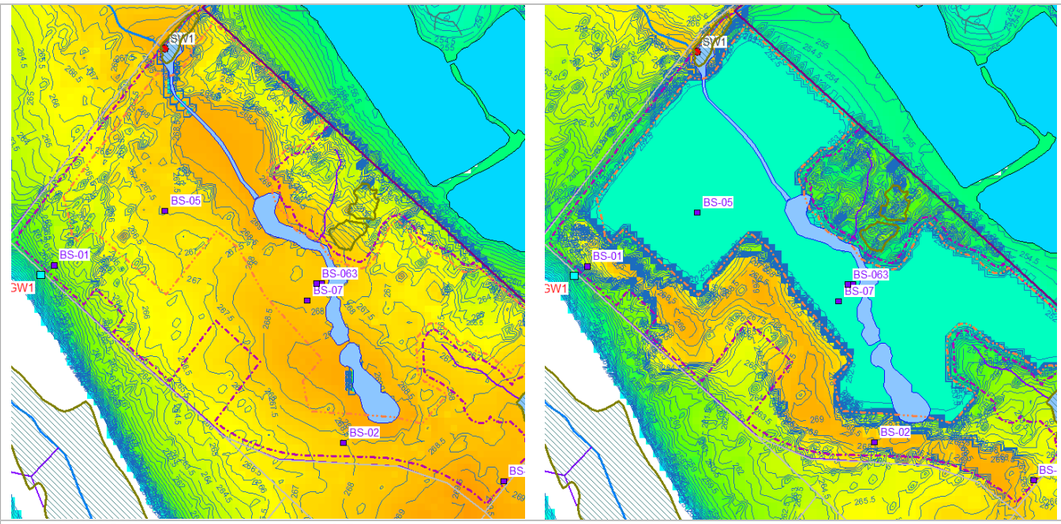
	preceding paragraph refers to a time period of WY2015-WY2019. The retained consultant could also be wrong about the assumed elevation for calculating the available drawdown. It might be the middle or the bottom of Layer 8. The reporting of the thickness for layer 8 could not be found. It is described as 'representing a thin lower fracture zone' (page 481 second last paragraph). More important than simply checking the reliability of the calculation of the values of the available drawdown shown in Figure 7.3, it is not possible to assess the reliability of the simulated groundwater levels used in the calculations. In Figures 18.3 and 19.3, simulated average water levels are compared with water levels reported in the well records for the private wells beyond the site boundary. The results shown in these two figures suggest that the likely mismatch at the location of an individual well is relatively large, on the order of ±10.0 metres. No comparable assessment of the match to the average water levels for on-site monitoring intervals in the Amabel Lower Fracture Zone is presented in the report. Observed and simulated hydrographs for 12 observation wells are presented in Figures 19.22 through 19.33; however, there is no indication of the average levels, nor is it indicated which of the wells are open across only the Lower Fracture Zone. It is noted that there is a phase shift in these hydrographs resulting in a difference of 0.5 to 1.0 metre at the south end of the southern extension between measured and simulated water levels of the lower Amabel (OW03-17A, 18A, 19A, 29A -Figures 19-30, 19-31, 19-33, and 19-32, respectively). A similar difference is noted along the west side of the southern extension at MW03-01 (Figure 19-29). This difference increases to several metres closer to the existing quarry at MW03-02 (Figure 19-28).				
195.	'The Medad Valley is an interesting setting, for Figure 7.20 shows that there is groundwater discharge to the soil zone along the flanks of the valley, yet the main stream in the centerline of the valley is leaking water to the groundwater system (Figure 7.21). This demonstrates that the incised Medad wetlands and streams are somewhat isolated from, and functionally different than, the streams and wetlands of the upland plateau (where the quarry is located).' What measured field data are there to support the conclusion that the main stream in the Medad Valley is losing water?	Page 179 Section 7.2.5.4. Stream Leakage (Hyporheic Exchange), 2nd Paragraph	Norbert M. Woerns	Access to the Medad Valley was limited, so there are only flow measurements at the gauges for comparison. The map needs a bit of explanation, since it portrays the average of stream leakage over the simulation period. Areas of dark red on the map tend to exhibit heads that are always higher than stream stage and net leakage is from the aquifer into the stream (first figure below). Areas of dark blue on the map exhibit heads that are always lower than stream stage and net leakage is from the stream to the aquifer (second figure). Reaches with lighter shades of reds and blues are areas where heads and stage reverse over the simulation period and leakage in or out varies over time (third figure).	

				 	
196.	Please provide digital, daily water levels, presented graphically (to depict the wetland hydroperiod) and summarize daily water balance analyses as average monthly water volumes presented in tabular format integrated in the report. Compare driest year, average and wettest year monthly water volumes to assess potential impact.	Page 179 Section 7.2.6. Wetland Water Budgets	Conservation Halton	Extensive additional information related to the wetlands was provided in response to MNRF for more information regarding the wetlands. This has been provided in Schedules B and C.	
197.	'There are 24 wetlands within the study area (locations are shown in Figure 7.22). Detailed feature-based water budgets were calculated to analyze the inflows and outflows to 22 of these local wetlands.' Of the 22 wetlands within the study area, there appears to be groundwater shallow instrumentation only at five wetlands SW5, SW11, SW12, SW13, and SW16 for purposes of water budget analysis. How were water budgets completed for the remaining wetlands where there was no shallow groundwater instrumentation? Do the water budgets represent average, conditions or were drought and wet conditions considered?	Page 179 Section 7.2.6. Wetland Water Budgets, 1st Paragraph	Norbert M. Woerns	The water budgets were prepared using simulation period averages of all PRMS and MODFLOW inflows and outflows. The flows were averaged over all cells falling within the polygons defined by the wetland area. The purpose was to compare the flow terms under each scenario to see how they change and re-balance under the different conditions. Water budgets for the instrumented wetlands are presented in the Tatham report. Please also refer to Response 5 and 14	
198.	Figures 7.20 and 7.21 show groundwater discharge to the soil zone under wetlands and streams and discharge to streams, respectively. Some of these areas are within less than 200.0 metres of the proposed south extraction. How would these	Pages 183-184 Figures 7.20 and 7.21	Conservation Halton	The model was used to evaluate the magnitude of likely change in groundwater/surface water interaction as a result of quarry expansion by comparing baseline conditions and conditions under the various scenarios. Because of the drawdown created by dewatering P12, there are small changes in groundwater discharge to streams and streamflow, generally restricted to within the 2 m drawdown zone. The magnitude of the changes are reduced significantly when levels in P!2 recover and a lake is formed.	

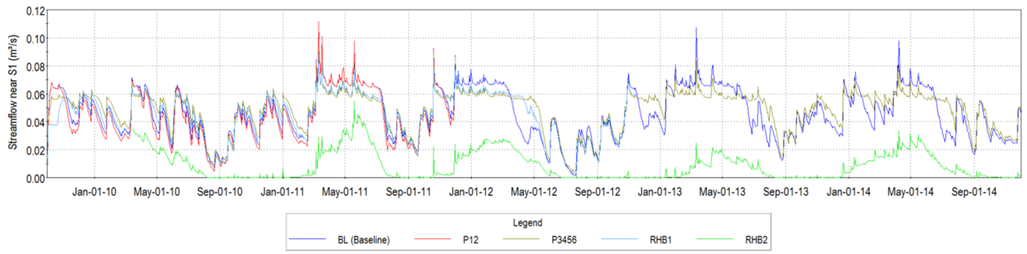
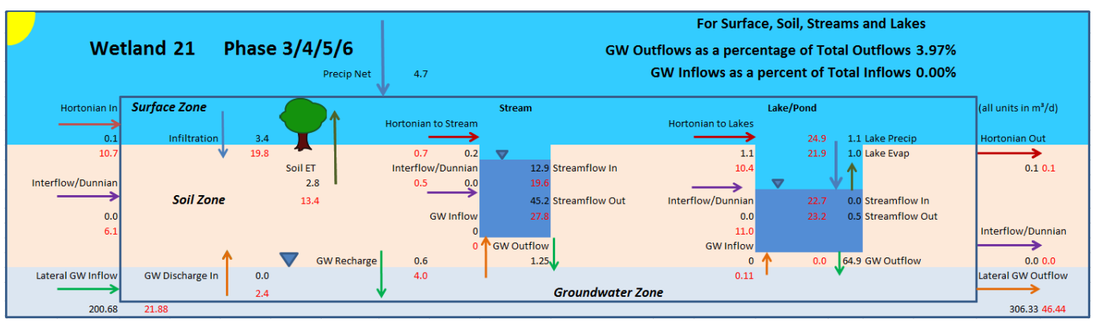
	functions be maintained during and after extraction?				
199.	How was the level of detail generated for this figure where there are widely dispersed data control points or monitoring locations?	Page 184 Figure 7.21. Average Simulated Streamflow Loss to Groundwater (blue) or Groundwater Discharge to Streams (red) (m^3/d) under Baseline Conditions	Norbert M. Woerns	As noted in the caption these are average <u>simulated</u> values. The model computes stream leakage, surface discharge, overland runoff, and groundwater leakage at every cell in the model grid. The daily cell-by-cell values were averaged over the simulation period. You are probably more used to model results presented as coloured rectangular cell values (see below); we used a new VIEWLOG option to colour the stream segment crossing the cell based on the cell value.  	
200.	Wetland 9 (13014) water balance summary shows no groundwater discharge, however based on Figure 6.26, at OW03-21 there are documented upward gradients between the deep and shallow bedrock. Please provide hydrograph of all available monitoring data for OW03-30, OW03-31, MW03-08, MW03-10 and MW03-11 located in and around Wetland 9.	Page 186 Figure 7.23	Conservation Halton	A hydrograph for MW03-10 is presented below as it is closer to the wetland than OW03-21 and also has a shallow (C) well. There is some crossover between the B and A wells, but the shallow well consistently shows downward gradients between the overburden and the deep bedrock. Similar conditions exist in all nearby wells It is important to note that simulated heads in Layer 1 were below land surface while stage was close to land surface the entire simulation period. The water budget shown summed up the stream leakage for all cells within the wetland polygon as discharge to groundwater.	

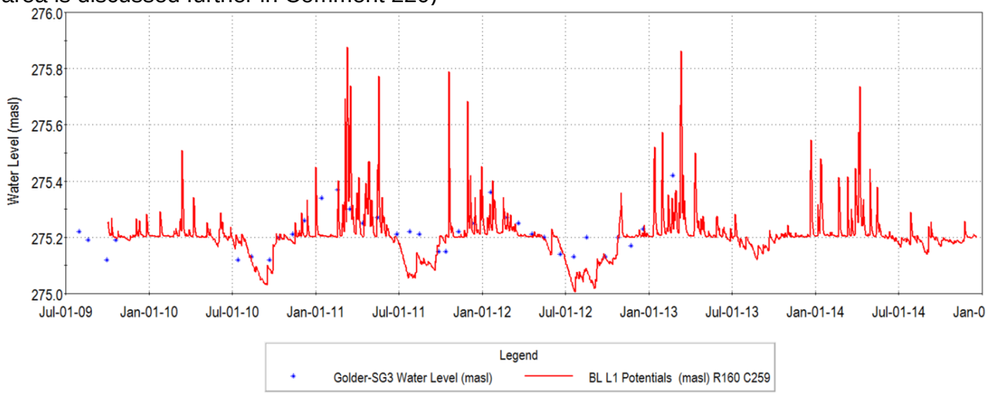
					
201.	The water budget inputs do not appear to match the outputs. Please clarify.	Pages 186-188 Figures 7.23-7.28. Wetland Water Budgets	Norbert M. Woerns	The wetland water budgets should nearly close. There are round-off errors due to: Change in storage. The lake or soil zone may have more or less water remaining in it at the end of the assessment period Mass balance error. There can be a small mass balance error (2-3%) over the simulation Precipitation and ET directly in/out of streams calculated but not tabulated here (usually small) The SW and GW models are solved iteratively, with the surface water system solved first and then the GW model, so there is potential for small discrepancies Internal transfers between processes After further investigation, the key problem turns out to be the way the polygon was drawn and the cells selected. For example, the polygon for Wetland 9 missed two cells that the stream touched but were not included in the summation. Hortonian and Interflow to streams was underreported by 10% because of this. This would account for the difference between those terms and stream pickup through the wetland. We tried hard to be careful not to miss any cells (see the selected cells versus the polygons for the two small wetlands (10 and 11) but may have missed some. 	
202.	To evaluate the results of the wetland water balance results please submit all available water level monitoring data in and around the wetlands.	Pages 186-189 Figures 7.24-7.30	Conservation Halton	A package of interdisciplinary tables integrating wetland and watercourse characterization and analysis has been prepared and provided in Schedules B and C.	
203.	'The Baseline surface water analysis demonstrates that, while there are some interactions between the surface and groundwater systems, they are frequently limited by the regionally extensive, and low	Page 190 Section 7.3. Baseline Conditions,	Norbert M. Woerns	Golder (2006) states that "As shown on Figure 18, no water level response is observed in the shallow overburden sediments and pockets of standing water. This indicates that there is essentially no hydraulic connection between surface water in the wetland and groundwater in the underlying bedrock during the testing period. This assessment is further supported by observed monitoring data from Cluster I and 3	

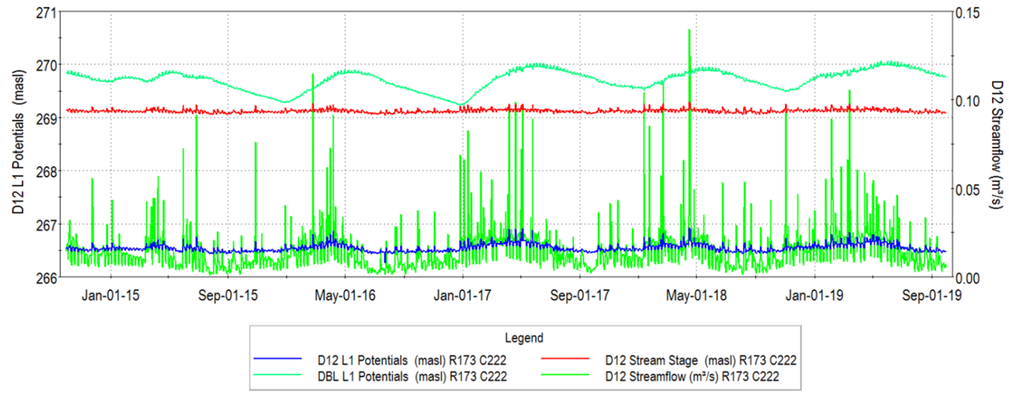
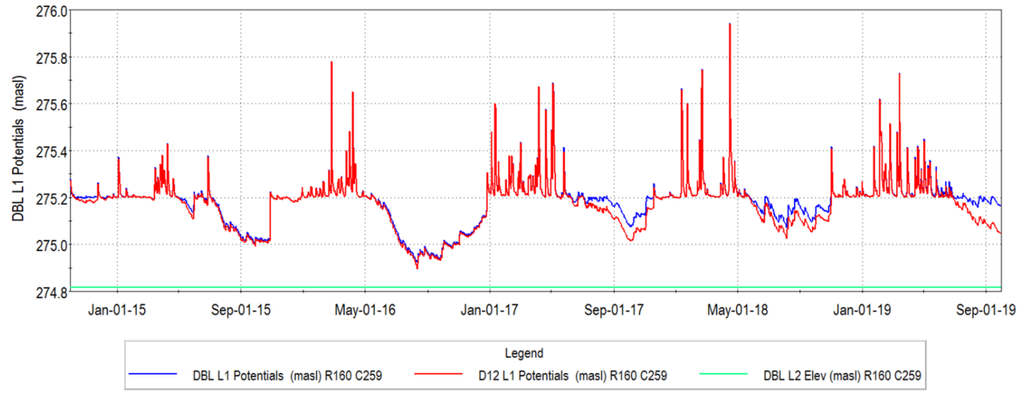
	permeability, Halton Till.' The Halton Till is recognized as consisting of relatively fine grained materials. However, no consideration has been given to the pump test results completed by Golder (2010) showing a response in the overburden materials presumably consisting of Halton Till to pumping test 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.	2nd Paragraph		which are presented in Figure C-3 and C-4 respectively in Appendix C. Some of the C series wells responded to the pumping tests. These wells are drilled to top of bedrock and therefore would respond differently than wells screened solely within the overburden. Most of the C wells showed no response. As in the bedrock, there are likely some vertical fractures penetrating the till. This would allow heads to respond to recharge events, but it does not mean that there is significant flow across the unit.	
204.	''None of the wetlands in the immediate vicinity of the quarry receive significant groundwater inflows.' How can this be determined with any certainty without instrumentation and monitoring of both groundwater and surface at each of the wetlands? Only five of the 22 wetlands have groundwater instrumentation installed for this investigation. Clarification is required.	Page 190 Section 7.3. Baseline Conditions, 2nd Paragraph	Norbert M. Woerns	This section is summarizing the results of the simulations which used property information from testing and monitoring at the five instrumented wetlands.	
205.	'Near the existing quarry that available drawdown is reduced, but many existing wells are in close proximity to the quarry, and yet have been providing suitable water supply for many years.' Evidence to support the conclusion regarding suitable water supply for wells in close proximity to the existing quarry should be provided.	Page 190 Section 7.3. Baseline Conditions, 3rd Paragraph	Norbert M. Woerns	The observation being made here is simply that adequate water quantity has not been a problem in the quarry vicinity despite ongoing operations at the quarry and climate variability. It is recognized that additional drawdowns will likely occur as a result of the quarry extensions. This is discussed in Chapter 8. Please refer to the well survey discussion for more information on local water supply.	
206.	'However, the off-site discharge will continue as per the conditions of Nelson's PTTW and ECA.' There is a recommendation to increase the discharge volume for Sump 100. Tatham page 92 last paragraph. This is contradictory to the above statement. No assessment of the impact of this increase in pumping on downstream areas has been completed to support this increase in pumping. An assessment of the impact of the increase in pumping on downstream areas is required to support this increase in pumping.	Page 191 Section 8.1. Proposed Extraction, 1st Paragraph	Norbert M. Woerns	The model simulated the discharge volumes for the expanded quarry in a similar manner as the baseline conditions where discharge was triggered based on the elevations of the water in the sumps. Thus, discharge was increased automatically in the model due to expansion of the quarry and the assumed drainage of water (precipitation and groundwater inflow). Accordingly, the assessment of the impact of the increase in pumping on downstream areas has been completed.	
207.	'For the western extraction area, the existing sump (0100) will continue to operate and discharge water to the Collins Road roadside ditch and into the Weir Pond. The existing golf course irrigation ditch and pond will be relocated to an area outside of the extraction area but inside of the license boundary to replicate the artificial groundwater mound they currently create.' Has the groundwater mound beneath the existing irrigation ditch and pond been confirmed with field data or is it only assumed to exist? If the Halton Till limits surface and groundwater interaction as	Page 191 Section 8.1. Proposed Extraction, 2nd Paragraph	Norbert M. Woerns	The baseline simulation indicates that heads would be elevated in the vicinity of the golf course ponds, Under Scenario P3456, the mound would be shifted to underneath the infiltration pond (see figures below). The observation data covered a limited period and wells were not positioned to detect mounding. Seepage out of the infiltration pond is higher because it is excavated to the weathered bedrock. The model simulates higher average seepage by about a factor of 6.	

	postulated above, the proposed infiltration pond may not provide significant recharge to the underlying aquifer. Please clarify				
208.	'The Level 2 Assessment surface and groundwater issues are fully addressed by the integrated model.' The Level 2 assessment has not addressed water quality issues with respect to potential impact of the quarry on water quality discharge as surface water and potentially being recharged back into the aquifer through an infiltration pond(s). The drinking water quality implications of this have not been addressed in the assessment. Potential sources of contamination affecting surface and groundwater quality have also not been addressed in this assessment. The nearby high pressure oil pipeline along the southern side of Collins Road and partially beneath the wetland adjacent to SW1 and the weir to control quarry discharge water, presents a potential water quality risk to the quarry operations. (see Site Plan Sheet 1 of 4 and Explotech Blasting Report page 19). A more complete analysis of water quality issues is required.	Page 191 Section 8.3. Level 2 Assessment Overview, 1st Paragraph	Norbert M. Woerns	Please refer to Response 7 and 8.	
209.	It is stated that from a hydrogeological perspective the proposed west quarry extension is located in a favorable area due to the Medad Valley which is "a locally significant groundwater discharge area" which reduces the amount of inter-seasonal water level fluctuations. The Medad Valley is downstream of the proposed extension and although it is a hydraulic boundary which reduces the amount of water level fluctuations, a reduction of flow towards it would be considered a direct negative impact on this feature. Furthermore, most of the proposed west quarry	Pages 191-192 Section 8.3. Level 2 Assessment Overview	Conservation Halton	The baseline simulation indicates that heads would be elevated in the vicinity of the golf course ponds, Under Scenario P3456, the mound would be shifted to underneath the infiltration pond (see figures in response 207).	

	extension is upgradient of numerous private water supplies, an area which provides recharge to the underlying aquifer. Since most of this area would be extracted causing groundwater lowering due to quarry cone of influence and reducing the upgradient area providing recharge for the private water supplies, an infiltration pond had to be proposed to mitigate the impacts, feasibility of which is uncertain (please see comments below, re: Page 226, Section 8.6.1 Infiltration Pond).				
210.	Right Hand Column - Level 2 Assessment Needed?, 3rd row 'Limited potential for water quality effects as groundwater dewatering will maintain flow directions into the quarry.' There is no information provided in the hydrogeological report to support the above statement. Clarification is required.	Page 192 Table 8.1. Evaluation for Need for Level 2 Hydrogeological Assessment	Norbert M. Woerns	Please refer to Response 7 and 8. Water quality monitoring is discussed in the AMP. As noted, the quarry forms a local groundwater sink and the general direction of flow in the quarry vicinity is inward into the quarry. Accordingly, contaminant spills within the quarry or close to the quarry face will be drawn in to the quarry.	
211.	The Level 2 Impact Assessment of the Hydrogeological Assessment report (Section 8) refers to the Medad Valley as a "significant discharge area" (Page 192, first paragraph). Table 8.1 specifically identifies the need to evaluate springs: "Springs located downgradient of the Site in the Medad Valley, and headwater streams located in and around the Mt. Nemo escarpment area" for which there is a need to "assess potential impact on springs."	Section 8 Page 192, 1st Paragraph, and Table 8.1	Daryl W. Cowell & Associates Inc.	Comment noted.	
212.	The Medad Valley Wetland Complex is within 120.0 metres of the proposed western extension development boundary yet Table 8.1 does not identify the need to assess impacts to the wetland complex per se as required under the PPS and under HRCA Regulation 162/06. Although most of the western extension quarry operations will technically occur beyond 120.0 metres (but within the 240.0 metres specified by the NEC), there is no doubt that impacts to groundwater flows to the springs could significantly impact "hydrological and hydrogeological functions" in the Medad Valley Wetland Complex.	Table 8.1	Daryl W. Cowell & Associates Inc.	Changes in groundwater and surface water flow to the Medad Valley were addressed in the simulations and analyses of model results.	
213.	A more robust discussion of the anticipated changes in stream flows should be provided. At a minimum, the analysis should include: • Maximum changes in stream flow rates for each tributary/flow node (in addition to the change in average stream flow rates provided). • Percentage change in average and maximum stream flow rates. • Any change in the duration of no flow or baseflow periods.	Pages 193-302 Section 8.4. Model Evaluation of Extraction Phases	Conservation Halton	The hydrograph below compares flows for Willoughby Tributary immediately downstream of Collings Road for the baseline and four scenarios. Flow statistics are provided in the accompanying table. In general, flows under P12 are generally similar to the baseline. Flows under P3456 and RHB1 are similar to each other but are generally lower in the winter and early spring compared to baseline but higher in the late spring. Flows do not differ much in the summer and fall. Flows under RHB2 are significantly lower due to cessation of pumping to dewater the quarry.	

	• Simulated stream hydrographs and analysis for Willoughby Tributary immediately downstream of Collings Road.			 **Station Near S1** / Baseline / P12 / P3456 / RHB1 / RHB2 Average Flow: 0.044 / 0.042 / 0.046 / 0.045 / 0.008 Maximum Flow: 0.122 / 0.120 / 0.091 / 0.088 / 0.055 Minimum Flow: 0.005 / 0.002 / 0.000 / 0.003 / 0.000 Q50: 0.043 / 0.040 / 0.053 / 0.048 / 0.004 Q95: 0.015 / 0.012 / 0.015 / 0.013 / 0.000 **Change in Flow by Volume** Average Decrease (m³/s): 0.003 / -0.001 / 0.000 / 0.038 Maximum Decrease (m³/s): 0.016 / 0.085 / 0.030 / 0.082 Maximum Increase (m³/s): -0.034 / -0.032 / -0.028 / 0.002 **Change in Flow by PerCent** Average Decrease (%): 7.504 / -7.862 / -2.113 / 85.132 Maximum Decrease (%): 55.919 / 99.954 / 43.332 / 100.000 Maximum Increase (%): -119.872 / -220.597 / -105.933 / 37.005 % of Days below Q50BL: 50.019 / 55.105 / 42.745 / 50.000 / 99.888 % of Days below Q95BL: 5.010 / 7.419 / 5.233 / 6.119 / 78.795	
214.	Detailed water budget for wetland figures should include baseline and proposed values to facilitate reviews.	Pages 193-302 Section 8.4. Model Evaluation of Extraction Phases	Conservation Halton	Baseline water budgets were provided in figures 7.23 to Figure 7.30 for 8 key wetlands. Wetland water budgets for the four scenarios are provided in subsequent sections of the report. If you are asking for the baseline values to be posted on the scenario results figures, it can be done but would take some effort and would not provide any new information. An example for Wetland 21 is shown below with baseline values posted in red. 		
215.	Table 8.3, Scenario Summary – The climate data periods used to analyse extraction scenarios are not	Page 196 Section 8.4.1.	Conservation Halton	As noted earlier, there were model stability issues related to modelling the Niagara Escarpment near Mt. Nemo. The periods posted in the table denote the successful run times. For key scenarios, we were able	

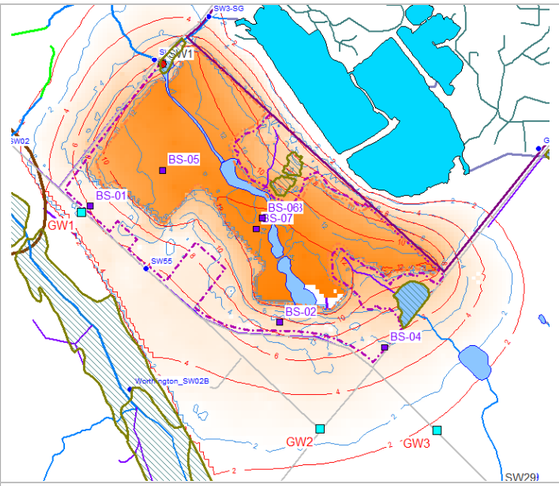
	consistent. Explanation and justification for the start and end dates should be provided.	Model Evaluation of Extraction Phases, Scenario Summary		to cover most or all of the 10-year period; sometimes requiring a separate drought period restart. The rehabilitation scenarios were run long enough to derive key information, such as lake stage and quarry discharge under the each rehabilitation scenarios. This information provided useful feedback and was incorporated into design modifications.	
216.	Up to 14 m or more drawdown predicted using equivalent porous media assumptions in model. Pumping tests (west extension area Well BS-07 and BS06) and well flow profiling in south extension area (S. McFarland Witness Statement Sept. 2010 PDF pages 284-286) show significantly different hydraulic conditions within short distances. These results question the reliability of the model to predict local conditions. Please explain how the site variability impacts the model assumptions and the reliability of the model predictions.	Page 200 Figure 8.5. Average Simulated Drawdown in Model Layer 6 (m) and Increase/ Decrease in Streamflow	Norbert M. Woerns	The 14 m drawdowns within the quarry footprint are a result of dewatering the P12 quarry extension and are to be expected. The point of the figure is to show how far the drawdowns would extend outside of the quarry footprint. The question has been answered multiple times. There are unknowable local variations in hydraulic conductivity because of the fractured nature of the bedrock. What we did is use a reasonably conservative EPM assumption with mean values to represent he entire study area. We believe that in this way, the model was able to produce reasonably conservative estimates of the likely time-dependent drawdowns across the study area.	
217.	'The transient simulations through 2015-2016 provide insight into the effects of P12 during seasonal and interannual variation, including a Level 2 drought.' These simulations lack comparison (calibration) of predicted drawdowns to sites with measured groundwater levels during this time period. What is the impact of the lack of data for calibration of the model and on predictions of the model?	Page 204 Section 8.5.2. P12 Seasonal and Inter-annual Groundwater Levels, 1st Paragraph	Norbert M. Woerns	This question has been asked multiple times. The model was calibrated to streamflow, regional groundwater levels, and local response to pump tests and quarry advancement. The transient baseline heads were compared to Golder wells with observation data for earlier time periods. Although there were gaps in the observation data, the results for earlier periods demonstrate the predictive capability of the model. As an example, the figure below shows a hydrograph for Wetland 17 and Golder SG3. There is reasonably good agreement between the monthly staff gauge measurements and the daily stage. (This area is discussed further in Comment 220) 	
218.	'Under drought conditions there will, however, continue to be up to 20 m of available drawdown in the Amabel Aquifer. (Figure 8.21)' No consideration is given well productivity in assessing interference potential and groundwater availability. Available drawdown alone does not guarantee adequate water supplies. Well productivity and water quality should be considered in quarry impacts on private wells and the assessment of groundwater availability.	Page 204 Section 8.5.2. P12 Seasonal and Inter-annual Groundwater Levels, Last Paragraph	Norbert M. Woerns	This has been asked multiple times. The point is that there is adequate available drawdown and deeper wells should not be affected. Affected shallow wells could be deepened to address those that go dry due to quarry impacts. There may be individual wells with construction-related issues or areas where well yield proves inadequate. Well operation issues can be mitigated.	
219.	'Figure 8.24 presents the average simulated streamflow loss to groundwater (blue areas) and the areas of groundwater discharge to streams (red	Page 211 Section 8.5.3. P12 Surface	Norbert M. Woerns	While most reaches are perched, because of variations in topography, some reaches in the west are gaining under baseline conditions (i.e. heads are higher than stream stage, see light green line in hydrograph near SW6 versus red line). Due to decreases in groundwater levels under P12 (see blue	

	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?	Water/ Groundwater Interaction, 2nd Paragraph		line), these reaches shift to losing reaches. In addition, increased discharge from the quarry raises stream stage in the west streams, thereby increasing leakage out of the perched reaches. 	
220.	'Under P12 conditions, water levels have declined by up to 5 m under Wetland 17. What is the impact of lowering groundwater levels by 5 metres on the hydroperiod of this wetland?	Page 211 Section 8.5.3. P12 Surface Water/ Groundwater Interaction, 2nd Paragraph	Norbert M. Woerns	As discussed in the report, groundwater inflow into Wetland 17 comprises about 1.3% of the overall water budget, on average, under baseline conditions. The reduction in water levels will eliminate this inflow. The hydrograph shows simulated wetland stage during the drought period under baseline and P12 conditions at SG-3 (see Comment 217). The model indicates that wetland stage will drop in the summer in most years as much as 10 cm; however the stage in this wetland cell remains above the wetland base (green line). Each cells within the wetland complex will behave differently, this one is located in the centre. The water budget looked at the average response of all cells. 	
221.	'Water budgets were completed to analyze inflows and outflows to 22 local wetlands (locations shown in Figure 7.22).' Only five wetlands have shallow groundwater monitors installed for this study. How can water budgets completed without groundwater monitoring data and surface water monitoring data at each wetland be considered reliable?	Page 211 Section 8.5.4. P12 Wetland Water Budgets,1st paragraph	Norbert M. Woerns	This question has been asked multiple times. These are water budgets based on model simulations. Most items in a typical water budget including runoff, infiltration, canopy capture, ET, cannot be measured directly with simple instrumentation such as staff gages and piezometers. Instead, the model was calibrated to match water levels (stage and head) and streamflow and checked against other secondary indicators such as soil moisture. The assumption is that if measurable outputs are matched over a wide range of conditions, the partitioning of flows within the water budget is reasonable. The extension of this assumption is that if reasonable parameter values are used to represent processes in the monitored catchment, they can be used with reasonable confidence in the unmonitored catchments.	
222.	Wetland 21 (13201) is considered compromised due to the road and culvert, and its water budget is not considered representative of future conditions. There is also minor groundwater discharge to the wetland.	Page 212 Section 8.5.4. P12 Wetland Water	Conservation Halton	An extensive package of **interdisciplinary** tables integrating wetland and watercourse characterization and analysis has been prepared and provided in Schedules B and C. Wetland 13201 is discussed in detail.	

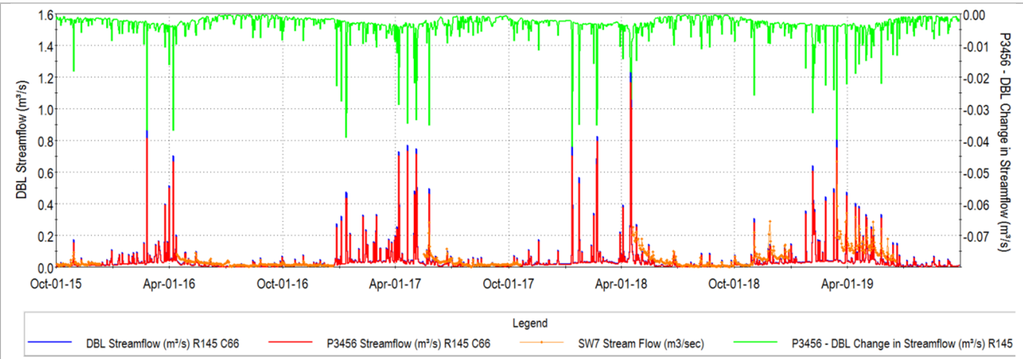
	Please confirm how changes to this wetland will be assessed and mitigated. The NETR identifies this wetland as adjacent to a rare vegetation community and this should be considered when assessing impacts.	Budgets		As noted, there are small changes in groundwater inflows to Wetland 21. Also noted is that further review of the wetland is planned and inflows may be supplemented. The model did not consider possible flow augmentation, so the effects of the water budget, if any, will likely be smaller than predicted.	
223.	The baseline conditions are compared to the Phase12 conditions in this figure for layer 2 (Halton Till overburden) and Layer 8 (Lower Fracture Zone). The section line extends in a northwest-southeast direction parallel to a series of wetlands east of the southern extension. The baseline conditions show water levels in layer 2 at or slightly above surface at Wetland #17 with progressively lower levels toward the northwest as one approaches the existing quarry. The layer 8 water levels follow a similar pattern with relatively high groundwater levels at wetland #17 with progressively lower levels to the northwest as one approaches the quarry. The drop in water levels closer to the quarry are likely the result of the existing quarry dewatering. (See Section 5.3.3.2 Quarry Water Level Patterns). Consequently, the current hydrogeologic conditions beneath the wetlands between wetland #17 and the quarry appear to represent altered groundwater conditions. It is also possible that wetland #17 has been impacted by the existing quarry. The current or baseline conditions of these wetlands are being used to measure the impact of the quarry expansion. The simulated Phase12 conditions show a similar pattern of decreasing water levels toward the northwest with water levels in both Layer 2 and Layer 8 being lower than baseline conditions. Please explain the appropriateness of using impacted wetland conditions as a baseline for purposes of site rehabilitation.	Page 218 Figure 8.27. Wetland Cross Section	Norbert M. Woerns	This question has been asked multiple times. The analysis focussed on how streamflow, groundwater levels, and wetland stage and related measures would be affected by quarry expansion.	
224.	The water budget inputs do not appear to match the outputs. It would be useful to illustrate water budget inputs and outputs in a table format for comparison. It is not clear how GW Outflows and Inflows as a percentage of Total outflows were calculated. Please clarify.	Page 221-224 Wetland Water Budget Figures 8.30-8.37	Norbert M. Woerns	See Response 201. In general, the matches between inputs and outputs are close. We recognize some problems where a stream crossed the edge of a wetland cell but was not accounted for. We divided the sum of all the outflows to groundwater by the sum of all the wetland area outflows and multiplied by 100. GW outflow terms included GW recharge, GW discharge to streams, and GW discharge to lakes. The other outflows included Soil ET, streamflow out, lake evaporation, Hortonian runoff out, and interflow/Dunnian runoff out. GW inflow terms included GW discharge (surface leakage), GW inflow from streams, and GW inflow from lakes. The other outflows included Net Precipitation, streamflow in, lake precipitation, Hortonian runoff in, and interflow/Dunnian runoff in.	
225.	Phases P34, P3456, RHB1 - The report suggests that water is not discharged to the tributary of Mt. Nemo Creek during these phases, while other reports indicate the discharge from Quarry Sump Q200 will continue through these phases and will potentially increase. Analysis should be consistent with proposed mitigation plan and the modeling updated as necessary.	Page 225 Section 8.6. Scenario P34; Page 230 Scenario P3456; Page 260 Section 8.8, Scenario RHB1	Conservation Halton	Discharge from Quarry Sump Q200 to dewater the existing quarry would continue through phases P34, P3456, and RHB1. The increased discharge from the sump during Phase 12 would be discontinued and the South Quarry Extension would be allowed to fill.	
226.	Scenario P34 assumes that extraction in Phase 1 and	Page 225	Conservation	The simulations of P34 assumed that the P12 quarry would fill in a relatively short amount of time	

	2 is complete and the water levels filled to the natural conditions. How long will it take for P12 to fill to the natural conditions? Unless P12 is filled before extraction commences in P34 the proposed approach does not represent cumulative impacts.	Section 8.6. Scenario P34	Halton	(assumed to be several years) with a high rate initially and tapering off over time. It was also assumed that P34 would be fully excavated at the start of the simulation, so that a conservative analysis of impacts could be conducted. There will likely be a period where some of the P34 area has been partly excavated and the P12 not fully recovered, but we do not believe that this will represent a worst condition than the two end-members.	
227.	'The wetland water budgets confirm that the wetlands will leak a small amount more to the groundwater system under P12 conditions, but the effect of this change is so small that it cannot be measured in the field and will not change the overall water budget of the wetland.' Leakage of water from the wetlands into the groundwater system can only be confirmed for those wetlands with shallow groundwater monitoring data along with surface water monitors. What effect is this loss of water from the wetlands expected to have on the wetlands?	Page 225 Section 8.5.5. P12 Level 2 Conclusions, 4th Paragraph	Norbert M. Woerns	See Response 220. The response discusses Wetland 17 which is typical of wetlands close to the P12 quarry extension. The responses at all other wetlands were evaluated and formed the basis of our statement.	
228.	The proposed infiltration pond (as shown on Figure 8.38) does not match the pond shape on the submitted site plans. The pond on the site plans does not have a spur parallel to Cedar Springs Road in the northwest corner of the site. The grades on the site plans suggest that the spur cannot be constructed as shown on Figure 8.38. Please clarify.	Page 226 Section 8.6.1. Infiltration Pond	Conservation Halton	The graphical presentation may be slightly different, but the function is consistent.	
229.	Is the proposed infiltration pond an appropriate measure to mitigate impacts on private water supplies? The proposed infiltration pond would make most, if not all downstream wells, categorized as groundwater under direct influence of surface water (GUDI wells). Although, the proposed infiltration pond could be used as a measure to mitigate impacts on the NHS (Medad Valley), assuming that the pre-extraction groundwater heads could be maintained, considering private water supplies exist downstream of the proposed pond, how would the construction of the ponds be carried out to ensure ample and good quality of water is available for downgradient groundwater users? What measures would be implemented to ensure that water quality meets ODWQS? How would the pond be constructed to ensure continued infiltration: it is stated in the report that wetlands are perched, what would be done to ensure that the infiltration pond does not lose its intended functionality with time? How would water be prevented to flow back into the extraction zone? Monitoring, mitigation and contingency details should be provided to ensure that there is no water quantity and quality impacts on the downstream groundwater users in this area.	Page 226 Section 8.6.1. Infiltration Pond	Conservation Halton	1) Wells were already affected by the golf course irrigation ponds 2) Many private wells are already close to ditches and streams 3) The water quality is monitored and fit for discharge to surface water (i.e. to the unnamed tributary to Willoughby Creek. A discussion of surface water quality is presented in Response 7 and 8 The pond is to be excavated to the top of the weathered bedrock. Significantly higher infiltration rates (than from the golf course irrigation ponds) would be expected. Some infiltrated water is likely to discharge to the quarry and be recirculated.	

230.	'Water is currently routinely diverted from the north quarry discharge pond, through golf course ditches, to the golf course ponds. This water is used for irrigation and a portion also likely infiltrates directly to the groundwater system. The proposed infiltration pond is intended to function in a similar manner to the irrigation ditches and golf course ponds, so as to help maintain the current surface and groundwater system patterns. In addition, based on the findings of this report, Tatham (2020), and Savanta (2020), pumping to the north and south (Quarry discharge locations Sump 0100 and 0200), must be maintained.' The infiltration capability of the irrigation pond is assumed and has not been confirmed with field instrumentation. A compelling case for the maintenance of pumping to the north and south (Quarry discharge locations Sump 0100 and 0200) is not supported with the analysis. A more complete analysis of the impact of the rehabilitation scenarios should be completed considering not only individual stream reaches but the sub-watershed as a whole.	Page 226 Section 8.6.1. Infiltration Pond, 1st Paragraph	Norbert M. Woerns	Modelling analysis showed that leakage from the infiltration pond, presumed to be in contact with the weathered bedrock, would be much higher than for the golf course ponds. Pumping to the sumps would continue in order to: (1) dewater the existing quarry and the quarry extensions, and (2) to help maintain hydrologic and biologic features that have adapted to the higher flows. Predicted changes in discharge from the sumps were analyzed in each scenario. The comprehensive analysis of the rehabilitation scenarios (RHB1 and RHB2) considered potential impacts to groundwater and streamflow across the entire study area including the Willoughby Creek sub-watershed.	
231.	'Figure 8.40 also shows the average simulated change in streamflow. Increases in simulated flow occur at the Northwest sump (and in new quarry floor drains and the conduits carrying flow to the infiltration pond). Decreases in simulated flow occur in the Medad Valley, reaching a maximum of approximately $1.0x10.0^{-3}$ m3/s (1.0 litre/second) in the Medad creek immediately west of the P34 excavation.' What accounts for the decrease in flow to Medad Valley given the increase in flow of quarry discharge and subsequent discharge into the proposed infiltration pond?	Page 226 Section 8.6.2. P34 Drawdowns and Surface Water Flows, 2nd Paragraph	Norbert M. Woerns	The infiltration pond is intended to mitigate the effects of the quarry expansion as best as possible. Small changes in flows, groundwater levels, and groundwater discharge still occur across the study area despite the infiltration pond and are reflected in the small changes in flow in the Medad Valley.	
232.	Scenario P3456 assumes that extraction in Phase 1 and 2 is complete and the water levels filled to the natural conditions. How long will it take for P12 to fill to the natural conditions? Unless P12 is filled before extraction commences in P3456 the proposed approached does not represent cumulative impacts.	Page 230 Section 8.7. Scenario P3456	Conservation Halton	See response 226	
233.	'Figure 8.42 shows the average simulated heads in Model Layer 6, representing the middle fracture zone in the Amabel aquifer and average simulated streamflow for the same period under Scenario P3456. Figure 8.43 shows the average simulated drawdown in Model Layer 6. The water levels rise rapidly with distance from the excavation, and exhibit less than 2.0 m of drawdown at a distance of 500 m from the active face.' The depth of excavation will extend to 252.5 mASL to	Page 230 Section 8.7.1. P3456 Drawdowns and Surface Water Flows, 1st Paragraph	Norbert M. Woerns	The sumps were assumed to be at the elevation of the quarry floor. Water levels will decrease in Layer 8 as well as Layer 6. The drawdowns extend out a bit (< 100 m) further in Layer 8 (red contours) compared to Layer 6.	

	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?				
234.	No changes to the water budget for Wetland 22 (13200) are suggested, as the wetland is perched and there is no change to its contributing area, however as noted in the Surface Water Assessment drawings DP-1 and DP-2, it appears that there will be changes to the catchment area of the wetland. Please discuss if these changes will impact the water budget for this wetland.	Page 242 Section 8.7.4. P3456 Wetland Water Budgets	Conservation Halton	Our assessment did not find significant changes to the area directly contributing to the wetlands and, therefore, no significant change to the water budget.	
235.	'Wetland 22 is located between the P3456 extraction area and the existing quarry. This wetland had no change in the water budget compared to baseline conditions because it is perched year-round and there was no change in the contributing area.' This wetland is located relatively close to the existing quarry within about 100.0 metres, and appears to be perched, likely due to the impacts of the existing quarry. It is reasonable to assume that the proposed western expansion will not substantially change the conditions beneath Wetland #22 as quarry impacts on the groundwater system have already occurred. There is no water level data from the overburden in this area to confirm shallow groundwater table. The nearest monitors BS-03A and BS-03B are completed into the underlying bedrock. The hydrograph for BS-03A and BS-03B shown on the lower figure on page 395 (no figure no.) indicated very slight downward gradient from data logger data. It is unclear what the red line and red symbol on the hydrograph for BS-03 represents. Is this BS-03A or BS-03B? Water level data in the wetland and underlying overburden along with the underlying bedrock is required to asses the water budget and potential impact of the proposed expansion.	Page 242 Section 8.7.4. P3456 Wetland Water Budgets, 2nd Paragraph	Norbert M. Woerns	For a discussion of this specific wetland please refer to the package of interdisciplinary tables integrating wetland and watercourse characterization and analysis has been prepared and provided in Schedules B and C. Additional water level data are being collected at this site.	
236.	It is not clear from water budget figures 8.62 to 8.69,	Page 243	Norbert M.	We divided the sum of all the outflows to groundwater by the sum of all the wetland area outflows and	

	how the percent groundwater outflow and inflow was determined. Please clarify.	Section 8.7.4. P3456 Wetland Water Budgets Table 8.6	Woerns	multiplied by 100. GW outflow terms included GW recharge, GW discharge to streams, and GW discharge to lakes. The other outflows included Soil ET, streamflow out, lake evaporation, Hortonian runoff out, and interflow/Dunnian runoff out. GW inflow terms included GW discharge (surface leakage), GW inflow from streams, and GW inflow from lakes. The other outflows included Net Precipitation, streamflow in, lake precipitation, Hortonian runoff in, and interflow/Dunnian runoff in.	
237.	'Under P3456 conditions, current levels of quarry discharge will continue to pass through this pond. Diversions for golf course operations will no longer be necessary, however a portion of flow will be diverted to the newly constructed infiltration pond, which will locally support groundwater levels in a similar manner to the current golf course ditch and pond system.' The degree to which the existing irrigation pond is contributing to the groundwater system is questionable since Earthfx has concluded 'while there are some interactions between the surface and groundwater systems, they are frequently limited by the regionally extensive, and low permeability, Halton Till.' What is the impact of low permeability Halton Till on the proposed infiltration pond? What is the potential for infiltrated water from the proposed infiltration pond to be intercepted by the underlying sand layer and the karst layer, Model Layer 4 and not reach the wells?	Page 243 Section 8.7.5. P3456 North Quarry Discharge and Infiltration Pond, 2nd Paragraph	Norbert M. Woerns	This question has been asked multiple times. The purpose of the infiltration pond is to replace the golf course ponds that may have contributed to groundwater recharge in the area. It is assumed that the pond will be in good hydraulic contact with the bedrock surface and should provide higher leakage than the natural ponds with their accumulated sediments.	
238.	It is not clear from these figures how the percentage of groundwater inflow and out flow were determined. Please clarify.	Page 248-251 Figures 8.62-8.69. Detailed water budget for wetlands	Norbert M. Woerns	See Response 236	
239.	Further, Section 8.7.6 of the assessment report concludes "Overall, the construction of the west extension has a minor impact on the Medad Valley. No water is diverted away from this natural discharge zone, but some water is discharged slightly to the north via north quarry discharge stream."	Section 8.7.6	Daryl W. Cowell & Associates Inc.	Comment noted.	
240.	'The effects of P3456 development on the Medad Valley is distributed across this elongated feature. Figure 8.70 shows the areas where changes in groundwater discharge to the soil zone (seepage) will occur between the baseline and P3456 scenarios. (Values are presented on a cell-by-cell basis in m3/d). Summing those values from the start-of-flow-of Medad Creek to SW07 yields a net average decrease in seepage of 2.1 L/s at SW07. The hydrograph for SW07 (Figure 8.49) shows that the change is primarily a minor reduction in winter and spring peak flows.' Tatham measured average baseflow at SW7 at 4.0 litres/second (Tatham page 10 Monitoring Location SW7, 2nd paragraph, 1st sentence). SW7 is located on Willoughby Creek immediately downstream of the	Page 252 Section 8.7.6. P3456 Effects on Medad Valley, 1st Paragraph	Norbert M. Woerns	It should be noted that, except in 2019, Tatham pulled their loggers in December and replaced them in May, thereby missing much of the high flows. Our model was continuous. As we state, the larger change is in the winter and early spring. There is much less change in the summer flows.	

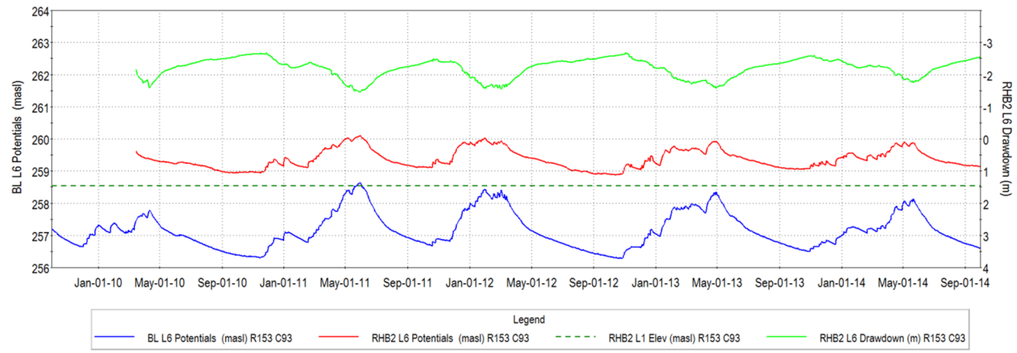
	confluence with the unnamed tributary to Willoughby Creek. As per the above, modeled net average decrease in seepage is 2.1 litres/second or just over 50.0% of the average baseflow measured at SW7. The significance of this reduction in baseflow should be addressed.				
241.	'the construction of the west extension has a minor impact on the Medad Valley. No water is diverted away from this natural discharge zone, but some water is discharged slightly to the north via north quarry discharge stream.' Tatham measured average baseflow at SW7 as 4.0 litres/second. The reduction in seepage is calculated to be 2.1 litres/second at SW7. This is about 50.0% reduction in average baseflow. The significance of this should be addressed.	Page 252 Section 8.7.6. P3456 Effects on Medad Valley, 5th Paragraph	Norbert M. Woerns	See Response 240 The effects on this wetland are discussed in more detail in the package of interdisciplinary tables integrating wetland and watercourse characterization and analysis that has been prepared and provided in Schedules B and C.	
242.	'The water levels rise rapidly with distance from the excavation, and exhibit less than 2.0 m of drawdown at a distance of 500 m from the active face.' Most of the homes along Cedar Springs Road directly down-gradient of the proposed quarry expansion are within 300.0 metres of the limit of extraction. What is the risk of interference to these wells from the quarry expansion and what is the potential for deepening wells on these properties to maintain well productivity and water quality? Please address this issue.	Page 256 Section 8.7.7. P3456 Level 2 Conclusions, 1st Paragraph	Norbert M. Woerns	As noted, this is a groundwater discharge area and is not significantly sensitive to change.	
243.	'The basal Layer 8 lower fracture will maintain, on average, between 6 and 20 m of available drawdown in the aquifer (Figure 8.75). As a result, private domestic water wells, some of which are partially penetrate the Amabel Formation, could be deepened if necessary. The proposed groundwater monitoring program has been designed to ensure that there are no changes to the quantity or quality of private water supplies (Section 9.3).' What is proposed for existing private wells that do not have 5 metres of available drawdown to support their water supply or for wells that are poorly productive and cannot supply adequate supplies of water? Please address this.	Page 256 Section 8.7.7. P3456 Level 2 Conclusions, 2nd Paragraph	Norbert M. Woerns	This question has been asked and answered multiple times	
244.	'Under baseline conditions, none of the wetlands receive more than 3% of their total inflows from the	Page 256 Section 8.7.7.	Norbert M. Woerns	As per Response 236, we divided the sum of all the outflows to groundwater by the sum of all the wetland area outflows and multiplied by 100. GW outflow terms included GW recharge, GW discharge to streams,	

	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?	P3456 Level 2 Conclusions, 5th Paragraph		and GW discharge to lakes. The other outflows included Soil ET, streamflow out, lake evaporation, Hortonian runoff out, and interflow/Dunnian runoff out. GW inflow terms included GW discharge (surface leakage), GW inflow from streams, and GW inflow from lakes. The other outflows included Net Precipitation, streamflow in, lake precipitation, Hortonian runoff in, and interflow/Dunnian runoff in. Specifically, water budgets were conducted using an Earthfx GSFLOW post-processor to analyze the daily flows produced as outputs from the PRMS and MODFLOW models. MODFLOW fluxes were analyzed with an Earthfx version of the USGS ZoneBudget tool. It processes all the direct cell-by-cell flow terms (e.g. groundwater recharge or stream leakage). Lateral flows are summed for all cells on the wetland boundary. Direct PRMS flows are also summed on a cell-by cell basis. Overland runoff and interflow required analyzing the cascade flow map to determine which cells have runoff leaving the wetland boundary and which cells receive runoff and interflow from upslope cells. Streams crossing the wetland boundaries were detected by analyzing the SFR2 input to locate stream segments entering and leaving the cells. Lake water budgets were saved on a daily basis and used to determine Lake precipitation, evaporation, and GW and streamflow inputs and outputs. The post-processor output was produced as a CSV file and pasted into an Excel spreadsheet to tabulate and combine flows to create the wetland water budget figures.	
245.	'The effects of the quarry extension are small and distributed across the long Medad Valley wetland. SW07, in the northern section of the Medad, shows some gains and losses in baseflow (Figure 8.43), but the largest change in flows at SW07 are a loss in peak flows, due to the increased buffering effect of the west extension (Figure 8.49). The changes in SW07 flows are so small that they will not be measurable in the field.' Tatham (p.10) measured average baseflow at 4 litres/second in Willoughby Creek at SW7. The model predicts a loss of seepage of 2.1 itres/second. This suggest a significant loss of stream baseflow. It is reasonable to assume that restoration of groundwater levels would restore most if not all of the loss in baseflow. This would be the case with Rehabilitation Scenario 2 (RHB2) whereas Rehabilitation Scenario 1 (RHB1) would continue to maintain lower groundwater levels. Please address this.	Page 257 1st Paragraph Section 8.7.7. P3456 Level 2 Conclusions	Norbert M. Woerns	See Responses 240 and 241. The loss is on an annual basis. Again, the model showed that flows would be affected mainly in the winter and spring not summer.	
246.	'Scenario RHB1 represents a managed rehabilitation and it is assumed that discharge from the Sump 0100 will be ongoing to maintain dry conditions in the rest of the quarry area and to keep the P5 lake at the specified elevation of 255.5 masl.' How does RHB1 conform to the rehabilitation plan for the adjacent existing quarry?	Page 260 Section 8.8. Scenario RHB1, 2nd Paragraph	Norbert M. Woerns	RHB1 is a plan for the entire quarry and would replace existing rehab plans.	
247.	How does the retained consultant know that the infiltration pond will provide groundwater discharge to the deeper bedrock (Model Layers 6 to 8) and not short circuit groundwater discharge only to the shallow bedrock system (Model Layers 4&5 weathered/fractured Amabel) and Upper Bulk Amabel) before discharging at surface along the Medad Valley? Note the upper bulk Amabel (Model Layer 5)	Page 263 Figure 8.79. Average Simulated Drawdown in Model Layer 6(m) and Increase	Norbert M. Woerns	As previously explained, water leaks out of the infiltration pond and forms a groundwater mound. As indicated in the model, heads rise in all layers.	

	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?	/Decrease in Stream Flow (m^3/s) for WY2010 to Y2012 under Scenario RHB1			
248.	'There are general decreases in flows within the existing quarry footprint and an overall decrease in the discharge from the Northwest sump. Decreases in simulated flow occur in the Medad Valley as a result, reaching a maximum of 5.2x10 -3 m3/s (5.2 L/s) compared to 3.6x10 -3 m3/s under Scenario P3456. Other streams in the east show small decreases in average flow compared to Baseline Conditions. Decreases in streamflow have been moderated compared to Scenario P12 due to the cessation of quarry dewatering at P12.' Why is there a decrease in flow in Medad valley of 5.2 litres/second under RHB1 when decrease in flow at SW7 is 2.1 litres/second under Scenario P3456 extraction? Why is there a larger decrease in flow in the Medad Valley as a result of rehabilitation Scenario 1 (RHB1) after extraction? Are these flows measured at different points?	Page 264 1st Paragraph Section 8.8.1. RHB1 Drawdowns and Surface Water Flows	Norbert M. Woerns	These were differences in average flows measured at SW7 (Average flows were 0.0423 m^3/s for baseline, 0.0387 for P3456, and 0.0372 for RHB1). The difference between Baseline and RHB1 is 5.1 L/s while the difference between baseline and P3456 is 3.6 L/s. The higher decrease for RHB1 is mainly because there is less quarry discharge under this scenario, therefore less leakage from the unnamed tributary and subsequent pickup in the Medad near SW7, as stated in the report (see next comment).	
249.	'SW07 in the Medad valley shows some gains and losses in baseflow, most likely due to changes in discharge from the Northwest sump that recharges the groundwater system as it flows through the karst feature.' SW7 gains and losses. How does this compare to decreases reported in Medad Valley above i.e., maximum 5.2 litres/second.	Page 264 2nd Paragraph Section 8.8.1. RHB1 Drawdowns and Surface Water Flows	Norbert M. Woerns	The 5.2 L/s is an average value. Figure 8.84 shows that there are decreases in the peak flows but baseflows actually increase slightly. The small increase is due to the higher head in the RHB1 lake and added leakage to groundwater but the peak flows decrease due to less quarry discharge. This demonstrates why a model is needed because there are a number of opposing factors affecting flow in the Medad and it is impossible to intuit which is likely to dominate.	
250.	'The wetlands are located at various distances from the existing quarry and the extension areas. Wetland 22 is located between the P3456 extraction area and the existing quarry. This wetland had no change in the water budget compared to baseline conditions because it is perched year-round and there was no change in the contributing area. Most of the other wetland areas are slightly more similar to baseline conditions than P3456 because of internal quarry configuration changes.' For wetland 22, the simulated water budget appears to rely upon model calibrations for validity without actual data collected from this wetland. Little is known of Wetland 22 (MNRF wetland #13200) due to a lack of monitoring data. Tatham indicated that surface water monitoring of this wetland will be established in the spring of 2020 with monitoring station SW 37	Page 272 Section 8.8.4. RHB1 Wetland Water Budgets, 2nd Paragraph	Norbert M. Woerns	As previously discussed, the model calibrated model was checked and found to produce reasonable results at instrumented wetlands. Assuming that underlying conditions are similar, the response at the remaining wetlands was felt to be predictable.	

	(Tatham, 2020, Table 39, page 81). No surface water monitoring data for this location are included in the Tatham report. The nearest groundwater monitor to wetland 22 is BS-03 which is about 100.0 metres from this wetland. A similar situation exists for wetland 21 located adjacent the north side of No. 2 Side Road. The nearest groundwater monitor location, BS-04, is about 150.0 metres from wetland 21. Quarterly surface water flow monitoring data was recorded at M33 at wetland 21. How does the lack of monitoring data for wetland 22 affect the reliability of the computer simulations of the water budget?				
251.	It is not clear how the percent of groundwater inflow and outflow have been determined. Please clarify.	Page 277-279 Wetland Water Budgets, Figures 8.98-8.103	Norbert M. Woerns	See Response 244.	
252.	'From a groundwater perspective, the differences between P3456 and the RHB1 scenario are minor. Under RHB1, a small rise in the water levels in the modified quarry ponds has a minor but positive effect on the water levels in the vicinity of the private wells near the Medad Valley. Quarry discharge and operations are similar. In summary, the Level 2 analysis of available drawdown and wetland function conclusions, presented for P3456 (Section 8.7.7) is essentially the same for RHB1.' This indicated that the preferred rehabilitation option, RHB1, will have very similar impacts on the groundwater and surface water system as the phase 3 to 6 proposed western quarry extension. This condition is proposed to be maintained in perpetuity. The rational for maintaining pumping and the low groundwater levels is based upon perceived fish habitat impacts on two stream reaches currently artificially maintained by pumping. There is no analysis of overall impact on the local sub-watershed. A broader analysis of the impacts on the sub-watershed should be completed.	Page 280 Section 8.8.5. RHB1 Level 2 Conclusions	Norbert M. Woerns	This report discusses groundwater conditions. There are a number of factors that make RHB1 a preferred alternative that are not discussed here. From a hydrologic/ecologic point of view, this is the preferred alternative because the flows to the fisheries are maintained. The distributed integrated model fully addresses overall impact on a sub-watershed scale. We specifically assess both local and distant surface water monitoring.	
253.	'Figure 8.106 shows the simulated change in average head in Model Layer 6. Only a very small area west of Phase 5 had a drawdown greater than 2 m, which was due to the elimination of quarry discharge and leakage to groundwater. Some residual drawdowns, less than 1.3 m, are noted in the P12 area, due to the flattening of the water table in the vicinity of the P12 lake. Most of the quarry vicinity showed a significant increase in heads ranging from 0 to 12 m, with the 2 m rise extending out up to 630 m from the west side of the existing quarry.'	Pages 280-281 Section 8.9.1. RHB2 Drawdowns and Surface Water Flows, 2nd Paragraph	Norbert M. Woerns	Yes, from a groundwater perspective, this may be a better alternative. As noted previously, there are concerns related to cessation of pumping at the existing quarry and therefore the preferred alternative was RHB1. We evaluated both scenarios with the integrated model.	

	The predicted increase in groundwater levels should result in restoration of groundwater conditions. The overall impact of this on surface water and on local wells should be assessed and factored into the rehabilitation scenario assessment.				
254.	‘Surface water flow in the upper reaches of a tributary of Willoughby Creek and the West Arm of the West Branch of Mount Nemo Creek will cease when the quarry discharge is discontinued, resulting in an adverse impact to downstream fish habitat compared to baseline conditions (See Savanta, 2020 and Tatham, 2020 for details).’ Model simulation results in flows deceasing in upper reaches of Willoughby Creek and the West Arm of the west branch of Mount Nemo Tributary of Grindstone Creek when quarry discharge is discontinued. Model simulation shown on Figure 8.105 (page 283) indicate that stream flows within these stream reaches continues but at a reduced rate compared to baseline conditions as shown on Figure 8.106 (page 284). The model shows an increase in stream flows of most of the other streams in the area (Figure 8.106). The stream flow increases have been quantified in the next two paragraphs on page 285. An overall analysis should be completed weighing the benefits of the stream flow increases against the disadvantages of reduced streamflow in selected areas. (Note: The impact of these changes in streamflow is a fish habitat issue and requires fisheries expert input.)	Page 281 Section 8.9.1. RHB2 Drawdowns and Surface Water Flows, 2nd Paragraph	Norbert M. Woerns	Typo, you are correct, the text should have said decrease not cease.	
255.	‘SW07 in the Medad valley shows very small gains in baseflow, most likely due to cessation of discharge from the Northwest Sump that served to recharge the groundwater system as it flowed through the karst feature. Decreases in event flows reach a maximum value of 0.05 m3/s.’ The simulated loss of seepage within Willoughby Creek down stream of the western expansion area was simulated to be 2.1 litres/second under the Phase 3456 extraction compared to current baseline conditions. Under RHB2 the quarry dewatering will cease and groundwater levels will increase up to 12.0 metres closest to the excavation. Given the large projected increase or rebound in groundwater levels under RHB2, it is not clear why there would not be a proportional increase or restoration of seepage in the Medad Valley as opposed to ‘very small gains in baseflow’ at SW7 downstream of the proposed western expansion as shown on Figure 8.112, page 288. Please clarify.	Page 285 2nd Paragraph Section 8.9.1. RHB2 Drawdowns and Surface Water Flows	Norbert M. Woerns	This sentence is a bit unclear. With quarry discharge ceasing, there is no inflow into the infiltration pond. The lack of infiltration from the pond though is offset by leakage from the filled quarry lake so overall there is a very small increase in baseflow. The event flows decrease because there is no quarry discharge and to SW1 and leakage from the karst feature.	
256.	The surface elevation should be shown on each of these hydrograph figures representing each of the	Page 289-292 Figures	Norbert M. Woerns	With the exception of GW1 (below) all heads are below land surface.	

	eight assessment points.	8.113-8.120			
257.	'Leakage below the final quarry lake contributes to the groundwater flow system and contributes to the higher heads outside of the quarry.' It is not clear how higher heads will be contributed to by the final quarry lake assuming that the lake levels will be slightly below the surrounding ground surface. As long as the water levels in the lake are maintained below the surrounding ground level, the quarry will act as a groundwater sink lowering groundwater levels in adjacent areas that occur above the lake level. Please clarify.	Page 293 Section 8.9.3 RHB2 Surface Water/ Groundwater Interaction, 1st Paragraph	Norbert M. Woerns	The comment is unclear from a hydrologic sense. Ground surface has nothing to do with groundwater levels. The quarry lake will be allowed to refill. It will reach an equilibrium where seepage in from the north, precipitation, lake evaporation, runoff in, and seepage to the south will balance. The lake becomes the local high point for the groundwater system across from Cedar Springs Road and heads slope down from the lake to the Medad Valley as per Figure 8.105.	
258.	'Surface water flow in the upper reaches of a tributary of Willoughby Creek and the West Arm of the West Branch of Mount Nemo Creek will cease when the quarry discharge is discontinued, resulting in an adverse impact to downstream fish habitat compared to baseline conditions (See Savanta, 2020 and Tatham, 2020 for details).' Figure 8.105 shows simulated flows within these stream reaches although reduced flow as shown on Figure 8.106. The model results therefore indicate that these stream reaches will continue to have stream flow albeit reduced flow and not cease totally as suggested in the above statement. It is acknowledged that these stream reaches will likely have periods of no flow during dry periods as was likely the case prior to quarry discharge being directed to these stream reaches. A more detailed assessment of changes to the sub-watershed should be completed to asses changes in the surface and groundwater flow regime and their impacts on natural heritage features and habitats.	Page 293, Section 8.9.5 RHB2 Level 2 Conclusions, 3rd paragraph	Norbert M. Woerns	Same as Comment 254.	
259.	It is unclear how the groundwater outflows and inflows as a percent of total flows were determined from these figures. No wetland water budget was shown for wetland no.19 for comparison to previous scenarios for wetland no. 19. Please clarify.	Page 298-300 Figures 8.125-8.130. Water Budget for Wetlands	Norbert M. Woerns	This has been previously addressed.	

260.	The impact assessment was done using a background scenario which represents altered conditions. As summarized in section 8.10.2, there is 2.0 metres of drawdown predicted up to 1000.0 metres from the excavation, which suggest that the baseline conditions scenario does not document natural functions within surrounding wetlands and watercourses - please clarify.	Page 301 Section 8.10. Level 2 Impact Assessment Conclusions	Conservation Halton	This has been previously addressed.	
261.	'The Level 2 impact assessment scenarios present a detailed and exhaustive comparison of the proposed developments to the baseline conditions. All pertinent aspects of the surface water and ground water system have been compared across a wide range of climate conditions.' The assessment scenarios provide a detailed comparison of water quantity issues. They do not address groundwater quality issues and therefore this should not be considered a complete assessment of quarry impacts. Water quality should be addressed in more detail.	Page 301 Section 8.10. Level 2 Impact Assessment Conclusions, 1st Paragraph	Norbert M. Woerns	A discussion of surface water quality is presented in Response 7 and 8	
262.	'The long-term monitoring (including the monitoring of the 2005-2019 advancement of the south extraction face) provides a clear groundwater response that has been accurately simulated by the transient integrated model. The detailed field investigations, together with the simulation of this large-scale response, provides significant confidence in the assessment.' Although ground water monitoring data have been collected in the vicinity of the southern expansion area there are significant data gaps in the groundwater monitoring data. There is limited groundwater monitoring data for the western expansion area since boreholes were drilled between June 2016 and May 2019 and monitors installed between January 2019 and August 2019. Groundwater thresholds (i.e., quantity and quality) have not been established or discussed due to insufficient monitoring data to establish baseline conditions (see Page 315, Section 9.6.3 Groundwater Thresholds, 1st paragraph). The existing off-site irrigation ponds are thought to infiltrate water that originates to a large extent from the existing quarry discharge from the existing sump no. 100 and result in a groundwater mound beneath the ponds. There is no field data to support this conclusion. The feasibility of the proposed recharge pond should be confirmed with supporting field data.	Page 301 Section 8.10.1. System Understanding, 1st Paragraph	Norbert M. Woerns	This point has been raised multiple times and answered. There was a substantial effort to collect data in the vicinity of the proposed western and southern extensions. The southern extension benefitted from historic data collected as part of a previous quarry expansion study. We took advantage of the data to develop a very detailed model of the study area. The lack of a long period of record in the west does not detract the understanding of baseline conditions developed for the site. The infiltration ponds are discussed in numerous comments, above.	
263.	'Similarly, the extensive record of stream flow and wetland monitoring produces an unprecedented level of understanding of the shallow surface water and ground water system.'	Page 301 Section 8.10.1. System Understandin	Norbert M. Woerns	An extensive package of interdisciplinary tables integrating wetland and watercourse characterization and analysis has been prepared and provided in Schedules B and C. Wetland monitoring is discussed in Response 14	

	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.	g, 2nd Paragraph			
264.	'The 2.0 m drawdown cone associated with P3456 extends 330 m to 450 m from the excavation. P3456 is next to a locally significant groundwater discharge area, so water levels are relatively stable and less subject to drought, seasonal fluctuations and the effects of excavation.' There are a number of private wells along Cedar Springs Road that are within 330m and directly down gradient of the proposed west expansion area excavation limit. Private wells along Cedar Springs Road are therefore considered to be at high risk of impacts from the proposed quarry expansion. The proposed west Extension area will be removed along with the underlying aquifer that contributes to the maintenance of private wells along Cedar Springs Road. Threshold values should be established for these wells especially those with less than 5.0 metres of assumed available drawdown.	Page 301 Section 8.10.2. Drawdowns, 3rd Paragraph	Norbert M. Woerns	The point is raised here and in a number of previous and succeeding comments. We recognized that drawdowns due to dewatering the west expansion could impact private wells on Cedar Springs Road. This was the main point of adding an infiltration pond is to replace the golf course ponds that may have contributed to groundwater recharge in the area. It is assumed that the infiltration pond will be in good hydraulic contact with the bedrock surface and should provide higher leakage than the natural ponds with their accumulated sediments. Some of the water will be picked up in the expanded excavation area and recirculated, but the main effect is to recharge the groundwater west of the quarry and maintain higher heads and prevent the private wells from going dry. Other provisions for the private wells are discussed in the report.	
265.	'The analysis confirms that there is between 5 and 23 m of available drawdown across the study area, confirming that there is ample groundwater available for current and future private water supply use.' According to the model analysis (Figure 8-75, Average available drawdown under P3456 conditions)	Page 301 Section 8.10.3. Water Supply, 1st Paragraph	Norbert M. Woerns	This has been previously addressed.	

	a number of wells along Cedar Springs Road west of the western extension have simulated available drawdowns of 10m or less during phase 3456. A number of these have less than 5.0 metres of available drawdown. The analysis has not considered evidence provided in previous studies by Golder that deepening of wells completed within the Amabel Formation may not be a viable option for increasing well yields. A number of wells along Cedar Springs Road may in fact be completed into bedrock units below the Amabel Formation due to their low elevation. These lower bedrock units are not recognized as significant aquifers. Please clarify how private wells with less than 5.0 metres of projected available drawdown will be treated with respect to quarry impacts and how wells occurring near or below the bottom of the Amabel Formation will have their water supply protected with respect to quantity and quality.				
266.	'The wide distribution of low permeability Halton Till in and round the quarry is the dominant feature controlling surface and groundwater interaction. The wetlands and streams are generally perched above the water table and isolated from the groundwater system by the low permeability till. None of the wetlands receive significant groundwater inflow, and are thus isolated from any changes in the water table due to quarry development.' MNRF wetland no. 13027 (Earthfx wetland no. 17) has shown ground water levels at or above surface and this wetland, at least seasonally, does not exhibit perched groundwater conditions. A number of other wetlands closer to the existing quarry occur within areas that have been influenced by historical dewatering of the existing quarry and as such have altered hydrogeological conditions which historically may have not exhibited perched conditions beneath the wetlands. It has not been demonstrated with certainty that none of the wetlands receive significant groundwater inflow. Please clarify.	Page 302 Section 8.10.4. Stream and Wetland Function, 1st Paragraph	Norbert M. Woerns	Yes, Wetland 17 was noted to have higher rates of groundwater inflows than the other features under current conditions. Pre-development conditions may have been altered over the 70 year life of the existing quarry. However, the scope of this work was to analyze the likely impact of quarry expansion. The effects on this wetland are discussed in more detail in the package of interdisciplinary tables integrating wetland and watercourse characterization and analysis that has been prepared and is provided in Schedules B and C.	
267.	The groundwater monitoring program must include shallow monitoring wells including wells completed in overburden to understand full impact of the proposed extraction.	Page 303 Section 9.2. On-Site Monitoring Wells	Conservation Halton	A detailed discussion of the monitoring program and AMP is presented in our response to comments from the MECP (Schedule A). We will take this comment under consideration as the monitoring program and AMP are finalized.	
268.	Staff support using private water wells to supplement monitoring and impact assessment, however, the efficacy of this monitoring "to act as an early warning system" as said in the first paragraph on page 304 is questionable. Especially, for the south extension area, where most of the proposed private wells for monitoring are more than 1.0 kilometre from the	Page 303 Section 9.3. Off-Site Domestic Water Wells	Conservation Halton	A detailed discussion of the monitoring program and AMP is presented in our response to comments from MECP (A copy is provided in Schedule A). We will take this comment under consideration as the monitoring program and AMP are finalized.	

	extraction zone (Figure 9.1). Monitoring wells between the extraction zone and groundwater receptors should be proposed to proactively assess impacts.				
269.	'The intent of the groundwater monitoring program is to serve four (4) primary purposes: These are listed as: 1. to determine the background quality and seasonal groundwater level fluctuations in the vicinity of the extraction activities; 2. to assess and characterize the quality and seasonal groundwater level fluctuations throughout the quarry operations and upon closure of the Burlington Quarry; 3. to evaluate whether unforeseen changes within the groundwater regime is occurring from the extraction of aggregate and quarry dewatering; and if they are 4. to determine the presence of, and risk to, private well receptors of the unforeseen changes and if the implementation of mitigation measures is required to off-set the unexpected changes in the groundwater regime.' The above objectives do not address potential for water quality impacts of quarry operations and impacts on water uses. Water quality objectives should be clearly stated and threshold levels and mitigation measures should be identified.	Page 303 Section 9.1. Development and Monitoring Program, Objectives, 1st Paragraph	Norbert M. Woerns	A detailed discussion of the monitoring program and AMP is presented in our response to comments from the MECP (see Schedule A). We will take this comment under consideration as the monitoring program and AMP are finalized. Additional water quality data and discussions are presented in our response to the MECP comments.	
270.	'Based on the findings of the impact assessment, key sentry groundwater monitoring wells have been selected and incorporated into the long-term groundwater monitoring program. The groundwater monitoring program consists of water level and water quality monitoring. Water levels will be collected manually on a monthly basis as well as continuously with automatic water level transducers. The manual measurements are used to calibrate the continuous data, which allows for a comprehensive assessment of the water level responses and trends.' Threshold levels should be identified for water quality in addition to water levels and should include monitoring stations for all phases of quarry expansion.	Page 303 Section 9.2. On-site Monitoring Wells, 1st Paragraph	Norbert M. Woerns	A detailed discussion of the monitoring program and AMP is presented in our response to comments from MECP (see Schedule A). We will take this comment under consideration as the monitoring program and AMP are finalized.	
271.	Typographical errors in this paragraph: W03-1A should be MW03-1A and M03-1B should be MW03-1B.	Page 303 Section 9.2. On-site Monitoring Wells, 2nd Paragraph	Norbert M. Woerns	Comment noted.	
272.	'Water quality sampling will be completed on a semi-annual basis. Parameters will include general water	Page 303 Section 9.2.	Norbert M. Woerns	A detailed discussion of the monitoring program and AMP is presented in our response to comments from MECP (see Schedule A). We will take this comment under consideration as the monitoring program and	

	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.	On-site Monitoring Wells, 3rd Paragraph		AMP are finalized. Additional discussions of the water quality are presented in our response to the MECP comments (see Schedule A).	
273.	It is reported that the south extension area has been monitored extensively for 7 years. Considering most of the monitors were most likely impacted by present quarry operation during that time, how reliable is the data to establish baseline conditions?	Page 304 Section 9.4. Groundwater Impact Assessment Methodology	Conservation Halton	Please refer to Response 3, 15 and 78 for a discussion of cumulative impact and what is considered baseline	
274.	'The Level 1 and 2 Hydrogeological Assessment must identify potential receptors, outline the compliance monitoring program, as well as identify threshold values to assess and mitigate the potential impact to those receptors that may be impacted by the quarry development.' There are no threshold levels for groundwater quality. These should be identified for all monitoring stations.	Page 304 Section 9.4. Groundwater Impact Assessment Methodology, 1st Paragraph	Norbert M. Woerns	A detailed discussion of the monitoring program and AMP is presented in our response to comments from MECP (see Schedule A). We will take this comment under consideration as the monitoring program and AMP are finalized. Our response to MECP Comment 7 discusses the use of data trends as part of the AMP.	
275.	'The impact assessment methodology has been developed for the initial five (5) years of quarry operation. During these five (5) years, Nelson will have only operated in the south extension and will have completed extraction from Phase 1 and will have partially extracted Phase 2. The area surrounding the south extension area has been monitored extensively for over seven (7) years. As a result, the awareness of how the groundwater regime behaves is enough to develop the assessment tools, such as threshold values and threshold trend analysis for the south extension.' The Phase 12 area has been monitored for the past 7 years. Over this period of time extraction has continued in the existing quarry and has resulted in increased drawdowns in monitoring wells over this period indicating that groundwater conditions have been in flux over this period of time and are probably still changing in response into the quarry operations. The threshold values based upon simulated water levels of drought conditions in 2016 do not fully	Page 304 Section 9.4. Groundwater Impact Assessment Methodology, 2nd Paragraph	Norbert M. Woerns	A detailed discussion of the monitoring program and AMP is presented in our response to comments from MECP (see Schedule A). We will take this comment under consideration as the monitoring program and AMP are finalized. Our response to MECP Comment 7 discusses the use of data trends as part of the AMP.	

	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.				
276.	'The impact assessment methodology proposed for the Burlington Quarry extension involves both an evidence-based and a predicted-based approach to ensure that the complexity of fractured rock hydrogeology is addressed. The evidence-based approach requires a comprehensive understanding of the natural variability of groundwater elevations at key monitoring locations. This understanding requires several years of monitoring data that shows the groundwater systems natural response to varying climatic conditions, including how the aquifer responds during and following dry/drought conditions. The baseline conditions allow for an improved ability to identify unforeseen trends in water level data, which could be a result of the quarry operations.' The groundwater monitoring data available for the southern extension has data gaps that occur between 2004 and 2007 and again between 2013 and 2018 (Earthfx Section 5.3.1.2, Transient Water Level Data, page 109). The missing data included the drought period of 2015-2016 as well as 2017 the wet period (Earthfx, section 7.2.2 Scenario Summary and Nomenclature, page 166). Calibration of the model against actual on-site water level conditions during this period of time was therefore not possible. Please clarify the validity of the computer model calibration against extreme wet and dry conditions.	Page 304 Section 9.4. Groundwater Impact Assessment Methodology, 2nd Paragraph	Norbert M. Woerns	The close calibration to seasonal fluctuations in water levels (that vary, in the near vicinity to the quarry, by more than 7 m) suggests that the model is able to replicate and respond to significant climate variation.	
277.	'A key component of the evidence-based groundwater monitoring program is the availability of background water level data that reports the natural conditions during quarry extraction.' The analysis has not considered the cumulative effect of the existing quarry and the proposed expansion in establishing background water level data. Cumulative impacts of the existing quarry should be included in the impact assessment.	Page 304 Section 9.4. Groundwater Impact Assessment Methodology, 4th Paragraph	Norbert M. Woerns	Please refer to Response 3, 15 and 78 for a discussion of cumulative impact	
278.	Considering that private well referred to as DW2 is	Page 305	Conservation	Well DW2 has been continuously monitored since August 2019. Also refer to Response 280, below.	

	located within the present quarry zone of influence, it may not represent the natural variability of the groundwater elevation fluctuations as stated. How many years of DW2 monitoring data is available to date?	Section 9.4.1. Monitoring of Background groundwater Conditions	Halton		
279.	Please provide an example of the trend analysis. How often would this analysis be repeated based on actual measurements rather than simulated levels?	Page 305 Section 9.4.2. Comprehensive Groundwater Elevation Trend Analysis	Conservation Halton	Please see: https://www.nvca.on.ca/Shared%20Documents/NVCA%20Groundwater%20Trend%20Analysis%20Using%20the%20PGMN%20May%202013.pdf For a discussion of seasonal trend analysis. A detailed discussion of the monitoring program and AMP is presented in our response to comments from MECP (see Schedule A). Our response to MECP Comment 7 discusses the use of data trends as part of the AMP.	
280.	'To assist in the evaluation of the water levels measured as part of the groundwater monitoring program, a background monitoring well has been incorporated to the program. The background monitoring well is a domestic water well located north of the existing quarry at 2377 Collins Road (referred to as DW2; Figure 9.1). The purpose of this background monitoring well is to document the natural variability of the groundwater elevation fluctuations and trends under various future climatic conditions. This background monitoring well has shown to have no drawdown from the proposed quarry extension.' Please provide evidence to support the conclusion that background monitor DW-2 has no drawdown impacts from the proposed quarry. Is this from computer simulations or actual measurements over time? Has this monitoring well been impacted from the existing quarry?	Page 305 Section 9.4.1. Monitoring of Background Groundwater Conditions, 1st Paragraph	Norbert M. Woerns	Historical air photos show that the north quarry face wall has been largely remediated (with sloping backfill) since 1979. MP35, located in Wetland 3 near DW2, has shown a consistent seasonal water level pattern in data recorded since 2010. Please refer to our MNRF Comment Response (Earthfx Section 4.3) for maps and hydrographs.	
281.	'Trigger values set based on the traditional approach have caused numerous false positive trigger exceedances. The reasons for these exceedances include the oversimplification of the methodology to setting trigger values in a fractured rock environment (fundamental principles of how aquifers respond to abstraction), and more importantly the neglect to account for the full impact of climate change. Seasonal variability in groundwater level as well as season creep, which refers to observed changes in the timing of the seasons, have been widely observed in Ontario.' The influence of climate on groundwater levels is acknowledged, however the analysis relies upon remote climatic stations for data. Given the importance of climate, why is there no	Page 305 Section 9.4.2. Comprehensive Groundwater Elevation Trend Analysis, 2nd Paragraph	Norbert M. Woerns	A detailed discussion of the monitoring program and AMP is presented in our response to comments from MECP (see Schedule A). Our response to MECP Comment 7 discusses the use of data trends as part of the AMP. There are a number of climate stations in the area. Our calibration match to numerous minipiezometers, presented in our response to MNRF comments, illustrates that the model is very closely matching local soil moisture conditions. This indicates that the climate data available for the calibration is more than adequate.	

	recommendation for an on-site climate station for purposes of monitoring and evaluating groundwater levels?				
282.	What groundwater mitigation measures would be implemented to mitigate impacts (if identified through monitoring) on the natural environment features? e.g. groundwater discharge to Medad Valley, wetlands and streams.	Page 307 Section 9.4.4. Proposed Groundwater Mitigation Measures	Conservation Halton	The change in soil moisture conditions in the Medad Valley is discussed in our Wetland characterization table included in the MNRF comment response. These changes are small and are broadly distributed along the valley wall. The water intercepted by the western extension (and not infiltrated through the infiltration pond) will be ultimately be discharged to the Medad Valley slightly to the north, so no downstream impacts are likely.	
283.	'The Seasonal Mann-Kendall Test considers the seasonality of the data series. This means that for monthly data with seasonality of 12 months, one will not try to find a trend in the overall series, but a trend from one of January to another, and from one February and another, and so on.' The Mann-Kendall test may be useful in assessing natural groundwater level trends but are limited in assessing quarry impacts without taking into account variations in on-site climatic conditions. How does the Mann-Kendall test compare season data from different years and relate that to a trend analysis? How will climatic factors be considered in this analysis without on-site climatic data?	Page 307 1st Paragraph Section 9.4.2. Comprehensive Groundwater Elevation Trend Analysis	Norbert M. Woerns	Interannual fluctuations in climate could be compared to the variability observed in the 10 year model simulations. Additional refinement of the AMP approach is open to discussion. Fortunately, the site has an extensive network and history of monitoring, and a proven and highly advanced predictive tool (the GSFLOW Model) that are available for monitoring and analysis.	
284.	'The proposed thresholds have been calculated from the simulated water level elevations from the difference between the simulated average baseline water levels and the simulated drought water levels with Phase 1 and 2 extracted during a drought period. If the 0th percentile equals the minimum water level simulated, the 10th and 5th percentile values will be relied upon for the threshold values. Level 1 Threshold conditions occur when the measured water level falls below the Threshold 1 value (10th percentile) for a 15-day period. Level 2 conditions occur when the water level falls below the Threshold 2 value (5th percentile) for a 15-day period. This statistical approach to reviewing and assessing the impacts associated with the quarry development meets the objectives of the AMP, which is to implement a system that allows for a comprehensive evaluation of how the groundwater regime behaves with quarry development and to identify unforeseen changes in this system that provides time to implement appropriate mitigation strategies to protect local water use.' Method for calculating thresholds requires clarification. The simulated average baseline and simulated drought water levels represent a discrete and limited time interval, a portion of which has no monitoring data for model calibration purposes. Average and drought conditions are expected to	Page 307 Section 9.4.3. Proposed Groundwater Thresholds Levels, 2nd Paragraph	Norbert M. Woerns	Additional refinement of the AMP approach is open to discussion. Fortunately, the site has an extensive network and history of monitoring, and a proven and highly advanced predictive tool (the GSFLOW Model) that are available for monitoring and analysis.	

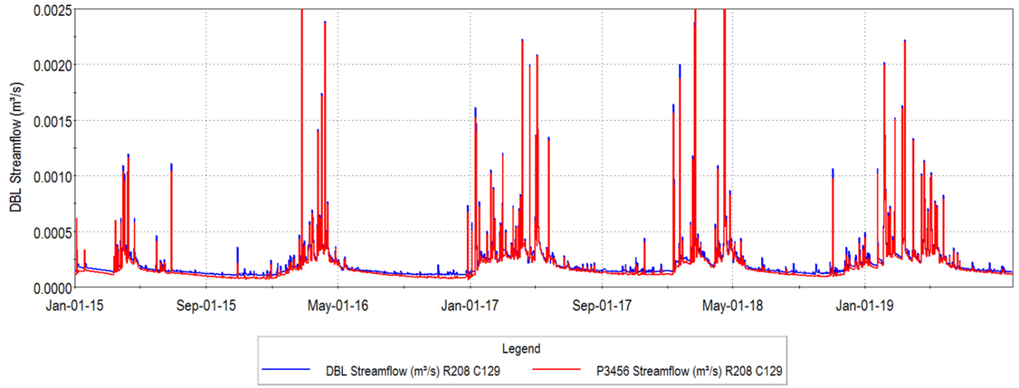
	change with an increasing record of data, rather than the limited discrete time interval and climatic conditions represented in the model simulations. How are existing climatic conditions factored into the threshold determination? Does the threshold level need to be met consistently over a 15 day period 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.				
285.	'A key finding of the Level 1 and 2 Hydrogeological Assessment and Numerical Modelling (Earthfx et. al., 2020), is that the drawdown associated with the extension of the Burlington Quarry does not adversely impact the available drawdown in the regional bedrock aquifer found at an elevation beneath 252 masl (elevation of the quarry floor). ----It is generally accepted that 5 m of available drawdown is a safe available drawdown for domestic water wells constructed in bedrock aquifers.' It is assumed that available drawdown estimates in each private well was determined from static water level recorded on the well record at the time of well completion. This is not a reliable measure of the available drawdown as the accuracy of these measurements is questionable. What is the source of this generally accepted available drawdown of 5.0 metres as a 'safe available drawdown'? It is not clear what is meant as a 'safe available drawdown'. This does not take into consideration the productivity of the well or water quality considerations.	Pages 307-308 Section 9.4.4. Proposed Groundwater Mitigation Measures, 2nd Paragraph	Norbert M. Woerns	The overall available drawdown at each well was calculated using the simulated water levels and the elevation of the base of the Amabel. Wells may be deepened and operationally treated and restored as necessary.	
286.	A number of important monitors are not included in the monitoring program, e.g.: MW03-02, OW03-16 and MW next to it (based on Figure 3.4 cannot decipher what the MW number is), OW03-32, MW03-03, OW03-31, MW03-08, MW03-10. All monitoring well intervals should be monitored (including shallow either bedrock or overburden installations, which are usually designated C).	Page 308 Section 9.5.1. Groundwater Monitoring Program	Conservation Halton	A key component of the monitoring for the AMP is to assess the extent of possible impacts in areas more distant from the quarry. A number of the wells suggested by the reviewer are located in closer proximity to the proposed quarry extension. Others are near already proposed monitoring nests. The AMP, however, is currently under review and finalization.	
287.	'Data collected from existing domestic water wells along No. 2 Sideroad, which are within 80 m of the quarry, show that wells constructed in the hydrostratigraphy layer beneath the quarry floor (Layer 8) can meet peak domestic water demands with between 2 and 5 m of available drawdown.'	Page 308 2nd Paragraph Section 9.4.4. Proposed Mitigation Measures	Norbert M. Woerns	Long term monitoring data from the private wells is not available, but no well complaints or issues have been noted in this area. The extensive network of monitors in the P12 extension area demonstrates that water levels recover quickly with distance from the existing quarry.	

	Please provide data from existing domestic wells in this area to support this assertion?				
288.	'Nelson will commence with planning the required compensation if unforeseen trends suggest off-site impacts will be greater than predicted and threaten the available drawdown in private wells. Compensation must be acceptable to the homeowner and the quarry operator and could include all or part of the costs associated with drilling of a new well, deepening a well, and abandonment of the old well.' What contingencies are proposed if well replacement /deepening are not adequate? It is not clear how 'Nelson will commence planning the required compensation' will be implemented. Please clarify.	Page 308 3rd Paragraph Section 9.4.4. Proposed Mitigation Measures	Norbert M. Woerns	Additional refinement of the AMP response is open to discussion. Given the long history of compatible coexistence between the quarry and the home owners and the extensive and productive Amabel aquifer, it is highly unlikely that the proposed solution will not be sufficient.	
289.	'Upon completion of the well construction, a comprehensive water quality analysis will be completed to characterize the water supply. If it is shown that the water quality has deteriorated from intercepting poor water quality at depth (for example increased chlorides and sulphates), the appropriate water treatment system will be purchased and installed.' Although not stated, it is assumed that water quality sampling and analysis will be completed within the well in question prior to deepening or replacing the well. Please confirm. Who pays for the maintenance of the water treatment system? There is no discussion of potential for water quality impacts on private wells and monitoring data necessary to establish baseline water quality data and thresholds for specific water quality parameters. Water quality thresholds should be identified for monitoring stations.	Page 308 4th Paragraph, Section 9.4.4. Proposed Mitigation Measures	Norbert M. Woerns	Additional refinement of the AMP approach is open to discussion.	
290.	'The integrated surface water/groundwater model results predict groundwater mounding beneath the existing irrigation ponds in the West Extension. --- To replicate the existing artificial groundwater mounding produced by the irrigation ponds, a pond will be constructed outside the extraction area within the licence boundary between the extraction limit and Cedar Springs Road. To replicate the existing artificial groundwater mounding produced by the irrigation ponds, a pond will be constructed outside the extraction area within the licence boundary between the extraction limit and Cedar Springs Road' The report concludes that the regionally extensive and low permeability Halton Till limits interaction between surface water and groundwater systems (Page 190, Section 7.3, 2nd paragraph). This brings into question the effectiveness of the existing irrigation ponds and the proposed infiltration pond in maintaining	Page 308 5th Paragraph. Section 9.4.4. Proposed Mitigation Measures	Norbert M. Woerns	Please refer to Response 116	

	groundwater levels. Please provide field data to confirm the recharge capability of the existing irrigation ponds and the proposed recharge pond.				
291.	'Interference will be in part masked or, coupled by local climatic conditions. Key groundwater monitoring locations that have over 7 years of water level data have been selected to act as the long-term sentry wells to ensure the influence on the groundwater regime is consistent with the predicted influence from quarry operations (Figure 9.2). The monitoring locations, well construction details, and predicted drawdown conditions during a drought period (expressed as water level elevation, simulated drawdown, and simulated available drawdown), are provided on Table 9.1.' Climatic conditions are acknowledged to play a role in masking interference by quarry operations. It is not clear how the method for identifying threshold levels will take into account ongoing on-site climatic conditions. There is a need to monitor climatic data on-site to effectively evaluate quarry impacts versus climatic impacts on groundwater levels. Please clarify.	Page 309 1st Paragraph Section 9.5.1. Groundwater Monitoring Program	Norbert M. Woerns	Please refer to Response 284.	
292.	Typographical errors; M03-9 and M03-14 should be MW03-9 and MW03-14.	Page 311 2nd Paragraph, Section 9.5.1. Groundwater Monitoring Program	Norbert M. Woerns	Comment noted.	
293.	'The closest receptor (private water well) is located approximately 120 m to the west of MW03-15, and currently has 4.6 m of available drawdown.' Will existing private wells that currently have less than 5 metres of available drawdown receive mitigation measures? A number of wells having less than 5.0 metres of available drawdown are shown on Figure 9.3 and 9.5, (Minimum available drawdown in Layer 8, P12, Drought Conditions, page 312 and minimum available drawdown in Layer 8, P3456, Drought Conditions, Page 317).	Page 311 2nd Paragraph, Section 9.5.1. Groundwater Monitoring Program	Norbert M. Woerns	Nelson is committed to addressing water supply issues as outlined in the AMP. The model has been comprehensively used to identify both average and the **minimum** available drawdown (under drought conditions) which demonstrates a commitment to understanding of the full range of response.	
294.	Provided thresholds in Table 9.2 assume that there are no impacts to the shallow zone. It seems, if the Level 1 and 2 Threshold conditions are met, a very similar response is proposed and there is no action proposed after reaching Threshold 1 to avoid Threshold 2. There is no action proposed to avoid reaching a minimum water level nor any action if it is reached or exceeded. Please revise to propose appropriate actions.	Page 313 Section 9.5.2. Groundwater Thresholds	Conservation Halton	The shallow bedrock is not used as a water supply aquifer, and shallow seasonal variability is larger (some shallow monitors go dry). The deeper monitors provide a more representative measurement that is less susceptible to false alarms.	
295.	'The response to a Level 1 Threshold condition, would	Page 313	Norbert M.	The purpose to the thresholds is to actively monitor the system *before* action is required. That is what	

	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.	Last Three Paragraph Section 9.5.2. Groundwater Thresholds	Woerns	makes them useful. The commitments to mitigation are clearly defined.	
296.	'The extraction of the proposed West Extension (Phase 3 through to 6) is scheduled to commence approximately 10-years following the issuance of the ARA licence. No groundwater thresholds are proposed until enough groundwater monitoring data is collected to establish baseline conditions.' What are baseline conditions to represent? In the case of phases 3,4,5 and 6, the conditions forming baseline are defined during the active excavation of Phase 12. How much groundwater monitoring data is considered enough to establish groundwater	Page 315 Section 9.6.3. Groundwater Thresholds, 1st Paragraph	Norbert M. Woerns	The site already has an extensive network and history of monitoring, and a proven and highly advanced predictive tool (the GSFLOW Model) could be used for further assessment. The 10 year period of monitoring will provide an excellent extension to the baseline data already available.	

	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)?				
297.	Please provide groundwater quality and quantity monitoring details. What would be the frequency of the trend analysis? Shallow monitoring wells and a number of wells listed in comment re Section 9.5.1 should be added to the monitoring program. Nitrite and nitrate should be added to water quality monitoring.	Page 319 Section 10.1.1. On-Site Groundwater Monitoring Program	Conservation Halton	Further information about the quantity and quality monitoring program and AMP is presented in our response to comments from MECP (see Schedule A). The issues with shallow monitors are discussed in Response 294.	
298.	Groundwater quality parameters should include parameters related to site operations including dust suppressants, explosives, fuels, any on-site stored materials, and any identified potential sources of contamination from on-site or directly adjacent areas. There is no discussion of water quality thresholds or mitigation required in the event of water quality impacts either through normal operations or an on-site spill. Note that surface water drainage areas which direct external surface water onto the property and into the sump discharges may contain potential contaminant sources. Water quality analysis should be included with threshold levels and mitigation measures.	Page 320 Table 10.2. Groundwater Quality Parameters	Norbert M. Woerns	Further information on the monitoring program and AMP is presented in our response to comments from MECP (see Schedule A). We will take this comment under consideration as the monitoring program and AMP are finalized. A discussion of water quality is presented in Response 7 and 8	
299.	There are no groundwater monitoring locations upgradient and to the north of the quarry operations to monitor impacts of the quarry expansion and rehabilitation scenarios. The only exception to this is one private well DW-2. Monitoring data should be presented to demonstrate that DW-2 has not been impacted by the existing quarry. It would be useful to have a corresponding figure for AMP surface water monitoring stations.	Page 321 Figure 10.1. AMP Groundwater Locations	Norbert M. Woerns	The north discharge has been shown to support (recharge) the shallow water levels. This will be ongoing, in the future so no impacts are expected.	
300.	'The Private Well Monitoring Program includes the collection of water quality samples and water levels, like the on-site monitoring program outlined in Section 10.1.1. Similarly, the impact assessment on each well will include a trend analysis and threshold value.' This suggests that the trend analysis and threshold values will be established for both groundwater levels and groundwater quality for private wells. No water quality thresholds have been established for the on-site groundwater monitoring program. Semi-annual and annual water quality monitoring is suggested in Table 10.1, page 319. It is not clear that this is sufficient to protect groundwater quality of downgradient wells. Water quality thresholds should be identified along with mitigation measures.	Page 322 Section 10.1.2. Private Water Well Monitoring, 1st Paragraph	Norbert M. Woerns	Further information on the monitoring program and AMP is presented in our response to comments from MECP (see Schedule A). We will take this comment under consideration as the monitoring program and AMP are finalized. A discussion of water quality is presented in Response 7 and 8.	
301.	Although the springs in the Medad Valley are singled	Section 11.2,	Daryl W.	From a modelling perspective, we noted the presence of springs and "disappearing" streams and	

	out as a target of impact assessment and mitigation in Table 8.1, there is no other mention of springs in the remainder of the document other than a brief note in the summary (Section 11.2, page 324) “There are other groundwater springs (karst discharge features) in the Medad Valley, but these are masked by the wetlands that fill the valley.”	Page 324, and Table 8.1	Cowell & Associates Inc.	represented them as best as possible in the model. The representation of the subsurface flow is discussed in Response 120. Except for the gauges on Willoughby Creek there were no transient measurements at these features for comparison. There are relatively small changes in the event-driven flows at the locations of the springs discharging to the Medad Valley under the different scenarios. For example, the figure shows simulated drought flows under baseline and P3456. There are small changes in the peak flows (0.1 to 0.2 L/s) and very small changes in the very small baseflows. There were no significant changes under P12. The cumulative effects of changes on flow in Willoughby Creek were discussed in the report. 	
302.	Permanent and intermittent streams as well as seepage areas and springs are considered key hydrologic features by the NEP. Section 11.3 of the report lacks detailed discussion on the effects on these features specifically on the western expansion lands where streams and ponds are proposed to be entirely relocated to a proposed discharge pond.	Section 11.3	Niagara Escarpment Commission	Section 11 is a summary of the findings. There are detailed discussions on predicted changes in the groundwater levels, streamflow, and wetland stage for each scenario. In particular, Section 8.5 and 8.6 discuss the effects of P12 excavation and refilling on western streams and wetlands.	
303.	In addition, groundwater discharges to the Medad Valley occur via discrete spring locations which are clearly fed by one or more fractures (“karst discharge features” page 324). Enhanced solution of these fractures is on-going for some distance above the springs. If EPM conditions existed along the Medad Valley escarpment face, the entire lower portion of the face would discharge groundwater not only at discrete spring points.	Page 324	Daryl W. Cowell & Associates Inc.	Yes, there are discrete fractures that have become solution enhanced over geologic time. Where data were available, these were simulated explicitly. Otherwise, we believe the network of multiple short fractures and zones of moderately fractured bedrock behave as an EPM. There is likely diffuse discharge along the flanks of the Medad Valley wall as well as discrete discharge points. The effects on the Medad Valley are discussed in more detail in the package of interdisciplinary tables integrating wetland and watercourse characterization and analysis that has been prepared and provided in Schedules B and C. **Worthington Response** The entire lower portion of the face would discharge groundwater if the aquifer were a porous medium. However, an EPM model explicitly assumes that an aquifer is not a porous medium, but behaves very similar to one for the purposes for which the model is used.	
304.	‘The numerical simulations confirm that the majority of the wetlands and streams are isolated from the water table by the low permeability Halton Till. A total of 5 of the 22 mapped wetlands in and around the quarry receive groundwater upwelling in the spring, however groundwater is in every case a very small percentage (less than 3%) of the overall inflows into the wetland.’	Page 324 3rd Paragraph Section 11.2. Hydrogeologic and Hydrologic System Summary	Norbert M. Woerns	As noted, our wetland characterization tables and response to MNRF comments provide extensive additional information for each wetland. Earthfx Section 2.2.1 in that document provides details on over 62 minipiezometers, soil core boreholes, and Guelph Permeameter test locations. Table 13 lists twelve of the key wetlands that have one or more minipiezometer, including MNRF Wetland 13033, which has 5 minipiezometers. The key larger wetlands, Wetland 17 in particular, were instrumented. Matching the dynamics of these features gave us confidence in our ability to represent the remaining ones.	

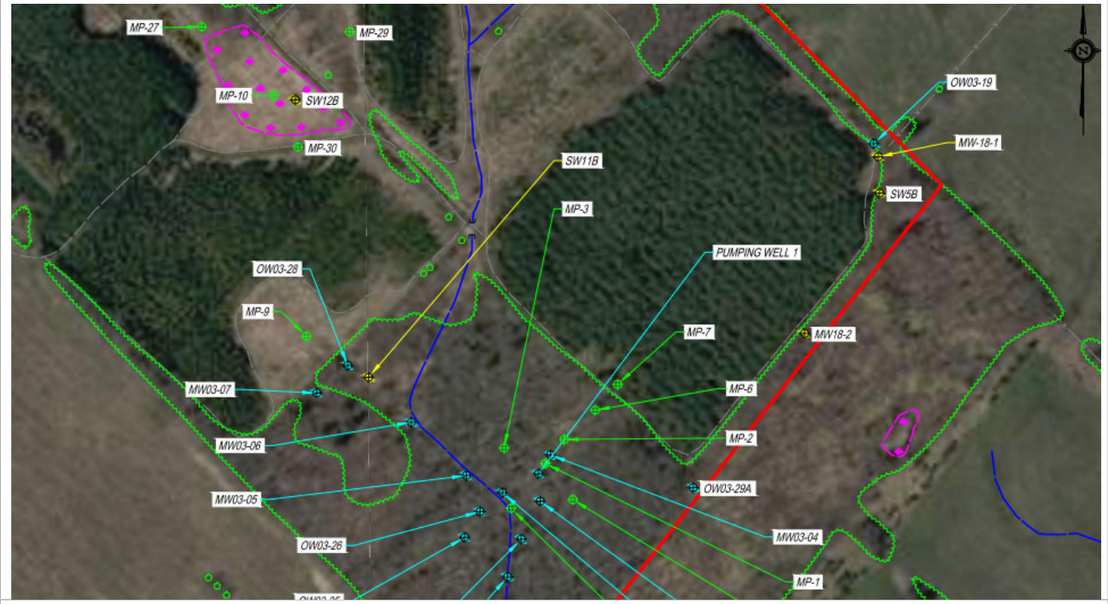
	The Tatham surface water investigation instrumented only five wetlands with shallow groundwater monitors in addition to surface water monitoring for water budget purposes. For the remaining wetlands the analysis relied upon simulated groundwater conditions without the benefit of having actual groundwater level data to confirm groundwater upwelling. Field data including groundwater levels for all identified wetlands should be provided to support the computer simulations.				
305.	'The Level 2 impact assessment scenarios present a detailed and exhaustive comparison of the proposed developments to the baseline conditions. All pertinent aspects of the surface water and ground water system have been compared across a wide range of climate conditions. The integrated approach ensures that surface and groundwater functions and water budgets are fully reconciled.' It may be appropriate to consider existing conditions for purposes of assessing impact of the proposed expansions. The cumulative impacts of the existing quarry and the proposed expansion have not been addressed. A map showing the existing cone of influence and drawdown of the existing quarry should be provided as part of the impact assessment. The impact assessment scenarios should also address groundwater quality.	Page 324 Section 11.3.1. Baseline Conditions, 3rd Paragraph	Norbert M. Woerns	This has been previously addressed.	
306.	Include a summary of effects on watercourses in these sections.	Page 325 Sections 11.3.2.2 & 11.3.3.2. Wetlands and Surface Water Features	Conservation Halton	An extensive summary of the effects on wetlands and streams has been compiled for MNRF and has been provided in Schedules B and C.	
307.	Outline proposed pumping/discharge points for Rehabilitation Scenario 1.	Page 326 Section 11.3.4. Rehabilitation and Closure	Conservation Halton	These will remain as before at Sump 001 and Sump 002	
308.	'The private wells in the vicinity of the West Extension will see a decline of approximately 2 m in available drawdown, however the majority of the wells have between 10 and 16 m of Amabel Aquifer drawdown after excavation, so deepening a well is a viable mitigation measure. Near the intersection of Colling Road and Cedar Springs Road there are a few wells that will have between 5 and 10 m of available drawdown, however these are in a significant discharge area so it is likely that there will be sufficient flow to meet their private supply needs.' Numerous residences along Cedar Springs Road are	Page 326 Section 11.3.3.3. Domestic Water Wells	Norbert M. Woerns	Please see Response 285 and 293.	

	located 200.0 to 300.0 metres from proposed limit of extraction. Some properties at the northwest portion of the proposed western extension are between 100.0 and 200.0 metres from the proposed limit of extraction. Wells along Cedar Springs Road are directly downgradient of the existing quarry and proposed expansion. The existing quarry has intercepted groundwater that would have flowed towards these wells under natural gradients. The groundwater seepage into the quarry as well as surface runoff from precipitation events is converted to surface water discharge via the existing quarry sumps. These wells are likely already impacted by the existing quarry and may depend to some extent upon infiltrating discharge water via a series of irrigation ponds on the upgradient golf course property much of which is to be removed through the western quarry expansion and replaced with an infiltration pond. Data provided by Golder, 2010 as well as pump tests completed in the proposed western expansion area indicate that groundwater conditions vary considerably between groundwater monitors and test wells. Available drawdown by itself is therefore not a reliable indicator of water availability for wells. The productivity of the aquifer at each well location will also be a significant determining factor of water availability. Flow profiling results (Figure A8 and A9, pages 434 and 435 respectively of the Earthfx hydrogeological Assessment Report) completed by Golder, 2004 indicate diminishing water flow with depth in existing monitoring wells in the southern extension area. This suggests that deepening wells may not be a viable solution to addressing well interference issues. A detailed analysis of this information and the implications to proposed mitigation measures should be completed and included in the report.				
309.	'Furthermore, surface water flow in the upper reaches of a tributary of Willoughby Creek and the West Arm of the West Branch of Mount Nemo Creek will cease when the quarry discharge is discontinued resulting in an adverse impact to downstream fish habitat compared to baseline conditions (See Savanta, 2020 and Tatham, 2020 for details).' The analysis of impact of discontinuing quarry discharge does not appear to be complete. Anticipated increased seepage from higher water levels under rehabilitation scenario 2 (RHB2) and the overall benefit of this to the sub-watershed does not appear to have been given consideration in this analysis. A detailed analysis of the impacts of cessation of pumping to the sub-watershed should be completed.	Page 326 Section 11.3.4. Rehabilitation and Closure, 4th Paragraph	Norbert M. Woerns	We have analyzed the likely flows in Willoughby Creek and its tributaries under RHB2 conditions. These results were transmitted to other team members to analyze potential impact on hydrologic and natural heritage features.	

310.	'The final rehabilitation plan will preserve the form and function of the upper reaches of a tributary of Willoughby Creek and the West Arm of the West Branch of Mount Nemo Creek as quarry discharge will continue.' The current conditions within the unnamed tributary of Willoughby Creek and the upper reaches of the West Arm of the West Branch of Mount Nemo Creek have been altered by quarry pump discharge. Is it appropriate to preserve an artificial condition that has altered a natural system? (This requires input from a natural heritage and fisheries habitat perspective.)	Page 326 Section 11.4. Conclusions, 2nd Paragraph	Norbert M. Woerns	We have analyzed the likely flows in Willoughby Creek and its tributaries under RHB1 conditions. These results were transmitted to other team members to analyze potential impact on hydrologic and natural heritage features. We recognize that quarry discharge has modified the pre-development conditions, but there may now be ecological features (e.g., fish populations) that developed over the 70 years of operations that have adapted to or require these flow conditions.	
311.	'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.	Page 327 1st Paragraph Section 11.4. Conclusions	Norbert M. Woerns	A discussion of water quality is presented in Response 7 and 8 and discussed in our response to the MECP AMP questions (see Schedule A).	
312.	'Incorporate the mitigation and monitoring requirements as outlined in this report into the Adaptive Management Plan (Earthfx and Tatham, April 2020) for the site; as outlined in Sections 9 and 10 of this report.' This report does not address potential water quality impacts from the proposed quarry extension with the identification of threshold levels and mitigation measures. This report is missing a recommendation for monitoring of climate data on-site for the duration of the proposed quarry extension and monitoring period following cessation of quarry operations. Consequently, these have not been included in the Adaptive Management Plan. Additions are required to the Adaptive Management Plan for completeness	Page 328 Section 12. Recommendations 2	Norbert M. Woerns	A discussion of water quality is presented in Response 7 and 8 and discussed in our response to the MECP AMP questions (see Schedule A).	
313.	Typographical Error; Worthington 2019 should be Worthington 2020	Page 332 Section 14. References Cited, Last Entry	Norbert M. Woerns	Comment noted.	
314.	Please submit all borehole logs used for the assessment (Only 50 out of 100 reported borehole logs were provided).	Page 334 Section 15.1. Drilling Program	Conservation Halton	An extensive suite of logs and monitoring details has been provided in our response the MNRF (see Schedule D). Available borehole logs have been provided, as per the request, in schedules B and C and additional information is also provided in Schedule E.	
315.	'The Keith Lang boreholes were drilled to supplement the original HQ boreholes and expand the geological and hydrogeological coverage of the Western Lands. These boreholes are 6-inch in diameter and were constructed using a conventional rotary water well rig. As such, no core was recovered in these boreholes.' Borehole/well logs for the Keith Lang holes drilled are not included in report. These should be provided as	Page 334 Section 15.1. Drilling Program, 2nd Paragraph	Norbert M. Woerns	See response to Comment 11. It should be noted that the Keith Lang boreholes are BS-04 to BS-07 and data have been provided for these wells in the report. The original MECP drillers logs are provided in Schedule E	

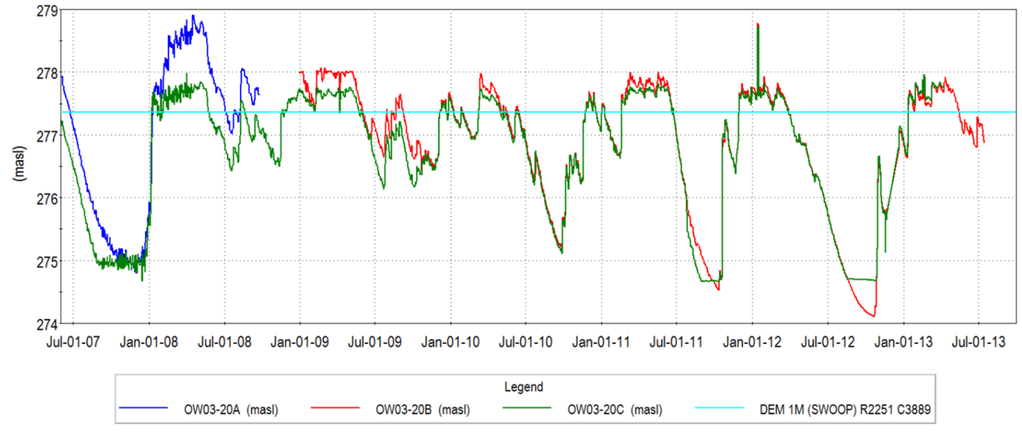
	background information within the report.				
316.	‘Finally, two additional overburden monitoring wells were constructed in November 2019 at the southeast corner of the Southern Lands (MW18-1 and MW18-2).’ The location of MW18-1 and MW18-2 should be shown on report figures.	Page 334 Section 15.1. Drilling Program, Last Paragraph	Norbert M. Woerns	Well construction and location data are provided below. Slug test data for the wells are provided in Schedule E. Well locations are shown below.	
317.	Selected borehole logs are presented with a number of borehole logs missing. In addition, a table showing monitoring construction details is missing. Monitor details were provided in a separate submission received September 29, 2020 for the shallow groundwater monitors installed in the five wetlands noted by Tatham. No soil descriptions were included. In addition, no monitoring details or soil/bedrock descriptions were provided for test wells BS-06 and BS-07 completed by Azimuth. Monitoring details should be provided in a table format within the report and borehole logs for BS-06 and BS-07 should also be included in the report.	Pages 335-365 Borehole logs	Norbert M. Woerns	As per the response to Comment 11 and 315, drillers logs for BS-06 and 07 are provided in Schedule E. As indicated in the report: *“The Keith Lang boreholes* [including BS-06 and BS-07] *were drilled to supplement the original HQ boreholes and expand the geological and hydrogeological coverage of the Western Lands. These boreholes are 6-inch in diameter and were constructed using a conventional rotary water well rig. As such, no core was recovered in these boreholes”.* Spinner logs were recorded in BS-06 and BS-07 and these are also included in Schedule E. For additional details refer to Borehole Log BS-03, (Earthfx, 2020, Page 361) which is less than 10 m from BS-06. The borehole log for BS-03 shows that the water table was at the bedrock surface contact at the time of drilling so no monitor was installed above the water table.	
318.	Monitoring well packer test and slug test results for all tested wells should be provided (please provide location of MW18-1 and MW18-2 monitoring wells). On page 367, last paragraph of section 15.2.1 it is reported that the packer testing results are in section 11.1, but section 11.1 is an introduction to Summary and Conclusions. Borehole logs in section 15.1 for reported in section 15.2 packer tested wells do not show the information either.	Page 367 Section 15.2.1. Downhole Packer Testing	Conservation Halton	A spreadsheet with packer test data has been provided in Schedule E. The information has also been presented in a table in a MS-Word document. Figures showing the packer test locations are also provided.	

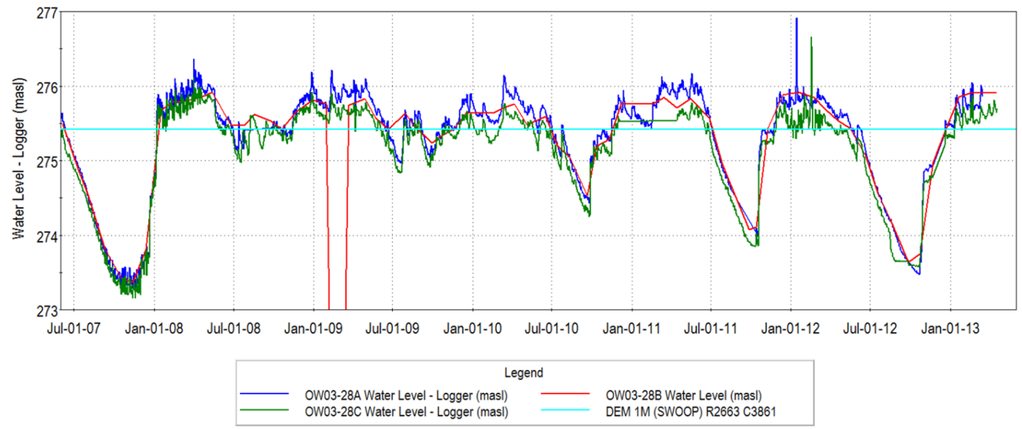
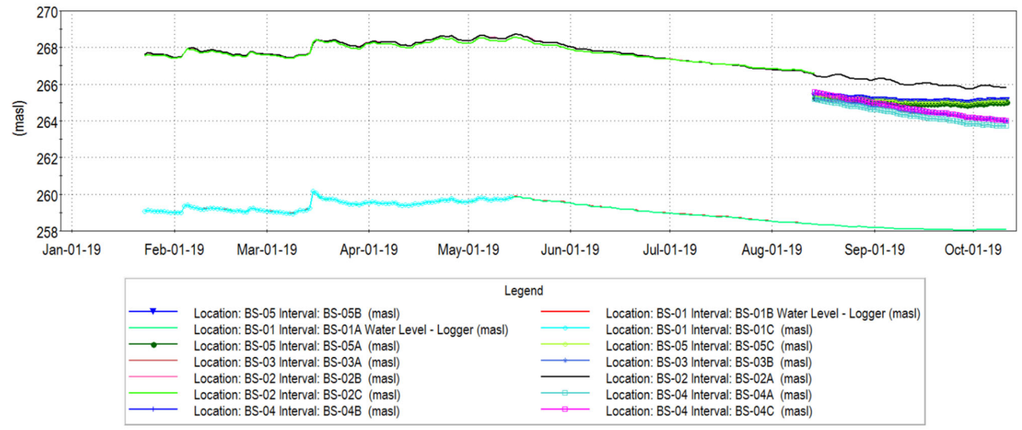
Well ID	Ground Elevation (masl)	Reference Elevation (masl)	Static WL (mbgs)	Static WL (masl)	Stickup (m)	Top of Sand Pack* (mbgs)	Top of Sand Pack* (masl)	Bottom of Sand Pack * (mbgs)	Bottom of Sand Pack * (masl)	Length of Screen (m)	Test Date	Test method	Formation	Hydraulic Conductivity Analysis (m/s)	Interval Tranmissivity (m2/s)
MW18-1	284.60	285.40	1.55	283.05	0.80	3.00	281.60	6.00	278.60	3.0	14-May-19	Rising Head	Overburden	1.6E-08	4.8E-08
MW18-2	281.10	281.85	0.76	280.34	0.75	2.10	279.00	3.60	277.50	1.5	14-May-19	Falling Head	Overburden	6.7E-08	1.0E-07



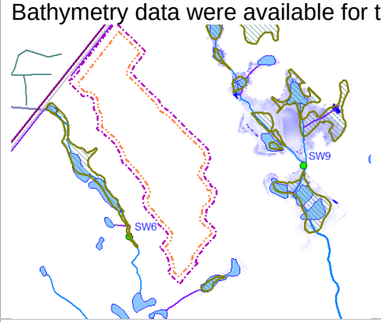
319.	In addition to reporting elevations of the packer testing zones, the corresponding bedrock or model layer zones for the reported packer test results should be identified.	Pages 367-368 Sections 15.2.1.1-15.2.1.4. Packer Test Interpretation	Norbert M. Woerns	A spreadsheet with pack test data has been provided in Schedule E. The packer test depth intervals are listed in the table. The information has also been presented in a table in a MS-Word document. Figures showing the packer test locations are also provided.	
320.	Typographic error; 1615 Cedar Springs Road should be 5161 Cedar Springs Road as referenced in text at top of page 371.	Page 372 BS-06 Pump Test Hydrograph	Norbert M. Woerns	Comment noted.	
321.	'In fact, BS-07 was to originally be used as the pumped well. However, the water level in this well drew down too quickly and therefore the test was abandoned and the pump moved to the BS- 06 well which proved to be more conductive than BS-07.' What is the significance of the difference in hydraulic response between BS-07 and BS-06 within the bedrock? How has this variability been accounted for in the computer model?	Page 374 4th Paragraph Section 15.2.2.2. Pumping Test Interpretation	Norbert M. Woerns	As demonstrated by these two close wells, some locations will be proximal to a well-connected fracture, some locations will not. There distribution of fracture connectivity is likely random and not mappable. Reasonable EPM aquifer properties were adopted in the model, but there will not be a match to K variation at specific locations.	
322.	'The test response for the Westerns Lands is unique in terms of the unconfined response and is attributed to the local setting at the pumping well. This is stated since the bedrock profile at the pumping well is overridden by a thickness of sand which has not been seen elsewhere on the Western Lands and the Southern Lands. This delayed response (i.e., late-time unconfined response) is attributed to the overlying sand sequence as opposed to the larger interconnected fractured rock network. This also accounts for the fact that the same response was not observed during the former Golder pumping test sequences (Golder, 2006). The clay till overburden evident over the regional setting has no capacity to yield any significant response. ' The pump test was able to assess the hydraulic conductivity of the bedrock aquifer. No borehole logs of the test wells BS-06 and BS-07 were provided to confirm the bedrock intervals that were tested. The lack of groundwater monitors within the overburden shallow water table prevented an assessment of the degree of leakage from surface and the degree of interconnection between surface water features such as wetlands and the underlying bedrock. Pumping test of the bedrock should include a groundwater monitor completed within the overburden to assess the interconnection between the overburden and bedrock. Monitoring of nearby surface water features should also be conducted during the pumping test. The pumping test should be of sufficient length to	Page 378 2nd Paragraph Section 15.2.2.2. Pumping Test Interpretation	Norbert M. Woerns	As per the response to Comment 11 and 315, drillers logs for BS-06 and 07 are provided in Schedule E. As indicated in the report: "The Keith Lang boreholes [including BS-06 and BS-07] were drilled to supplement the original HQ boreholes and expand the geological and hydrogeological coverage of the Western Lands. These boreholes are 6-inch in diameter and were constructed using a conventional rotary water well rig. As such, no core was recovered in these boreholes". Spinner logs were recorded in BS-06 and BS-07 and these are also included in Schedule E. For additional details refer to Borehole Log BS-03, (Earthfx, 2020, Page 361) which is less than 10 m from BS-06. The borehole log for BS-03 shows that the water table was at the bedrock surface contact at the time of drilling so no monitor was installed above the water table.	

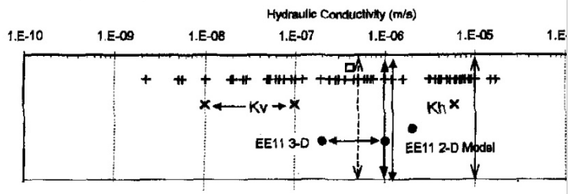
	determine the degree to which there is hydraulic connection between the overburden and bedrock.				
323.	'For the three HQ (4-inch diameter) boreholes (BS-01, BS-02, & BS-03), the borehole diameter limited the installation of two formal monitoring well instrumentations, both of which were standard one-inch (25 mm) diameter PVC construction, while BS-01 and BS-02 had the upper part of the boreholes left open such that they targeted the upper saturated fractures and could be monitored and sampled similar to the deeper well constructions. The larger diameter 6-inch water wells (BS-04 & BS-05) were able to have three formal monitoring well installations with 1.25-inch (32 mm) diameter PVC construction. All these wells were constructed with either a 1.5 m or 3 m machine slotted well screen with standard monitoring well sand pack. The intervening borehole spacing was sealed with bentonite holeplug to ensure proper vertical sealing between monitoring wells within each borehole.' How can be sure the bentonite seals between the multi level monitors within one borehole were not leaking to explain the similar water level response in each monitor?	Page 378 Section 15.3. Monitoring Well Construction, 2nd Paragraph	Norbert M. Woerns	Monitors were constructed by experienced staff so there should be little chance of interconnection. BS-01 to BS-05 contain multi-level monitors. Similar water levels between screened aquifer units were expected at these wells due to the findings presented by Golder on the south lands (MW03-04, MW03-28, and MW03-32) along with the aquifer testing results on the western expansion land wells. There is also a constant supply of recharge water from the golf course irrigation ponds which influence the aquifer systems. The vertical gradients are also discussed in Section 5.3.3.2 where it is noted that that with increasing distance from the quarry, the difference in head between the shallow and deep system is reduced and when the quarry no longer influences the lower system, the water levels in the shallow and deep system are nearly identical.	
324.	Downhole geophysical results for all tested wells should be provided. Section 15.4 presents a summary of how the testing was carried out. Does section 15.4 include all results of geophysical logging?	Page 379 Section 15.4. Geophysical Logging	Conservation Halton	Three holes were surveyed by DGI on the West Expansion. These results were integrated into the geological model as were the findings presented by Golder on the southern lands. Geophysical logs for the boreholes are included in Schedule E	
325.	Groundwater Level Monitoring – The groundwater monitoring stations considered in the Level 1/2 Hydrogeological and Hydrological Impact Assessment are shown in Figure 2.1 of the Earthfx (2020) report. Three different types of monitoring locations are indicated in the figure: • "GW Monitoring Nests"; • "Minipiezometers"; and • "MECP Wells". A listing of the wells shown in Figure 2.1 is not presented in the report. It is indicated in Earthfx (2020) Section 15.5 that between November 2018 and October 2019, a total of 100 monitoring wells were monitored at 39 locations. An extensive compilation of earlier water level records (hydrographs) is presented In Golder (2010; Appendix D). Many of the records extend from April 2003 through August 2010. Hydrographs are presented for 133 monitoring intervals at 81 locations: • 31 nests of the "MW" series, with 85 monitoring intervals; • 6 wells of the "GP" series;	Section 15.5 and Figure 2.1	S.S. Papadopulos & Associates, Inc.	A spreadsheet providing data for of all monitoring wells is provided in Schedule E. The data is also presented in an MS-Word table along with figures showing well locations. The wells include many of the Golder wells plus additional wells drilled for this study and several private wells. Wells are classed as active or inactive and wells that are part of wells nests are identified. Information about the type of measurement (manual, logger, or both) is shown along with the period of record for each monitor and average water level. Schedule B and C contain borehole data for wells in the vicinity of the wetlands and water courses. Additional long-term hydrographs have also been included.	

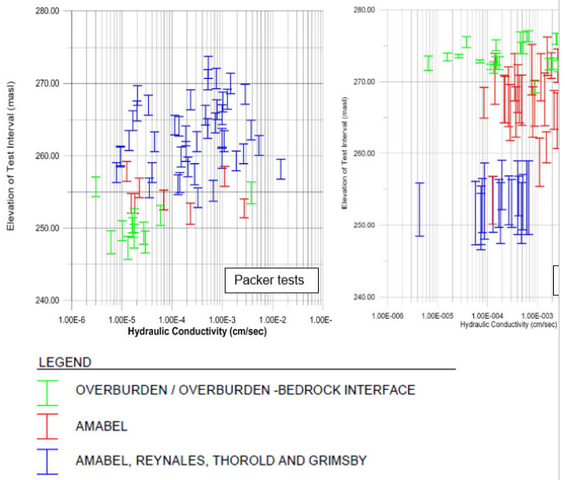
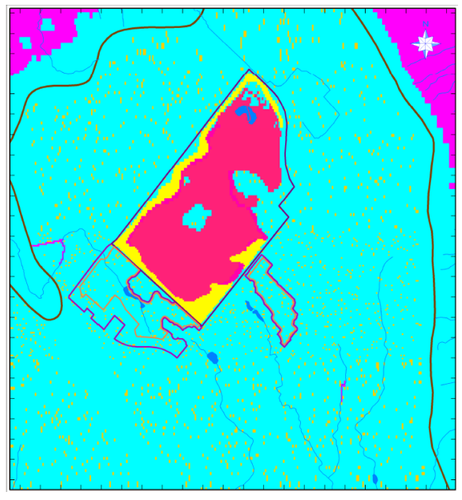
	• 2 wells “Pump well 1” and PW-2; • 6 on-site quarry wells; • 35 minipiezometers of the “MP” series; and • 1 staff gauge, SG-4.				
326.	Only hydrographs for monitoring wells proposed for the long-term monitoring are provided. All available groundwater level monitoring data should be included in the submission to help understand local conditions and measured progression of groundwater lowering due to quarry operations.	Page 389 Section 15.5. Groundwater Monitoring Program	Conservation Halton	Wells were selected for long-term monitoring and for inclusion in the report specifically because they provided observations that could help interpret local conditions as well as monitor potential change in groundwater levels due to quarry expansion. We did not feel that it would be helpful to pad the report with additional hydrographs. Additional hydrographs have been included in Schedule B and C for wells located near wetlands and water courses.	
327.	‘In total, 100 monitoring wells were monitored at 39 locations (nested locations) with dataloggers targeting 34 monitoring wells for at least part of the monitoring period of November 2018 to October 2019. It is also noted that a single domestic well located at 5161 Cedar Springs Road was also included in this monitoring program and had a datalogger installed for continuous monitoring.’ Need a figure to show which monitors were monitored. Were manual water level readings taken and available drawdown assessed in these wells? If so, these data should be provided as background information to the report. Shallow overburden wells need to be monitored to assess impacts to wetlands. Note that water level data was subsequently provided in a excel spreadsheet in a separate information package received September 29, 2020. The data was transcribed from the original files into a computer input file for computer model purposes and was of limited usefulness for peer review purposes.	Page 389 Section 15.5. Groundwater Monitoring Program, 2nd Paragraph	Norbert M. Woerns	As noted in Comment 325, a spreadsheet providing data for of all monitoring wells is provided in Schedule E. The data is also presented in an MS-Word table along with figures showing well locations. Average water levels are provided in the table along with ground surface and monitor top and bottom elevations so that depth to water and available drawdown can be determined.	
328.	OW03-20 documented groundwater levels suggest upward gradients at this location suggesting groundwater discharge conditions. Please provide simulated data for all OW03-20 (A, B and C) intervals.	Page 392 Section 15.5	Conservation Halton	The wells are located next to a ditch and therefore may intermittently receive groundwater discharge. The remainder of the wetland may be perched. A spreadsheet with the observed and simulated groundwater levels has been provided in Schedule E. 	
329.	OW03-28 documented groundwater levels suggest	Page 393	Conservation	The wells are located in a low lying area and therefore may intermittently receive groundwater discharge.	

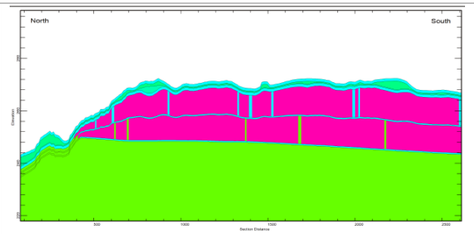
	upward gradients at this location suggesting groundwater discharge conditions. Please provide simulated data for all OW03-28 (A, B and C) intervals.	Section 15.5	Halton	The remainder of the wetland is likely perched. A spreadsheet with the observed and simulated groundwater levels has been provided in Schedule E. 	
330.	BS-01 through BS-05 reported groundwater level monitoring period is less than 1 year. Please extend the monitoring period to include the most recent data. Please include BS-06 and BS7 groundwater level data, borehole logs and location of these two wells.	Page 394-396 Section 15.5	Conservation Halton	The analyses were completed using the available data. Data for the BS series wells starts in January 2019 for some of the wells and in August 2019 for the remainder. Observations were provided until mid-October 2019. Monitoring has continued since that time to assist with the development of the AMP. We did not have water levels for BS-06 or BS-07. Well locations are shown below. 	

					
331.	'During the field program completed by Azimuth in 2019, 24 ground water samples were collected from 13 locations, while eight additional samples were collected from the Southern Lands to complement the previous geochemical sampling completed by Golder in 2003. This previous sampling of the Southern Lands included 22 water quality samples collected from 21 locations.' Laboratory results should be provided as background information to the report. Copies of laboratory data results were provided in a separate information package received September 29, 2020. A summary and analysis of these data with respect to water quality characterization has not been provided and should be included in the assessment report.	Page 397 Section 15.6. Hydrogeochemical Testing, 1st Paragraph	Norbert M. Woerns	Additional water quality information has been compiled and supplied in the response to the MECP comments and AMP discussion included in Schedule A.	
332.	'Of the 156 homes visited, only eleven (11) homeowners indicated that they were interested in participating in the monitoring program. Seven (7) of the eleven (11) private domestic water wells were accessible and, as a result, have been added to the current groundwater monitoring program ' A summary of the well survey results should be provided as background to the report and there should be a discussion of findings from the well survey. All of the locations included in the well survey should be identified on a figure. Copies of 26 well forms were	Page 400 Section 15.7. Residential Well Survey, 2nd Paragraph	Norbert M. Woerns	Additional details about the well survey are included in the AMP document (together with a map showing the locations that responded). The AMP also states that a follow-up well survey will be completed at a later date due to again invite well owners to participate. The seven wells to which access was provided in the first survey did not provide significant insight beyond the publicly available well record. Additional documentation could be provided now, however the AMP states that Nelson's website will have a page dedicated to Private Well Monitoring details once the second survey is complete.	

	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.				
333.	The northing coordinate for the model lower left-hand corner cannot be 4,794,585,500 metres. Although no coordinates are indicated in Figure 18.4, the coordinate must be wrong by a factor of 1,000.	Page 481 and Figure 18.4	S.S. Papadopulos & Associates, Inc.	Typo. The ",500" should have been deleted.	
334.	The right side of Equation (18.4) is missing an area term.	Page 483	S.S. Papadopulos & Associates, Inc.	There is an area term, A_L. The second part of the equation (= - Kdh/dx) is a typo and does not belong there.	
335.	Please clarify for which wetlands field surveyed bathymetry data was used.	Page 486 Section 18.3.2. Lake and Wetland Representation	Conservation Halton	Bathymetry data were available for the golf course ponds and wetlands to the south and east of P12. 	
336.	It is indicated that the model does not include the "many" constructed in-line and off-line ponds in the Medad Valley. On page 486 it is indicated that the final model included 40 MODFLOW "lakes" and the inspection of Figures 6.21 and 18.9 suggests that this includes many small features elsewhere. Why were small ponds included in some areas but not others?	Pages 486 and 523 and Figures 6.21 and 18.19	S.S. Papadopulos & Associates, Inc.	We made sure to simulate the lakes, ponds, and inundated portions of wetlands above the Escarpment especially if they were close to the quarry. We did not expect significant changes below the Escarpment so there are about 5 ponds that are mapped in the Ontario Hydrologic Network (OHN) waterbody coverage that we did not include. There are also many small ponds along Cedar Springs Road, for example, that are not mapped in the OHN coverage but are visible in Google maps. We did not include these.	
337.	Please explain why specific yield values for weathered and fractured zone hydrostratigraphic layers are so low (Weathered Amabel, Middle Amabel bedding plane fracture zone and Lower fracture zone)? They are an order of magnitude smaller than respective competent bedrock layers. As per section 5.2.4 Layer 4 may act as unconfined aquifer when specific yield rather than storage is used. It should be noted that this is also possible in lower layers closer to the extraction where water table drops significantly.	Page 492 Table 18.4. Final calibrated model parameter values	Conservation Halton	In general, the pump test and responses to recharge all indicated that storage is very low in the bedrock system. The assumption was that if the bulk layers were dewatered, they would exhibit a higher storage than the fracture zones, so a higher value was assigned.	
338.	The expectation is that the horizontal and vertical hydraulic conductivity of the Halton Till is a critical parameter in the analyses, particularly the vertical hydraulic conductivity. Are the values of the horizontal and vertical hydraulic conductivities inferred through calibration, 5.0×10.0^{-7} metres/second and 2.0×10.0^{-7} metres/second (Table 18.4) consistent with estimates reported for other sites? A compilation of hydraulic conductivity estimates for	Table 18.4	S.S. Papadopulos & Associates, Inc.	Yes. The values are consistent with the literature that you cited. The values are also within the range of packer testing by Golder which varied several orders of magnitude. The values worked well in terms of matching observed responses in the wetlands and were felt to be conservative. In earlier responses, we discussed the fact that because the till is fractured, there are likely to be areas with more vertical fractures and areas with less. The location of these areas is unmapped and generally unknowable. An extensive discussion of the testing, analysis and simulation of the Halton Till is included in our response to the MNRF comments. Copies are provided in Schedules B and C. The calibration to more than 20 minipiezometers is included.	

	the Halton Till is reproduced below (Gerber and Howard, 2000).  Gerber (2010) has suggested the following representative average values for the Halton Till (Gerber, 2010): • Weathered Halton Till: K_H ~5.0×10.0^{-6} metres/second; $K_V = K_H$; and • Unweathered Halton Till: K_H ~5.0×10.0^{-7} metres/second; $K_V = 0.1\ K_H$. Sharpe et al. (2013; Table 4) suggest a value of 2.0×10.0^{-5} metres/second for the vertical hydraulic conductivity of the weathered Halton Till. The value of the vertical hydraulic conductivity of the Halton Till inferred through calibration appears to be substantially smaller than literature values. This is not to imply that the values specified in the groundwater model are inappropriate. However, there is no discussion of how the values were inferred through calibration. How sensitive is the match of the calibration targets to the values of the vertical hydraulic conductivity of the Halton Till that are specified? How sensitive are the predictions to the vertical hydraulic conductivity of the Halton Till, in particular the predicted impacts to shallow features such as wetlands?				
339.	Final calibrated values of the hydraulic conductivities for each model layer are listed on Table 18.4. There is no indication as to whether the inferred uniform values for each hydrostratigraphic unit are consisent with the results of independent testing. This is an essential check for model acceptance. Previous summaries of hydraulic testing presented are reproduced below (Golder, 2010; Figures C.2 and C.3). These compilations should be updated, with the values inferred through calibration superimposed. A well-by-well, or test-by-test review is not expected. Rather, some general appraisal of whether the hydraulic conductivity values inferred through calibration are consistent with the bulk of the available estimates from site hydraulic testing is expected.	Table 18.4	S.S. Papadopulos & Associates, Inc.	We looked at the packer test, slug test, and pump test results and the range of values they encompass. These helped us select reasonable initial estimates for aquifer properties. As per earlier responses, we did replicate the aquifer tests at an early point in model development as well as applying PEST with pilot points to try and determine larger–scale spatial variability in bedrock and overburden properties. In the end, we felt the spatial variability was a result of variable fracture properties at a smaller scale that could not be reliably determined. Therefore, we used reasonably conservative uniform values for the properties that produced good but not perfect matches to the observations.	

					
340.	The approach that has been adopted to incorporate hydraulic connections between the weathered top of rock and the middle flow zone, and between the middle and lower flow zones is shown in Figures 18.20, 18.21 and 18.7 of the report. The approach is illustrated below. The approach that has been adopted to incorporate the vertical hydraulic connections is not physically based 	Figures 18.7. 18.20, and 18.21	S.S. Papadopulos & Associates, Inc.	The approach attempts to mimic the physical response of the groundwater system to randomly occurring vertical fractures, specifically, to increase the vertical connection between units without compromising the semi-confining nature of the bulk units. As was noted in earlier responses, the fractures do not appreciably affect head distributions or flow patterns, but are more manifest in the transient response to precipitation events and in the vicinity of the quarry face.	

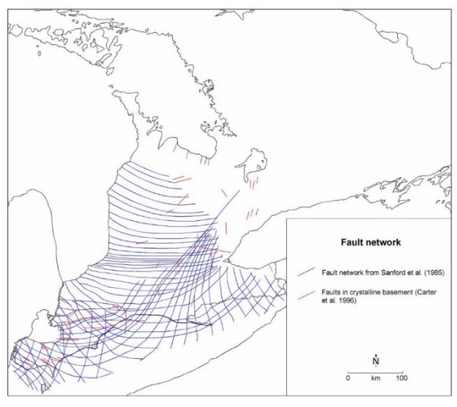


The approach does not provide either an improved representation of the fractures in the bedrock system, or the hydraulic connections between the flow zones. The approach that has been adopted is not internally consistent. Finally, the approach compromises the reliability of the predictions of potential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

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

There are no data to constrain the assumed distribution or properties of the chimneys.

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



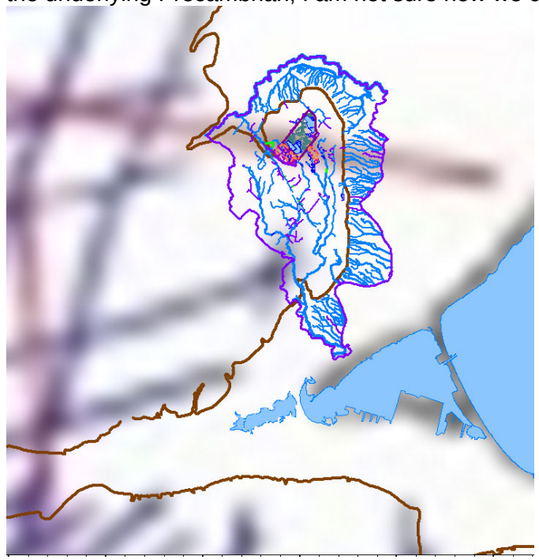
Regional faulting in southern Ontario (from Mazurek, 2004)

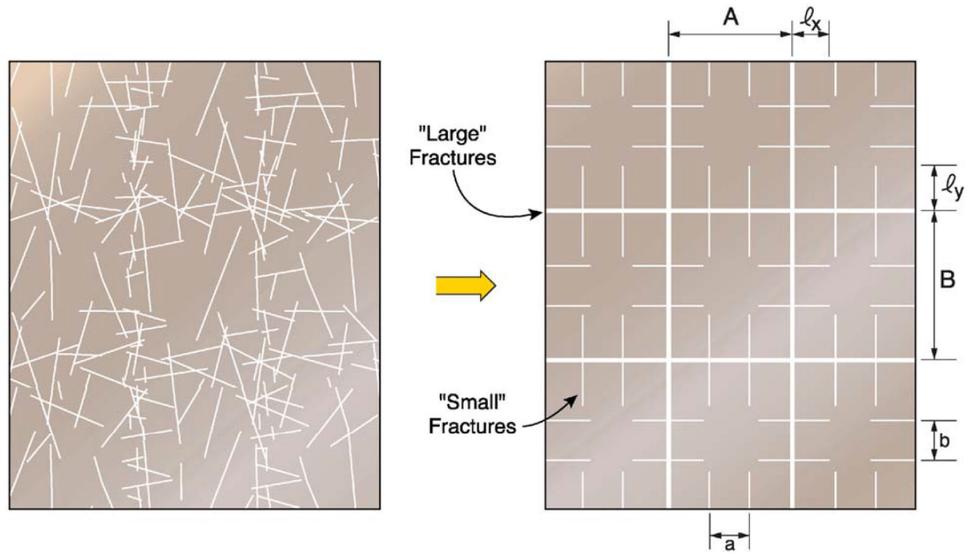
We strongly disagree with the assertions that the approach does not provide either an improved representation of the fractures in the bedrock system, or the hydraulic connections between the flow zones, that the approach that has been adopted is not internally consistent, and that the approach compromises the reliability of the predictions of potential impacts of the quarry expansion. No quantitative proof was provided with these statements; while, on the other hand, we have shown the improved calibration to response in the deep system and at the quarry face.

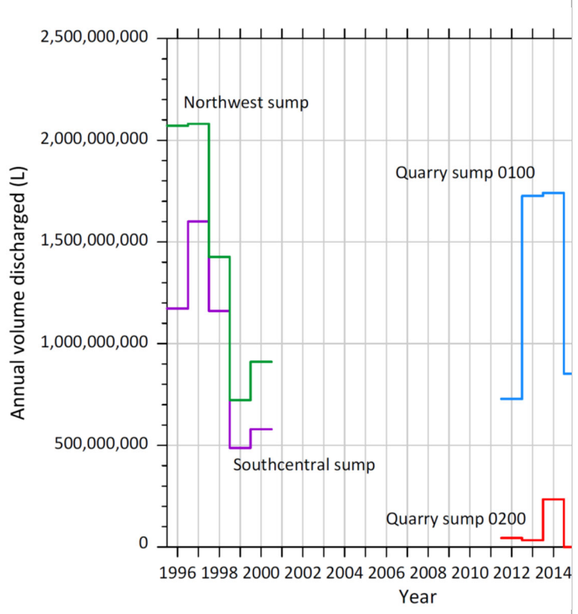
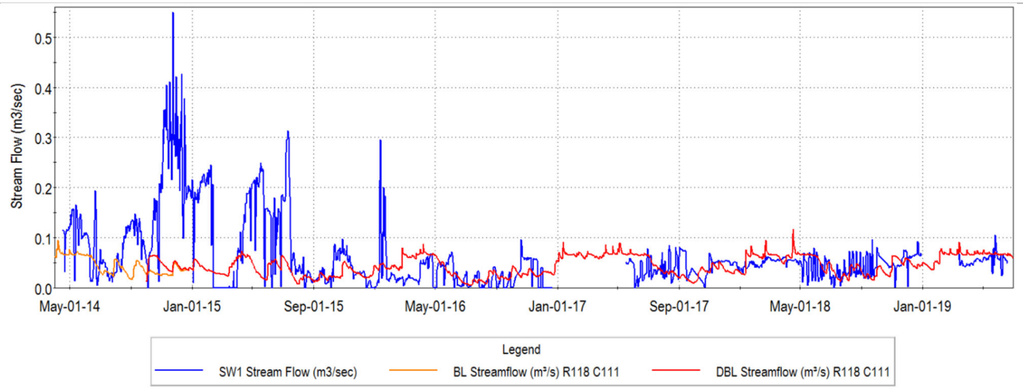
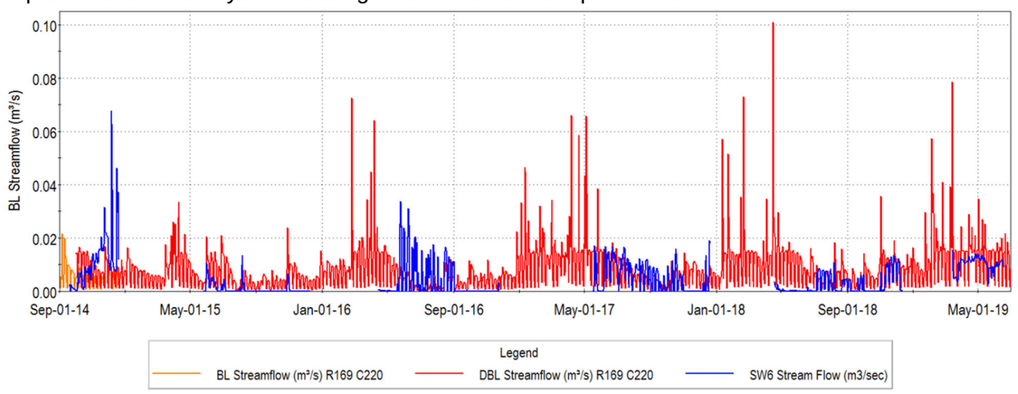
We agree that the size of the higher hydraulic conductivity connections are not ideal to represent individual fractures but are more representative of small zones with higher frequency of vertical fractures. Both would likely give identical response at distances within 2 to 3 times the aquifer thickness.

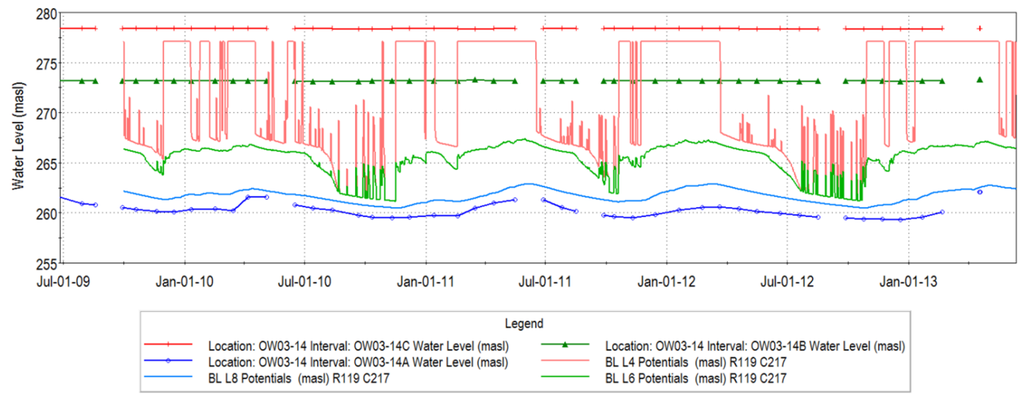
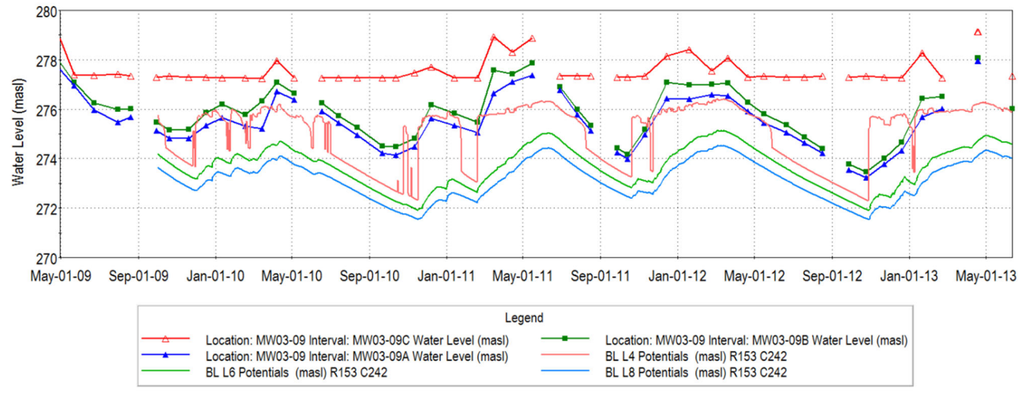
As locations of fractures or fracture zones are unknowable, the calibration focussed on the frequency of these occurrences. This is how we settled on the 5% occurrence.

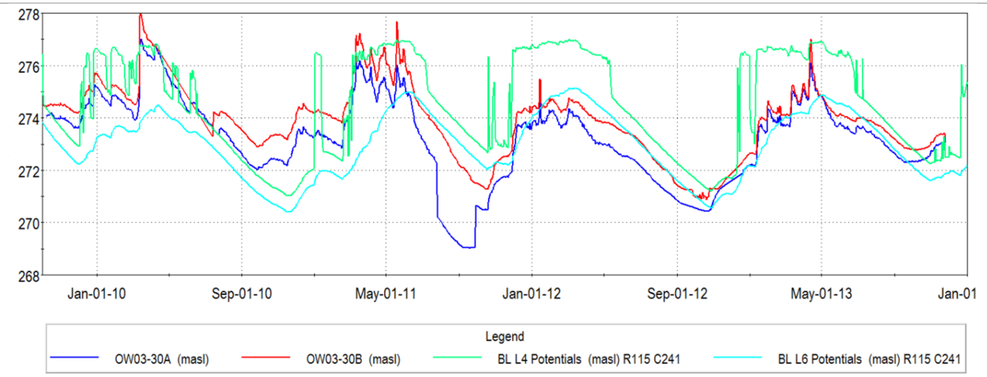
This is your figure compared to the model extent and scale. Other than noting that there may be a fault in the underlying Precambrian, I am not sure how we could incorporate this information.



	The bedrock in the study area has been simulated using the equivalent porous medium (EPM) approach. Bulk-average hydraulic conductivities are assigned to the bedrock units, the weathered top-of-rock zone and the middle and lower flow zones. This approach is appropriate given the scale of the potential impacts of the development, and recognition that the results of the model are not predictions of what is likely to happen at discrete locations but what is likely to happen on average. However, the introduction of the chimneys runs counter to the EPM approach. A consistent approach involves specifying bulk-average vertical hydraulic conductivities, rather than introducing discrete artificial features. The bulk-average vertical hydraulic conductivities would account, in an average sense, for the presence of discontinuities that might give rise to enhanced connections between the horizontal flow zones. The introduction of the chimneys compromises the reliability of the predictions of potential impacts of the quarry expansion. The predictions of the model at particular locations will depend on the proximity to one of the simulated chimneys, about which nothing is known. The simulation approach introduces an impression of exactitude that is not supported by any data.			We disagree that this is counter to an EPM approach. For example, the dual-continuum approach has been extended into a triple-continuum approach in a similar manner to our representation. Wu et al. (2004) recognized that there is a network of larger and smaller fractures that are important to represent in the simulations of the Yucca Mountain site.  Fig. 5. Basic conceptualization for triple-continuum approximation of two-dimensional large-fracture, small-fracture, and rock matrix systems. Wu, Y.S., H.H. Liu, and G.S. Bodvarsson. “A triple-continuum approach for modeling flow and transport processes in fractured rock,” Journal of Contaminant Hydrology, 73: 145-179 (2004). In Response 123, we provided maps showing that there are small differences in heads locally due to proximity of the fracture zones, more so in Layer 6 than Layer 8. If anything, the presence of a fracture zone in the vicinity of a wetland or stream feature would magnify the effect of quarry dewatering rather than minimizing it, thus yielding a more conservative analysis of possible impacts. We did not imply any knowledge of locations of vertical fracture zones, but noted that these were placed randomly to mimic the random, unknowable occurrence of vertical fracture zones in the study area.	
341.	A key result for any model calibration is the match to observed groundwater discharges. The understanding is that the North Quarry discharge corresponds to the flows measured at SW1, and that the final model results are compared against the observations in Figure 19.10. Why is the discharge shown for only 5 years? The impression is that the model results do not approximate the observations.	Figure 19.10	S.S. Papadopulos & Associates, Inc.	The available discharge data starts in April 2014. The restarted baseline (drought period) started in August 2015. We assumed that there would be enough overlap to show the correspondence. The figure below shows the results of the first baseline run for April to December 2014 (in orange) covering the missing simulation results. Quarry discharge is lower than observed in 2014 and early 2015 but settles down and the match is good over the rest of the five year simulation and seems consistent with current quarry operating procedures.	

	It is further understood that the South Quarry discharge corresponds to the flows measured at SW6, and that the final model results are compared against the observations in Figure 19.11? Why is the discharge shown for only 7 years? The impression is that again the model results do not approximate the observations. The annual quarry discharges from 2012-2019 are listed in Tatham (2020; Table 1). In the following figure the values reported by Tatham are supplemented with sump pump between 1996 and 2003 (Golder, 2010; Table E-8). The impression is that there have been important variations in the quarry discharges. How have these variations been considered in the analyses?  			 A revised hydrograph for SW6 is shown with the missing baseline data in orange. Again, the match improves in the last 5 years as we get closer to current operations.  It is important to note that the objective of simulating the pumping from the sump rather than using recorded pumping was so that we could reasonably predict pumping rates under future conditions for which recorded data would not be available.	
342.	Simulation results are presented for stream gauge SW2 in the Medad Valley. Referring to Figure 19.4, were results also obtained for the other stream gauges in the Medad Valley, SW14 and SW7? The impression is that the reach between SW14 and SW7 will be critical with respect to an appreciation of potential impacts to streamflows of the proposed extension.	Page 523 and Figure 19.14	S.S. Papadopulos & Associates, Inc.	These were shown in Figure 8.72 and 8.73	
343.	Please include simulated and observed water levels for OW03-14B. It should be noted OW03-14A water levels are also constantly overestimated by some 1-2 m.	Page 533 Section 19.5.3. Wells within 100m of the Quarry	Conservation Halton	OW03-14C and OW14B are nonresponsive and are either plugged or dry. The simulated water levels for all well are shown on the figure below for the overlapping observation/simulation period.	

		Face			
344.	Contrary to wells within 100.0 metres of the extraction the model underestimates deep system groundwater levels by some 1.0-2.5 metres, moreover, simulated water levels from model layer 7 or 8 should be presented and compared to MW03-09A. Shallow zone observed and simulated groundwater levels should be also included on this figure.	Page 535 Figure 5.25. Comparison of observed and simulated water levels at monitor MW03-09	Conservation Halton	It is difficult to match water levels exactly, given that we are trying to simulate heads close to a quarry face with a large-scale model where the local quarry geometry 10 years ago is not the same as now (further, some main quarry rehab has already taken place along the south wall). The figure shows simulated water levels in Layer 8 and observations in MW03-09A in blue. 	
345.	OW03-30 – observed groundwater levels in the deep and middle zones seem to be higher than simulated water levels. Simulated water levels from model layer 7 should be presented and compared to OW03-30A. Shallow zone groundwater OW03-30C observed and simulated water level data should be included.	Page 535 Figure 19.26. Comparison of observed and simulated water levels at monitor OW03-30	Conservation Halton	Hydrographs for OW03-30 A and B are provided. There is no shallow well OW03-30C. Groundwater level data and the hydrograph have been provided in Schedule E. Simulated water levels at OW03-21 for Layer 1 and 2 were very similar to those for Layer 4. There are a number of possible reasons for this anomaly, including well construction, survey error, local shallow topographic/drainage effects and others.	

					
346.	It is indicated that the simulated deep water levels at MW03-2 is "somewhat higher than the observed values." The inspection of Figure 19.28 suggests that the simulated average water level is about 267.5 metres amsl, substantially higher than the observed average of 259.5 metres amsl. It is also noted that the match shown to MW03-01A levels is also relatively poor, capturing none of the significant declines that are observed through time. The observed levels range from 271.5 to 267.0 metres amsl, compared with the simulated range of 271.0 to 269.0 metres amsl.	Page 536 and Figure 19.28	S.S. Papadopulos & Associates, Inc.	As noted above, this monitor is adjacent to the stream carrying the south quarry discharge. The monitor is also immediately beside a randomly placed vertical fracture; that is also under a wetland cell fed by the south quarry discharge. In summary, this cell probably receives too much leakage from above, explaining the high simulated water level. This is expected given the placement of the random vertical features and does not raise any alarms about the model.	
347.	The large difference between simulated and observed water levels in MW03-02 as presented on Figure 19.28 puts in question using the model to predict local conditions. Perhaps the difference between the observed and simulated water levels can be explained by heterogeneity of the bedrock aquifer. Has there been any hydraulic testing done on MW03-02 to identify local hydraulic properties of the aquifer? Please provide a borehole log for MW03-02. Please include MW03-02B observed and simulated data.	Page 537 Figure 19.28. Comparison of observed and simulated water levels at monitor MW03-02	Conservation Halton	See response 346	
348.	Considering MW03-01C is a shallow well (about 2.0 metre deep), simulated water levels from an appropriate layer should be presented on Figure 19.28. Please include MW03-01B observed and simulated data.	Page 537 Figure 19.28. Comparison of observed and simulated water levels at monitor MW03-01	Conservation Halton	MW03-01C data does not appear on Figure 19.28.	
349.	Please explain a 2-3-month lag between the observed and simulated water levels at monitor OW03-17.	Page 538 Figure 19.30. Comparison of observed and simulated water levels at monitor	Conservation Halton	See Comment 173. As we noted, there is a bit of a lag in the fall recovery. This is likely due to the need to bring soils up to field capacity before groundwater discharge or dunnian flow occurs. In the field, the values of soil storage capacity will likely vary, with some areas contributing flow earlier than others. Randomizing the storage capacity values wihin each class might help but was not implemented in this model.	

		OW03-17			
350.	Please explain a couple month lag between observed and simulated water levels as visible on Figures 19.35, 19.38, 19.39, 19.40 and implications of using the model for predictive analysis. Please provide construction details of the mini-piezometers used in the assessment.	Page 540 Section 19.5.6. Shallow System Calibration (Mini-piezometers)	Conservation Halton	See Comment 173. As we noted, there is a bit of a lag in the fall recovery. This is likely due to the need to bring soils up to field capacity before groundwater discharge or dunnian flow occurs. In the field, the values of soil storage capacity will likely vary, with some areas contributing flow earlier than others. Randomizing the storage capacity values wihin each class might help but was not implemented in this model. Minipiezometer data have been provided.	
351.	Referring to Table 19.1, the “inflow” reported for evaporation from interception represents 125.0% of the precipitation. If the correct percentage of the precipitation is indeed 12.8%, the correct value must be 26,070.0 cubic metres/day.	Page 554 and Table 19.1	S.S. Papadopulos & Associates, Inc.	Typo during round-off. Should be 26071	
352.	It is not possible to reproduce the reported overall discrepancy in the GSFLOW groundwater budget for WY2010-WY2014 (Table 19.1). The components of the budget are reproduced below. **Item** / **Volumetric rate (m^3/d)** **INFLOWS** Recharge 28,155 Stream leakage 2,885 Lake leakage 2,103 **Total inflows** **33,143** **OUTFLOWS** Evapotranspiration from the water table -2,817 Discharge to the soil zone (rejected recharge?) -28,482 Net boundary outflows -84.3 Groundwater discharge to streams -2,498 Groundwater discharge to lakes -1,229 **Total outflows** **-35,110.3** Assuming that “net outflow from storage” represents a source of water to the groundwater system from a net decline in groundwater levels, the overall water budget discrepancy is written as: $\%\ \text{Discrepancy} = 100 \times \frac{(\text{Total inflows} + \text{Net outflow from storage}) - \text{T}}{\frac{1}{2}[(\text{Total inflows} + \text{Net outflow from storage}) + \text{T}}$ $= 100 \times \frac{(33{,}143 + 852) - 35{,}110.3}{\frac{1}{2}[(33{,}143 + 852) + 35{,}110.3]} = -3.2\%$ In contrast, the reported % Discrepancy is -0.6%.	Page 554 and Table 19.1	S.S. Papadopulos & Associates, Inc.	Your analysis is correct, but the table was reporting the discrepancy in the last column, that is, as percent of precipitation.	
353.	The Level 1 and 2 Hydrogeological Assessment also documented open fractures in boreholes located within the western extension. This included references to the presence of “moderately open” fractures in the composite video log (Appendix A, Figure 4.2.3) and several of the borehole logs were annotated as “heavily fractured” (BS01), and “larger fractures” (BS02).	Appendix A and Figure 4.2.3	Daryl W. Cowell & Associates Inc.	Comment noted.	

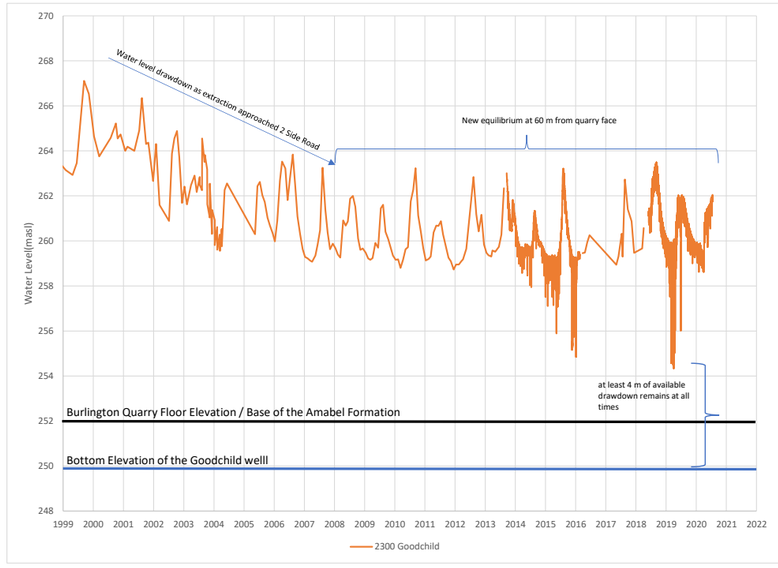
354.	The final calibration of the GSFLOW model is presented in Appendix E (Section 19). It is not clear from the presentation what the targets for the calibration were (apart from the total streamflow at Aldershot), what parameters were varied during the calibration, and how the ranges were established over which the parameter values would be adjusted to match the calibration targets. Upon review of this section, these were left: Which parameters make a real difference in the calibration, and are there data to constrain the most important parameters?	Section 19. Appendix E	S.S. Papadopulos & Associates, Inc.	The basis for this comment is unclear. The reviewer acknowledges that there is an entire section discussing the calibration of the GSFLOW model, with 46 pages including sections on calibration strategy, region calibration to streamflow (the Aldershot gauge mentioned) and regional groundwater levels, local-scale calibration to 8 streamflow gauges, calibration to quarry discharge, calibration to groundwater levels at the quarry face and the need to adjust hydraulic conductivities to match the observations along with discussions, tables, maps, and hydrographs of model results. This section follows two other sections providing detailed discussions on the input data and preliminary calibration of the hydrologic and groundwater submodels. The calibration was done over a two-year period with multiple revisions, innovations, improvements to derive a good match to the observations (particularly in the shallow subsurface), and reasonably constrained parameter values. This was all accomplished using a highly advanced integrated model, despite long run times and instabilities related to the Niagara Escarpment, in a fractured rock/till environment, and with highly complex GW/SW interaction between headwater streams and shallow wetlands. We do not believe that there has ever been such a complex integrated transient analysis ever done in Ontario to analyze a proposed quarry extension. We believe that we accomplished the goal of producing a model that can successfully predict the likely changes in streamflow, groundwater levels, and wetland stage under the quarry extension scenarios considered. Results from this model provided useful input to other team members evaluating the impact to hydrologic and natural heritage features. Please refer to Response 61 and 63 for additional discussion.	

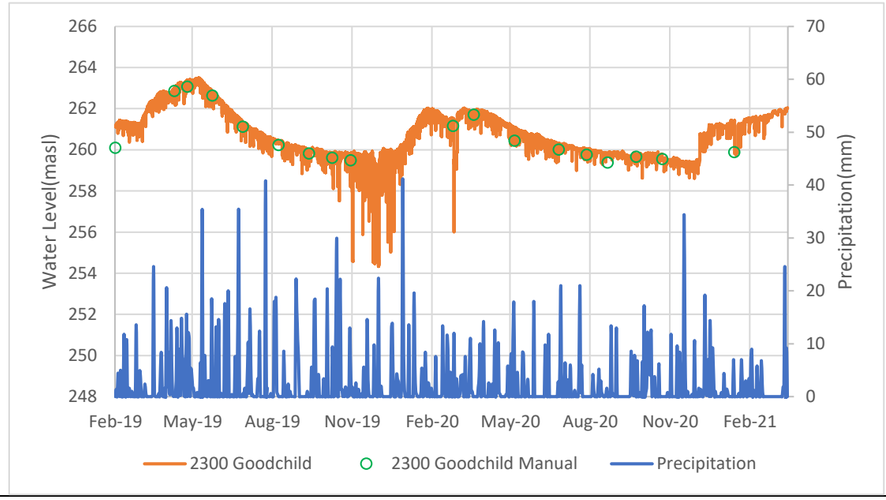
Aggregate Resources Act **(ARA) Licence Application - 626477**
Nelson Aggregate Co. (Burlington Quarry Extension)

WATER TAKING	MECP COMMENT	NESLON RESPONSE
1	The reporting should provide some discussion on the proposed methods of dewatering and should acknowledge whether site dewatering is anticipated to require a PTTW. Although detailed dewatering rates are not required at this stage, the numerical model may be able to provide an estimate of the expected and worst-case dewatering rates.	Nelson is currently permitted to pump continuously from two source locations (NW Sump 0100 and SC Sump 0200) at rates of 4090 and 945 L/min. The proposed expansion will not be altering the sump locations for the existing and western expansion. For the southern expansion, dewatering will be required resulting in a requirement to amend the existing PTTW. During the initial phases of extraction, surface and groundwater accumulating on the quarry floor will be pumped to a settling pond constructed at surface for treatment prior to off-site discharge to the West Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek. As the extraction area expands, a sump will be constructed on the quarry floor; replacing the settling pond constructed at existing grade. Water accumulating in the quarry sump will continue to be discharged off-site to the West Arm. Initial estimates indicate that a maximum required discharge rate of 3,000 L/min (50L/s) is required for the south extension to manage intercepted surface and groundwater and incidental precipitation. However, the water taking rates will be refined moving forward during the ARA Licence application process.
2	The reporting does not identify the source of water for potential wash plant operations. It should be indicated whether wash water will be sourced from an onsite supply well or other source (i.e. recycled water obtained from dewatering, runoff collected in storm water management ponds, or surface water). If a private supply well will be required, additional comments on the target aquifer, radius of influence, and need for PTTW should be provided.	Nelson Aggregate will not be washing at the Burlington Quarry. No washing has ever occurred at the site and there is no future requirement to do so.
3.	The future PTTW application should include a history of private well complaints related to the existing quarry operations, evaluation of monitoring efficacy in terms of predicting the potential impacts, and the mitigation/restoration measures implemented.	Nelson commits to providing a detailed history of any well complaint received and how the compliant was resolved as part of any future PTTW application
4.	Since groundwater resources around the quarry are dependent upon the storage capacity of the two fracture zones within the Amabel formation, when the quarry extracts the material at the Western Extension (Burlington Springs Golf Club), the private wells on the west side of Cedar Springs Road are likely to be impacted and probably will eventually fail. While those wells are probably now deriving their water from the lower fracture zone just above the Reynales contact, deepening the wells into the underlying shale interface will likely encounter both poor quality water and low yields. As such this is probably not a good option (bringing municipal water from Burlington may require a booster pumping station and necessitate considerable cost to reach this location).	A summary of the groundwater quantity assessment presented in the Level 1 and 2 Hydrogeological Assessment is presented below. Of particular importance are the results of the impact assessment and proposed mitigation for domestic wells, which did not indicate that wells will need to be deepened into the Cabot Head Shale unit. The results indicate that the lower fracture zone at the Reynales Formation is a regionally active flow zone of good quality. As part of the Level 1 and 2 Hydrogeological Assessment, comprehensive assessments of the private water wells and active fractures zones were completed and concluded that the lower fracture zone at the Reynales Formation currently supports and will continue to support domestic water supply. There are three lines of evidence to support this conclusion: 1. the geological formations slope to the west and therefore, along Cedar Springs Road, there is an increased thickness of Lower Amabel above the Reynales Formation beneath the proposed quarry floor elevation. This is detailed in the Earthfx Report in Section 8.7. 2. the Karst Assessment concluded that on the western lands (along Cedar Springs Road), at BS-06 and BS07 that there are active fractures at 25 m below ground surface (at an elevation 248-250 masl); and 3. the current operational condition of water supplies along No. 2 Sideroad where wells are located within 60 m of the quarry face continue to have adequate supplies (both quality and quantity). Cross-sections along Cedar Springs and No. 2 Sideroad have been prepared to illustrate the current well depths (appended). It is evident from both cross-sections that the primary water supply depth is from above the quarry floor east of the crest of the Medad Valley. However, there are many wells that obtain their supply from the lower fracture zone and the Reynales Formation (particularly west of the crest of the Medad Valley). As discussed in Section 11.3.3.3 of the Earthfx report, the private wells in the vicinity of the West Extension will see a decline of approximately 2 m in available drawdown. It is well reported that the lower fracture zone at the Reynales Formation will have between 10 and 16 m of available drawdown after excavation, so deepening a well is a viable mitigation measure which will maintain both the quality and quantity of the private supplies. 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.

The best evidence to show that the lower Amabel fracture zone and Reynales Formation will continue to support domestic water wells is the on-going operation of wells immediately adjacent to the existing quarry along No. 2 Sideroad. The "Goodchild" well is located approximately 60 m from the quarry face and has been monitored since 1999.

The water level monitoring shows the water level drawdown associated with the advancement of the quarry face towards the Goodchild well. In 2008 the quarry face was at 60 m from the water well, where a new equilibrium was reached. On-going monitoring shows the continued operation of the water supply well, which functions at times with less than 4 m of available drawdown.





		The water from the Goodchild well is of excellent quality. The only exceedance of the Ontario Drinking Water Standards (ODWS) is iron and hardness, which are operational parameters. The parameter concentrations are as follows: **Non-detected Parameters** 			
Aluminum	Europium	Tellurium
Ammonia (as N)	Gallium	Thallium
Antimony	Lanthanum	Thorium
Arsenic	Lithium	Tin
Beryllium	Mercury	Tungsten
Bismuth	Niobium	Yttrium
Bromide	Phosphorus	Zirconium
Cerium	Selenium	
Cesium	Silver	| **Health Related Guidelines (mg/L)** | Parameter	ODWS	Value
Barium	1	0.038
Boron	5	0.026
Cadmium	0.005	0.0001
Chromium	0.05	0.004
Fluoride	1.5	0.07
Lead	0.01	0.001
Uranium	0.02	0.001
Nitrate (as N)	10	0.19
Nitrite (as N)	1	<0.05 | **General Water Quality (mg/L)** | Parameter	Value	Parameter	Value
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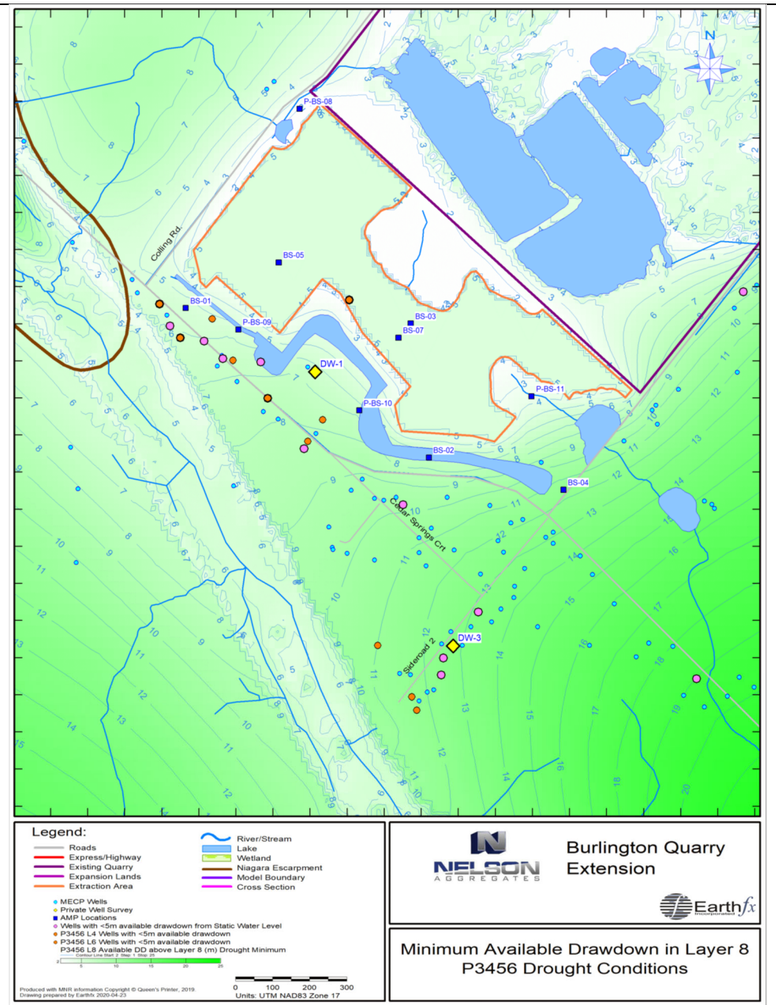
M-Alkalinity (pH 4.5)	363	Molybdenum	0.005
Bicarbonate	361	Nickel	0.01
Conductivity	983	Rubidium	0.001
Total Dissolved Solids	614	Scandium	0.002
Total Phosphorus (as P)	0.012	Silicon	4.26
Calcium	136	Strontium	0.317
Magnesium	30.8	Sulfur	48.3
Potassium	1.23	Titanium	0.001
Cobalt	0.0004	Vanadium	0.001 | **Aesthetic and Operational Guidelines (mg/L)** | Parameter	ODWS	Value
Chloride	250	34.7
Copper	1	0.012
Iron	0.3	0.4
Manganese	0.05	0.022
Sodium	20/200	17.8
Sulphate	500	141
Zinc	5	0.2
True Colour	5	2
Turbidity	5	1.1
pH	6.5-8.5	7.73
Total Hardness (as	80-100	466 | Based on the long-term data collected from the closest domestic water well, the results support that the water quantity and quality of the lower Amabel and Reynales Formations is excellent.
5	Further evaluation of potential impacts on groundwater supplies around the West Extension area near Cedar Spring Road is recommended as water supply in this area is expected to diminish. On the west side of Cedar Springs Road there is a sharp drop in the land surface towards the Medad Valley. In conjunction with the drop, the private wells become marginal water supplies for the domestic residences.	Please see response to Items 4 and 6, which addresses the concern with the domestic wells and requests further evaluation of the lower fracture unit.
6	Evaluation is recommended regarding effects from excavation on the lower Amabel fracture zone near the West Extension area, and if that formation exists and/or is feasible as a water supply unit west of Cedar Springs Road.	The fully integrated model supports the findings of the field program, which indicates that the lower Amabel/Reynales Formations will support domestic water wells (both quality and quantity). If shallower wells need to be depended, even under worst case drought conditions (such during the Level 2 Provincial Low Water Advisory that was issued in 2016), there will continue to be between 5 and 20 m of available drawdown in the Amabel Aquifer.

		 It is important to note that the Medad Valley is a locally significant groundwater discharge area, and as such it is less susceptible to seasonal and inter-annual water level fluctuations. The basal Layer 8 lower fracture will maintain, on average, between 6 and 20 m of available drawdown in the aquifer. As a result, private domestic water wells, some of which partially penetrate the Amabel Formation, could be deepened if necessary. Data collected from existing domestic water wells along No. 2 Sideroad, which are within 60 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.
7	As reported by Earthfx (2020a), considering that water levels at observation locations may exhibit over 2 m of seasonal/inter-annual variation, the determination of quarry impacts on	Agreed. As part of the AMP, Nelson has proposed to rely on the Seasonal Mann-Kendall Test to statistically interpret trend analysis of groundwater elevations at select sentry wells. The Nottawasaga Valley Conservation Authority has relied on the Seasonal Mann-

	water levels may be challenging. During the PTTW application review stage, additional discussion/details will have to be provided related to well complaint investigation approach, and resolution.	Kendall Test to interpret Provincial Groundwater Monitoring Network (PGMN) groundwater levels after it was recognized that statistically definable results can be utilized to manage groundwater resources, assess drought conditions, evaluate the impact of human activities on groundwater and evaluate long-term groundwater trends. 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 out if there is a trend in the overall series, but if from one month of January to another, and from one month February and another, and so on, there is a trend. The Seasonal Mann-Kendall test is established on the basis that the trend is cyclically varying in relation to the seasons of the year. It is used to analyse time series data for the possible existence of an upward or downward trend, at a significance level, while accounting for the effect of seasonality. This approach will allow for early detection of a trend, prior to reaching any threshold value set for sentry or private water well.
8	A more detailed evaluation of potential impacts to specific individual private water wells is recommended.	Agreed. Key information on individual wells would be required to complete a more detailed assessment, such as confirmation of well location, construction details, and current quality and quantity characteristics. As discussed in the Level 1 and 2 Hydrogeological Assessment, a preliminary private door-to-door water well survey was completed. The survey was completed for all residents located within 1 km of the proposed extension lands, including those located on both the north and south sides of Sideroad No. 1. In total, 156 homes were visited. 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. It has been found that the public interest in participating in a well survey drastically increases if an ARA licence has been issued. Therefore, Nelson is committed to complete a follow-up door-to-door water well survey to inform residents that they are still able to participate in the program if interested. Focus will be on wells located within 500 m of the proposed extraction area and wells that have an available drawdown of less than 10 m. Based on the information obtained from the MECP database, there are 36 water wells that meet this requirement. An impact assessment will be completed on these wells based on their individual construction details and performance. The monitoring and proposed mitigation strategies will be updated prior to in the Adaptive Management Plan.

<table>
<tr><th>WATER QUALITY</th><th>MECP COMMENT</th><th>NESLON RESPONSE</th></tr>
<tr><td>9</td><td>A discussion related to potential contaminants of concerns to be introduced to the subsurface during blasting activities and discharge should be prepared, along with an assessment of potential impacts to groundwater quality. The assessment should include recommendations for best management practices, monitoring, and mitigation measures. The applicant can use data collected under the existing operation.</td><td>The Burlington Quarry currently holds a sewage works Environmental Compliance Approval (ECA # NUMBER 5203-AN6NGV) for the collection, transmission, treatment and disposal of surface water and quarry water. As part of the MECPs review of the supporting documentation for the application of this ECA, PCOC for aggregate operations were identified, and best management practices, monitoring, and mitigation measures were included in the site's instrument.

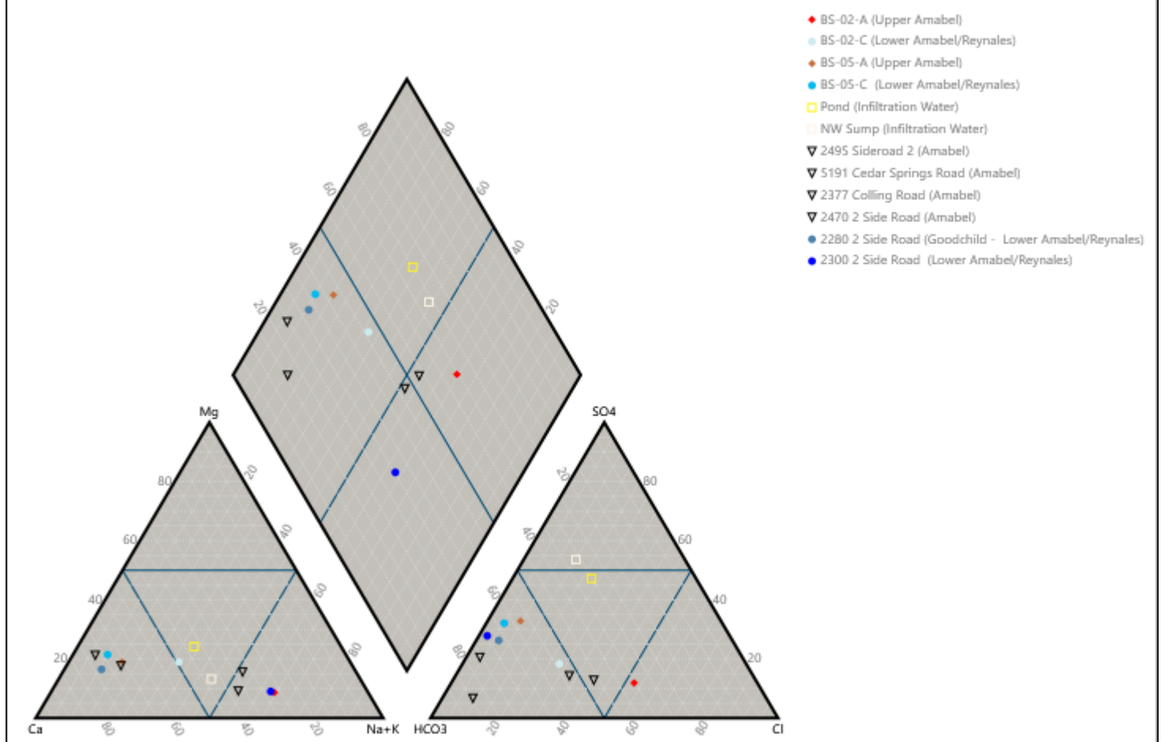
The two quarry sumps are required to be sampled both monthly and quarterly. Details are provided below.

<table><tr><th>Monthly Monitoring Parameters</th><th>Quarterly Monitoring Parameters</th></tr><tr><td>pH (field), Temperature (field), Dissolved Oxygen (field), Conductivity (field), Total Suspended Solids, Total Dissolved Solids, Alkalinity, Hardness, Total Ammonia, calculated Unionized Ammonia, Oil and Grease</td><td>Chloride, Sulphate, Total Kjeldahl Nitrogen, Dissolved Organic Carbon, Total Phosphorus, Nitrate, Nitrite, Phenols, PAHs, Metals (Total Aluminum, Antimony, Arsenic, Barium, Boron, Cadmium, Chromium, Copper, Iron, Lead, Manganese, Mercury, Selenium, Silver and Zinc)</td></tr></table></td></tr>
<tr><td>10</td><td>A list of proposed parameters (relevant to quarry operations/dewatering) to be tested as part of the water quality monitoring (baseline and future) at on-site and private water wells should be provided in the report.</td><td>The specific details of the proposed on-site and private well sampling program are provided in the AMP (April 2020 Version 1.0)

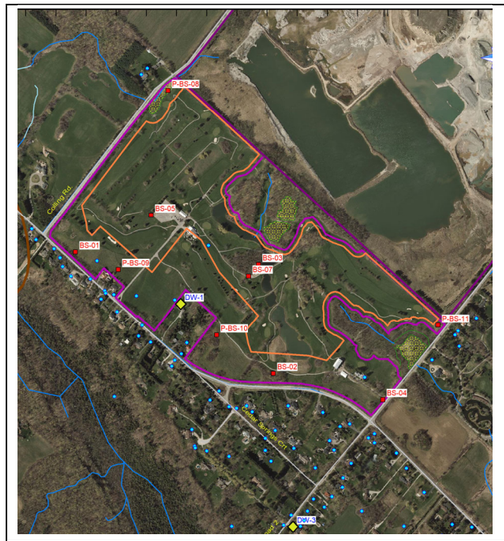
<table><tr><th>Water Quality Sampling Frequency</th><th>Parameters</th></tr><tr><td>Semi-Annual</td><td>pH, Conductivity, Alkalinity, Hardness, Bicarbonate, Total Phosphorus, Metals (Antimony, Arsenic, Barium, Beryllium, Boron, Cadmium, Calcium, Cobalt, Copper, Lead, Iron, Magnesium, Manganese, Mercury, Molybdenum, Nickel, Potassium, Selenium, Sodium, Silver, Strontium, Sulfur, Thallium, Thorium, Tin, Titanium, Tungsten, Uranium, Vanadium, Zinc),</td></tr><tr><td>Annual</td><td>Petroleum Hydrocarbons (BTEX, F1-F4)</td></tr></table></td></tr>
<tr><td>11</td><td>Discharge water quality should include the analysis for nitrate and diesel as these are the constituents of ANFO (Ammonium Nitrate and Fuel Oil) the explosive likely used on site.</td><td>As per the response provide in Item 9; Total Ammonia, calculated Unionized Ammonia and Oil and Grease are monitored monthly, while nitrate is monitored quarterly at the two off-site discharge locations.</td></tr>
<tr><td>12</td><td>A discussion of discharge water quality in relation to recharge areas, including at the proposed new infiltration pond feature in the West Extension, and potential impacts to water quality of private water wells in the area is recommended.</td><td>Details of the existing water management program are provided in Section 2.1.1 of the Surface Water Assessment Report (Tatham, 2020). Generally, the existing aggregate operation is permitted to discharge under PTTW 96-P-3009. Water may be taken from quarry sumps 0100 and 0200 at rates of 4,090 L/min and 945 L/min, respectfully. Water taken from Quarry Sump 0100 is discharged northwest to the roadside ditch along Colling Road which drains southwest to a wetland feature located in the northeast corner of the Burlington Springs Golf and Country Club. A weir structure constructed by the golf course maintains water levels in the wetland, maintains flow downstream to an unnamed tributary of Willoughby Creek and diverts flow to a series of constructed irrigation ponds on the golf course via a diversion channel.

The details outlining the influence this program has on the recharge areas is provided in the Level 1 and 2 Hydrogeological and Hydrogeological Assessment Report (Earthfx, 2020). A key simulation that was modelled was the relocation of the</td></tr>
</table>

		ponds on the golf course. The relocation of the pond (i.e., the proposed infiltration pond) is intended to function in a similar manner to the irrigation ditches and golf course ponds, to help maintain the current surface and groundwater patterns. The model results show groundwater mounding beneath the existing irrigation ponds in the West Extension. This groundwater mounding is generally maintained year-round by the diversion of quarry discharge into the irrigation ponds and raises groundwater levels in the area artificially. This is supported by the evidence provided in the Karst Investigation (Appendix B of the Earthfx Report) Dr. Worthington (Worthington Groundwater) reported a shift to higher temperatures in the groundwater at BS-07 during the aquifer testing program. This shift represents the warmer pond water entering the groundwater regime. Temperature was the only parameter that could be used as a tracer as the groundwater and pond quality are one in the same (pond water is sourced from the quarry sump). A comparison of the groundwater quality is provided in Section 15.6 of the Earthfx (2020) report. As expected, there is a strong carbonate signature owing to the host dolostone (based on the collection and analysis of 66 groundwater samples). Some variations owing to external influences (ex., road salt) have been detected in certain wells at the Western Lands (ex., BS-04 and BS-02). This external influence is far less obvious for the wells geochemically sampled on the Southern Lands. A focused Piper diagram has been prepared to illustrate the water quality signatures from the quarry sump, the irrigation pond, two groundwater monitoring wells, and three domestic water wells located immediately adjacent to the existing quarry, and the expansion lands. The results indicate that most of the groundwater samples fall within the calcium-magnesium bicarbonate type water, which is not unexpected for the Amabel Formation (dolostone $CaMg(CO_3)_2$) Road salt contamination is evident at BS-02-A. Muted road salt signatures are evident within the groundwater collected at 2470 and 2495 Sideroad 2. The water classified as the infiltration waters (water from the quarry sump and the irrigation pond) fall within the Ca-Mg-Cl portion of the Piper Diagram, indicating an intermediate (mixed) chemical character of the groundwater, with none of the cation–anion pairs being dominant in the chemical composition. The only change in the movement of quarry discharge is the relocation of the irrigation pond (quarry sump fed). This pond will move approximately 50 to 250 m westward from within the proposed extraction footprint where the irrigation pond is now, to within the buffer lands between the extraction and licensed boundary. Therefore, no negative impacts to the groundwater quality from the water management plan are anticipated. If anything, the infiltration of quarry discharge in proximity to Cedar Springs Road will help dilute road salt impacted groundwater year-round.

		Water Quality Assessment *Comparison of sump and ifiltraton waters to the Upper and Bulk Amabel to Lower Amabel and Reynales quality* 
13	Details regarding the proposed depth of the sump pump pit during dewatering of the work area should be provided, as depending upon the pump depth, the poor-quality water within the underlying shale contact (elevated sulphate and sodium) may be intercepted, requiring additional monitoring and treatment.	The depth of the sump proposed in the south extension is 2.5 m or to a floor elevation of 252.50 m, like the existing sumps constructed in the existing Burlington Quarry.
14	An assessment is recommended to evaluate whether the reduction in the water column at impacted water wells may trigger a change in water quality.	Please refer to responses provided to Items 4, 6, and 12
15	It is noted that deeper groundwater resources (Reynales Formation and the underlying contact with shale) are reported to be poorer in quality, particularly with elevated sulphate and sodium as compared to shallower formations (Amabel Formation). As such, mitigation measures should consider replacement of water supply both in terms of quantity and quality. In addition, a discussion of water quality of the lower Amabel Formation and beyond that may potentially be used as a replacement water supply for impacted wells should be presented. Water quality monitoring of wells screened in the lower formation located in potentially impacted areas near the South and West Extensions is recommended.	

<table>
<tr><th>MONITORING</th><th>MECP COMMENT</th><th>NESLON RESPONSE</th></tr>
<tr><td>16</td><td>Additional groundwater monitoring locations (sentry wells) are recommended for the area around the West Extension near Cedar Spring Road, preferably on the west side of Cedar Springs Road and to the north west.</td><td>Installing groundwater monitoring wells off Nelson owned lands will require the permission of the landowner, or the municipality. In the AMP, Nelson has recommended adding 8 wells nested in four locations within the setbacks (between the quarry face and the property boundary). This would allow for the long-term monitoring of the cone of influence and act as sentry well locations.

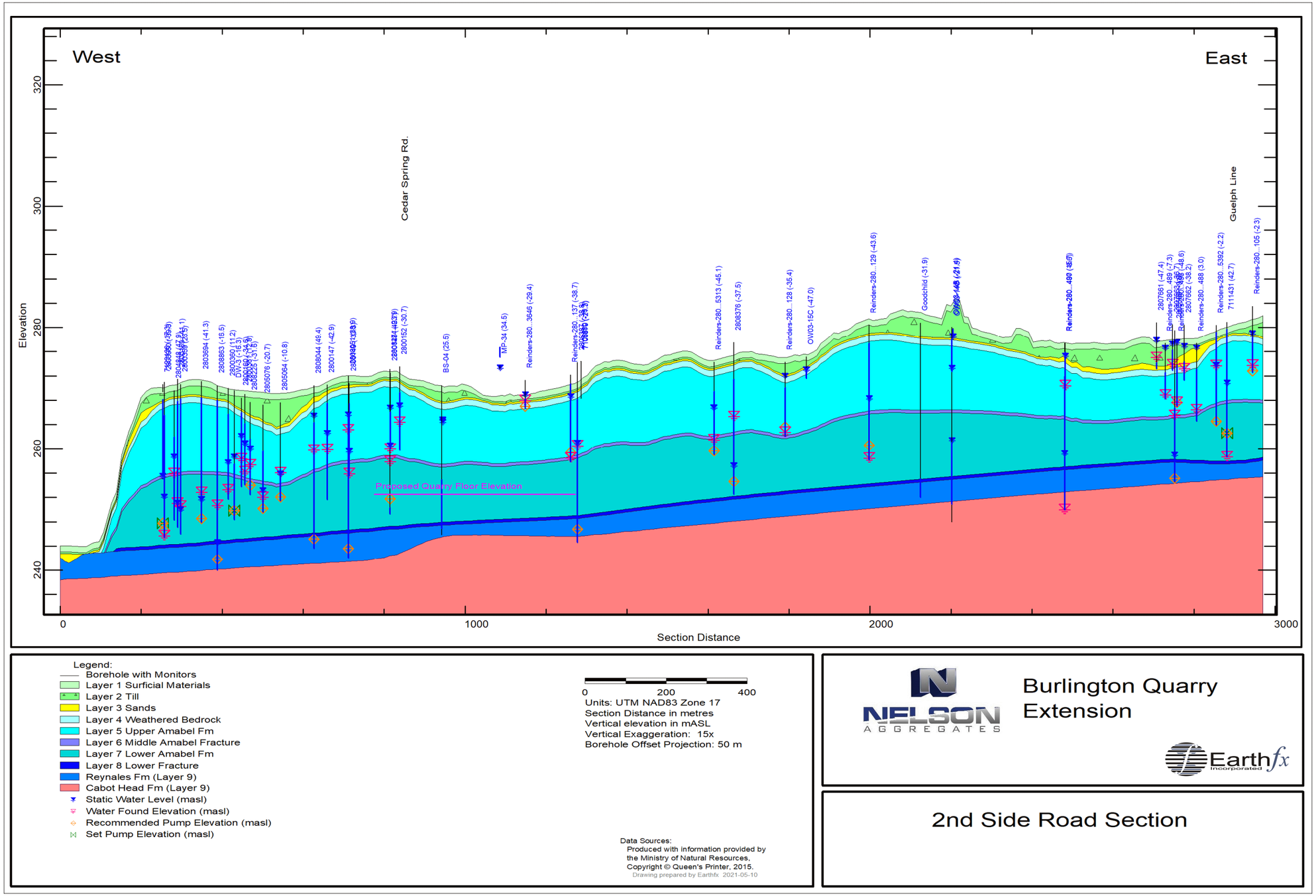
<table>
<tr><th rowspan="2">Borehole</th><th rowspan="2">Well ID</th><th colspan="2">Survey Coordinates (NAD83)</th><th rowspan="2">Well Depth (m)</th><th>Simulated Water Levels (masl)</th><th>Simulated Drawdown (m)</th><th>Available Drawdown in Aquifer (m)</th></tr>
<tr><th>Easting</th><th>Northing</th><th colspan="3">Post-Extraction (Phase 3-6) During Drought Conditions</th></tr>
<tr><td>BS-01</td><td>BS-01A</td><td>588,765</td><td>4,805,342</td><td>18.50</td><td>258.43</td><td>6.71</td><td rowspan="2">5.9</td></tr>
<tr><td></td><td>BS-01B</td><td></td><td></td><td>15.20</td><td>257.90</td><td>3.41</td></tr>
<tr><td>BS-02</td><td>BS-02A</td><td>589,421</td><td>4,805,342</td><td>23.1</td><td>262.72</td><td>10.08</td><td rowspan="2">7.7</td></tr>
<tr><td></td><td>BS-02B</td><td></td><td></td><td>18.9</td><td>263.63</td><td>6.25</td></tr>
<tr><td>BS-03</td><td>BS-03A</td><td>589,368</td><td>4,805,298</td><td>18.8</td><td>262.34</td><td>12.27</td><td rowspan="2">1.7</td></tr>
<tr><td></td><td>BS-03B</td><td></td><td></td><td>12.8</td><td>263.64</td><td>13.44</td></tr>
<tr><td>BS-04</td><td>BS-04A</td><td>589,777</td><td>4,804,855</td><td>24.5</td><td>264.07</td><td>7.61</td><td rowspan="2">11.9</td></tr>
<tr><td></td><td>BS-04B</td><td></td><td></td><td>19.9</td><td>264.90</td><td>5.91</td></tr>
<tr><td>BS-05</td><td>BS-05A</td><td>589,015</td><td>4,805,462</td><td>24.3</td><td>261.05</td><td>11.43</td><td rowspan="2">2.5</td></tr>
<tr><td></td><td>BS-05B</td><td></td><td></td><td>18.2</td><td>261.65</td><td>12.45</td></tr>
<tr><td>BH-07</td><td>BS-07</td><td>589,363</td><td>4,805,271</td><td>25.0</td><td>262.31</td><td>12.47</td><td>2.1</td></tr>
<tr><td>P-BS-08</td><td>BS-08A</td><td>589,072</td><td>4,805,879</td><td colspan="4" rowspan="6">Well to be drilled and constructed during the extraction of Phase 1</td></tr>
<tr><td></td><td>BS-08B</td><td></td><td></td></tr>
<tr><td>P-BS-09</td><td>BS-09A</td><td>588,907</td><td>4,805,284</td></tr>
<tr><td></td><td>BS-09B</td><td></td><td></td></tr>
<tr><td>P-BS-10</td><td>BS-10A</td><td>589,233</td><td>4,805,066</td></tr>
<tr><td></td><td>BS-10B</td><td></td><td></td></tr>
<tr><td>P-BS-11</td><td>BS-11A</td><td>589,968</td><td>4,805,104</td><td colspan="4" rowspan="2"></td></tr>
<tr><td></td><td>BS-11B</td><td></td><td></td></tr>
</table></td></tr>
<tr><td>17</td><td>As extraction progresses, it is recognized that decommissioning of on-site monitoring wells will be required. It is recommended that a plan to replace wells within the extraction area with sentry well locations around the Site’s perimeter in buffer areas should be prepared in advance of extraction activities.</td><td>Agreed. If any wells must be decommissioned, they will be replaced.</td></tr>
</table>

MITIGATION MEASURES	MECP COMMENT	NESLON RESPONSE
18	An updated Adaptive Management Plan will be subject to review as part of any future PTTW application. Additional monitoring/mitigation requirements may be included as a condition of a future PTTW.	The AMP is a dynamic document and will be updated to reflect comments received during the ARA application process. It is understood that amendments may be required to satisfy the MECP as part of any future PTTW approvals
19	It is recommended that Nelson evaluate and consider mitigative measures, such as limiting quarry floor depth at certain extraction phase locations (adjacent to areas with considerable impact potential) and evaluate additional mitigation options for prolonged drought condition periods.	For the southern quarry expansion, the proposed extraction floor elevations are set at three difference elevations. The purpose of this extraction plan is to provide a beach area under rehabilitation conditions. In the Western Expansion area, the quarry floor will remain at 252 masl. However, as shown on the appended cross-sections, the base of the Amabel Formation drops to the west from an approximate elevation of 252.5 masl below the existing quarry floor to approximately 248 masl. Nelson is leaving this material in place (aka limiting quarry depth by leaving ~4.5 m of Amabel beneath the proposed quarry floor). This provides an added layer of protection to the lower aquifer system.
20	It is recommended that a private well survey be completed around the site. The survey should clearly communicate to residents the potential for impacts to their water supply and the complaints procedure, and provide well owners with clear information on potential mitigation options that will	Agreed. As discussed in Appendix A; Section 15.7 of the Earthfx Report, A preliminary private door-to-door water well survey was completed by Nelson personnel and a Professional Geoscientist on July 29th and July 30th, 2019. The survey was completed

	be implemented to restore water supply, including cistern option. The ministry does not recommend the long-term use of cisterns as a mitigation measure for water quantity interference and expects the restoration of a water supply to those affected.	all residents located within 1 km of the proposed expansion lands, including those located on both the north and south sides of Sideroad No. 1. In total, 156 homes were visited. The purpose of the water well survey was to collect baseline information on the local water use (quality and quantity) to ensure the sustained quality and quantity of the water supply and to discuss the proposed expansion. If residents were not home, an information package was left at their front door. The package included an informative flier on the proposed application, details about the well monitoring program, and Nelson's contact information. 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. Furthermore, it was discussed in Section 9.3 of the main report that a follow-up door-to-door water well survey will be completed to attempt to expand the Private Well Monitoring Program. This program will be offered to residents within 1 km of the extension lands by a qualified well technician (as is required by law [Ontario Regulation 903, as amended]). This program will be designed to establish baseline conditions of existing domestic water wells. Domestic water wells need to be determined case-by-case as the physical characteristics of each well will need to be evaluated and documented to provide an understanding of the current conditions, including water quality, well yield and the available drawdown.
21	Further, there should be a discussion on the potential mitigation options in the event the lower fractured Amabel unit is not present at impacted domestic water well site. Well deepening in that case might intersect Reynales Formation and/or a lower shale interface. It is known that around the Nelson quarry site there is a definite deterioration of water quality and quantity in the underlying Reynales Formation and at the shale contact below.	Please refer to responses provided to Items 4, 6, and 12

SURFACE WATER	MECP COMMENT	NESLON RESPONSE
1	Water quality samples have not been analyzed for chloride, sulphate, total Kjeldahl nitrogen, nitrite and nitrate. These parameters must be analyzed in surface water and groundwater quality samples.	As per the response provided for Item 9, the ECA for the site requires the quarry discharge to be analyzed for chloride, total Kjeldahl nitrogen, nitrite and nitrate. The ECA does not require Sulphate, but as part of laboratory package, sulphate is included in the quarterly analyses. **Monthly Monitoring Parameters**: pH (field), Temperature (field), Dissolved Oxygen (field), Conductivity (field), Total Suspended Solids, Total Dissolved Solids, Alkalinity, Hardness, Total Ammonia, calculated Unionized Ammonia, Oil and Grease **Quarterly Monitoring Parameters**: **Chloride**, Sulphate, **Total Kjeldahl Nitrogen**, Dissolved Organic Carbon, Total Phosphorus, **Nitrate, Nitrite**, Phenols, PAHs, Metals (Total Aluminum, Antimony, Arsenic, Barium, Boron, Cadmium, Chromium, Copper, Iron, Lead, Manganese, Mercury, Selenium, Silver and Zinc)
2	During surface water sampling no dissolved oxygen readings have been taken. Dissolved oxygen should be included in the monitoring program.	Field and laboratory analysis of dissolved oxygen are collected under the ECA
3	It is noted that the current and proposed stream flow and surface water quality monitoring networks are rather excessive. Some distant monitoring stations can be removed from the monitoring program.	Noted. The final surface water monitoring program will be determined based on the technical review comments from the review and commenting agencies.
4	In general, the modelled wetland water balances have shown good results for 2016, 2017 and 2018, but not so good results for 2015 and 2019, which leaves us with a reasonable doubt concerning the long-term predictive reliability of the model.	The wetland water balances will be updated during the ARA licence application process as additional baseline monitoring data is collected. The model will be refined to improve calibration so the water balances can be used reliably as long-term predictive models. It is also noted, the baseline surface water monitoring data calibration will be refined as additional baseline monitoring data is collected moving forward.

5	It is recommended to run the integrated surface water groundwater model for the surface water monitoring locations SW10 and SW29 to predict possible impacts on stream flow.	Please refer to Schedule A (Water Course Characterization Table).
6	Additional information/discussion regarding anticipated changes in surface water inflow/outflow to wetlands 13037 and 13203 is required.	Wetland 13037 – the drainage area contributing surface water runoff to Wetland 13037 will not be altered because of extraction; the drainage catchment has been respected and maintained in the development of the expansion plans. Seasonally (primarily in the spring), groundwater discharges into Wetland 13037 account for approximately 1.8% of the total inflow into the wetland. The integrated model results predict that the groundwater discharge will cease during extraction in the south extension. However, the overall reduction in inflow to Wetland 13037 will be 1.8%. Refer to Schedule B (Wetland Characterization Summaries) for additional details regarding the potential change to surface water inflow/outflow from Wetland 13037. Wetland 13203 – The primary source of water in the West Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek is the quarry discharge from Sump 0200. Wetland 13203 is located online along the West Arm downstream of the quarry discharge from Sump 0200 between No. 2 Sideroad and monitoring location SW6. Without quarry discharge, the West Arm runs dry as illustrated in the monitoring data provided in the Surface Water Assessment (Tatham, April 2020). As proposed, the quarry discharge is to continue long-term consistent with the historic discharge at this location and the terms and conditions of the quarries existing ECA and PTTW. During extraction in the South Extension, the catchment area to the upstream reach of the West Arm will be reduced. However, the monitoring data collected to date illustrates that little surface runoff enters the West Arm and the quarry discharge is the primary source of flow. During extraction, an additional discharge from the South Extension will be added to the West Arm. The discharge rates from the South Extension are still to be refined and they will be established recognizing the historic flows measured in the West Arm, natural heritage requirements, the capacity of the West Arm and the existing discharge from Sump 0200. Refer to the Wetland Characterization Summaries enclosed for additional details regarding the potential change to surface water inflow/outflow from Wetland 13203.
7	The proposed minimum baseflow, water temperature and wetland hydroperiod thresholds must be revised to provide a higher degree of protection for the local surface water features.	The minimum baseflow, water temperature and wetland hydroperiod thresholds will be refined during the ARA licence application process as additional monitoring data is collected and in consideration of the requirements of the various review agencies.
8	The report does not discuss possible impacts on water quality in the local watercourses because of the increased dewatering discharge from the proposed extraction areas of the quarry. Further discussion of this is recommended.	Dewatering from the NW (0100 Sump) and the SC (0200 Sump) has been on-going for over 50 years. The discharge from the quarry is the primary source of flow to the Unnamed Tributary of Willoughby Creek and the West Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek. The discharge of water to the two off-site watercourses will continue moving forward in accordance with the terms and conditions of the existing quarries PTTW and ECA, including water quality sampling. An additional discharge to the West Arm is required as part of the South Extension. An amendment to the existing PTTW and ECA is required in support of this discharge and it's recommended the same water quality terms and conditions applied in the current PTTW and ECA be applied to the amended PTTW and ECA. The results of the water quality sampling completed to remain in compliance with the quarries ECA are enclosed for reference.
9	No current discharge water quality data are provided. Discharge water quality data should be included and discussed in the report.	
10	In addition to the water quality thresholds to be set for SW2 and SW10, it is recommended to set the similar threshold for SW29. Future water quality thresholds must not exceed the Provincial Water Quality Objectives, Canadian Water Quality Guidelines or background concentrations.	Water from Quarry Sump 0100 will be discharged into Wetland 13201 as required to maintain the wetland hydroperiod during and post extraction. However, there is no direct connection of Wetland 13201 to the Unnamed Tributary of Lake Medad, or a direct discharge from the quarry into the Unnamed Tributary. As such, a water quality threshold was not deemed necessary at monitoring location SW29. However, if deemed necessary during the ARA Licence application process, the AMP will be updated to include a water quality threshold for SW29.



Legend:
- Borehole with Monitors
- Layer 1 Surficial Materials
- Layer 2 Till
- Layer 3 Sands
- Layer 4 Weathered Bedrock
- Layer 5 Upper Amabel Fm
- Layer 6 Middle Amabel Fracture
- Layer 7 Lower Amabel Fm
- Layer 8 Lower Fracture
- Reynales Fm (Layer 9)
- Cabot Head Fm (Layer 9)
- Static Water Level (masl)
- Water Found Elevation (masl)
- Recommended Pump Elevation (masl)
- Set Pump Elevation (masl)

0 200 400

Units: UTM NAD83 Zone 17
Section Distance in metres
Vertical elevation in mASL
Vertical Exaggeration: 15x
Borehole Offset Projection: 50 m

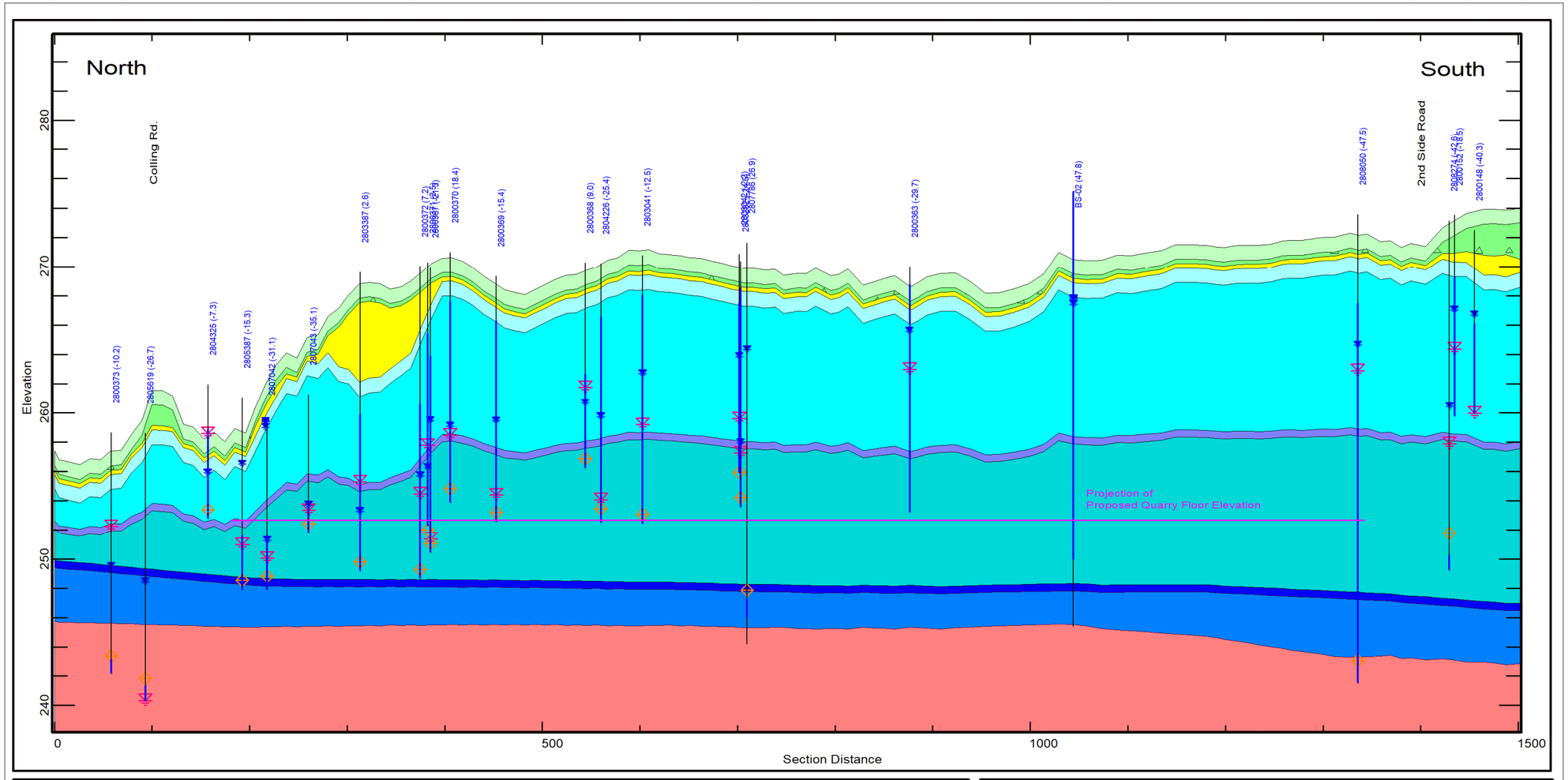
Data Sources:
Produced with information provided by the Ministry of Natural Resources, Copyright © Queen's Printer, 2015.
Drawing prepared by Earthfx 2021-05-10

NELSON AGGREGATES

Burlington Quarry Extension

Earthfx Incorporated

2nd Side Road Section



Legend:
- Borehole with Monitors
- Layer 1 Surficial Materials
- Layer 2 Till
- Layer 3 Sands
- Layer 4 Weathered Bedrock
- Layer 5 Upper Amabel Fm
- Layer 6 Middle Amabel Fracture
- Layer 7 Lower Amabel Fm
- Layer 8 Lower Fracture
- Layer 9 Lower Aquitards
- Reynales Fm (Layer 9)
- Cabot Head Fm (Layer 9)
- Static Water Level (masl)
- Water Found Elevation (masl)
- Recommended Pump Elevation (masl)
- Set Pump Elevation (masl)

0 100 200

Units: UTM NAD83 Zone 17
Section Distance in metres
Vertical elevation in mASL
Vertical Exaggeration: 15x
Borehole Offset Projection: 50 m

Data Sources:
Produced with information provided by the Ministry of Natural Resources, Copyright © Queen's Printer, 2015.
Drawing prepared by Earthfx 2021-05-10

NELSON AGGREGATES

Burlington Quarry Extension

Earthfx Incorporated

Cedar Spring Road Section

Watercourse Characterization Summaries Proposed Burlington Quarry Extension, Nelson Aggregates Co.

Prepared for:



April 2021
Version 1.0

April 2021

Nelson Aggregate Co.
2433 No. 2 Sideroad
Burlington, Ontario
L7P 0G8

Attention: Mr. Quinn Moyer, President

RE: Burlington Quarry Watercourse Characterization Summaries

Dear Mr. Moyer,

Earthfx Incorporated, Savanta Inc. and Tatham Engineering Limited are pleased to provide Nelson Aggregates Co. with the enclosed watercourse characterization summaries in support of the Proposed Burlington Quarry Extension. The watercourse characterization summaries have been prepared in response to comments received by the Ministry of Natural Resources and Forestry.

The watercourse characterization summaries have been prepared to summarize the watercourse information provided in the Level 1 and Level 2 Hydrogeological Impact Assessment, Level 1 and Level 2 Natural Environment Technical Report, and Surface Water Assessment. The hope is the watercourse characterization summaries will aid in the review of the reports and expedite the review process.

Regards,

Dirk Kassenaar, M.Sc., P.Eng.
President, Eartfx Incorporated

Shannon Catton, MSc.
Branch Manager & Senior Ecologist, Savanta Inc.

Daniel Twigger, B.Sc.Eng., P.Eng.
Senior Engineer, Group Leader, Tatham Engineering Limited

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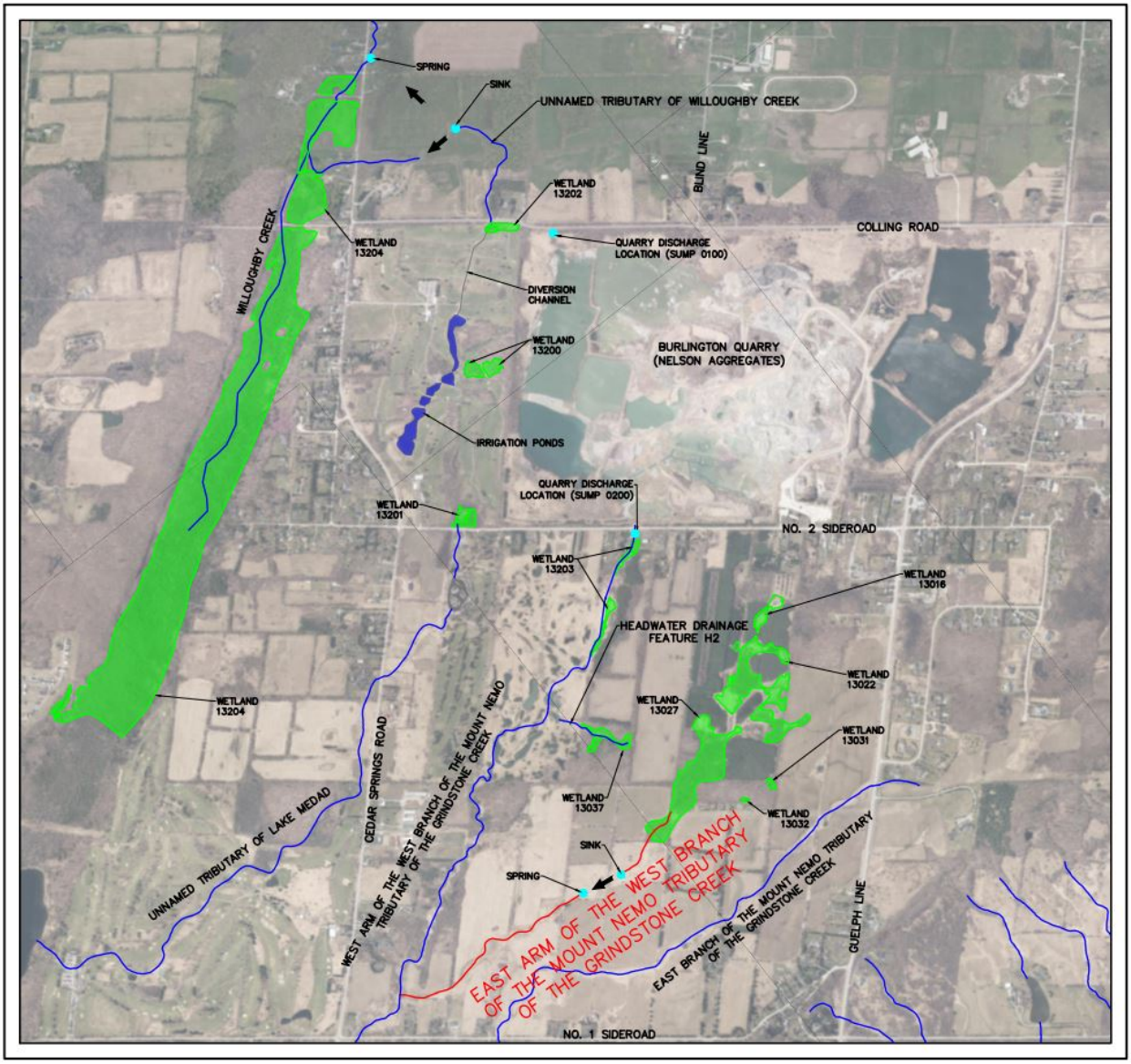
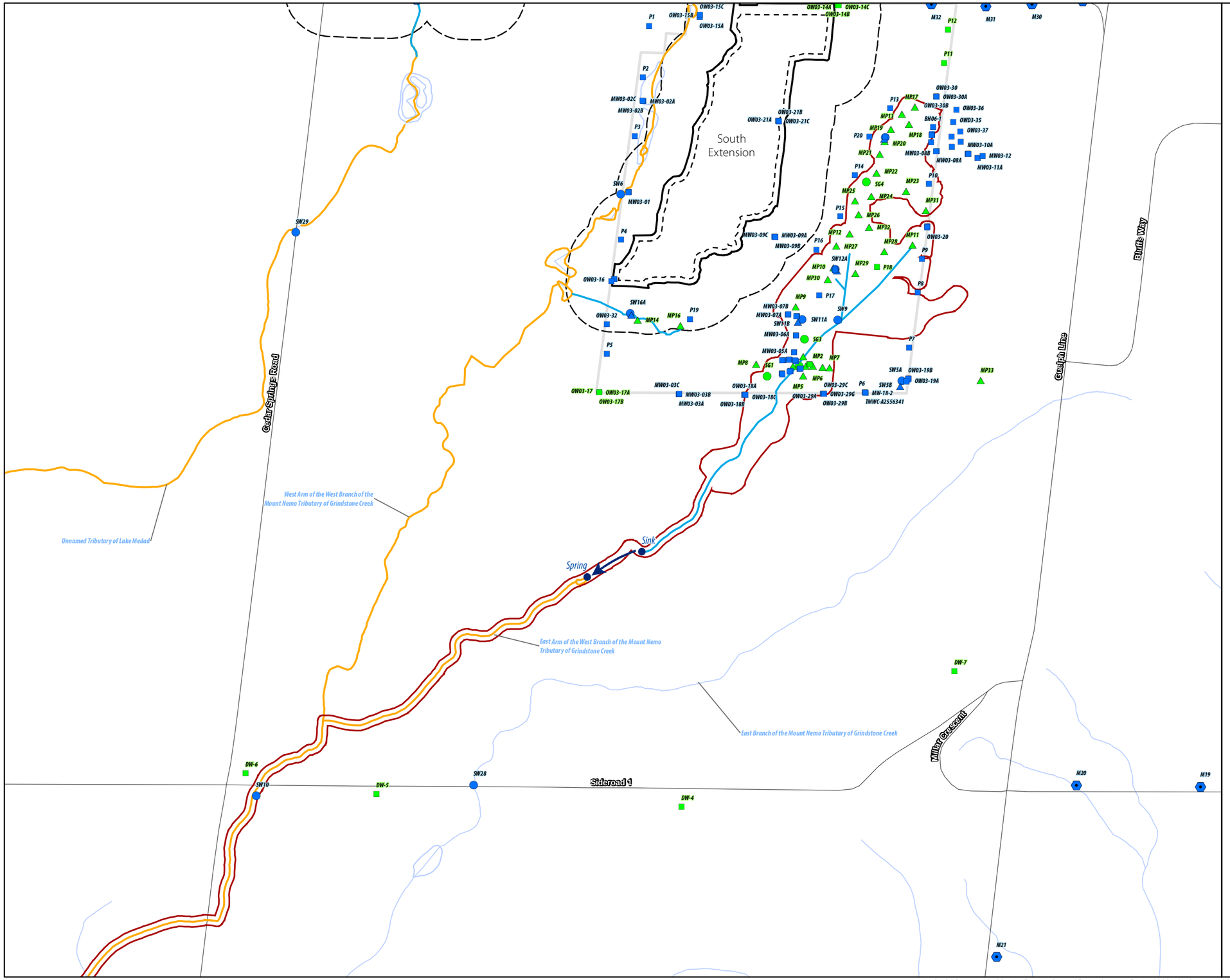
WILLOUGHBY CREEK....97

EAST ARM OF THE WEST BRANCH





Legend

- Licensed Boundary
- Limit of Extraction
- 120 m Adjacent Lands
- Subject Lands
- East Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek
- Road
- Indirect Fish Habitat
- Direct Fish Habitat
- Watercourse
- Waterbody
- Wetland (Savanta, 2020)

Current Instrumentation

- Groundwater Monitoring Station (EarthFx)
- Mini Piezometer (Tatham Engineering)
- Staff Gauge & Surface Water Monitoring Station (Tatham Engineering)
- Manual Stream Flow Measurement (Tatham Engineering)

Previous Instrumentation

- Groundwater Monitoring Station (Golder)
- Mini Piezometer (Golder)
- Staff Gauge & Surface Water Monitoring Station (Golder)

NOTES:

1. Coordinate System: NAD 1983 UTM Zone 17N.
2. Base features produced under license with the Ontario Ministry of Natural Resources and Forestry © Queen's Printer for Ontario, 2021.
3. Orthoimagery © First Base Solutions, 2021. Imagery taken in 2019.

Project 8133

Burlington Quarry Extension
Nelson Aggregates Co.

Figure 16
Watercourse Characterization

East Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek

0 180 m

1:10,000

N

[redacted]

Path: C:\Savanta\8133 - Burlington Quarry\figures\report_figures\2021 01 21 natural feature tech summary\8133_rpt_watercourse_char_mapbook.mxd Da

April 8, 2021

East Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek

Surface Water Characteristics	Description	Figure / Graph / Table	Reference	
			Report	Section / Page
Watercourse Name:	East Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek			
Watershed:	Grindstone Creek			
Sub-Watershed:	Mount Nemo Tributary of Grindstone Creek			
Located in Proposed Limit of Extraction:	No			
Located in Proposed License Boundary:	No			
Catchment Area (ha):	85 ha (at confluence with West Arm)			
Catchment ID:	N/A			
Primary Source(s) of Flow:	Surface runoff			
Discharge from Quarry / PTTW:	No			
Conditions of PTTW:	Not Applicable			
Surface Water Monitoring:	ID: SW9 (Tatham) Installation Date: October 2, 2014 Data Collection: Continuous water level and temperature, manual monthly in-situ streamflow measurements and calibration data (water level converted to flow using rating curve) Coordinates of Monitoring Station: Easting 591235.384, Northing 4805317.071	Graphs 1 & 2	SWA (Tatham, April 2020)	2.1.2 and Appendix C
Streamflow Conditions:	Intermittent	Graphs 1 & 2	SWA (Tatham, April 2020)	2.1.2 and Appendix C
Average Daily Flow (SW9):	Average Daily Streamflow (L/s)	Graph 1	SWA (Tatham, April 2020)	2.1.2 and Appendix C

Month	Minimum	Average	Maximum
January	N/A	N/A	N/A
February	N/A	N/A	N/A
March	1.2	9.1	62.1
April	0.0	2.6	27.1
May	0.0	1.2	13.2
June	0.0	0.3	5.1
July	0.0	0.0	1.2
August	0.0	0.0	0.0
September	0.0	0.0	0.0
October	0.0	0.0	0.0
November	0.0	0.5	36.3
December	0.0	0.2	9.7

Notes:

Minimum - lowest daily average streamflow recorded for period of record

Average - average daily streamflow recorded for period of record

Maximum - maximum daily average streamflow recorded for period of record

N/A - data not available as device removed from watercourse during winter months

East Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek

Surface Water Characteristics	Description					Figure / Graph / Table	Reference	
							Report	Section / Page
Watercourse Thermal Regime (SW9):	Average Daily Water Temperature (°C)				Notes:	Graph 2	SWA (Tatham, April 2020)	2.1.2 and Appendix C
	Month	Minimum	Average	Maximum	Minimum - lowest daily average streamflow recorded for period of record Average - average daily streamflow recorded for period of record Maximum - maximum daily average streamflow recorded for period of record N/A - data not available as device removed from watercourse during winter months			
	January	N/A	N/A	N/A				
	February	N/A	N/A	N/A				
	March	1.0	2.6	6.5				
	April	1.5	8.0	15.9				
	May	6.9	12.2	19.1				
	June	11.5	15.6	19.6				
	July	16.8	17.1	17.7				
	August	Dry	Dry	Dry				
	September	Dry	Dry	Dry				
	October	Dry	Dry	Dry				
	November	2.4	4.5	10.1				
	December	3.5	4.6	5.9				

Fish & Fish Habitat Features	Description	Figure / Graph / Table	Reference	
			Report	Section / Page
Fish Habitat (Direct/Indirect and Assumed/Confirmed):	1) The upstream reaches of the East Arm (from the headwaters to approximately 540 m downstream from the Subject Lands) are considered to be indirect fish habitat. These headwater areas are ephemeral to intermittent and have been observed to dry up completely in summer. Approximately 540 m downstream of the Subject Lands, the watercourse enters a karst sink, where it flows underground for approximately 162 m before discharging to a surface pond. No fish movement is expected to be possible through the 162 m long underground flow path, therefore, given that the upstream area is intermittent and dries out completely, and there is no upstream fish movement, fish are not present in the upper reaches. This upstream reach provides indirect contributing habitat functions to support the downstream fish community. 2) The remainder of the watercourse downstream from the karst outflow provides direct fish habitat. Fish have been previously captured by MNRF at the online pond at karst discharge and are assumed to be present through the watercourse downstream.		NETR (Savanta, April 2020)	44 - 45 and Figure 9b
Fish Species Present:	Stantec (2010) previously reported that in 2006, MNRF captured several different age classes of Fathead Minnow, Bluntnose Minnow, Brook Stickleback and Green Sunfish in the pond at the karst discharge point.		NETR (Savanta, April 2020)	44 - 45 and Figure 9b
Fish Community Thermal Regime:	Warm/Cool (based on fish species present)		NETR (Savanta, April 2020)	44 - 45 and Figure 9b
Fish Habitat Types Present:	1) The headwater wetlands, swales and drainage ditches on the Subject Lands provide indirect habitat that supports the downstream direct fish community. Habitat functions of these areas include flow conveyance and regulation, water quality maintenance and organic allochthonous inputs and potentially seasonal benthic drift. 2) No investigations were completed in the downstream (off-site reaches) providing direct fish habitat.		NETR (Savanta, April 2020)	44 - 45 and Figure 9b
Habitat Uses by Known Fish Community:	The local fish community likely uses the off-site habitat for the complete range of life history processes including spawning, nursery, foraging and overwintering.		NETR (Savanta, April 2020)	44 - 45 and Figure 9b
Known Barriers to Fish Movement:	The karst inlet and associated 162 m long underground reach are assumed to provide a barrier to upstream fish movement.		NETR (Savanta, April 2020)	44 - 45 and Figure 9b

East Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek

<table>
<tr><th rowspan="2">Groundwater Interaction</th><th rowspan="2">Description</th><th rowspan="2">Figure / Graph / Table</th><th colspan="2">Reference</th></tr>
<tr><th>Report</th><th>Section / Page</th></tr>
<tr><td>Underlying Deposits:</td><td>Halton Till. The harmonic mean hydraulic conductivity, based on testing by Golder (2007) of 10 mini-piezometers, was $1.2x10^{-8}$ m/s. Model value for the vertical hydraulic conductivity was $1.6x10^{-7}$ m/s, about an order of magnitude higher, to account for limited flow through fractures in the till.</td><td></td><td></td><td></td></tr>
<tr><td>Surface Water / Groundwater Interactions:</td><td>Seasonal groundwater contributions to watercourse. Groundwater seepage under baseline conditions during spring months equates to 0.1 L/s or less. Groundwater seepage is at its maximum during and immediately following the spring freshet.</td><td>Figures 1 & 2</td><td></td><td></td></tr>
<tr><td>Water Budget Results (SW9):</td><td>The baseline condition water budget results from the integrated model at monitoring location SW9 are presented in Figure 3a.
<table><tr><td>Condition</td><td>GW Out</td><td>GW In</td></tr><tr><td>Baseline (Existing)</td><td>23.13%</td><td>0.15%</td></tr></table></td><td>Figure 3a</td><td></td><td></td></tr>
<tr><td>Water Budget Results (600m Downstream of SW9):</td><td>The baseline condition water budget results from the integrated model 600 m downstream of monitoring location SW9 are presented in Figure 4a.
<table><tr><td>Condition</td><td>GW Out</td><td>GW In</td></tr><tr><td>Baseline (Existing)</td><td>22.18%</td><td>0.75%</td></tr></table></td><td>Figure 4a</td><td></td><td></td></tr>
<tr><td>Integrated Model Calibration:</td><td>SW9 monitors the flow through the wetland complex immediately to the east of the South extension. Simulated and observed streamflow at SW9 are presented in Earthfx (p. 414) for WY2017 to WY2019. Flow in the stream is intermittent and both the observed and simulated results are very flashy. The observed data also contain gaps. The match to the newly collected 2019 data is excellent (Earthfx, p.4141).</td><td>Graphs 3 & 4</td><td>HHIAR (Earthfx, April 2020)</td><td>411 - 414</td></tr>
</table>

East Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek

<table>
<tr><th rowspan="2">Impact Assessment</th><th rowspan="2">Description</th><th rowspan="2">Figure / Graph / Table</th><th colspan="2">Reference</th></tr>
<tr><th>Report</th><th>Section / Page</th></tr>
<tr><td>Direct Alterations to Watercourse:</td><td>No direct alterations to this watercourse are proposed.</td><td></td><td>NETR (Savanta, April 2020)</td><td>75</td></tr>
<tr><td>Change in Primary Source of Flow:</td><td>Modeling predicted less than a 1% reduction in groundwater discharge to the existing headwater wetlands on the Subject Lands. This was predicted to result in an approximate reduction in surface water runoff volume to the watercourse of less than 1%.</td><td></td><td></td><td></td></tr>
<tr><td>Change in Watercourse Catchment Area:</td><td>Catchment area to remain undisturbed, no change in catchment area.</td><td></td><td></td><td></td></tr>
<tr><td>Simulated Streamflow Change (Integrated Model Results):</td><td>The Earthfx report discusses changes in simulated streamflow under the different quarry expansion phases. The figure appended (GRaph 5) reproduces Figure 8.6 (p. 201) and presents simulated baseline(red) and Scenario P12 (blue) flows at location SW9. Decrease in flow (green) are plotted in reverse on the upper X axis with the scale shown on the right Y axis. Very small decreases in streamflow, primarily in winter and spring, are predicted Phase 12 area. A similar figure (Graph 6) is reproduced for Phase 3456 (Figure 8.44, p. 235) although the upper X axis shows the decrease in streamflow (with positive values indicating an decrease in flow relative to baseline). Spring flows are generally lower in the winter and spring but higher in the summer and fall periods.</td><td>Graphs 5, 6 & 7</td><td>HHIAR (Earthfx, April 2020)</td><td>198 - 203 and 230 - 237</td></tr>
<tr><td colspan="5">Water Budget Results at Monitoring Location SW9</td></tr>
<tr><td>Water Budget Results (Operational Phases 1 & 2):</td><td>The Operational Phases 1 and 2 water budget results from the integrated model at monitoring location SW9 are presented in Figure 3b.
<table>
<tr><td>Condition</td><td>GW Outflow</td><td>GW Inflow</td><td>%Δ GW Outflow</td><td>%Δ GW Inflow</td></tr>
<tr><td>Baseline (Existing)</td><td>23.13%</td><td>0.15%</td><td>-</td><td>-</td></tr>
<tr><td>Phases 1 & 2</td><td>22.51%</td><td>0.00%</td><td>-0.62%</td><td>-0.15%</td></tr>
</table></td><td>Figure 3b</td><td></td><td></td></tr>
<tr><td>Water Budget Results (Operational Phases 3 Through 6):</td><td>The Operational Phases 3 through 6 water budget results from the integrated model at monitoring location SW9 are presented in Figure 3c.
<table>
<tr><td>Condition</td><td>GW Outflow</td><td>GW Inflow</td><td>%Δ GW Outflow</td><td>%Δ GW Inflow</td></tr>
<tr><td>Baseline (Existing)</td><td>23.13%</td><td>0.15%</td><td>-</td><td>-</td></tr>
<tr><td>Phases 3 through 6</td><td>23.27%</td><td>0.10%</td><td>0.14%</td><td>-0.05%</td></tr>
</table></td><td>Figure 3c</td><td></td><td></td></tr>
<tr><td>Water Budget Results (Rehabilitation Scenario 1):</td><td>The Rehabilitation Scenario 1 water budget results from the integrated model at monitoring location SW9 are presented in Figure 3d.
<table>
<tr><td>Condition</td><td>GW Outflow</td><td>GW Inflow</td><td>%Δ GW Outflow</td><td>%Δ GW Inflow</td></tr>
<tr><td>Baseline (Existing)</td><td>23.13%</td><td>0.15%</td><td>-</td><td>-</td></tr>
<tr><td>Rehab Scenario 1</td><td>22.39%</td><td>0.12%</td><td>-0.74%</td><td>-0.03%</td></tr>
</table></td><td>Figure 3d</td><td></td><td></td></tr>
<tr><td>Water Budget Results (Rehabilitation Scenario 2):</td><td>The Rehabilitation Scenario 2 water budget results from the integrated model at monitoring location SW9 are presented in Figure 3d.
<table>
<tr><td>Condition</td><td>GW Outflow</td><td>GW Inflow</td><td>%Δ GW Outflow</td><td>%Δ GW Inflow</td></tr>
<tr><td>Baseline (Existing)</td><td>23.13%</td><td>0.15%</td><td>-</td><td>-</td></tr>
<tr><td>Rehab Scenario 2</td><td>23.81%</td><td>0.28%</td><td>0.68%</td><td>0.13%</td></tr>
</table></td><td>Figure 3e</td><td></td><td></td></tr>
</table>

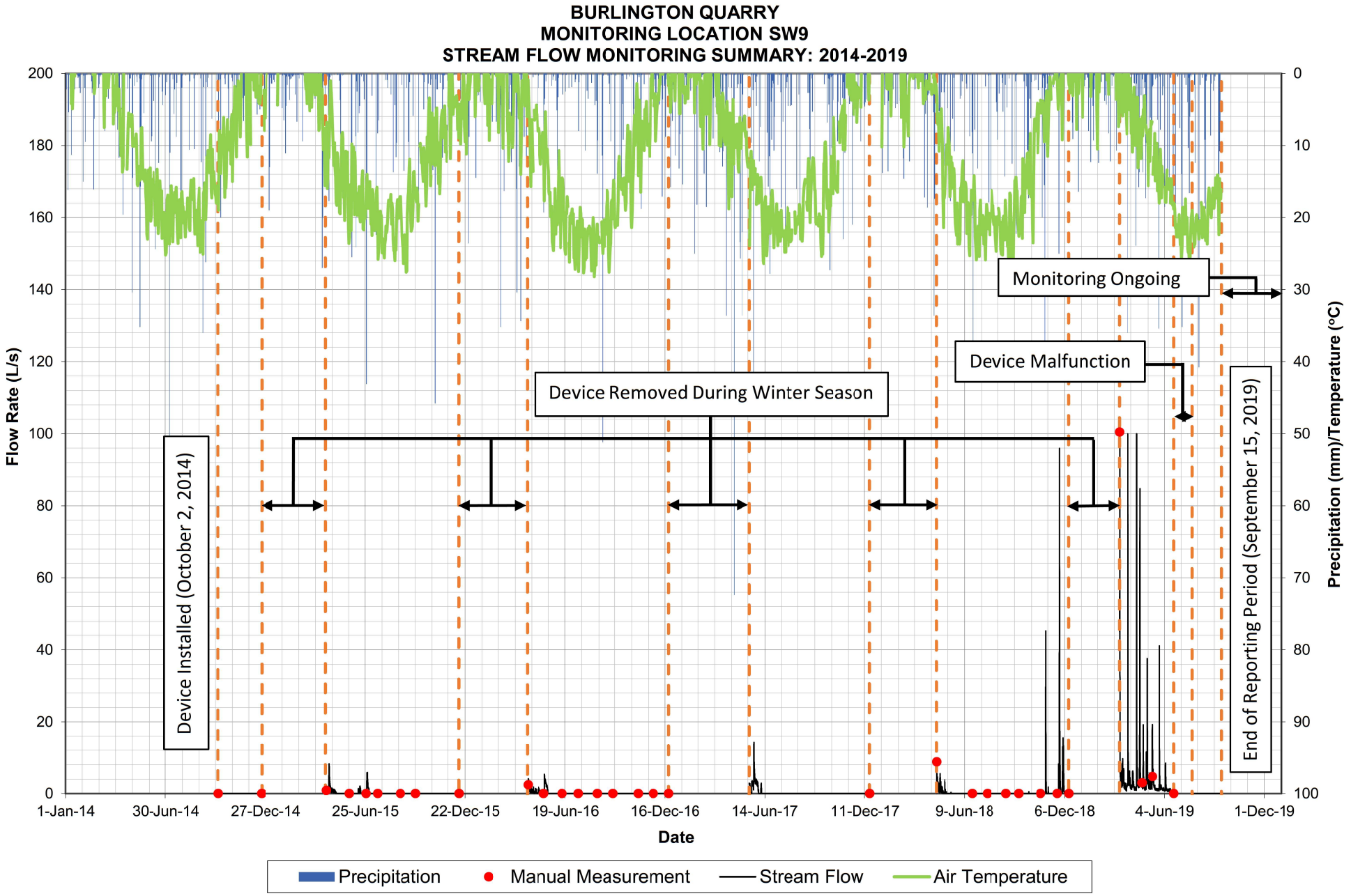
East Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek

<table>
<tr><th>Impact Assessment</th><th>Description</th><th>Figure / Graph / Table</th><th colspan="2">Reference</th></tr>
<tr><th></th><th></th><th></th><th>Report</th><th>Section / Page</th></tr>
<tr><td colspan="5">Water Budget Results 600 m Downstream of Monitoring Location SW9</td></tr>
<tr><td>Water Budget Results (Operational Phases 1 & 2):</td><td>The Operational Phases 1 and 2 water budget results from the integrated model 600 m downstream of monitoring location SW9 are presented in Figure 4b.
<table>
<tr><td>Condition</td><td>GW Outflow</td><td>GW Inflow</td><td>%Δ GW Outflow</td><td>%Δ GW Inflow</td></tr>
<tr><td>Baseline (Existing)</td><td>22.18%</td><td>0.75%</td><td>-</td><td>-</td></tr>
<tr><td>Phases 1 & 2</td><td>22.32%</td><td>0.00%</td><td>0.14%</td><td>-0.75%</td></tr>
</table></td><td>Figure 4b</td><td></td><td></td></tr>
<tr><td>Water Budget Results (Operational Phases 3 Through 6):</td><td>The Operational Phases 3 through 6 water budget results from the integrated model 600 m downstream of monitoring location SW9 are presented in Figure 4c.
<table>
<tr><td>Condition</td><td>GW Outflow</td><td>GW Inflow</td><td>%Δ GW Outflow</td><td>%Δ GW Inflow</td></tr>
<tr><td>Baseline (Existing)</td><td>22.18%</td><td>0.75%</td><td>-</td><td>-</td></tr>
<tr><td>Phases 3 through 6</td><td>22.67%</td><td>0.43%</td><td>0.49%</td><td>-0.32%</td></tr>
</table></td><td>Figure 4c</td><td></td><td></td></tr>
<tr><td>Water Budget Results (Rehabilitation Scenario 1):</td><td>The Rehabilitation Scenario 1 water budget results from the integrated model 600 m downstream of monitoring location SW9 are presented in Figure 4d.
<table>
<tr><td>Condition</td><td>GW Outflow</td><td>GW Inflow</td><td>%Δ GW Outflow</td><td>%Δ GW Inflow</td></tr>
<tr><td>Baseline (Existing)</td><td>22.18%</td><td>0.75%</td><td>-</td><td>-</td></tr>
<tr><td>Rehab Scenario 1</td><td>21.68%</td><td>0.52%</td><td>0.50%</td><td>-0.23%</td></tr>
</table></td><td>Figure 4d</td><td></td><td></td></tr>
<tr><td>Water Budget Results (Rehabilitation Scenario 2):</td><td>The Rehabilitation Scenario 2 water budget results from the integrated model 600 m downstream of monitoring location SW9 are presented in Figure 4e.
<table>
<tr><td>Condition</td><td>GW Outflow</td><td>GW Inflow</td><td>%Δ GW Outflow</td><td>%Δ GW Inflow</td></tr>
<tr><td>Baseline (Existing)</td><td>22.18%</td><td>0.75%</td><td>-</td><td>-</td></tr>
<tr><td>Rehab Scenario 2</td><td>23.16%</td><td>0.61%</td><td>0.98%</td><td>-0.14%</td></tr>
</table></td><td>Figure 4e</td><td></td><td></td></tr>
<tr><td>Change in Groundwater Contributions to Watercourse:</td><td>The Baseline groundwater seepage to the watercourse catchment (to SW9) is shown in Graph 8. Under P12 conditions this seepage is lost. The change in stream leakage between Baseline and P12 conditions is shown in Graph 9. There are short periods of time when leakage under Baseline conditions (blue line) is slightly higher than P12 conditions.</td><td>Graphs 8 and 9</td><td></td><td></td></tr>
<tr><td>Change in Watercourse Thermal Regime:</td><td>Negative changes on water temperature are not expected given that the wetlands and catchment area feeding the East Arm will remain undisturbed.</td><td></td><td></td><td></td></tr>
<tr><td>Change in Water Quality:</td><td>Negative changes on water quality are not expected given that the wetlands and catchment area feeding the East Arm will remain undisturbed.</td><td></td><td></td><td></td></tr>
<tr><td>Potential Impact to Form and Function of Feature:</td><td>A reduction of less than 1% in groundwater contributions to the headwaters will result in immeasurable changes to flows in the feature, but this reduction is not expected to negatively impact direct fish habitat given that the small change is within the range of natural fluctuation.</td><td></td><td></td><td></td></tr>
<tr><td>Potential Impact to Identified Species and Habitat:</td><td>A reduction of less than 1% in groundwater contributions to the headwaters will result in immeasurable changes to flows in the feature, but this reduction is not expected to negatively impact fish species in the watercourse given that the small change is within the range of natural fluctuation.</td><td></td><td></td><td></td></tr>
</table>

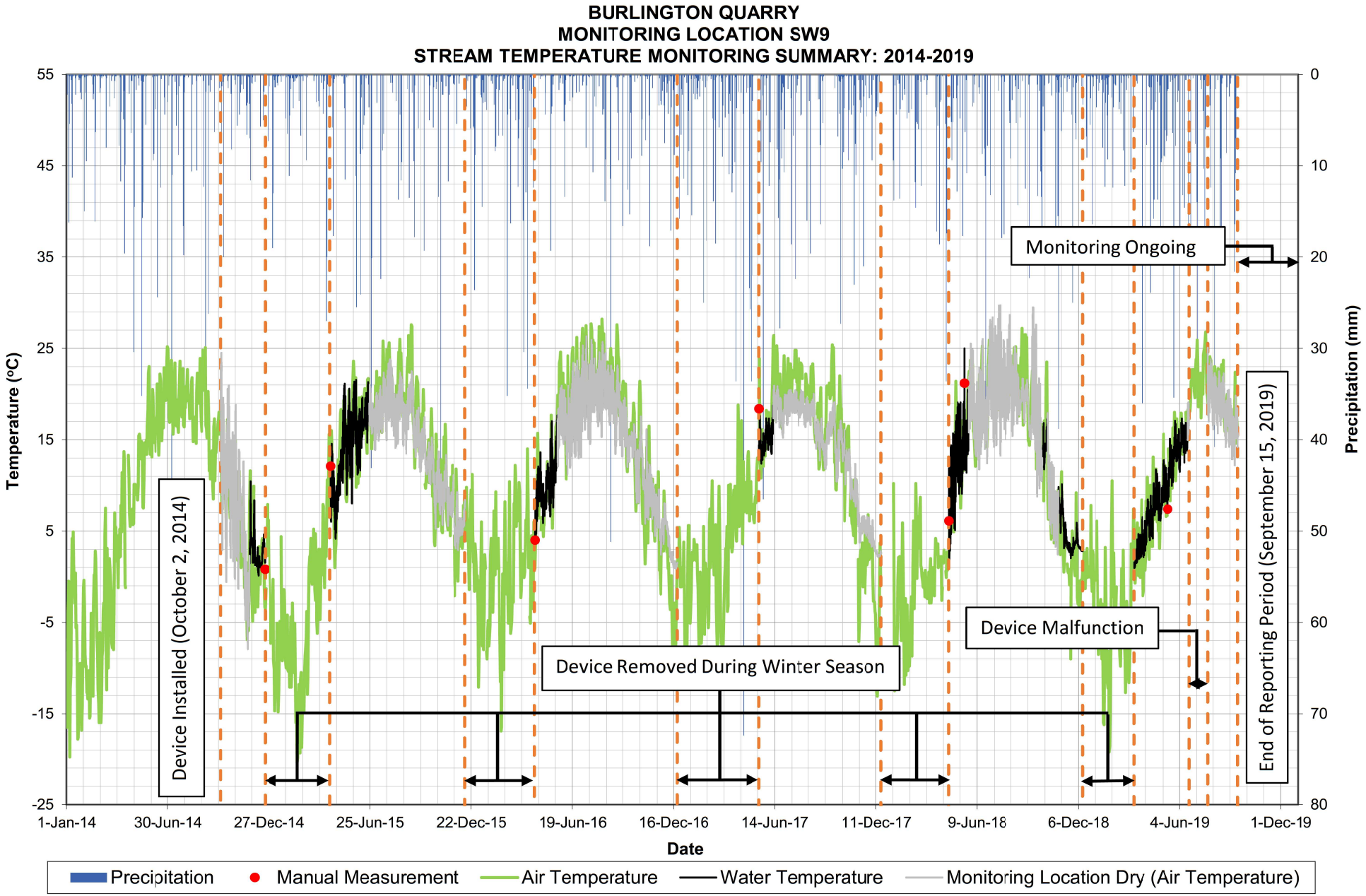
East Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek

Mitigation	Description	Figure / Graph / Table	Reference	
			Report	Section / Page
Direct Alteration Mitigation:	No direct alterations are proposed.		NETR (Savanta, April 2020)	75
Source Water Mitigation:	None required.			
Groundwater Contribution Mitigation:	None required.			
Erosion Mitigation:	None required.			
Thermal Mitigation:	None required.			
Water Quality Mitigation:	None required.			

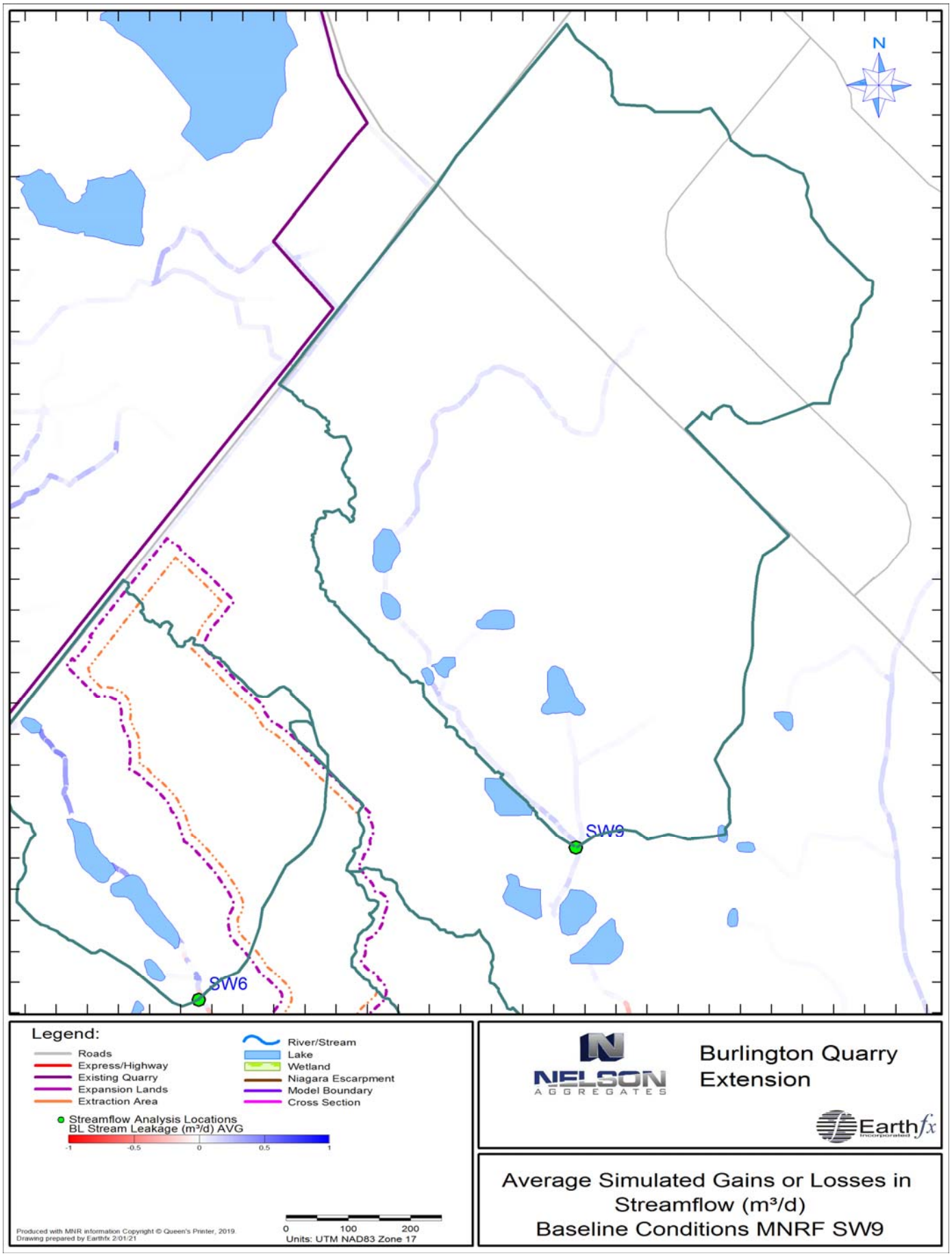
EAST ARM OF THE WEST BRANCH OF THE MOUNT NEMO TRIBUTARY OF GRINDSTONE CREEK - GRAPH 1



EAST ARM OF THE WEST BRANCH OF THE MOUNT NEMO TRIBUTARY OF GRINDSTONE CREEK - GRAPH 2



* Grey data indicates the monitoring location was dry and therefore the recorded values are respresentative of the air temperature.


N
SW9
SW6
Legend:
Roads
Express/Highway
Existing Quarry
Expansion Lands
Extraction Area
River/Stream
Lake
Wetland
Niagara Escarpment
Model Boundary
Cross Section
Streamflow Analysis Locations
BL Stream Leakage (m³/d) AVG
-1
-0.5
0
0.5
1
0
100
200
Units: UTM NAD83 Zone 17
Produced with MNR information Copyright © Queen's Printer, 2019.
Drawing prepared by Earthfx 2/01/21
NELSON AGGREGATES
Burlington Quarry Extension
Earthfx
Average Simulated Gains or Losses in Streamflow (m³/d)
Baseline Conditions MNRF SW9

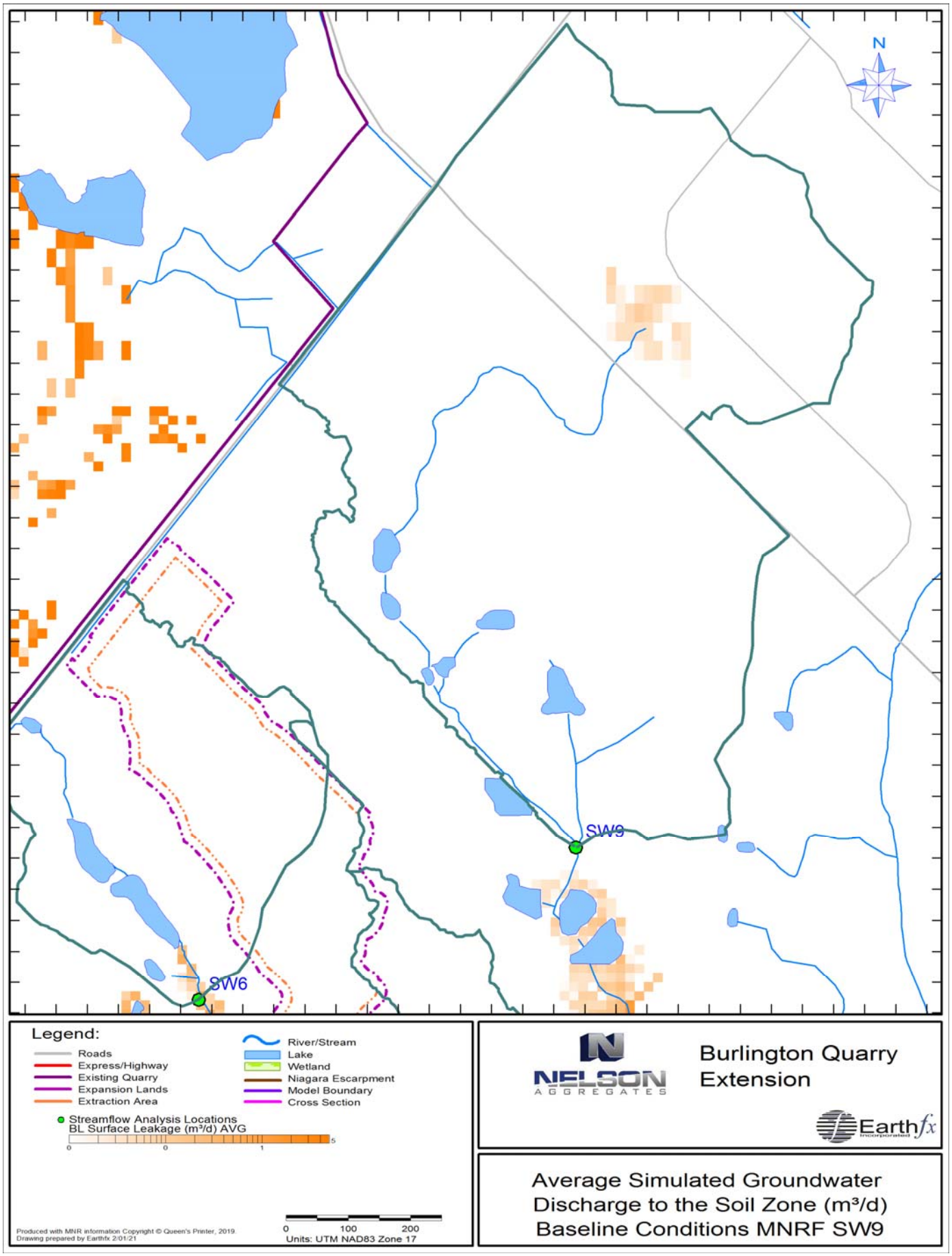

N
SW9
SW6
Legend:
Roads
Express/Highway
Existing Quarry
Expansion Lands
Extraction Area
River/Stream
Lake
Wetland
Niagara Escarpment
Model Boundary
Cross Section
Streamflow Analysis Locations
BL Surface Leakage (m³/d) AVG
0
0
1
5
0
100
200
Units: UTM NAD83 Zone 17
Produced with MNR information Copyright © Queen's Printer, 2019.
Drawing prepared by Earthfx 2/01/21
NELSON AGGREGATES
Burlington Quarry Extension
Earthfx
Average Simulated Groundwater Discharge to the Soil Zone (m³/d)
Baseline Conditions MNRF SW9

FIGURE 3A

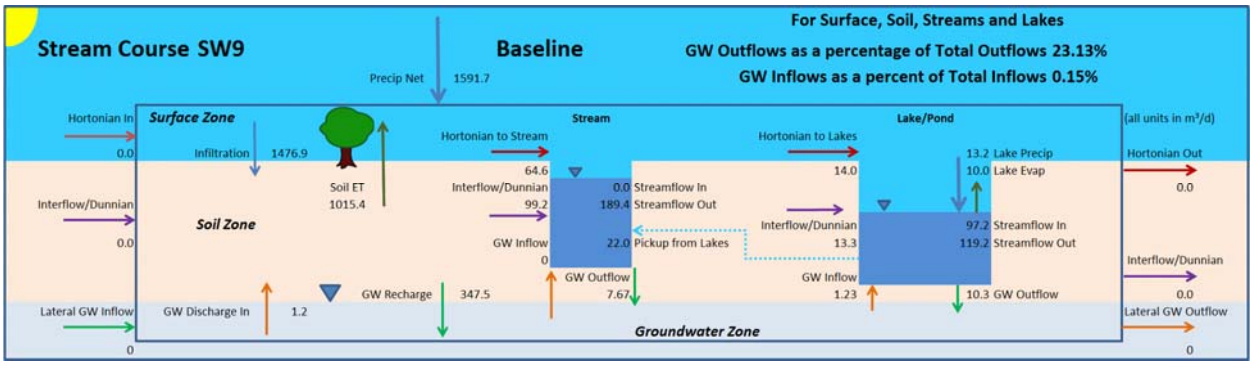


FIGURE 3B

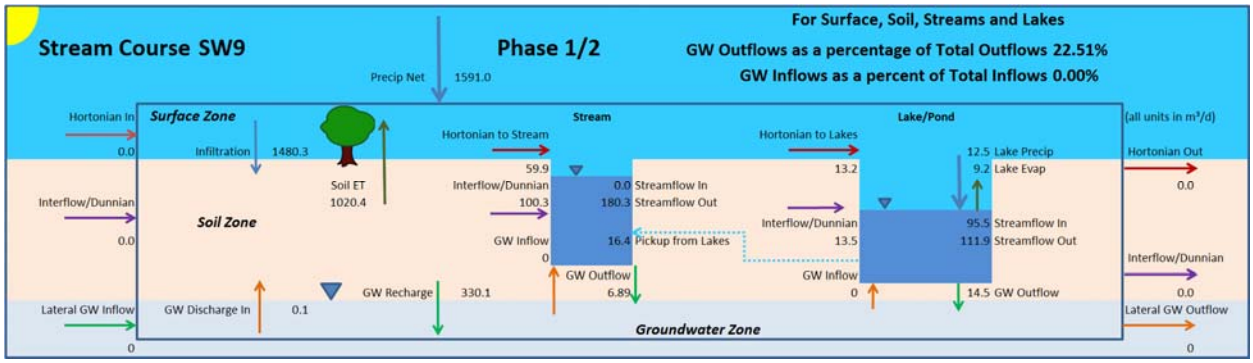


FIGURE 3C

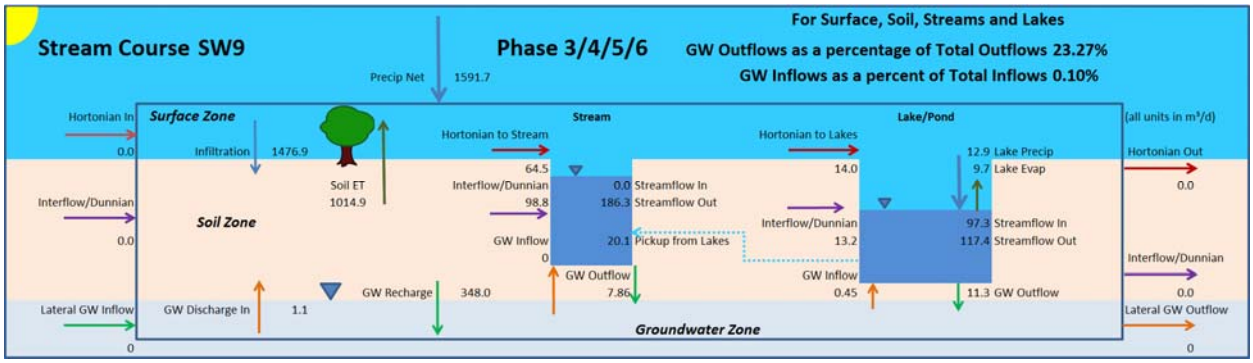


FIGURE 3D

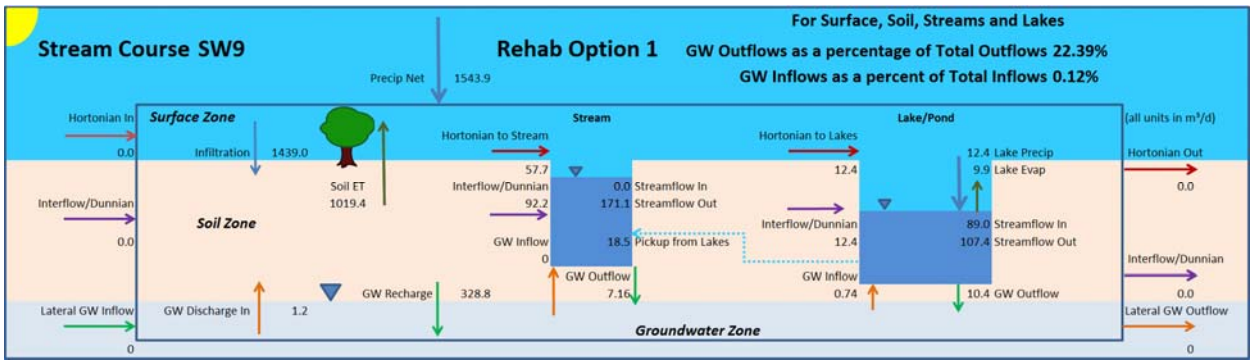


FIGURE 3E

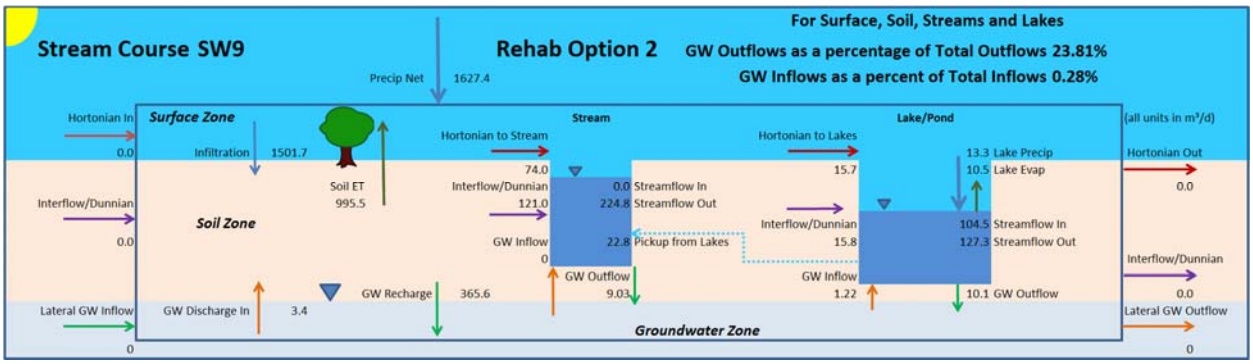


FIGURE 4A

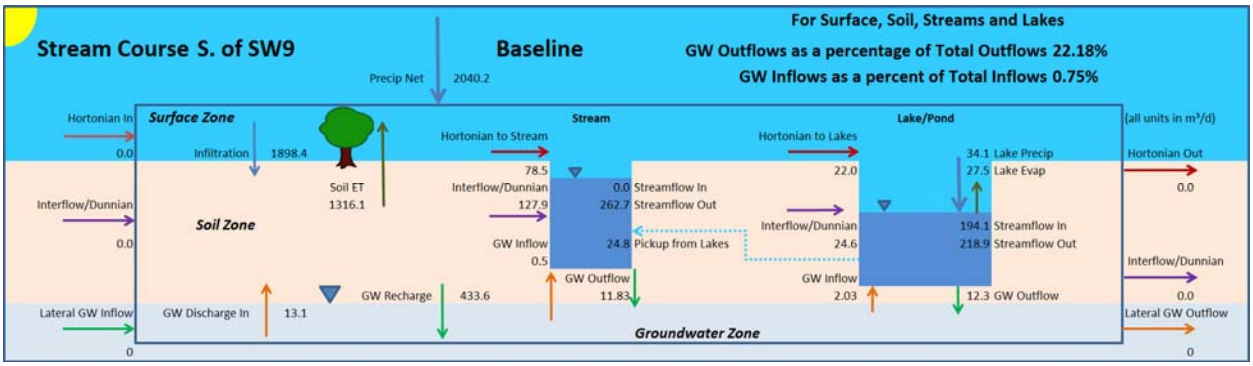


FIGURE 4B

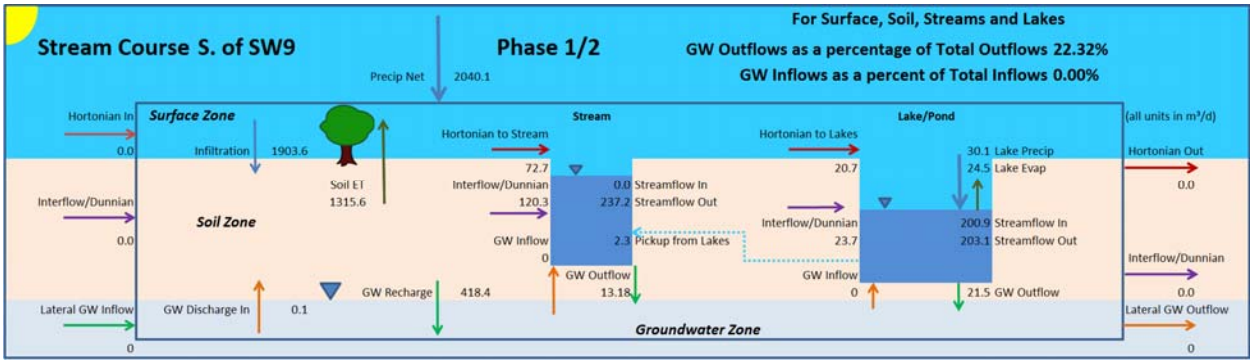


FIGURE 4C

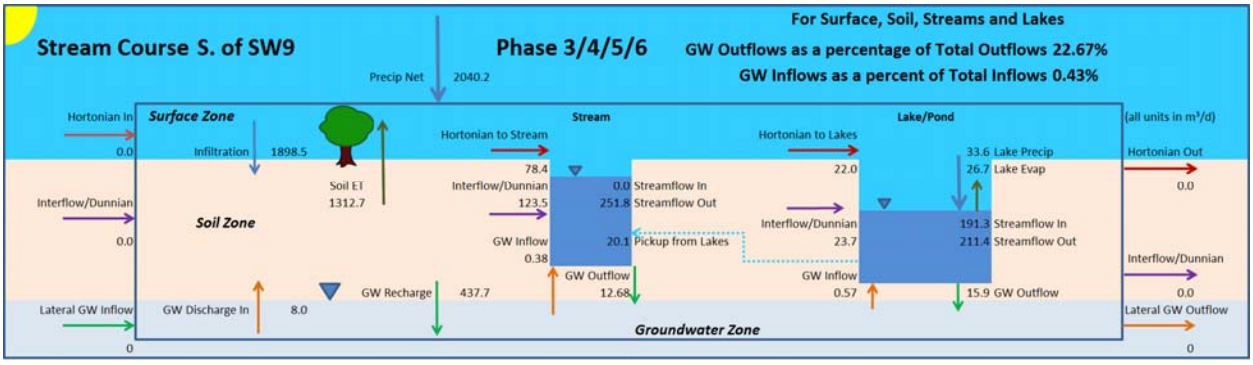


FIGURE 4D

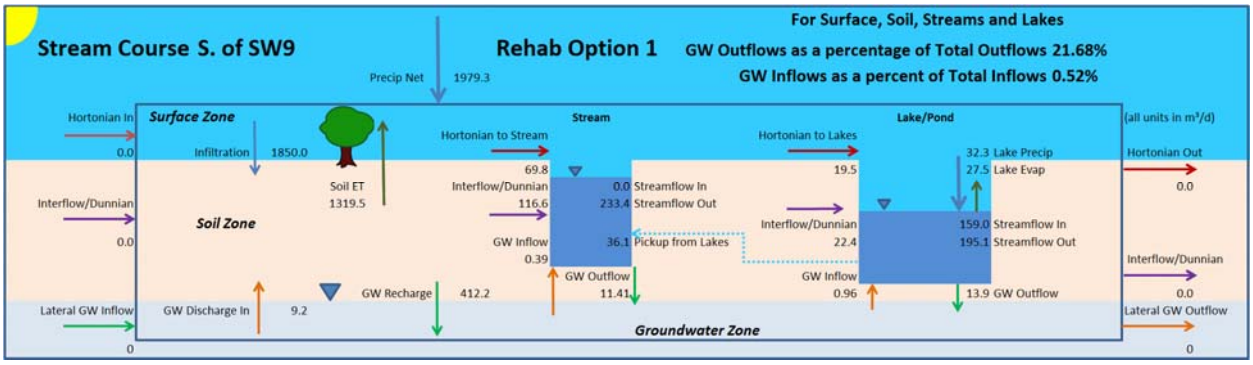
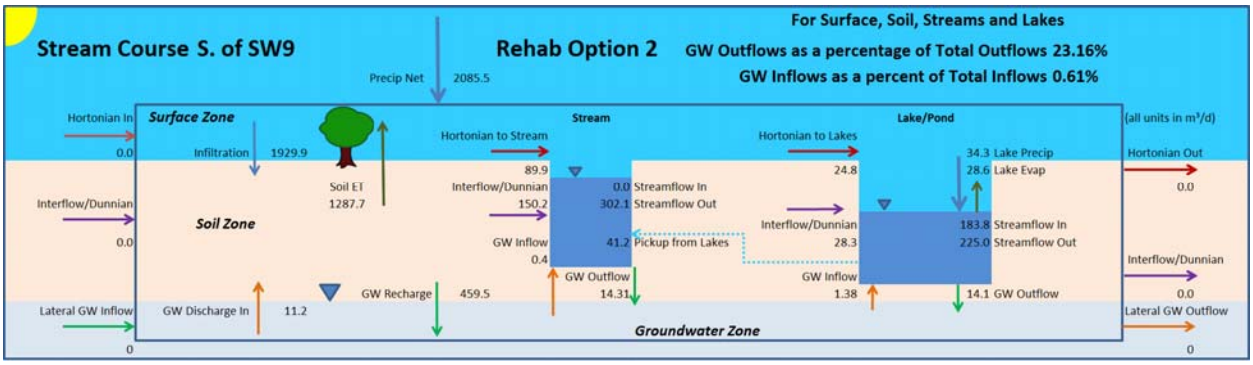
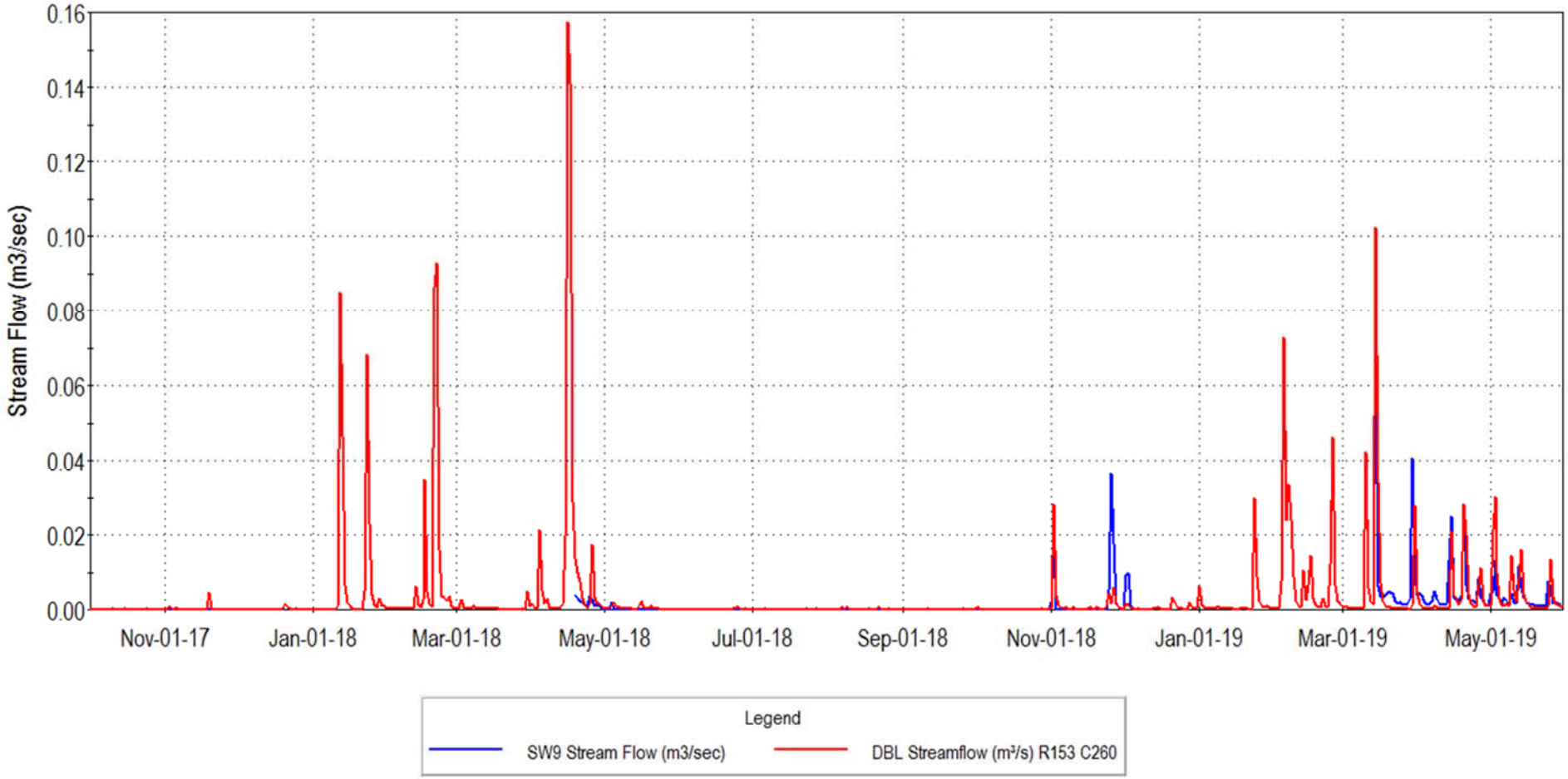


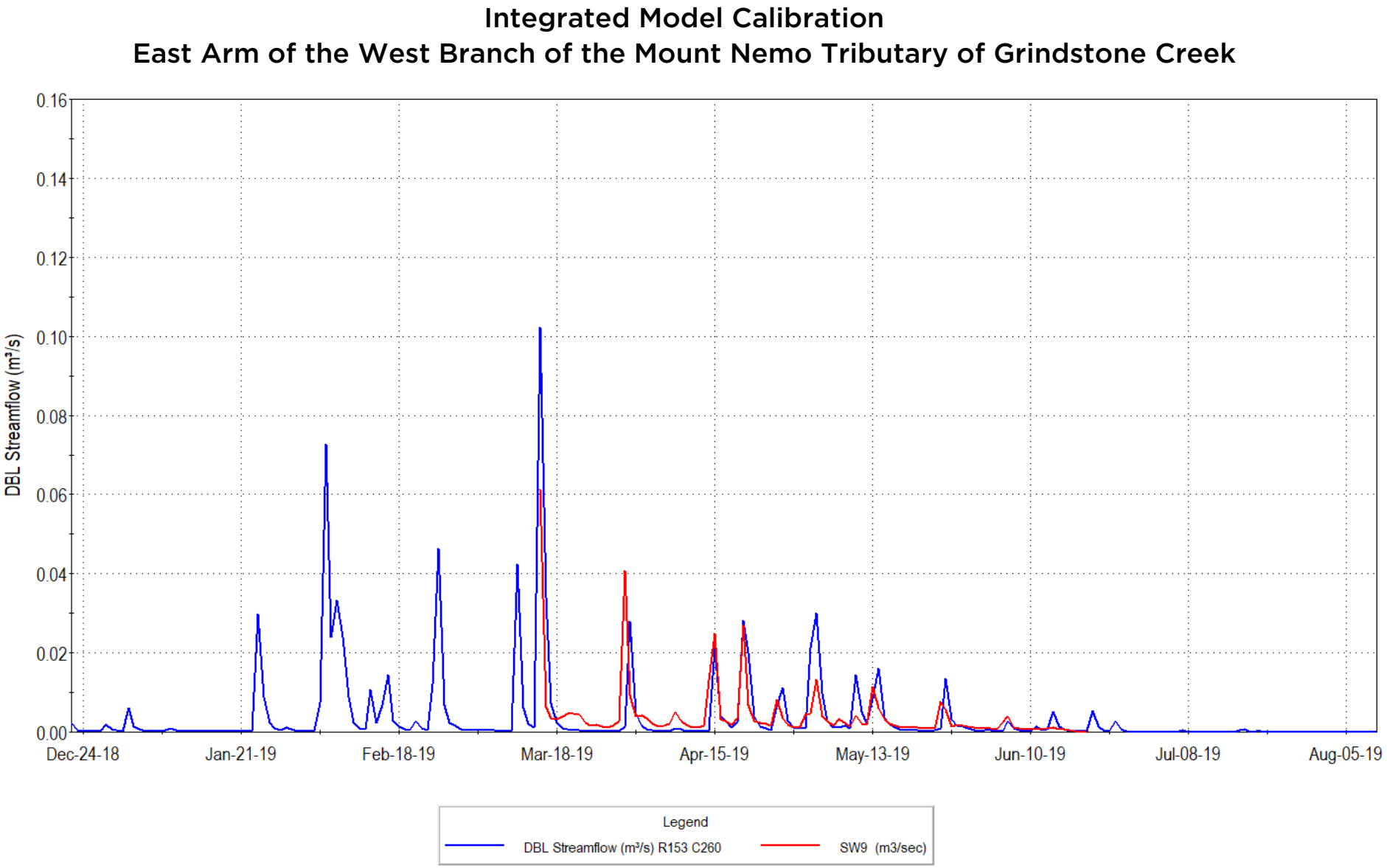
FIGURE 4E



Integrated Model Calibration
East Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek

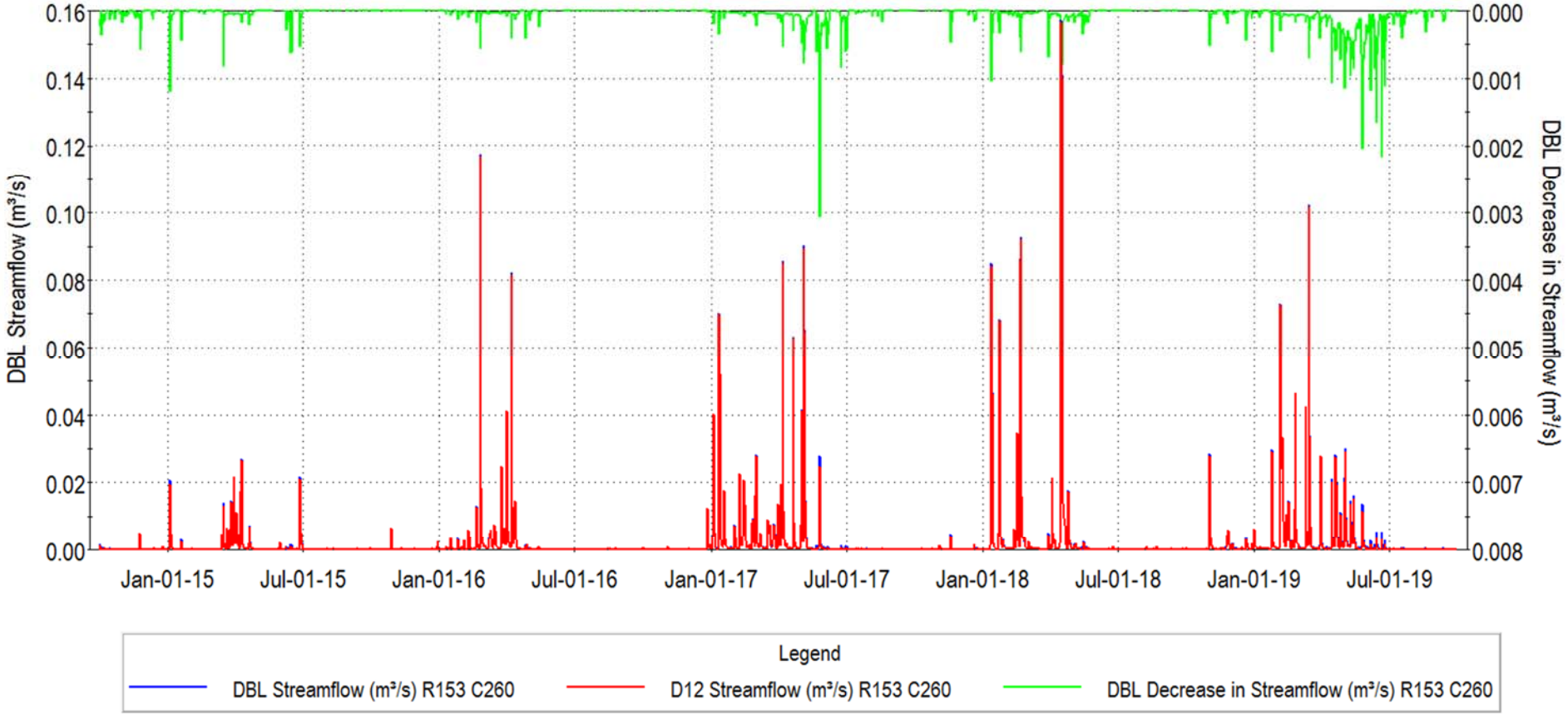


EAST ARM OF THE WEST BRANCH OF THE MOUNT NEMO TRIBUTARY OF GRINDSTONE CREEK - GRAPH 4



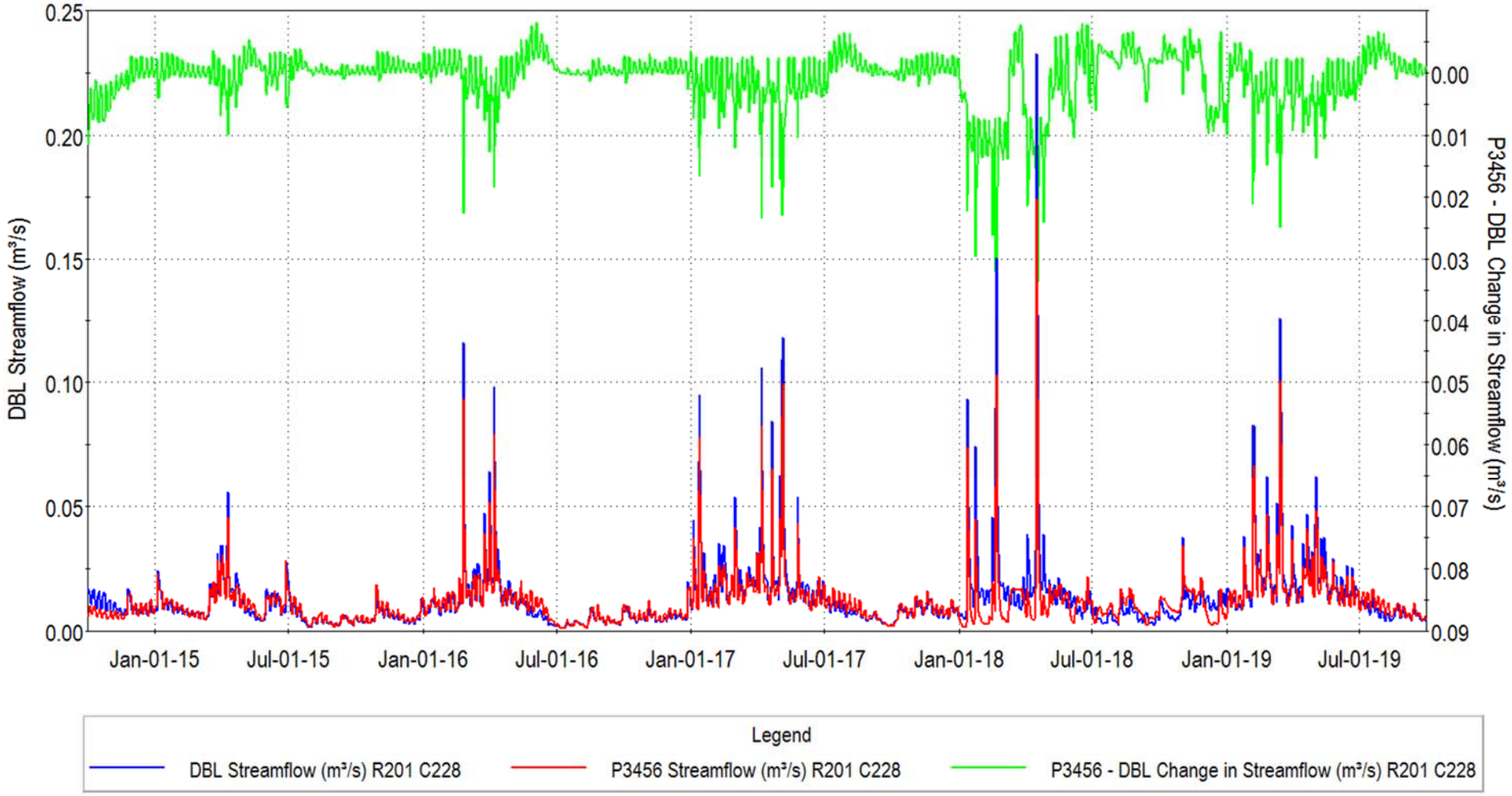
EAST ARM OF THE WEST BRANCH OF THE MOUNT NEMO TRIBUTARY OF GRINDSTONE CREEK - GRAPH 5

Simulated Streamflow Change - Integrated Model
East Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek

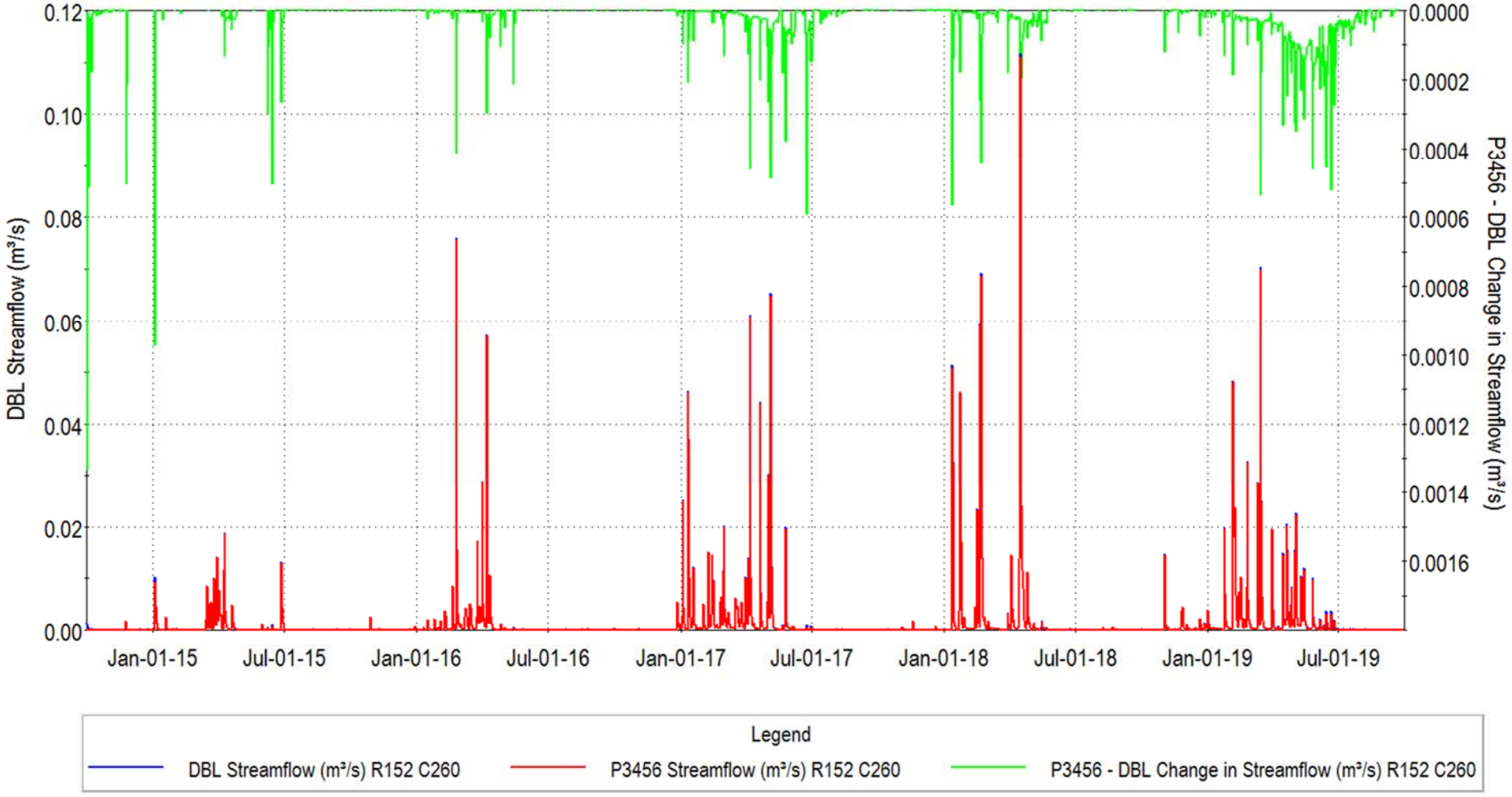


EAST ARM OF THE WEST BRANCH OF THE MOUNT NEMO TRIBUTARY OF GRINDSTONE CREEK - GRAPH 6

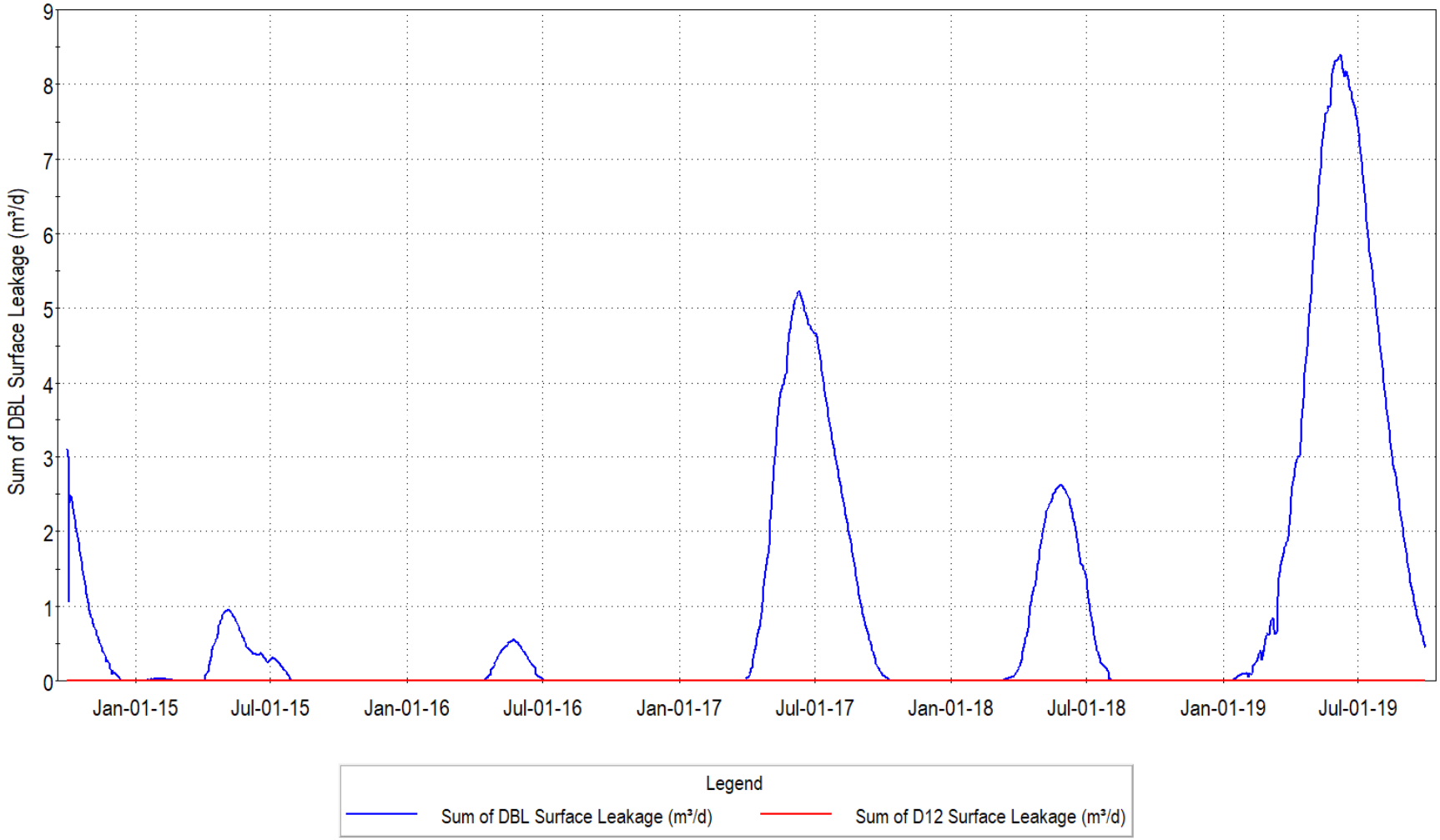
Simulated Streamflow Change - Integrated Model
East Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek



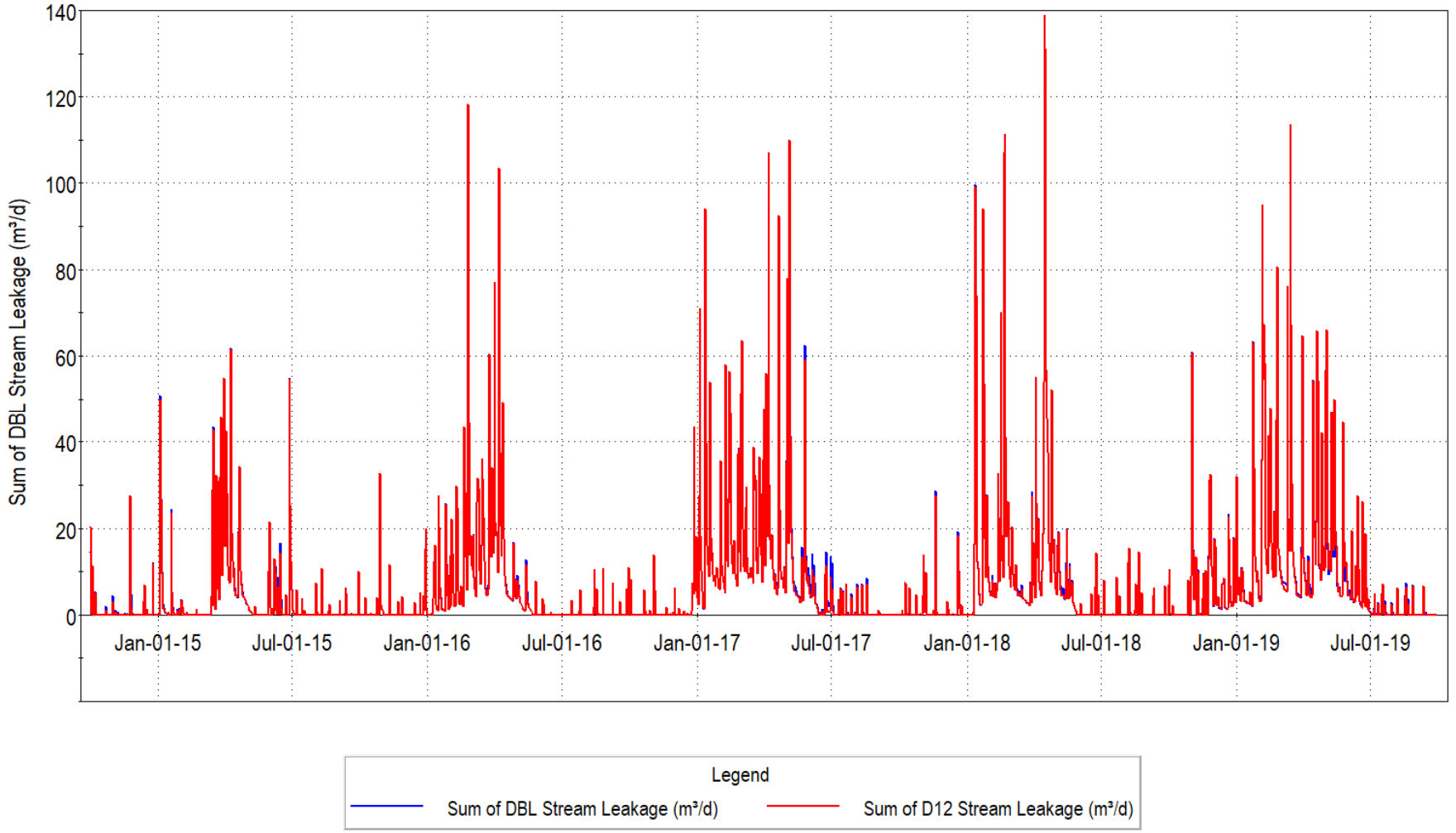
Simulated Streamflow Change - Integrated Model
East Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek



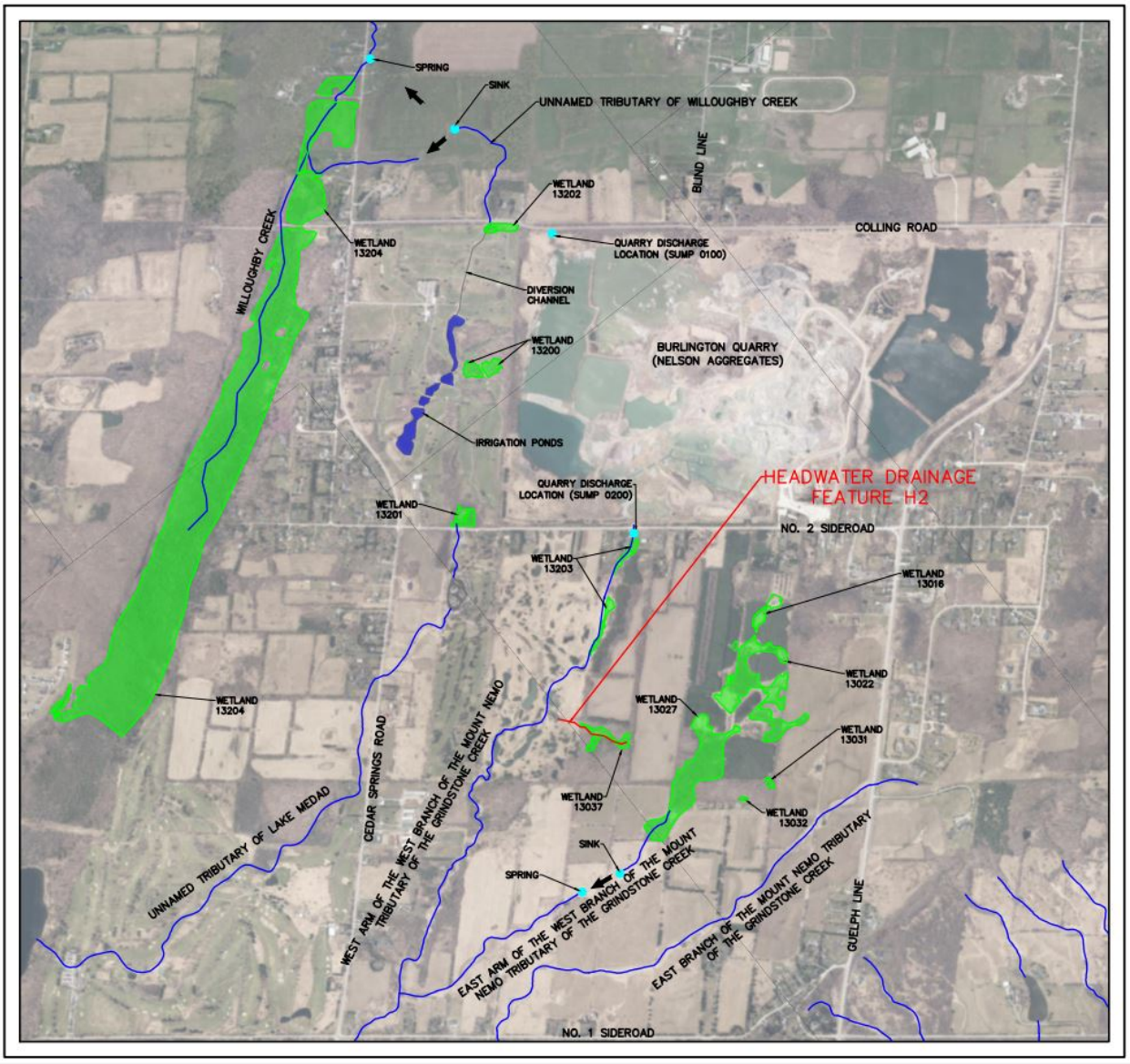
Change in Groundwater Contributions to Watercourse
East Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek

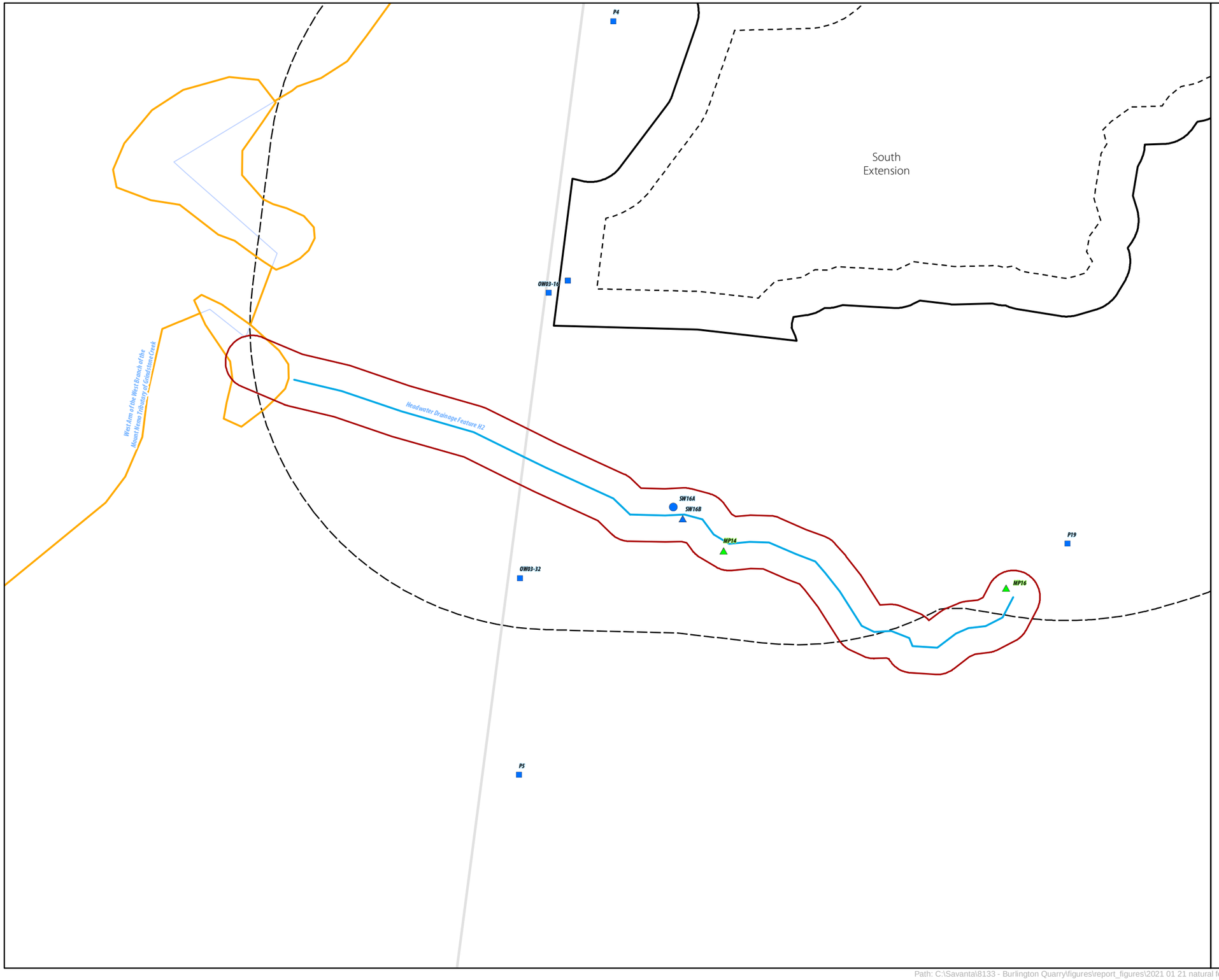


Change in Groundwater Contributions to Watercourse
East Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek



HEADWATER DRAINAGE FEATURE H2





Legend

- Licensed Boundary
- Limit of Extraction
- 120 m Adjacent Lands
- Subject Lands
- Headwater Drainage Feature H2
- Indirect Fish Habitat
- Direct Fish Habitat
- Watercourse
- Wetland (Savanta, 2020)

Current Instrumentation

- Groundwater Monitoring Station (EarthFx)
- Mini Piezometer (Tatham Engineering)
- Staff Gauge & Surface Water Monitoring Station (Tatham Engineering)

Previous Instrumentation

- Mini Piezometer (Golder)

NOTES:

1. Coordinate System: NAD 1983 UTM Zone 17N.
2. Base features produced under license with the Ontario Ministry of Natural Resources and Forestry © Queen's Printer for Ontario, 2021.
3. Orthoimagery © First Base Solutions, 2021. Imagery taken in 2019.

Project 8133

Burlington Quarry Extension
Nelson Aggregates Co.

Figure 17
Watercourse Characterization

Headwater Drainage Feature H2

0 25 m

1:1,500

[redacted]

Headwater Drainage Feature H2

<table>
<tr><th>Surface Water Characteristics</th><th>Description</th><th>Figure / Graph / Table</th><th colspan="2">Reference</th></tr>
<tr><th></th><th></th><th></th><th>Report</th><th>Section / Page</th></tr>
<tr><td>Watercourse Name:</td><td>Headwater Drainage Feature H2</td><td></td><td></td><td></td></tr>
<tr><td>Watershed:</td><td>Grindstone Creek Watershed</td><td></td><td></td><td></td></tr>
<tr><td>Sub-Watershed:</td><td>West Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek</td><td></td><td></td><td></td></tr>
<tr><td>Located in Proposed Limit of Extraction:</td><td>No</td><td></td><td></td><td></td></tr>
<tr><td>Located in Proposed License Boundary:</td><td>No</td><td></td><td></td><td></td></tr>
<tr><td>Catchment Area (ha):</td><td>10 ha</td><td></td><td></td><td></td></tr>
<tr><td>Catchment ID:</td><td>S125 and S126</td><td></td><td>SWA (Tatham, April 2020)</td><td>Drawing DP-1</td></tr>
<tr><td>Primary Source(s) of Flow:</td><td>Surface runoff</td><td></td><td></td><td></td></tr>
<tr><td>Discharge from Quarry / PTTW:</td><td>No</td><td></td><td></td><td></td></tr>
<tr><td>Conditions of PTTW:</td><td>Not applicable</td><td></td><td></td><td></td></tr>
<tr><td>Surface Water Monitoring:</td><td>ID: SW39 (Tatham)
Installation Date: March 25, 2021
Data Collection: Continuous water level and temperature, manual monthly in-situ streamflow measurements and calibration data (water level converted to flow using rating curve)
Coordinates of Monitoring Station: Easting 590856.53, Northing 590856.53</td><td></td><td></td><td></td></tr>
<tr><td>Streamflow Conditions:</td><td>Intermittent</td><td></td><td></td><td></td></tr>
<tr><td>Average Daily Flow:</td><td>To be determined. To date, water levels and temperatures have been collected in Wetland 13037 at the origin of the Headwater Drainage Feature H2. A streamflow monitoring gauge was installed in the spring of 2021 to monitor streamflow in this feature. Average daily flow will be established from the monitoring data collected moving forward. It is noted, Wetland 13037 dries out in the early summer, as early as May 25th, and has remained dry until as late as December 25th. Headwater Drainage Feature H2 runs dry consistent with the upstream wetland.</td><td></td><td></td><td></td></tr>
<tr><td>Watercourse Thermal Regime (SW16A):</td><td>
<table>
<tr><th colspan="4">Average Daily Water Temperature (°C)</th></tr>
<tr><th>Month</th><th>Minimum</th><th>Average</th><th>Maximum</th></tr>
<tr><td>January</td><td>N/A</td><td>N/A</td><td>N/A</td></tr>
<tr><td>February</td><td>N/A</td><td>N/A</td><td>N/A</td></tr>
<tr><td>March</td><td>-6.3</td><td>2.6</td><td>20.5</td></tr>
<tr><td>April</td><td>-5.9</td><td>6.8</td><td>24.4</td></tr>
<tr><td>May</td><td>0.7</td><td>12.0</td><td>31.7</td></tr>
<tr><td>June</td><td>8.2</td><td>16.5</td><td>30.3</td></tr>
<tr><td>July</td><td>Dry</td><td>Dry</td><td>Dry</td></tr>
<tr><td>August</td><td>Dry</td><td>Dry</td><td>Dry</td></tr>
<tr><td>September</td><td>Dry</td><td>Dry</td><td>Dry</td></tr>
<tr><td>October</td><td>Dry</td><td>Dry</td><td>Dry</td></tr>
<tr><td>November</td><td>-5.3</td><td>5.2</td><td>26.4</td></tr>
<tr><td>December</td><td>-1.5</td><td>2.7</td><td>5.5</td></tr>
</table>
Notes:
Minimum - lowest daily average streamflow recorded for period of record
Average - average daily streamflow recorded for period of record
Maximum - maximum daily average streamflow recorded for period of record
N/A - data not available as device removed from watercourse during winter months
</td><td>Graph 1</td><td>SWA (Tatham, April 2020)</td><td>2.1.2 and Appendix C</td></tr>
</table>

Headwater Drainage Feature H2

Fish & Fish Habitat Features	Description	Figure / Graph / Table	Reference	
			Report	Section / Page
Fish Habitat (Direct/Indirect and Assumed/Confirmed):	1) The portion of the Headwater Drainage Feature H2 on the Subject Lands does not appear to provide direct fish habitat, based on the presence of a barrier to movement at the downstream end, intermittent nature (dries out in summer), and generally small size of the feature. No fish were observed in the feature during headwater drainage feature investigations in 2019. 2) The off-site (downstream) reach of this feature consists of an excavated, linear ditch on the adjacent golf course property. It runs for approximately 90 m before draining into an online golf course pond on the West Arm of the West Branch. There is a high probability that this pond contains fish, which could potentially have access to the channelized portion of this headwater drainage feature. However, based on low flows observed in 2019 and lack of suitable wetted width and depth to support fish, it has been assessed as providing indirect fish habitat.		NETR (Savanta, April 2020)	39 and 40
Fish Species Present:	Fish are assumed to not directly use the headwater drainage feature. No information on fish species in the online pond at the downstream end of the feature is known to exist. Pumpkinseed and Brook Stickleback are known to be present in upstream reaches of the West Arm of the West Branch.		NETR (Savanta, April 2020)	39 and 40
Fish Community Thermal Regime:	Fish are assumed to not directly use the headwater drainage feature.		NETR (Savanta, April 2020)	39 and 40
Fish Habitat Types Present:	The feature provides indirect fish habitat contributing to the downstream West Arm of the West Branch. On the Subject Lands, the feature consists of a headwater wetland and an approximately 50-m long, low flow channel running through a wooded area, before flowing into the off-site channelized reach on the adjacent property.		NETR (Savanta, April 2020)	39 and 40
Habitat Uses by Known Fish Community:	No direct use by fish is expected to occur. Indirect habitat functions provided by the feature include water storage and release (headwater wetlands), water quality maintenance, conveyance of flow, sediment transport and organic inputs.		NETR (Savanta, April 2020)	39 and 40
Known Barriers to Fish Movement:	There is a culvert at the Subject Lands property line that provides a barrier to upstream fish movement.		NETR (Savanta, April 2020)	39 and 40

Groundwater Interaction	Description	Figure / Graph / Table	Reference	
			Report	Section / Page
Underlying Deposits:	Halton Till. The harmonic mean hydraulic conductivity, based on testing by Golder (2007) of 10 mini-piezometers, was $1.2x10^{-8}$ m/s. Model value for the vertical hydraulic conductivity was $1.6x10^{-7}$ m/s, about an order of magnitude higher, to account for limited flow through fractures in the till.			
Surface Water / Groundwater Interactions:	Seasonal groundwater contributions to watercourse. Groundwater seepage under baseline conditions during spring months equates to 0.1 L/s or less. Groundwater seepage is at its maximum during and immediately following the spring freshet.	Figures 1 & 2		
Water Budget Results:	The baseline condition water budget results from the integrated model are presented in Figure 3a.	Figure 3a		

Condition	GW Out	GW In
Baseline (Existing)	18.07%	1.11%

Integrated Model Calibration:	This area was not discussed in the model calibration due to the lack of observations.			

Headwater Drainage Feature H2

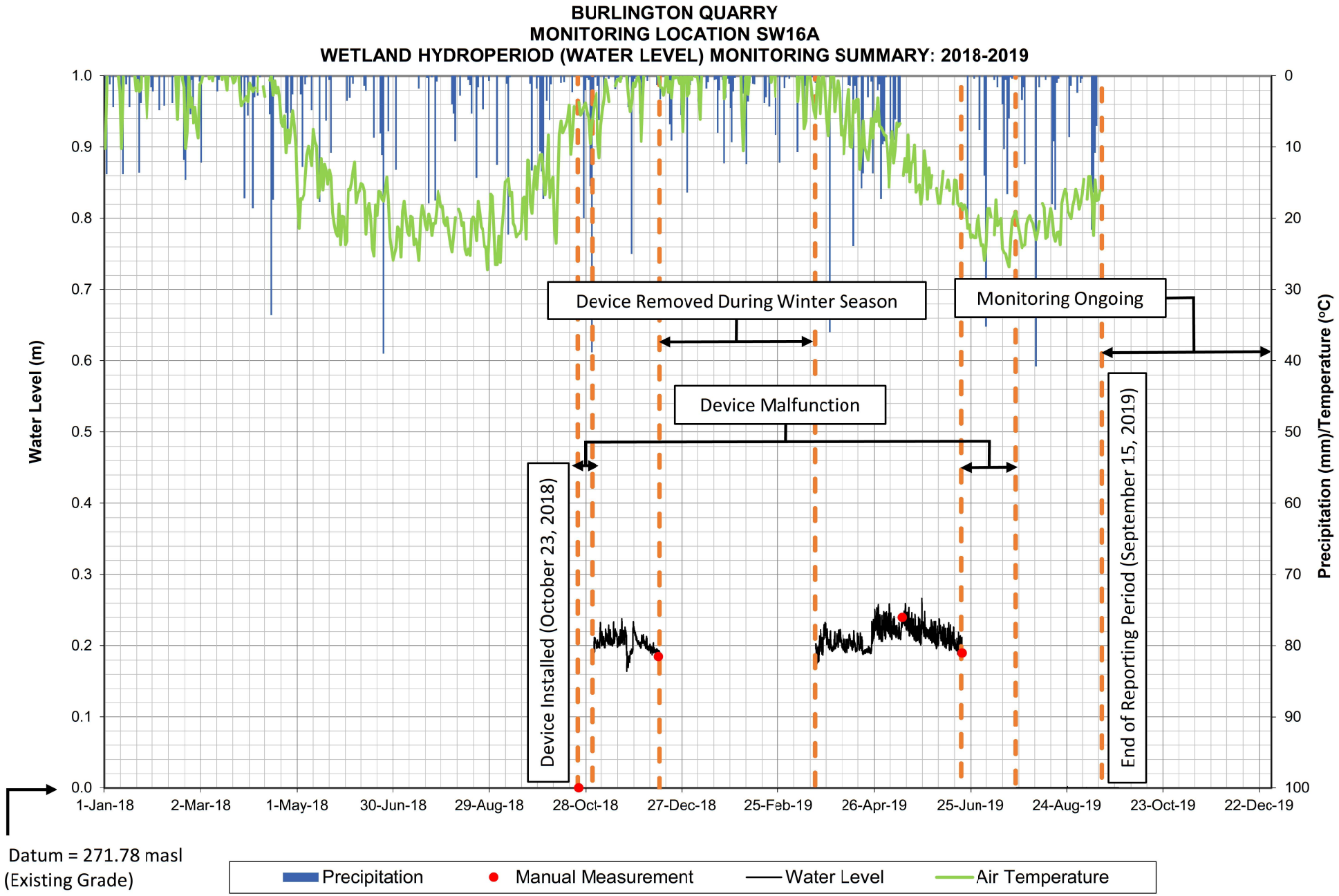
<table>
<tr><th>Impact Assessment</th><th>Description</th><th>Figure / Graph / Table</th><th colspan="2">Reference</th></tr>
<tr><th></th><th></th><th></th><th>Report</th><th>Section / Page</th></tr>
<tr><td>Direct Alterations to Watercourse:</td><td>No direct alterations to this headwater drainage feature are proposed.</td><td></td><td>NETR (Savanta, April 2020)</td><td>80</td></tr>
<tr><td>Change in Primary Source of Flow:</td><td>No change in surface water input as the catchment area of the Headwater Drainage Feature H2 will remain undisturbed. The headwater drainage feature is perched above the water table, generally losing rather than gaining flow from the groundwater system. The headwater drainage feature is primarily located in Halton Till, so the low permeability of the till limits GW/SW interactions.</td><td></td><td></td><td></td></tr>
<tr><td>Change in Watercourse Catchment Area:</td><td>Catchment area to remain undisturbed, no change in catchment area.</td><td></td><td></td><td></td></tr>
<tr><td>Simulated Streamflow Change (Integrated Model Results):</td><td>The Earthfx report discusses changes in simulated streamflow under the different quarry expansion phases. This tributary was not discussed, but Graphs 2 and 3 show simulated baseline(red) and Scenario P12 (blue) flows. Decrease in flow (green) are plotted in reverse on the upper X axis with the scale shown on the right Y axis. Very small decreases in streamflow, primarily in winter and spring, are predicted.</td><td>Graphs 2 & 3</td><td>HHIAR (Earthfx, April 2020)</td><td>198 - 203 and 230 - 237</td></tr>
<tr><td>Water Budget Results (Operational Phases 1 & 2):</td><td>The Operational Phases 1 and 2 water budget results from the integrated model are presented in Figure 3b.
<table>
<tr><td>Condition</td><td>GW Outflow</td><td>GW Inflow</td><td>%Δ GW Outflow</td><td>%Δ GW Inflow</td></tr>
<tr><td>Baseline (Existing)</td><td>18.07%</td><td>1.11%</td><td>-</td><td>-</td></tr>
<tr><td>Phases 1 & 2</td><td>18.57%</td><td>0.00%</td><td>0.50%</td><td>-1.11%</td></tr>
</table></td><td>Figure 3b</td><td></td><td></td></tr>
<tr><td>Water Budget Results (Operational Phases 3 Through 6):</td><td>The Operational Phases 3 through 6 water budget results from the integrated model are presented in Figure 3c. Its noted the rehabilitation of the south extension is complete under this scenario.
<table>
<tr><td>Condition</td><td>GW Outflow</td><td>GW Inflow</td><td>%Δ GW Outflow</td><td>%Δ GW Inflow</td></tr>
<tr><td>Baseline (Existing)</td><td>18.07%</td><td>1.11%</td><td>-</td><td>-</td></tr>
<tr><td>Phases 3 though 6</td><td>19.18%</td><td>19.06%</td><td>1.11%</td><td>17.95%</td></tr>
</table></td><td>Figure 3c</td><td></td><td></td></tr>
<tr><td>Water Budget Results (Rehabilitation Scenario 1):</td><td>The Rehabilitation Scenario 1 water budget results from the integrated model are presented in Figure 3d.
<table>
<tr><td>Condition</td><td>GW Outflow</td><td>GW Inflow</td><td>%Δ GW Outflow</td><td>%Δ GW Inflow</td></tr>
<tr><td>Baseline (Existing)</td><td>18.07%</td><td>1.11%</td><td>-</td><td>-</td></tr>
<tr><td>Rehab Scenario 1</td><td>18.25%</td><td>18.43%</td><td>0.18%</td><td>17.32%</td></tr>
</table></td><td>Figure 3d</td><td></td><td></td></tr>
<tr><td>Water Budget Results (Rehabilitation Scenario 2):</td><td>The Rehabilitation Scenario 2 water budget results from the integrated model are presented in Figure 3e.
<table>
<tr><td>Condition</td><td>GW Outflow</td><td>GW Inflow</td><td>%Δ GW Outflow</td><td>%Δ GW Inflow</td></tr>
<tr><td>Baseline (Existing)</td><td>18.07%</td><td>1.11%</td><td>-</td><td>-</td></tr>
<tr><td>Rehab Scenario 2</td><td>19.04%</td><td>17.37%</td><td>0.97%</td><td>16.26%</td></tr>
</table></td><td>Figure 3e</td><td></td><td></td></tr>
<tr><td>Change in Groundwater Contributions to Watercourse:</td><td>Under Baseline conditions, the H2 catchment receives minimal amounts of groundwater seepage during drought years (more under wet years). Under P12 conditions, this seepage is lost due to the dewatering as shown in Graph 4. Leakage between the stream and groundwater system is shown in Graph 5 for Baseline and P12 conditions. The vast majority of the leakage is from the stream to the groundwater system. Under Baseline conditions there is a very minor amount of upwards leakage into the stream in the late spring (shown as negative leakage in blue).</td><td>Graphs 4 and 5</td><td></td><td></td></tr>
<tr><td>Change in Watercourse Thermal Regime:</td><td>Negative changes on water temperature are not expected given that the wetlands and catchment area feeding the Headwater Drainage Feature H2 will remain undisturbed.</td><td></td><td></td><td></td></tr>
<tr><td>Change in Water Quality:</td><td>Negative changes on water quality are not expected given that the wetlands and catchment area feeding the Headwater Drainage Feature H2 will remain undisturbed.</td><td></td><td></td><td></td></tr>
</table>

Headwater Drainage Feature H2

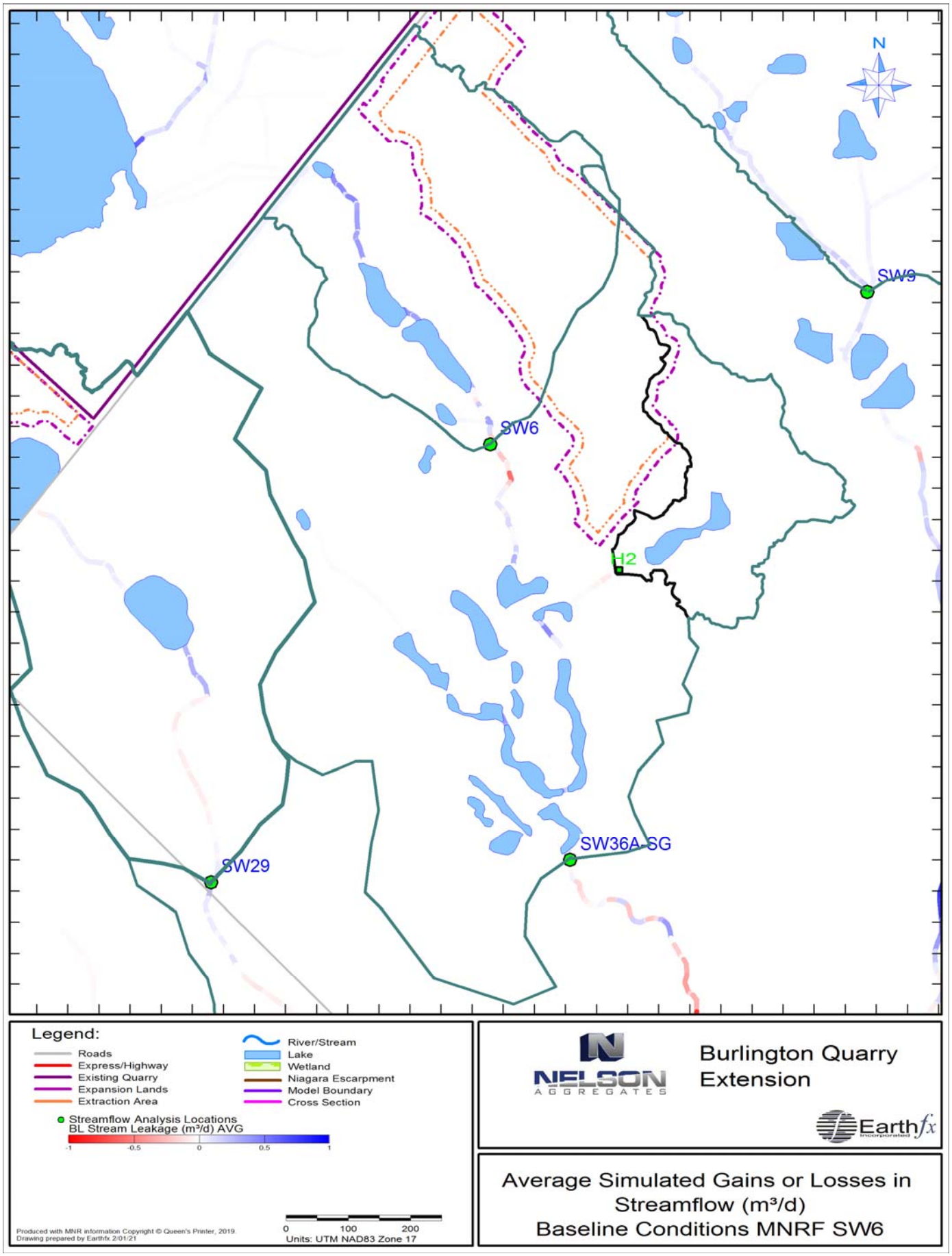
Impact Assessment	Description	Figure / Graph / Table	Reference	
			Report	Section / Page
Potential Impact to Form and Function of Feature:	A 1% or 0.1 L/s reduction in groundwater discharge to the headwater wetland may have a corresponding 1% reduction in the volume of water conveyed downstream to the West Arm of the West Branch. The feature is predicted to continue to provide indirect fish habitat functions supporting the downstream watercourse as it will continue to convey flow downstream on a seasonal basis. The 0.1 L/s reduction in surface flow into the online pond on the West Arm of the West Branch (where Headwater Drainage Feature H2 drains) is not expected to have a measurable effect on direct fish habitat in the pond or watercourse.		NETR (Savanta, April 2020)	80
Potential Impact to Identified Species and Habitat:	No impacts to species or habitat in the downstream West Arm of the West Branch are predicted.		NETR (Savanta, April 2020)	80

Mitigation	Description	Figure / Graph / Table	Reference	
			Report	Section / Page
Direct Alteration Mitigation:	No direct alterations are proposed; therefore, no mitigation is required.		NETR (Savanta, April 2020)	80
Source Water Mitigation:	No alterations to surface water catchment area; therefore, no mitigation is required.		NETR (Savanta, April 2020)	80
Groundwater Contribution Mitigation:	Given the minor nature of proposed changes in groundwater discharge to the wetland, no mitigation is proposed to supplement flows. However, the feature will continue to be monitored throughout the operations period, as specified in the AMP. If adverse effects on flow and/or wetland function are observed as a result of quarry extraction, mitigation (e.g., pumping from the quarry to the headwater wetland) could be implemented, if needed, to maintain ecological and biophysical functions of the feature.		NETR (Savanta, April 2020)	80
Erosion Mitigation:	None required.			
Thermal Mitigation:	None required.			
Water Quality Mitigation:	None required.			

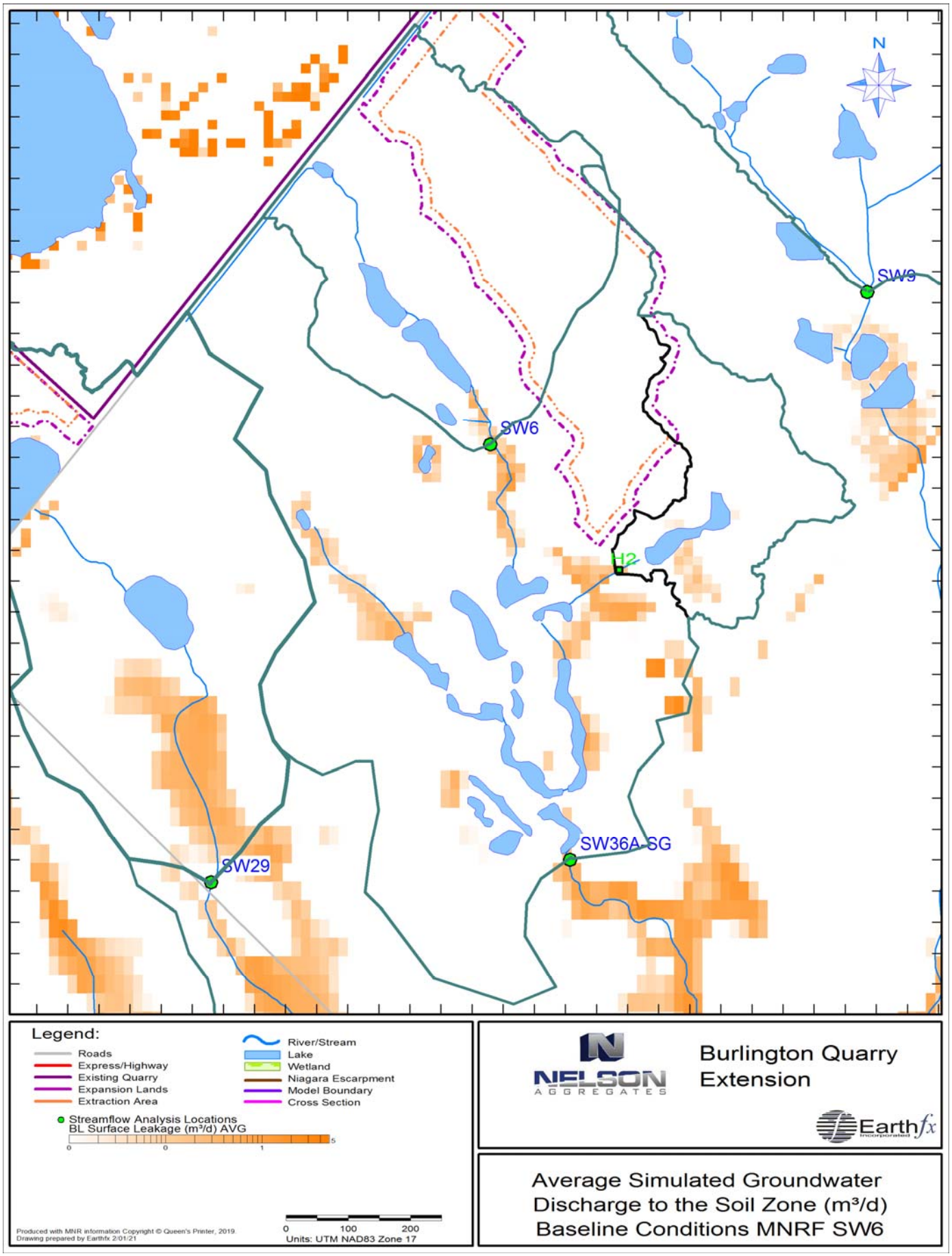
HEADWATER DRAINAGE FEATURE H2 - GRAPH 1



HEADWATER DRAINAGE FEATURE H2 - FIGURE 1



HEADWATER DRAINAGE FEATURE H2 - FIGURE 2



HEADWATER DRAINAGE FEATURE H2

FIGURE 3A

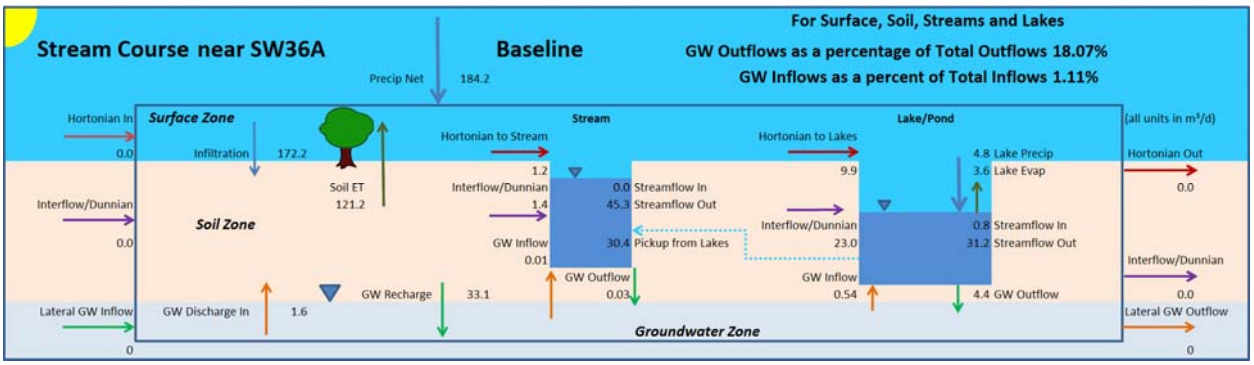


FIGURE 3B

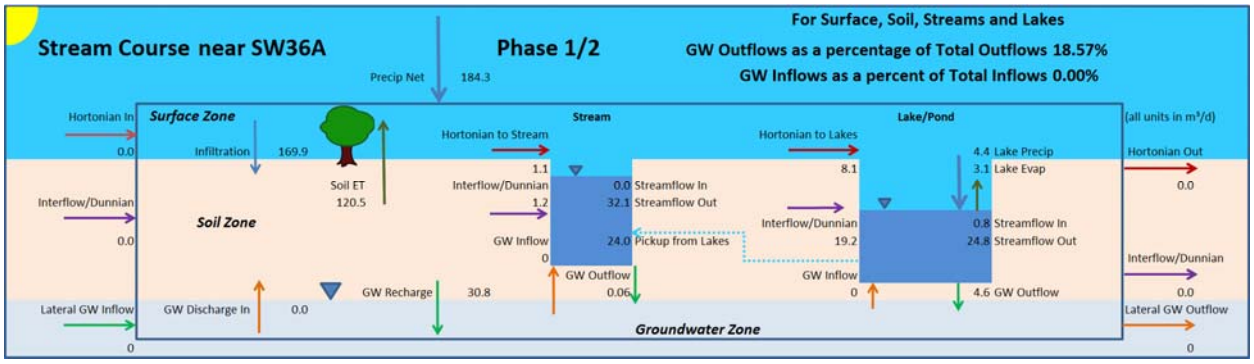


FIGURE 3C

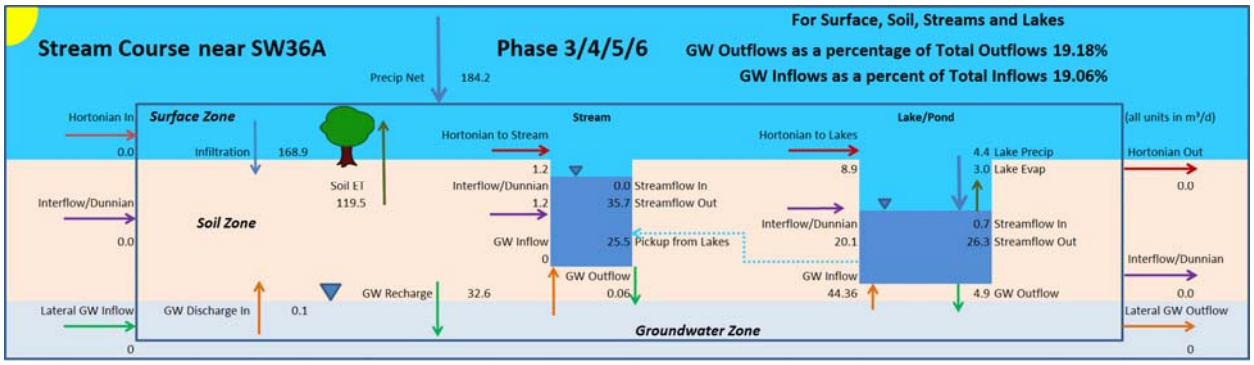


FIGURE 3D

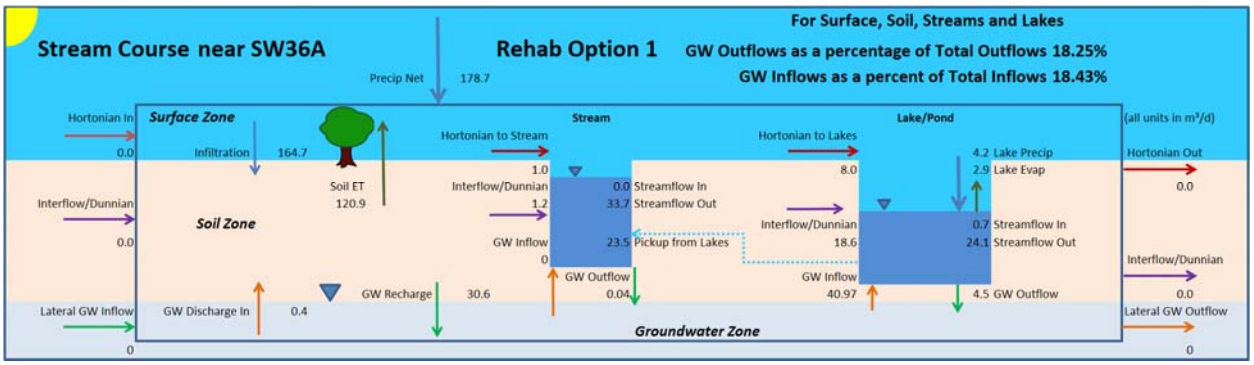
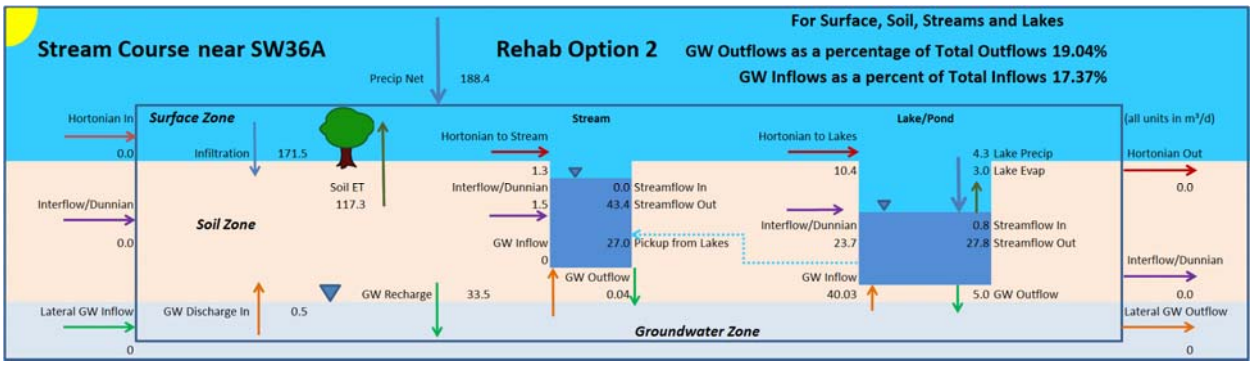
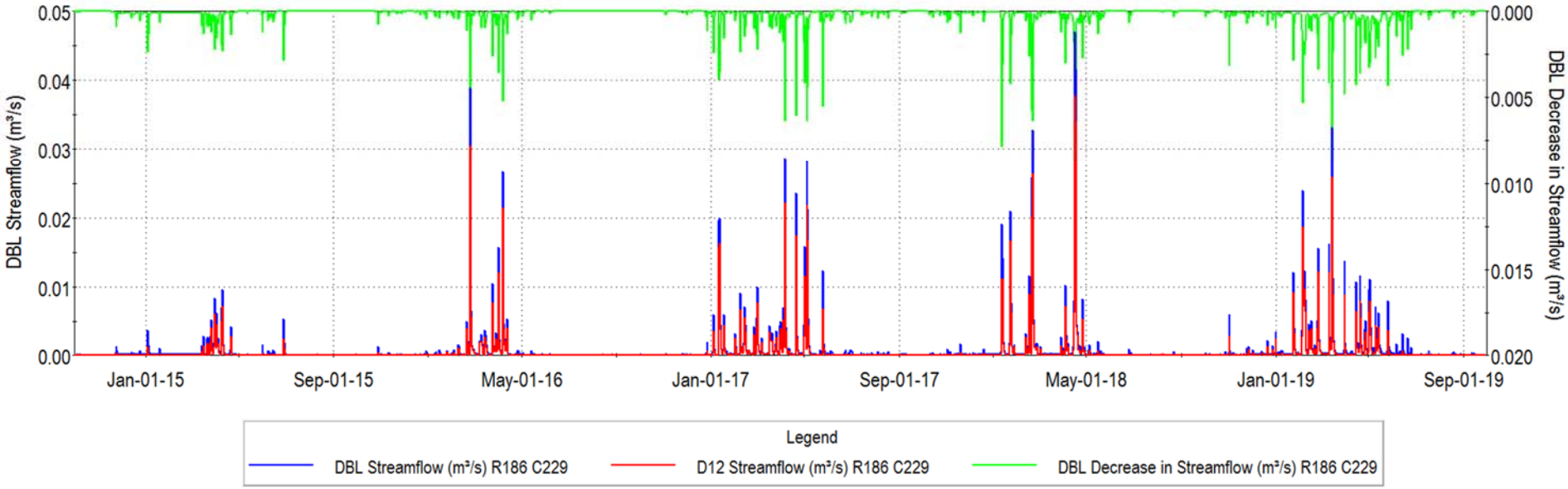


FIGURE 3E



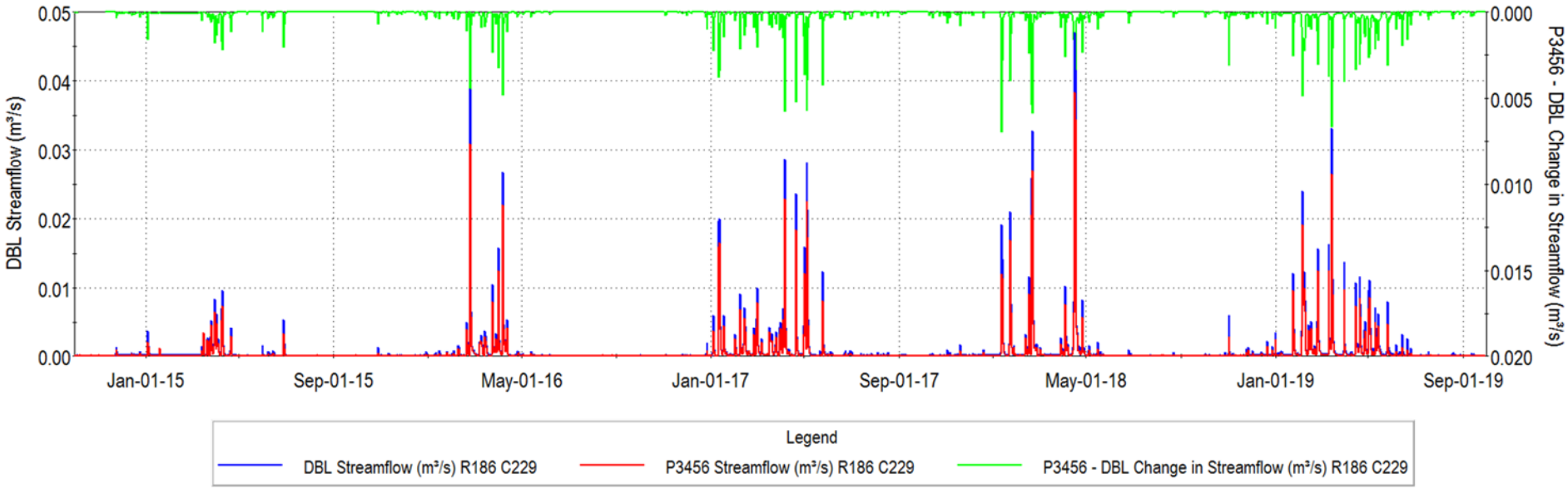
HEADWATER DRAINAGE FEATURE H2 - GRAPH 2

Simulated Streamflow Change - Integrated Model
Headwater Drainage Feature H2

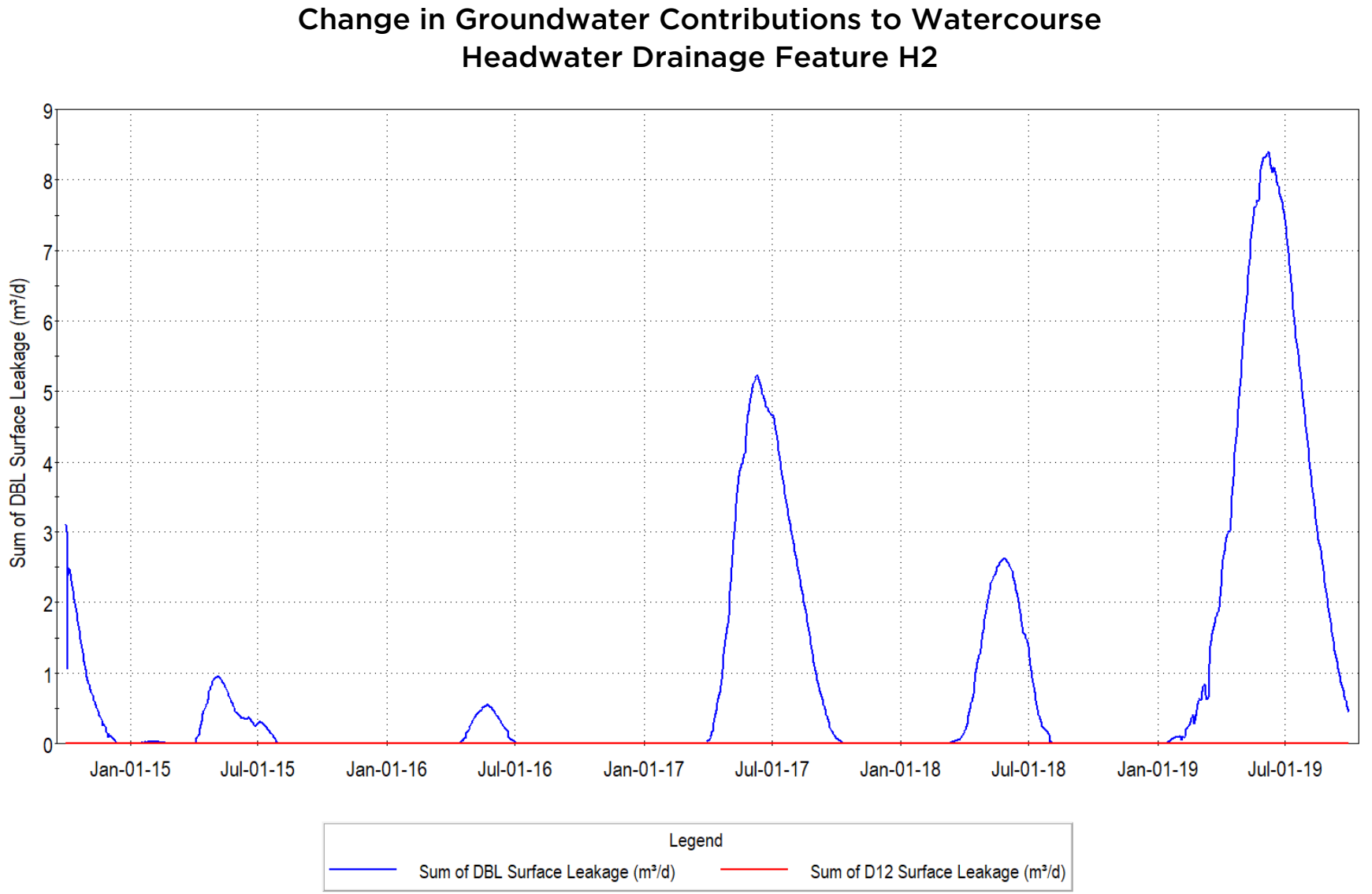


HEADWATER DRAINAGE FEATURE H2 - GRAPH 3

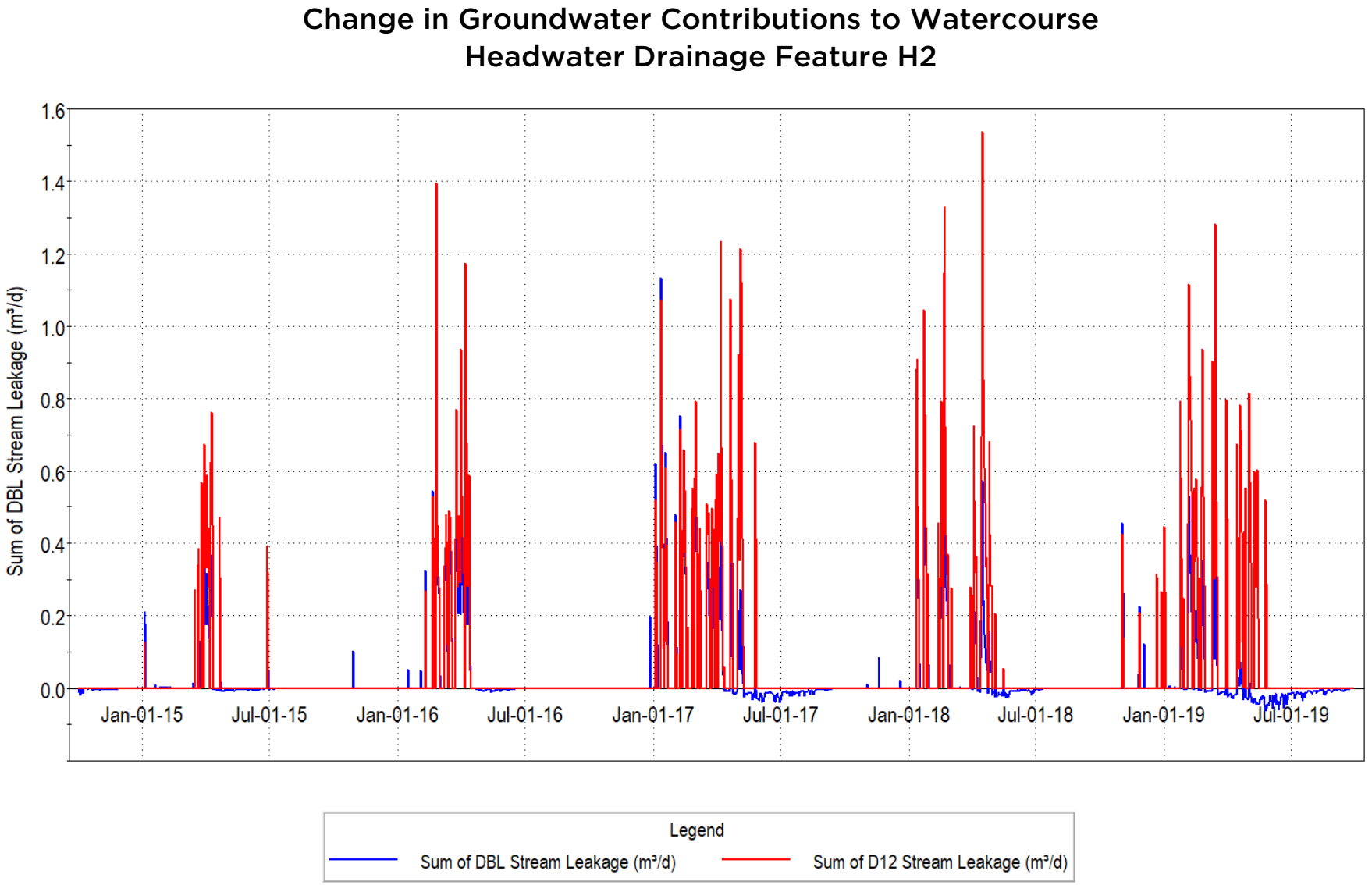
Simulated Streamflow Change - Integrated Model
Headwater Drainage Feature H2



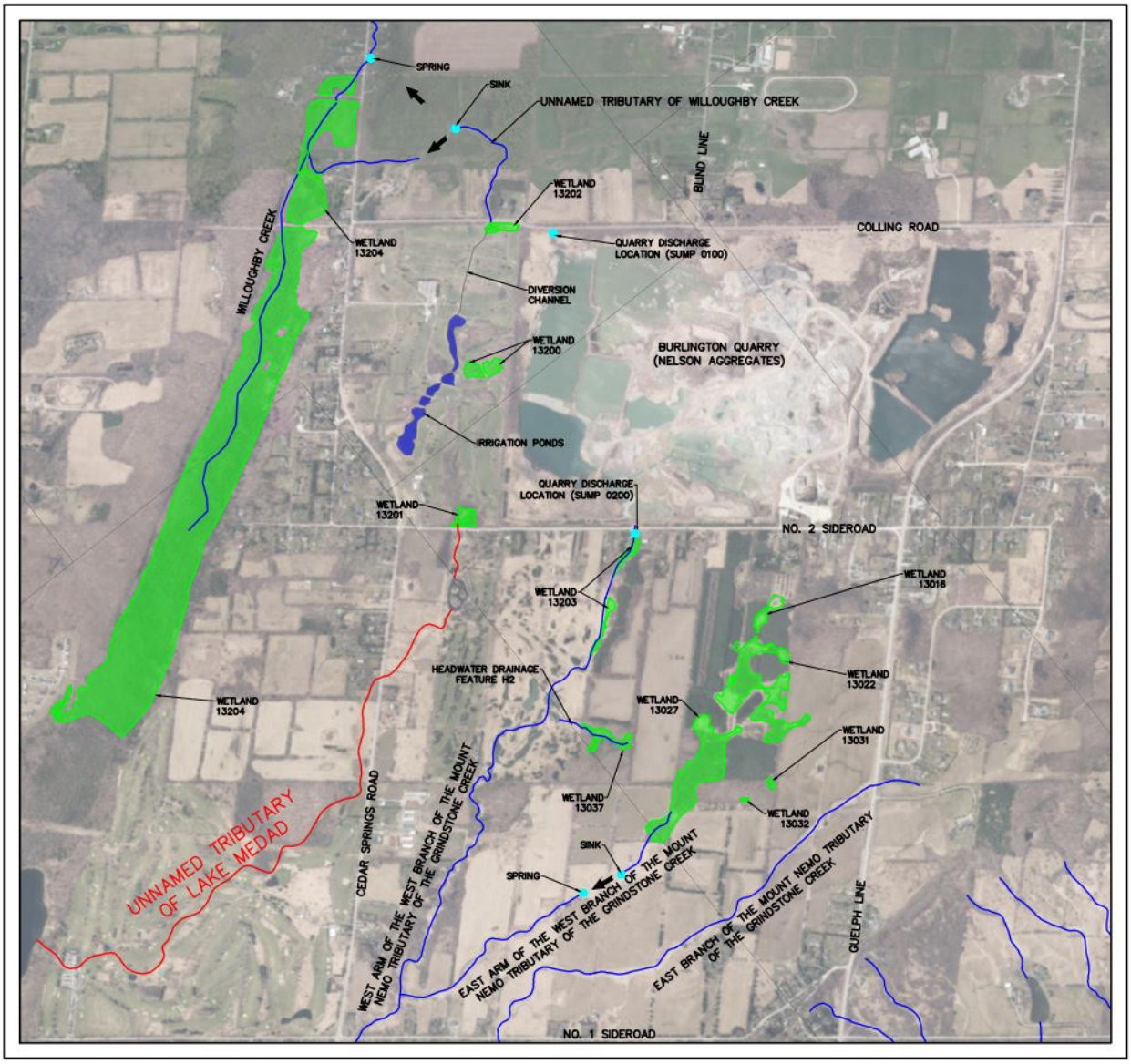
HEADWATER DRAINAGE FEATURE H2 - GRAPH 4



HEADWATER DRAINAGE FEATURE H2 - GRAPH 5



UNNAMED TRIBUTARY OF LAKE MEDAD



West Extension

Willoughby Creek

Unnamed Tributary of Lake Medad

West Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek

Lake Medad

Milloughby Line

Sideroad 2

Cedar Springs Court

Cedar Springs Road

SW14

DW-3

M34

BS-04

SW36

M33

Well 5

SW29

Legend

- Licensed Boundary
- Limit of Extraction
- 120 m Adjacent Lands
- Subject Lands
- Unnamed Tributary of Lake Medad
- Road
- Indirect Fish Habitat
- Direct Fish Habitat
- Watercourse
- Waterbody
- Wetland (Savanta, 2020)

Current Instrumentation

- Groundwater Monitoring Station (EarthFx)
- Mini Piezometer (Tatham Engineering)
- Staff Gauge & Surface Water Monitoring Station (Tatham Engineering)
- Manual Stream Flow Measurement (Tatham Engineering)

Previous Instrumentation

- Groundwater Monitoring Station (Golder)

NOTES:

1. Coordinate System: NAD 1983 UTM Zone 17N.
2. Base features produced under license with the Ontario Ministry of Natural Resources and Forestry © Queen's Printer for Ontario, 2021.
3. Orthoimagery © First Base Solutions, 2021. Imagery taken in 2019.

Project 8133

Burlington Quarry Extension
Nelson Aggregates Co.

Figure 14
Watercourse Characterization

Unnamed Tributary of Lake Medad

0 130 m

1:7,000

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Path: C:\Savanta\8133 - Burlington Quarry\figures\report_figures\2021 01 21 natural feature tech summary\8133_rpt_watercourse_char_mapbook.mxd Date: April 8, 2021

Unnamed Tributary of Lake Medad

Surface Water Characteristics	Description	Figure / Graph / Table	Reference	
			Report	Section / Page
Watercourse Name:	Unnamed Tributary of Lake Medad			
Watershed:	Grindstone Creek Watershed			
Sub-Watershed:	Lake Medad			
Located in Proposed Limit of Extraction:	No			
Located in Proposed License Boundary:	No			
Catchment Area (ha):	138 ha (at Lake Medad)			
Catchment ID:	N/A			
Primary Source(s) of Flow:	Surface runoff			
Discharge from Quarry / PTTW:	No			
Conditions of PTTW:	Not applicable			
Surface Water Monitoring:	ID: SW29 (Tatham) Installation Date: October 25, 2018 Data Collection: Continuous water level and temperature, manual monthly in-situ streamflow measurements and calibration data (water level converted to flow using rating curve) Coordinates of Monitoring Station: Easting 590180.497, Northing 4804363.89	Graphs 1 & 2 and Table 1	SWA (Tatham, April 2020)	2.1.2, Appendix C and Appendix H
Streamflow Conditions:	Intermittent	Graphs 1 & 2 and Table 1	SWA (Tatham, April 2020)	2.1.2 and Appendix C
Average Daily Flow (SW29):	Average Daily Streamflow (L/s)	Graphs 1	SWA (Tatham, April 2020)	2.1.2 and Appendix C

Month	Minimum	Average	Maximum
January	N/A	N/A	N/A
February	N/A	N/A	N/A
March	3.3	7.3	21.1
April	1.9	4.6	8.6
May	1.0	2.8	5.8
June	0.0	0.6	2.2
July	0.0	0.0	0.2
August	0.0	0.0	0.0
September	0.0	0.0	0.0
October	0.0	0.0	0.0
November	0.2	0.9	4.4
December	0.4	0.8	2.2

Notes:

Minimum - lowest daily average streamflow recorded for period of record

Average - average daily streamflow recorded for period of record

Maximum - maximum daily average streamflow recorded for period of record

N/A - data not available as device removed from watercourse during winter months

Unnamed Tributary of Lake Medad

Watercourse Thermal Regime (SW29):

Average Daily Water Temperature (°C)

Month	Minimum	Average	Maximum
January	N/A	N/A	N/A
February	N/A	N/A	N/A
March	-0.6	0.6	9.0
April	-0.1	6.2	14.8
May	4.9	11.4	18.6
June	10.4	15.5	26.4
July	11.6	18.8	28.3
August	Dry	Dry	Dry
September	Dry	Dry	Dry
October	Dry	Dry	Dry
November	-3.9	3.0	8.2
December	1.3	2.2	4.5

Notes:

Minimum - lowest daily average streamflow recorded for period of record

Average - average daily streamflow recorded for period of record

Maximum - maximum daily average streamflow recorded for period of record

N/A - data not available as device removed from watercourse during winter months

Graph 2

SWA (Tatham, April 2020)

2.1.2 and Appendix C

Water Quality (SW29):

Water Quality Sample Results

Parameter	Units	Minimum	Average	Maximum
Turbidity	NTU	11.3	11.8	12.3
TDS	mg/L	437	469	500
TSS	mg/L	7.67	10.49	13.30
COD	mg/L	32	32	32
BOD5	mg/L	1.3	1.4	1.5
DOC	mg/L	8.1	9.8	11.4
pH		7.8	7.9	8
Alkalinity	mg/L	257	312	366
Conductivity	µS/cm	648	763	878
Phosphorus	ug/L	<50	77	104
Ammonia	mg/L	0.01	0.05	0.08
Hardness	mg/L	271	305	338

Table 1

SWA (Tatham, April 2020)

2.4 and Appendix H

Unnamed Tributary of Lake Medad

Fish & Fish Habitat Features	Description	Figure / Graph / Table	Reference	
			Report	Section / Page
Fish Habitat (Direct/Indirect and Assumed/Confirmed):	1) The uppermost reach of the watercourse (i.e., within 150 m downstream from the head of the watercourse at Sideroad No. 2) does not appear capable of providing direct fish habitat, based on aerial photo analysis, given a lack of a defined channel. Therefore, this portion of the watercourse is assumed to provide indirect fish habitat. 2) The remainder of the watercourse (i.e., beyond 150 m downstream from Sideroad No. 2) is assumed to provide direct fish habitat, although no fish community sampling is known to have been completed to confirm this assumption. There is a series of online ponds associated with the adjacent golf course approximately 150 m downstream from Sideroad No. 2 and there is a high probability that these ponds contain fish, as they appear to be permanent features.		NETR (Savanta, April 2020)	45 and Figure 9a
Fish Species Present:	No information on fish species present is known to exist.			
Fish Community Thermal Regime:	No information on fish community thermal regime is known to exist. Based on the presence of large, online ponds on the adjacent golf course, it is expected that a primarily warmwater fish community would be present.			
Fish Habitat Types Present:	No information on fish habitat types is known to be available for this watercourse.			
Habitat Uses by Known Fish Community:	The local fish community likely uses the off-site habitat for the complete range of life history processes including spawning, nursery, foraging and overwintering (in the online ponds or Lake Medad, given the intermittent nature of the watercourse).			
Known Barriers to Fish Movement:	There are no known barriers to fish movement in this watercourse.			

Groundwater Interaction	Description	Figure / Graph / Table	Reference	
			Report	Section / Page
Underlying Deposits:	Halton Till. The harmonic mean hydraulic conductivity, based on testing by Golder (2007) of 10 mini-piezometers, was $1.2x10^{-8}$ m/s. Model value for the vertical hydraulic conductivity was $1.6x10^{-7}$ m/s, about an order of magnitude higher, to account for limited flow through fractures in the till.			
Surface Water / Groundwater Interactions:	Seasonal groundwater contributions to watercourse. Groundwater seepage under baseline conditions during spring months equates to 1 L/s or less. Groundwater seepage is at its maximum during and immediately following the spring freshet.	Figures 1 & 2		
Water Budget Results:	The baseline condition water budget results from the integrated model are presented in Figure 3a. Condition / GW Out / GW In Baseline (Existing) / 21.81% / 5.06%	Figure 3a		
Integrated Model Calibration:	SW29 monitors the watershed west of the South extension. Both the model and the observations suggest an intermittent, flashy watershed response. Simulated and observed streamflow at SW29 are presented in Earthfx (p. 415) for WY2017 to WY2019. The model slightly underpredicts the baseflows and overpredicts the peak flows. Uncertainty regarding the diversions of streamflow to the golf course ponds and rates of irrigation may be contributing to the poorer match at this gauge. Comparisons at the other gauges showed a similar pattern with very good matches to the east and west of the quarry and poorer matches to the southwest.	Graph 3	HHIAR (Earthfx, April 2020)	19.4.2 (page 415)

Unnamed Tributary of Lake Medad

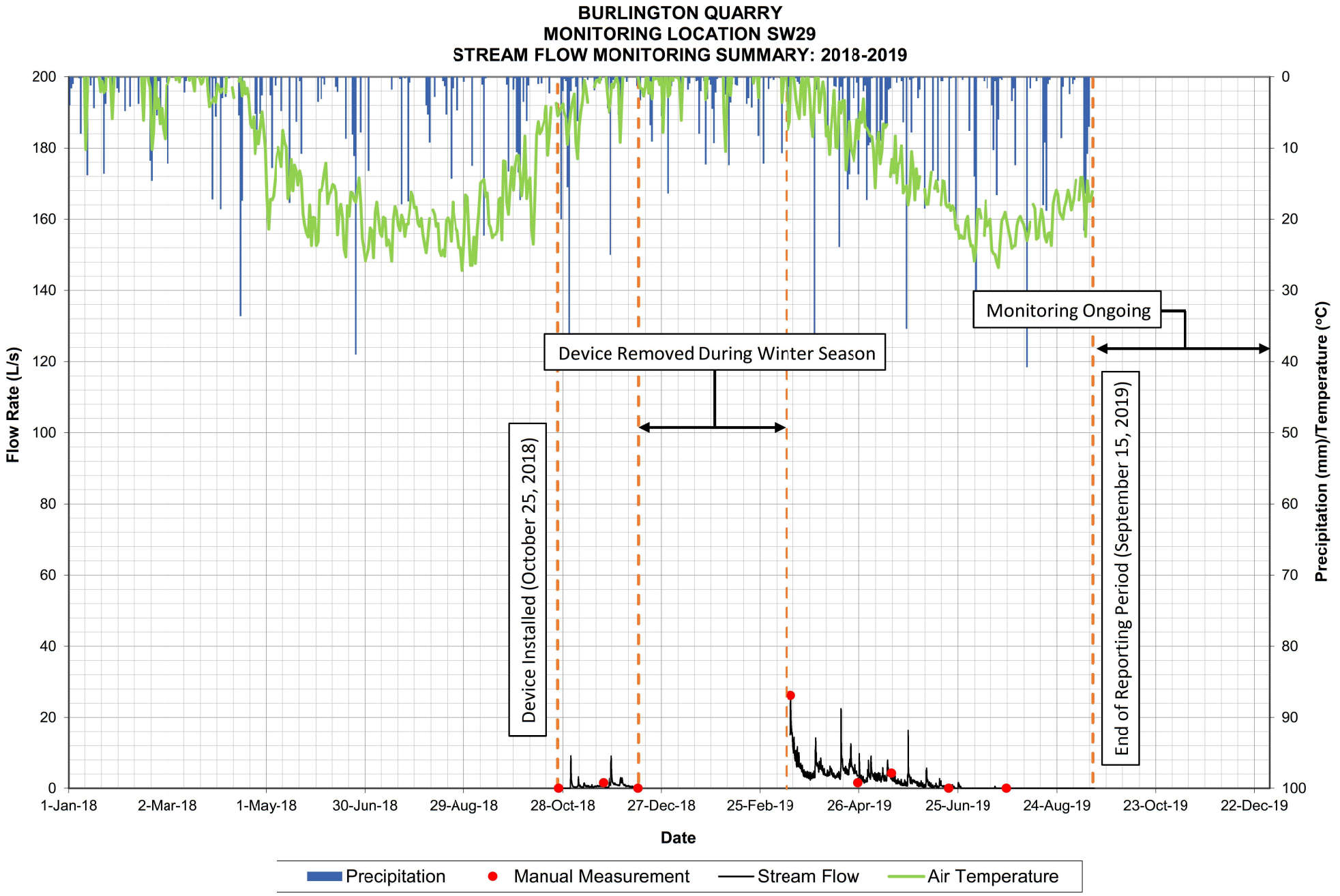
<table>
<tr><th>Impact Assessment</th><th>Description</th><th>Figure / Graph / Table</th><th colspan="2">Reference</th></tr>
<tr><th></th><th></th><th></th><th>Report</th><th>Section / Page</th></tr>
<tr><td>Direct Alterations to Watercourse:</td><td>No direct alterations to this watercourse are proposed.</td><td></td><td>NETR (Savanta, April 2020)</td><td>78</td></tr>
<tr><td>Change in Primary Source of Flow:</td><td>No change in surface water input as culvert under No. 2 Sideroad is plugged and there is no evidence of a connection between Wetland 13201 and the Unnamed Tributary of Lake Medad. Many streams are perched above the water table, they generally lose rather than gain flow from the groundwater system. The streams are primarily located in Halton Till, so the low permeability of the till limits GW/SW interactions.</td><td></td><td></td><td></td></tr>
<tr><td>Change in Watercourse Catchment Area:</td><td>Culvert under No. 2 Sideroad is plugged and there is no evidence of a culvert or watercourse immediately downstream. As such, extraction in west extension will not alter the catchment area of the Unnamed Tributary of Lake Medad.</td><td></td><td></td><td></td></tr>
<tr><td>Simulated Streamflow Change (Integrated Model Results):</td><td>The Earthfx report discusses changes in simulated streamflow under the different quarry expansion phases. Graph 4 reproduces Figure 8.7 (p. 201) and presents simulated baseline(red) and Scenario P12 (blue) flows at location SW29. Decreases in flow (green) are plotted in reverse on the upper X axis with the scale shown on the right Y axis. Very small decreases in streamflow, primarily in winter and spring, are predicted Phase 12 area.</td><td>Graphs 4 & 5</td><td>HHIAR (Earthfx, April 2020)</td><td>198 - 230 and 230 - 237</td></tr>
<tr><td>Water Budget Results (Operational Phases 1 & 2):</td><td>The Operational Phases 1 and 2 water budget results from the integrated model are presented in Figure 3b.
<table><tr><td>Condition</td><td>GW Outflow</td><td>GW Inflow</td><td>%Δ GW Outflow</td><td>%Δ GW Inflow</td></tr><tr><td>Baseline (Existing)</td><td>21.81%</td><td>5.06%</td><td>-</td><td>-</td></tr><tr><td>Phases 1 & 2</td><td>22.22%</td><td>2.30%</td><td>0.41%</td><td>-2.76%</td></tr></table></td><td>Figure 3b</td><td></td><td></td></tr>
<tr><td>Water Budget Results (Operational Phases 3 Through 6):</td><td>The Operational Phases 3 through 6 water budget results from the integrated model are presented in Figure 3c.
<table><tr><td>Condition</td><td>GW Outflow</td><td>GW Inflow</td><td>%Δ GW Outflow</td><td>%Δ GW Inflow</td></tr><tr><td>Baseline (Existing)</td><td>21.81%</td><td>5.06%</td><td>-</td><td>-</td></tr><tr><td>Phases 3 through 6</td><td>23.94%</td><td>1.91%</td><td>2.13%</td><td>-3.15%</td></tr></table></td><td>Figure 3c</td><td></td><td></td></tr>
<tr><td>Water Budget Results (Rehabilitation Scenario 1):</td><td>The Rehabilitation Scenario 1 water budget results from the integrated model are presented in Figure 3d.
<table><tr><td>Condition</td><td>GW Outflow</td><td>GW Inflow</td><td>%Δ GW Outflow</td><td>%Δ GW Inflow</td></tr><tr><td>Baseline (Existing)</td><td>21.81%</td><td>5.06%</td><td>-</td><td>-</td></tr><tr><td>Rehab Scenario 1</td><td>22.35%</td><td>3.34%</td><td>0.54%</td><td>-1.72%</td></tr></table></td><td>Figure 3d</td><td></td><td></td></tr>
<tr><td>Water Budget Results (Rehabilitation Scenario 2):</td><td>The Rehabilitation Scenario 2 water budget results from the integrated model are presented in Figure 3e.
<table><tr><td>Condition</td><td>GW Outflow</td><td>GW Inflow</td><td>%Δ GW Outflow</td><td>%Δ GW Inflow</td></tr><tr><td>Baseline (Existing)</td><td>21.81%</td><td>5.06%</td><td>-</td><td>-</td></tr><tr><td>Rehab Scenario 2</td><td>16.70%</td><td>10.90%</td><td>-4.21%</td><td>5.84%</td></tr></table></td><td>Figure 3e</td><td></td><td></td></tr>
<tr><td>Change in Groundwater Contributions to Watercourse:</td><td>The change in groundwater seepage in the SW29 stream catchment under Baseline conditions is shown in Graph 6. A reduction in seepage will occur under P3456 conditions due to a decline in groundwater levels due to the excavation. The change in stream leakage between Baseline and P3456 is shown in Graph 7. The changes reflect a lowering of the water table. Groundwater seepage under baseline conditions during spring months equates to 1 L/s or less.</td><td>Graphs 6 and 7</td><td></td><td></td></tr>
<tr><td>Change in Watercourse Thermal Regime:</td><td>No negative impacts on temperature expected.</td><td></td><td></td><td></td></tr>
<tr><td>Change in Water Quality:</td><td>No negative impacts on water quality expected.</td><td></td><td></td><td></td></tr>
</table>

Unnamed Tributary of Lake Medad

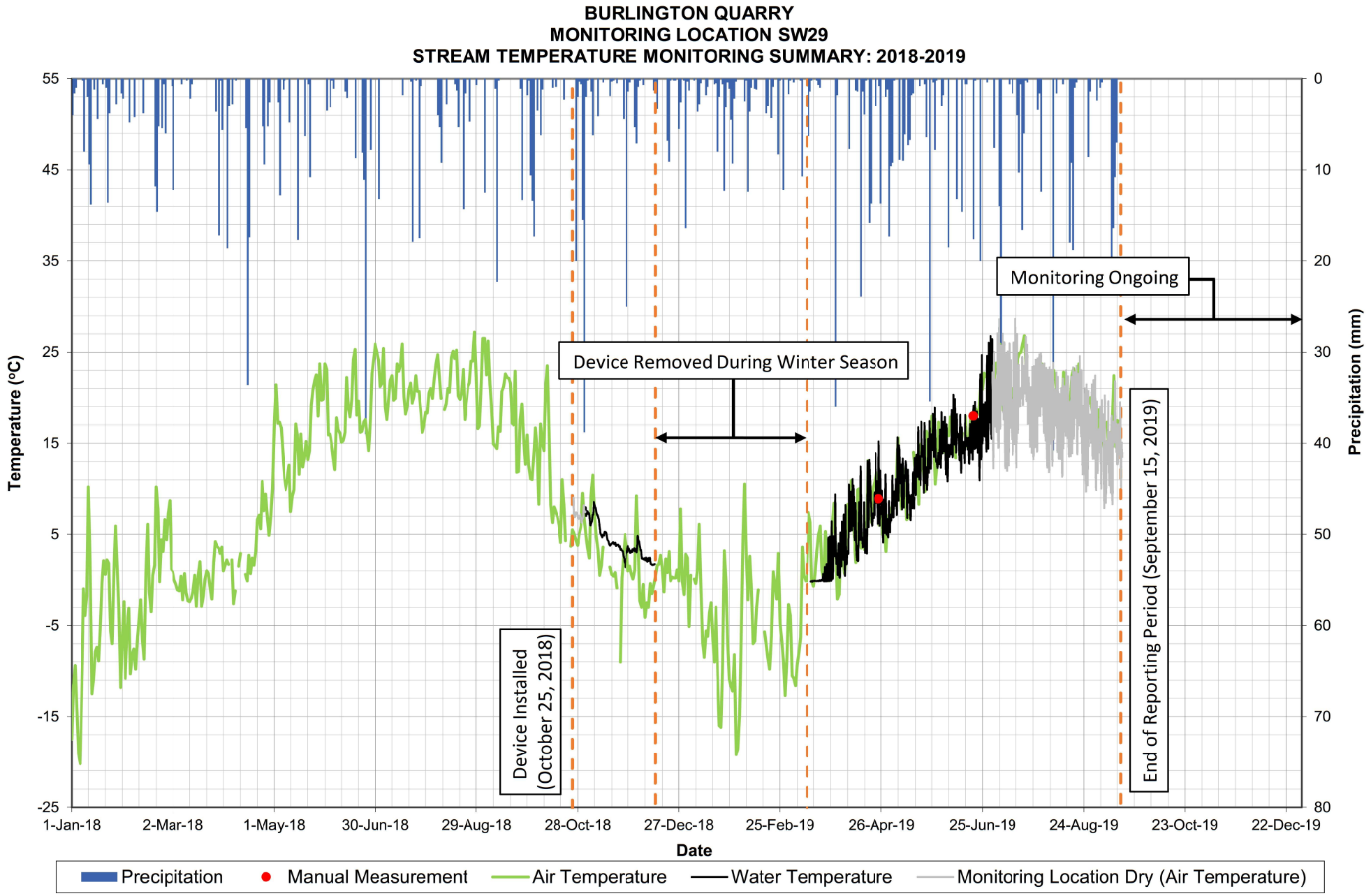
Impact Assessment	Description	Figure / Graph / Table	Reference	
			Report	Section / Page
Potential Impact to Form and Function of Feature:	Unmitigated flow reductions could have negative impacts on habitat availability during low flow (baseflow) periods through reductions in wetted width and depth and limiting movements throughout the watercourse.		NETR (Savanta, April 2020)	78
Potential Impact to Identified Species and Habitat:	Unmitigated flow reductions could have negative impacts on fish species in the watercourse (e.g., lack of access to sufficient habitat, concentrating fish in residual features, increased competition for resources, increased vulnerability to predators).		NETR (Savanta, April 2020)	78

Mitigation	Description	Figure / Graph / Table	Reference	
			Report	Section / Page
Direct Alteration Mitigation:	No direct alterations are proposed; therefore, no mitigation is required.		NETR (Savanta, April 2020)	75
Source Water Mitigation:	None required. Primary source of flow is surface runoff and catchment area will not be altered.			
Groundwater Contribution Mitigation:	None required. Groundwater contributions under baseline conditions equate to 1 L/s or less and overall percent change predicted at approximately 3%.			
Erosion Mitigation:	None required.			
Thermal Mitigation:	None required.			
Water Quality Mitigation:	None required.			

TRIBUTARY OF LAKE MEDAD - GRAPH 1



TRIBUTARY OF LAKE MEDAD - GRAPH 2



* Grey data indicates the monitoring location was dry and therefore the recorded values are respresentative of the air temperature.

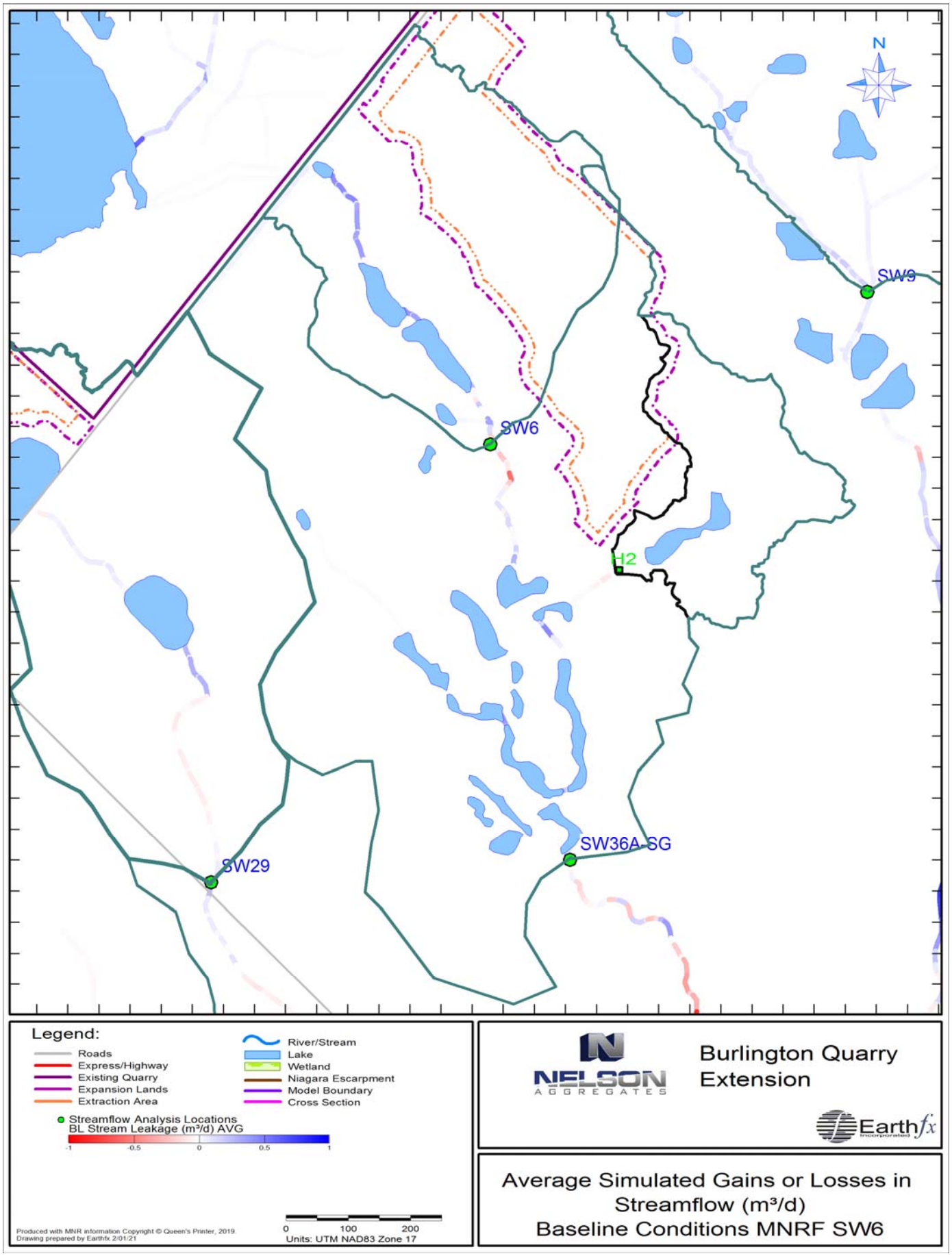
TRIBUTARY OF LAKE MEDAD - TABLE 1

BURLINGTON QUARRY
TATHAM ENGINEERING PROJECT NO.: 113187
SURFACE WATER MONITORING

WATER QUALITY SAMPLE RESULTS

Monitoring Location SW29													
		Sample Date:	24-Oct-18	24-Apr-19	19-Jun-19	25-Sep-19	20-May-20	15-Jul-20	16-Sep-20	11-Nov-20	Maximum	Minimum	Average
Parameter:	Units:	M.D.L.	CM/JG	CM/JG	CM	CM	JG	JG/JH/JM	JH/JM	JG/JH			
M-Alkalinity (pH 4.5)	mg/L as CaCO3	2		257	366						366	257	311.5
Ammonia (as N)	mg/L	0.01		0.01	0.08						0.08	0.01	0.05
BOD (5 day)	mg/L	1		1.3	1.5						1.5	1.3	1.4
Bicarbonate	mg/L as CaCO3	1		255							255	255	255
Carbonate	mg/L as CaCO3	1		2							2	2	2
Conductivity	µS/cm	1		648	878						878	648	763
Dissolved Organic Carbon	mg/L	0.4		8.1	11.4						11.4	8.1	9.8
Field pH	pH	N/A			8.3						8.3	8.3	4.2
Field Temp	°C	N/A			18						18.0	18.0	9.0
Aluminum	ug/L	1		113	79						113	79	96
Antimony	ug/L	0.5		<0.5	<0.5						<0.5	<0.5	0.5
Arsenic	ug/L	1		<1	1						1	1	1
Barium	ug/L	1		36	34						36	34	35
Beryllium	ug/L	0.5		<0.5	<0.5						<0.5	<0.5	0.5
Bismuth	ug/L	1		<1	<1						<1	<1	1
Boron	ug/L	2		10	<2						10	10	6
Cadmium	ug/L	0.1		<0.1	<0.1						<0.1	<0.1	0.1
Calcium	ug/L	500		71900	92100						92100	71900	82000
Cerium	ug/L	1		<1	<1						<1	<1	1
Cesium	ug/L	1		<1	<1						<1	<1	1
Chromium	ug/L	1		5	7						7	5	6
Cobalt	ug/L	0.1		0.2	0.3						0.3	0.2	0.25
Copper	ug/L	1		2	4						4	2	3
Europium	ug/L	1		<1	<1						<1	<1	1
Gallium	ug/L	1		<1	<1						<1	<1	1
Iron	ug/L	20		232	511						511	232	372
Lanthanum	ug/L	1		<1	<1						<1	<1	1
Lead	ug/L	0.1		0.5	0.5						0.5	0.5	0.5
Lithium	ug/L	5		<5	<5						<5	<5	5
Magnesium	ug/L	5		22200	26300						26300	22200	24250
Manganese	ug/L	10	DRY	51	529	DRY	DRY	DRY	DRY	DRY	529	51	290
Mercury	ug/L	0.1		<0.1	<0.1						<0.1	<0.1	0.1
Molybdenum	ug/L	1		<1	1						1	1	1
Nickel	ug/L	1		3	4						4	3	4
Niobium	ug/L	1		<1	<1						<1	<1	1
Phosphorus	ug/L	50		<50	104						104	104	77
Potassium	ug/L	1		2510	324						2510	324	1417
Rubidium	ug/L	1		<1	<1						<1	<1	1
Scandium	ug/L	1		<1	<1						<1	<1	1
Selenium	ug/L	0.5		0.7	<0.5						0.7	0.7	0.6
Silicon	ug/L	2		2600	2280						2600	2280	2440
Silver	ug/L	0.1		<0.1	<0.1						<0.1	<0.1	0.1
Sodium	ug/L	1000		31500	66400						66400	31500	48950
Strontium	ug/L	1		432	483						483	432	458
Sulphur	ug/L	800		11100	5920						11100	5920	8510
Tellurium	ug/L	1		<1	<1						<1	<1	1
Thallium	ug/L	0.1		<0.1	<0.1						<0.1	<0.1	0.1
Thorium	ug/L	1		<1	<1						<1	<1	1
Tin	ug/L	1		<1	<1						<1	<1	1
Titanium	ug/L	1		3	2						3	2	2.5
Tungsten	ug/L	1		<1	<1						<1	<1	1
Uranium	ug/L	1		<1	<1						<1	<1	1
Vanadium	ug/L	1		2	2						2	2	2
Yttrium	ug/L	1		<1	<1						<1	<1	1
Zinc	ug/L	1		<1	21						21	21	11
Zirconium	ug/L	1		<1	<1						<1	<1	1
pH	pH	N/A		7.97	7.8						8.0	7.8	7.9
Total Hardness (as CaCO3)	mg/L	0.1		271	338						338	271	305
Chemical Oxygen Demand	mg/L	5		32	32						32	32	32
Total Dissolved Solids	mg/L	3		437	500						500	437	469
Total Suspended Solids	mg/L	0.67		13.3	7.67						13.30	7.67	10.49
Turbidity	NTU	0.1		12.3	11.3						12.3	11.3	11.8

TRIBUTARY OF LAKE MEDAD - FIGURE 1



TRIBUTARY OF LAKE MEDAD - FIGURE 2

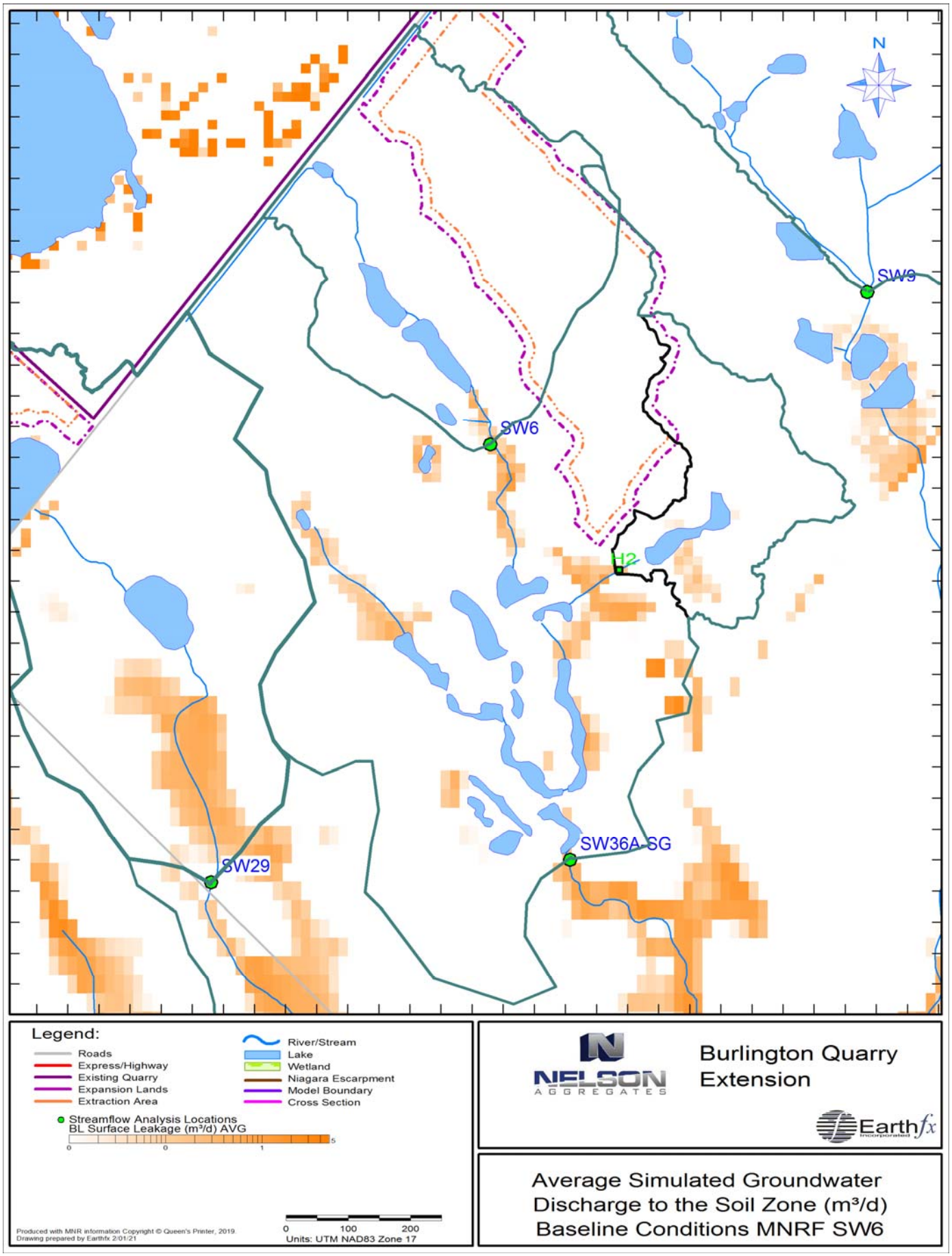


FIGURE 3A

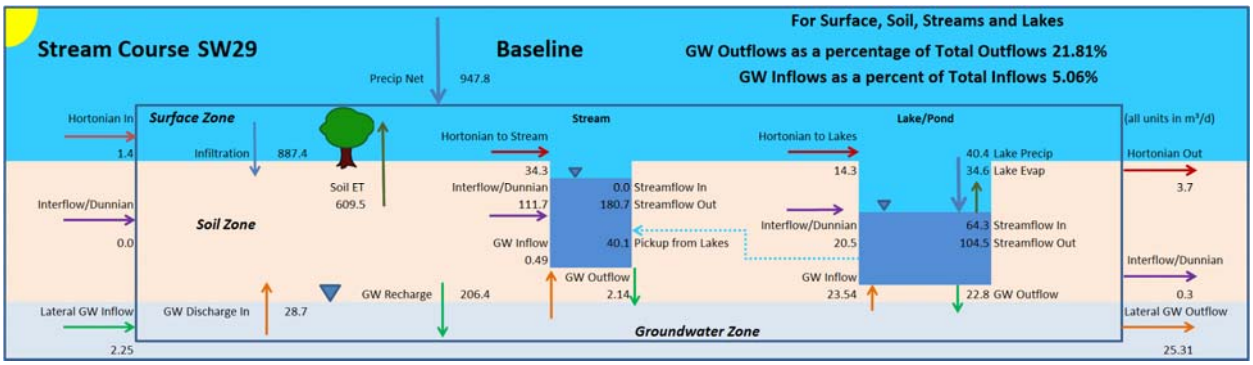


FIGURE 3B

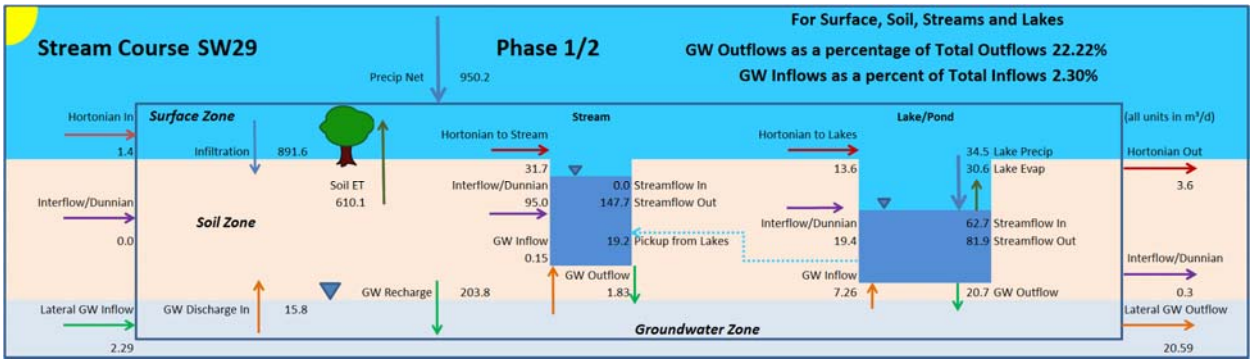


FIGURE 3C

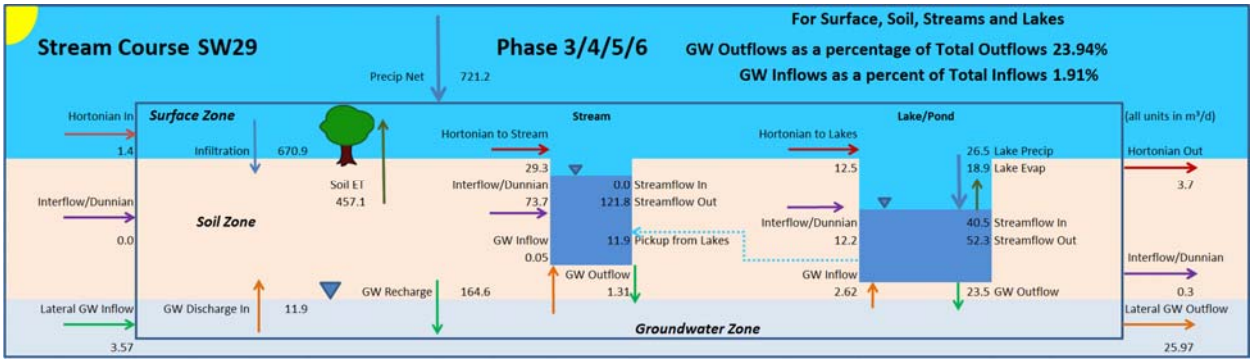


FIGURE 3D

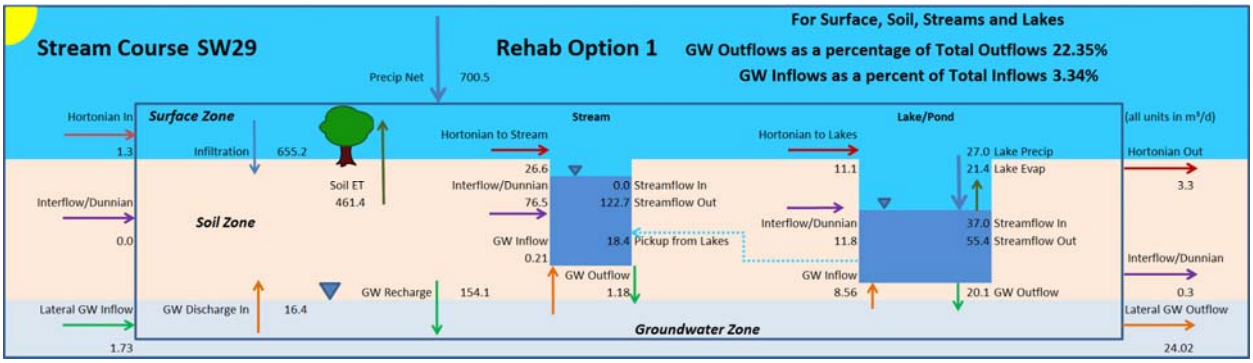
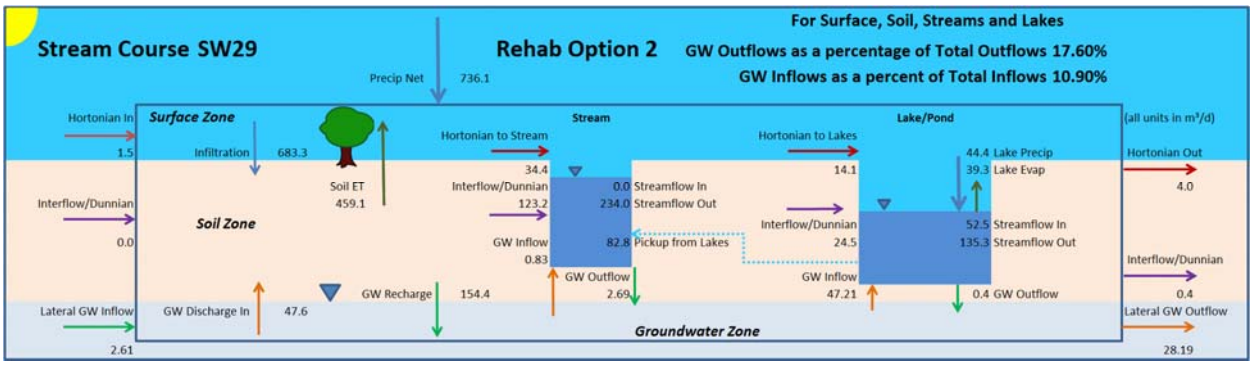
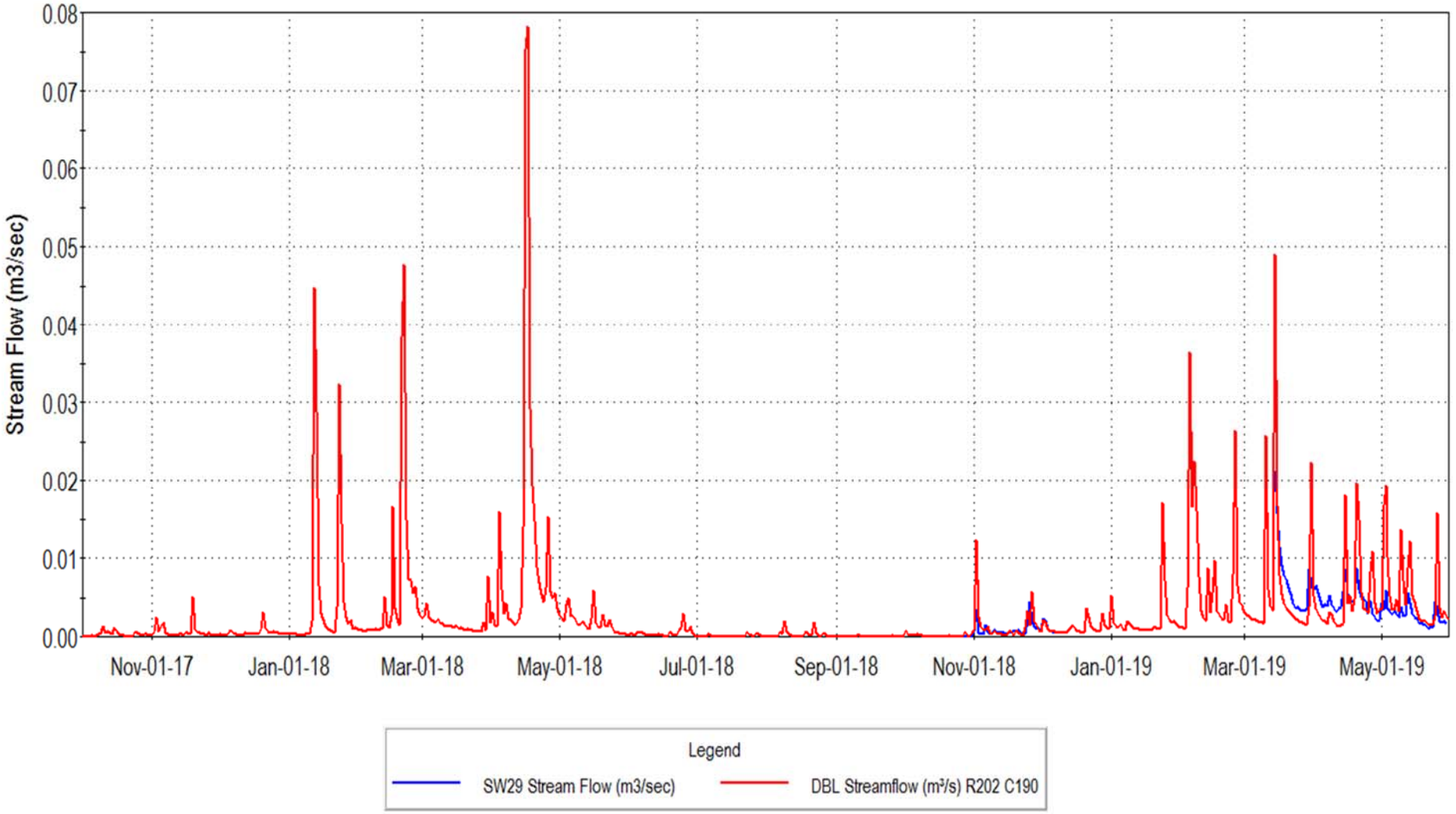


FIGURE 3E

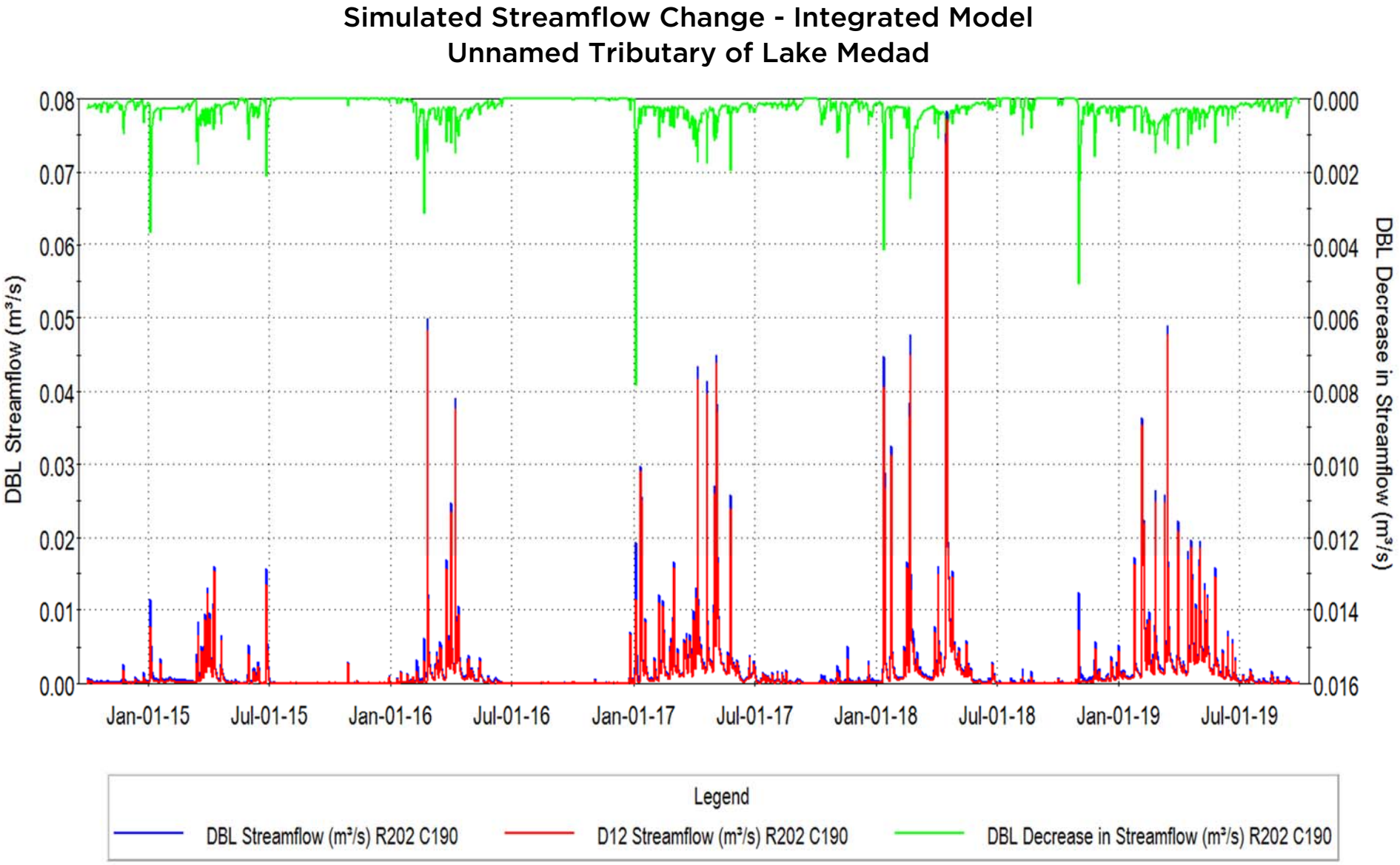


TRIBUTARY OF LAKE MEDAD - GRAPH 3

Integrated Model Calibration
Unnamed Tributary of Lake Medad

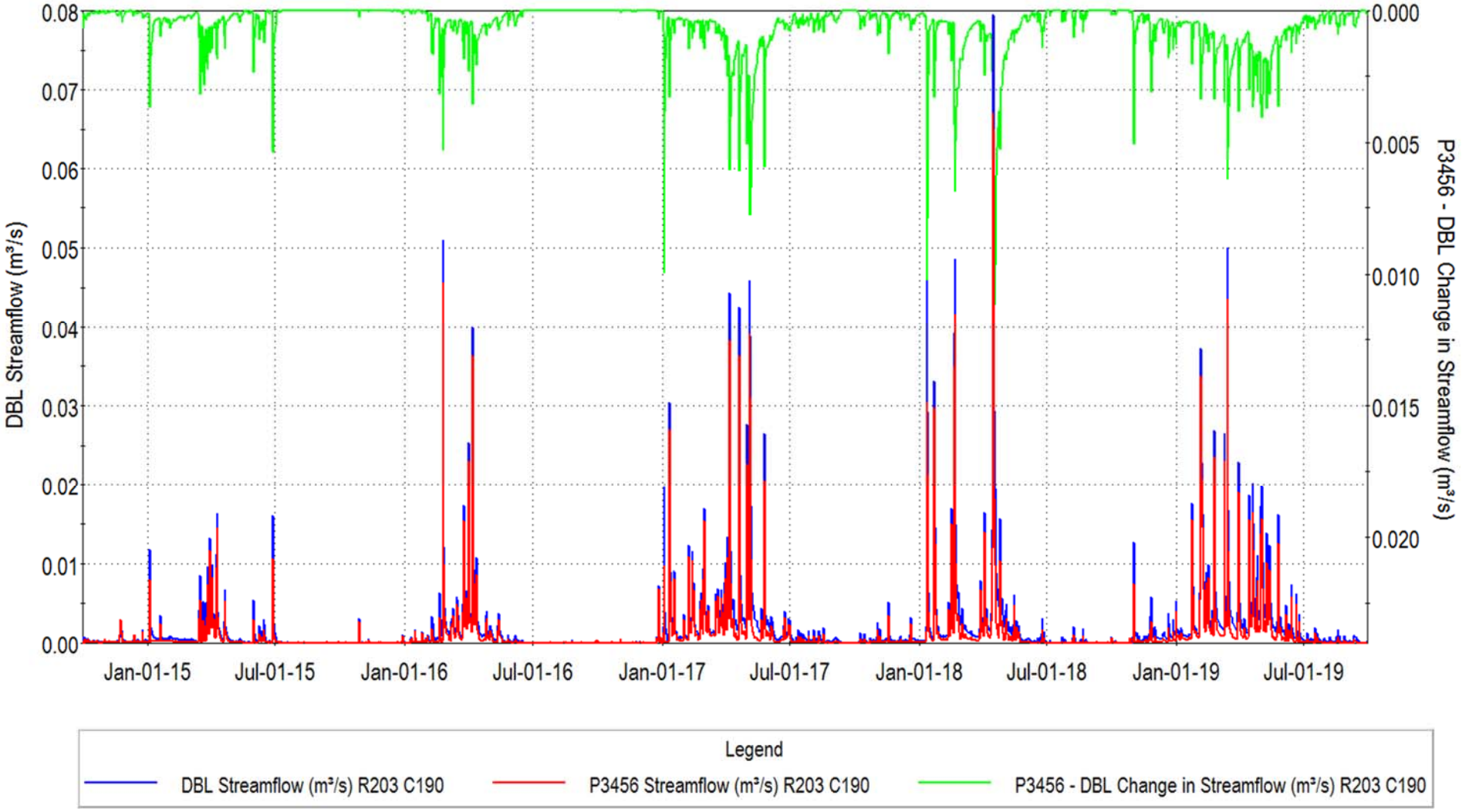


TRIBUTARY OF LAKE MEDAD - GRAPH 4

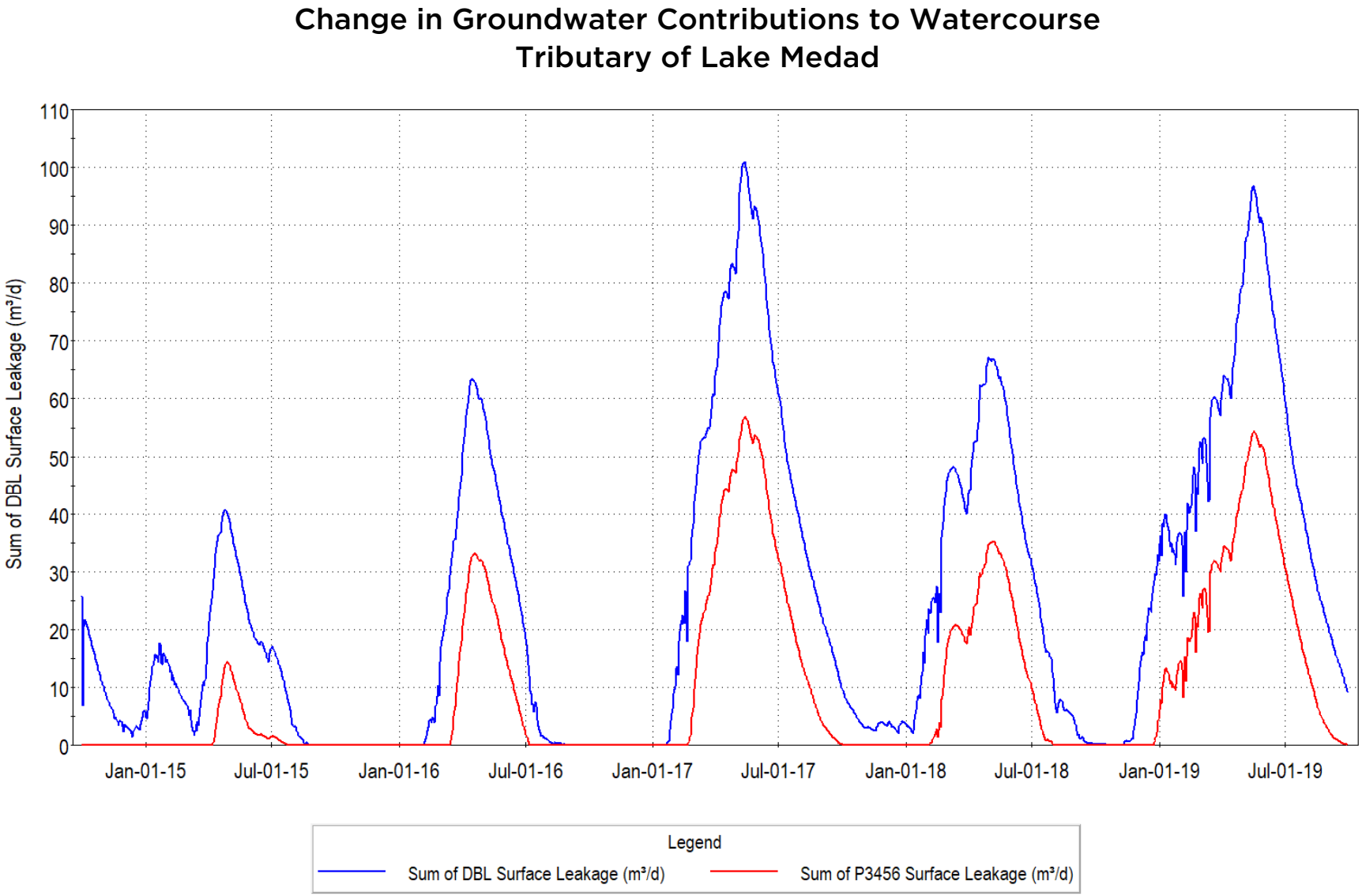


TRIBUTARY OF LAKE MEDAD - GRAPH 5

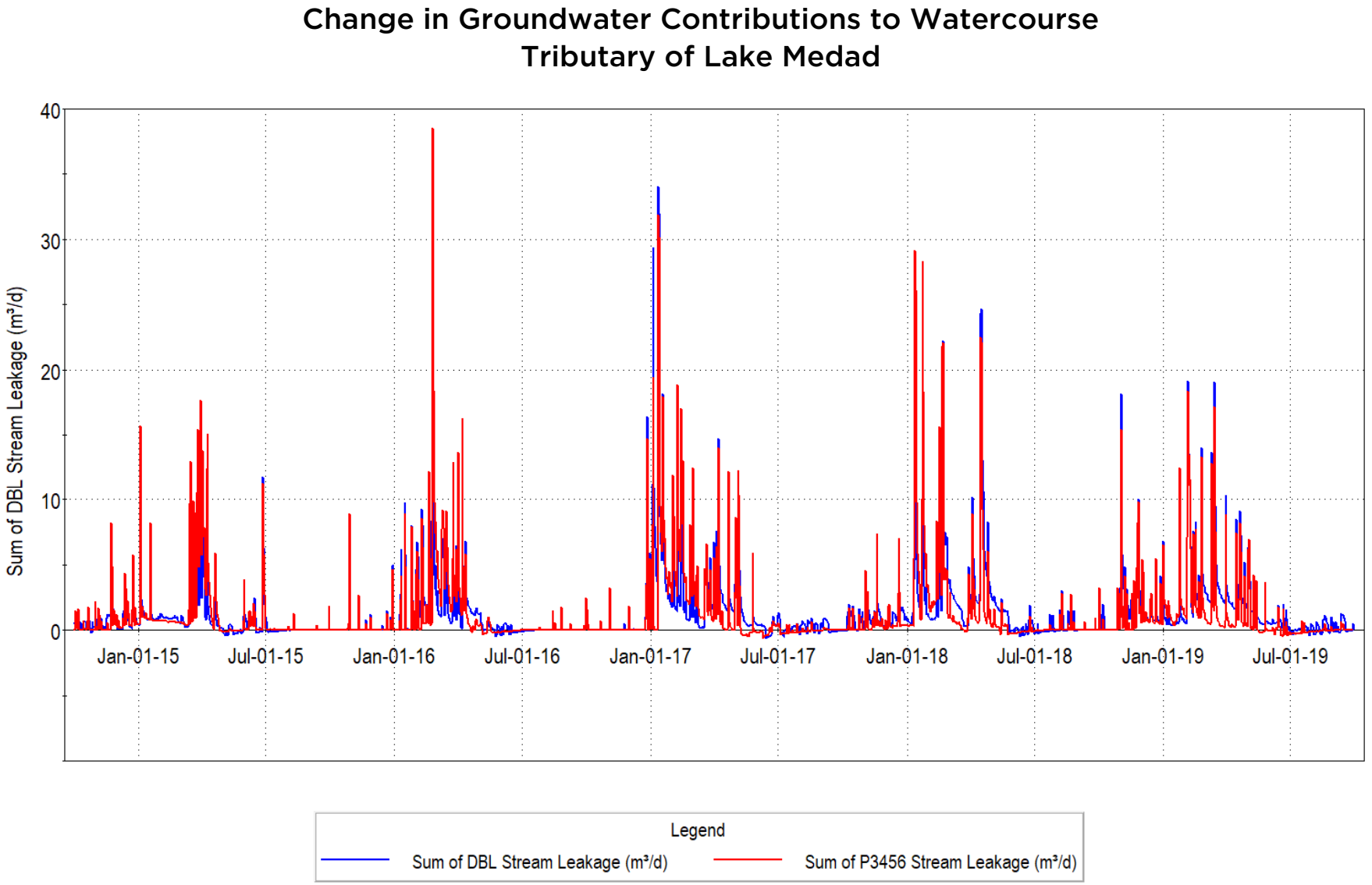
Simulated Streamflow Change - Integrated Model
Unnamed Tributary of Lake Medad



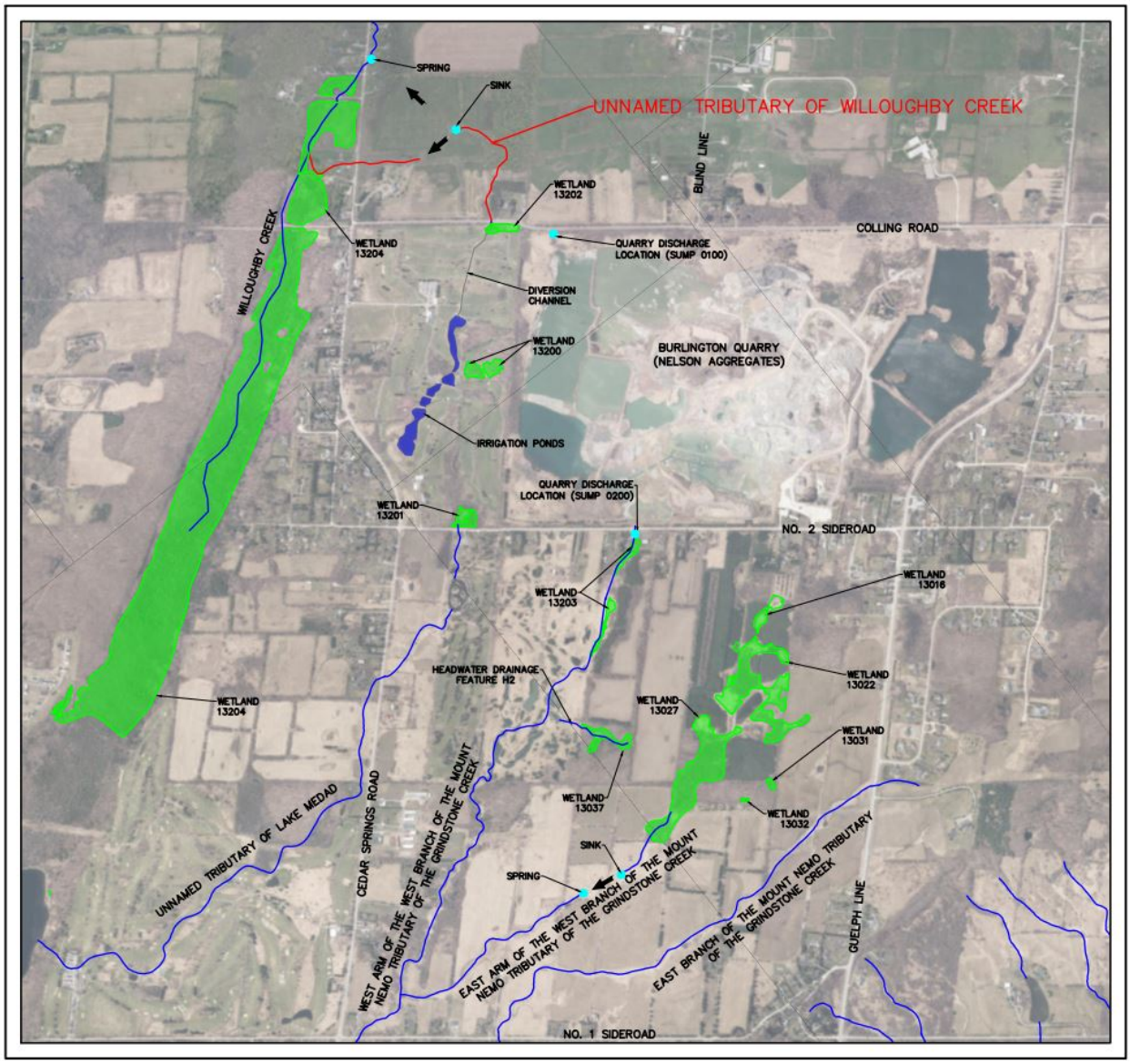
TRIBUTARY OF LAKE MEDAD - GRAPH 6

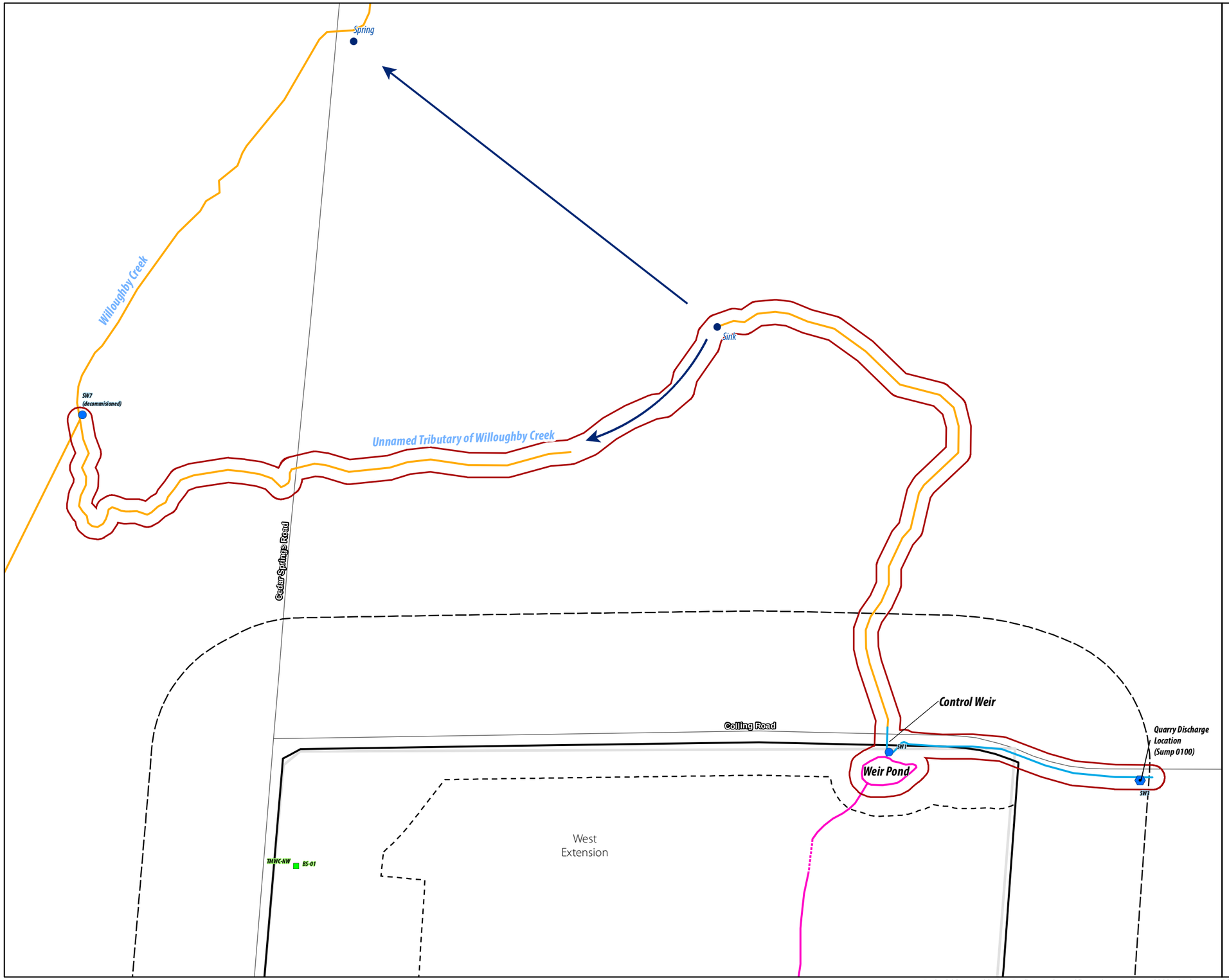


TRIBUTARY OF LAKE MEDAD - GRAPH 7



UNNAMED TRIBUTARY OF WILLOUGHBY CREEK





Legend

- Licensed Boundary
- Limit of Extraction
- 120 m Adjacent Lands
- Subject Lands
- Unnamed Tributary of Willoughby Creek
- Road
- Golf Course Irrigation Ponds and Channel
- Indirect Fish Habitat
- Direct Fish Habitat
- Watercourse
- Wetland (Savanta, 2020)

Current Instrumentation

- Staff Gauge & Surface Water Monitoring Station (Tatham Engineering)
- Manual Stream Flow Measurement (Tatham Engineering)

Previous Instrumentation

- Groundwater Monitoring Station (Golder)

NOTES:

1. Coordinate System: NAD 1983 UTM Zone 17N.
2. Base features produced under license with the Ontario Ministry of Natural Resources and Forestry © Queen's Printer for Ontario, 2021.
3. Orthoimagery © First Base Solutions, 2021. Imagery taken in 2019.

Project 8133

Burlington Quarry Extension
Nelson Aggregates Co.

Figure 13
Watercourse Characterization

Unnamed Tributary of Willoughby Creek

0 60 m

1:3,500

N

Path: C:\Savanta\8133 - Burlington Quarry\figures\report_figures\2021 01 21 natural feature tech summary\8133_rpt_watercourse_char_mapbook.mxd Date: April 8, 2021

Unnamed Tributary of Willoughby Creek

<table>
<tr><th>Surface Water Characteristics</th><th>Description</th><th>Figure / Graph / Table</th><th colspan="2">Reference</th></tr>
<tr><th></th><th></th><th></th><th>Report</th><th>Section / Page</th></tr>
<tr><td>Watercourse Name:</td><td>Unnamed Tributary of Willoughby Creek</td><td></td><td></td><td></td></tr>
<tr><td>Watershed:</td><td>Bronte Creek Watershed</td><td></td><td></td><td></td></tr>
<tr><td>Sub-Watershed:</td><td>Willoughby Creek Watershed</td><td></td><td></td><td></td></tr>
<tr><td>Located in Proposed Limit of Extraction:</td><td>No</td><td></td><td></td><td></td></tr>
<tr><td>Located in Proposed License Boundary:</td><td>Yes</td><td></td><td></td><td></td></tr>
<tr><td>Catchment Area (ha):</td><td>511 ha (at confluence with Willoughby Creek)</td><td></td><td></td><td></td></tr>
<tr><td>Catchment ID:</td><td>N/A</td><td></td><td></td><td></td></tr>
<tr><td>Primary Source(s) of Flow:</td><td>Primary - discharge from Burlington Quarry (Sump 0100)
Intermittent - discharge from Burlington Springs Golf and Country Club irrigation ponds and diversion channel
The outlet from the weir pond consists of a low flow by-pass pipe designed to convey a minimum baseflow of 2 L/s downstream when flow is available and a concrete weir that can be fitted with stop blocks to further control discharge. The concrete weir with stop blocks installed creates a backwater condition upstream, diverting water to the irrigation ponds on the Burlington Springs Golf & Country Club property. Water taking from the weir pond by the Burlington Springs Golf & Country Club occurs under the approval of PTTW Number 0624-8BXML3.</td><td></td><td></td><td></td></tr>
<tr><td>Discharge from Quarry / PTTW:</td><td>Yes - PTTW 96-P-3009</td><td></td><td>SWA (Tatham, April 2020)</td><td>Appendix A</td></tr>
<tr><td>Conditions of PTTW:</td><td>Maximum discharge rate = 4,090 L/min (68.17 L/s)
Maximum discharge amount = 5,889,600 L/day</td><td></td><td>SWA (Tatham, April 2020)</td><td>Appendix A</td></tr>
<tr><td>Surface Water Monitoring:</td><td>ID: SW1 (Tatham)
Installation Date: April 17, 2014
Data Collection: Continuous water level and temperature, manual monthly in-situ streamflow measurements and calibration data (water level converted to flow using rating curve)
Coordinates of Monitoring Station: Easting 589015.325, Northing 4805832.639</td><td>Graphs 1, 2 & 3 and Table 1</td><td>SWA (Tatham, April 2020)</td><td>2.1.1, Appendix B and Appendix H</td></tr>
<tr><td>Streamflow Conditions:</td><td>Intermittent (flow is dependent on quarry discharge); the tributary will dry out when quarry discharge ceases</td><td>Graphs 1, 2 & 3 and Table 1</td><td>SWA (Tatham, April 2020)</td><td>2.1.1 and Appendix B</td></tr>
<tr><td>Average Daily Flow (SW1):</td><td colspan="3">Average Daily Streamflow (L/s)
Month | Minimum | Average | Maximum
January | 0.0 | 92.3 | 226.9
February | 0.0 | 48.8 | 245.0
March | 0.0 | 28.7 | 68.0
April | 0.0 | 75.8 | 203.5
May | 0.0 | 86.6 | 249.6
June | 0.0 | 54.2 | 194.3
July | 0.5 | 48.5 | 313.3
August | 0.0 | 41.9 | 126.9
September | 0.6 | 48.3 | 147.2
October | 0.0 | 61.6 | 225.7
November | 0.0 | 102.9 | 549.8
December | 0.0 | 81.0 | 426.9</td><td>Notes:
Minimum - lowest daily average streamflow recorded for period of record
Average - average daily streamflow recorded for period of record
Maximum - maximum daily average streamflow recorded for period of record
N/A - data not available as device removed from watercourse during winter months</td><td>Graphs 1 & 2</td><td>SWA (Tatham, April 2020)</td><td>2.1.1 and Appendix B</td></tr>
</table>

Unnamed Tributary of Willoughby Creek

Watercourse Thermal Regime (SW1):

Average Daily Water Temperature (°C)

Month	Minimum	Average	Maximum
January	0.8	3.5	6.9
February	-0.9	3.5	6.8
March	-1.1	4.0	8.2
April	-0.8	7.6	14.6
May	7.5	13.5	19.1
June	14.6	19.4	28.9
July	18.9	23.0	28.5
August	17.3	23.6	32.3
September	15.9	21.5	29.5
October	8.4	14.3	21.1
November	1.1	8.5	14.4
December	0.2	4.9	8.5

Notes:

Minimum - lowest daily average water temperature recorded for period of record

Average - average daily water temperature recorded for period of record

Maximum - maximum daily average water temperature recorded for period of record

N/A - data not available as device removed from watercourse during winter months

Graph 3

SWA (Tatham, April 2020)

2.1.1 and Appendix B

Water Quality (SW1):

Water Quality Sample Results

Parameter	Units	Minimum	Average	Maximum
Turbidity	NTU	0.9	2.1	3.5
TDS	mg/L	517	564	597
TSS	mg/L	1	1.92	3.67
COD	mg/L	<5	9	12
BOD5	mg/L	1.0	1.4	2.4
DOC	mg/L	3.1	3.8	4.3
pH		7.97	8.01	8.03
Alkalinity	mg/L	112	152	180
Conductivity	µS/cm	742	784	877
Phosphorus	ug/L	<50	68.5	124
Ammonia	mg/L	0.02	0.04	0.11
Hardness	mg/L	277	318	340

Table 1

SWA (Tatham, April 2020)

2.4 and Appendix H

Unnamed Tributary of Willoughby Creek

Fish & Fish Habitat Features	Description	Figure / Graph / Table	Reference	
			Report	Section / Page
Fish Habitat (Direct/Indirect and Assumed/Confirmed):	1) The reach from the quarry discharge point to the Colling Road culvert has been identified as indirect fish habitat as no fish were captured in this reach during baseline fish community studies in 2019. The reach is directly connected to the Weir Pond on the golf course, which is known to contain a likely introduced population of Largemouth Bass. These fish may have access to portions of this watercourse reach, but these are excluded from the determination of providing indirect habitat, since once the drainage feature on the golf course is removed, the Largemouth Bass population will also be removed. Fish in the downstream portions of the reach (i.e., downstream from Colling Road) would not be able to move upstream into this reach based on the barrier provided by the weir at the downstream end of the Weir Pond. 2) The reach between Colling Road and the mouth of this Tributary at Willoughby Creek has been assumed to provide direct fish habitat. However, no fish community studies were possible in this reach due to private land access constraints. Conservation Halton does not have any information on the fish community of this reach and identifies it as "Unclassified Habitat" in the 2002 Bronte Creek Watershed Study. Although assumed to be present for the purposes of the NETR (Savanta 2020), the actual potential for fish in the upstream portions of this reach is limited by the presence of an underground flow section where the watercourse runs underground through karst features before re-emerging at two different locations. No upstream fish movement is expected to be possible past these two underground flow sections.		NETR (Savanta, April 2020)	19, 41-42 and Figure 9a
Fish Species Present:	1) Largemouth Bass are known to be present in the Weir Pond, although they were not confirmed in the Unnamed Tributary of Willoughby Creek upstream from the Weir Pond during baseline studies in 2019. 2) No information on fish species present downstream from Colling Road is available as no fish community studies are known to have been completed on the private lands where this watercourse flows.		NETR (Savanta, April 2020)	19, 41-42 and Figure 9a
Fish Community Thermal Regime:	N/A – No fish species that would be native to this watercourse have ever been captured (i.e., excluding Largemouth Bass known to be present in the drainage feature on the golf course).		NETR (Savanta, April 2020)	19, 41-42 and Figure 9a
Fish Habitat Types Present:	1) Indirect habitat - reach upstream from Colling Road provides contributing habitat functions (e.g., flow conveyance, water quality maintenance, allochthonous inputs from riparian vegetation, sediment transport) although limited by the presence of the Weir Pond and weir. 2) Fish habitat types present in the reach downstream from Colling Road have not been confirmed due to private land issues. Visual observations from the Colling Road shoulder indicate this portion of the watercourse consists of a natural channel with well-developed riparian vegetation (woodland). If fish are present, the reach would be expected to provide habitat for all necessary life history functions required to support the species (given barriers to upstream and downstream movement).		NETR (Savanta, April 2020)	19, 41-42 and Figure 9a
Habitat Uses by Known Fish Community:	N/A – no known fish community downstream from Colling Road culvert.		NETR (Savanta, April 2020)	19, 41-42 and Figure 9a
Known Barriers to Fish Movement:	1) Karst sink between Colling Road and Cedar Springs road would prevent upstream fish movement. 2) Overflow weir at the outlet of the Weir Pond on the golf course is a barrier to upstream movement.		NETR (Savanta, April 2020)	19, 41-42 and Figure 9a

Unnamed Tributary of Willoughby Creek

Groundwater Interaction	Description	Figure / Graph / Table	Reference	
			Report	Section / Page
Underlying Deposits:	Halton Till. The harmonic mean hydraulic conductivity, based on testing by Golder (2007) of 10 mini-piezometers, was $1.2x10^{-8}$ m/s. Model value for the vertical hydraulic conductivity is $1.6x10^{-7}$ m/s, approximately an order of magnitude higher, to account for limited flow through fractures in the till.			
Surface Water / Groundwater Interactions:	This reach is predominantly a losing stream up to the point where it disappears into the subsurface. There are, however, short periods of the year where the water table rises and discharges into the stream. The GW/SW interactions at a point 250 m downstream of Wetland 13202 are illustrated in Graph 4. The blue line on the graph shows the stage in the stream, which is fairly constant because of the quarry discharge. The red line shows the shallow groundwater levels, which seasonally rise up to (and slightly above) the stream stage. The green dotted line shows the GW discharge (right axis) into the riparian soil zone (this is shown in orange on the maps in Earthfx, 2020). The purple line shows stream leakage (right axis - loss of water from the stream to the GW system). In summary, the stream is mostly a losing stream, except for short periods when the water table is high.	Graph 4, Figures 1 & 2		
Water Budget Results:	The baseline condition water budget results from the integrated model are presented in Figure 3a. Condition / GW Out / GW In Baseline (Existing) / 25.17% / 21.97%	Figure 3a		
Integrated Model Calibration:	Section 19.4.2 (p.415) discusses the calibration of the model to North Quarry discharge. The north sump was simulated with a set of "generalized operating rules" based on information provided by Nelson and the PTTW. The rules define a 7 day per week discharge rate, with an extra stage-dependent discharge rule that kept the internal quarry pond from over-topping a specified level. Actual operations were more intermittent, but it is apparent in the data that the rules were followed more closely after January, 2016, as shown in Earthfx (p. 416) and reproduced below. Overall, the model appears to be effective at representing the north quarry discharge in recent times.	Graph 5	HHIAR (Earthfx, April 2020)	19.4.2 (page 415 & 416)

Unnamed Tributary of Willoughby Creek

Impact Assessment	Description	Figure / Graph / Table	Reference	
			Report	Section / Page
Direct Alterations to Watercourse:	1) The existing temporary weir just upstream from the Colling Road culvert (i.e., at the outflow of the Weir Pond) will be replaced with a permanent overflow weir plate. This will result in a direct alteration to instream habitat and temporary disruption due to in-water work. 2) A new inlet will be constructed at the edge of the Weir Pond to divert flow into the new pond (infiltration pond) proposed on the western side of the West Extension Area. Some encroachment of the inlet into the Weir Pond may occur during installation of the diversion pipe, resulting in potential direct and indirect impacts. 3) Removal of the golf course irrigation ponds and channels could potentially result in indirect effects on the downstream watercourse (e.g., erosion and sedimentation, water quality impacts).		NETR (Savanta, April 2020)	75
Change in Primary Source of Flow:	1) Quarry discharge from Sump 0100 represents the primary source of flow to the Unnamed Tributary of Willoughby Creek. Current quarry approvals permit this discharge to cease once quarry operations are complete. Cessation of quarry discharge into the Unnamed Tributary of Willoughby Creek would be expected to have a substantial negative impact on flow availability to support current fish habitat functions and fish community assumed to be present. As discussed in the Mitigation section below, it has been recommended that quarry discharge continue indefinitely at current levels to prevent these associated negative impacts. 2) Diversion from catchment area S101 (northwest of Colling Road) will alter surface water inputs to the Unnamed Tributary. Currently, this catchment area discharges directly to the quarry and the flow would be discharged to the Unnamed Tributary through Sump 0100. Nelson is proposing to redirect surface water drainage from catchment area S101 directly into the Unnamed Tributary at the existing quarry discharge point. Overall, this diversion will result in the same volume of water being discharged to the tributary, although, given it will no longer pass through the quarry, it is expected that the hydrological regime of this discharge will be more natural, with seasonal peaks. 3) Removal of the golf course irrigation ponds and channels will alter the hydrology of the watercourse, given that no water taking would be required from the watercourse to support irrigation and that during high flow periods, there will be no discharge from the golf course back to the feature. However, the proposed new pond (infiltration pond) west of the West Extension will draw water from the Weir Pond in the same manner as the existing irrigation ponds. Therefore, there will be no net change in source water hydrology.		NETR (Savanta, April 2020)	76 and 77
Change in Watercourse Catchment Area:	Increase in catchment area of 25.8 ha. Additional catchment area will drain to the existing quarry settling ponds and be discharged to the Unnamed Tributary via Sump 0100 at rates consistent with existing. Additional storage will be provided in the settling ponds to accommodate the additional flow as the discharge to the Unnamed Tributary will not change.		SWA (Tatham, April 2020)	Drawings DP-1, DP-2 and DP-3
Simulated Streamflow Change (Integrated Model Results):	The Earthfx report discusses changes in simulated quarry discharge to the North Quarry Pond. No change was expected under Scenario P12. Scenario P3456 is discussed in Section 8.7.5 (p. 243). Under P3456 conditions, current levels of quarry discharge will continue to pass through the 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 as the current golf course ditch and pond system. Figure 8.71(p. 254) shows that there will be an increase in flow through the Unnamed Tributary as a result of the diversion of flow along Colling Road, and that the flow will continue through the karst conduit as under current conditions. The increase in flow will enter the Medad Valley just downstream of SW7, so there will be no significant change downstream at SW2. Under RHB1, discharge continues to the north from the quarry sump 0100 and is similar to that of P3456. Under RHB2, surface water flow in the upper reaches of a Unnamed Tributary of Willoughby Creek and the West Arm of the West Branch of Mount Nemo Tributary of Grindstone Creek will cease when the quarry discharge is discontinued, resulting in possible impact to downstream fish habitat compared to baseline conditions (See Savanta, 2020 and Tatham, 2020 for details).		HHIAR (Earthfx, April 2020)	8.7.5 (page 243)

Unnamed Tributary of Willoughby Creek

<table>
<tr><th>Impact Assessment</th><th>Description</th><th>Figure / Graph / Table</th><th colspan="2">Reference</th></tr>
<tr><th></th><th></th><th></th><th>Report</th><th>Section / Page</th></tr>
<tr><td>Water Budget Results (Operational Phases 1 & 2):</td><td>The Operational Phases 1 and 2 water budget results from the integrated model are presented in Figure 3b.
<table>
<tr><td>Condition</td><td>GW Outflow</td><td>GW Inflow</td><td>%Δ GW Outflow</td><td>%Δ GW Inflow</td></tr>
<tr><td>Baseline (Existing)</td><td>25.17%</td><td>21.97%</td><td>-</td><td>-</td></tr>
<tr><td>Phases 1 & 2</td><td>26.38%</td><td>22.94%</td><td>1.21%</td><td>0.97%</td></tr>
</table></td><td>Figure 3b</td><td></td><td></td></tr>
<tr><td>Water Budget Results (Operational Phases 3 Through 6):</td><td>The Operational Phases 3 through 6 water budget results from the integrated model are presented in Figure 3c.
<table>
<tr><td>Condition</td><td>GW Outflow</td><td>GW Inflow</td><td>%Δ GW Outflow</td><td>%Δ GW Inflow</td></tr>
<tr><td>Baseline (Existing)</td><td>25.17%</td><td>21.97%</td><td>-</td><td>-</td></tr>
<tr><td>Phases 3 through 6</td><td>25.12%</td><td>21.11%</td><td>-0.05%</td><td>-0.86%</td></tr>
</table></td><td>Figure 3c</td><td></td><td></td></tr>
<tr><td>Water Budget Results (Rehabilitation Scenario 1):</td><td>The Rehabilitation Scenario 1 water budget results from the integrated model are presented in Figure 3d.
<table>
<tr><td>Condition</td><td>GW Outflow</td><td>GW Inflow</td><td>%Δ GW Outflow</td><td>%Δ GW Inflow</td></tr>
<tr><td>Baseline (Existing)</td><td>25.17%</td><td>21.97%</td><td>-</td><td>-</td></tr>
<tr><td>Rehab Scenario 1</td><td>26.08%</td><td>22.12%</td><td>0.91%</td><td>0.15%</td></tr>
</table></td><td>Figure 3d</td><td></td><td></td></tr>
<tr><td>Water Budget Results (Rehabilitation Scenario 2):</td><td>The Rehabilitation Scenario 2 water budget results from the integrated model are presented in Figure 3d.
<table>
<tr><td>Condition</td><td>GW Outflow</td><td>GW Inflow</td><td>%Δ GW Outflow</td><td>%Δ GW Inflow</td></tr>
<tr><td>Baseline (Existing)</td><td>25.17%</td><td>21.97%</td><td>-</td><td>-</td></tr>
<tr><td>Rehab Scenario 2</td><td>34.19%</td><td>32.35%</td><td>9.02%</td><td>10.38%</td></tr>
</table></td><td>Figure 3e</td><td></td><td></td></tr>
<tr><td>Change in Groundwater Contributions to Watercourse:</td><td>The unnamed tributary of Willoughby Creek is generally a losing stream. The change in stream stage and groundwater levels under Baseline and P3456 conditions at a point 250 m downstream of Wetland 13202 is shown in Graph 6. The P3456 drawdown in groundwater levels prevents the upwelling of groundwater that occurred intermittently under baseline conditions at this point in the reach. This example illustrates the change in conditions at one point in the stream; the overall change in leakage is discussed next. During P3456 the overall average net stream leakage to groundwater from this tributary will increase from a Baseline rate of 98.23 m^3/d to 143.2 m^3/d; an increase of 44.97 m^3/d. The increase in leakage is caused by the lowering of the water table in the vicinity of the P3456 extension. This change is a very small fraction of the average baseline streamflow of 4106.0 m^3/d (which includes quarry discharge). The baseline and P3456 net stream leakage over time is shown in Graph 7. The dark blue (Baseline) and dark red (P3456) curves represent total daily leakage from the surface stream reach. The light blue and light red represent leakage from the underground karst portion of the stream (flowing along the Layer 4 bedrock interface). The surface stream leakage is less than the karst stream leakage because the surface stream is isolated from the groundwater system by the low permeability Halton Till. Leakage rates from the surface portion of the stream increase under P3456 through the winter and spring because the water table is lower due to P3456. Leakage in the summer and fall remains the same as Baseline during the summer and fall of dry years because the stream is perched above the water table under those conditions. In summary, the average increase in stream leakage under P3456 conditions, 44.97 m3/d, is a very small fraction of the average baseline streamflow of 4106.0 m^3/d.</td><td>Graphs 6 & 7</td><td></td><td></td></tr>
</table>

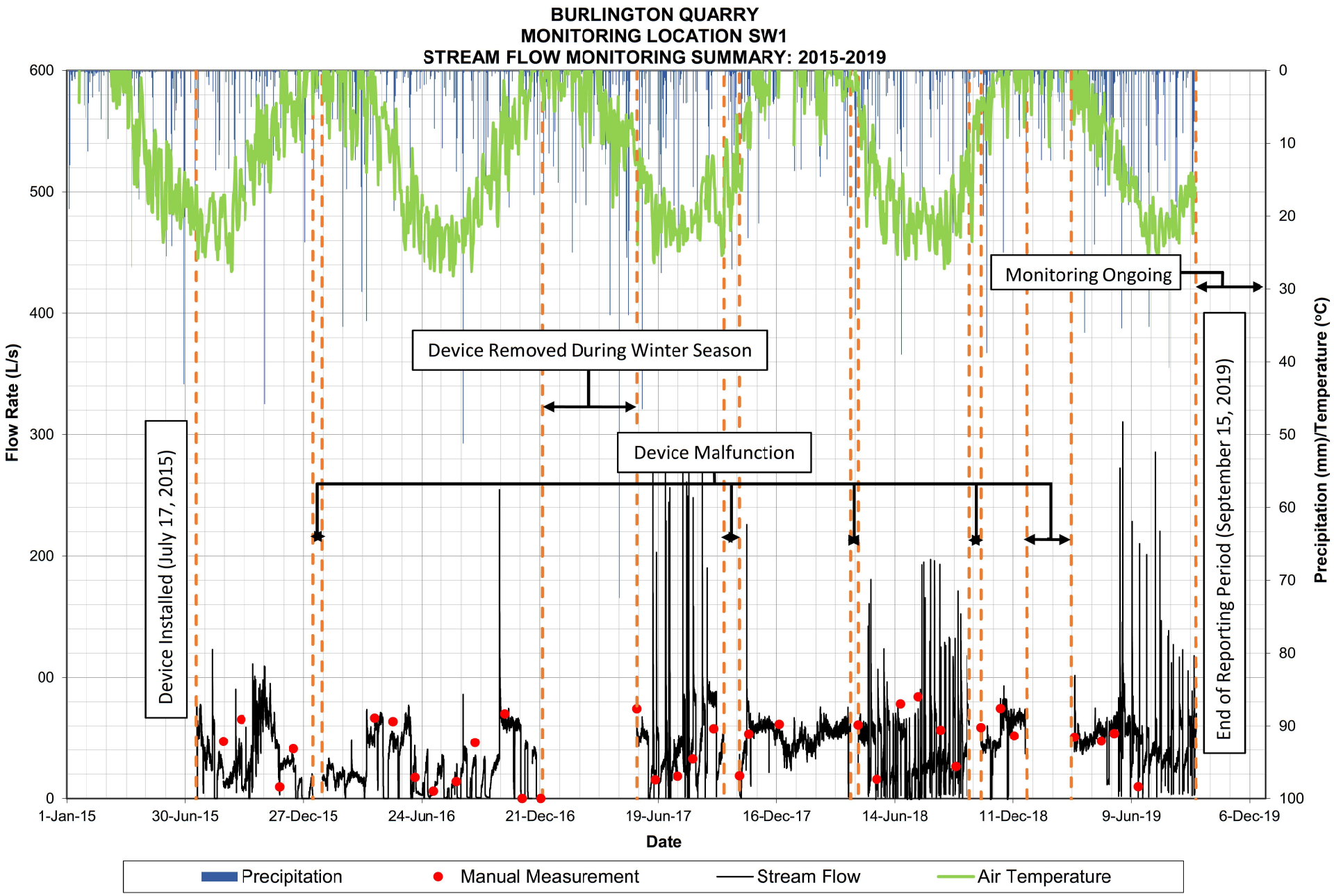
Unnamed Tributary of Willoughby Creek

Impact Assessment	Description	Figure / Graph / Table	Reference	
			Report	Section / Page
Change in Watercourse Thermal Regime:	1) Negative changes in water temperature are not expected given that the watercourse will continue to receive its primary input from quarry discharge. Temperature of water being discharge from Quarry Sump 0100 is not expected to change as a result of the proposed Quarry Extension, therefore, no change in water temperature is anticipated. 2) Artificial warming that may be occurring as a result of discharge of relatively warm surface water from the artificial golf course ponds into the tributary will cease once the golf course ponds are removed. This may result in a beneficial effect in downstream water temperatures, given that the ponds are anthropogenic. 3) The diversion of flow from catchment S101 directly to the Unnamed Tributary will also positively impact the thermal regime in the watercourse as it will no longer pass through the quarry settling ponds.		NETR (Savanta, April 2020)	75 76
Change in Water Quality:	1) Negative changes in water quality are not expected given that the watercourse will continue to receive its primary input from quarry discharge. Quality of water being discharged from Quarry Sump 0100 is not expected to change as a result of the proposed Quarry Extension, therefore, no change in water quality is expected. 2) Water quality impacts that may be occurring as a result of discharge of water from the artificial golf course ponds and irrigation channels into the tributary will cease once the golf course ponds are removed. This may result in a positive effect on downstream water quality, given that golf course discharge may be having a negative impact on water quality (e.g., due to fertilizers, erosion and sedimentation, nutrients).		NETR (Savanta, April 2020)	76
Potential Impact to Form and Function of Feature:	1) Direct impacts associated with permanent weir plate installation and diversion pipe installation are not expected to have any negative effects on the general form and function of this portion of the watercourse, which provides indirect fish habitat. 2) Alterations to quarry discharge (if unmitigated) could potentially have negative impacts on the form and habitat functions of this watercourse. 3) Diversion of upstream catchment S101 is not expected to have negative impacts on the form and function of the watercourse. The more natural hydrograph predicted due to the diversion may enhance fish habitat in downstream reaches of the Tributary.		NETR (Savanta, April 2020)	75 - 77
Potential Impact to Identified Species and Habitat:	1) In-water work could potentially result in indirect negative impacts on downstream fish communities (i.e., in lower reaches of the Unnamed Tributary or in Willoughby Creek) as a result of erosion and downstream sediment and/or accidental spills during construction. 2) Alterations to quarry discharge (if unmitigated) could potentially have negative impacts on the species and habitat functions of this watercourse. 3) Diversion of upstream catchment S101 is not expected to have negative impacts on fish in the watercourse. The more natural hydrograph predicted due to the diversion may enhance fish habitat in downstream reaches of the Tributary.		NETR (Savanta, April 2020)	75 76 77

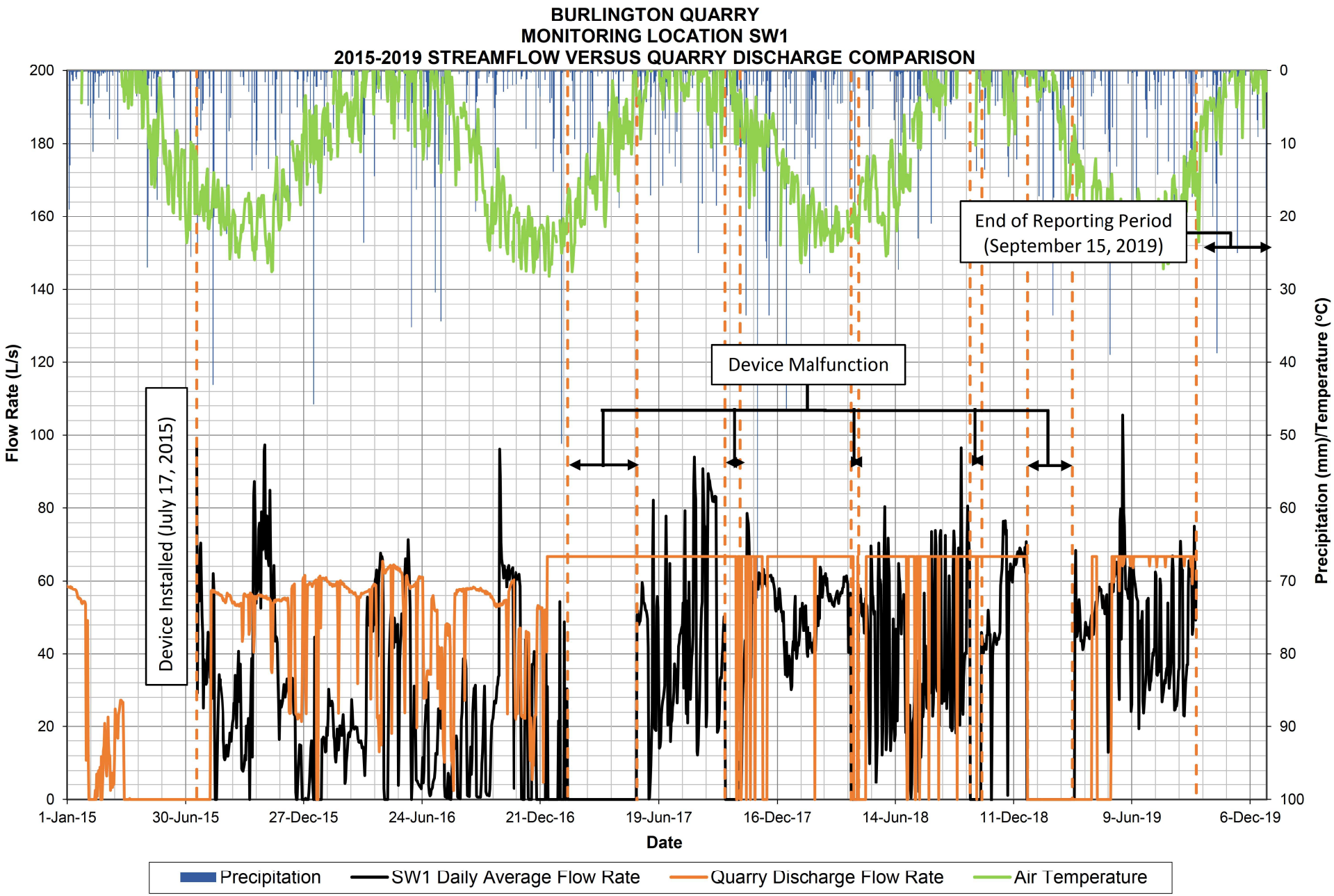
Unnamed Tributary of Willoughby Creek

Mitigation	Description	Figure / Graph	Reference	
			Report	Section / Page
Direct Alteration Mitigation:	1) In-water work required to install the permanent weir plate and the diversion structure inlet will be completed between July 16 and August 30 to minimize the potential for indirect impacts on the reproductive activities of the downstream fish communities in the Unnamed Tributary of Willoughby Creek and in Willoughby Creek itself (e.g., due to sedimentation or accidental spills). 2) Erosion and sedimentation control measures and spill prevention and response measures will be used throughout the duration of any in-stream works in the watercourse. 3) The Limit of Extraction has been set back 30 m from the limit of the bankfull channel of the Unnamed Tributary of Willoughby Creek and the Weir Pond in order to prevent disturbance to the watercourse. No operational activities will occur within the 30 m setback. A visual mitigation berm will be constructed within the 30 m setback (with associated grading encroaching a minimum of 14 m from the edge of the Weir Pond). Erosion and sedimentation control measures will be in place prior to grading for the berm. The berm will be vegetated following completion of grading to ensure soil stability and prevent erosion. 4) Where areas within the 30 m setback are not currently naturally vegetated (i.e., on portions of the active golf course), these areas will be naturalized with native species plantings to assist in maintaining and enhancing riparian functions adjacent to the watercourse. 5) To mitigate potential for negative impacts during removal of the golf course irrigation ponds and channels, it is recommended that the downstream end of the irrigation channel be blocked off at the edge of the Weir Pond in order to isolate the work area from the Unnamed Tributary. If water is to be pumped from the irrigation ponds and channels, it should be appropriately treated, as may be necessary, prior to discharge to the downstream watercourse. This could include pumping to a localized treatment method (e.g., filtration bag) or direct pumping into the quarry (which would be expected to provide suitable level of water quality control, based on the quarry's existing discharge limits). If in-water work is required (e.g., to isolate the irrigation ponds and channels), it should be completed between July 16 and August 30 to minimize potential for disruption of downstream coldwater fish community reproductive activities. The existing golf cart path and culvert at the interface of the irrigation channel and Weir Pond should be removed and the area should be restored to create a naturalized pond bank.		NETR (Savanta, April 2020)	75 66 and 67 74 78
Source Water Mitigation:	In order to mitigate impacts on fish and fish habitat in Willoughby Creek, pumping and discharge from the quarry are recommended to occur at the same location at the upstream end of the Unnamed Tributary of Willoughby Creek and in the same manner as existing pumping in accordance with the existing PTTW and Environmental Compliance Approvals regulating current quarry discharge.		NETR (Savanta, April 2020)	76 and 77
Groundwater Contribution Mitigation:	None required. The Unnamed Tributary is generally a losing stream with minor groundwater contributions typically occuring following spring freshet. During extraction the groundwater contributions are predicted to be reduced by less than 1.0%			
Erosion Mitigation:	Erosion and sedimentation control measures and spill prevention and response measures will be used throughout the duration of any in-stream works in the watercourse.			
Thermal Mitigation:	1) No specific thermal mitigation is proposed given that maintaining existing quarry outflows at Sump 0100 are expected to maintain the existing thermal regime of the watercourse without any additional mitigation. 2) Removal of the golf course ponds and diversion of flow from catchment S101 may have an indirect positive effect on the thermal regime of the watercourse.		NETR (Savanta, April 2020)	76 78
Water Quality Mitigation:	1)No specific water quality mitigation over and above that of the existing quarry operations is proposed given that maintaining existing quarry outflows at Sump 0100 is expected to maintain the existing water quality regime of the watercourse. The quarry extension is not predicted to result in any changes in the quality of water being discharged from Sump 0100. 2) Removal of the golf course ponds may have an indirect positive effect on the water quality of the watercourse.		NETR (Savanta, April 2020)	76 78

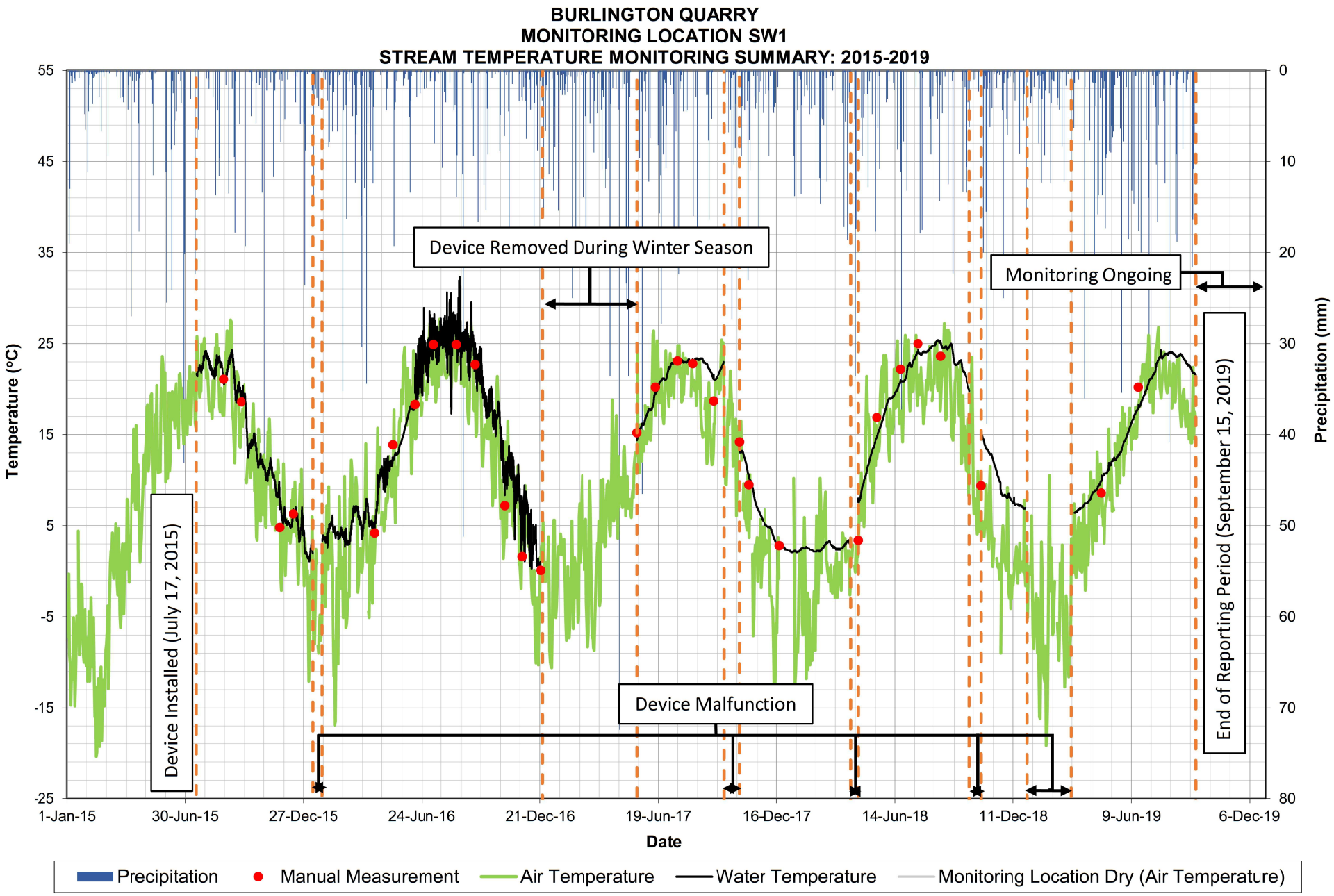
TRIBUTARY OF WILLOUGHBY CREEK - GRAPH 1



TRIBUTARY OF WILLOUGHBY CREEK - GRAPH 2



TRIBUTARY OF WILLOUGHBY CREEK - GRAPH 3



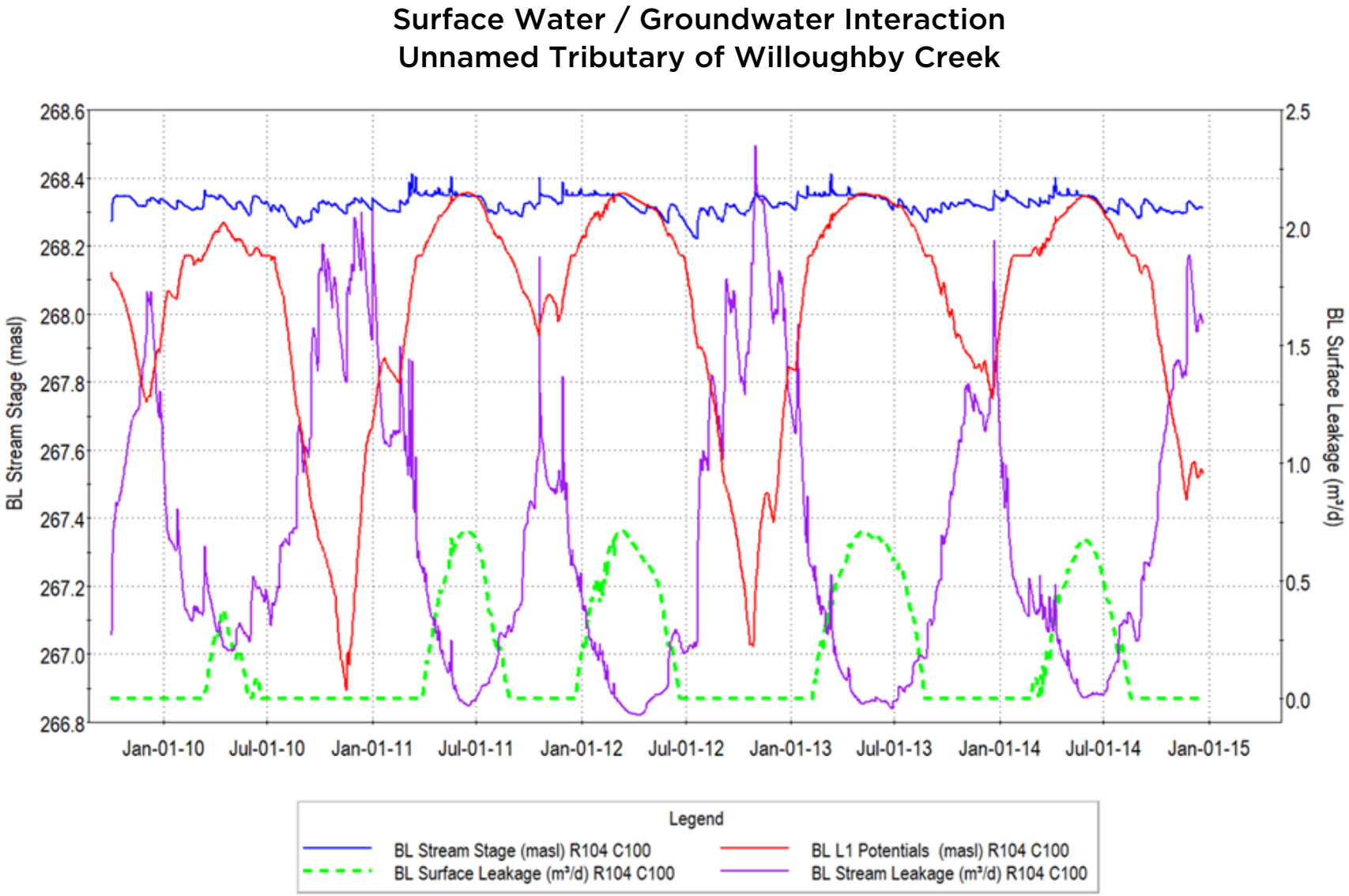
TRIBUTARY OF WILLOUGHBY CREEK - TABLE 1

BURLINGTON QUARRY
TATHAM ENGINEERING PROJECT NO.: 113187
SURFACE WATER MONITORING

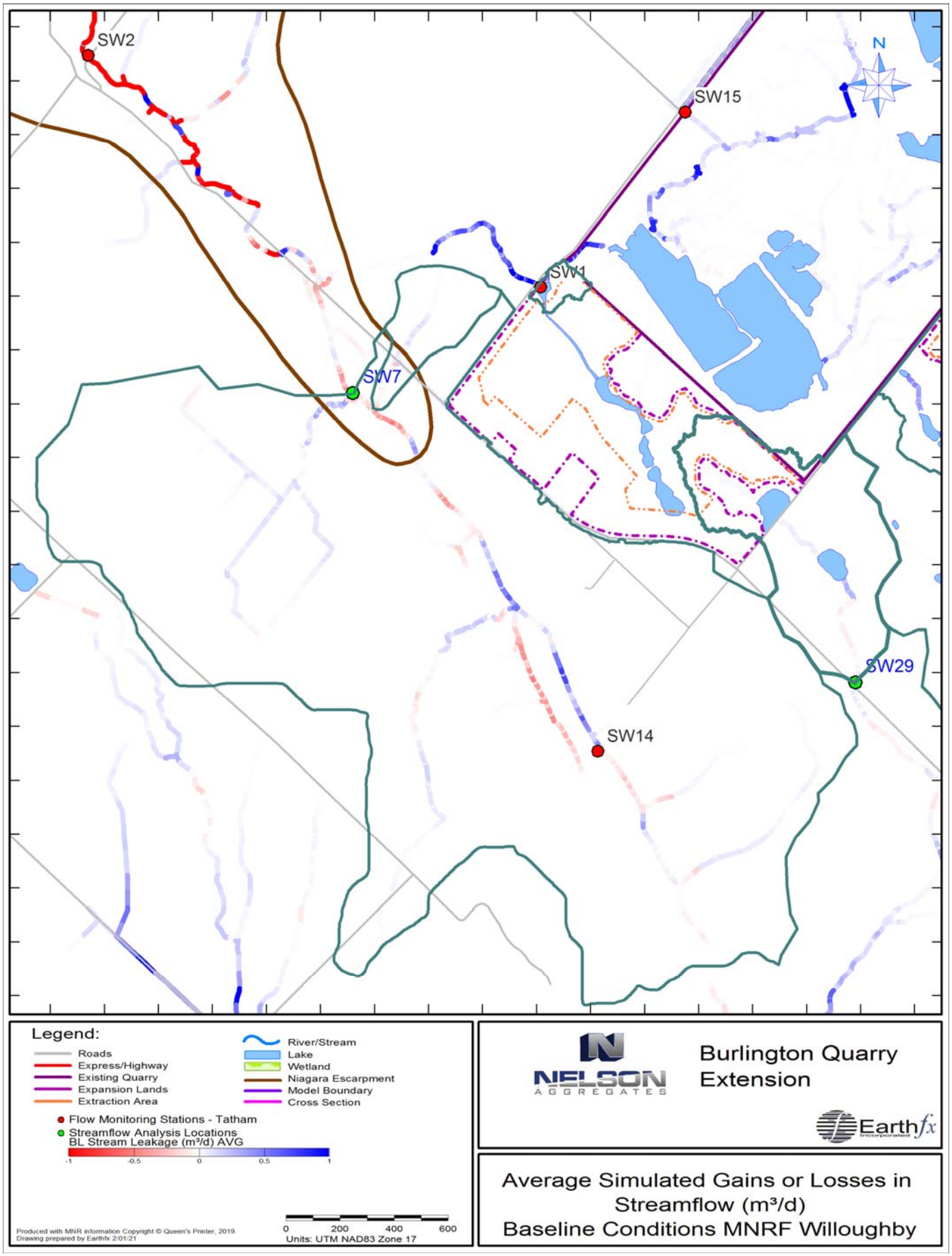
WATER QUALITY SAMPLE RESULTS

Monitoring Location SW1													
		Sample Date:	24-Oct-18	24-Apr-19	19-Jun-19	25-Sep-19	20-May-20	15-Jul-20	16-Sep-20	11-Nov-20	Maximum	Minimum	Average
Parameter:	Units:	M.D.L.	CM/JG	CM/JG	CM	CM	JG	JG/JH/JM	JH/JM	JG/JH			
M-Alkalinity (pH 4.5)	mg/L as CaCO3	2	137	179	180	112	160	94	107	117	180	112	152
Ammonia (as N)	mg/L	0.01	0.11	<0.01	0.03	0.02	<0.01	0.45	<0.01	0.01	0.11	0.02	0.04
BOD (5 day)	mg/L	1	1	2.4	1.3	1	1.6	1.1	1.3	1.2	2.4	1.0	1.4
Bicarbonate	mg/L as CaCO3	1	136	177	-	111		93	106	116	177	111	141
Carbonate	mg/L as CaCO3	1	1	2	-	<1		<1	<1	<1	2	1	1
Conductivity	µS/cm	1	877	742	763	755	790	690	799	886	877	742	784
Dissolved Organic Carbon	mg/L	0.4	4.3	4	3.1	3.7	3.9	2.3	3	3.3	4.3	3.1	3.8
Field pH	pH	N/A	8.8	8.5	8.6	8.8	8.9	8.6	8.9	9.1	8.8	8.5	8.7
Field Temp	°C	N/A	8.6	7.8	20.2	20.4	18.4	24.7	18.5	12.8	20.4	7.8	14.3
Aluminum	ug/L	1	21	64	15	9	10	50	4	2	64	9	27
Antimony	ug/L	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.5
Arsenic	ug/L	1	5	3	4	4	2	4	4	<1	5	3	4
Barium	ug/L	1	38	30	32	29	32	19	29	33	38	29	32
Beryllium	ug/L	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.5
Bismuth	ug/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Boron	ug/L	2	109	56	31	88	59	52	108	123	109	31	71
Cadmium	ug/L	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1
Calcium	ug/L	500		77100	79600	51100	65000	39600	52300	65400	79600	51100	51950
Cerium	ug/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Cesium	ug/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Chromium	ug/L	1	<1	4	3	3	2	<1	2	3	4	3	3
Cobalt	ug/L	0.1	0.2	0.3	0.2	0.1	0.2	0.3	0.1	0.1	0.3	0.1	0.2
Copper	ug/L	1	<1	1	8	1	2	3	1	2	8	1	3
Europium	ug/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Gallium	ug/L	1	<1	<1	<1	<1	<1	<1	<1	1	<1	<1	1
Iron	ug/L	20	40	160	210	140	253	160	160	200	210	40	138
Lanthanum	ug/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Lead	ug/L	0.1	<1	0.1	<0.1	<0.1	<0.1	0.2	<0.1	<0.1	0.1	0.1	0.1
Lithium	ug/L	5	9	7	8	8	8	11	12	12	9	7	8
Magnesium	ug/L	5		30700	34200	36400	34000	28800	36100	41300	36400	30700	25325
Manganese	ug/L	10	9	15	18	15	21	59	9	7	18	9	14
Mercury	ug/L	0.1	<1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1
Molybdenum	ug/L	1	3	2	2	3	2	2	2	3	3	2	3
Nickel	ug/L	1	4	4	3	2	3	2	2	2	4	2	3
Niobium	ug/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Phosphorus	ug/L	50	<50	124	<50	<50	<50	<50	<50	<50	124	124	68.5
Potassium	ug/L	1	5990	4230	4510	5620	4680	3830	5920	6800	5990	4230	5088
Rubidium	ug/L	1	3	2	2	3	2	2	3	2	3	2	3
Scandium	ug/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Selenium	ug/L	0.5	1.6	1.1	<0.5	1.5	1.1	<0.5	1.7	<0.5	1.6	1.1	1.175
Silicon	ug/L	2	1600	1560	888	659	568	447	1010	616	1600	659	1177
Silver	ug/L	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.3	<0.1	<0.1	0.1
Sodium	ug/L	1000	50600	36500	34900	41800	42300	43700	48900	51200	50600	34900	40950
Strontium	ug/L	1	982	942	895	823	807	564	722	982	982	823	911
Sulphur	ug/L	800	63800	49400	59200	59100	50000	40300	56300	79800	63800	49400	57875
Tellurium	ug/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Thallium	ug/L	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1
Thorium	ug/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Tin	ug/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Titanium	ug/L	1	<1	2	<1	<1	<1	1	<1	<1	2	2	1.25
Tungsten	ug/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Uranium	ug/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Vanadium	ug/L	1	<1	1	1	<1	<1	<1	<1	<1	1	1	1
Yttrium	ug/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Zinc	ug/L	1	5	<1	7	4	4	9	5	2	7	4	4
Zirconium	ug/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
pH	pH	N/A	8.02	8.03	8	7.97	8.34	7.97	7.86	7.88	8.0	8.0	8.0
Total Hardness (as CaCO3)	mg/L	0.1	335	319	340	277	302	217	279	333	340.000	277.000	317.750
Chemical Oxygen Demand	mg/L	5	8	12	8	<5	12	11	16	15	12	8	8
Total Dissolved Solids	mg/L	3	597	517	564	576	525	460	536	574	597	517	564
Total Suspended Solids	mg/L	0.67	1.3	3.67	1	1.7	5	4	2.3	2.7	3.67	1.00	1.92
Turbidity	NTU	0.1	2.4	3.5	1.4	0.9	2.4	2	0.5	1.2	3.5	0.9	2.1

TRIBUTARY OF WILLOUGHBY CREEK - GRAPH 4



TRIBUTARY OF WILLOUGHBY CREEK - FIGURE 1



TRIBUTARY OF WILLOUGHBY CREEK - FIGURE 2

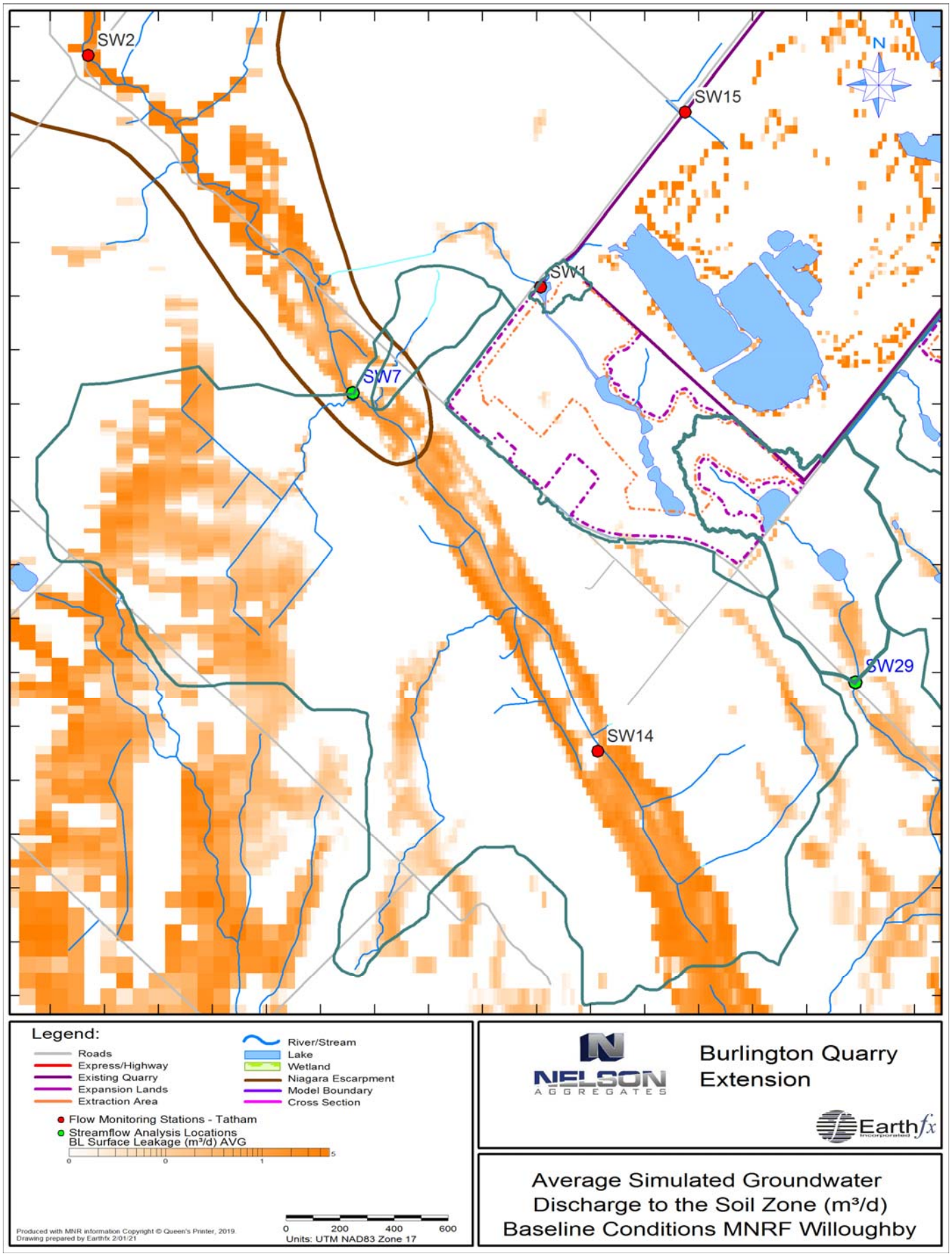


FIGURE 3A

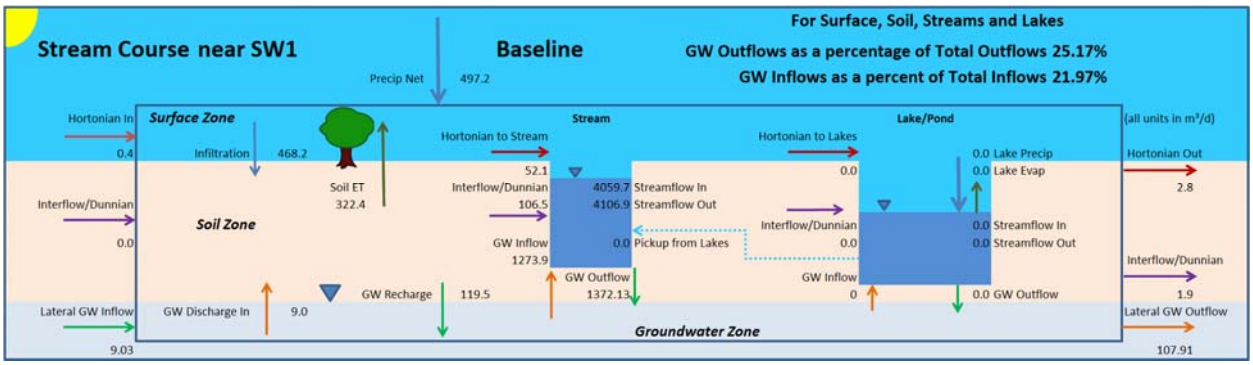


FIGURE 3B

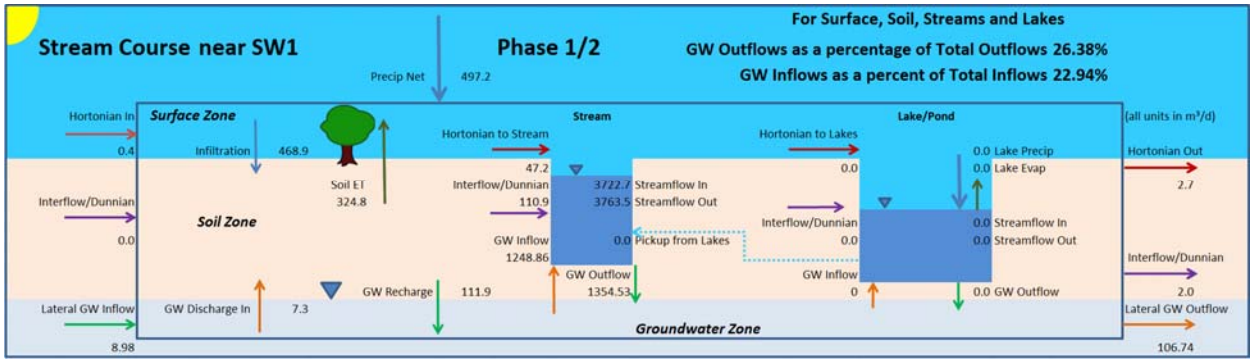


FIGURE 3C

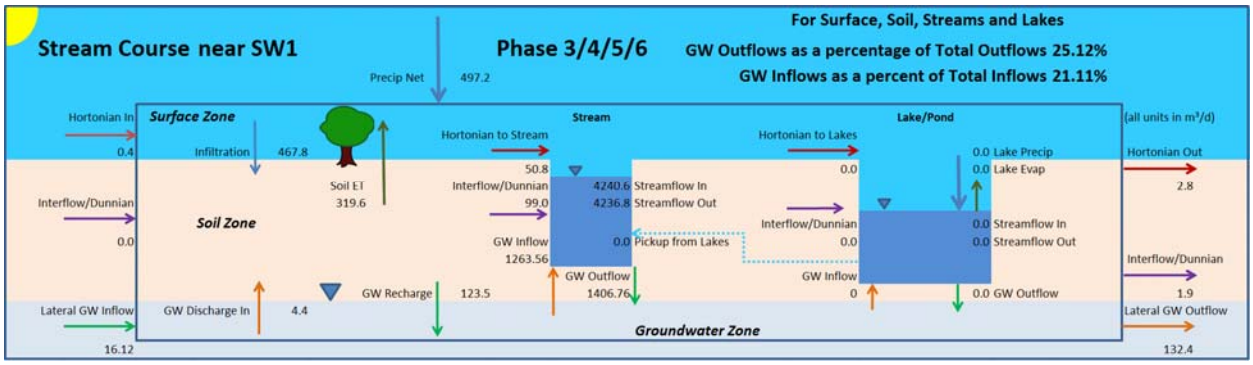


FIGURE 3D

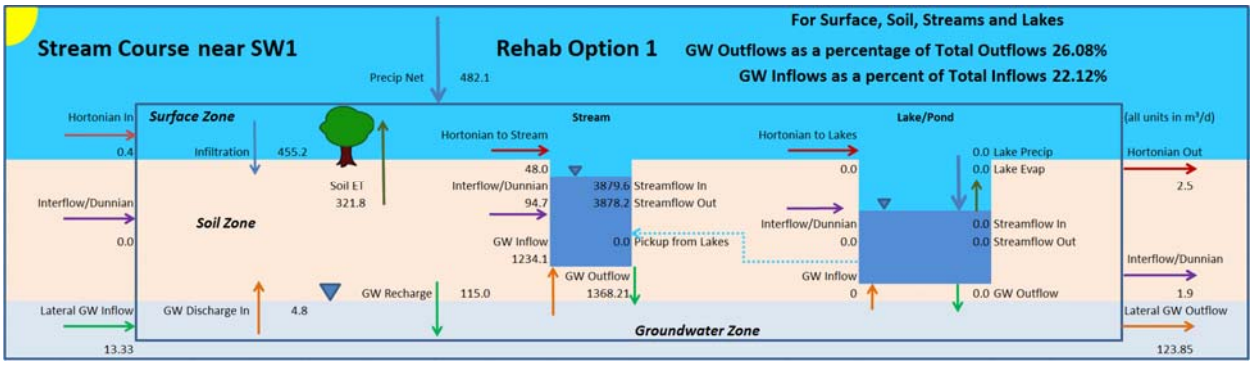
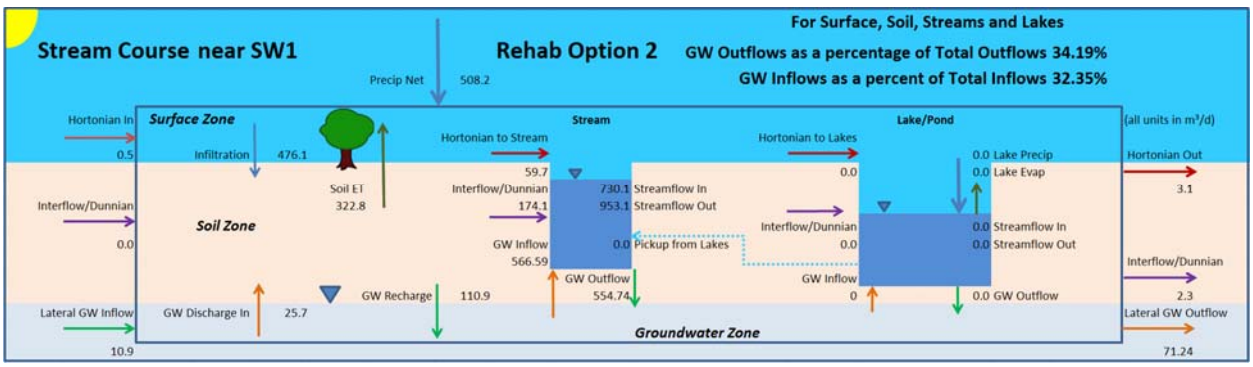
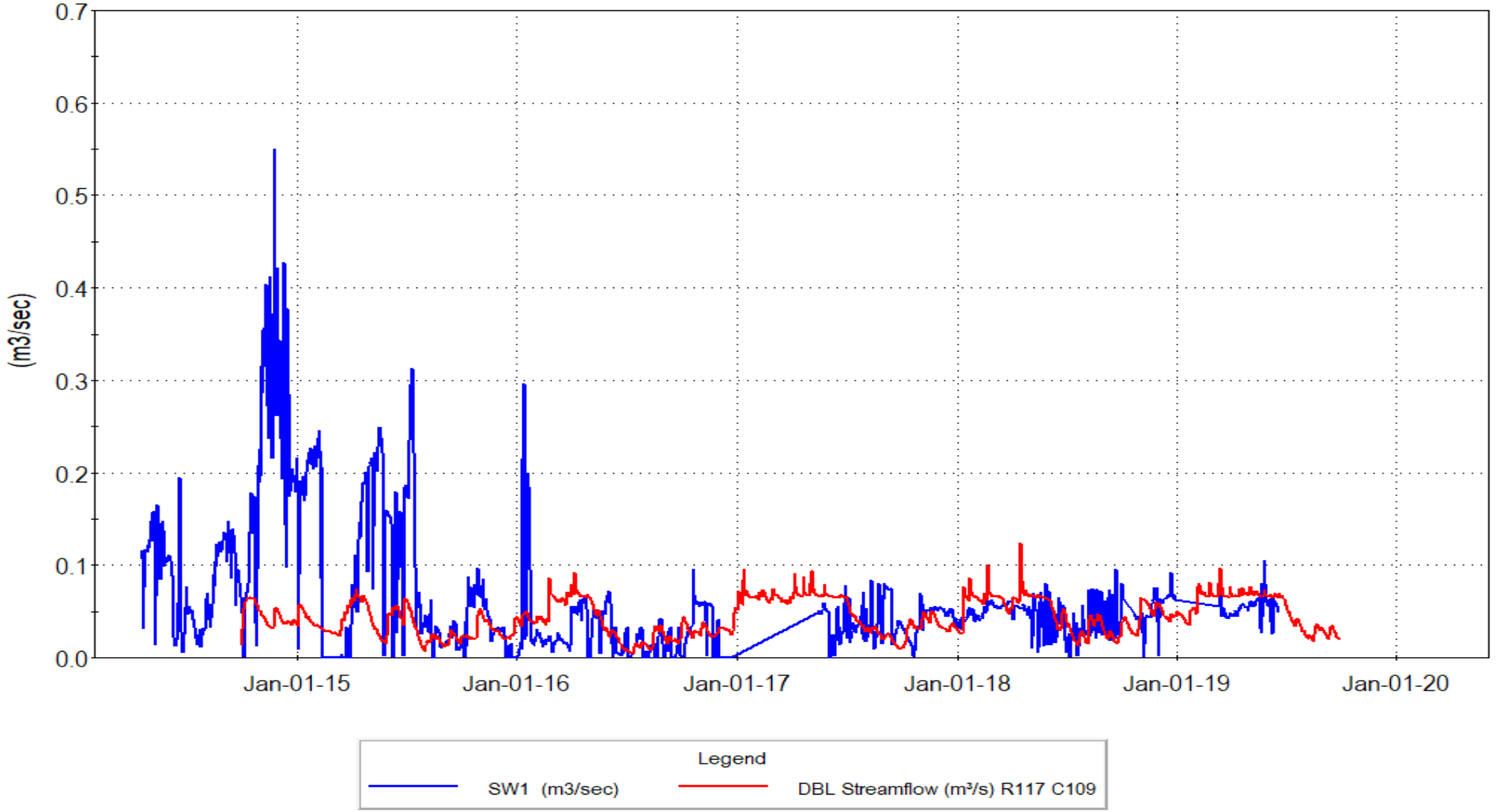


FIGURE 3E



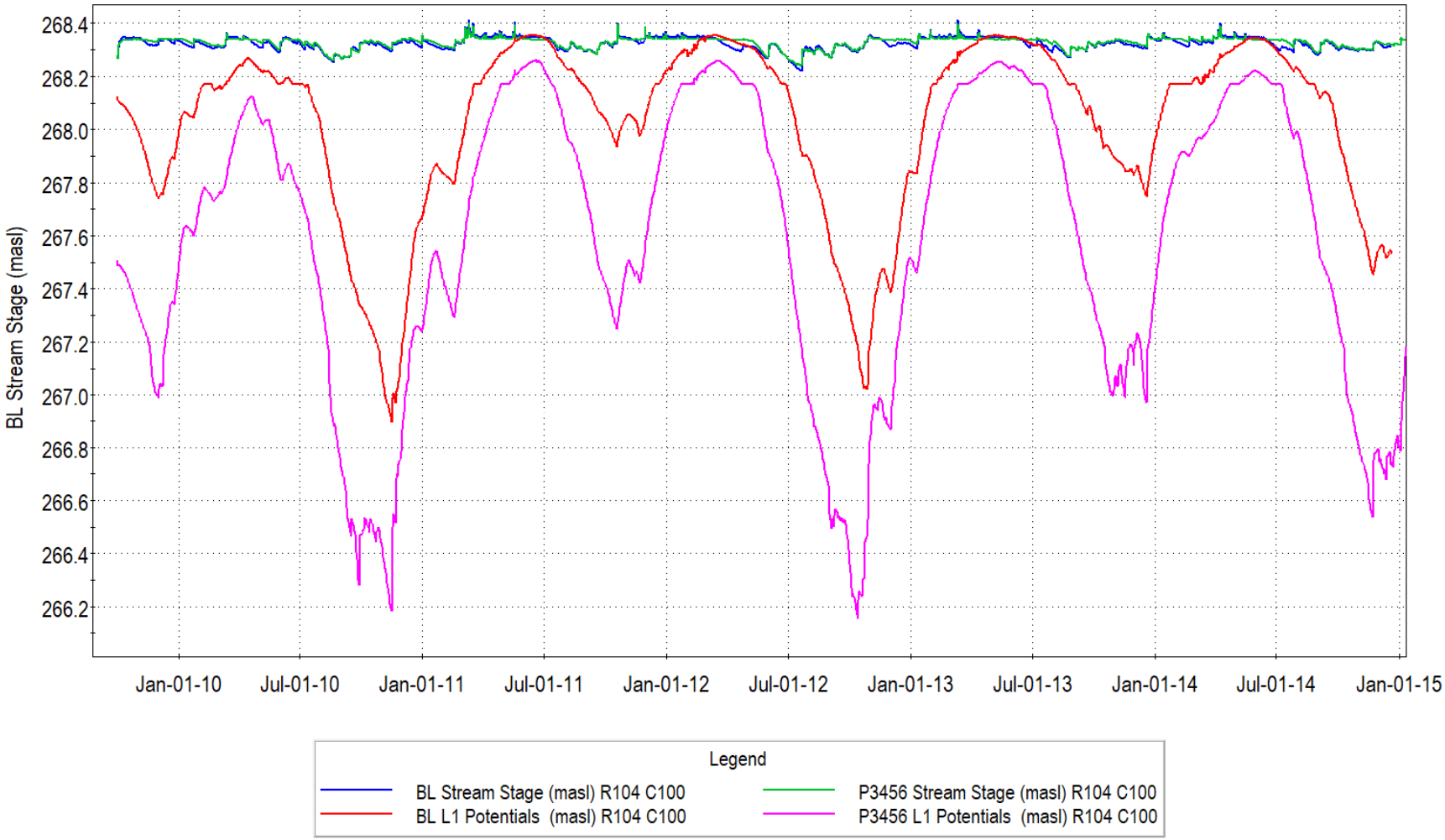
TRIBUTARY OF WILLOUGHBY CREEK - GRAPH 5

Integrated Model Calibration
Unnamed Tributary of Willoughby Creek

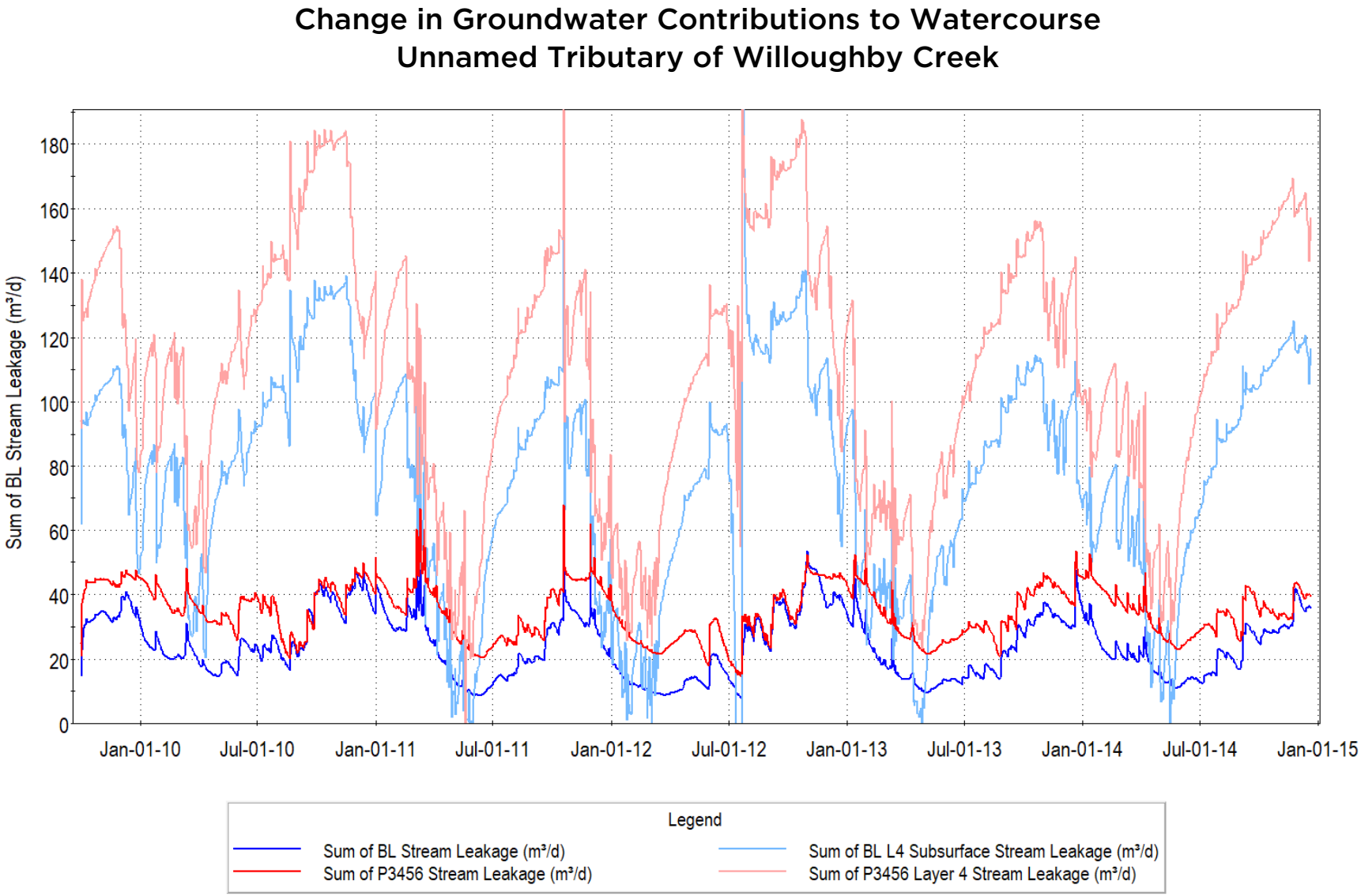


TRIBUTARY OF WILLOUGHBY CREEK - GRAPH 6

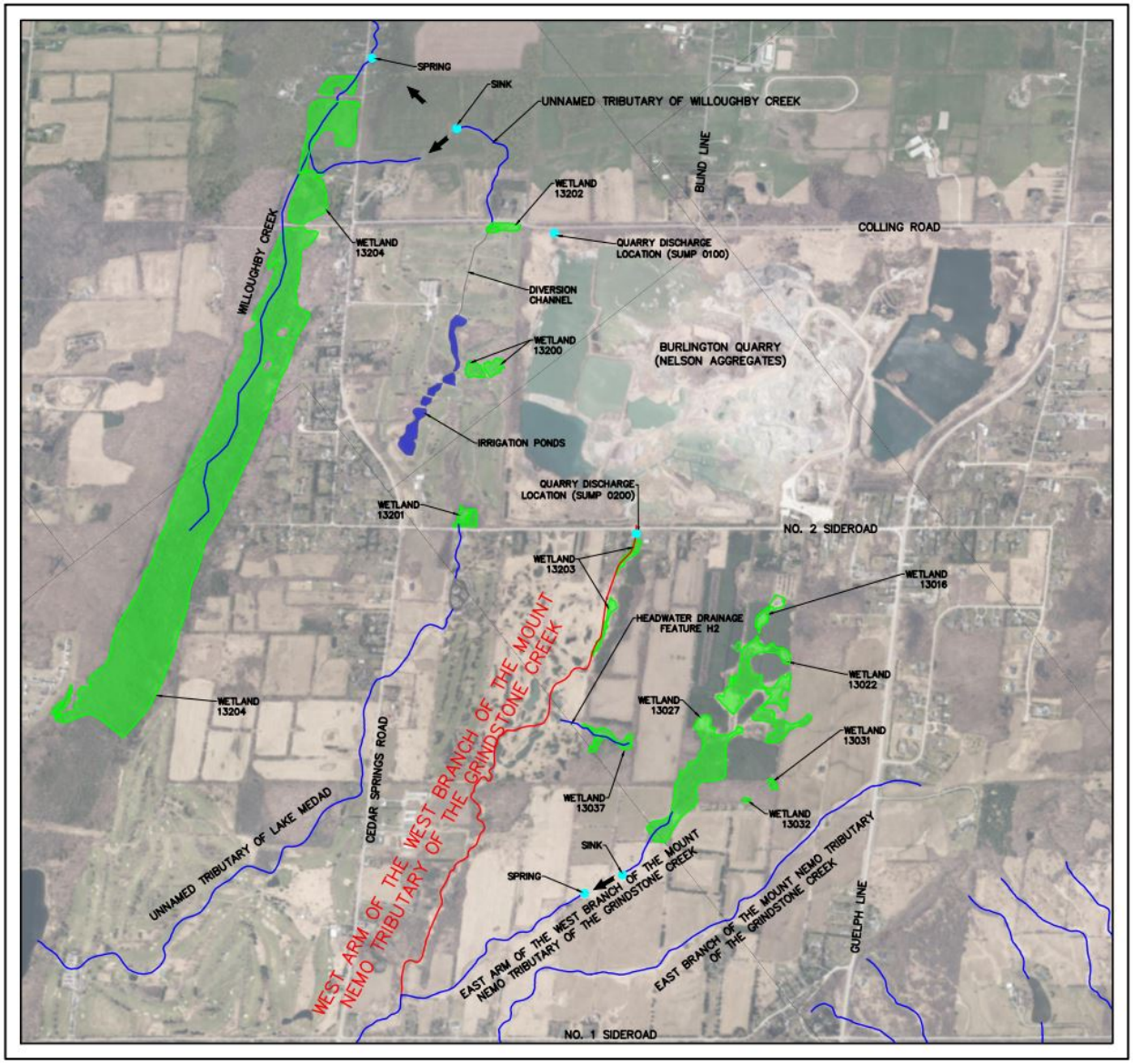
Change in Groundwater Contributions to Watercourse
Unnamed Tributary of Willoughby Creek

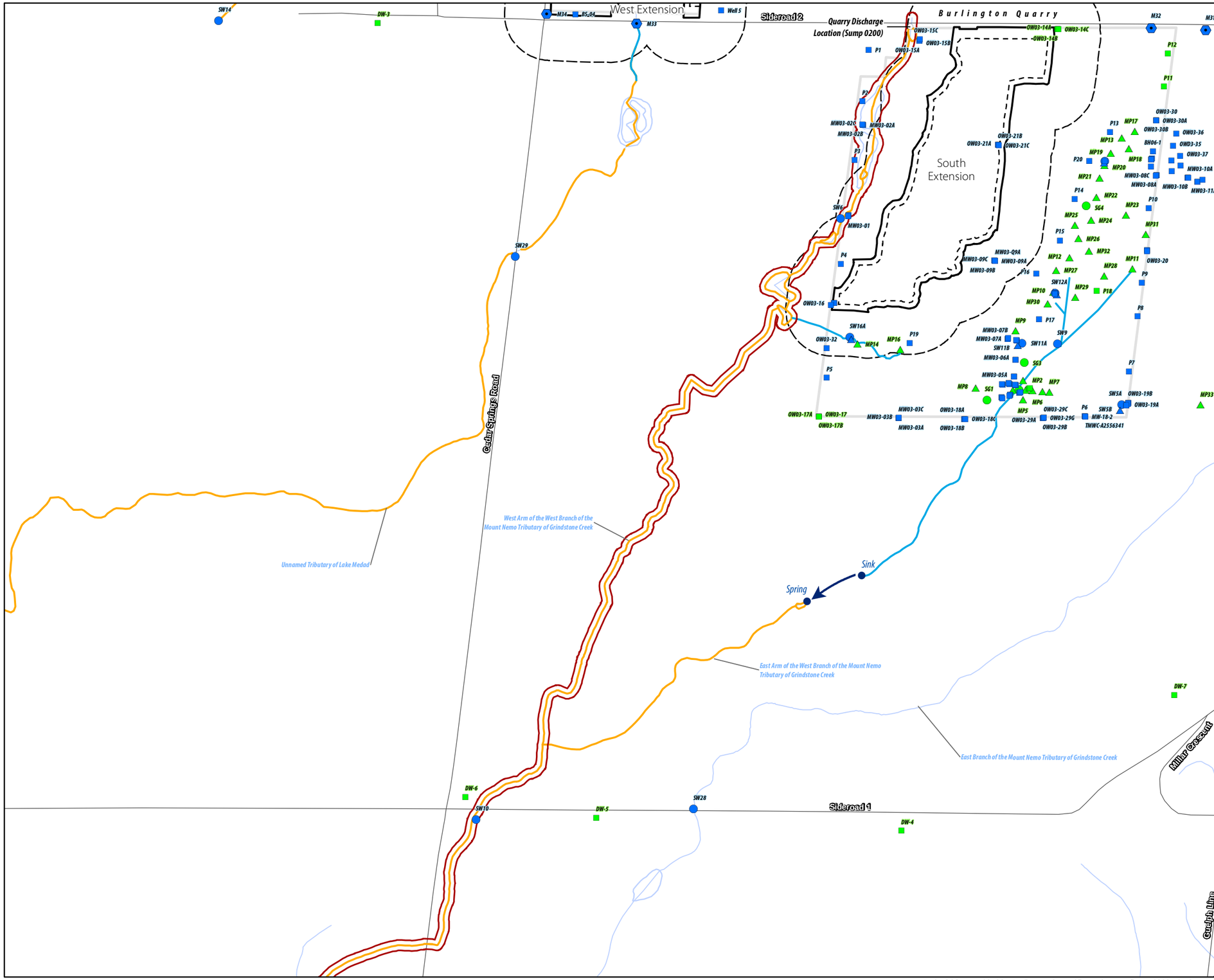


TRIBUTARY OF WILLOUGHBY CREEK - GRAPH 7



WEST ARM OF THE WEST BRANCH





Legend

- Licensed Boundary
- Limit of Extraction
- 120 m Adjacent Lands
- Subject Lands
- West Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek
- Road
- Indirect Fish Habitat
- Direct Fish Habitat
- Watercourse
- Waterbody
- Wetland (Savanta, 2020)

Current Instrumentation

- Groundwater Monitoring Station (EarthFx)
- Mini Piezometer (Tatham Engineering)
- Staff Gauge & Surface Water Monitoring Station (Tatham Engineering)
- Manual Stream Flow Measurement (Tatham Engineering)

Previous Instrumentation

- Groundwater Monitoring Station (Golder)
- Mini Piezometer (Golder)
- Staff Gauge & Surface Water Monitoring Station (Golder)

NOTES:

1. Coordinate System: NAD 1983 UTM Zone 17N.
2. Base features produced under license with the Ontario Ministry of Natural Resources and Forestry © Queen's Printer for Ontario, 2021.
3. Orthoimagery © First Base Solutions, 2021. Imagery taken in 2019.

Project 8133

Burlington Quarry Extension
Nelson Aggregates Co.

Figure 15
Watercourse Characterization

West Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek

0 180 m

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[redacted]

Path: C:\Savanta\8133 - Burlington Quarry\figures\report_figures\2021 01 21 natural feature tech summary\8133_rpt_watercourse_char_mapbook.mxd D April 8, 2021

West Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek

Surface Water Characteristics	Description	Figure / Graph / Table	Reference	
			Report	Section / Page
Watercourse Name:	West Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek			
Watershed:	Grindstone Creek			
Sub-Watershed:	Mount Nemo Tributary of Grindstone Creek			
Located in Proposed Limit of Extraction:	No			
Located in Proposed License Boundary:	No			
Catchment Area (ha):	135 ha (at confluence with East Arm); 26.2 ha (at streamflow monitoring location SW6)			
Catchment ID:	N/A			
Primary Source(s) of Flow:	Discharge from Burlington Quarry (Sump 0200)			
Discharge from Quarry / PTTW:	Yes - PTTW 96-P-3009		SWA (Tatham, April 2020)	Appendix A
Conditions of PTTW:	Maximum discharge rate = 945 L/min (15.75 L/s) Maximum discharge amount = 1,360,800 L/day		SWA (Tatham, April 2020)	Appendix A
Surface Water Monitoring:	ID: SW6 (Tatham) Installation Date: September 19, 2014 Data Collection: Continuous water level and temperature, manual monthly in-situ streamflow measurements and calibration data (water level converted to flow using rating curve) Coordinates of Monitoring Station: Easting 590629.123, Northing 4805071.124	Graphs 1, 2 & 3 and Table 1	SWA (Tatham, April 2020)	2.1.2, Appendix C and Appendix H
Streamflow Conditions:	Intermittent (flow is dependent on quarry discharge); the tributary will dry out when quarry discharge ceases	Graphs 1, 2 & 3	SWA (Tatham, April 2020)	2.1.2 and Appendix C
Average Daily Flow (SW6):	Average Daily Streamflow (L/s)	Graphs 1 & 2	SWA (Tatham, April 2020)	2.1.2 and Appendix C

Month	Minimum	Average	Maximum
January	N/A	N/A	N/A
February	N/A	N/A	N/A
March	3.6	7.4	15.3
April	0.1	6.4	14.3
May	0.0	4.6	33.8
June	0.0	6.5	31.0
July	0.0	5.3	17.7
August	0.0	5.2	23.6
September	0.0	2.4	21.6
October	0.0	2.1	16.0
November	0.0	4.1	21.9
December	0.0	7.8	44.6

Notes:

Minimum - lowest daily average streamflow recorded for period of record

Average - average daily streamflow recorded for period of record

Maximum - maximum daily average streamflow recorded for period of record

N/A - data not available as device removed from watercourse during winter months

West Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek

Watercourse Thermal Regime (SW6):

Average Daily Water Temperature (°C)

Month	Minimum	Average	Maximum
January	N/A	N/A	N/A
February	N/A	N/A	N/A
March	4.7	6.0	8.0
April	5.6	9.5	12.3
May	7.3	14.4	25.0
June	9.4	17.7	26.5
July	12.3	21.0	27.2
August	12.2	21.1	28.9
September	9.5	17.8	25.1
October	2.7	12.2	20.2
November	0.2	7.2	13.2
December	0.5	4.9	9.6

Notes:

Minimum - lowest daily average streamflow recorded for period of record

Average - average daily streamflow recorded for period of record

Maximum - maximum daily average streamflow recorded for period of record

N/A - data not available as device removed from watercourse during winter months

Figure / Graph / Table: Graph 3

Reference: SWA (Tatham, April 2020), 2.1.2 and Appendix C

Water Quality (SW6):

Water Quality Sample Results

Parameter	Units	Minimum	Average	Maximum
Turbidity	NTU	0.2	0.4	0.5
TDS	mg/L	593	640	695
TSS	mg/L	<0.67	1.11	2.00
COD	mg/L	<5	8	12
BOD5	mg/L	<0.9	0.9	0.9
DOC	mg/L	2.7	3.0	3.4
pH		7.7	7.9	8.2
Alkalinity	mg/L	137	160	172
Conductivity	µS/cm	798	858	934
Phosphorus	ug/L	<50	<50	<50
Ammonia	mg/L	<0.01	0.02	0.04
Hardness	mg/L	357	364	376

Figure / Graph / Table: Table 1

Reference: SWA (Tatham, April 2020), 2.4 and Appendix H

West Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek

Fish & Fish Habitat Features	Description	Figure / Graph / Table	Reference	
			Report	Section / Page
Fish Habitat (Direct/Indirect and Assumed/Confirmed):	The West Arm is known to provide direct fish habitat, based on fish community sampling completed in 2019 by Savanta. Fish were captured in a small, online pond approximately 400 m downstream from Sideroad No. 2. For the purposes of the NETR, the entire watercourse up to the quarry discharge point at Sideroad No. 2 is assumed to provide direct fish habitat.		NETR (Savanta, April 2020)	44 and Figure 9b
Fish Species Present:	1) Savanta captured Brook Stickleback in the watercourse in 2019. 2) Stantec (2010) previously reported that Brook Stickleback and Pumpkinseed were captured in the West Arm.		NETR (Savanta, April 2020)	44 and Figure 9b
Fish Community Thermal Regime:	Cool to Warmwater (based on fish species present)		NETR (Savanta, April 2020)	44 and Figure 9b
Fish Habitat Types Present:	The reach of the watercourse between the upstream end at Sideroad No. 2 and the Nelson property line generally consists of a poorly defined to well-defined natural low flow channel within a low-lying, densely vegetated floodplain. With some reaches, the low flow channel is barely observable and only approximates a shallow depression amongst dense emergent wetland vegetation. In other reaches, the low flow channel is more well defined, with observable bed and banks that are distinguishable from the riparian vegetation community. The average wetted width of the channel is approximately 2 m, with abundant vegetation and multiple flow paths through wetland areas. Water depth on June 3, 2019 ranged from 0.1 to 0.5 m. Morphology is generally uniform, consisting of long runs with soft substrate, although several deeper scour pools are present, as well as one approximately 18 m long by 10 m wide online pond. A larger (~40 m by 20 m) online pond (which receives the inflow from the quarry Sump 0200) is present immediately adjacent to Sideroad No. 2. Riparian vegetation is generally meadow marsh and cultural meadow, although shrub thickets are present at various points.		NETR (Savanta, April 2020)	44 and Figure 9b
Habitat Uses by Known Fish Community:	The local fish community likely uses the habitat for the complete range of life history processes including spawning, nursery, foraging and overwintering (primarily in the online ponds at the upstream end and mid-point of the reach). Larger online ponds are also present on the downstream golf course property and these may also provide overwintering and refuge functions for the local fish community.		NETR (Savanta, April 2020)	44 and Figure 9b
Known Barriers to Fish Movement:	A culvert is present at the downstream Subject Lands property boundary. Fish may be able to pass upstream through this culvert under lower flow rates, although at higher flows, when velocities are expected to be higher, the culvert may provide some barrier effect.		NETR (Savanta, April 2020)	44 and Figure 9b

West Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek

<table>
<tr><th rowspan="2">Groundwater Interaction</th><th rowspan="2">Description</th><th rowspan="2">Figure / Graph / Table</th><th colspan="2">Reference</th></tr>
<tr><th>Report</th><th>Section / Page</th></tr>
<tr><td>Underlying Deposits:</td><td>Halton Till. The harmonic mean hydraulic conductivity, based on testing by Golder (2007) of 10 mini-piezometers, was 1.2x10^{-8} m/s. Model value for the vertical hydraulic conductivity was 1.6x10^{-7} m/s, about an order of magnitude higher, to account for limited flow through fractures in the till.</td><td></td><td></td><td></td></tr>
<tr><td>Surface Water / Groundwater Interactions:</td><td>Seasonal groundwater contributions to watercourse. Groundwater seepage under baseline conditions during spring months equates to 0.08 L/s or less. Groundwater seepage is at its maximum during and immediately following the spring freshet.</td><td>Figures 1 & 2</td><td></td><td></td></tr>
<tr><td>Water Budget Results (300 m Upstream of SW6):</td><td>The baseline condition water budget results from the integrated model 300 m upstream of monitoring location SW6 are presented in Figure 3a.<table><tr><td>Condition</td><td>GW Out</td><td>GW In</td></tr><tr><td>Baseline (Existing)</td><td>8.77%</td><td>0.00%</td></tr></table></td><td>Figure 3a</td><td></td><td></td></tr>
<tr><td>Water Budget Results (SW6):</td><td>The baseline condition water budget results from the integrated at monitoring location SW6 are presented in Figure 4a.<table><tr><td>Condition</td><td>GW Out</td><td>GW In</td></tr><tr><td>Baseline (Existing)</td><td>9.70%</td><td>0.32%</td></tr></table></td><td>Figure 4a</td><td></td><td></td></tr>
<tr><td>Integrated Model Calibration:</td><td>A graph comparing simulated and observed flows at SW6 is provided in Graph 4. It should be noted that quarry discharge amounts are not specified in the model but are estimated based on simulated inflows to the quarry. As noted in Section 19.4.2 (p. 416) of the Earthfx report, the discharge to the south sump (upstream of SW6) was simulated with a set of “operating rules” and therefore also may not match the variations in the observed data. The rules defined a 5 day per week discharge rate, with an extra stage-dependent discharge rule that kept the internal quarry pond at a specified level. Actual operations were more intermittent, with spring pumping rates varied on a manual basis</td><td>Graph 4</td><td>HHIAR (Earthfx, April 2020)</td><td>19.4.2 (page 416)</td></tr>
</table>

<table>
<tr><th rowspan="2">Impact Assessment</th><th rowspan="2">Description</th><th rowspan="2">Figure / Graph / Table</th><th colspan="2">Reference</th></tr>
<tr><th>Report</th><th>Section / Page</th></tr>
<tr><td>Direct Alterations to Watercourse:</td><td>The only direct impact on this watercourse will be due to installation of an outlet from the temporary settling pond/sump outlet from the adjacent South Extension area. The outlet is expected to be constructed at the channel bank, although no detailed design has been completed to date. The outlet could be as simple as a pipe laid on the ground (given that it won’t be buried where it runs through the adjacent woodland), or it could require some structural measures (e.g., a headwall) to keep the outlet in place. Therefore, some minor disruption to the bed and banks of the watercourse could occur.</td><td></td><td>NETR (Savanta, April 2020)</td><td>75</td></tr>
<tr><td>Change in Primary Source of Flow:</td><td>Quarry discharge from Sump 0200 represents the major source of flow to the West Arm. Current quarry approvals permit this discharge to cease once quarry operations are complete. Cessation of quarry discharge into the West Arm would have a negative impact on flow available to support current fish habitat and fish community. As discussed in the Mitigation section below, it has been recommended that quarry discharge continue indefinitely at current levels to prevent these associated negative impacts.</td><td></td><td>NETR (Savanta, April 2020)</td><td>79</td></tr>
<tr><td>Change in Watercourse Catchment Area:</td><td>Reduction in catchment area of 11.7 ha. Quarry discharge from Sump 0200 represents the major source of flow to the West Arm. During Phase 1 operations, an additional source of flow will be from dewatering the Phase 1 and 2 extraction area. The quarry discharge from Sump 0200 is to continue throughout Phases 1 and 2 and no impacts are anticipated as a result of the reduction in catchment area.</td><td></td><td>SWA (Tatham, April 2020)</td><td>Drawings DP-1, DP-2 and DP-3</td></tr>
</table>

West Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek

<table>
<tr><th rowspan="2">Impact Assessment</th><th rowspan="2">Description</th><th rowspan="2">Figure / Graph / Table</th><th colspan="2">Reference</th></tr>
<tr><th>Report</th><th>Section / Page</th></tr>
<tr><td>Simulated Streamflow Change (Integrated Model Results):</td><td>The Earthfx report discusses changes in simulated streamflow under the different quarry expansion phases. Graph 5 reproduces Figure 8.8 (p. 202) and presents simulated baseline(red) and Scenario P12 (blue) flows at location approximately 800 m downstream of SW6. Increase in flow (green) are plotted in reverse on the upper X axis with the scale shown on the right Y axis. Streamflow is predicted to increase due to the discharge of water from dewatering the Phase 12 area. A similar figure (Graph 6) is reproduced for Phase 3456 (Figure 8.46, p. 236), although the upper X axis shows the decrease in streamflow (with positive values indicating an decrease in flow relative to baseline). Flows are generally lower in the winter and spring but higher in the summer and fall periods.</td><td>Graphs 5 & 6</td><td>HHIAR (Earthfx, April 2020)</td><td>198 - 203 and 230 - 237</td></tr>
<tr><td colspan="5">Water Budget Results 300 m Upstream of Monitoring Location SW6</td></tr>
<tr><td>Water Budget Results (Operational Phases 1 & 2):</td><td>The Operational Phases 1 and 2 water budget results from the integrated model 300 m upstream of monitoring location SW6 are presented in Figure 3b.
<table>
<tr><td>Condition</td><td>GW Outflow</td><td>GW Inflow</td><td>%Δ GW Outflow</td><td>%Δ GW Inflow</td></tr>
<tr><td>Baseline (Existing)</td><td>8.77%</td><td>0.00%</td><td>-</td><td>-</td></tr>
<tr><td>Phases 1 & 2</td><td>4.81%</td><td>0.00%</td><td>-3.96%</td><td>0.00%</td></tr>
</table></td><td>Figure 3b</td><td></td><td></td></tr>
<tr><td>Water Budget Results (Operational Phases 3 Through 6):</td><td>The Operational Phases 3 through 6 water budget results from the integrated model 300 m upstream of monitoring location SW6are presented in Figure 3c.
<table>
<tr><td>Condition</td><td>GW Outflow</td><td>GW Inflow</td><td>%Δ GW Outflow</td><td>%Δ GW Inflow</td></tr>
<tr><td>Baseline (Existing)</td><td>8.77%</td><td>0.00%</td><td>-</td><td>-</td></tr>
<tr><td>Phases 3 through 6</td><td>5.66%</td><td>0.00%</td><td>-3.17%</td><td>0.00%</td></tr>
</table></td><td>Figure 3c</td><td></td><td></td></tr>
<tr><td>Water Budget Results (Rehabilitation Scenario 1):</td><td>The Rehabilitation Scenario 1 water budget results from the integrated model 300 m upstream of monitoring location SW6are presented in Figure 3d.
<table>
<tr><td>Condition</td><td>GW Outflow</td><td>GW Inflow</td><td>%Δ GW Outflow</td><td>%Δ GW Inflow</td></tr>
<tr><td>Baseline (Existing)</td><td>8.77%</td><td>0.00%</td><td>-</td><td>-</td></tr>
<tr><td>Rehab Scenario 1</td><td>4.83%</td><td>0.00%</td><td>-3.94%</td><td>0.00%</td></tr>
</table></td><td>Figure 3d</td><td></td><td></td></tr>
<tr><td>Water Budget Results (Rehabilitation Scenario 2):</td><td>The Rehabilitation Scenario 2 water budget results from the integrated model 300 m upstream of monitoring location SW6are presented in Figure 3e.
<table>
<tr><td>Condition</td><td>GW Outflow</td><td>GW Inflow</td><td>%Δ GW Outflow</td><td>%Δ GW Inflow</td></tr>
<tr><td>Baseline (Existing)</td><td>8.77%</td><td>0.00%</td><td>-</td><td>-</td></tr>
<tr><td>Rehab Scenario 2</td><td>6.56%</td><td>0.00%</td><td>-2.21%</td><td>0.00%</td></tr>
</table></td><td>Figure 3e</td><td></td><td></td></tr>
</table>

West Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek

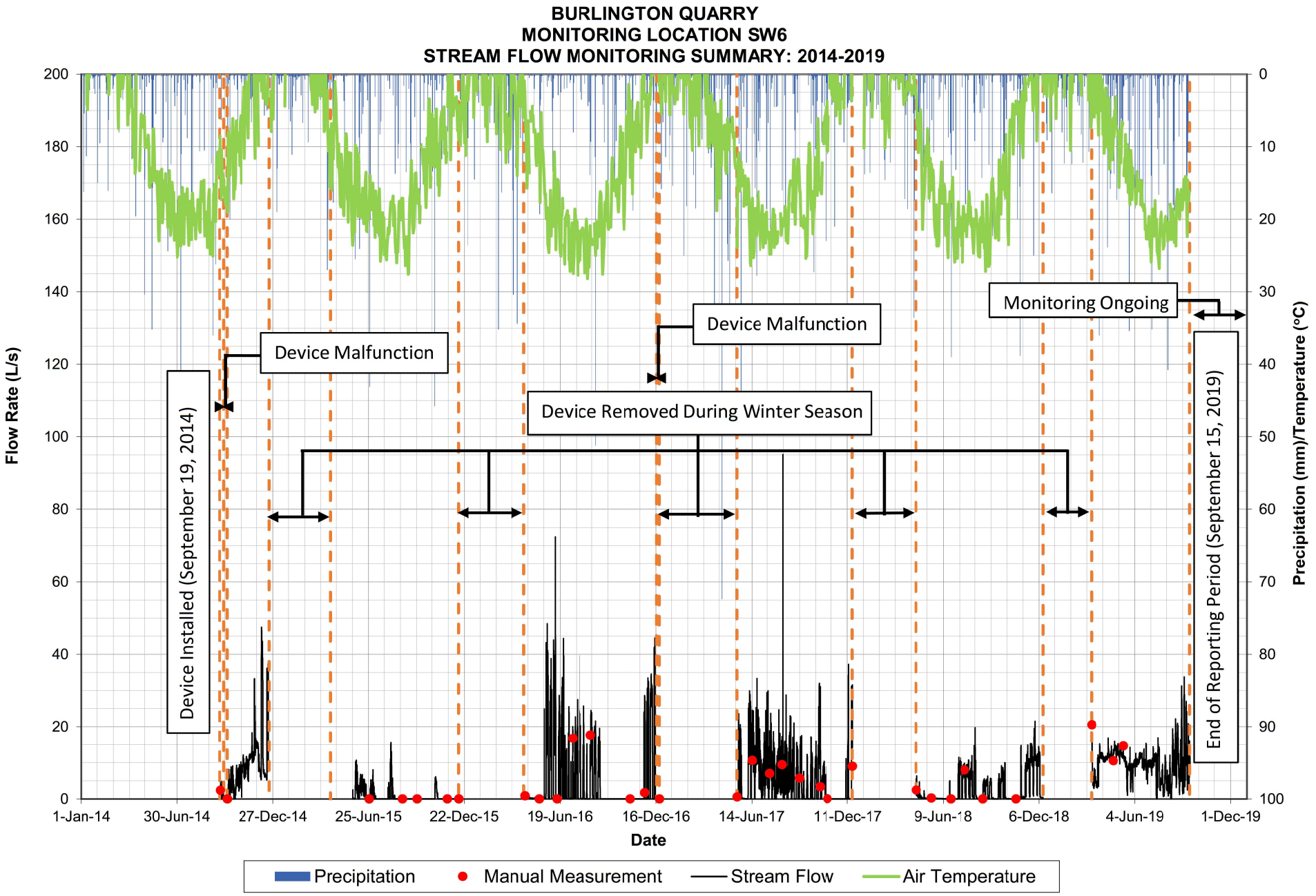
<table>
<tr><th>Impact Assessment</th><th>Description</th><th>Figure / Graph / Table</th><th colspan="2">Reference</th></tr>
<tr><th></th><th></th><th></th><th>Report</th><th>Section / Page</th></tr>
<tr><td colspan="5">Water Budget Results at Monitoring Location SW6</td></tr>
<tr><td>Water Budget Results (Operational Phases 1 & 2):</td><td>The Operational Phases 1 and 2 water budget results from the integrated model at monitoring location SW6 are presented in Figure 4b.
<table><tr><td>Condition</td><td>GW Outflow</td><td>GW Inflow</td><td>%Δ GW Outflow</td><td>%Δ GW Inflow</td></tr><tr><td>Baseline (Existing)</td><td>9.70%</td><td>0.32%</td><td>-</td><td>-</td></tr><tr><td>Phases 1 & 2</td><td>10.07%</td><td>0.00%</td><td>0.37%</td><td>-0.32%</td></tr></table></td><td>Figure 4b</td><td></td><td></td></tr>
<tr><td>Water Budget Results (Operational Phases 3 Through 6):</td><td>The Operational Phases 3 through 6 water budget results from the integrated model at monitoring location SW6 are presented in Figure 4c.
<table><tr><td>Condition</td><td>GW Outflow</td><td>GW Inflow</td><td>%Δ GW Outflow</td><td>%Δ GW Inflow</td></tr><tr><td>Baseline (Existing)</td><td>9.70%</td><td>0.32%</td><td>-</td><td>-</td></tr><tr><td>Phases 3 through 6</td><td>7.92%</td><td>0.02%</td><td>-1.78%</td><td>-0.30%</td></tr></table></td><td>Figure 4c</td><td></td><td></td></tr>
<tr><td>Water Budget Results (Rehabilitation Scenario 1):</td><td>The Rehabilitation Scenario 1 water budget results from the integrated model at monitoring location SW6 are presented in Figure 4d.
<table><tr><td>Condition</td><td>GW Outflow</td><td>GW Inflow</td><td>%Δ GW Outflow</td><td>%Δ GW Inflow</td></tr><tr><td>Baseline (Existing)</td><td>9.70%</td><td>0.32%</td><td>-</td><td>-</td></tr><tr><td>Rehab Scenario 1</td><td>6.13%</td><td>0.09%</td><td>-3.57%</td><td>-0.23%</td></tr></table></td><td>Figure 4d</td><td></td><td></td></tr>
<tr><td>Water Budget Results (Rehabilitation Scenario 2):</td><td>The Rehabilitation Scenario 2 water budget results from the integrated model at monitoring location SW6 are presented in Figure 4e.
<table><tr><td>Condition</td><td>GW Outflow</td><td>GW Inflow</td><td>%Δ GW Outflow</td><td>%Δ GW Inflow</td></tr><tr><td>Baseline (Existing)</td><td>9.70%</td><td>0.32%</td><td>-</td><td>-</td></tr><tr><td>Rehab Scenario 2</td><td>8.76%</td><td>2.06%</td><td>-0.94%</td><td>1.74%</td></tr></table></td><td>Figure 4e</td><td></td><td></td></tr>
<tr><td>Change in Groundwater Contributions to Watercourse:</td><td>Groundwater seepage to the watercourse catchment under Baseline conditions is shown in Graph 7. Under P12 conditions, the dewatering associated with the excavation will reduce that seepage to zero. Under P12 conditions, the leakage from the watercourse will increase. This includes the effect of changes in the south quarry discharge.</td><td>Graphs 7 and 8</td><td></td><td></td></tr>
<tr><td>Change in Watercourse Thermal Regime:</td><td>Negative changes in water temperature are not expected given that the watercourse will continue to receive its primary input from quarry discharge. Temperature of water being discharge from Quarry Sump 0200 is not expected to change as a result of the proposed Quarry Extension, therefore, no change in water temperature is anticipated.</td><td></td><td>NETR (Savanta, April 2020)</td><td>79</td></tr>
<tr><td>Change in Water Quality:</td><td>1) Negative changes on water quality are not expected given that the watercourse will continue to receive its primary input from quarry discharge. Quality of water being discharged from Quarry Sump 0200 is not expected to change as a result of the proposed Quarry Extension, therefore, no change in water quality in the major source of inflow is expected.

2) Discharge from the temporary settling pond/sump from the South Extension will meet water quality discharge objectives. Therefore, no negative impacts on water quality are expected.</td><td></td><td>NETR (Savanta, April 2020)</td><td>79</td></tr>
<tr><td>Potential Impact to Form and Function of Feature:</td><td>Alterations to quarry discharge (if unmitigated) could potentially have negative impacts on the form and habitat functions of this watercourse.</td><td></td><td>NETR (Savanta, April 2020)</td><td>79</td></tr>
<tr><td>Potential Impact to Identified Species and Habitat:</td><td>Alterations to quarry discharge (if unmitigated) could potentially have negative impacts on the species and habitat functions of this watercourse.</td><td></td><td>NETR (Savanta, April 2020)</td><td>79</td></tr>
</table>

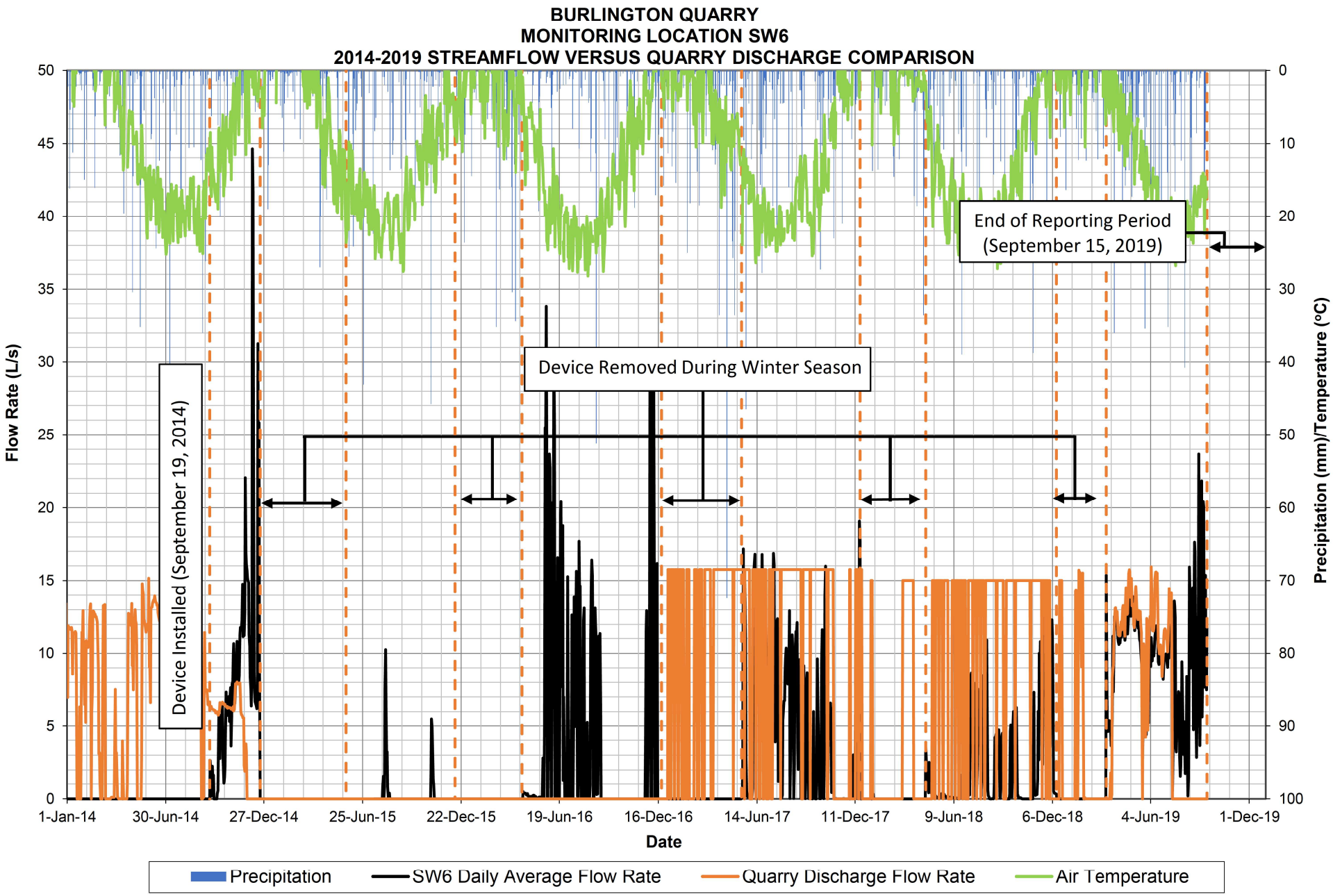
West Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek

Mitigation	Description	Figure / Graph / Table	Reference	
			Report	Section / Page
Direct Alteration Mitigation:	1) In-water work required to install the settling pond/sump outlet is recommended to be completed between July 16 and March 14 to minimize the potential for direct and indirect impacts on the reproductive activities of the fish community in the West Arm. 2)Erosion and sedimentation control measures and spill prevention and response measures will be used throughout the duration of any in-stream works in the watercourse. Work-site isolation measures should be considered depending on the final design of the outlet and proposed installation methodology and location. 3) Any riparian areas disturbed during installation of the outlet should be rehabilitated with appropriate native vegetation species following installation of the outlet structure.		NETR (Savanta, April 2020)	75
Source Water Mitigation:	In order to mitigate impacts on fish and fish habitat in the West Arm, pumping and discharge are recommended to occur at the same location at the upstream end of watercourse and in the same manner as existing pumping in accordance with the existing PTTW and Environmental Compliance Approvals regulating current quarry discharge.		NETR (Savanta, April 2020)	79
Groundwater Contribution Mitigation:	None required. Predicted reductions in groundwater contribution to the West Arm are 0.32% or 0.08 L/s or less.			
Erosion Mitigation:	Erosion and sedimentation control measures and spill prevention and response measures will be used throughout the duration of any in-stream works in the watercourse. Work-site isolation measures should be considered depending on the final design of the outlet and proposed installation methodology and location.			
Thermal Mitigation:	No specific thermal mitigation is proposed given that maintaining existing quarry outflows at Sump 0200 are expected to maintain the existing thermal regime of the watercourse without any additional mitigation.		NETR (Savanta, April 2020)	79
Water Quality Mitigation:	1) No specific water quality mitigation over and above that of the existing quarry operations is proposed given that maintaining existing quarry outflows at Sump 0200 are expected to maintain the existing water quality regime of the watercourse without any additional mitigation. The quarry extension is not predicted to result in any changes in the quality of water being discharged from Sump 0200. 2) The temporary settling pond and longer-term sump that will discharge to the West Arm will be required to meet discharge water quality criteria with respect to total suspended solids and other potential contaminants.		NETR (Savanta, April 2020)	79

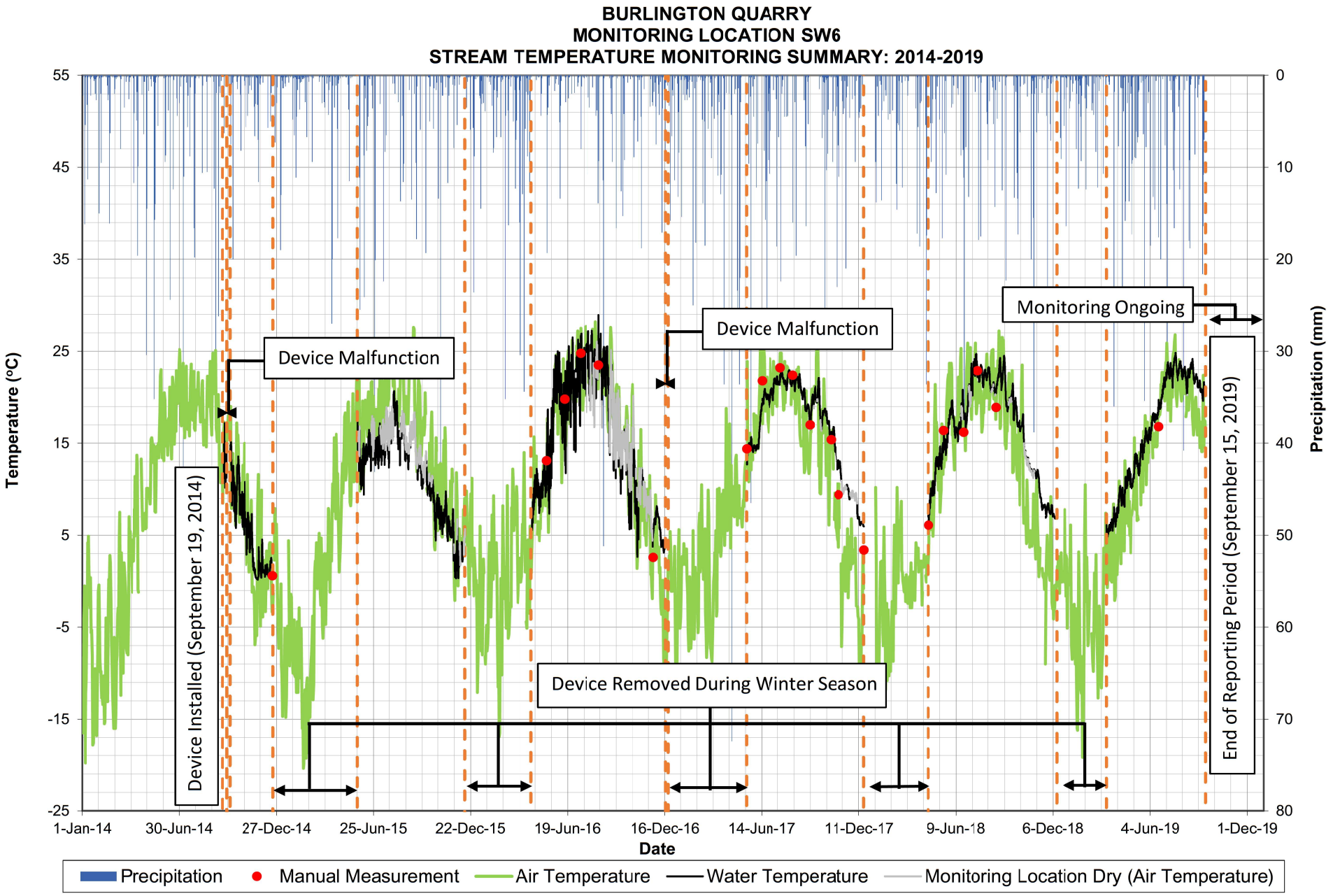
WEST ARM OF THE WEST BRANCH OF THE MOUNT NEMO TRIBUTARY OF GRINDSTONE CREEK - GRAPH 1



WEST ARM OF THE WEST BRANCH OF THE MOUNT NEMO TRIBUTARY OF GRINDSTONE CREEK - GRAPH 2



WEST ARM OF THE WEST BRANCH OF THE MOUNT NEMO TRIBUTARY OF GRINDSTONE CREEK - GRAPH 3



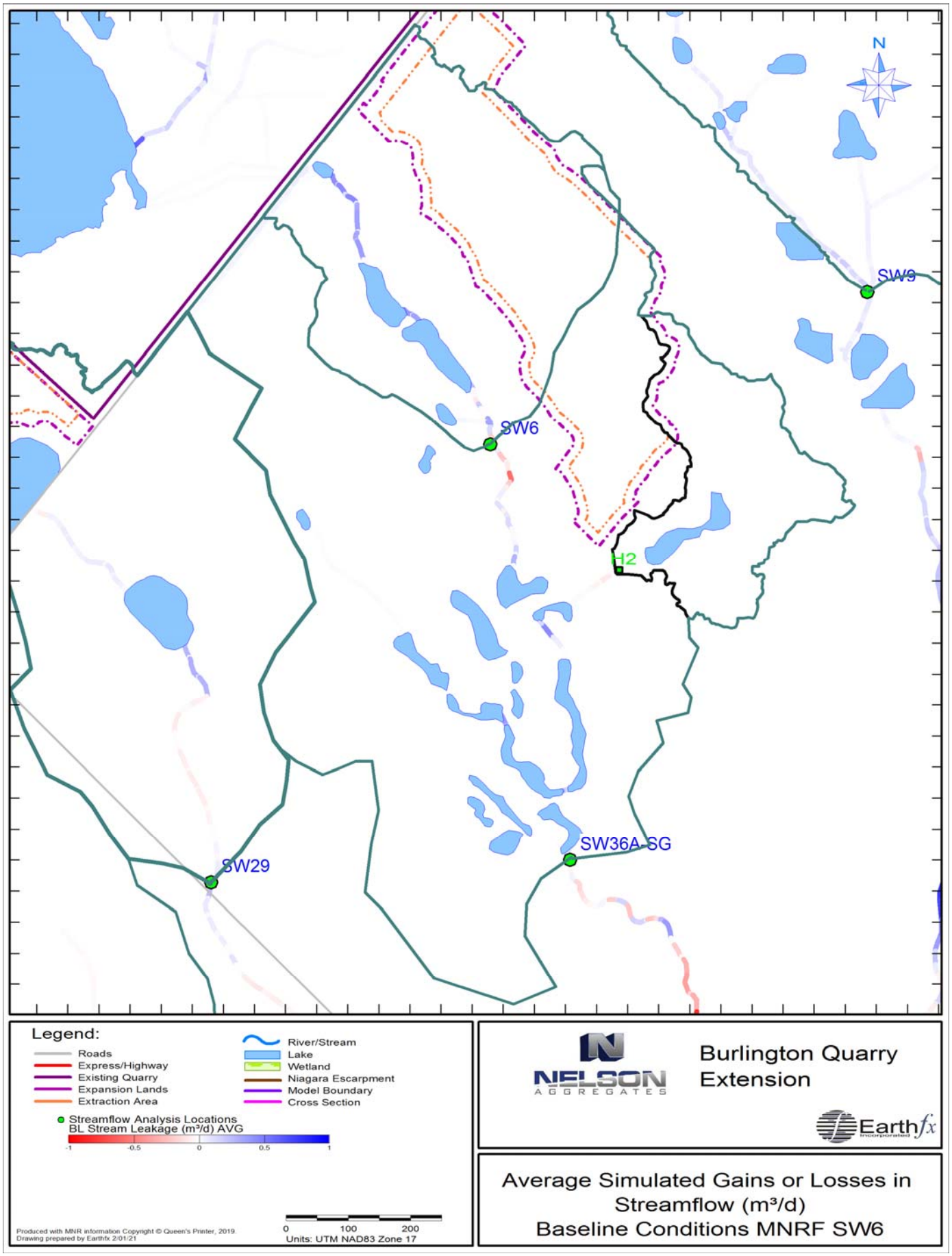
* Grey data indicates the monitoring location was dry and therefore the recorded values are respresentative of the air temperature.

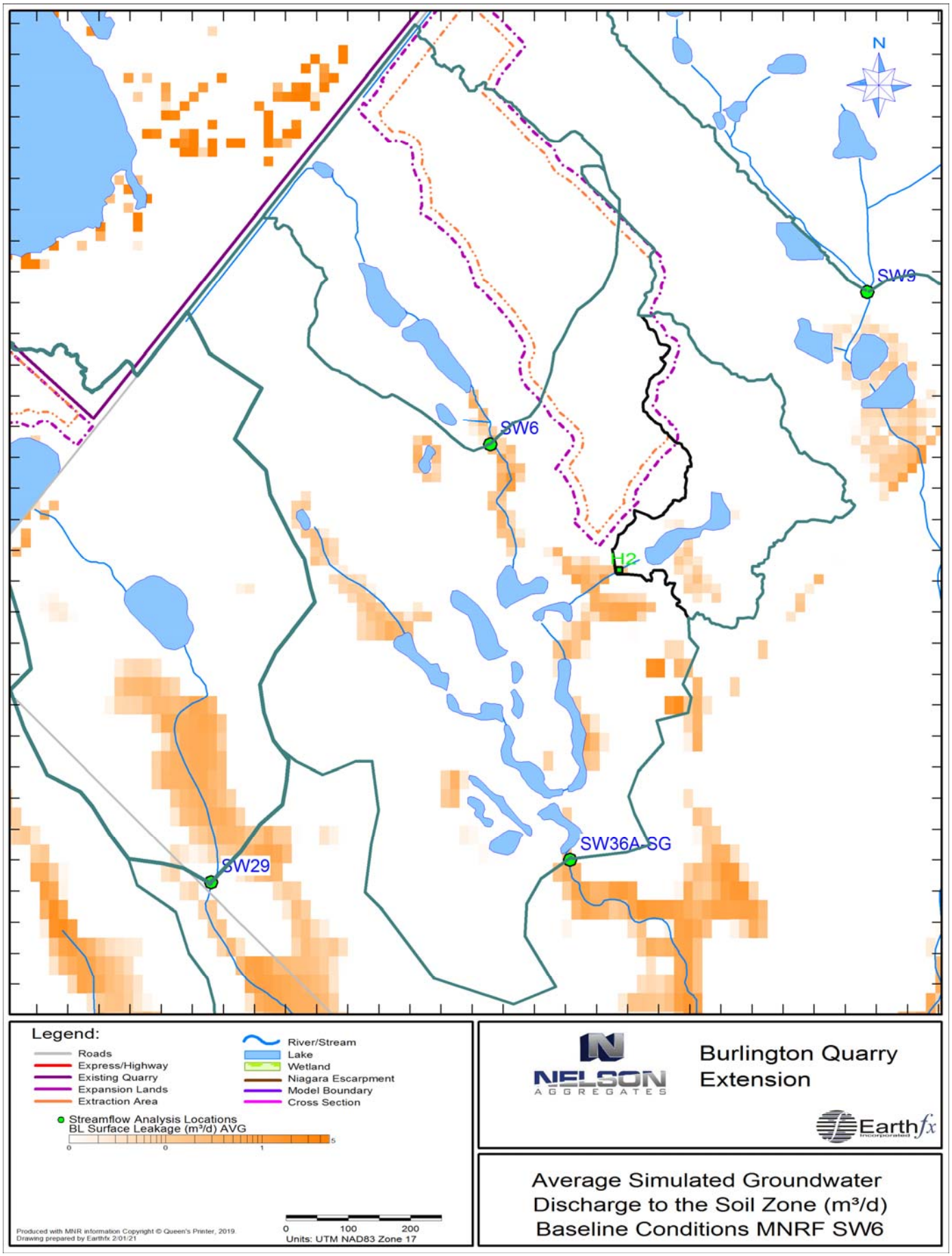
WEST ARM OF THE WEST BRANCH OF THE MOUNT NEMO TRIBUTARY OF GRINDSTONE CREEK - TABLE 1

BURLINGTON QUARRY
TATHAM ENGINEERING PROJECT NO.: 113187
SURFACE WATER MONITORING

WATER QUALITY SAMPLE RESULTS

Monitoring Location SW6													
		Sample Date:	24-Oct-18	24-Apr-19	19-Jun-19	25-Sep-19	20-May-20	15-Jul-20	16-Sep-20	11-Nov-20	Maximum	Minimum	Average
Parameter:	Units:	M.D.L.	CM/JG	CM/JG	CM	CM	JG	JG/JH/JM	JH/JM	JG/JH			
M-Alkalinity (pH 4.5)	mg/L as CaCO3	2		170	172	137	169	125			172	137	160
Ammonia (as N)	mg/L	0.01		<0.01	0.04	0.02	<0.01	<0.01			0.04	0.02	0.02
BOD (5 day)	mg/L	1		0.9	<0.9	0.9	<1	<1			0.9	0.9	0.9
Bicarbonate	mg/L as CaCO3	1		169		136		124			169	136	102
Carbonate	mg/L as CaCO3	1		1		<1		<1			1	1	1
Conductivity	µS/cm	1		798	843	934	975	1020			934	798	858
Dissolved Organic Carbon	mg/L	0.4		2.7	3	3.4	2.2	3.4			3.4	2.7	3.0
Field pH	pH	N/A			8.4	8.7	8.4				8.7	8.4	5.7
Field Temp	°C	N/A			15.1	16.1	17.2				16.1	15.1	10.4
Aluminum	ug/L	1		6	2	<1	<1	<1			6	2	3
Antimony	ug/L	0.5		<0.5	<0.5	<0.5	<0.5	<0.5			<0.5	<0.5	0.5
Arsenic	ug/L	1		2	3	4	2	6			4	2	3
Barium	ug/L	1		31	30	32	33	23			32	30	31
Beryllium	ug/L	0.5		<0.5	<0.5	<0.5	<0.5	<0.5			<0.5	<0.5	0.5
Bismuth	ug/L	1		<1	<1	<1	<1	<1			<1	<1	1
Boron	ug/L	2		66	71	160	116	157			160	66	99
Cadmium	ug/L	0.1		<0.1	<0.1	<0.1	<0.1	<0.1			<0.1	<0.1	0.1
Calcium	ug/L	500		85600	85900	74700	87100	80800			85900	74700	82067
Cerium	ug/L	1		<1	<1	<1	<1	<1			<1	<1	1
Cesium	ug/L	1		<1	<1	<1	<1	<1			<1	<1	1
Chromium	ug/L	1		3	3	3	2	1			3	3	3
Cobalt	ug/L	0.1		0.2	0.2	0.1	0.2	0.2			0.2	0.1	0.2
Copper	ug/L	1		<1	4	<1	2	2			4	4	2
Europium	ug/L	1		<1	<1	<1	<1	<1			<1	<1	1
Gallium	ug/L	1		<1	<1	<1	<1	<1			<1	<1	1
Iron	ug/L	20		89	211	180	282	180			211	89	160
Lanthanum	ug/L	1		<1	<1	<1	<1	<1			<1	<1	1
Lead	ug/L	0.1		<0.1	<0.1	<0.1	<0.1	<0.1			<0.1	<0.1	0.1
Lithium	ug/L	5		10	11	13	14	23			13	10	11
Magnesium	ug/L	5		35500	39100	41300	45500	42300			41300	35500	38633
Manganese	ug/L	10	DRY	<1	31	15	8	37	DRY	DRY	31	15	19
Mercury	ug/L	0.1		<0.1	<0.1	<0.1	<0.1	<0.1			<0.1	<0.1	0.1
Molybdenum	ug/L	1		4	4	3	4	5			4	3	4
Nickel	ug/L	1		4	4	3	4	3			4	3	4
Niobium	ug/L	1		<1	<1	<1	<1	<1			<1	<1	1
Phosphorus	ug/L	50		<50	<50	<50	<50	<50			<50	<50	50
Potassium	ug/L	1		3980	4380	6510	4950	6480			6510	3980	4957
Rubidium	ug/L	1		2	2	3	2	3			3	2	2
Scandium	ug/L	1		<1	<1	<1	<1	<1			<1	<1	1
Selenium	ug/L	0.5		1.7	1.1	0.9	2.2	<0.5			1.7	0.9	1.2
Silicon	ug/L	2		670	900	1230	500	1550			1230	670	933
Silver	ug/L	0.1		<0.1	<0.1	<0.1	<0.1	<0.1			<0.1	<0.1	0.1
Sodium	ug/L	1000		30400	36800	46100	48200	44500			46100	30400	37767
Strontium	ug/L	1		1270	1190	1380	1310	1440			1380	1190	1280
Sulphur	ug/L	800		63600	74400	79100	82400	83800			79100	63600	72367
Tellurium	ug/L	1		<1	<1	<1	<1	<1			<1	<1	1
Thallium	ug/L	0.1		<0.1	<0.1	<0.1	<0.1	<0.1			<0.1	<0.1	0.1
Thorium	ug/L	1		<1	<1	<1	<1	<1			<1	<1	1
Tin	ug/L	1		<1	<1	<1	<1	<1			<1	<1	1
Titanium	ug/L	1		2	<1	<1	<1	<1			2	2	1
Tungsten	ug/L	1		<1	<1	<1	<1	<1			<1	<1	1
Uranium	ug/L	1		<1	<1	<1	1	1			<1	<1	1
Vanadium	ug/L	1		<1	<1	<1	<1	<1			<1	<1	1
Yttrium	ug/L	1		<1	<1	<1	<1	<1			<1	<1	1
Zinc	ug/L	1		<1	3	1	3	3			3	1	2
Zirconium	ug/L	1		<1	<1	<1	<1	<1			<1	<1	1
pH	pH	N/A		7.89	7.82	7.85	8.24	7.66			7.9	7.8	7.9
Total Hardness (as CaCO3)	mg/L	0.1		360	376	357	405	376			376	357	364
Chemical Oxygen Demand	mg/L	5		8	12	<5	<5	<5			12	8	8
Total Dissolved Solids	mg/L	3		593	631	695	709	724			695	593	640
Total Suspended Solids	mg/L	0.67		<0.67	<0.67	2	1	<0.67			2.00	2.00	1.11
Turbidity	NTU	0.1		0.5	0.4	0.2	0.4	0.2			0.5	0.2	0.4


N
SW9
SW6
H2
SW36A-SG
SW29
Legend:
Roads
Express/Highway
Existing Quarry
Expansion Lands
Extraction Area
River/Stream
Lake
Wetland
Niagara Escarpment
Model Boundary
Cross Section
Streamflow Analysis Locations
BL Stream Leakage (m³/d) AVG
-1
-0.5
0
0.5
1
0
100
200
Units: UTM NAD83 Zone 17
Produced with MNR information Copyright © Queen's Printer, 2019.
Drawing prepared by Earthfx 2/01/21
NELSON AGGREGATES
Burlington Quarry Extension
Earthfx Incorporated
Average Simulated Gains or Losses in Streamflow (m³/d)
Baseline Conditions MNRF SW6


N
SW9
SW6
H2
SW36A-SG
SW29
Legend:
Roads
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Existing Quarry
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Wetland
Niagara Escarpment
Model Boundary
Cross Section
Streamflow Analysis Locations
BL Surface Leakage (m³/d) AVG
0
0
1
5
0
100
200
Units: UTM NAD83 Zone 17
Produced with MNR information Copyright © Queen's Printer, 2019.
Drawing prepared by Earthfx 2/01/21
NELSON AGGREGATES
Burlington Quarry Extension
Earthfx Incorporated
Average Simulated Groundwater Discharge to the Soil Zone (m³/d)
Baseline Conditions MNRF SW6

FIGURE 3A

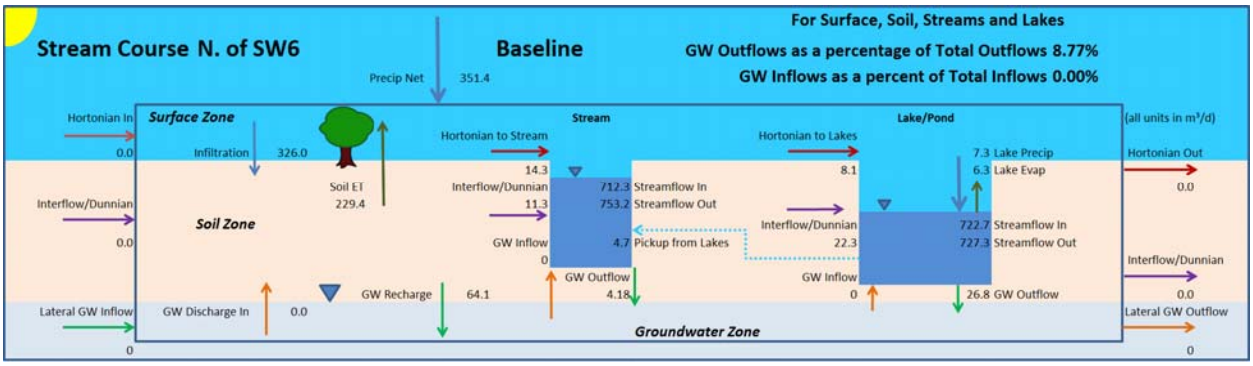


FIGURE 3B

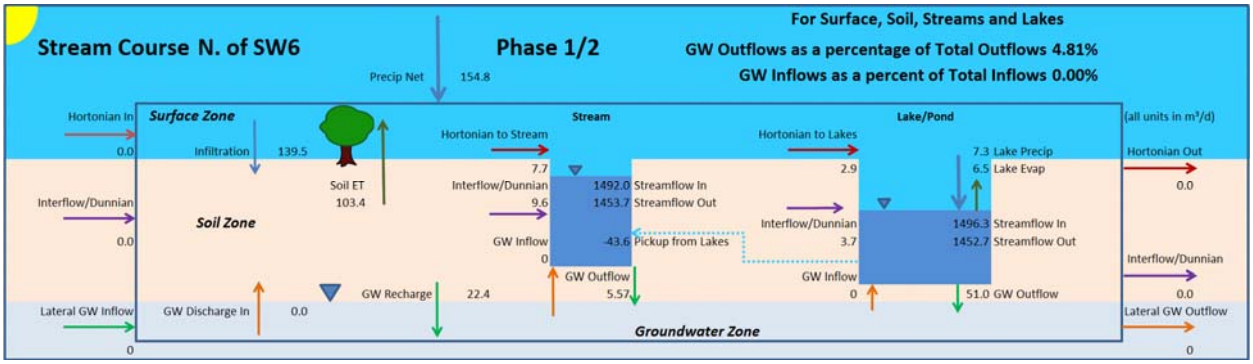


FIGURE 3C

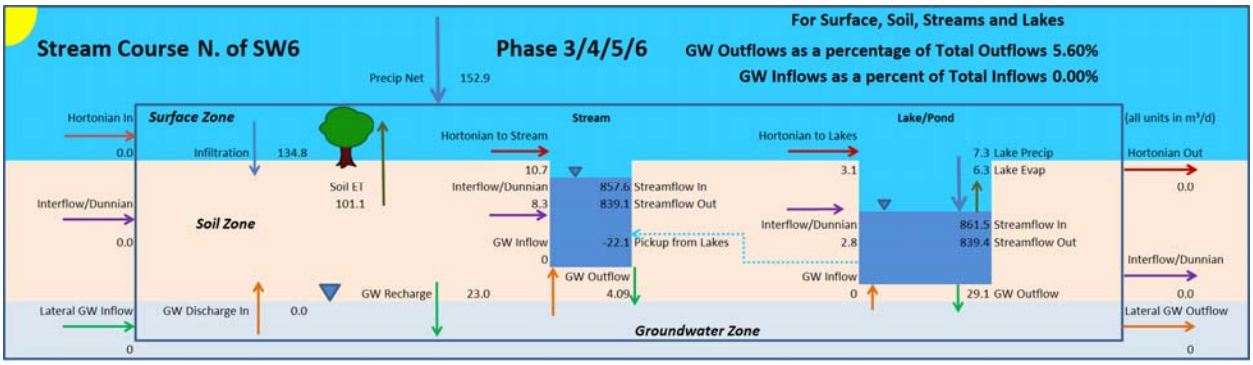


FIGURE 3D

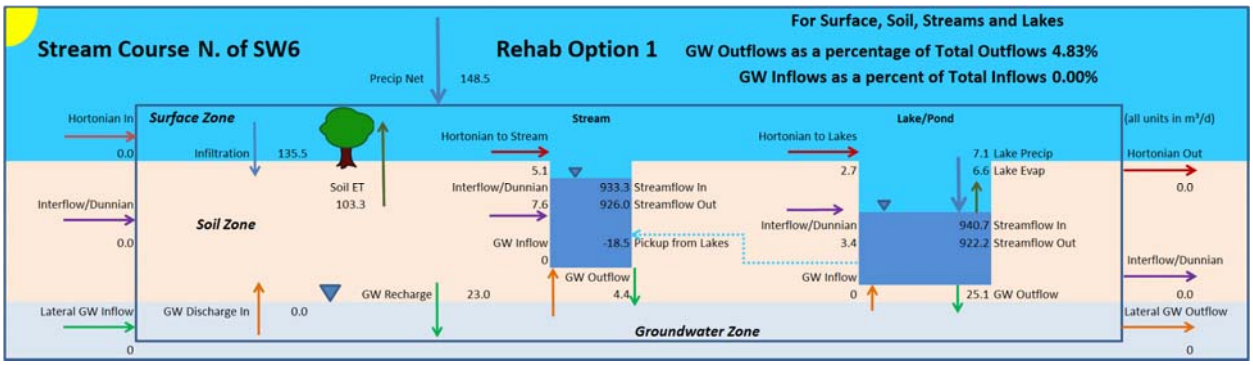


FIGURE 3E

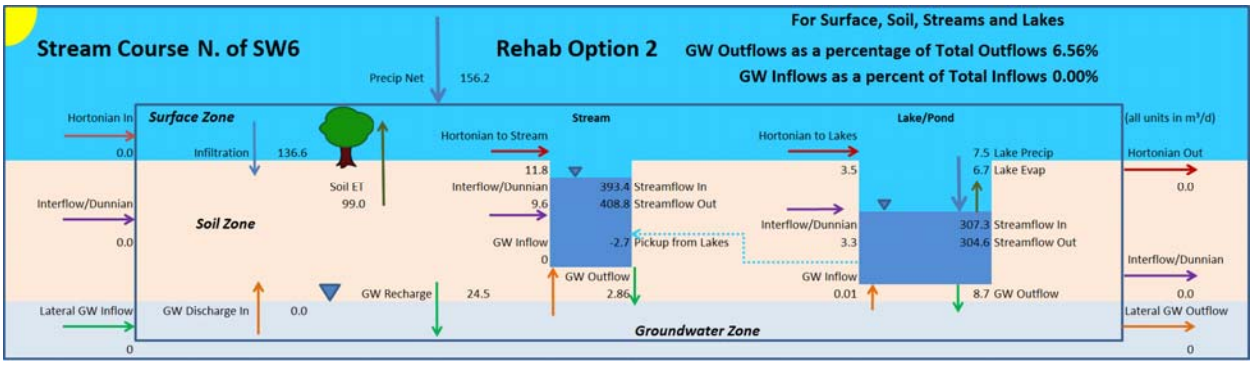


FIGURE 4A

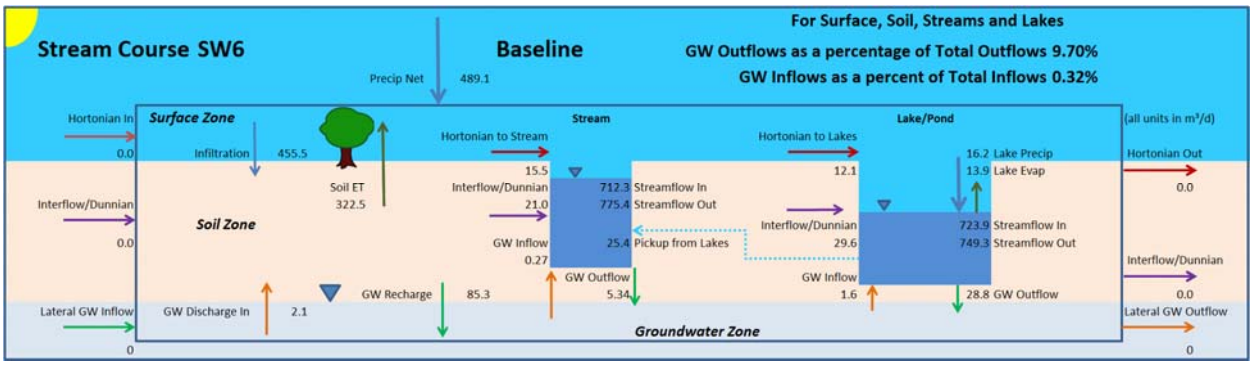
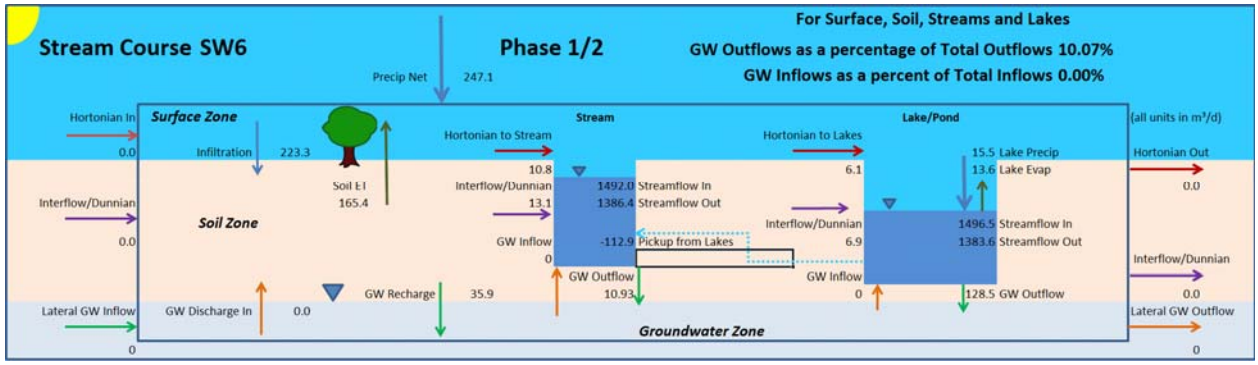


FIGURE 4B



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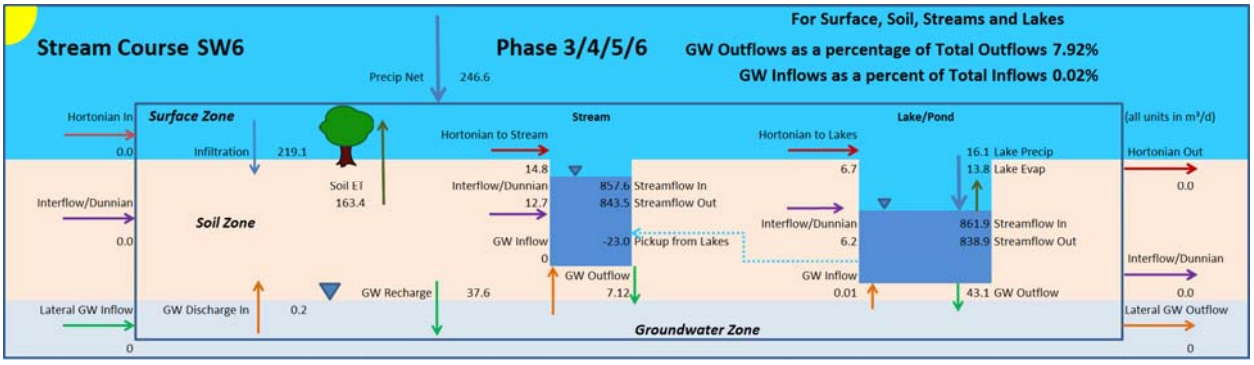


FIGURE 4D

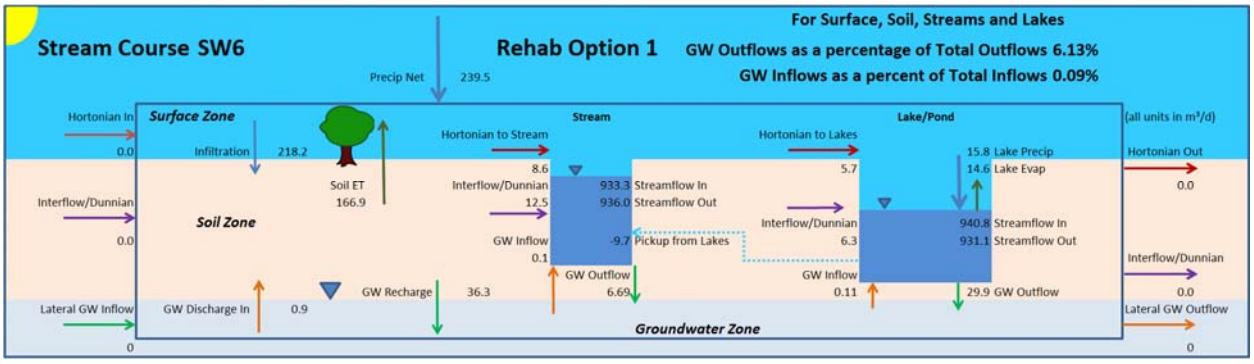
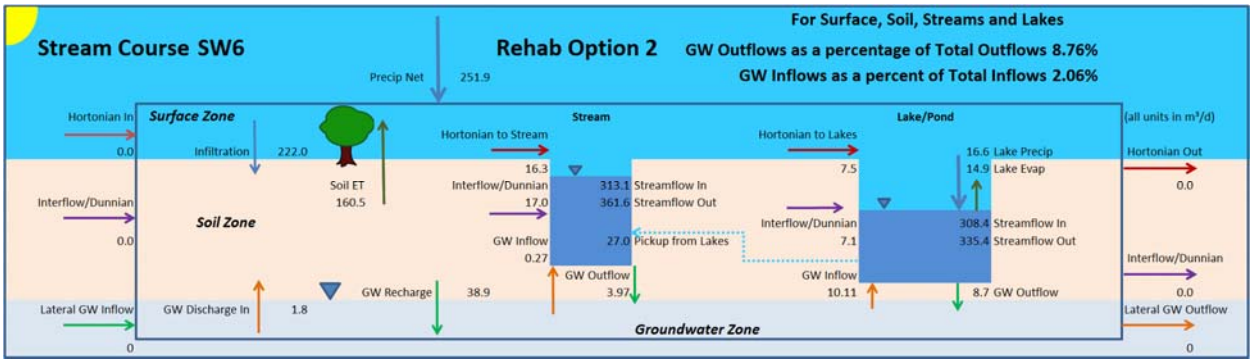
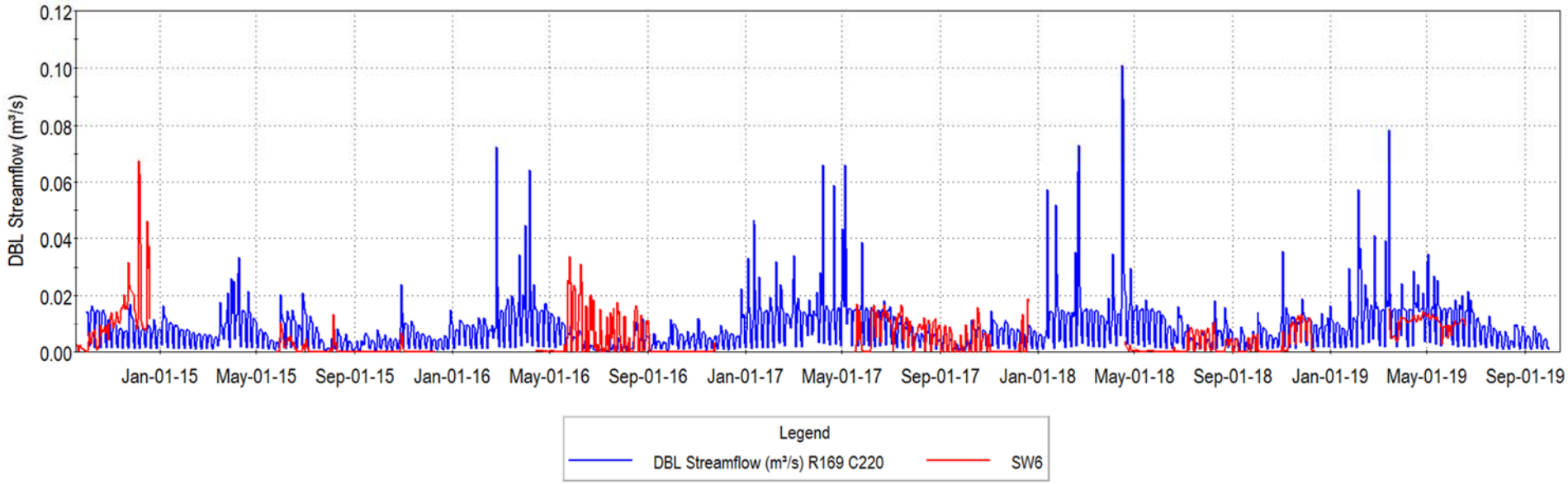


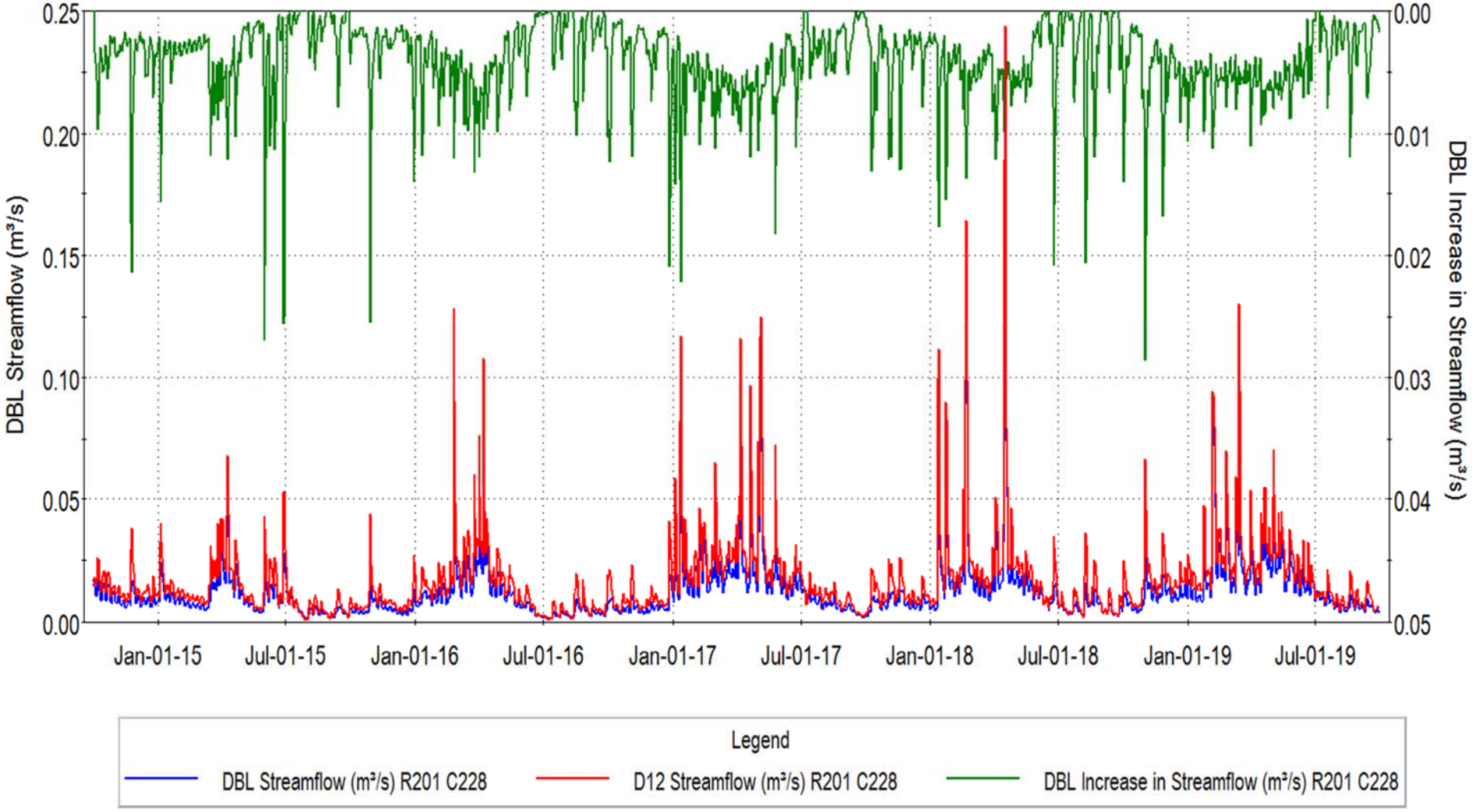
FIGURE 4E



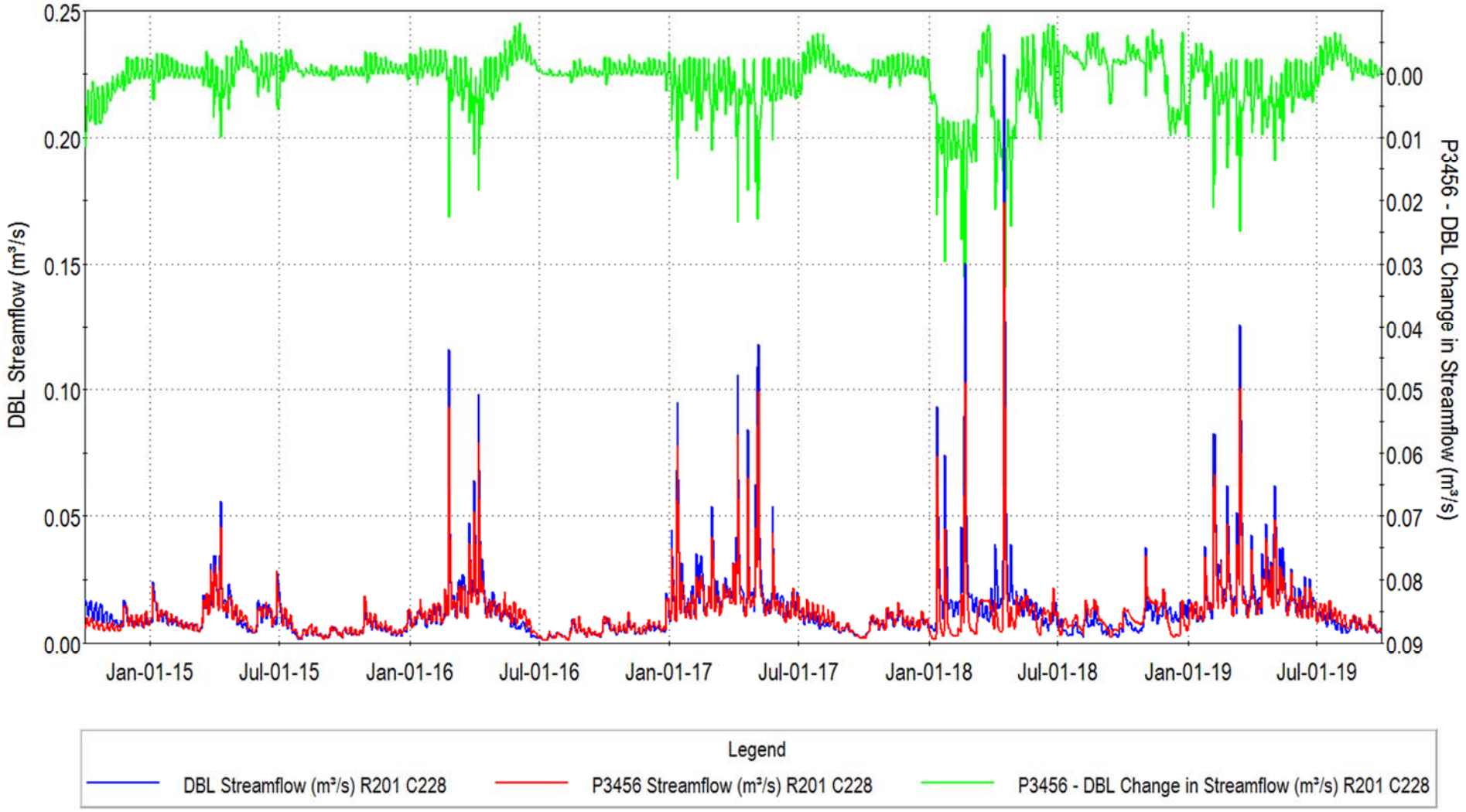
Integrated Model Calibration
West Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek



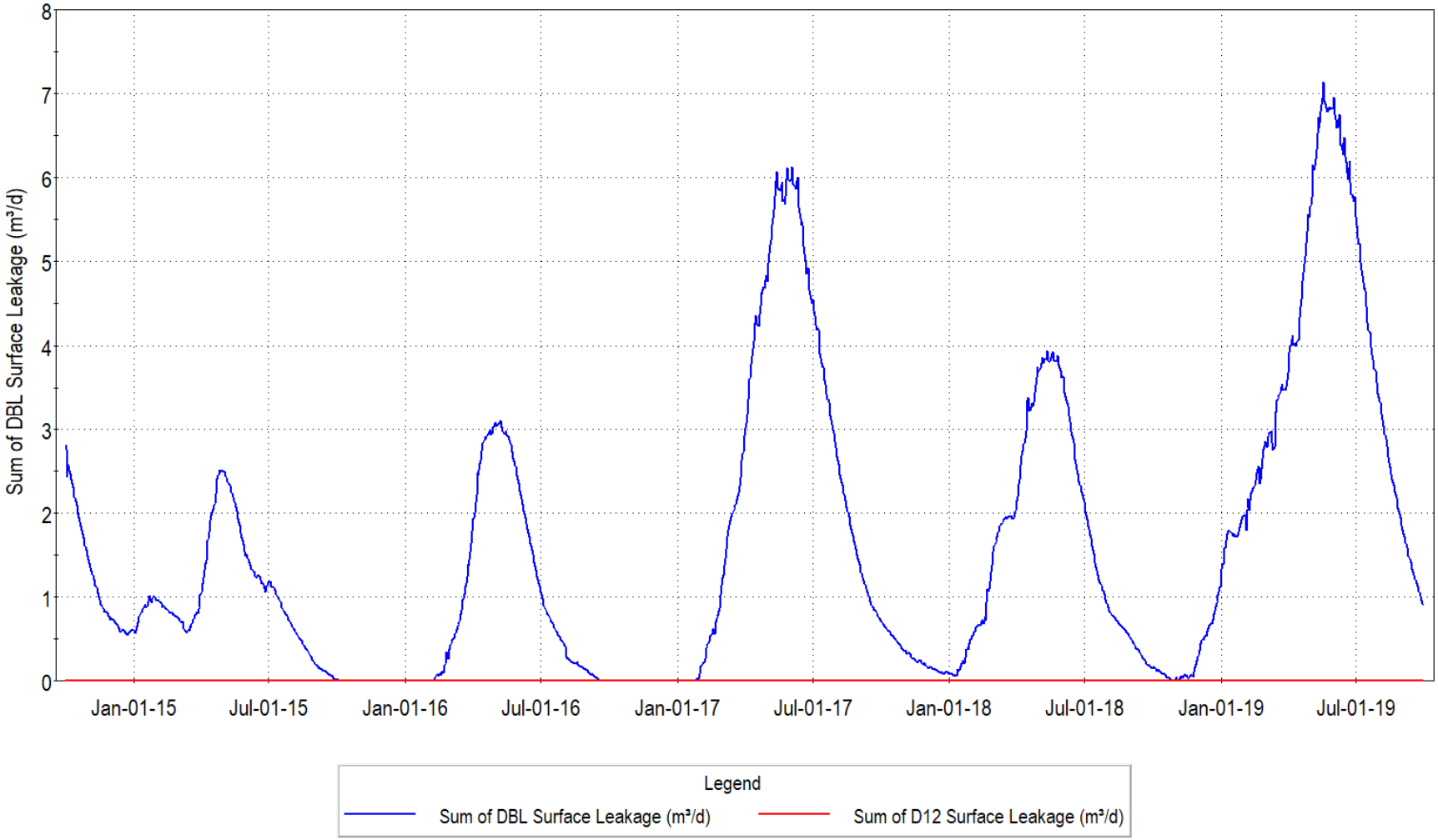
Simulated Streamflow Change - Integrated Model
West Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek



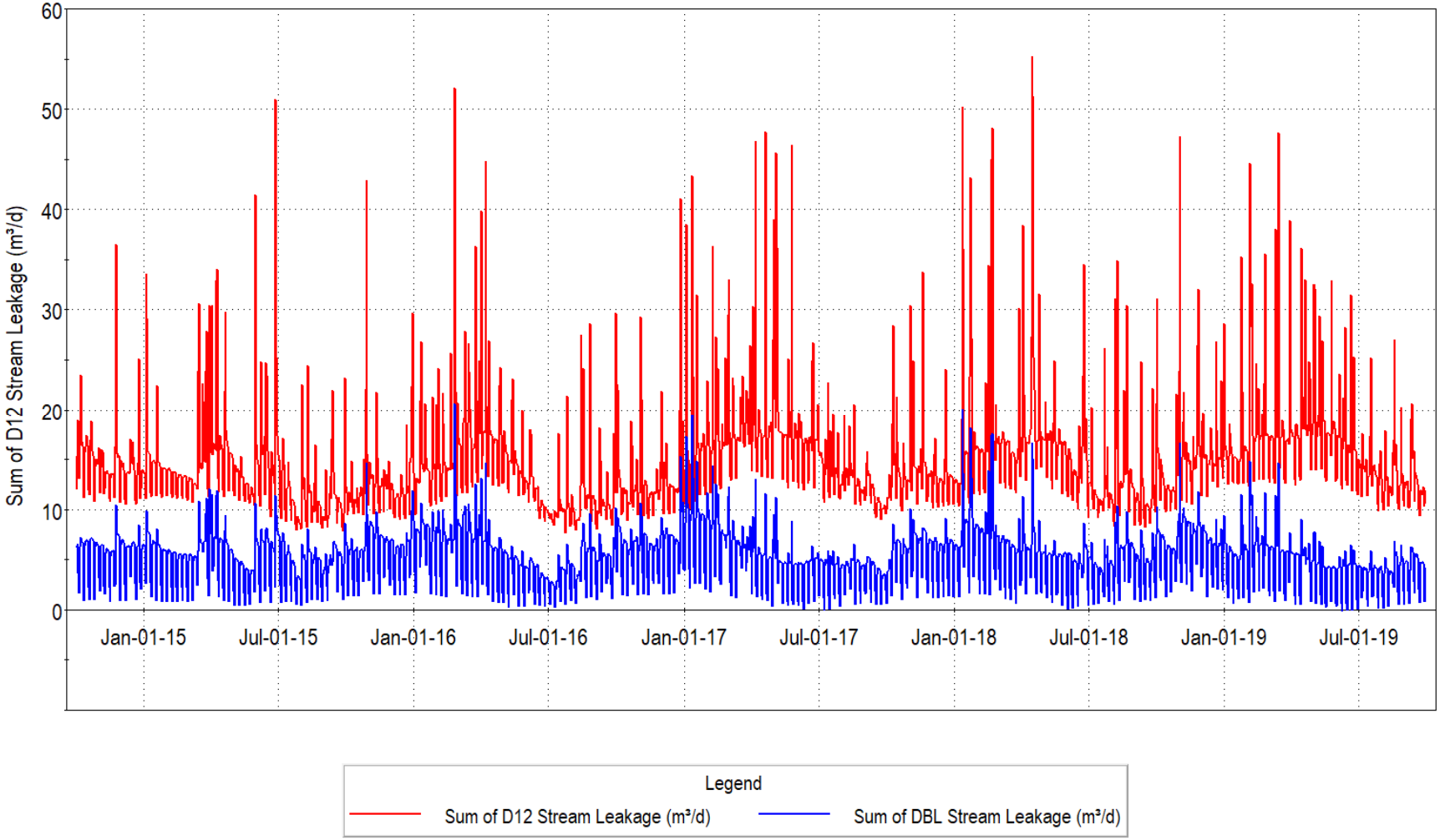
Simulated Streamflow Change - Integrated Model
West Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek



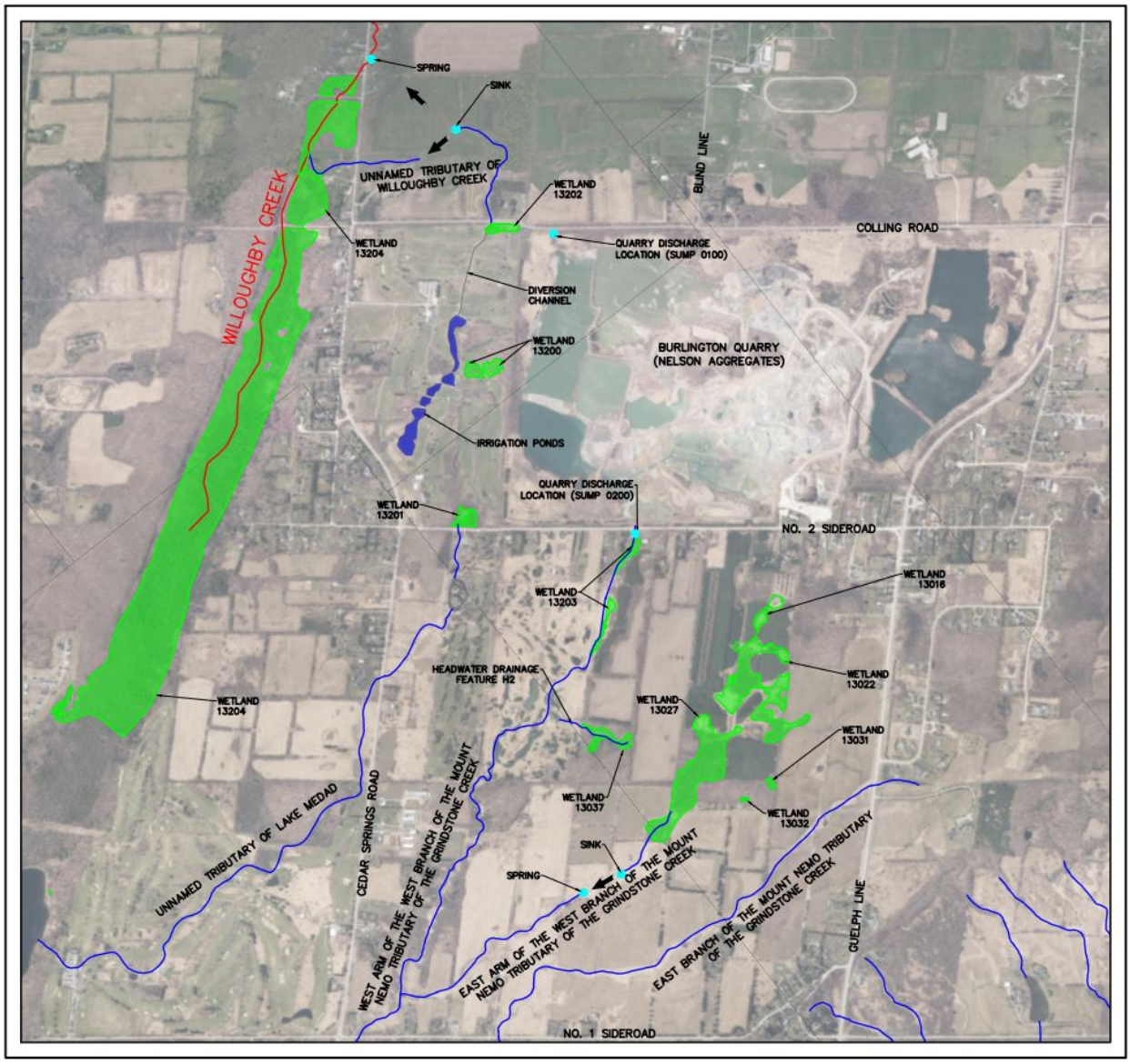
Change in Groundwater Contributions to Watercourse
West Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek

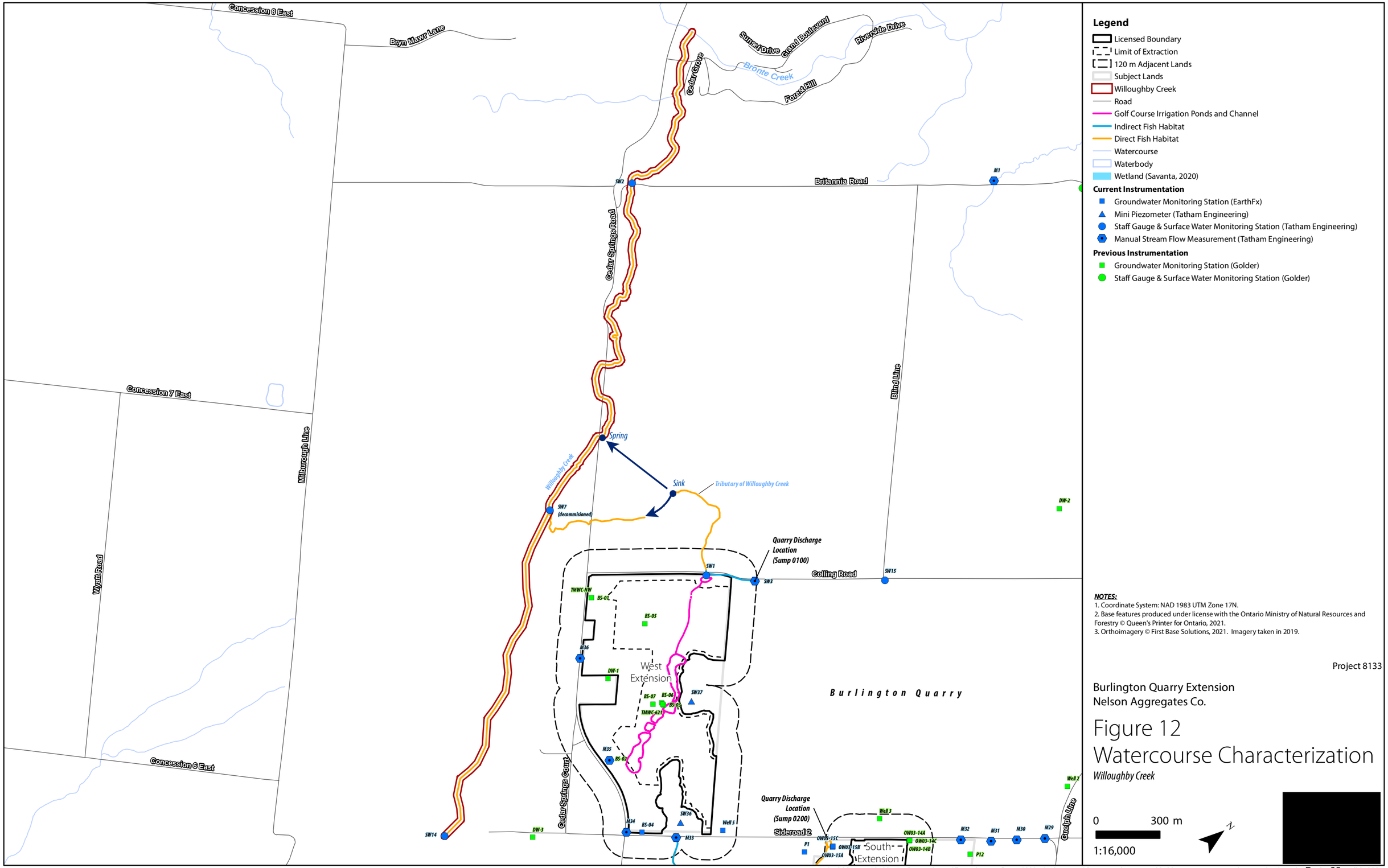


Change in Groundwater Contributions to Watercourse
West Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek



WILLOUGHBY CREEK





Legend

- Licensed Boundary
- Limit of Extraction
- 120 m Adjacent Lands
- Subject Lands
- Willoughby Creek
- Road
- Golf Course Irrigation Ponds and Channel
- Indirect Fish Habitat
- Direct Fish Habitat
- Watercourse
- Waterbody
- Wetland (Savanta, 2020)

Current Instrumentation

- Groundwater Monitoring Station (EarthFx)
- Mini Piezometer (Tatham Engineering)
- Staff Gauge & Surface Water Monitoring Station (Tatham Engineering)
- Manual Stream Flow Measurement (Tatham Engineering)

Previous Instrumentation

- Groundwater Monitoring Station (Golder)
- Staff Gauge & Surface Water Monitoring Station (Golder)

NOTES:

1. Coordinate System: NAD 1983 UTM Zone 17N.
2. Base features produced under license with the Ontario Ministry of Natural Resources and Forestry © Queen's Printer for Ontario, 2021.
3. Orthoimagery © First Base Solutions, 2021. Imagery taken in 2019.

Project 8133

Burlington Quarry Extension
Nelson Aggregates Co.

Figure 12
Watercourse Characterization

Willoughby Creek

0 300 m

1:16,000

Willoughby Creek

Surface Water Characteristics	Description	Figure / Graph / Table	Reference	
			Report	Section / Page
Watercourse Name:	Willoughby Creek			
Watershed:	Bronte Creek Watershed			
Sub-Watershed:	Willoughby Creek Watershed			
Located in Proposed Limit of Extraction:	No			
Located in Proposed License Boundary:	No			
Catchment Area (ha):	1091 ha (at Britannia Road)			
Catchment ID:	N/A			
Primary Source(s) of Flow:	Primary - discharge from Burlington Quarry (Sump 0100) Secondary - surface runoff Tertiary - groundwater seepage			
Discharge from Quarry / PTTW:	Yes - PTTW 96-P-3009		SWA (Tatham, April 2020)	Appendix A
Conditions of PTTW:	Maximum discharge rate = 4,090 L/min (68.17 L/s) Maximum discharge amount = 5,889,600 L/day		SWA (Tatham, April 2020)	Appendix A
Surface Water Monitoring:	ID: SW2 (Tatham) Installation Date: April 17, 2014 Data Collection: Continuous water level and temperature, manual monthly in-situ streamflow measurements and calibration data (water level converted to flow using rating curve) Coordinates of Monitoring Station: Easting 589015.325, Northing 4805832.639	Graphs 1 & 2 and Table 1	SWA (Tatham, April 2020)	2.1.1, Appendix B and Appendix H
	ID: SW7 (Tatham) Installation Date: September 19, 2014 Data Collection: Continuous water level and temperature, manual monthly in-situ streamflow measurements and calibration data (water level converted to flow using rating curve) Location Coordinates: Easting 588319.945, Northing 4805441.072	Graphs 3 & 4	SWA (Tatham, April 2020)	2.1.1 and Appendix B
	ID: SW14 (Tatham) Installation Date: October 2, 2014 Data Collection: Continuous water level and temperature, manual monthly in-situ streamflow measurements and calibration data (water level converted to flow using rating curve) Location Coordinates: Easting 589226.754, Northing 4804106.857	Graphs 5 & 6 and Table 2	SWA (Tatham, April 2020)	2.1.1, Appendix B and Appendix H
Streamflow Conditions:	Permanent watercourse at Britannia Road (SW2), intermittent watercourse at monitoring locations SW7 and SW14. Watercourse dependent on quarry discharge downstream of confluence with Unnamed Tributary of Willoughby Creek.	Graphs 1, 3 & 5	SWA (Tatham, April 2020)	2.1.1 and Appendix B

Surface Water Characteristics	Description					Figure / Graph / Table	Reference	
							Report	Section / Page
Average Daily Flow (SW2):	Average Daily Streamflow (L/s)				Notes:	Graph 1	SWA (Tatham, April 2020)	2.1.1 and Appendix B
	Month	Minimum	Average	Maximum	Minimum - lowest daily average streamflow recorded for period of record			
	January	37.3	119.9	512.7				
	February	39.8	116.5	779.3				
	March	35.1	150.0	989.1	Average - average daily streamflow recorded for period of record			
	April	86.1	219.0	697.8				
	May	36.4	207.8	1275.7	Maximum - maximum daily average streamflow recorded for period of record			
	June	41.5	117.7	939.1				
	July	35.3	81.0	402.5				
	August	27.8	91.2	1511.3	N/A - data not available as device removed from watercourse during winter months			
	September	29.3	83.9	300.2				
	October	31.6	86.2	282.9				
	November	38.8	105.8	513.3				
	December	30.8	90.7	230.6				
Average Daily Flow (SW7):	Average Daily Streamflow (L/s)				Notes:	Graph 3	SWA (Tatham, April 2020)	2.1.1 and Appendix B
	Month	Minimum	Average	Maximum	Minimum - lowest daily average streamflow recorded for period of record			
	January	N/A	N/A	N/A				
	February	N/A	N/A	N/A				
	March	102.1	217.9	665.9	Average - average daily streamflow recorded for period of record			
	April	31.8	115.1	314.4				
	May	16.7	75.0	285.2	Maximum - maximum daily average streamflow recorded for period of record			
	June	9.1	41.7	329.4				
	July	3.3	19.4	78.3				
	August	0.9	15.0	58.1	N/A - data not available as device removed from watercourse during winter months			
	September	1.8	16.0	87.2				
	October	1.8	24.1	99.3				
	November	7.5	38.0	288.3				
	December	7.1	35.0	140.4				
Average Daily Flow (SW14):	Average Daily Streamflow (L/s)				Notes:	Graph 5	SWA (Tatham, April 2020)	2.1.1 and Appendix B
	Month	Minimum	Average	Maximum	Minimum - lowest daily average streamflow recorded for period of record			
	January	N/A	N/A	N/A				
	February	N/A	N/A	N/A				
	March	N/A	N/A	N/A	Average - average daily streamflow recorded for period of record			
	April	6.1	25.3	67.5				
	May	2.7	17.0	56.6	Maximum - maximum daily average streamflow recorded for period of record			
	June	0.0	8.4	45.3				
	July	0.0	3.1	23.9				
	August	0.0	2.8	28.4	N/A - data not available as device removed from watercourse during winter months			
	September	0.0	1.7	19.3				
	October	0.0	5.8	34.6				
	November	0.0	6.3	74.3				
	December	0.0	2.9	10.0				

<table>
<tr><th>Surface Water Characteristics</th><th>Description</th><th>Figure / Graph / Table</th><th colspan="2">Reference</th></tr>
<tr><th></th><th></th><th></th><th>Report</th><th>Section / Page</th></tr>
<tr><td>Watercourse Thermal Regime (SW2):</td><td>Average Daily Water Temperature (°C)
<table><tr><th>Month</th><th>Minimum</th><th>Average</th><th>Maximum</th></tr><tr><td>January</td><td>-1.4</td><td>1.8</td><td>5.0</td></tr><tr><td>February</td><td>-1.6</td><td>1.9</td><td>7.9</td></tr><tr><td>March</td><td>-1.1</td><td>3.1</td><td>9.6</td></tr><tr><td>April</td><td>0.6</td><td>6.7</td><td>16.0</td></tr><tr><td>May</td><td>3.5</td><td>12.0</td><td>21.7</td></tr><tr><td>June</td><td>10.0</td><td>16.2</td><td>23.8</td></tr><tr><td>July</td><td>13.2</td><td>18.9</td><td>25.9</td></tr><tr><td>August</td><td>12.9</td><td>18.7</td><td>24.5</td></tr><tr><td>September</td><td>11.4</td><td>17.1</td><td>23.2</td></tr><tr><td>October</td><td>6.2</td><td>12.3</td><td>19.4</td></tr><tr><td>November</td><td>1.1</td><td>6.7</td><td>13.7</td></tr><tr><td>December</td><td>-1.5</td><td>3.3</td><td>8.9</td></tr></table></td><td>Notes:
Minimum - lowest daily average water temperature recorded for period of record
Average - average daily water temperature recorded for period of record
Maximum - maximum daily average water temperature recorded for period of record
N/A - data not available as device removed from watercourse during winter months</td><td>Graph 2</td><td>SWA (Tatham, April 2020)</td><td>2.1.1 and Appendix B</td></tr>
<tr><td>Watercourse Thermal Regime (SW7):</td><td>Average Daily Water Temperature (°C)
<table><tr><th>Month</th><th>Minimum</th><th>Average</th><th>Maximum</th></tr><tr><td>January</td><td>N/A</td><td>N/A</td><td>N/A</td></tr><tr><td>February</td><td>N/A</td><td>N/A</td><td>N/A</td></tr><tr><td>March</td><td>0.7</td><td>1.8</td><td>5.4</td></tr><tr><td>April</td><td>1.0</td><td>6.2</td><td>12.5</td></tr><tr><td>May</td><td>5.0</td><td>11.4</td><td>20.4</td></tr><tr><td>June</td><td>9.6</td><td>14.4</td><td>20.9</td></tr><tr><td>July</td><td>12.2</td><td>16.6</td><td>212.7</td></tr><tr><td>August</td><td>13.7</td><td>17.3</td><td>23.1</td></tr><tr><td>September</td><td>11.1</td><td>16.2</td><td>20.9</td></tr><tr><td>October</td><td>6.6</td><td>12.2</td><td>18.9</td></tr><tr><td>November</td><td>1.6</td><td>7.0</td><td>13.4</td></tr><tr><td>December</td><td>1.4</td><td>4.5</td><td>8.1</td></tr></table></td><td>Notes:
Minimum - lowest daily average water temperature recorded for period of record
Average - average daily water temperature recorded for period of record
Maximum - maximum daily average water temperature recorded for period of record
N/A - data not available as device removed from watercourse during winter months</td><td>Graph 4</td><td>SWA (Tatham, April 2020)</td><td>2.1.1 and Appendix B</td></tr>
<tr><td>Watercourse Thermal Regime (SW14):</td><td>Average Daily Water Temperature (°C)
<table><tr><th>Month</th><th>Minimum</th><th>Average</th><th>Maximum</th></tr><tr><td>January</td><td>N/A</td><td>N/A</td><td>N/A</td></tr><tr><td>February</td><td>N/A</td><td>N/A</td><td>N/A</td></tr><tr><td>March</td><td>N/A</td><td>N/A</td><td>N/A</td></tr><tr><td>April</td><td>-0.2</td><td>3.1</td><td>10.2</td></tr><tr><td>May</td><td>3.5</td><td>10.3</td><td>19.4</td></tr><tr><td>June</td><td>8.8</td><td>14.2</td><td>23.3</td></tr><tr><td>July</td><td>11.2</td><td>16.9</td><td>25.0</td></tr><tr><td>August</td><td>11.4</td><td>17.3</td><td>23.8</td></tr><tr><td>September</td><td>4.5</td><td>15.3</td><td>23.5</td></tr><tr><td>October</td><td>0.9</td><td>10.8</td><td>17.6</td></tr><tr><td>November</td><td>-1.4</td><td>6.2</td><td>14.6</td></tr><tr><td>December</td><td>-0.5</td><td>3.9</td><td>11.7</td></tr></table></td><td>Notes:
Minimum - lowest daily average water temperature recorded for period of record
Average - average daily water temperature recorded for period of record
Maximum - maximum daily average water temperature recorded for period of record
N/A - data not available as device removed from watercourse during winter months</td><td>Graph 6</td><td>SWA (Tatham, April 2020)</td><td>2.1.1 and Appendix B</td></tr>
</table>

Surface Water Characteristics	Description					Figure / Graph / Table	Reference	
							Report	Section / Page
Water Quality (SW2):	Water Quality Sample Results					Table 1	SWA (Tatham, April 2020)	2.4 and Appendix H
	Parameter	Units	Minimum	Average	Maximum			
	Turbidity	NTU	0.9	2.2	3.6			
	TDS	mg/L	433	521	589			
	TSS	mg/L	1	3	6			
	COD	mg/L	8	9	12			
	BOD5	mg/L	0.8	0.9	1			
	DOC	mg/L	0.4	3	4.7			
	pH		8.1	8.1	8.2			
	Alkalinity	mg/L	166	218	261			
	Conductivity	µS/cm	668	771	881			
	Phosphorus	ug/L	<50	<50	<50			
	Ammonia	mg/L	<0.01	0.02	0.04			
	Hardness	mg/L	309	327	346			
Water Quality (SW14):	Water Quality Sample Results					Table 2	SWA (Tatham, April 2020)	2.4 and Appendix H
	Parameter	Units	Minimum	Average	Maximum			
	Turbidity	NTU	1.3	1.8	2.1			
	TDS	mg/L	313	395	479			
	TSS	mg/L	3.67	4.59	5.70			
	COD	mg/L	20	21	24			
	BOD5	mg/L	0.8	1.0	1.0			
	DOC	mg/L	5.1	5.9	10.7			
	pH		8	8.1	8.2			
	Alkalinity	mg/L	239	292	324			
	Conductivity	µS/cm	457	587	696			
	Phosphorus	ug/L	<50	<50	<50			
	Ammonia	mg/L	0.03	0.04	0.07			
	Hardness	mg/L	239	302	347			

Fish & Fish Habitat Features	Description	Figure / Graph / Table	Reference	
			Report	Section / Page
Fish Habitat (Direct/Indirect and Assumed/Confirmed):	Willoughby Creek is known to provide direct fish habitat, based on fish community sampling information from Conservation Halton (2002, 2013, 2018). Fish community sampling is not known to be have been completed in the upper reaches of Willoughby Creek, although for the purposes of this assessment, the entire watercourse (as mapped by MNRF in the Land Information Ontario database) is assumed to provide direct fish habitat. Willoughby Creek is known to provide direct fish habitat, based on fish community sampling information from Conservation Halton (2002, 2013, 2018). Fish community sampling is not known to be have been completed in the upper reaches of Willoughby Creek, although for the purposes of this assessment, the entire watercourse (as mapped by MNRF in the Land Information Ontario database) is assumed to provide direct fish habitat.		NETR (Savanta, April 2020)	19 and 20
Fish Species Present:	1) Conservation Halton Station BRO-219 (600 m downstream from the mouth of the Unnamed Tributary): a)Blacknose Dace, Brook Stickleback, Creek Chub, Fantail Darter, White Sucker b)"Poor" index of Biotic Integrity assigned to the overall fish community at this station by Conservation Halton in 2018 2) Conservation Halton Station BRO-42 (approximately 1 km downstream from the mouth of the Unnamed Tributary): a)Atlantic Salmon (Young-of-the-year), Brook Trout, Blacknose Dace and Fantail Darter b)Reach stocked with Atlantic Salmon eggs in 2012 c)"Good" index of Biotic Integrity assigned to the overall fish community at this station by Conservation Halton in 2018		NETR (Savanta, April 2020)	19 and 20
Fish Community Thermal Regime:	Cool to coldwater		NETR (Savanta, April 2020)	19 and 20
Fish Habitat Types Present:	Site specific investigations were not completed in Willoughby Creek as part of the NETR as a result of private property access issues. However, based on the presence of a generally diverse fish community, it is assumed a range of habitat is available to support life history processes.		NETR (Savanta, April 2020)	19 and 20
Habitat Uses by Known Fish Community:	The local fish community likely uses the habitat for the complete range of life history processes including spawning, nursery, foraging and overwintering. Lower reaches of the creek may provide spawning and nursery habitat for migratory fish from Bronte Creek.		NETR (Savanta, April 2020)	19 and 20
Known Barriers to Fish Movement:	None confirmed. Numerous culverts and private online ponds may provide some barriers to localized movement, but this was not confirmed as part of the NETR.		NETR (Savanta, April 2020)	19 and 20

<table>
<tr><th>Groundwater Interaction</th><th>Description</th><th>Figure / Graph / Table</th><th colspan="2">Reference</th></tr>
<tr><th></th><th></th><th></th><th>Report</th><th>Section / Page</th></tr>
<tr><td>Underlying Deposits:</td><td>The Medad Valley is a partly-buried gorge that carried meltwater from the receding ice for a period of time (Karrow, 1987). The infill deposits are likely coarse-grained glaciofluvial deposits overlain by organic deposits. While there is limited data for the Medad Valley, there is some evidence that the sand deposits are thicker in the valley to the north and south of the site. Model value for the horizontal hydraulic conductivity of the MIS sands was $5.0x10^{-5}$ m/s and $2.5x10^{-5}$ m/s for vertical hydraulic conductivity.</td><td></td><td></td><td></td></tr>
<tr><td>Surface Water / Groundwater Interactions:</td><td>Gaining Stream</td><td>Figures 1 & 2</td><td></td><td></td></tr>
<tr><td>Water Budget Results (SW14):</td><td>The baseline condition water budget results from the integrated model at monitoring location SW14 are presented in Figure 3a.<table><tr><td>Condition</td><td>GW Out</td><td>GW In</td></tr><tr><td>Baseline (Existing)</td><td>17.42%</td><td>26.50%</td></tr></table></td><td>Figure 3a</td><td></td><td></td></tr>
<tr><td>Water Budget Results (5328 Cedar Springs Road Driveway Crossing):</td><td>The baseline condition water budget results from the integrated model at the driveway crossing for 5328 Cedar Springs Road are presented in Figure 4a.<table><tr><td>Condition</td><td>GW Out</td><td>GW In</td></tr><tr><td>Baseline (Existing)</td><td>17.82%</td><td>24.11%</td></tr></table></td><td>Figure 4a</td><td></td><td></td></tr>
<tr><td>Water Budget Results (SW7):</td><td>The baseline condition water budget results from the integrated model at monitoring location SW7 are presented in Figure 5a.<table><tr><td>Condition</td><td>GW Out</td><td>GW In</td></tr><tr><td>Baseline (Existing)</td><td>15.72%</td><td>21.10%</td></tr></table></td><td>Figure 5a</td><td></td><td></td></tr>
<tr><td>Water Budget Results (Road Culvert Crossing at 5535 Cedar Springs Road):</td><td>The baseline condition water budget results from the integrated model at the road culvert crossing at 5535 Cedar Springs Road are presented in Figure 6a.<table><tr><td>Condition</td><td>GW Out</td><td>GW In</td></tr><tr><td>Baseline (Existing)</td><td>17.98%</td><td>28.27%</td></tr></table></td><td>Figure 6a</td><td></td><td></td></tr>
<tr><td>Integrated Model Calibration:</td><td>Section 19.4.3 (p. 418-419) in the Earthfx report describes the model calibration to flows in Willoughby Creek. The section focused on the SW2 gauge which represents the total streamflow exiting the northern portion of the Medad Valley. Hydrographs illustrate the model matches to flow peak timing for the period of record and WY2017, but the model may underestimate low flows from Feb. 2018 to Feb. 2019. Several reasons were discussed.</td><td>Graphs 7, 8 & 9</td><td>HHIAR (Earthfx, April 2020)</td><td>19.4.3 (page 418 - 419)</td></tr>
</table>

Impact Assessment	Description	Figure / Graph / Table	Reference	
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Direct Alterations to Watercourse:	1) No direct alterations to this watercourse will occur as a result of the proposed Quarry Extension. 2) Potential direct effects on the Unnamed Tributary of Willoughby Creek (e.g., due to weir plate, diversion channel inlet, golf course pond/irrigation channel removal) could potentially cause indirect effects on Willoughby Creek (e.g., sedimentation), as discussed in more detail in the Unnamed Tributary of Willoughby Creek summary table.		NETR (Savanta, April 2020)	75
Change in Primary Source of Flow:	1) Quarry discharge from Sump 0100 represents a major source of flow to Willoughby Creek. Current quarry approvals permit this discharge to cease once quarry operations are complete. Cessation of quarry discharge into the Unnamed Tributary of Willoughby Creek and ultimately Willoughby Creek itself would have a negative impact on flow availability to support existing fish habitat and the current fish community. As discussed in the Mitigation section below, it has been recommended that quarry discharge continue indefinitely at current levels to prevent these associated negative impacts. 2) Diversion from catchment area S101 (northwest of Colling Road) will alter surface water inputs. Currently, this catchment area discharges directly to the quarry and the flow is eventually discharged to the Unnamed Tributary through Sump 0100 (and ultimately to Willoughby Creek). Nelson is proposing to redirect surface water drainage from catchment area S101 directly into the Unnamed Tributary at the existing quarry discharge point. Overall, this diversion will result in the same volume of water from catchment area S101 being discharged to the tributary and ultimately Willoughby Creek, although, given it will no longer pass through the quarry, it is expected that the hydrological regime of this discharge will be more natural, with seasonal peaks as opposed to being discharged at a generally more constant rate through the quarry sump. 3) Removal of the golf course irrigation ponds and channels will alter the hydrology of the watercourse, given that no water taking would be required from the watercourse to support golf course irrigation and that during high flow periods, there will be no discharge from the golf course back to the feature. However, the proposed new pond (infiltration pond) west of the West Extension will draw water from the Weir Pond in the same manner as the existing irrigation ponds. Therefore, there will be no net change in source water hydrology.		NETR (Savanta, April 2020)	76 and 77
Change in Watercourse Catchment Area:	Increase in catchment area of 7.2 ha. Additional catchment area will drain to the existing quarry settling ponds and be discharged to the Unnamed Tributary via Sump 0100 at rates consistent with existing. Additional storage will be provided in the settling ponds to accommodate the additional flow.		SWA (Tatham, April 2020)	Drawings DP-1, DP-2 and DP-3
Simulated Streamflow Change (Integrated Model Results):	The Earthfx report discusses changes in simulated quarry discharge to the North Quarry Pond. No change was expected under Scenario P12. Scenario P3456 is discussed in Section 8.7.5 (p. 243). Under P3456 conditions, current levels of quarry discharge will continue to pass through the 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 as the current golf course ditch and pond system. Figure 8.71(p. 254) showed that there will be an increase in flow through the north quarry discharge stream, and that the flow will continue through the karst conduit as under current conditions. The increase in flow will enter the Medad Valley just downstream of SW7, so there will be no significant change downstream at SW2. Under RHB1, discharge continues to the north from the quarry sump 0100 and is similar to that of P3456. Under RHB2, surface water flow in the upper reaches of the Unnamed Tributary of Willoughby Creek and the West Arm of the West Branch of Mount Nemo Tributary of Grindstone Creek will cease when the quarry discharge is discontinued, resulting in possible impact to downstream fish habitat compared to baseline conditions (See Savanta, 2020 and Tatham, 2020 for details).	Graphs 10 & 11	HHIAR (Earthfx, April 2020)	198 - 230 and 230 - 237

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<tr><td>Water Budget Results (Operational Phases 3 Through 6):</td><td>The Operational Phases 3 through 6 water budget results from the integrated model at monitoring location SW14 are presented in Figure 3c.<table><tr><td>Condition</td><td>GW Outflow</td><td>GW Inflow</td><td>%Δ GW Outflow</td><td>%Δ GW Inflow</td></tr><tr><td>Baseline (Existing)</td><td>17.42%</td><td>26.50%</td><td>-</td><td>-</td></tr><tr><td>Phases 3 through 6</td><td>17.90%</td><td>25.75%</td><td>0.48%</td><td>-0.75%</td></tr></table></td><td>Figure 3c</td><td></td><td></td></tr>
<tr><td>Water Budget Results (Rehabilitation Scenario 1):</td><td>The Rehabilitation Scenario 1 water budget results from the integrated model at monitoring location SW14 are presented in Figure 3d.<table><tr><td>Condition</td><td>GW Outflow</td><td>GW Inflow</td><td>%Δ GW Outflow</td><td>%Δ GW Inflow</td></tr><tr><td>Baseline (Existing)</td><td>17.42%</td><td>26.50%</td><td>-</td><td>-</td></tr><tr><td>Rehab Scenario 1</td><td>17.06%</td><td>26.44%</td><td>-0.36%</td><td>-0.06%</td></tr></table></td><td>Figure 3d</td><td></td><td></td></tr>
<tr><td>Water Budget Results (Rehabilitation Scenario 2):</td><td>The Rehabilitation Scenario 2 water budget results from the integrated model at monitoring location SW14 are presented in Figure 3e.<table><tr><td>Condition</td><td>GW Outflow</td><td>GW Inflow</td><td>%Δ GW Outflow</td><td>%Δ GW Inflow</td></tr><tr><td>Baseline (Existing)</td><td>17.42%</td><td>26.50%</td><td>-</td><td>-</td></tr><tr><td>Rehab Scenario 2</td><td>18.26%</td><td>26.59%</td><td>0.84%</td><td>0.09%</td></tr></table></td><td>Figure 3e</td><td></td><td></td></tr>
<tr><td colspan="5">Water Budget Results at 5328 Cedar Springs Road Driveway Crossing</td></tr>
<tr><td>Water Budget Results (Operational Phases 1 & 2):</td><td>The Operational Phases 1 and 2 water budget results from the integrated model at 5328 Cedar Springs Road Driveway Crossing are presented in Figure 4b.<table><tr><td>Condition</td><td>GW Outflow</td><td>GW Inflow</td><td>%Δ GW Outflow</td><td>%Δ GW Inflow</td></tr><tr><td>Baseline (Existing)</td><td>17.82%</td><td>26.50%</td><td>-</td><td>-</td></tr><tr><td>Phases 1 & 2</td><td>17.51%</td><td>23.36%</td><td>-0.31%</td><td>-0.75%</td></tr></table></td><td>Figure 4b</td><td></td><td></td></tr>
<tr><td>Water Budget Results (Operational Phases 3 Through 6):</td><td>The Operational Phases 3 through 6 water budget results from the integrated model at 5328 Cedar Springs Road Driveway Crossing are presented in Figure 4c.<table><tr><td>Condition</td><td>GW Outflow</td><td>GW Inflow</td><td>%Δ GW Outflow</td><td>%Δ GW Inflow</td></tr><tr><td>Baseline (Existing)</td><td>17.82%</td><td>24.11%</td><td>-</td><td>-</td></tr><tr><td>Phases 3 through 6</td><td>18.57%</td><td>22.23%</td><td>0.75%</td><td>-1.88%</td></tr></table></td><td>Figure 4c</td><td></td><td></td></tr>
<tr><td>Water Budget Results (Rehabilitation Scenario 1):</td><td>The Rehabilitation Scenario 1 water budget results from the integrated model at 5328 Cedar Springs Road Driveway Crossing are presented in Figure 4d.<table><tr><td>Condition</td><td>GW Outflow</td><td>GW Inflow</td><td>%Δ GW Outflow</td><td>%Δ GW Inflow</td></tr><tr><td>Baseline (Existing)</td><td>17.82%</td><td>24.11%</td><td>-</td><td>-</td></tr><tr><td>Rehab Scenario 1</td><td>17.61%</td><td>23.39%</td><td>-0.21%</td><td>-0.72%</td></tr></table></td><td>Figure 4d</td><td></td><td></td></tr>
<tr><td>Water Budget Results (Rehabilitation Scenario 2):</td><td>The Rehabilitation Scenario 2 water budget results from the integrated model at 5328 Cedar Springs Road Driveway Crossing are presented in Figure 4e.<table><tr><td>Condition</td><td>GW Outflow</td><td>GW Inflow</td><td>%Δ GW Outflow</td><td>%Δ GW Inflow</td></tr><tr><td>Baseline (Existing)</td><td>17.82%</td><td>24.11%</td><td>-</td><td>-</td></tr><tr><td>Rehab Scenario 2</td><td>18.54%</td><td>25.30%</td><td>0.72%</td><td>1.19%</td></tr></table></td><td>Figure 4e</td><td></td><td></td></tr>
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<tr><td colspan="5">Water Budget Results at Monitoring Location SW7</td></tr>
<tr><td>Water Budget Results (Operational Phases 1 & 2):</td><td>The Operational Phases 1 and 2 water budget results from the integrated model at monitoring location SW7 are presented in Figure 5b.<table><tr><td>Condition</td><td>GW Outflow</td><td>GW Inflow</td><td>%Δ GW Outflow</td><td>%Δ GW Inflow</td></tr><tr><td>Baseline (Existing)</td><td>15.27%</td><td>21.10%</td><td>-</td><td>-</td></tr><tr><td>Phases 1 & 2</td><td>14.95%</td><td>20.37%</td><td>-0.32%</td><td>-0.73%</td></tr></table></td><td>Figure 5b</td><td></td><td></td></tr>
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<tr><td>Water Budget Results (Rehabilitation Scenario 2):</td><td>The Rehabilitation Scenario 2 water budget results from the integrated model at monitoring location SW7 are presented in Figure 5e.<table><tr><td>Condition</td><td>GW Outflow</td><td>GW Inflow</td><td>%Δ GW Outflow</td><td>%Δ GW Inflow</td></tr><tr><td>Baseline (Existing)</td><td>15.27%</td><td>21.10%</td><td>-</td><td>-</td></tr><tr><td>Rehab Scenario 2</td><td>15.85%</td><td>22.19%</td><td>0.58%</td><td>1.09%</td></tr></table></td><td>Figure 5e</td><td></td><td></td></tr>
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<tr><td>Water Budget Results (Rehabilitation Scenario 2):</td><td>The Rehabilitation Scenario 2 water budget results from the integrated model at the road culvert crossing at 5535 Cedar Springs Road are presented in Figure 6e.<table><tr><td>Condition</td><td>GW Outflow</td><td>GW Inflow</td><td>%Δ GW Outflow</td><td>%Δ GW Inflow</td></tr><tr><td>Baseline (Existing)</td><td>17.98%</td><td>28.27%</td><td>-</td><td>-</td></tr><tr><td>Rehab Scenario 2</td><td>17.63%</td><td>24.06%</td><td>-0.35%</td><td>-4.21%</td></tr></table></td><td>Figure 6e</td><td></td><td></td></tr>
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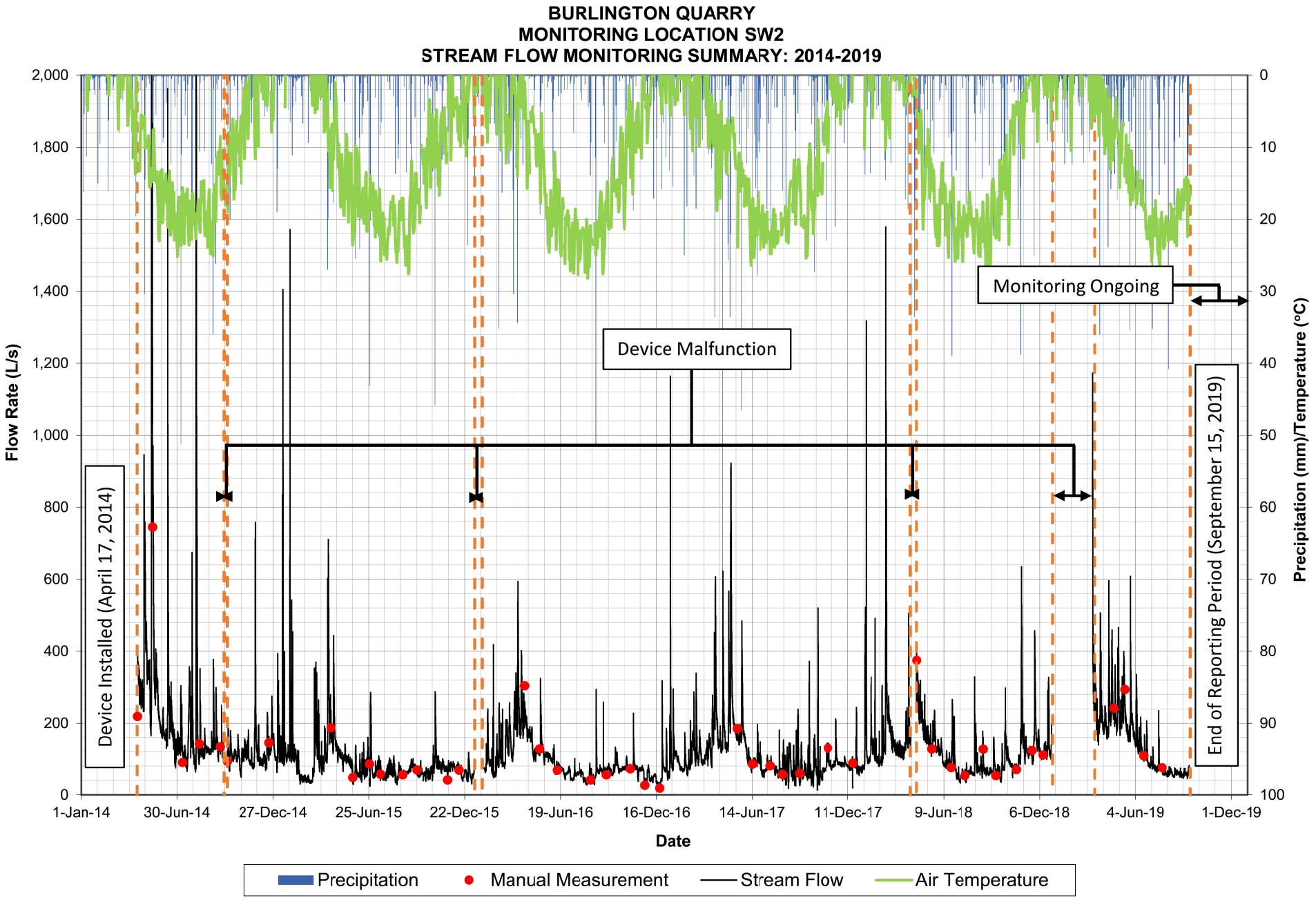
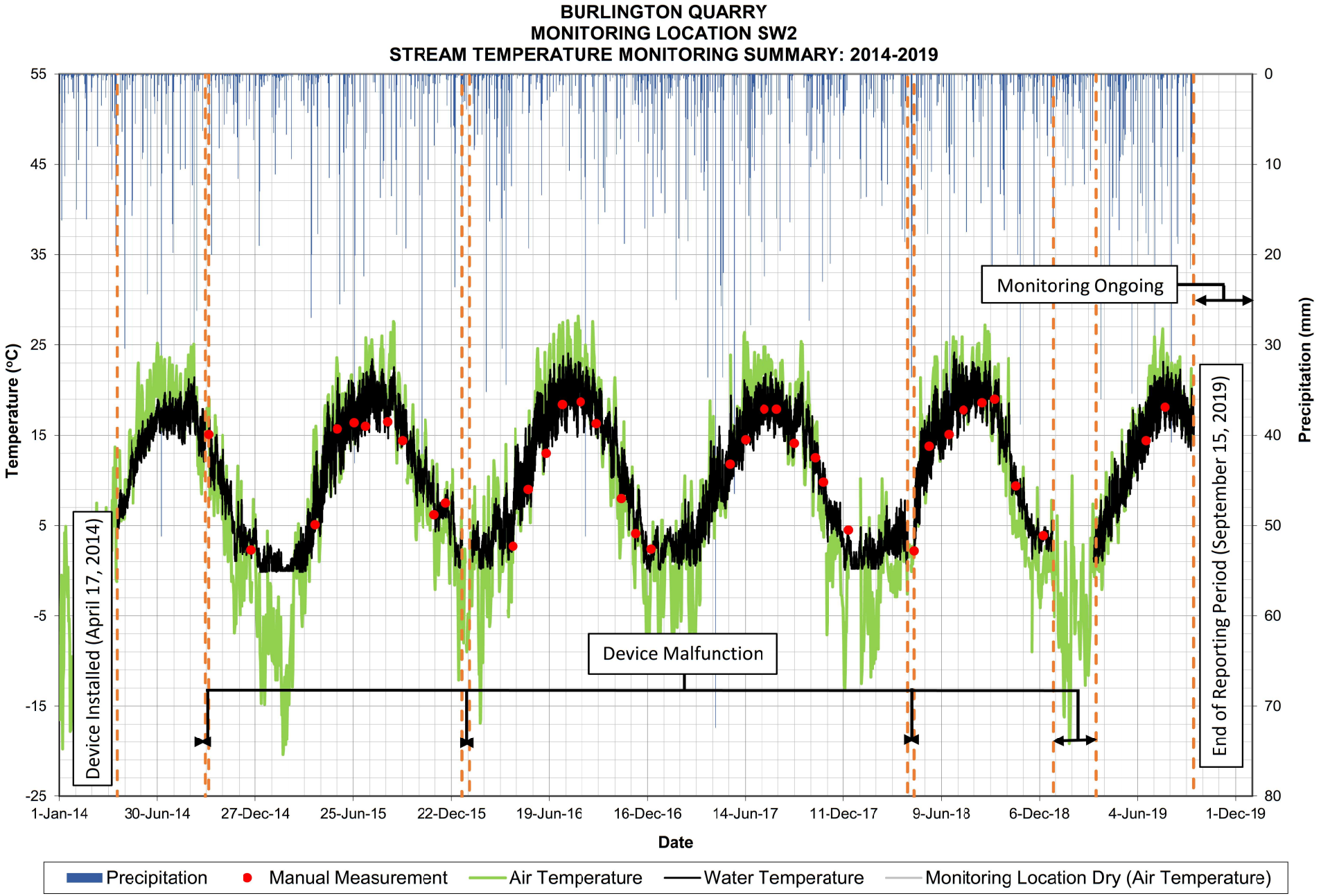
Change in Groundwater Contributions to Watercourse:	The total change in surface leakage (seepage) between Baseline and P3456 in catchment SW7 is shown in Graph 12. A small percentage of groundwater seepage will be intercepted by P3456 and discharged to the Medad Valley just downstream of SW7. This change in seepage is relatively uniform over time. The loss of seepage is diffuse and will not be observable. Additional maps and discussion are included in Earthfx, 2020. The stream leakage under Baseline and P3456 conditions is nearly identical, as shown in Graph 13.	Graphs 12 & 13		
Change in Watercourse Thermal Regime:	1)Negative changes in water temperature are not expected given that the watercourse will continue to receive its primary input from quarry discharge. Temperature of water being discharge from Quarry Sump 0100 is not expected to change as a result of the proposed Quarry Extension, therefore, no change in water temperature is anticipated. 2) Artificial warming that may be occurring as a result of discharge of relatively warm surface water from the artificial golf course ponds into the tributary will cease once the golf course ponds are removed. This may result in a beneficial effect in downstream water temperatures, given that the ponds are anthropogenic.		NETR (Savanta, April 2020)	75 - 78
Change in Water Quality:	1) Negative changes in water quality are not expected given that the watercourse will continue to receive its primary input from quarry discharge. Quality of water being discharged from Quarry Sump 0100 is not expected to change as a result of the proposed Quarry Extension, therefore, no change in water quality is expected. 2) Water quality impacts that may be occurring as a result of discharge of water from the artificial golf course ponds and irrigation channels into the tributary will cease once the golf course ponds are removed. This may result in a beneficial effect in downstream water quality, given that golf course discharge may be having a negative impact on water quality (e.g., due to fertilizers, erosion and sedimentation, nutrients).		NETR (Savanta, April 2020)	76 and 77
Potential Impact to Form and Function of Feature:	1) Alterations to quarry discharge (if unmitigated) could potentially have negative impacts on the form and habitat functions of this watercourse. 2) Diversion of upstream catchment S101 is not expected to have negative impacts on the form and function of the watercourse. The more natural hydrograph predicted due to the diversion may enhance fish habitat in downstream reaches of the Tributary. 3) Predicted decreases in streamflow are very minor and are not expected to have any negative impact on form and function of the watercourse.		NETR (Savanta, April 2020)	76 and 77
Potential Impact to Identified Species and Habitat:	1) Alterations to quarry discharge (if unmitigated) could potentially have negative impacts on the species and habitat functions of this watercourse. 2) Diversion of upstream catchment S101 is not expected to have negative impacts on fish in the watercourse. The more natural hydrograph predicted due to the diversion may enhance fish habitat in downstream reaches of the Tributary. 3) Predicted decreases in streamflow are very minor and are not expected to have any negative impact on form and function of the watercourse.		NETR (Savanta, April 2020)	76 and 77

Mitigation	Description	Figure / Graph / Table	Reference	
			Report	Section / Page
Direct Alteration Mitigation:	1) In-water work required to install the permanent weir plate and the diversion structure inlet will be completed between July 16 and August 30 to minimize the potential for indirect impacts on the reproductive activities of the downstream fish communities in the Unnamed Tributary of Willoughby Creek and in Willoughby Creek itself (e.g., due to sedimentation or accidental spills). 2) Erosion and sedimentation control measures and spill prevention and response measures will be used throughout the duration of any in-stream works in the watercourse. 3) The Limit of Extraction has been set back 30 m from the limit of the bankfull channel of the Unnamed Tributary of Willoughby Creek and the Weir Pond in order to prevent disturbance to the watercourse. No operational activities will occur within the 30 m setback. A visual mitigation berm will be constructed within the 30 m setback (with associated grading encroaching a minimum of 14 m from the edge of the Weir Pond). Erosion and sedimentation control measures will be in place prior to grading for the berm. The berm will be vegetated following completion of grading to ensure soil stability and prevent erosion. 4) Where areas within the 30 m setback are not currently naturally vegetated (i.e., on portions of the active golf course), these areas will be naturalized with native species plantings to assist in maintaining and enhancing riparian functions adjacent to the watercourse.		NETR (Savanta, April 2020)	75 66 and 67
Source Water Mitigation:	In order to mitigate impacts on fish and fish habitat in Willoughby Creek, pumping and discharge are recommended to occur at the same location at the upstream end of the Unnamed Tributary of Willoughby Creek and in the same manner as existing pumping in accordance with the existing PTTW and Environmental Compliance Approvals regulating current quarry discharge.		NETR (Savanta, April 2020)	76
Groundwater Contribution Mitigation:	Infiltration pond is intended to maintain seepage to GW in the vicinity of the West Expansion to maintain levels and GW discharge to the Medad Valley.			
Erosion Mitigation:	Erosion and sedimentation control measures and spill prevention and response measures will be used throughout the duration of any in-stream works in the watercourse.			
Thermal Mitigation:	1) No specific thermal mitigation is proposed given that maintaining existing quarry outflows at Sump 0100 are expected to maintain the existing thermal regime of the watercourse without any additional mitigation. 2) Removal of the golf course ponds may have an indirect positive effect on the thermal regime of the watercourse.		NETR (Savanta, April 2020)	78
Water Quality Mitigation:	1) No specific water quality mitigation over and above that of the existing quarry operations is proposed given that maintaining existing quarry outflows at Sump 0100 are expected to maintain the existing water quality regime of the watercourse without any additional mitigation. The quarry extension is not predicted to result in any changes in the quality of water being discharged from Sump 0100. 2) Removal of the golf course ponds may have an indirect positive effect on the water quality of the watercourse.		NETR (Savanta, April 2020)	78

WILLOUGHBY CREEK - GRAPH 1



WILLOUGHBY CREEK - GRAPH 2



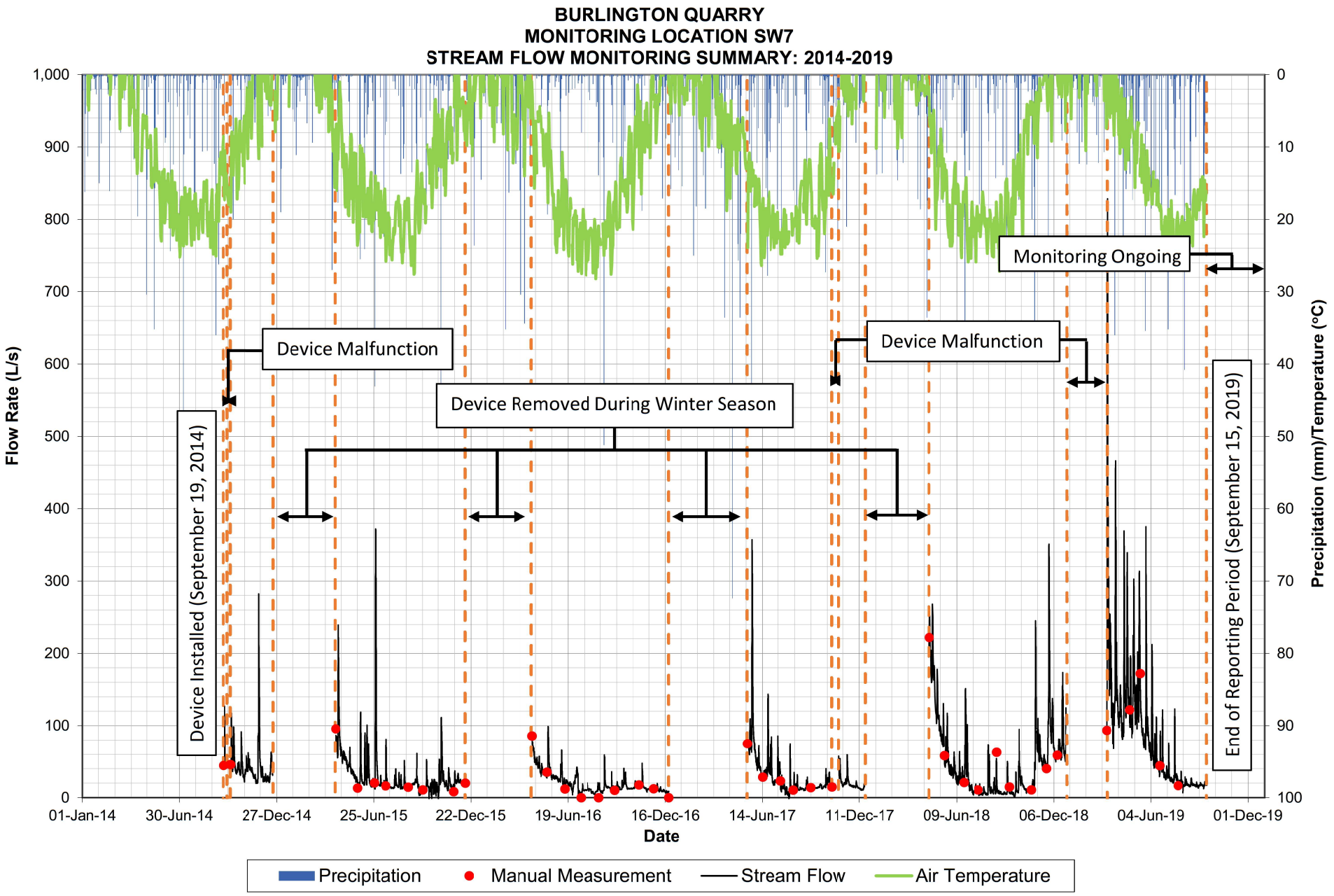
WILLOUGHBY CREEK - TABLE 1

BURLINGTON QUARRY
TATHAM ENGINEERING PROJECT NO.: 113187
SURFACE WATER MONITORING

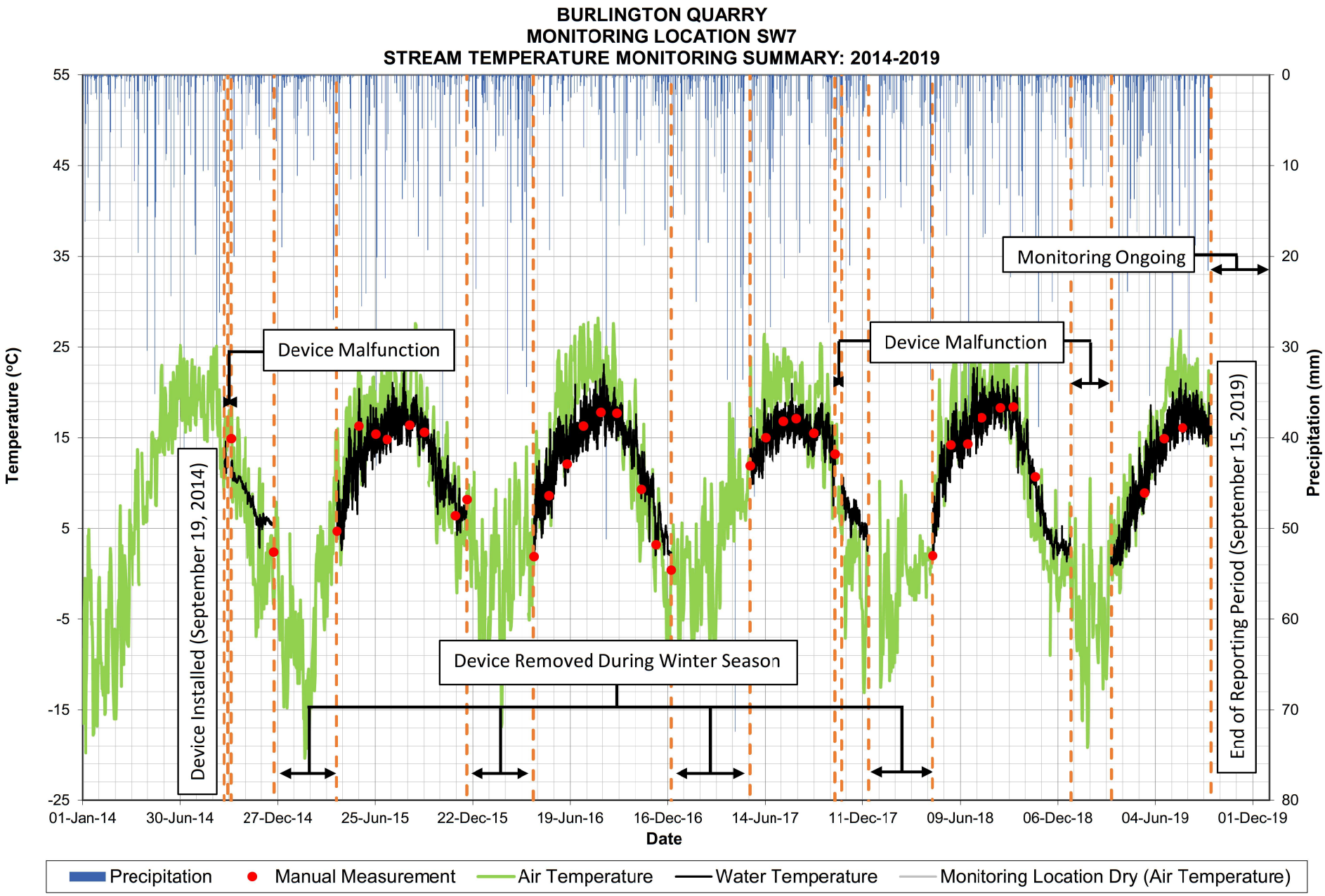
WATER QUALITY SAMPLE RESULTS

Monitoring Location SW2													
		Sample Date:	24-Oct-18	24-Apr-19	19-Jun-19	25-Sep-19	20-May-20	15-Jul-20	16-Sep-20	11-Nov-20	Maximum	Minimum	Average
Parameter:	Units:	M.D.L.	CM/JG	CM/JG	CM	CM	JG	JG/JH/JM	JH/JM	JG/JH			
M-Alkalinity (pH 4.5)	mg/L as CaCO3	2	196	250	261	166	238	180	152	178	261	166	218.25
Ammonia (as N)	mg/L	0.01	0.04	<0.01	0.02	0.02	<0.01	<0.01	<0.01	<0.01	0.04	0.02	0.02
BOD (5 day)	mg/L	1	1	0.9	0.9	0.8	1	<1	1.4	1.8	1.0	0.8	0.9
Bicarbonate	mg/L as CaCO3	1	194	247	-	164		178		176	247	164	202
Carbonate	mg/L as CaCO3	1	3	3	-	2		2		2	3	2	3
Conductivity	µS/cm	1	881	668	740	793	768	758	150	900	881	668	771
Dissolved Organic Carbon	mg/L	0.4	4	4.7	0.4	2.8	4.9	3.6	2	2.8	4.7	0.4	3.0
Field pH	pH	N/A	8.7	8.7	8.7	8.9	8.9	8.6	858	8.1	8.9	8.7	8.8
Field Temp	°C	N/A	8.3	6.7	15.2	16.6	12.9	18.9	4	9.4	16.6	6.7	11.7
Aluminum	ug/L	1	<1	11	17	<1	14	60	8	<1	17	11	8
Antimony	ug/L	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.5
Arsenic	ug/L	1	2	1	1	2	<1	2	2	2	2	1	1.5
Barium	ug/L	1	55	48	57	55	54	46	51	53	57	48	54
Beryllium	ug/L	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.5
Bismuth	ug/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Boron	ug/L	2	77	28	7	73	37	39	87	94	77	7	46.25
Cadmium	ug/L	0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	0.1	0.1
Calcium	ug/L	500	-	74800	85200	66700	73800	60000	65200	78700	85200	66700	56800
Cerium	ug/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Cesium	ug/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Chromium	ug/L	1	<1	5	5	3	3	1	3	4	5	3	4
Cobalt	ug/L	0.1	0.1	0.2	0.1	<0.1	0.2	0.1	0.1	0.1	0.2	0.1	0.125
Copper	ug/L	1	<1	<1	2	<1	2	2	1	2	2	2	1
Europium	ug/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Gallium	ug/L	1	<1	1	1	<1	1	2	2	2	1	1	1
Iron	ug/L	20	<20	157	237	170	317	251	233	232	237	157	146
Lanthanum	ug/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Lead	ug/L	0.1	<0.1	<0.1	0.2	<0.1	0.2	0.3	<0.1	<0.1	0.2	0.2	0.125
Lithium	ug/L	5	7	<5	6	8	6	9	11	10	8	6	6.5
Magnesium	ug/L	5	-	29600	32300	35200	32800	28800	34300	41500	35200	29600	24276
Manganese	ug/L	10	9	17	26	7	22	45	7	5	26	7	15
Mercury	ug/L	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1
Molybdenum	ug/L	1	2	<1	1	2	1	2	2	2	2	1	2
Nickel	ug/L	1	4	3	3	3	3	2	2	3	4	3	3
Niobium	ug/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Phosphorus	ug/L	50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	50
Potassium	ug/L	1	4490	2490	2840	4630	3420	2970	4940	5220	4630	2490	3613
Rubidium	ug/L	1	2	1	1	2	1	2	2	2	2	1	2
Scandium	ug/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Selenium	ug/L	0.5	0.9	0.8	<0.5	<0.5	0.7	<0.5	1.5	0.8	0.9	0.8	0.675
Silicon	ug/L	2	2100	2640	2700	1960	2380	1790	1820	2260	2700	1960	2350
Silver	ug/L	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1
Sodium	ug/L	1000	48600	27800	31800	43500	38700	41500	47800	51400	48600	27800	37925
Strontium	ug/L	1	715	417	510	678	499	478	653	800	715	417	580
Sulphur	ug/L	800	47400	20300	32500	48100	31400	30000	49200	65200	48100	20300	37075
Tellurium	ug/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Thallium	ug/L	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1
Thorium	ug/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Tin	ug/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Titanium	ug/L	1	<1	1	<1	<1	<1	1	<1	<1	1	1	1
Tungsten	ug/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Uranium	ug/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Vanadium	ug/L	1	<1	1	1	1	1	<1	1	1	1	1	1
Yttrium	ug/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Zinc	ug/L	1	9	<1	4	2	5	6	3	<1	9	2	4
Zirconium	ug/L	1	9	<1	<1	<1	<1	<1	<1	<1	9	9	3
pH	pH	N/A	8.16	8.14	8.18	8.09	8.4	8.13	8.09	8.08	8.2	8.1	8.1
Total Hardness (as CaCO3)	mg/L	0.1	342	309	346	312	319	268	304	367	346.000	309.000	327.250
Chemical Oxygen Demand	mg/L	5	8	12	12	<5	8	11	<5	15	12	8	9
Total Dissolved Solids	mg/L	3	589	433	515	548	508	484	533	580	589	433	521
Total Suspended Solids	mg/L	0.67	1	2	6	3	7.33	5.3	1.7	1.3	6.00	1.00	3.00
Turbidity	NTU	0.1	0.9	1.7	3.6	2.6	1.9	2.4	0.8	1.2	3.6	0.9	2.2

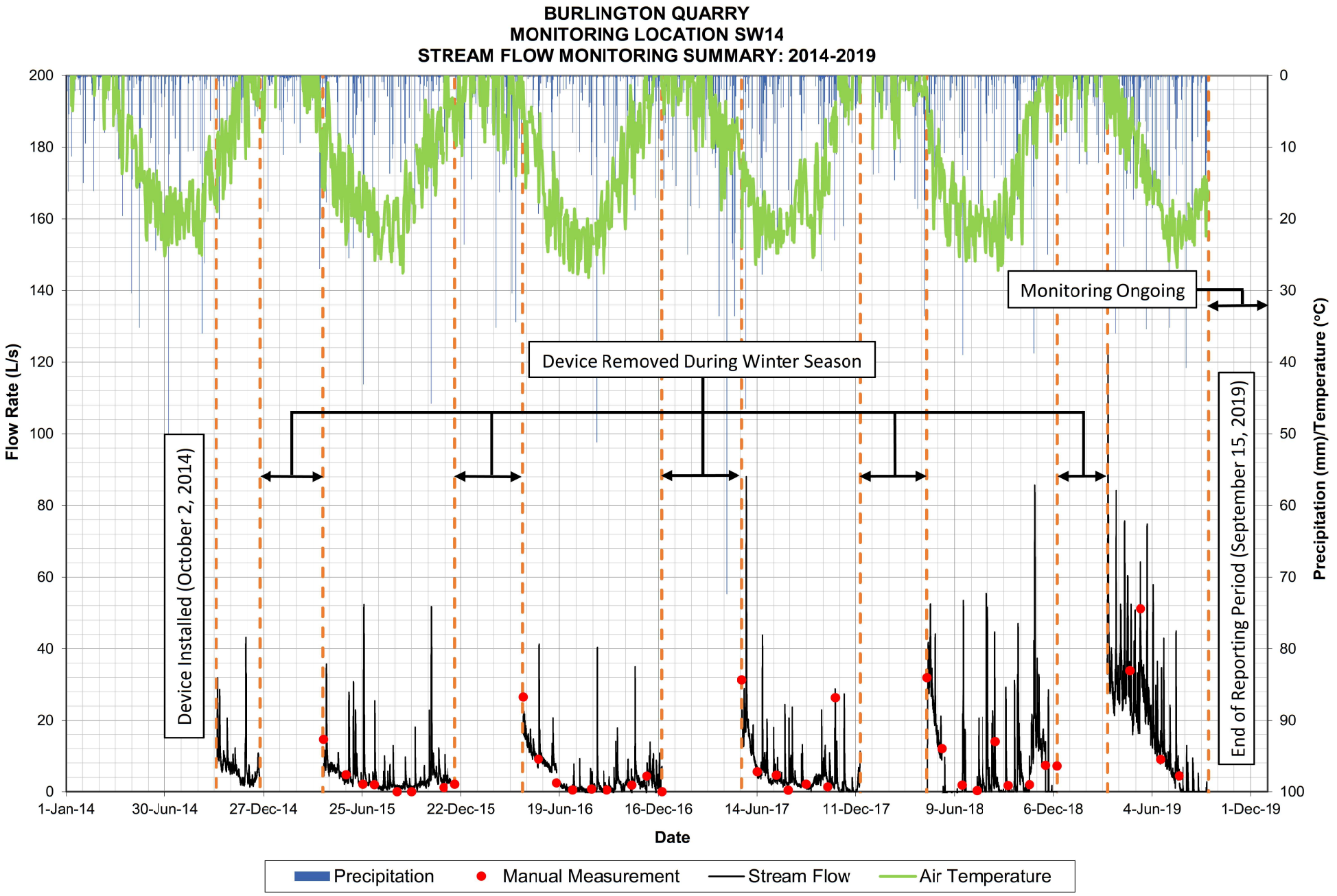
WILLOUGHBY CREEK - GRAPH 3

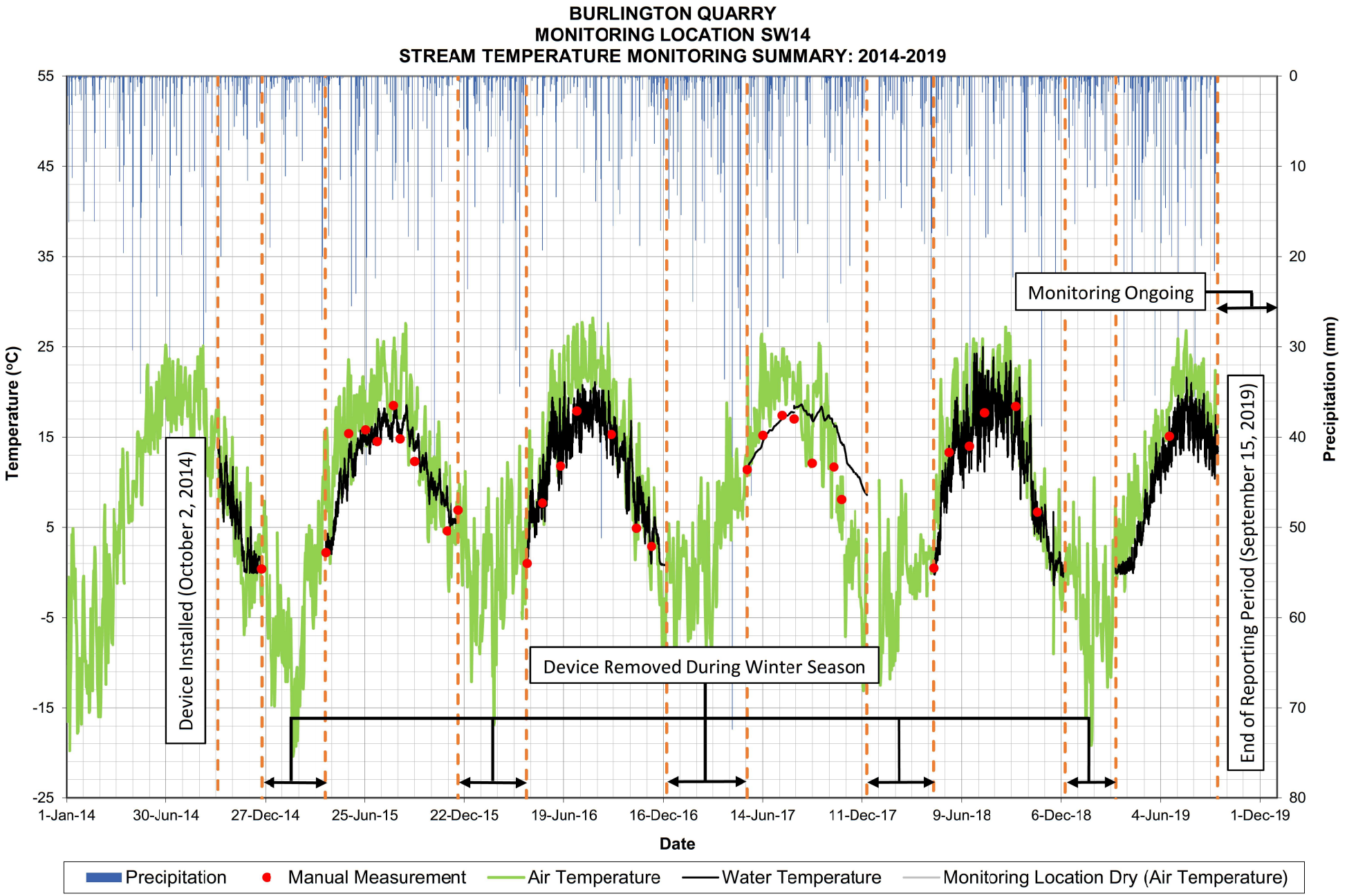


WILLOUGHBY CREEK - GRAPH 4



WILLOUGHBY CREEK - GRAPH 5




BURLINGTON QUARRY
MONITORING LOCATION SW14
STREAM TEMPERATURE MONITORING SUMMARY: 2014-2019
Temperature (°C)
Precipitation (mm)
55
45
35
25
15
5
-5
-15
-25
0
10
20
30
40
50
60
70
80
1-Jan-14
30-Jun-14
27-Dec-14
25-Jun-15
22-Dec-15
19-Jun-16
16-Dec-16
14-Jun-17
11-Dec-17
9-Jun-18
6-Dec-18
4-Jun-19
1-Dec-19
Date
Device Installed (October 2, 2014)
Device Removed During Winter Season
Monitoring Ongoing
End of Reporting Period (September 15, 2019)
Precipitation
Manual Measurement
Air Temperature
Water Temperature
Monitoring Location Dry (Air Temperature)

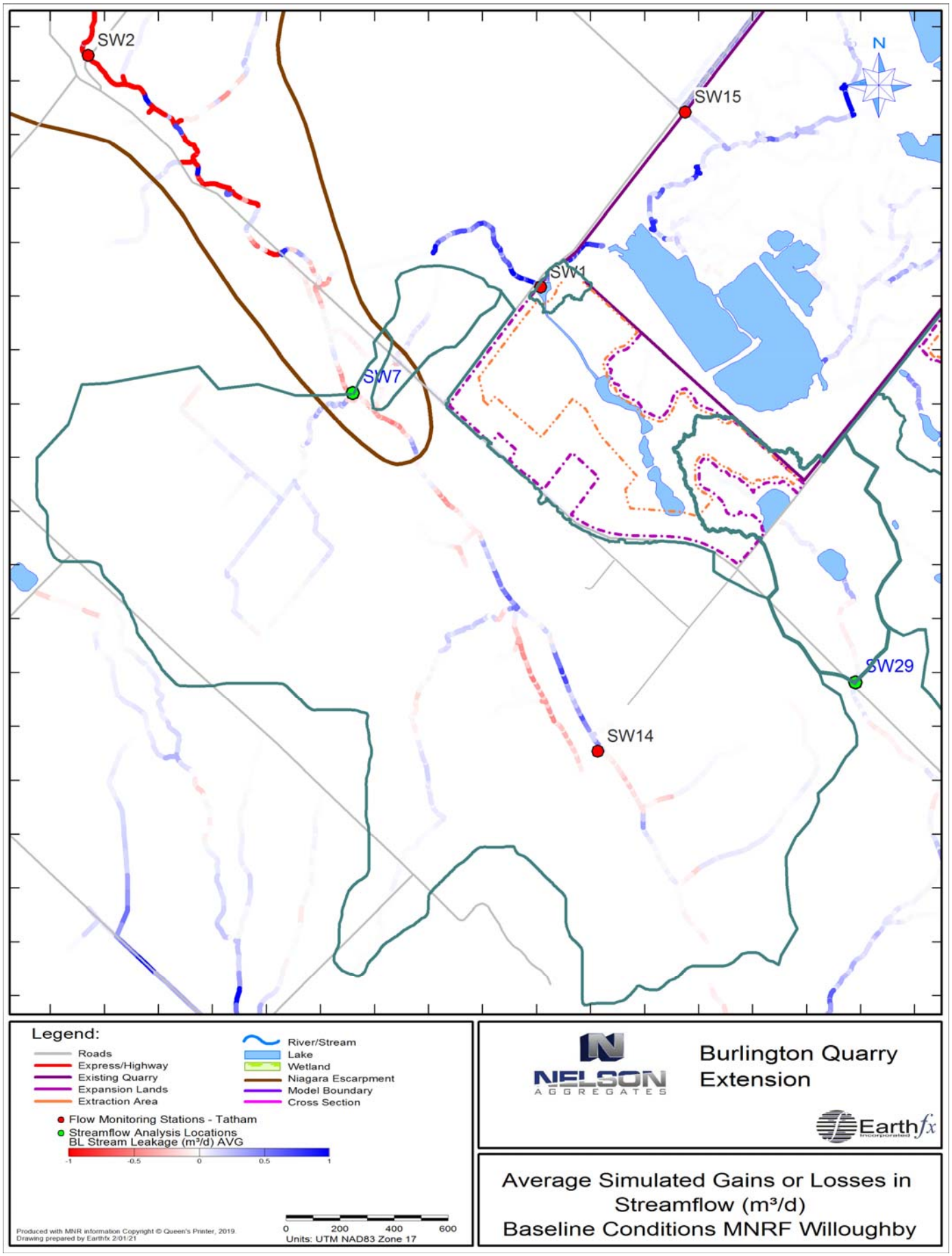
WILLOUGHBY CREEK - TABLE 2

BURLINGTON QUARRY
TATHAM ENGINEERING PROJECT NO.: 113187
SURFACE WATER MONITORING

WATER QUALITY SAMPLE RESULTS

Monitoring Location SW14													
		Sample Date:	24-Oct-18	24-Apr-19	19-Jun-19	25-Sep-19	20-May-20	15-Jul-20	16-Sep-20	11-Nov-20	Maximum	Minimum	Average
Parameter:	Units:	M.D.L.	CM/JG	CM/JG	CM	CM	JG	JG/JH/JM	JH/JM	JG/JH			
M-Alkalinity (pH 4.5)	mg/L as CaCO3	2	303	239	302	324	265	320	329	296	324	239	292
Ammonia (as N)	mg/L	0.01	0.04	<0.01	0.07	0.03	<0.01	<0.01	<0.01	0.1	0.07	0.03	0.04
BOD (5 day)	mg/L	1	<1	0.8	<0.9	1	<1	1.1	1.5	<1	1.0	0.8	1.0
Bicarbonate	mg/L as CaCO3	1	300	237		319		315	325	293	319	237	214
Carbonate	mg/L as CaCO3	1	3	2		4		5	4	3	4	2	2.25
Conductivity	µS/cm	1	646	457	549	696	566	683	770	664	696	457	587
Dissolved Organic Carbon	mg/L	0.4	10.7	7.4	<0.4	5.1	6.3	6.4	5	10	10.7	5.1	5.9
Field pH	pH	N/A	8.6	8.8	8.8	8.8	8.8		9	8.9	8.8	8.6	8.8
Field Temp	°C	N/A	5.4	4.2	15.1	17	11.9		15.7	11.2	17.0	4.2	10.4
Aluminum	ug/L	1	<1	5	5	19	4	26	6	5	19	5	8
Antimony	ug/L	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.5
Arsenic	ug/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Barium	ug/L	1	63	48	64	82	57	59	73	63	82	48	64
Beryllium	ug/L	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.5
Bismuth	ug/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Boron	ug/L	2	6	8	<2	17	<2	3	21	19	17	6	8.25
Cadmium	ug/L	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1
Calcium	ug/L	500	-	57000	72500	80000	65200	83600	94300	79400	80000	57000	52500
Cerium	ug/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Cesium	ug/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Chromium	ug/L	1	<1	3	5	7	4	3	5	5	7	3	4
Cobalt	ug/L	0.1	0.2	<0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.125
Copper	ug/L	1	<1	<1	1	<1	<1	1	<1	3	1	1	1
Europium	ug/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Gallium	ug/L	1	1	<1	1	1	1	2	2	2	1	1	1
Iron	ug/L	20	150	137	191	319	248	246	275	281	319	137	199
Lanthanum	ug/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Lead	ug/L	0.1	<0.1	0.4	0.2	1	0.3	0.5	0.1	0.2	1	0.2	0.425
Lithium	ug/L	5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	5
Magnesium	ug/L	5	-	23400	29300	35800	31100	32300	37000	35700	35800	23400	22126
Manganese	ug/L	10	69	17	19	61	22	42	9	13	69	17	42
Mercury	ug/L	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1
Molybdenum	ug/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Nickel	ug/L	1	3	2	2	2	2	2	2	3	3	2	2
Niobium	ug/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Phosphorus	ug/L	50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	50
Potassium	ug/L	1	1430	1160	892	1140	1160	1140	1100	1740	1430	892	1156
Rubidium	ug/L	1	<1	<1	<1	1	<1	1	1	2	1	1	1
Scandium	ug/L	1	<1	<1	<1	<1	<1	1	1	1	<1	<1	1
Selenium	ug/L	0.5	0.5	<0.5	<0.5	<0.5	1.2	<0.5	0.8	<0.5	0.5	0.5	0.5
Silicon	ug/L	2	3550	2300	3260	4020	2830	3430	3980	4420	4020	2300	3283
Silver	ug/L	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1
Sodium	ug/L	1000	15000	6600	8680	18800	11300	15400	20900	17800	18800	6600	12270
Strontium	ug/L	1	116	98	108	127	108	123	135	137	127	98	112
Sulphur	ug/L	800	2700	5290	5710	10100	5900	7100	11300	11900	10100	2700	5950
Tellurium	ug/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Thallium	ug/L	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1
Thorium	ug/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Tin	ug/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Titanium	ug/L	1	1	<1	<1	2	<1	<1	<1	<1	2	1	1.25
Tungsten	ug/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Uranium	ug/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Vanadium	ug/L	1	<1	1	2	2	1	1	2	2	2	1	1.5
Yttrium	ug/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Zinc	ug/L	1	11	<1	3	12	4	14	4	20	12	3	7
Zirconium	ug/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
pH	pH	N/A	8.06	7.96	8.11	8.17	8.24	8.18	8.15	8	8.2	8.0	8.1
Total Hardness (as CaCO3)	mg/L	0.1	318	239	302	347	291	342	388	345	347	239	302
Chemical Oxygen Demand	mg/L	5	20	24	20	20	19	38	8	464	24	20	21
Total Dissolved Solids	mg/L	3	416	313	371	479	342	433	459	23	479	313	395
Total Suspended Solids	mg/L	0.67	5.7	4	3.67	5	4.7	19.7	5.7	1	5.70	3.67	4.59
Turbidity	NTU	0.1	1.9	2	1.3	2.1	0.9	0.8	1.4	13.8	2.1	1.3	1.8

WILLOUGHBY CREEK - FIGURE 1



WILLOUGHBY CREEK - FIGURE 2

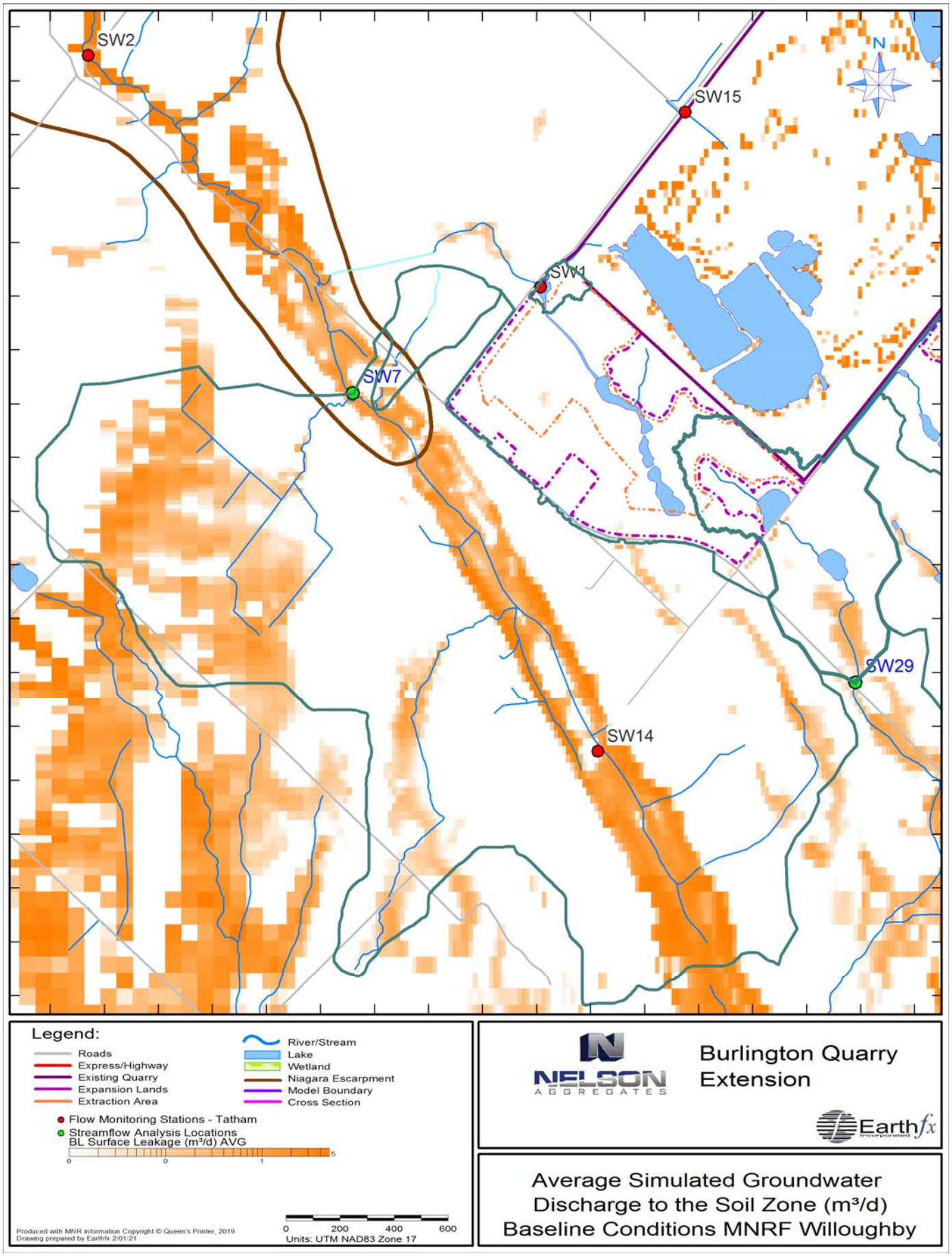


FIGURE 3A

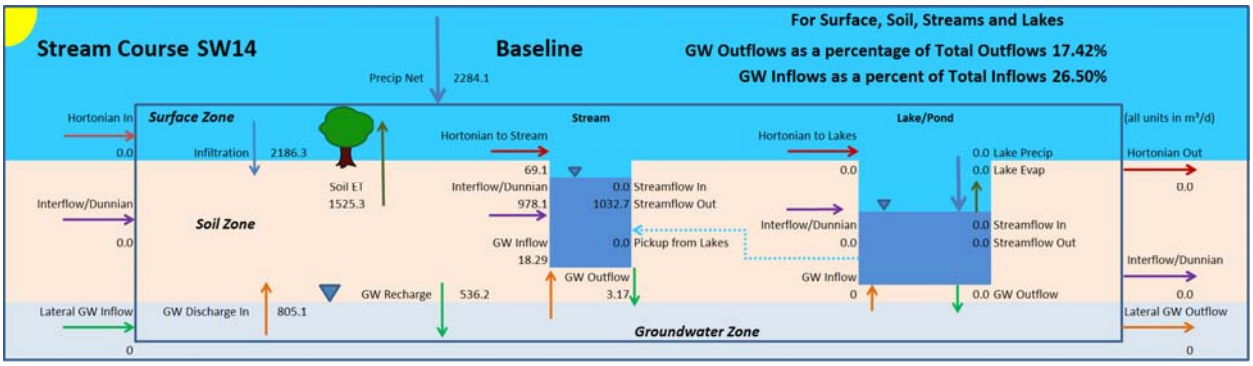


FIGURE 3B

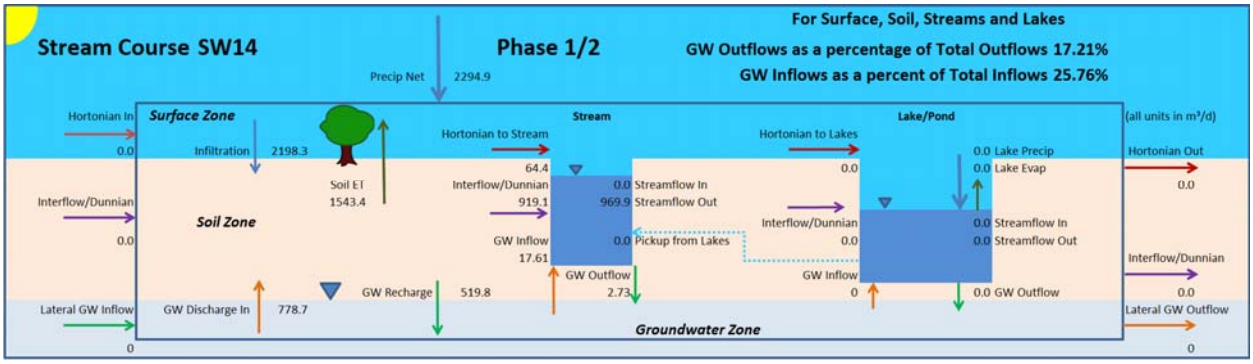


FIGURE 3C

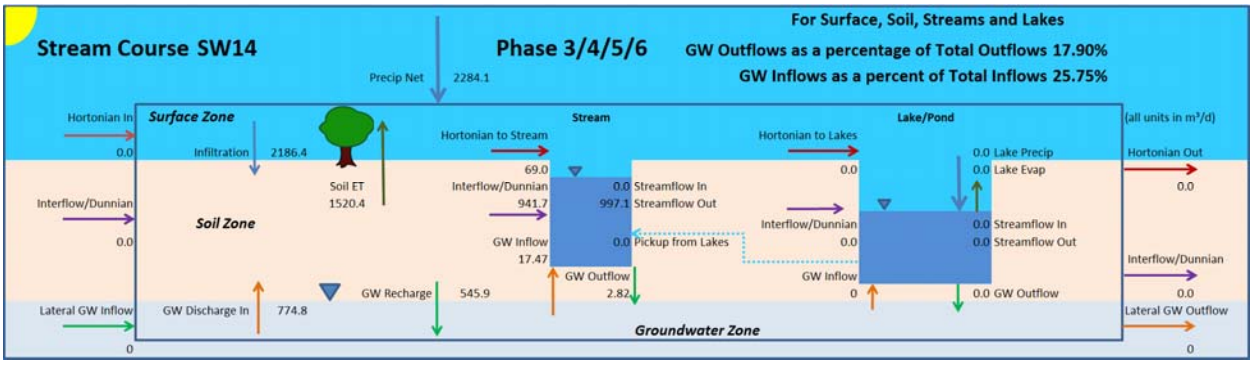


FIGURE 3D

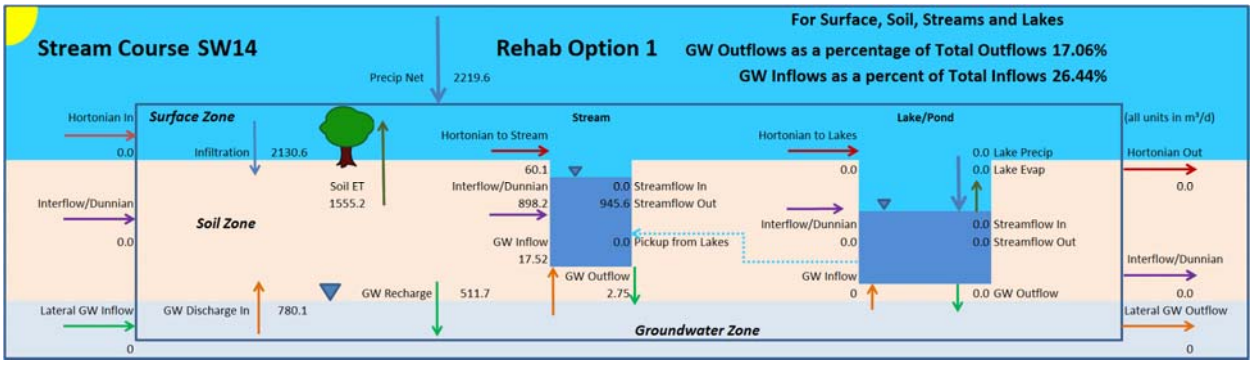


FIGURE 3E

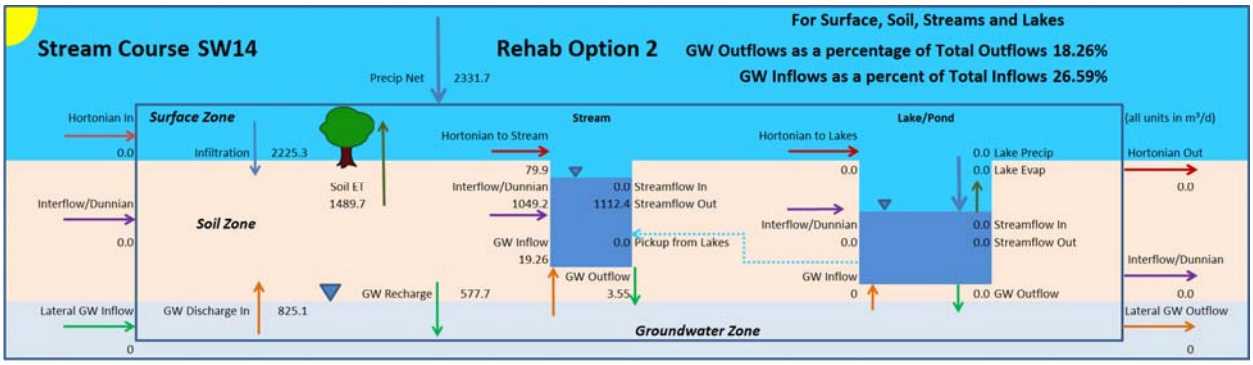


FIGURE 4A

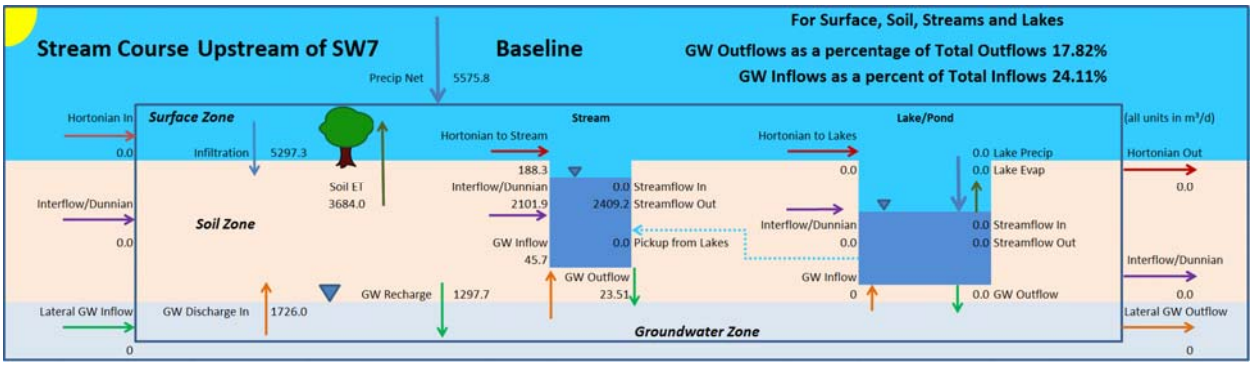
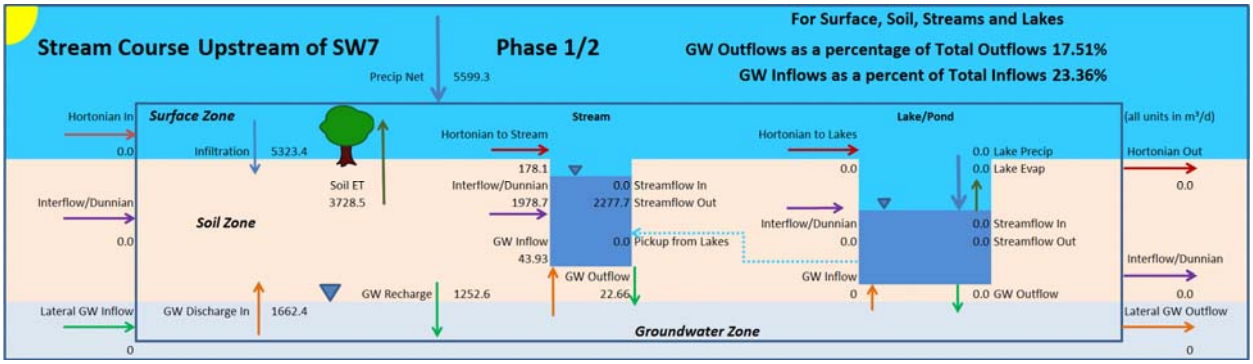


FIGURE 4B



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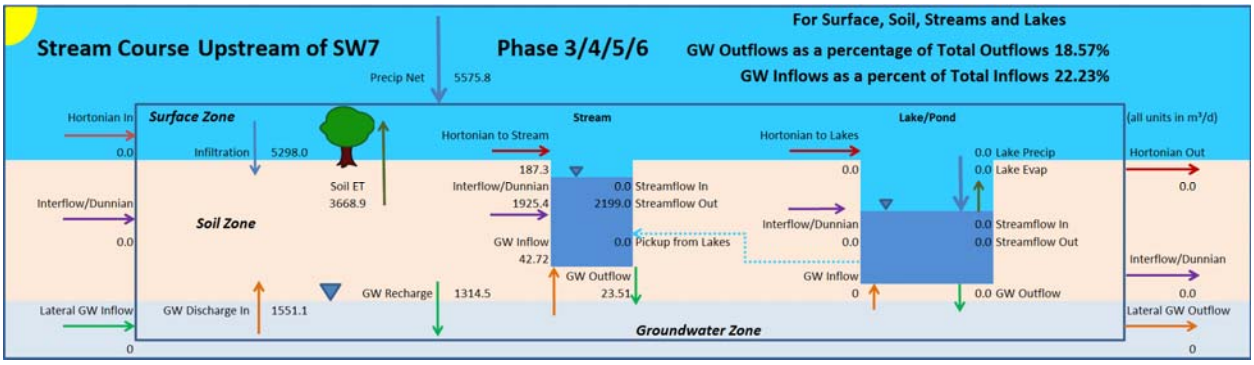
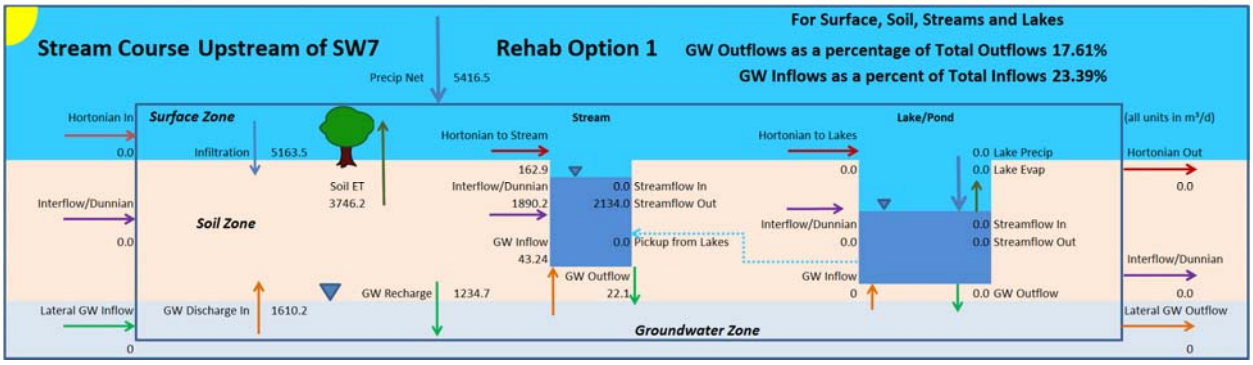


FIGURE 4D



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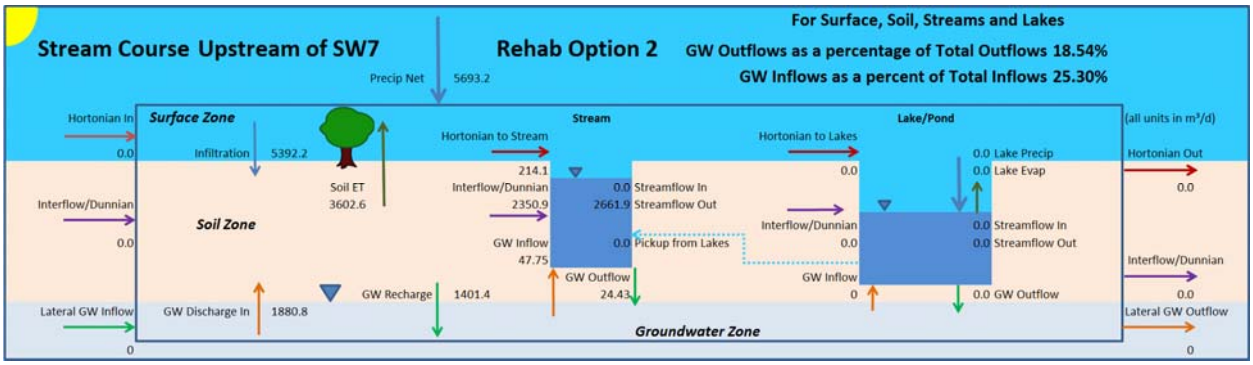


WILLOUGHBY CREEK

FIGURE 5A

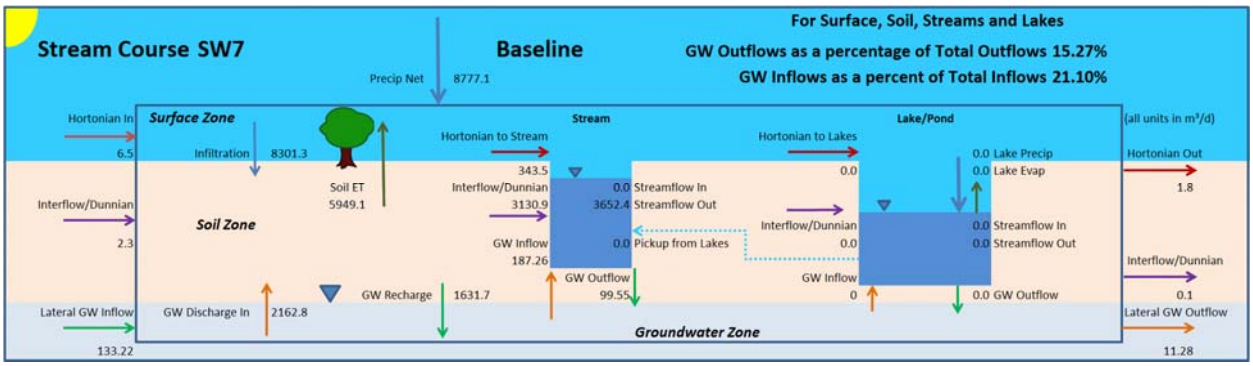


FIGURE 5B

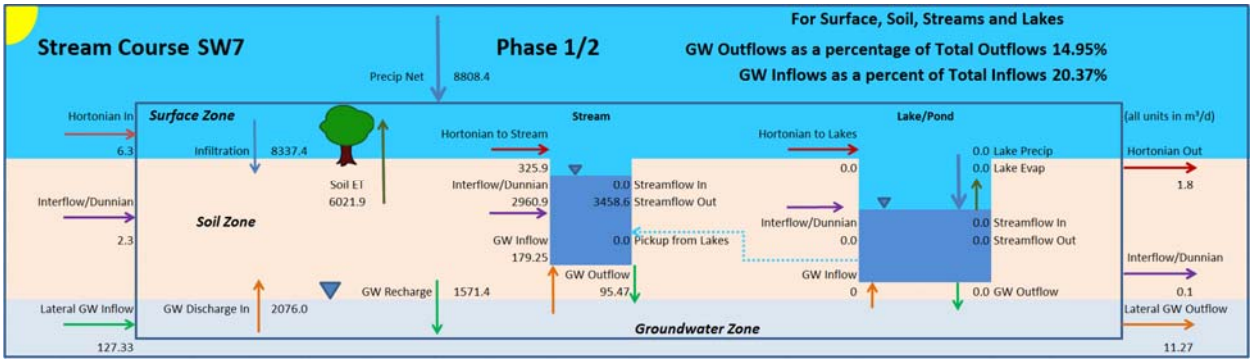


FIGURE 5C

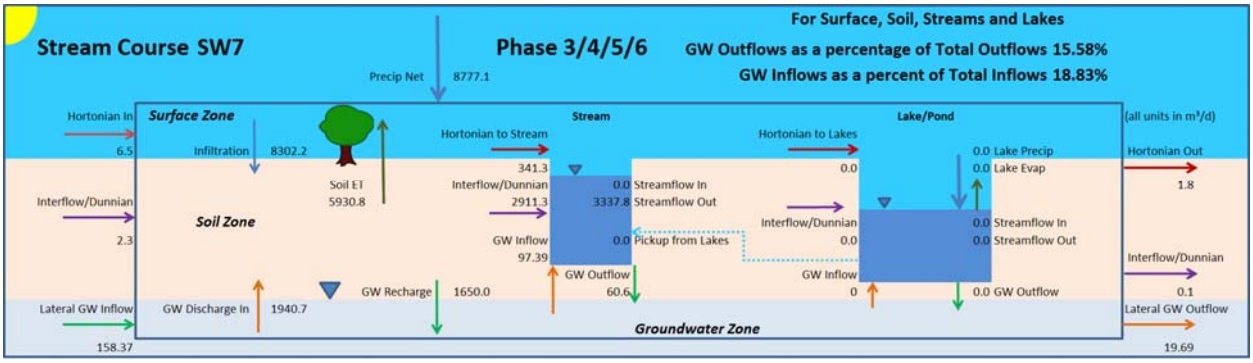


FIGURE 5D

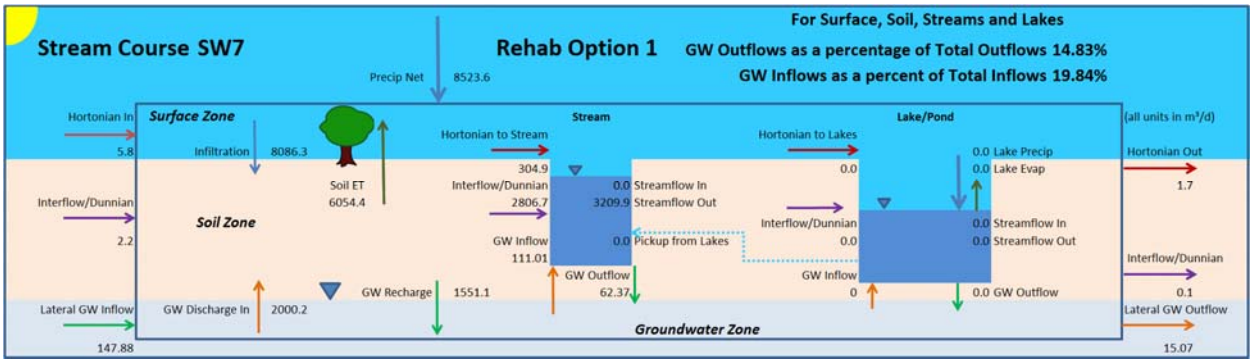
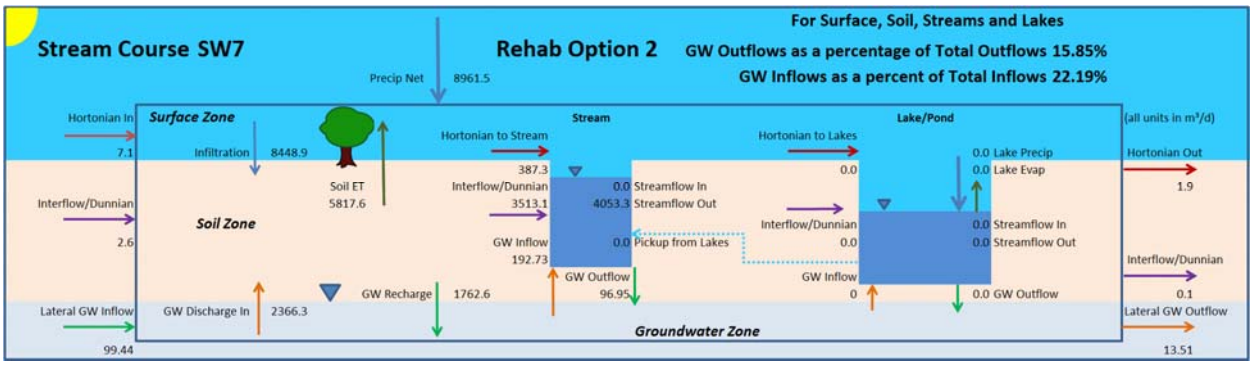


FIGURE 5E



WILLOUGHBY CREEK

FIGURE 6A

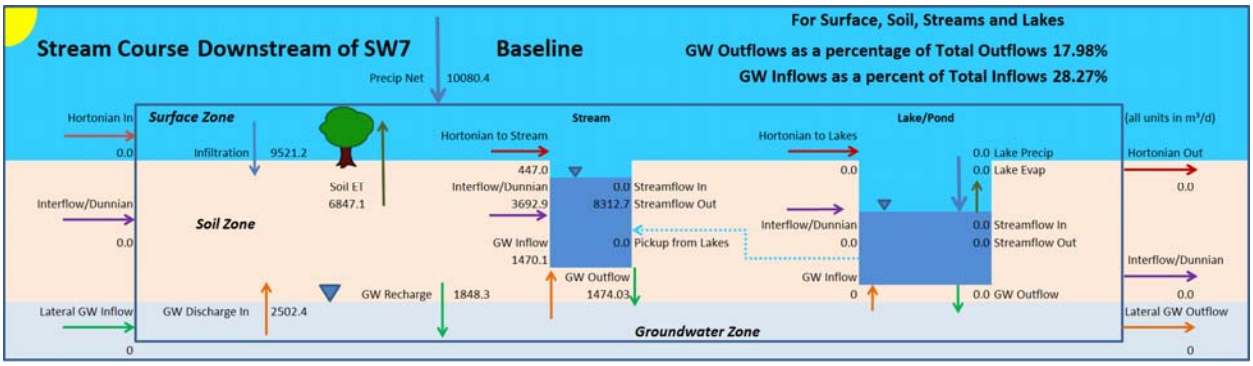


FIGURE 6B

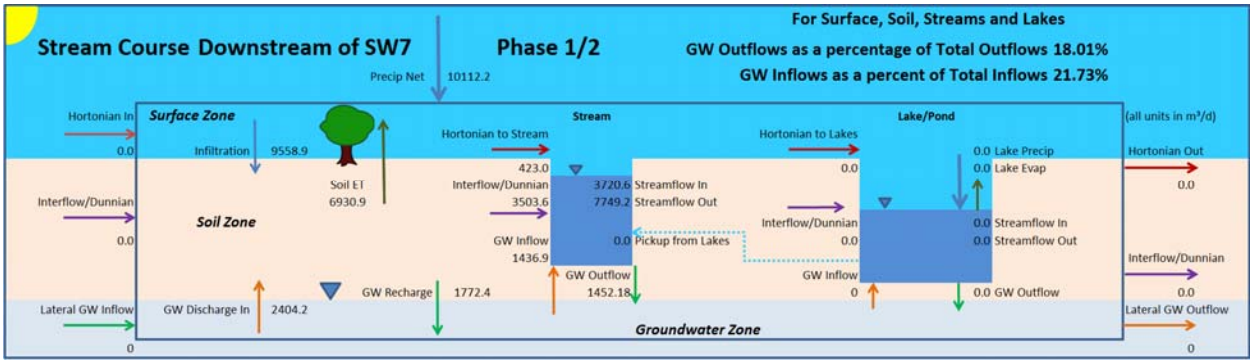


FIGURE 6C

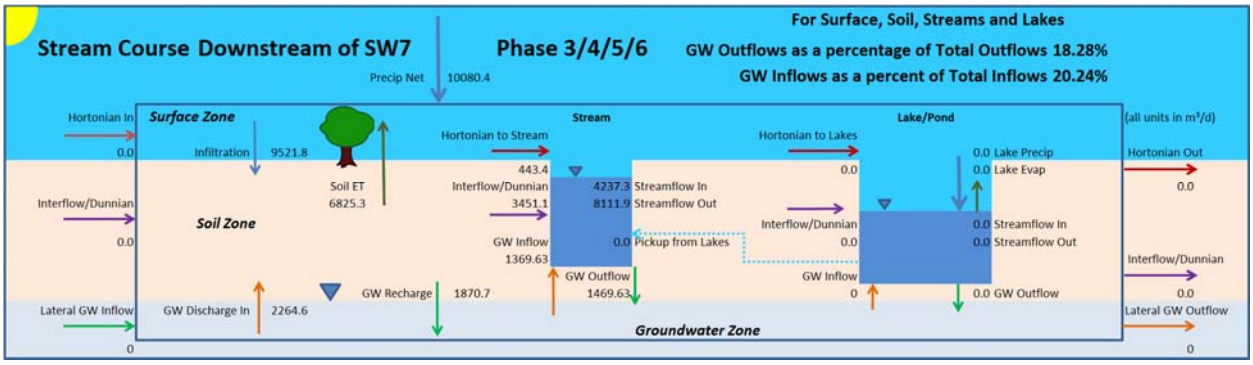


FIGURE 6D

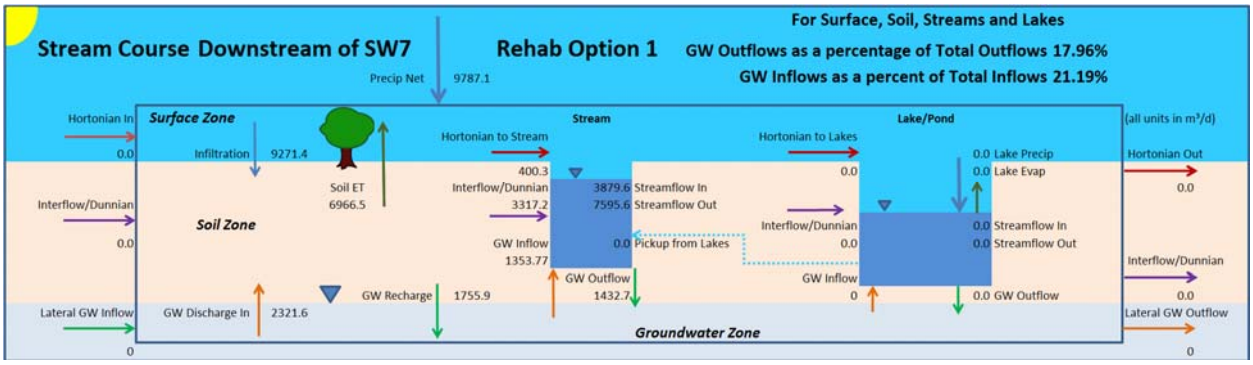
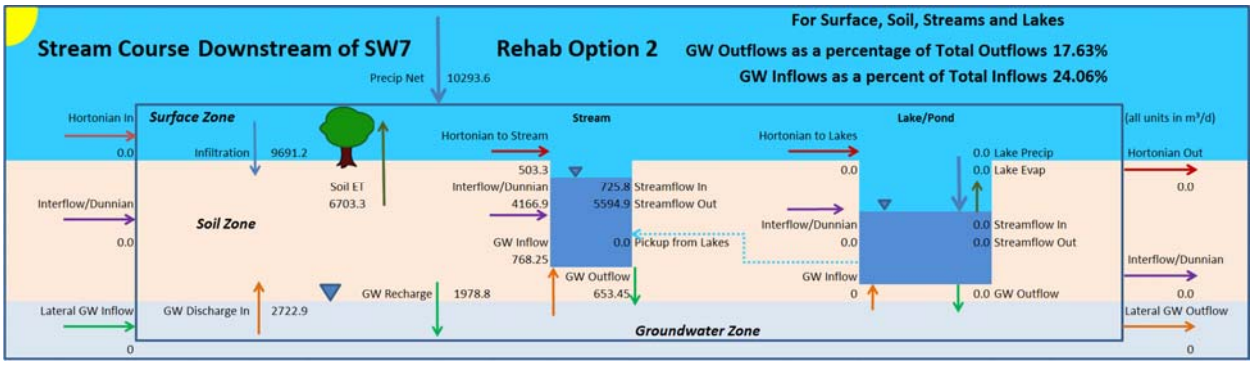
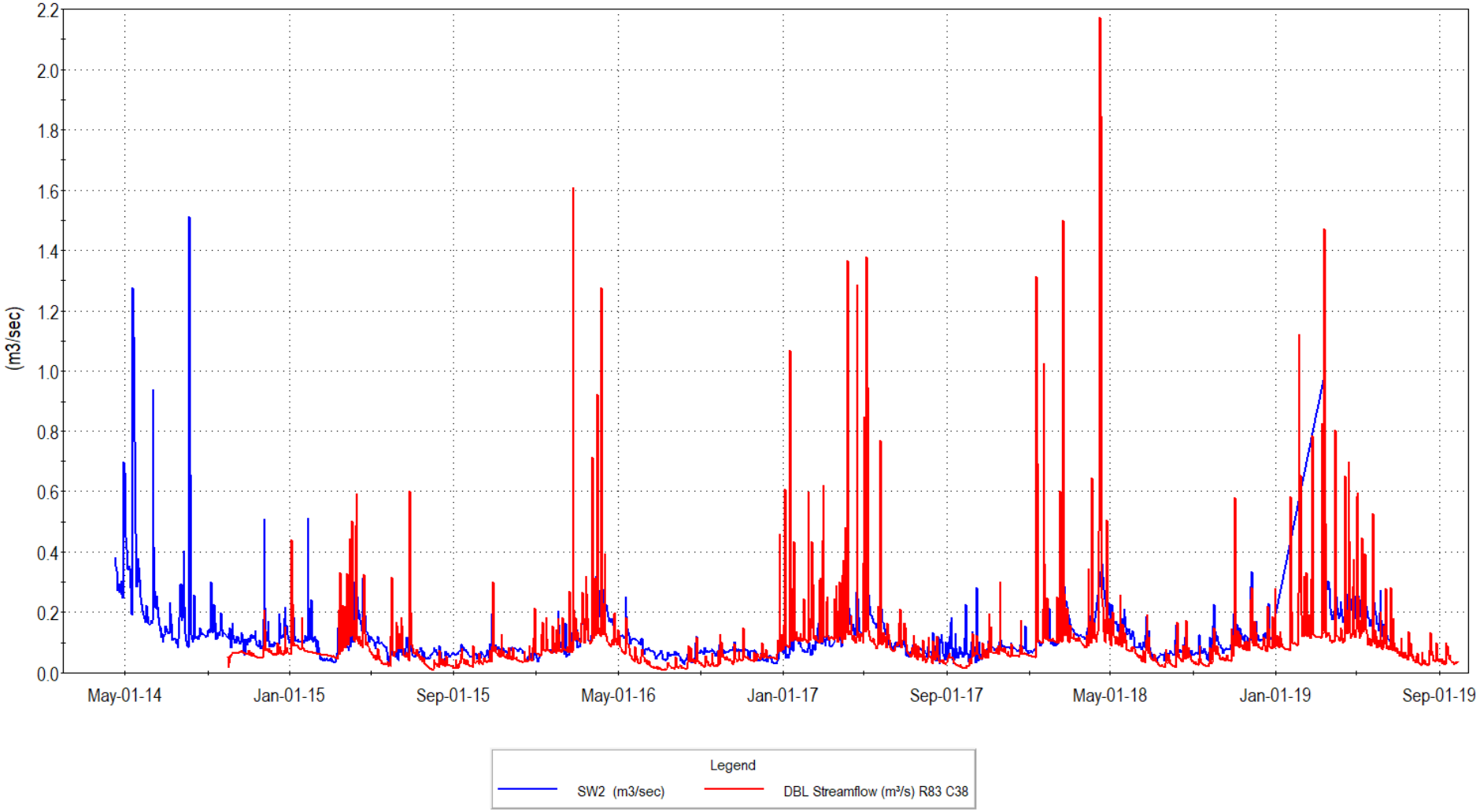


FIGURE 6E



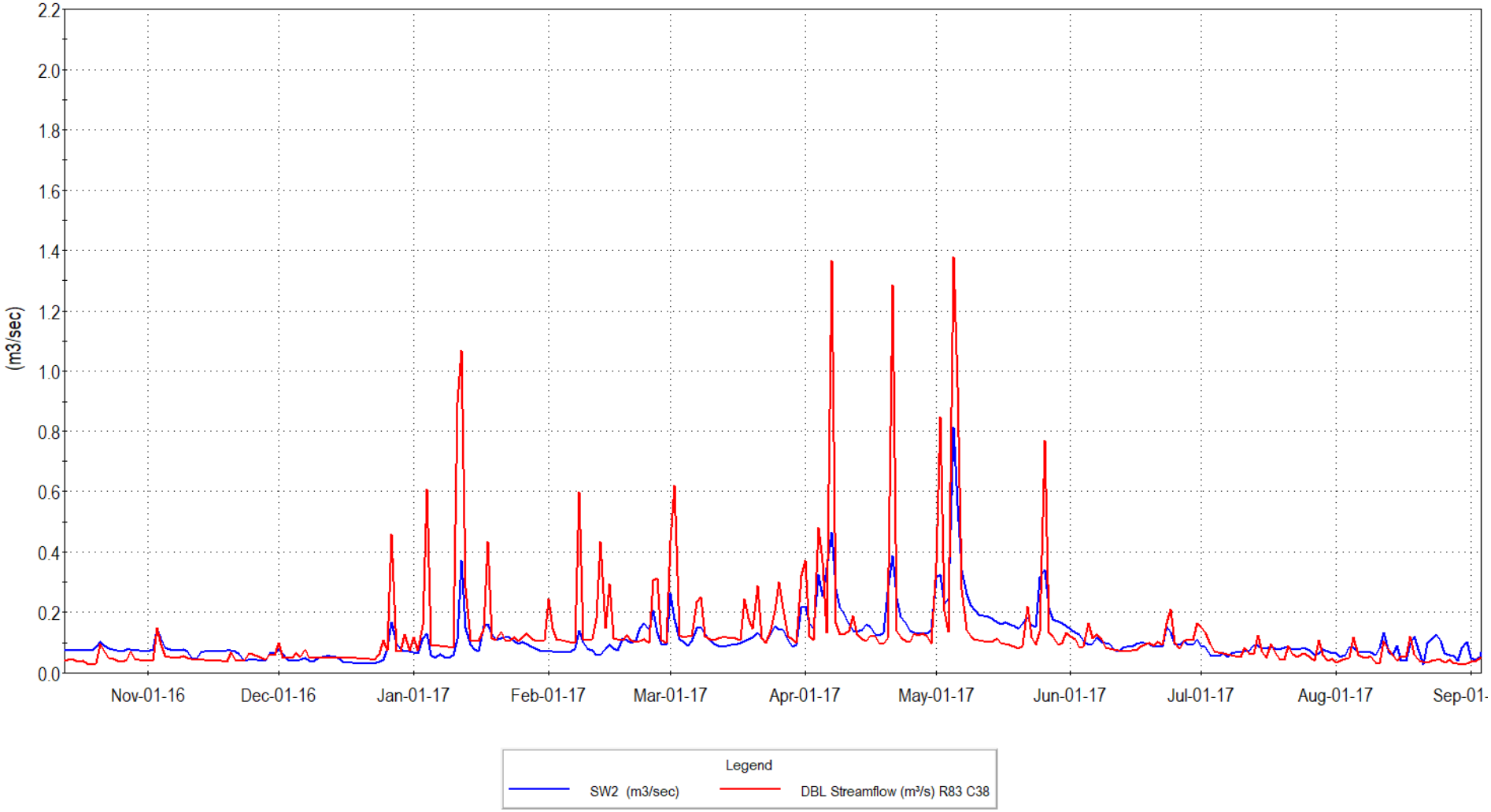
WILLOUGHBY CREEK - GRAPH 7

Integrated Model Calibration
Willoughby Creek

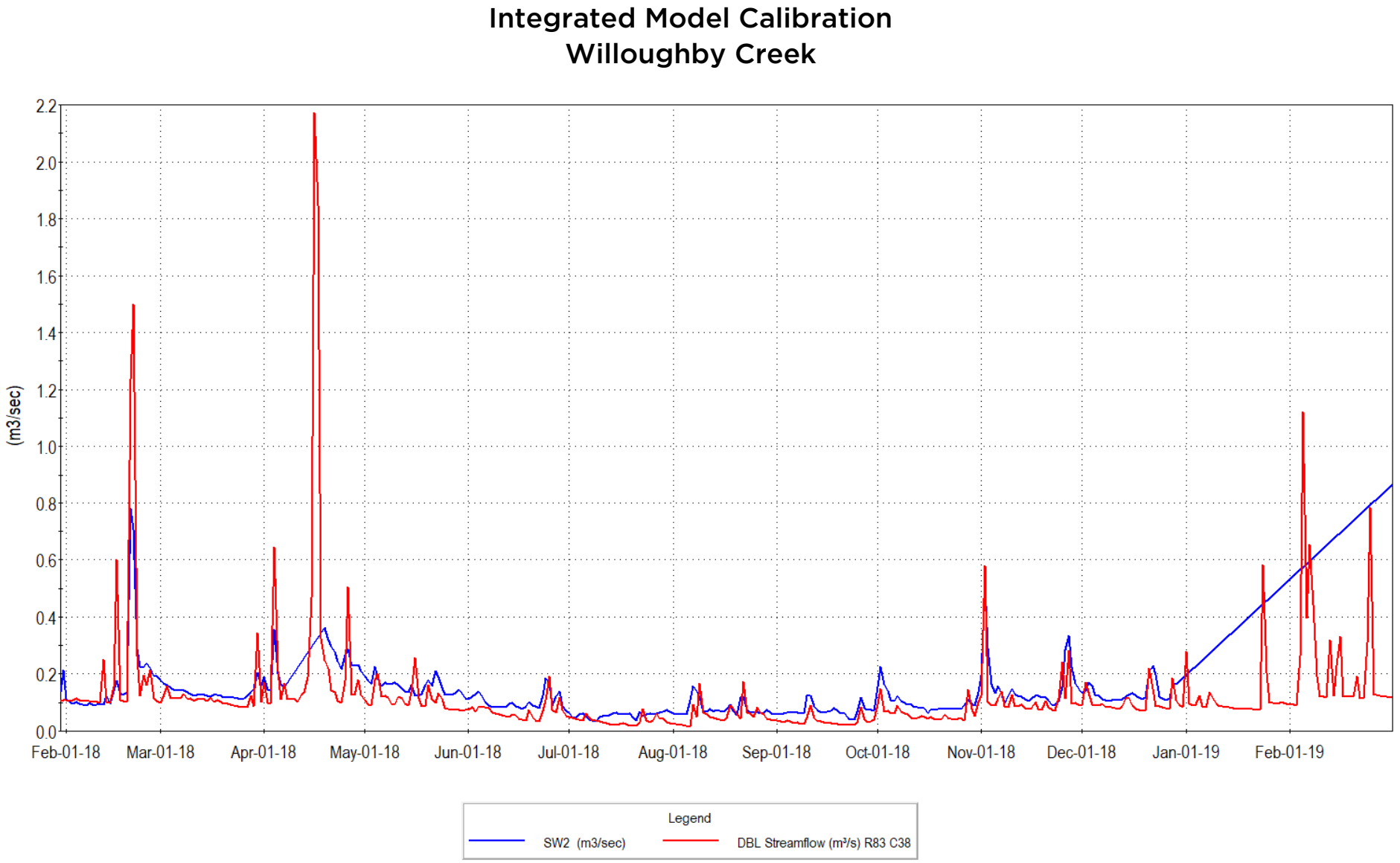


WILLOUGHBY CREEK - GRAPH 8

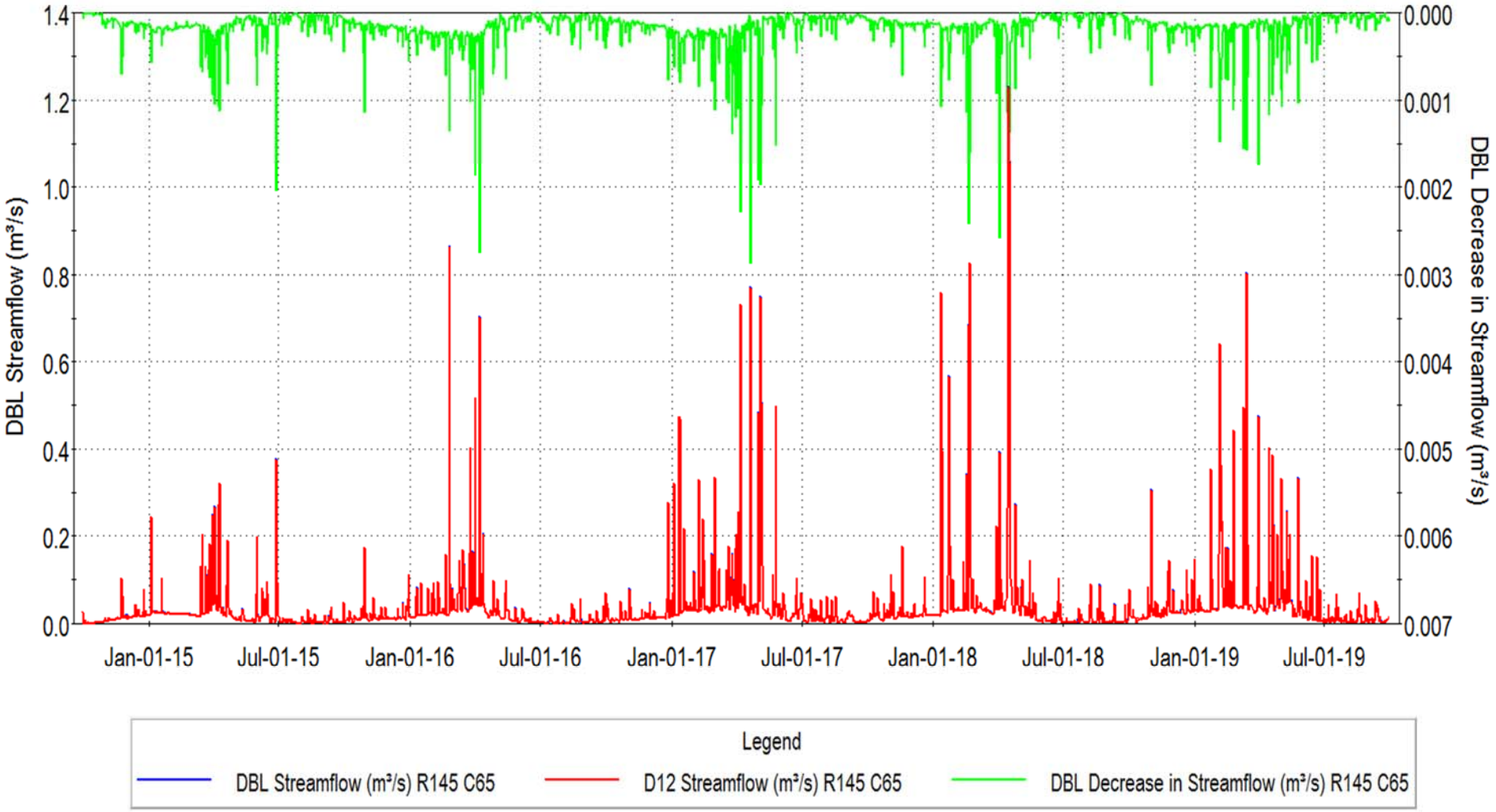
Integrated Model Calibration
Willoughby Creek



WILLOUGHBY CREEK - GRAPH 9

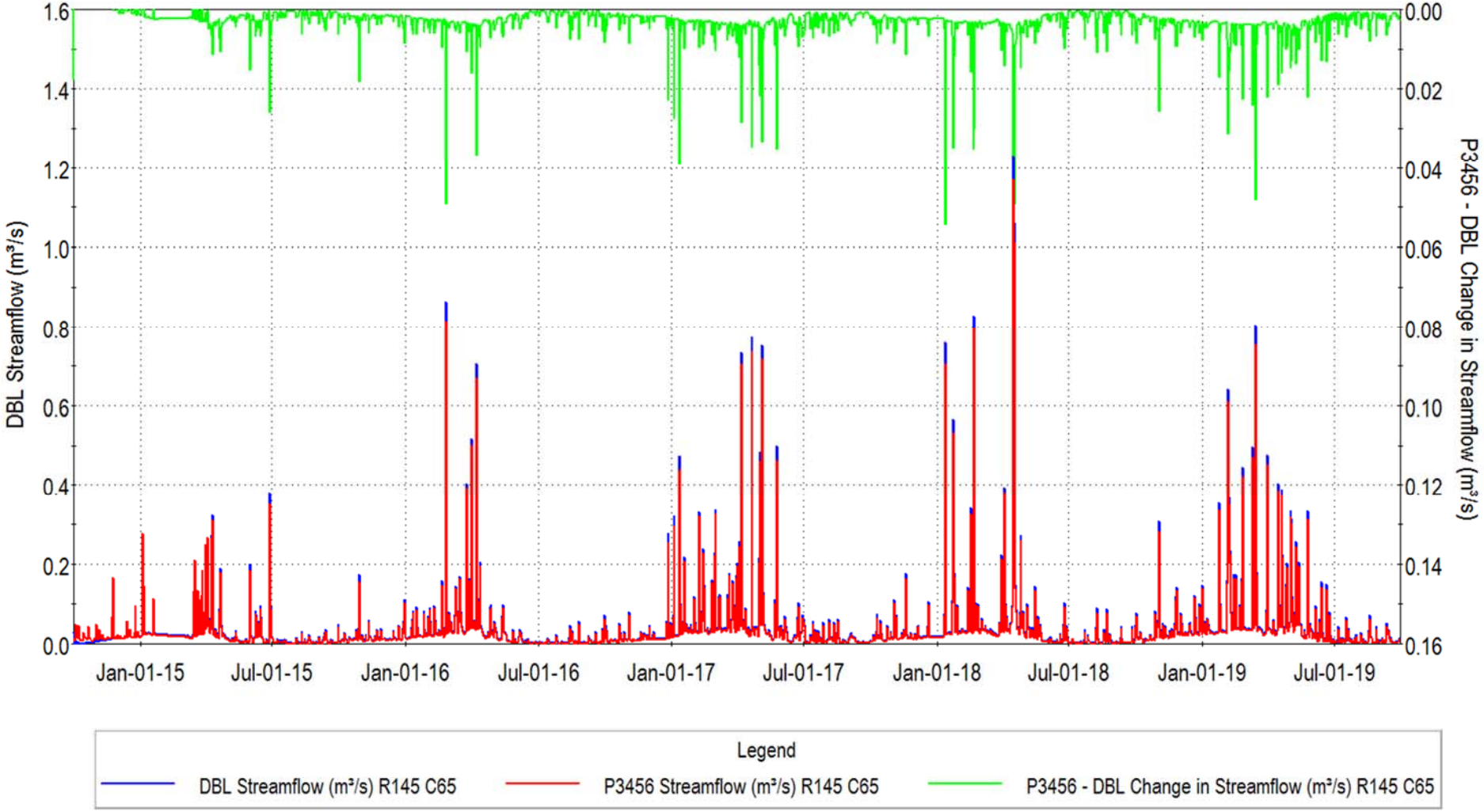


Simulated Streamflow Change - Integrated Model
Willoughby Creek

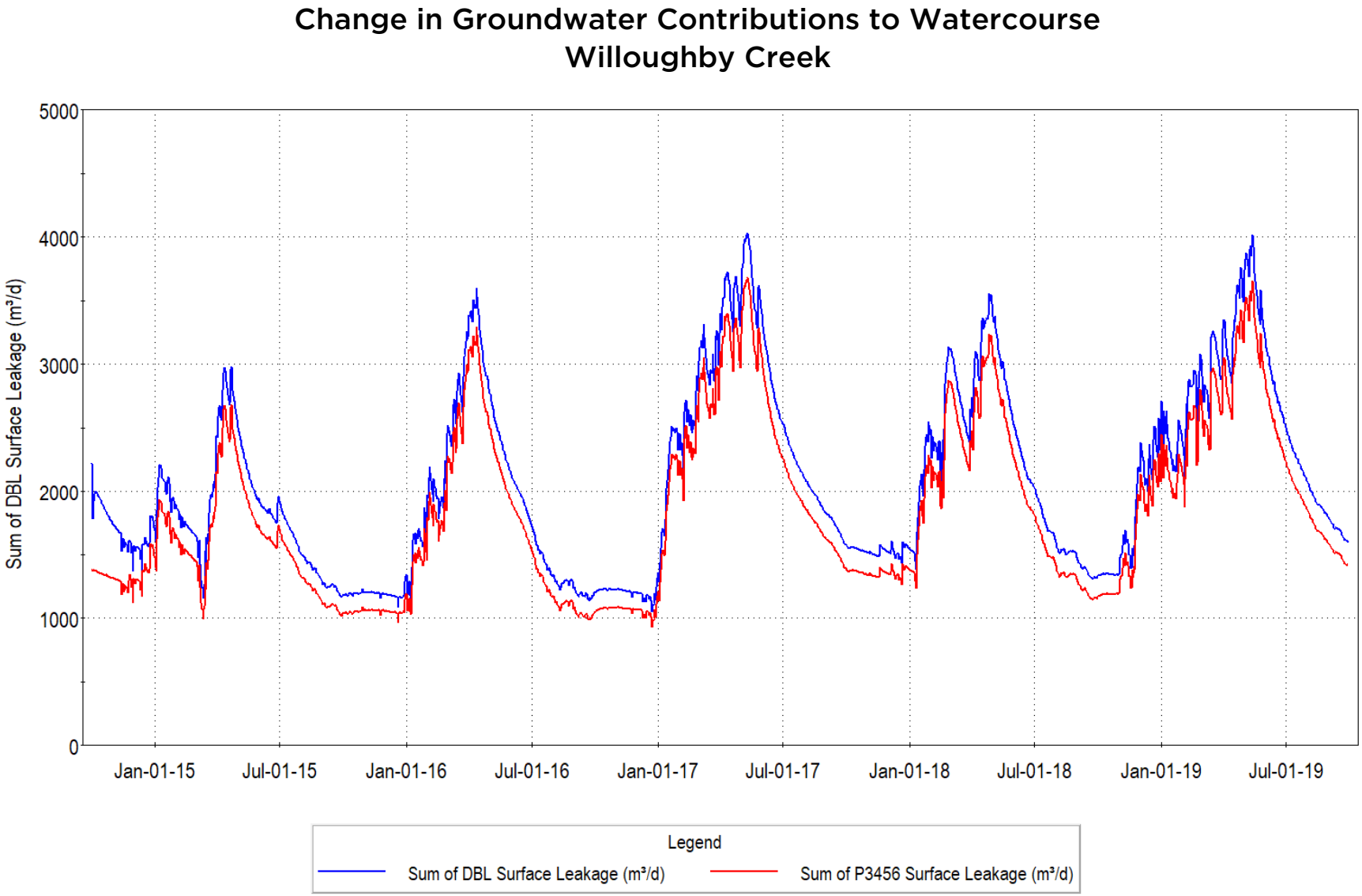


WILLOUGHBY CREEK - GRAPH 11

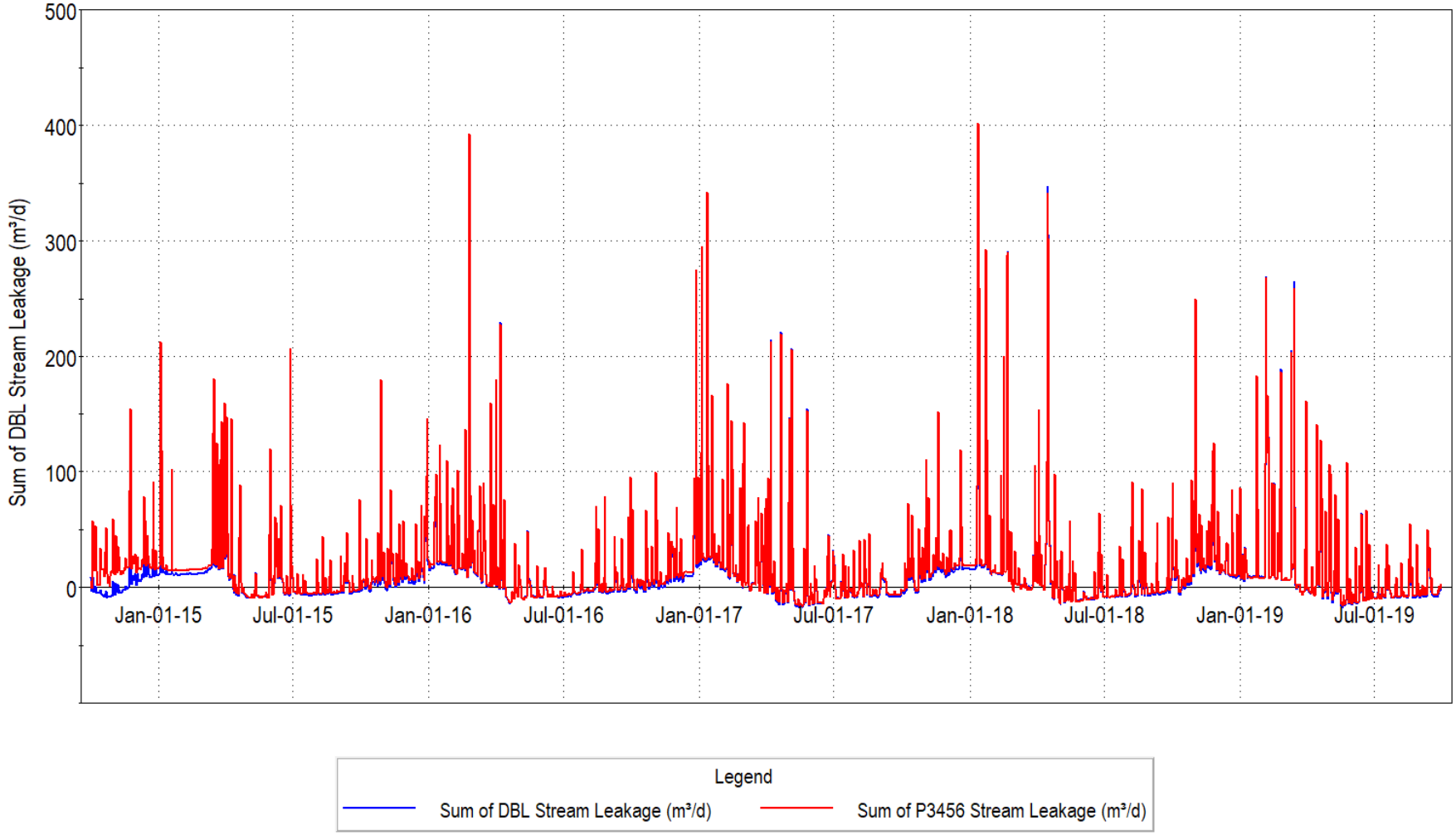
Simulated Streamflow Change - Integrated Model
Willoughby Creek



WILLOUGHBY CREEK - GRAPH 12



Change in Groundwater Contributions to Watercourse
Willoughby Creek



Wetland Characterization Summaries Proposed Burlington Quarry Extension, Nelson Aggregates Co.

Prepared for:

March 2021
Version 1.0

March 2021

Nelson Aggregate Co.
2433 No. 2 Sideroad
Burlington, Ontario
L7P 0G8

Attention: Mr. Quinn Moyer, President

RE: Burlington Quarry Wetland Characterization Summaries

Dear Mr. Moyer,

Earthfx Incorporated, Savanta Inc. and Tatham Engineering Limited are pleased to provide Nelson Aggregates Co. with the enclosed wetland characterization summaries in support of the Proposed Burlington Quarry Extension. The wetland characterization summaries have been prepared in response to comments received by the Ministry of Natural Resources and Forestry.

The wetland characterization summaries have been prepared to summarize the wetland information provided in the Level 1 and Level 2 Hydrogeological Impact Assessment, Level 1 and Level 2 Natural Environment Technical Report, and Surface Water Assessment. The hope is the wetland characterization summaries will aid in the review of the reports and expedite the review process.

Regards,

Dirk Kassenaar, M.Sc., P.Eng.
President, Eartfx Incorporated

Shannon Catton, MSc.
Branch Manager & Senior Ecologist, Savanta Inc.

Daniel Twigger, B.Sc.Eng., P.Eng.
Senior Engineer, Group Leader, Tatham Engineering Limited

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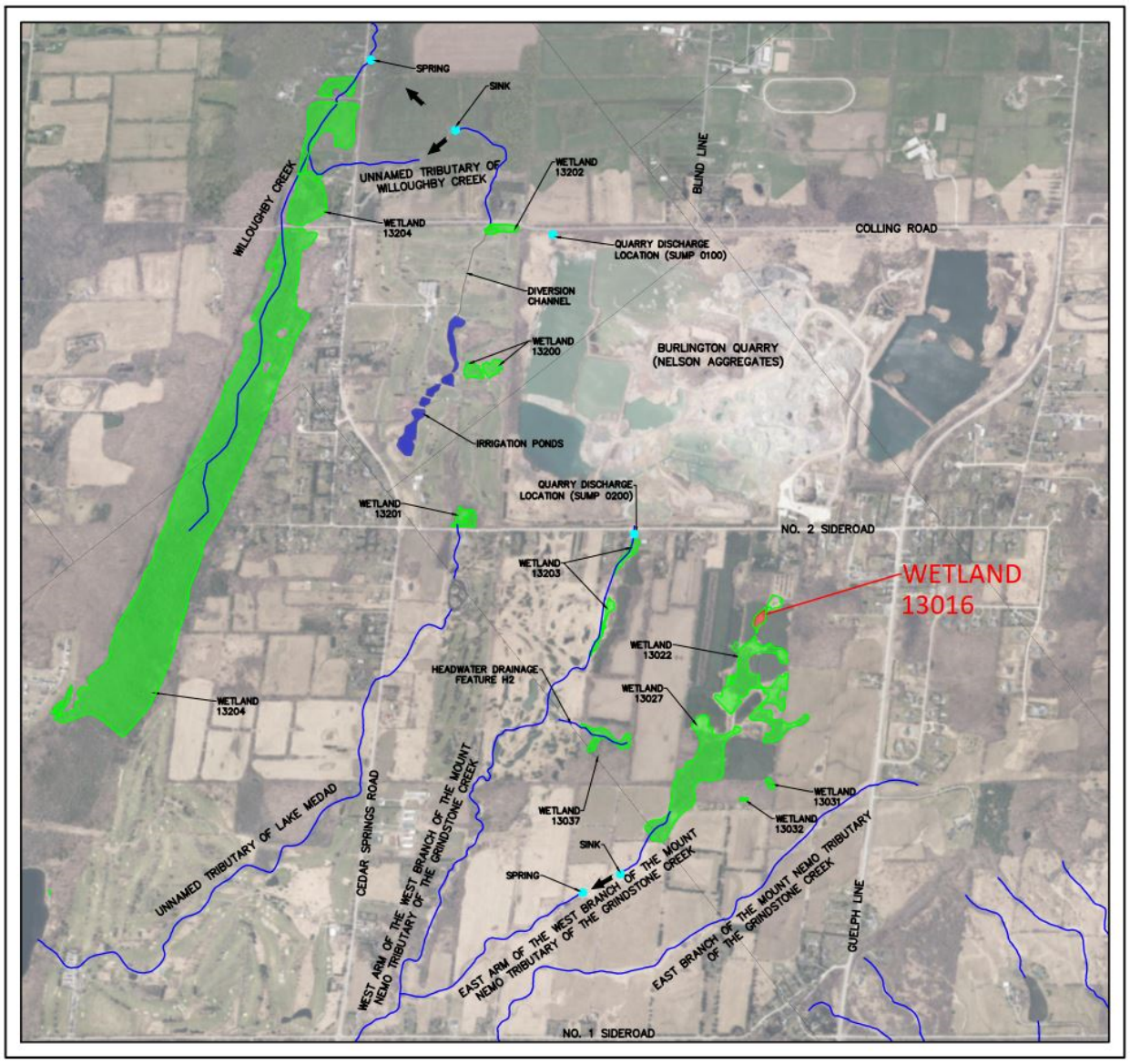
WETLAND 13201 137
WETLAND 13204 150

WETLAND 13016





Legend

- 120 m Adjacent Lands
- Subject Lands
- Existing Subcatchment Boundary (Tatham Engineering, 2020)
- Proposed Subcatchment Boundary - Operations and Post-Rehabilitation (Tatham Engineering, 2020
- Wetland (Savanta, 2020)
- Ecological Land Classification (Savanta, 2019 & 2020)
- Provincially Significant Wetland (LIO/MNRF, 2020)
- MECP Jefferson Salamander Regulated Habitat

Current Instrumentation

- Groundwater Monitoring Station (EarthFx)
- Mini Piezometer (Tatham Engineering)
- Staff Gauge & Surface Water Monitoring Station (Tatham Engineering)

Previous Instrumentation

- Mini Piezometer (Golder)

ELC Legend

CUM1, Mineral Cultural Meadow
CUP3-2, White Pine Coniferous Plantation
CUP3-13*, White Spruce Coniferous Plantation
CUT1-1, Sumac Cultural Thicket
CUW1, Mineral Cultural Woodland
HR, Hedgerow
MAM2-2, Reed-canary Grass Mineral Meadow Marsh
RES, Residential
SWD2-2, Green Ash Mineral Deciduous Swamp

NOTES:

1. Coordinate System: NAD 1983 UTM Zone 17N.
2. Base features produced under license with the Ontario Ministry of Natural Resources and Forestry © Queen's Printer for Ontario, 2021.
3. Orthoimagery © First Base Solutions, 2021. Imagery taken in 2019.

Project 8133

Burlington Quarry Extension
Nelson Aggregates Co.

Figure 1
Wetland Characterization
Wetland 13016 - South Extension

0 10 m
1:1,000

N

GEI Consultants
Savanta Division

Path: C:\Savanta\8133 - Burlington Quarry\figures\report_figures\2021 01 21 natural feature tech summary\8133_rpt_wetland_char_mapbook.mxd Date Saved: January 11, 2021

Wetland 13016

Wetland Characteristics	Description	Figure / Graph	Reference	
			Report	Section / Page
Wetland IDs:	MNRF - 67567121 (OGF ID 67657140) Earthfx - 11 Tatham - 13016 Savanta - 13016 Golder (Background) - 13016			
Wetland Area (ha):	LIO/MNRF - 0.28 Savanta - 0.22			
Watershed:	Grindstone Creek Watershed			
Sub-Watershed:	East Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek			
Located in Proposed Limit of Extraction:	No			
Located in Proposed License Boundary:	No			
Catchment Area (ha):	1.48		SWA (Tatham, April 2020)	Drawing DP-1
Catchment ID:	S118		SWA (Tatham, April 2020)	Drawing DP-1
Closed or Connected System:	On-line (connected to downstream wetland; cascading)			
Condition:	Natural			
Bathymetry:	A bathymetry survey of Wetland 13016 was completed by Tatham Engineering Limited and incorporated into the integrated model (see Earthfx Section 18.3, p.381). Wetland lakes were assigned to Layer 1 of the integrated model by adjusting the base of Layer 1 to correspond with the interpolated bottom elevation. Care was taken to ensure that the lowest elevation observed in the wetland was honored in the assigned elevations.	Figure 1	HHIAR (Earthfx, April 2020)	18.3 (page 381)
Outlet:	Downstream wetland (MNRF - OGF ID 67567143; Earthfx - 12; Tatham - 13018; Savanta - 13022; Golder {Background} - 13018)			
Hydroperiod:	Spring hydroperiod (date wetland dries out) - May 16th - July 22nd Fall hydroperiod (start of hydroperiod) - November 15th - February 18th	Graph 1	SWA (Tatham, April 2020)	2.2.4, 3 and Appendix F
Surface Water Monitoring:	ID: SW13A (Tatham) Installation Date: October 2, 2014 Data Collection: Continuous water level and temperature and manual monthly water level measurements Coordinates of Monitoring Station: Easting 591177.323, Northing 4805244.509	Graph 1	SWA (Tatham, April 2020)	2.2.4, 3 and Appendix F

Natural Heritage and Habitat Features	Description	Figure / Graph	Reference	
			Report	Section / Page
Wetland Name & Provincial Significance Evaluation:	Grindstone Creek Headwaters Wetland Complex – Provincially Significant		NETR (Savanta, April 2020)	6.1.2
ELC Unit(s):	Reed-canary Grass Mineral Meadow Marsh: MAM2-2			
Regulated Habitat (MECP):	Yes – Jefferson Salamander (not field verified during 2019 field program; regulated based on historical data) Hydroperiod sensitive species; water presence necessary until end of June		NETR (Savanta, April 2020)	6.1.2
Significant Wildlife Habitat:	Unknown – outside of 120 m adjacent lands			
Fish Habitat:	None			
Habitat of Endangered and Threatened Species:	Unknown – outside of 120 m adjacent lands			

Groundwater Interaction	Description	Figure / Graph	Reference	
			Report	Section / Page
Lithology:	Halton Till			
Hydraulic Conductivity:	Integrated Model (Earthfx) – The hydraulic conductivity for Golder MP19 was $1x10^{-9}$ m/s. The harmonic mean hydraulic conductivity, based on testing by Golder (2007) of 10 mini-piezometers, was $1.2x10^{-8}$ m/s. Model value for the vertical hydraulic conductivity was $1.6x10^{-7}$ m/s, about an order of magnitude higher, to account for limited flow through fractures in the till. Wetland Water Balance (Tatham) – $8.2x10^{-9}$ m/s.			
Surface Water/Groundwater Interaction:	The low permeability of the Halton Till underlying the wetland is the dominant control on 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. This wetland does not receive significant groundwater inflow and is isolated from any changes in the water table due to quarry development.			
Shallow Groundwater (Mini-piezometer) Monitoring:	ID: SW13B (Tatham) Installation Date: October 23, 2018 Data Collection: Continuous water level and temperature and manual monthly water level measurements Coordinates of Monitoring Station: Easting 591177.323, Northing 4805244.509	Graph 2	SWA (Tatham, April 2020)	2.3 and Appendix G

Background Shallow Groundwater (Mini-piezometer) Monitoring: — Graph 3

Mini-piezometer ID	Ground Elevation	Bottom Elevation	Average WL	Logger	Manual Meas.
Golder MP19	278.56	277.36	276.90	-	2007 - 2013
Golder MP20	278.36	277.16	276.86	-	2007 - 2013

Groundwater Monitoring (Monitoring Wells): — Graph 3

Monitoring Well ID	Distance (Dir.)	Geologic Unit	Ground Elevation	Monitoring Elev	Average WL
OW03-31A	122 (NE)	Bedrock	278.5	268.6 - 263.2	275.3
OW03-31B	122 (NE)	Bedrock	279.7	276.2 - 270.8	274.1

Water Budget Results: — Figure 2a

A detailed average water budget, as simulated by the integrated model, was not presented in the Main report but is provided in Figure 2a. The wetland is a net provider of groundwater. Simulated groundwater levels, groundwater discharge to riparian areas, and streamflow in the vicinity of Wetland 13016 (Earthfx Wetland 11) for baseline conditions is discussed in Section 7 of the main report.

Wetland 13016	GW Outflow (%)	GW Inflow (%)
Baseline (Existing)	3.97	0.00

Groundwater Interaction	Description	Figure / Graph	Reference	
			Report	Section / Page
Integrated Model Calibration:	Two mini-piezometers provide multiple years of monitoring in the soil zone and weathered Halton Till materials. These monitors correspond to the PRMS soil zone and upper-most part of Layer 1 of the GSFLOW model. A comparison of the mini-piezometer data to the simulated soil moisture conditions demonstrates that the model is closely matching both the soil moisture and hydroperiod of the shallow subsurface at this wetland.	Graphs 4 & 5		
	Earthfx Figure 19.41 (p.442) in the Main Report shows a hydrograph for SW13A along with simulated shallow water levels. The figure is reproduced in Graph 6. The total range in observed water level fluctuation is about 70 cm. A brief discussion of the Wetland 13016 (Earthfx Wetland 11) is contained in Appendix E, Section 19.6 (p. 441).	Graph 6	HHIAR (Earthfx, April 2020)	441 - 442

Impact Assessment (Operations Phases 1 & 2)	Description	Figure / Graph	Reference	
			Report	Section / Page
Change in Wetland Area (ha):	No change. Wetland located greater than 120 m from licensed boundary.		SWA (Tatham, April 2020)	4.2.1
Change in Wetland Catchment Area (ha):	No change. Subcatchment area protected.		SWA (Tatham, April 2020)	4.2.1 & Drawing DP-2
Change in Hydroperiod:	No Change. Wetland is perched and isolated from the groundwater system. Subcatchment area being protected.		SWA (Tatham, April 2020)	4.2.1
Change in Water Budget:	A detailed average water budget as simulated by the integrated model is not provided in the Main report. The water budget results for Scenario P12 are reproduced in Figure 2b. Results for nearby wetlands are provided in the Main Report. Simulated change in groundwater levels (drawdowns), groundwater discharge to riparian areas, and change in streamflow in the vicinity of Wetland 13016 (Earthfx Wetland 11) for each scenario are discussed in Section 8 of the main report.	Figure 2b	HHIAR (Earthfx, April 2020)	191 - 303
Change on Soil Moisture Conditions:	The Water Budget figures indicate that there is no groundwater seepage entering the wetland under baseline conditions, so there will be no change under P12 conditions.			
Potential Impact to Form and Function of Feature:	No wetlands will be removed and the wetlands subcatchment will be protected. There will be no encroachment from the project into the wetland. The proposed limit of extraction is >120 m from the wetland boundary. Licensed boundary will be demarcated and fenced to ensure site construction and operations do not extend beyond the proposed limits of the project .			

Wetland 13016	GW Outflow (%)	GW Inflow (%)	Δ in Outflow (%)	Δ in Inflow (%)
Baseline (Existing)	3.97	0.00	-	-
Operations Ph 1 & 2	3.90	0.00	-0.07	0.00

Mitigation (Operational Phases 1 & 2)	Description	Figure / Graph	Reference	
			Report	Section / Page
Proposed Mitigation Measures:	None required.			

Impact Assessment (Operations Phases 3 - 6)	Description	Figure / Graph	Reference	
			Report	Section / Page
Change in Wetland Area (ha):	No change. Wetland located greater than 120 m from licensed boundary.		SWA (Tatham, April 2020)	4.2.1
Change in Wetland Catchment Area (ha):	No change. Subcatchment area protected.		SWA (Tatham, April 2020)	4.2.1 & Drawing DP-2
Change in Hydroperiod:	No Change. Wetland is perched and isolated from the groundwater system. Subcatchment area being protected.		SWA (Tatham, April 2020)	4.2.1
Change in Water Budget:	A detailed average water budget as simulated by the integrated model is not provided in the Main report. The water budget results for Scenario P3456 are reproduced in Figure 2c. Results for nearby wetlands are provided in the Main Report. Simulated change in groundwater levels (drawdowns), groundwater discharge to riparian areas, and change in streamflow in the vicinity of Wetland 13016 (Earthfx Wetland 11) for each scenario are discussed in Section 8 of the main report.	Figure 2c	HHIAR (Earthfx, April 2020)	191 - 303
Change on Soil Moisture Conditions:	The Water Budget figures indicate that there is no groundwater seepage entering the wetland under baseline conditions, so there will be no change under P3456 conditions.			
Potential Impact to Form and Function of Feature:	No wetlands will be removed and the wetlands subcatchment will be protected. There will be no encroachment from the project into the wetland. The proposed limit of extraction is >120 m from the wetland boundary. Licensed boundary will be demarcated and fenced to ensure site construction and operations do not extend beyond the proposed limits of the project .			

Wetland 13016	GW Outflow (%)	GW Inflow (%)	Δ in Outflow (%)	Δ in Inflow (%)
Baseline (Existing)	3.97	0.00	-	-
Operations Ph 3 - 6	4.00	0.00	0.03	0.00

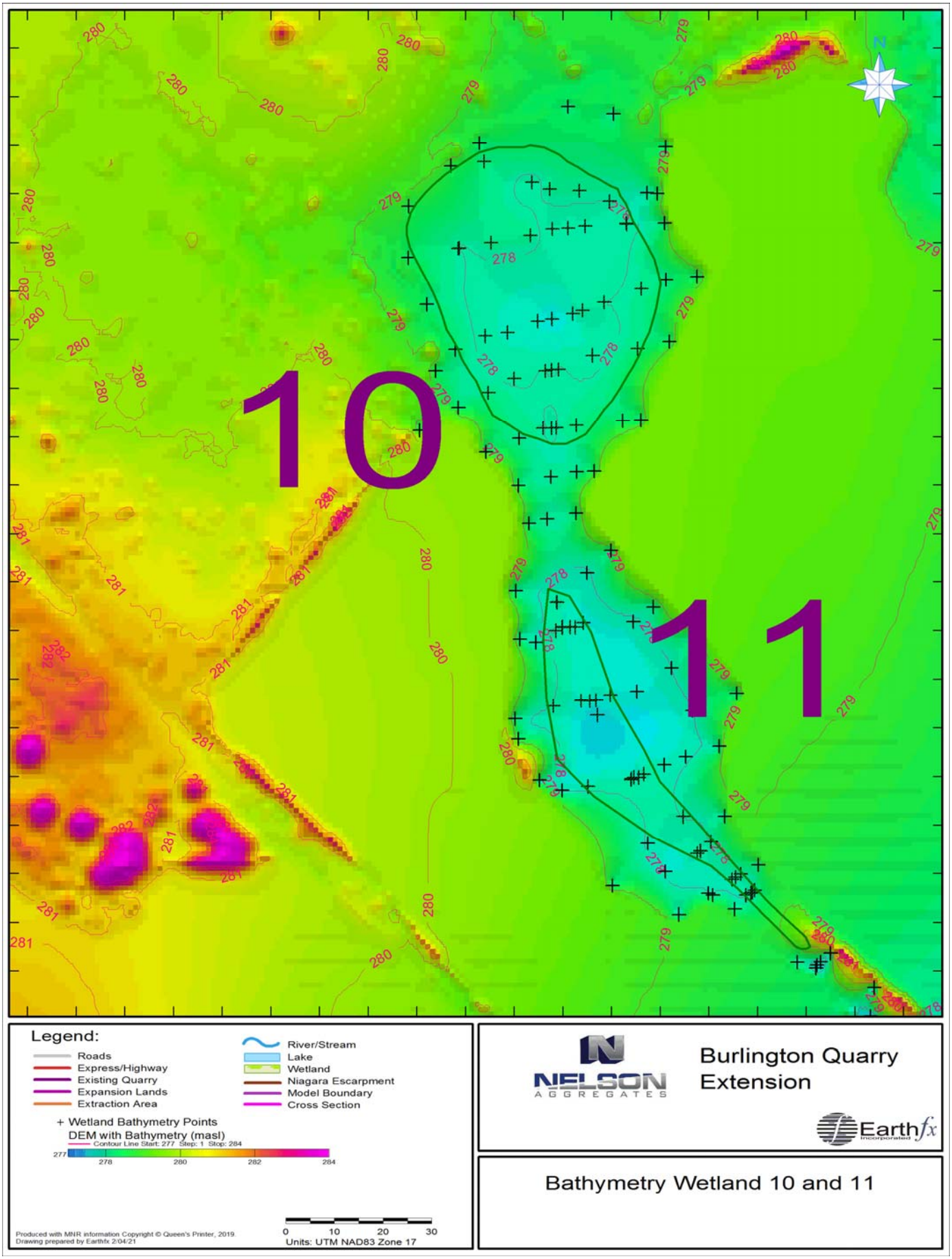
Mitigation (Operational Phases 3 - 6)	Description	Figure / Graph	Reference	
			Report	Section / Page
Proposed Mitigation Measures:	None required.			

Impact Assessment (Rehabilitation)	Description	Figure / Graph	Reference	
			Report	Section / Page
Change in Wetland Area (ha):	No change. Wetland located greater than 120 m from licensed boundary.		SWA (Tatham, April 2020)	5.4.1
Change in Wetland Catchment Area (ha):	No change. Subcatchment area protected.		SWA (Tatham, April 2020)	5.4.1 & Drawing DP-3
Change in Hydroperiod:	No Change. Wetland is perched and isolated from the groundwater system. Subcatchment area being protected.		SWA (Tatham, April 2020)	5.4.1
Change in Water Budget:	A detailed average water budget as simulated by the integrated model is not provided in the Main report. The water budget results for Scenarios RHB1 and RHB2 are reproduced in Figures 2d and 2e. Results for nearby wetlands are provided in the Main Report. Simulated change in groundwater levels (drawdowns), groundwater discharge to riparian areas, and change in streamflow in the vicinity of Wetland 13016 (Earthfx Wetland 11) for each scenario are discussed in Section 8 of the main report.	Figure 2d and 2e	HHIAR (Earthfx, April 2020)	191 - 303
Change on Soil Moisture Conditions:	The Water Budget figures indicate that there is no groundwater seepage entering the wetland under baseline conditions, so there will be no change under Rehab Scenario 1 and 2 conditions.			
Potential Impact to Form and Function of Feature:	No wetlands will be removed and the wetlands subcatchment will be protected. There will be no encroachment from the project into the wetland. The proposed limit of extraction is >120 m from the wetland boundary. Licensed boundary will be demarcated and fenced to ensure site construction and operations do not extend beyond the proposed limits of the project .			

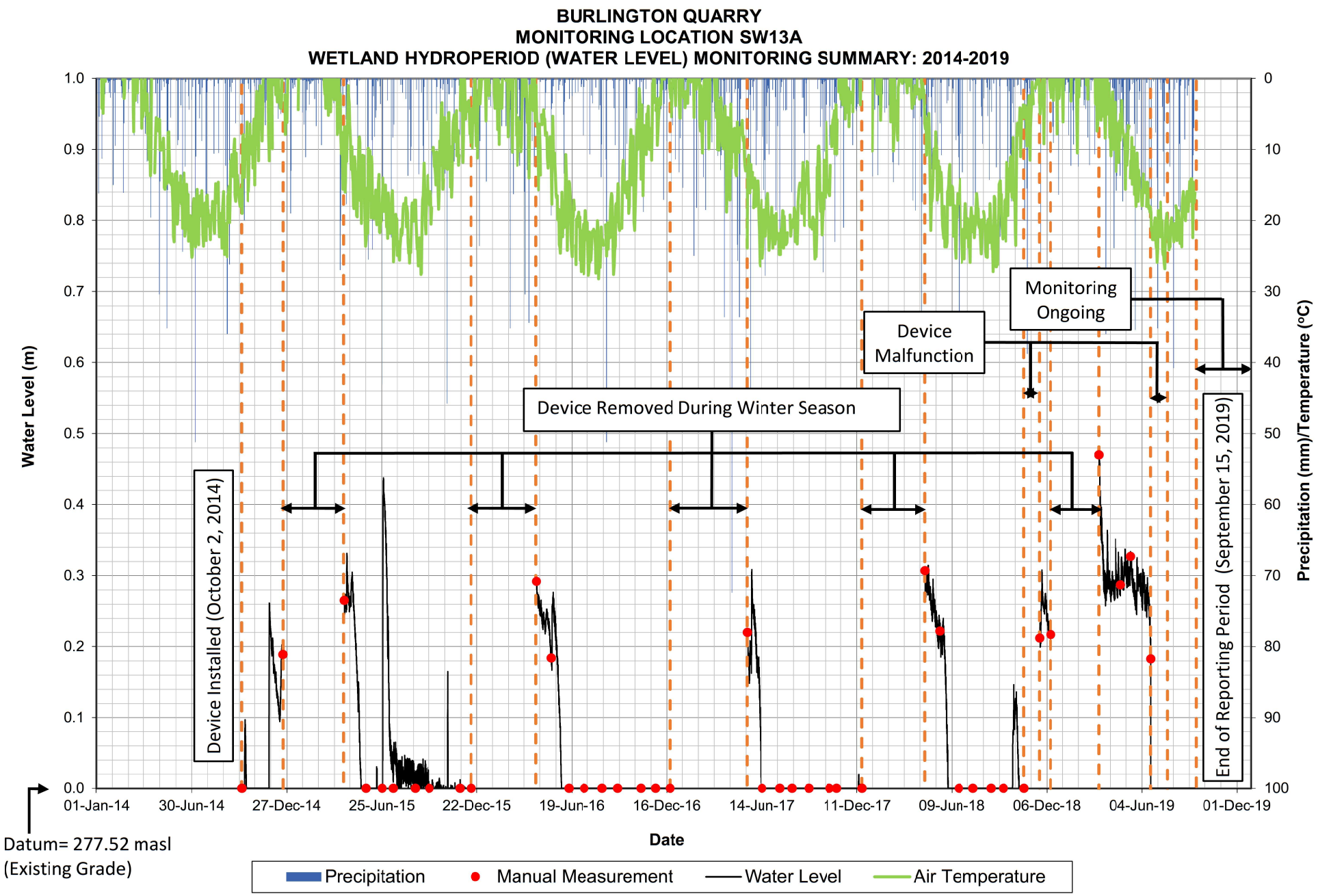
Wetland 13016	GW Outflow (%)	GW Inflow (%)	Δ in Outflow (%)	Δ in Inflow (%)
Baseline (Existing)	3.97	0.00	-	-
Rehab Scenario 1	4.15	0.00	0.18	0.00
Rehab Scenario 2	3.47	0.00	-0.05	0.00

Mitigation (Rehabilitation)	Description	Figure / Graph	Reference	
			Report	Section / Page
Proposed Mitigation Measures:	None required.			

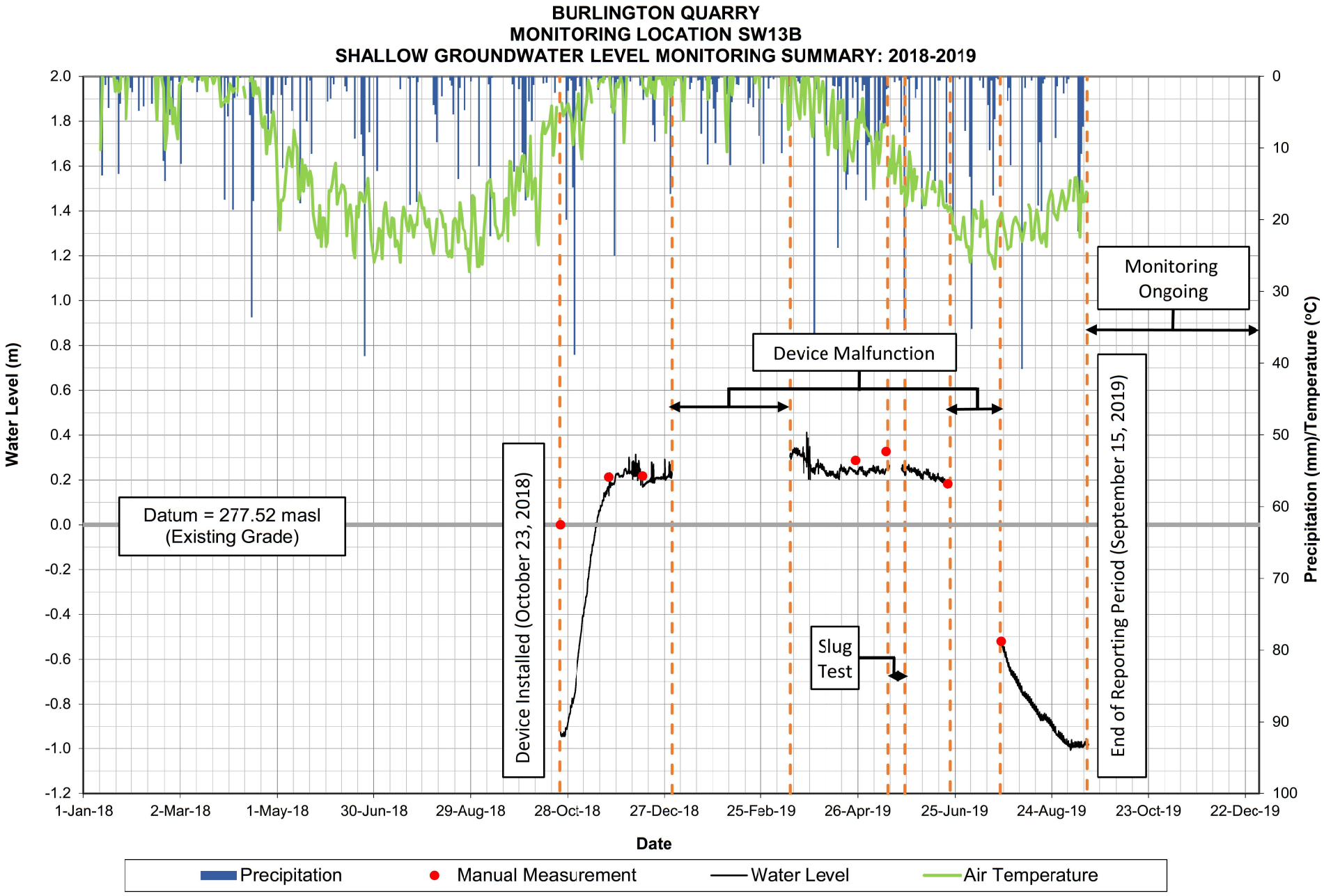
WETLAND 13016 - FIGURE 1



WETLAND 13016 - GRAPH 1

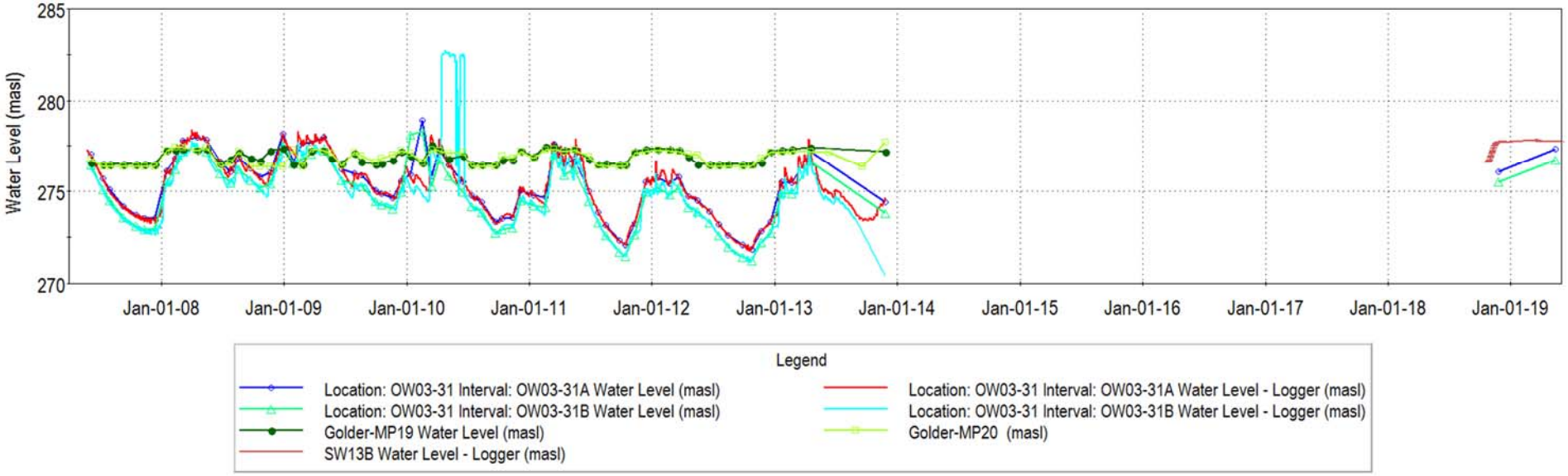


WETLAND 13016 - GRAPH 2



WETLAND 13016 - GRAPH 3

Shallow and Deep Groundwater Hydrographs
Wetland 13016



WETLAND 13016

FIGURE 2A

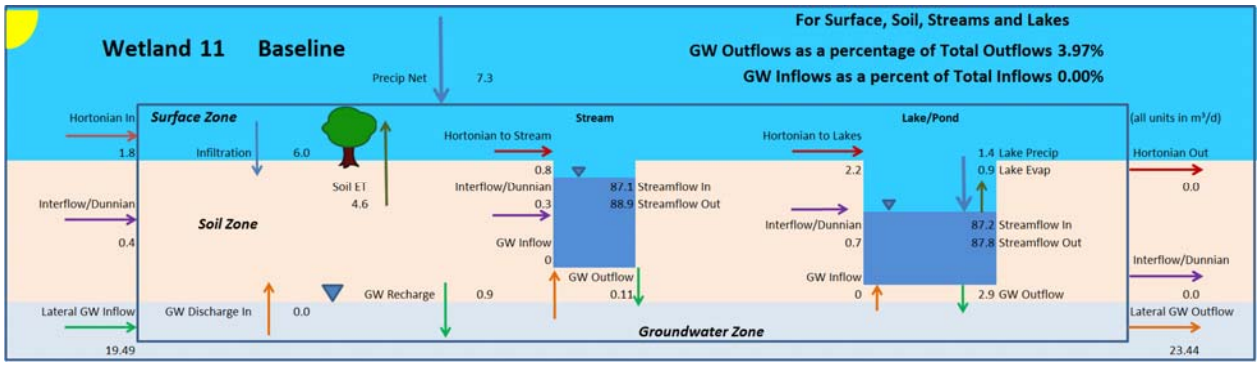


FIGURE 2B

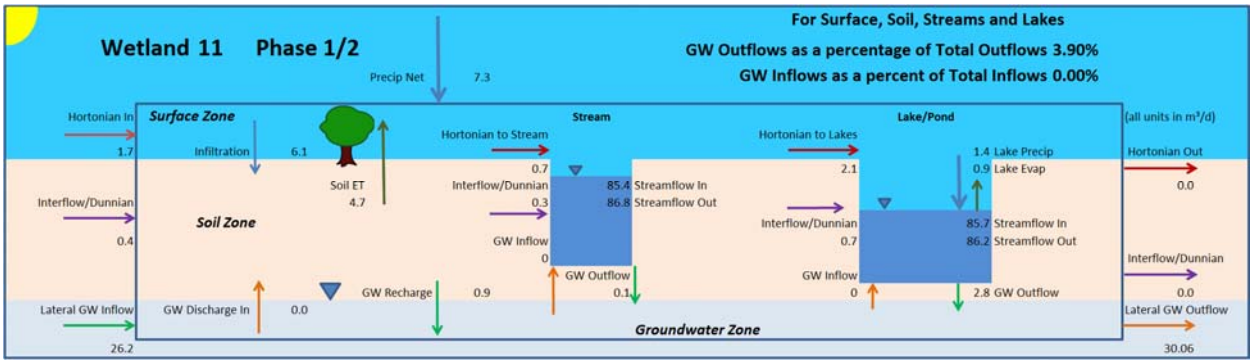


FIGURE 2C

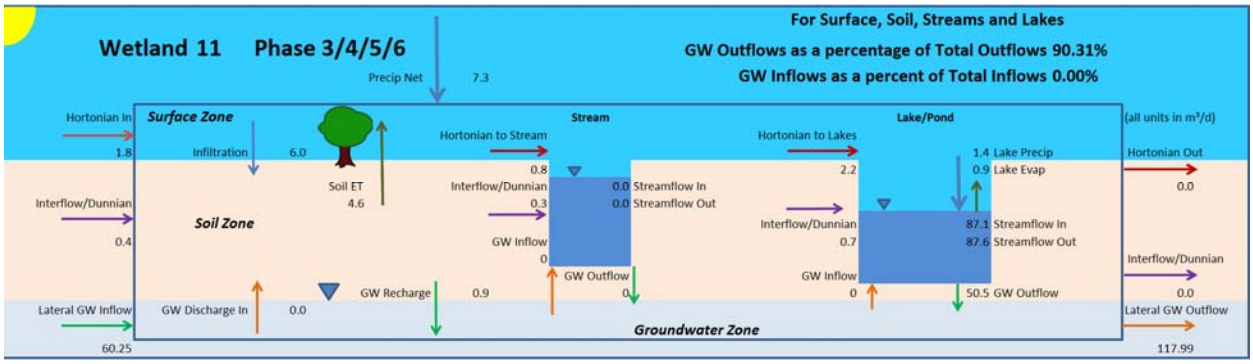


FIGURE 2D

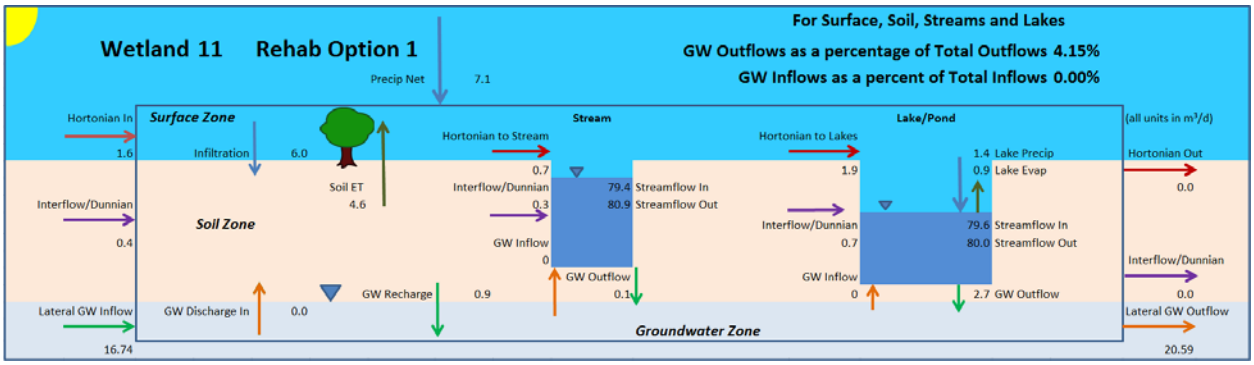
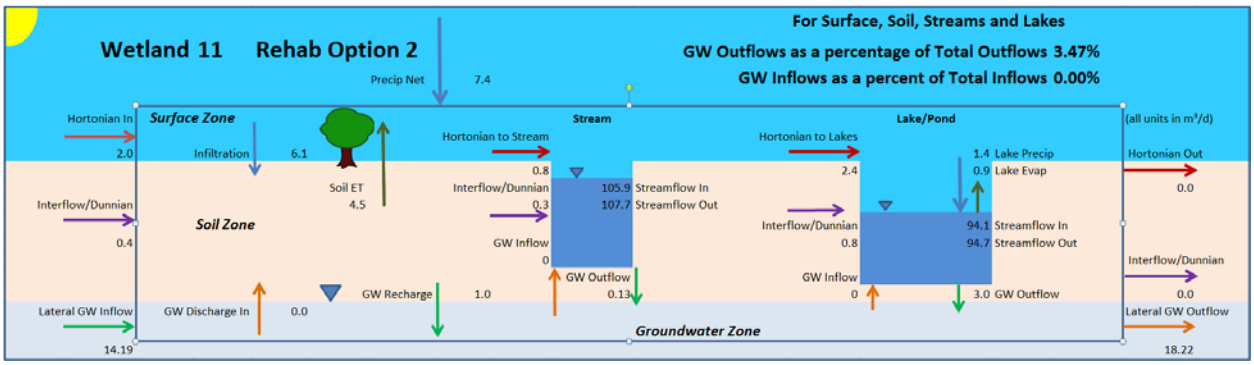
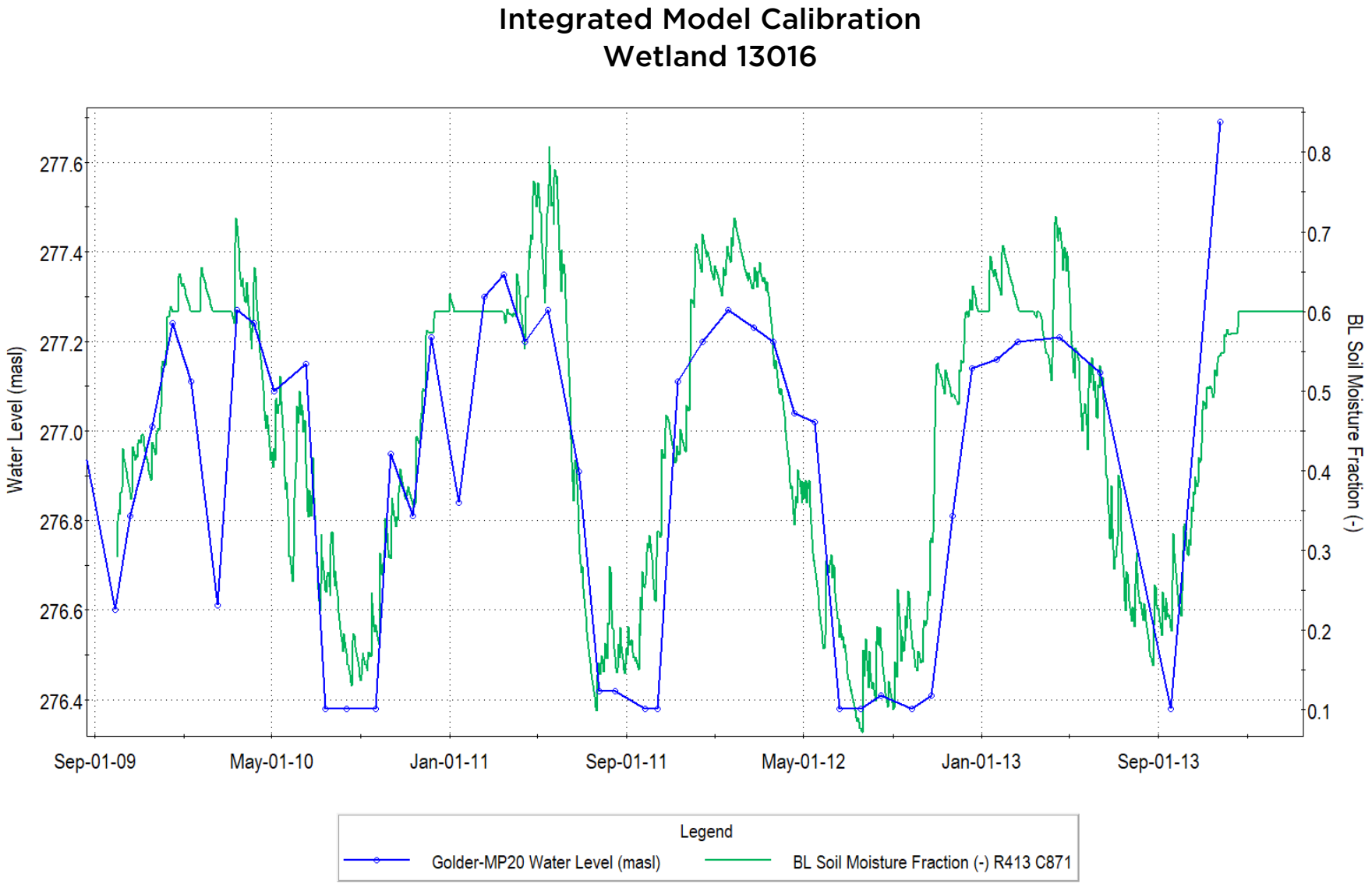


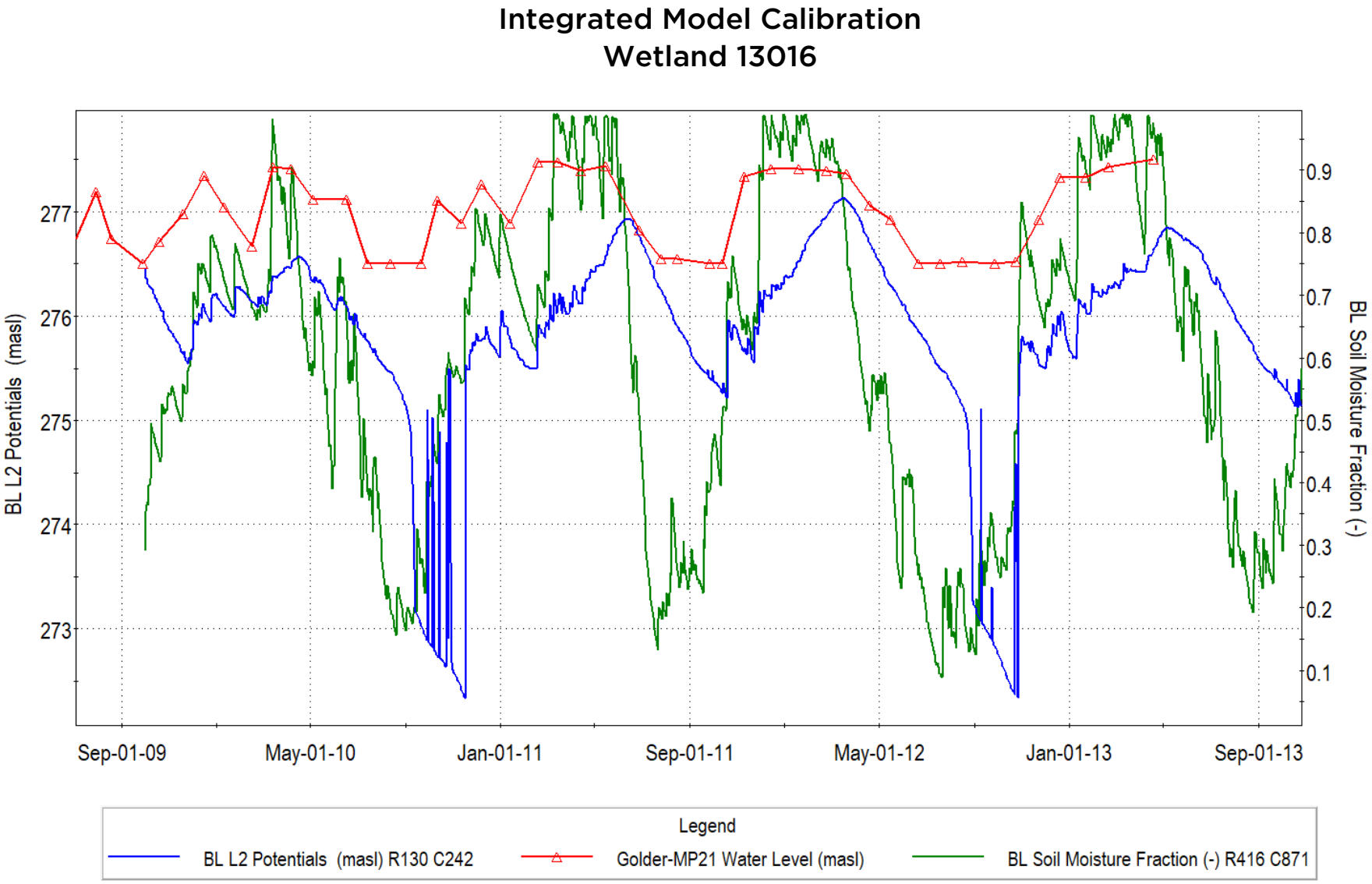
FIGURE 2E



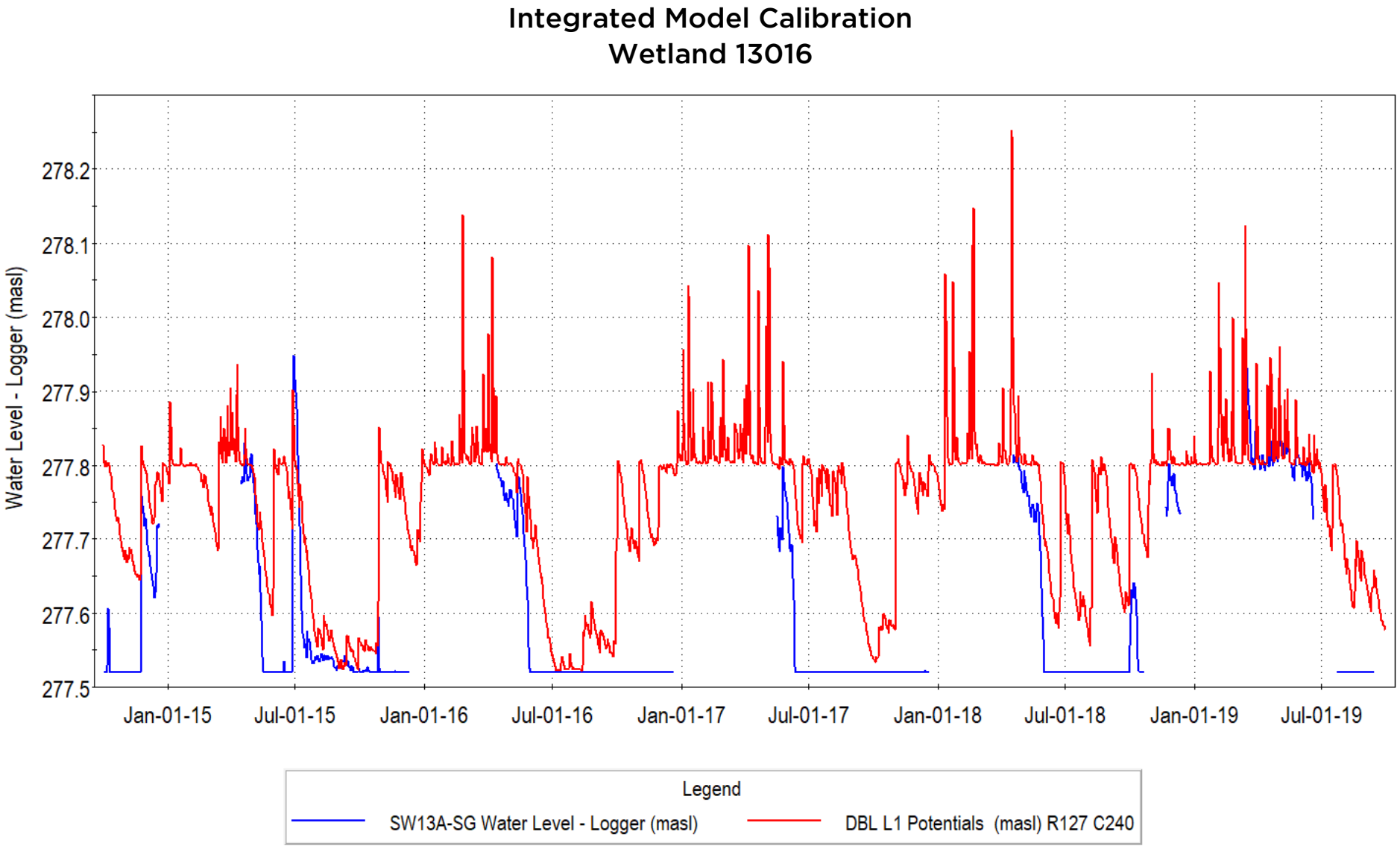
WETLAND 13016 - GRAPH 4



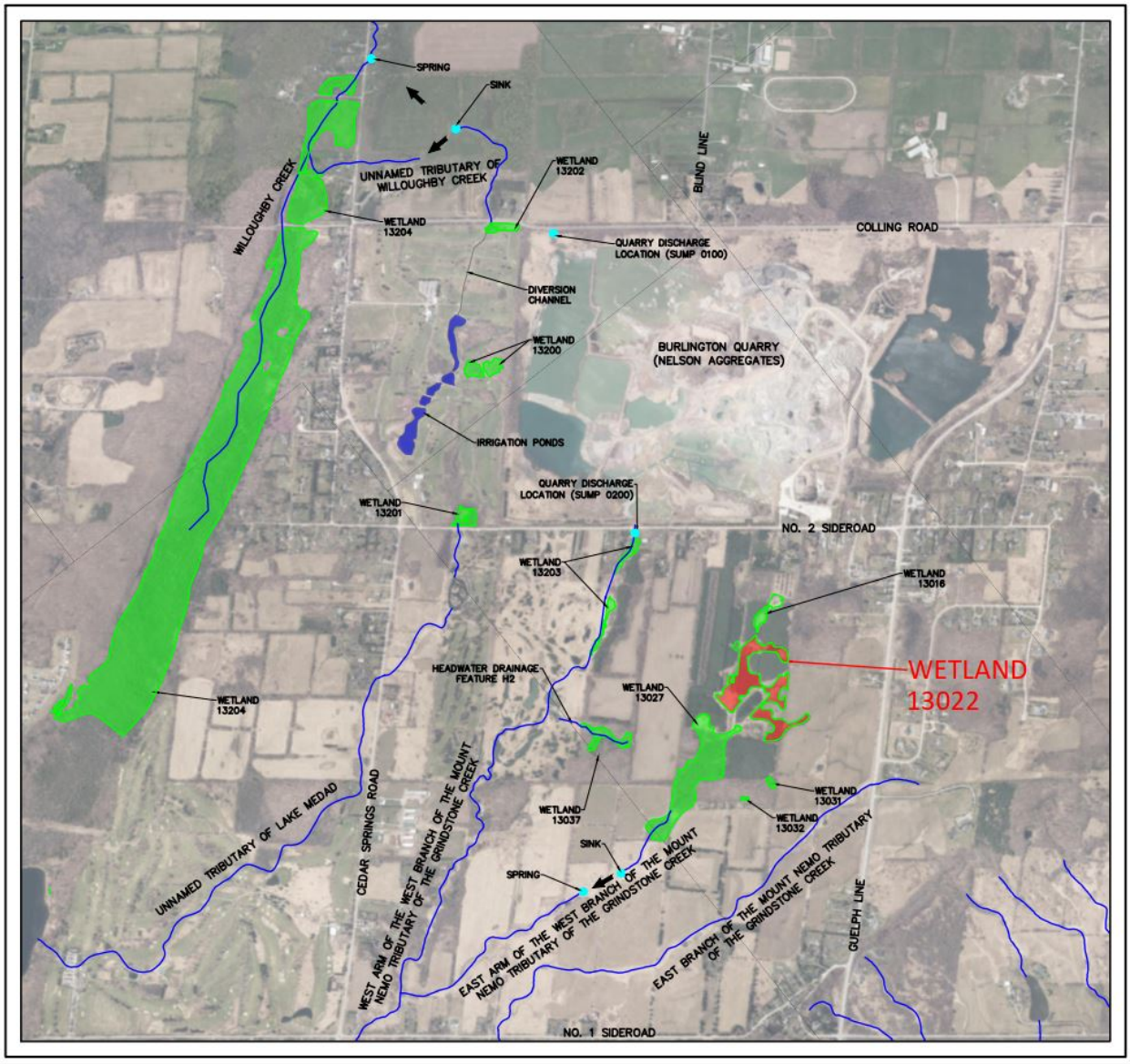
WETLAND 13016 - GRAPH 5

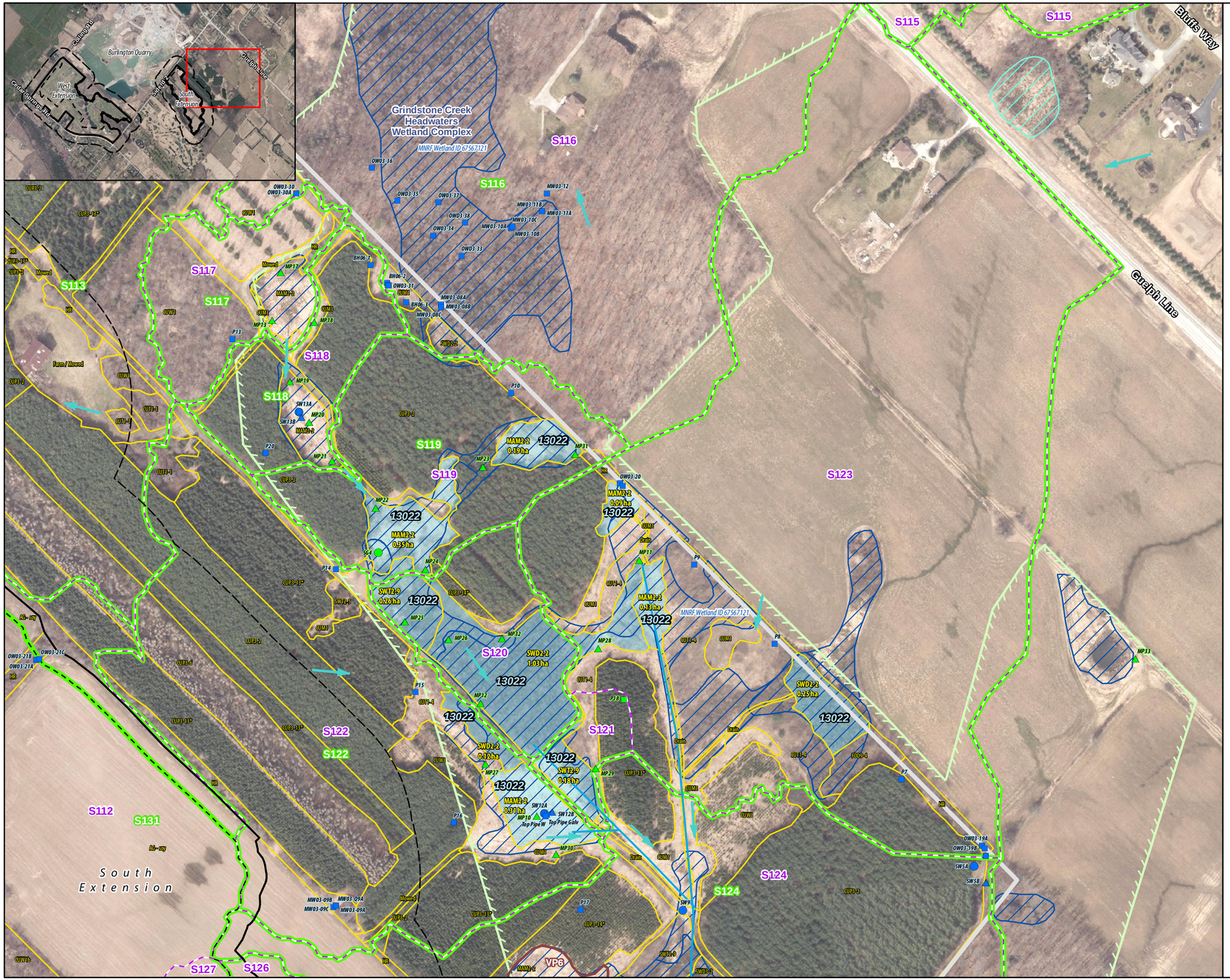


WETLAND 13016 - GRAPH 6



WETLAND 13022





Legend

- Licensed Boundary
- Limit of Extraction
- 120 m Adjacent Lands
- Subject Lands
- Salamander Habitat Assessment (2019)
- Indirect Fish Habitat
- Existing Subcatchment Boundary (Tatham Engineering, 2020)
- Proposed Subcatchment Boundary - Operations and Post-Rehabilitation (Tatham Engineering, 2020
- Wetland (Savanta, 2020)
- Ecological Land Classification (Savanta, 2019 & 2020)
- Provincially Significant Wetland (LIO/MNRF, 2020)
- Wetland - Not Evaluated per OWES (MNRF/LIO, 2020)
- MECP Jefferson Salamander Regulated Habitat

Current Instrumentation

- Groundwater Monitoring Station (EarthFx)
- Mini Piezometer (Tatham Engineering)
- Staff Gauge & Surface Water Monitoring Station (Tatham Engineering)
- Manual Stream Flow Measurement (Tatham Engineering)

Previous Instrumentation

- Groundwater Monitoring Station (Golder)
- Mini Piezometer (Golder)
- Staff Gauge & Surface Water Monitoring Station (Golder)

ELC Legend

AG, Agriculture
CUM1, Mineral Cultural Meadow
CUP3-2, White Pine Coniferous Plantation
CUP3-6, European Larch Coniferous Plantation
CUP3-13*, White Spruce Coniferous Plantation
CUP3-14*, White Cedar Coniferous Plantation
CUT1-1, Sumac Cultural Thicket
CUT1-4, Gray Dogwood Cultural Thicket
CUW1, Mineral Cultural Woodland
FOD9-4, Fresh – Moist Shagbark Hickory Deciduous Forest
HR, Hedgerow
MAM2-2, Reed-canary Grass Mineral Meadow Marsh
RES, Residential
SWD2-2, Green Ash Mineral Deciduous Swamp
SWD3-2, Silver Maple Mineral Deciduous Swamp
SWT2-5, Red-osier Dogwood Mineral Thicket Swamp
SWT2-9, Gray Dogwood Mineral Thicket Swamp

NOTES:

1. Coordinate System: NAD 1983 UTM Zone 17N.
2. Base features produced under license with the Ontario Ministry of Natural Resources and Forestry © Queen's Printer for Ontario, 2021.
3. Orthoimagery © First Base Solutions, 2021. Imagery taken in 2019.

Project 8133

Burlington Quarry Extension
Nelson Aggregates Co.

Figure 2
Wetland Characterization
Wetland 13022 - South Extension

0 50 m
1:3,000

N

GEI Consultants
Savanta Division

Wetland 13022

Wetland Characteristics	Description	Figure / Graph	Reference	
			Report	Section / Page
Wetland IDs:	MNRF – 67567121 (OGF ID 67567134, 67567144, 67567123, 67567137, 67567136, 67567146, 67567133, 67567146, 67567151) Earthfx – 12, 13, 14, 15, 16 Tatham – 13017, 13018, 13019, 13020, 13021, 13022, 13023, 13029, 13030, 13051 Savanta – 13022 Golder (Background) - 13017, 13018, 13019, 13020, 13021, 13022, 13023, 13029, 13030, 13051			
Wetland Area (ha):	LIO/MNRF - 4.45 Savanta - 2.91			
Watershed:	Grindstone Creek Watershed			
Sub-Watershed:	East Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek			
Located in Proposed Limit of Extraction:	No			
Located in Proposed License Boundary:	No			
Catchment Area (ha):	30.45		SWA (Tatham, April 2020)	Drawing DP-1
Catchment ID:	S119, S120, S121, S122, S123		SWA (Tatham, April 2020)	Drawing DP-1
Closed or Connected System:	On-line (connected to downstream wetland; cascading)			
Condition:	Natural			
Bathymetry:	A bathymetry survey of Wetland 13022 was completed by Tatham Engineering Limited and incorporated into the integrated model (see Earthfx Section 18.3, p.381). Wetland lakes were assigned to Layer 1 of the integrated model by adjusting the base of Layer 1 to correspond with the interpolated bottom elevation. Care was taken to ensure that the lowest elevation observed in the wetland was honored in the assigned elevations.	Figure 1	HHIAR (Earthfx, April 2020)	18.3 (page 381)
Outlet:	Downstream wetland (MNRF – OGF ID 67567149; Earthfx – 17, Tatham – 13049; Savanta – 13027; Golder {Background} – 13049)			
Hydroperiod:	Spring Hydroperiod (date wetland dries out) – March 20th – July 5th Fall Hydroperiod (start of hydroperiod) – October 8th – January 25th	Graph 1	SWA (Tatham, April 2020)	2.2.3, 3 and Appendix F
Surface Water Monitoring:	ID: SW12A (Tatham) Installation Date: October 2, 2014 Data Collection: Continuous water level and temperature and manual monthly water level measurements Coordinates of Monitoring Station: Easting 591126.758, Northing 4805392.503	Graph 1	SWA (Tatham, April 2020)	2.2.3, 3 and Appendix F

Natural Heritage and Habitat Features	Description	Figure / Graph	Reference	
			Report	Section / Page
Wetland Name & Provincial Significance Evaluation:	Grindstone Creek Headwaters Wetland Complex – Provincially Significant		NETR (Savanta, April 2020)	6.1.2
ELC Unit(s):	Reed-canary Grass Mineral Meadow Marsh: MAM2-2 Gray Dogwood Mineral Thicket Swamp: SWT2-9 Green Ash Mineral Deciduous Swamp: SWD2-2		NETR (Savanta, April 2020)	Table 2
Regulated Habitat (MECP):	Yes – Jefferson Salamander (not field verified during 2019 field program; regulated based on historical data) Hydroperiod sensitive species; water presence necessary until end of June		NETR (Savanta, April 2020)	6.7
Significant Wildlife Habitat:	Unknown – outside of 120 m adjacent lands			
Fish Habitat:	Indirect		NETR (Savanta, April 2020)	6.6
Habitat of Endangered and Threatened Species:	Unknown – outside of 120 m adjacent lands			

Groundwater Interaction	Description	Figure / Graph	Reference	
			Report	Section / Page
Lithology:	Halton Till			
Hydraulic Conductivity:	Integrated Model (Earthfx) - The hydraulic conductivity for Golder MP10 was $9x10^{-10}$ m/s. The harmonic mean hydraulic conductivity, based on testing by Golder (2007) of 10 mini-piezometers, was $1.2x10^{-8}$ m/s. Model value for the vertical hydraulic conductivity was $1.6x10^{-7}$ m/s, about an order of magnitude higher, to account for limited flow through fractures in the till. Wetland Water Balance (Tatham) – $3.8x10^{-9}$ m/s.			
Surface Water/Groundwater Interaction:	The low permeability of the Halton Till underlying the wetland is the dominant control on 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.			
Shallow Groundwater (Mini-piezometer) Monitoring:	ID: SW12B (Tatham) Installation Date: October 23, 2018 Data Collection: Continuous water level and temperature and manual monthly water level measurements Coordinates of Monitoring Station: Easting 591126.758, Northing 4805392.503	Graph 2	SWA (Tatham, April 2020)	2.3 and Appendix G

Background Shallow Groundwater (Mini-piezometer) Monitoring: — Graph 3 & 4

Mini-piezometer ID	Ground Elevation	Bottom Elevation	Average WL	Logger	Manual Meas.
Golder MP10	278.17	276.97	275.13	2006-2013	2006-2013
Golder MP11	279.5	278.3	276.53	2007-2013	2007-2013
Golder MP12	278.07	276.87	275.29	2006-2013	2006-2013
Golder MP15	278.76	277.9	-	-	-
Golder MP22	278.41	277.21	276.08	-	2012-2013
Golder MP23	280.17	278.97	277.26	-	2007-2013
Golder MP24	279.69	278.49	275.78	-	2007-2013
Golder MP25	278.35	277.15	275.6	-	2007-2013
Golder MP26	278.22	277.02	275.57	-	2007-2013
Golder MP27	278.61	277.41	275.23	-	2007-2013
Golder MP28	279.32	278.12	276.57	-	2007-2013
Golder MP29	277.66	276.46	276.23	-	2007-2013
Golder MP 30	279.12	277.92	275.31	-	2007-2013
Golder MP 31	280.63	279.43	277.26	-	2007-2013
Golder MP 32	276.6	275.53	275.99	-	2007-2013

Groundwater Monitoring (Monitoring Wells): — Graphs 5 & 6

Monitoring Well ID	Distance (Dir.)	Geologic Unit	Ground Elevation	Monitoring Elev	Average WL
MW03-09A	180 (WSW)	Bedrock	278.5	268.6 - 263.2	276.29
MW03-09B	180 (WSW)	Bedrock	279.7	276.2 - 270.8	276.68
MW03-09C	180 (WSW)	Overburden	279.7	276.2 - 270.8	277.60
OW03-20A	266 (NNW)	Overburden	277.68	259.0 - 252.2	277.03
OW03-20B	266 (NNW)	Overburden	277.69	275.2 - 268.2	276.90
OW03-20C	266 (NNW)	Overburden	277.66	275.5 - 273.9	276.74

Water Budget Results: — Figure 2a — HHIAR (Earthfx, April 2020) — 186

A detailed average water budget for Wetland 13022 (Earthfx Wetland 16), as simulated by the integrated model, is provided in the main report for Baseline Conditions (Earthfx Figure 7.24, p. 186). The baseline water budget is reproduced in Figure 1a. The wetland is a net provider of groundwater. Simulated groundwater levels, groundwater discharge to riparian areas, and streamflow in the vicinity of Wetland 13022 (Earthfx Wetland 16) for baseline conditions are discussed in Section 7 of the main report. Wetland budgets for Wetlands 12 to 15 are also provided.

Wetland 13022	GW Outflow (%)	GW Inflow (%)
Baseline (Existing)	1.25	0.34

Groundwater Interaction	Description	Figure / Graph	Reference	
			Report	Section / Page
Integrated Model Calibration:	Six mini-piezometers in the vicinity of this wetland provide multiple years of monitoring in the soil zone and weathered Halton Till materials. These monitors correspond to the PRMS soil zone and upper-most part of Layer 1 of the GSFLOW model. A comparison of the mini-piezometer data to the simulated soil moisture conditions demonstrates that the model is closely matching both the soil moisture and hydroperiod of the shallow subsurface at this wetland. Wetland 16 is not discussed in the Main Report. Other nearby wetlands are discussed in Appendix E, Section 19.6.	Graphs 7, 8, 9, 10, 11 & 12		

Impact Assessment (Operations Phases 1 & 2)	Description	Figure / Graph	Reference	
			Report	Section / Page
Change in Wetland Area (ha):	No change. Wetland located greater than 120 m from licensed boundary.		SWA (Tatham, April 2020)	4.2.1
Change in Wetland Catchment Area (ha):	No change. Subcatchment area protected.		SWA (Tatham, April 2020)	4.2.1 & Drawing DP-2
Change in Hydroperiod:	No Change. Wetland is perched and isolated from the groundwater system. Subcatchment area being protected.		SWA (Tatham, April 2020)	4.2.1
Change in Water Budget:	A detailed average water budget for Wetland 13022 (Earthfx Wetland 16), as simulated by the integrated model, is provided in the Earthfx report for Baseline Conditions (Figure 7.24, p. 186); Scenario P12 (Figure 8.31, p. 221); P3456 (Figure 8.63, p. 248); RHB1 (Figure 8.99, p. 277), and RHB2 (Figure 8.126, p. 299). The water budget results for Scenario P12 are reproduced in Figure 2b. Simulated change in groundwater levels (drawdowns), groundwater discharge to riparian areas, and change in streamflow in the vicinity of Wetland 13022 (Earthfx Wetland 16) for each scenario are discussed in Section 8 of the main report.	Figure 2b	HHIAR (Earthfx, April 2020)	191 - 303
Change on Soil Moisture Conditions:	The soil moisture and surface discharge patterns in Wetland 13 are shown in Graph 13, and pond leakage is shown in Graph 14 (Note the scale range is very small). The effects of development can be illustrated by comparing the average soil moisture in Wetland 13 under Baseline and P12 development conditions. Graph 13 shows average daily soil moisture for Baseline conditions as a blue line. The soil moisture under P12 development is shown in red, and it overlies (covers) the Baseline for much of the time period. Under P12 development, soil moisture is essentially identical in the winter and spring, but slightly dryer in the summer and fall during a wet year. Wetland 13 lake seepage (Graph 14) under Baseline (Blue) and P12 conditions (Red) are shown in Graph 13. Under Baseline conditions, the ponds leak water to the groundwater system for most of the year, and only receive upwelling (negative leakage or seepage) for short periods of the wetter years when the water table is higher (generally in late spring). Under P12 conditions (red line), the ponds leak water to the groundwater system at varying rates throughout the year; generally higher in the spring and declining through the summer.	Graphs 13 & 14		
Potential Impact to Form and Function of Feature:	No wetlands will be removed and the wetlands subcatchment will be protected. There will be no encroachment from the project into the wetland. The proposed limit of extraction is >120 m from the wetland boundary. Licensed boundary will be demarcated and fenced to ensure site construction and operations do not extend beyond the proposed limits of the project .			

Wetland 13022	GW Outflow (%)	GW Inflow (%)	Δ in Outflow (%)	Δ in Inflow (%)
Baseline (Existing)	1.25	0.34	-	-
Operations Ph 1 & 2	1.31	0.00	0.06	-0.34

Mitigation (Operational Phases 1 & 2)	Description	Figure / Graph	Reference	
			Report	Section / Page
Proposed Mitigation Measures:	None required.			

<table>
<tr><th>Impact Assessment (Operations Phases 3 - 6)</th><th>Description</th><th>Figure / Graph</th><th colspan="2">Reference</th></tr>
<tr><th></th><th></th><th></th><th>Report</th><th>Section / Page</th></tr>
<tr><td>Change in Wetland Area (ha):</td><td>No change. Wetland located greater than 120 m from licensed boundary.</td><td></td><td>SWA (Tatham, April 2020)</td><td>4.2.1</td></tr>
<tr><td>Change in Wetland Catchment Area (ha):</td><td>No change. Subcatchment area protected.</td><td></td><td>SWA (Tatham, April 2020)</td><td>4.2.1 & Drawing DP-2</td></tr>
<tr><td>Change in Hydroperiod:</td><td>No Change. Wetland is perched and isolated from the groundwater system. Subcatchment area being protected.</td><td></td><td>SWA (Tatham, April 2020)</td><td>4.2.1</td></tr>
<tr><td>Change in Water Budget:</td><td>A detailed average water budget for Wetland 13022 (Earthfx Wetland 16), as simulated by the integrated model, is provided in the Earthfx report for Baseline Conditions (Figure 7.24, p. 186); Scenario P12 (Figure 8.31, p. 221); P3456 (Figure 8.63, p. 248); RHB1 (Figure 8.99, p. 277), and RHB2 (Figure 8.126, p. 299). The water budget results for Scenario P3456 are reproduced in Figure 2c. Simulated change in groundwater levels (drawdowns), groundwater discharge to riparian areas, and change in streamflow in the vicinity of Wetland 13022 (Earthfx Wetland 16) for each scenario are discussed in Section 8 of the main report.
<table>
<tr><td>Wetland 13022</td><td>GW Outflow (%)</td><td>GW Inflow (%)</td><td>Δ in Outflow (%)</td><td>Δ in Inflow (%)</td></tr>
<tr><td>Baseline (Existing)</td><td>1.25</td><td>0.34</td><td>-</td><td>-</td></tr>
<tr><td>Operations Ph 3 - 6</td><td>1.34</td><td>0.00</td><td>0.09</td><td>-0.34</td></tr>
</table></td><td>Figure 2c</td><td>HHIAR (Earthfx, April 2020)</td><td>191 - 303</td></tr>
<tr><td>Potential Impact to Form and Function of Feature:</td><td>No wetlands will be removed and the wetlands subcatchment will be protected. There will be no encroachment from the project into the wetland. The proposed limit of extraction is >120 m from the wetland boundary. Licensed boundary will be demarcated and fenced to ensure site construction and operations do not extend beyond the proposed limits of the project .</td><td></td><td></td><td></td></tr>
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Mitigation (Operational Phases 3 - 6)	Description	Figure / Graph	Reference	
			Report	Section / Page
Proposed Mitigation Measures:	None required.			

<table>
<tr><th>Impact Assessment (Rehabilitation)</th><th>Description</th><th>Figure / Graph</th><th colspan="2">Reference</th></tr>
<tr><th></th><th></th><th></th><th>Report</th><th>Section / Page</th></tr>
<tr><td>Change in Wetland Area (ha):</td><td>No change. Wetland located greater than 120 m from licensed boundary.</td><td></td><td>SWA (Tatham, April 2020)</td><td>5.4.1</td></tr>
<tr><td>Change in Wetland Catchment Area (ha):</td><td>No change. Subcatchment area protected.</td><td></td><td>SWA (Tatham, April 2020)</td><td>5.4.1 & Drawing DP-3</td></tr>
<tr><td>Change in Hydroperiod:</td><td>No Change. Wetland is perched and isolated from the groundwater system. Subcatchment area being protected.</td><td></td><td>SWA (Tatham, April 2020)</td><td>5.4.1</td></tr>
<tr><td>Change in Water Budget:</td><td>A detailed average water budget for Wetland 13022 (Earthfx Wetland 16), as simulated by the integrated model, is provided in the Earthfx report for Baseline Conditions (Figure 7.24, p. 186); Scenario P12 (Figure 8.31, p. 221); P3456 (Figure 8.63, p. 248); RHB1 (Figure 8.99, p. 277), and RHB2 (Figure 8.126, p. 299). The water budget results for Scenarios RHB1 and RHB2 are reproduced in Figures 2d and 2e. Simulated change in groundwater levels (drawdowns), groundwater discharge to riparian areas, and change in streamflow in the vicinity of Wetland 13022 (Earthfx Wetland 16) for each scenario are discussed in Section 8 of the main report.
<table>
<tr><td>Wetland 13022</td><td>GW Outflow (%)</td><td>GW Inflow (%)</td><td>Δ in Outflow (%)</td><td>Δ in Inflow (%)</td></tr>
<tr><td>Baseline (Existing)</td><td>1.25</td><td>0.34</td><td>-</td><td>-</td></tr>
<tr><td>Rehab Scenario 1</td><td>1.37</td><td>0.02</td><td>0.12</td><td>-0.32</td></tr>
<tr><td>Rehab Scenario 2</td><td>1.17</td><td>0.04</td><td>-0.08</td><td>-0.30</td></tr>
</table></td><td>Figure 2d and 2e</td><td>HHIAR (Earthfx, April 2020)</td><td>191 - 303</td></tr>
<tr><td>Potential Impact to Form and Function of Feature:</td><td>No wetlands will be removed and the wetlands subcatchment will be protected. There will be no encroachment from the project into the wetland. The proposed limit of extraction is >120 m from the wetland boundary. Licensed boundary will be demarcated and fenced to ensure site construction and operations do not extend beyond the proposed limits of the project .</td><td></td><td></td><td></td></tr>
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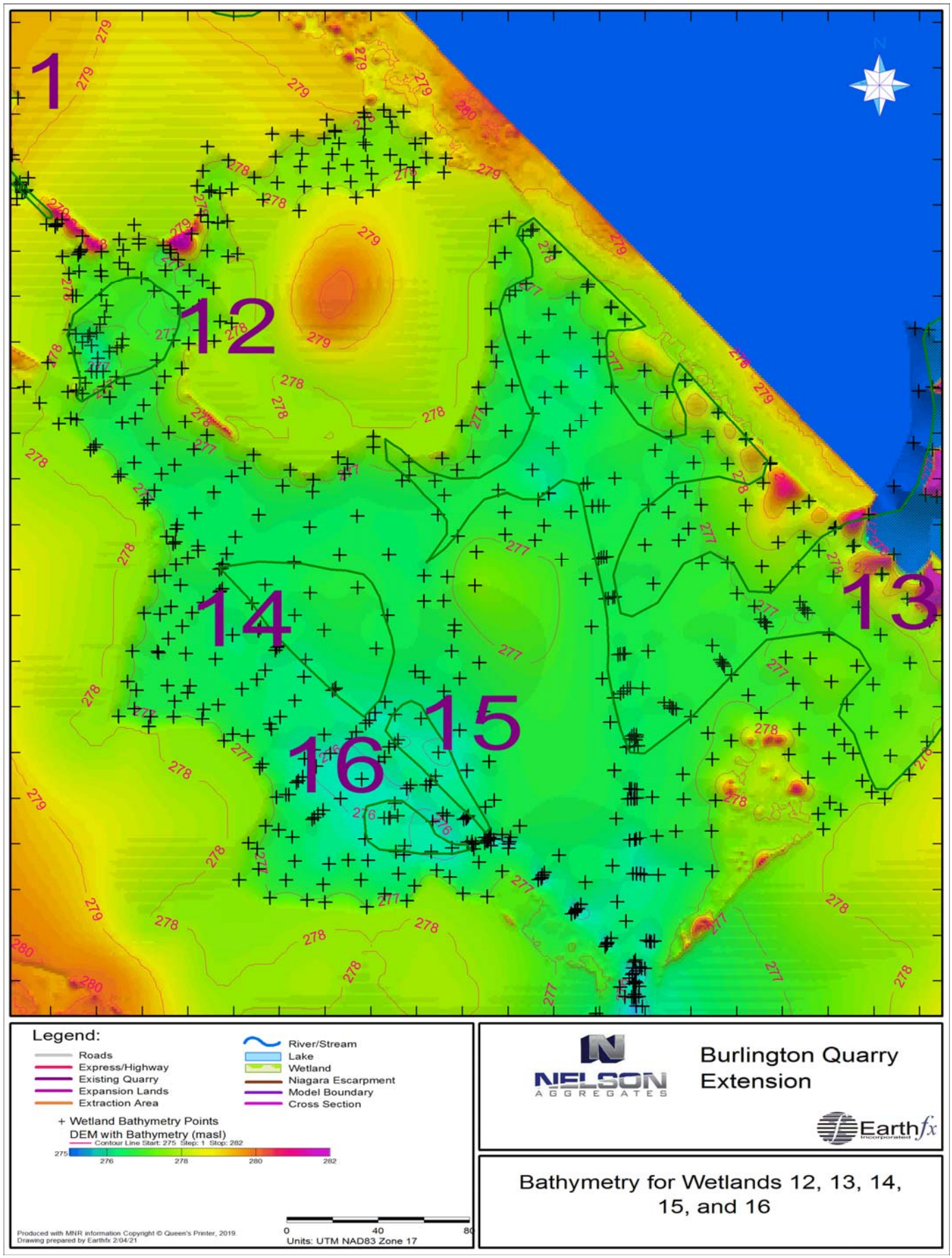
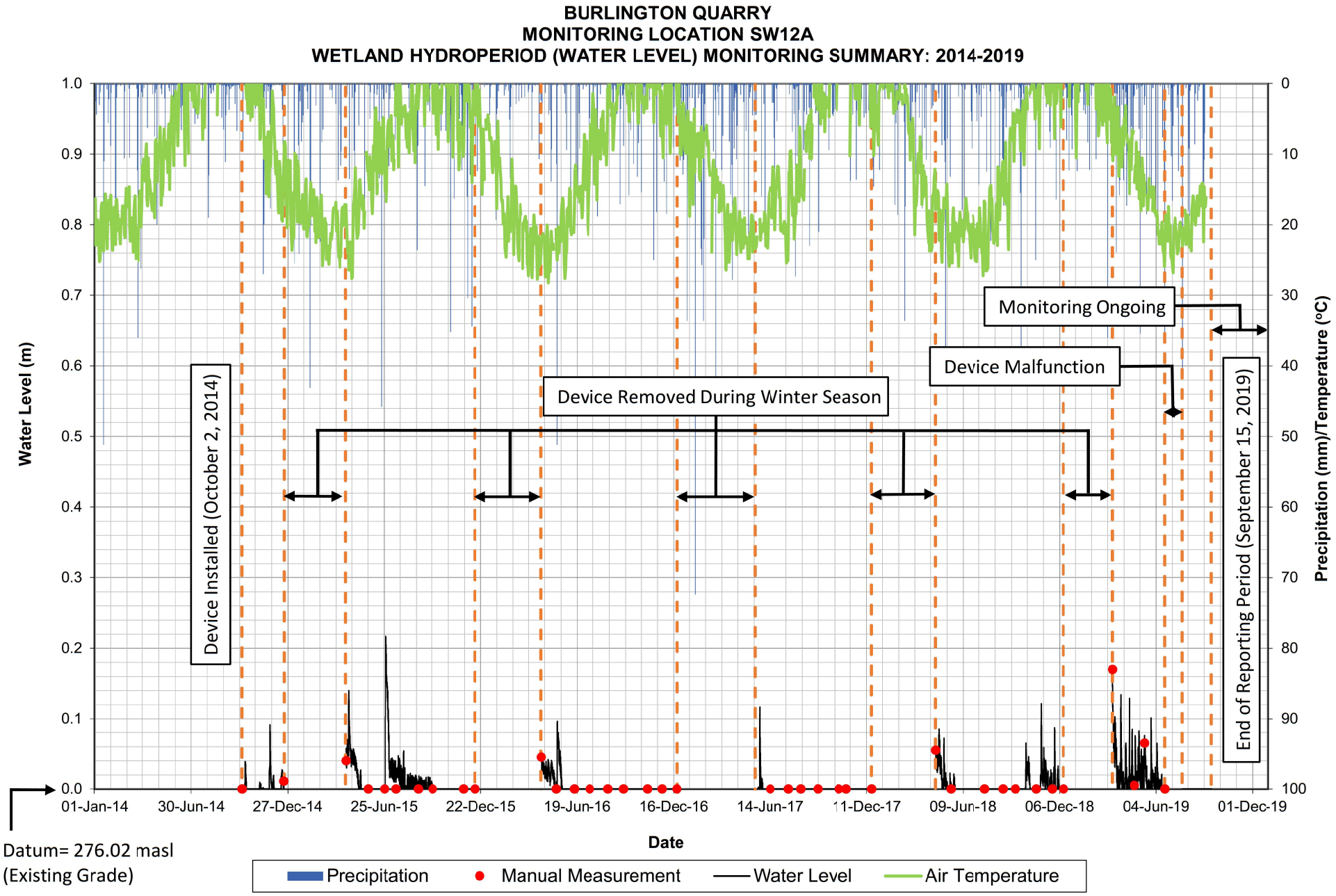
Mitigation (Rehabilitation)	Description	Figure / Graph	Reference	
			Report	Section / Page
Proposed Mitigation Measures:	None required.			

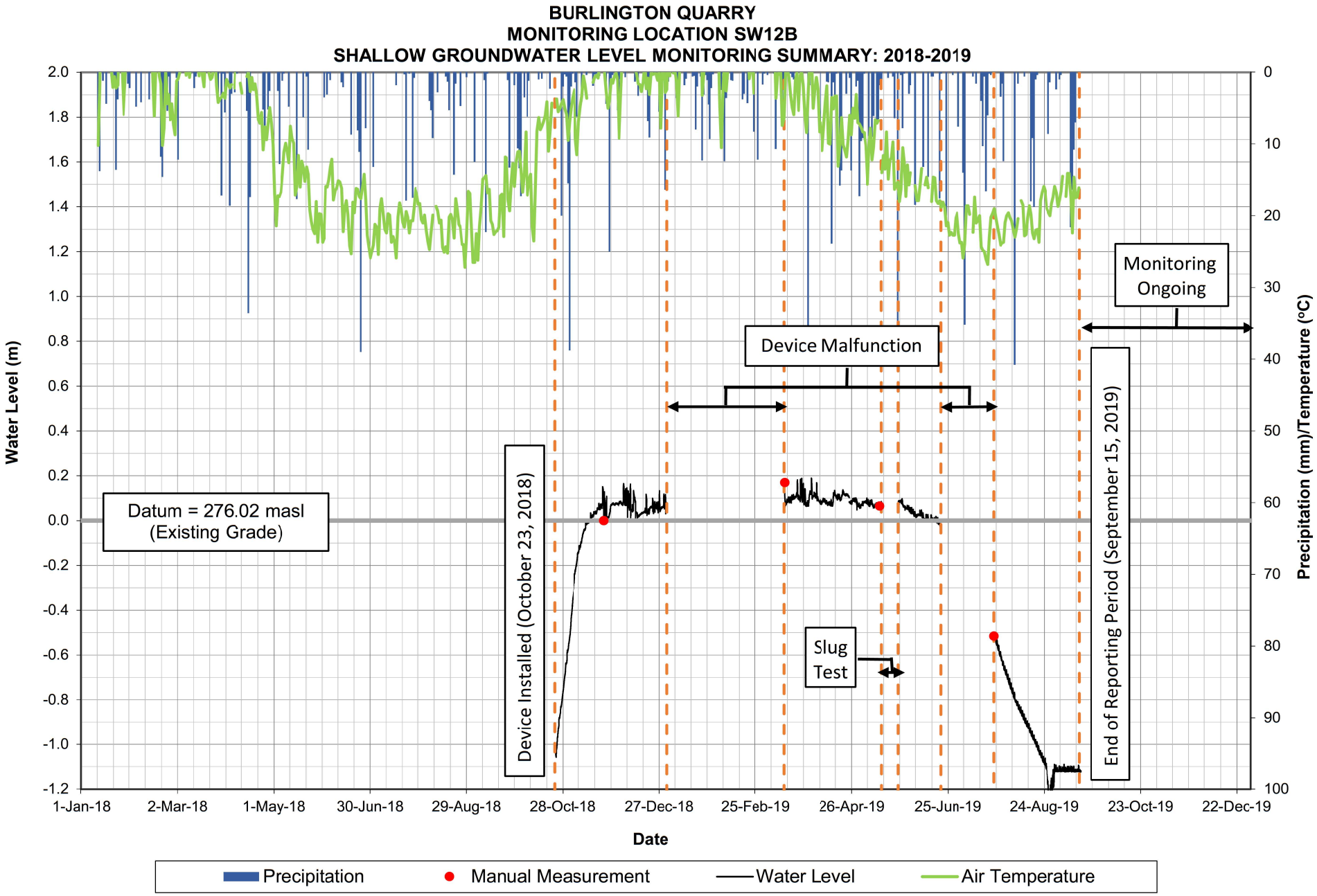
WETLAND 13022 - FIGURE 1



WETLAND 13022 - GRAPH 1

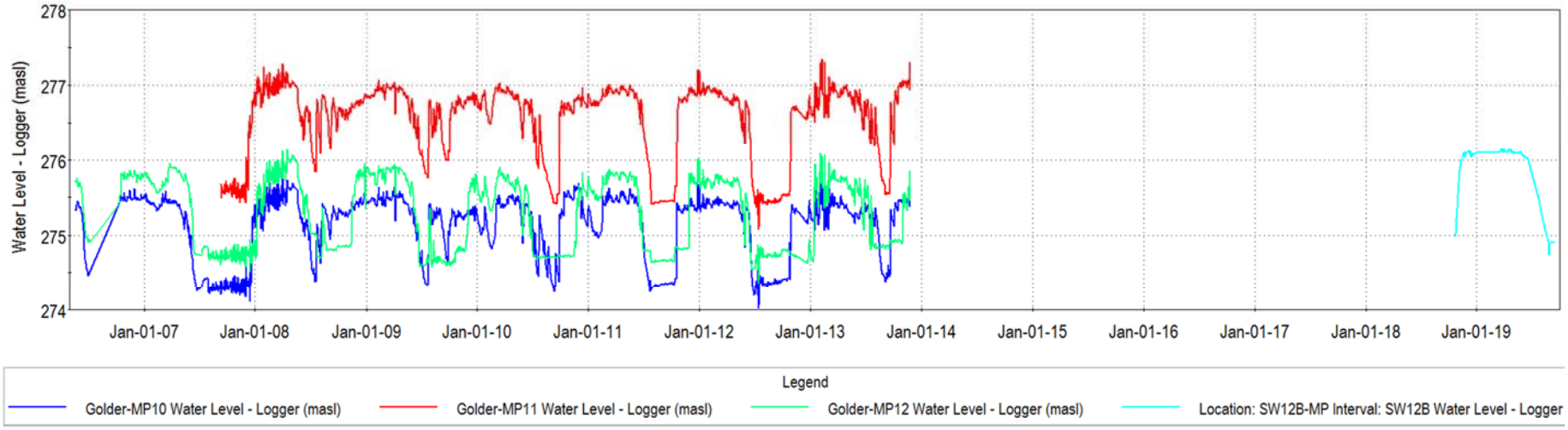


WETLAND 13022 - GRAPH 2



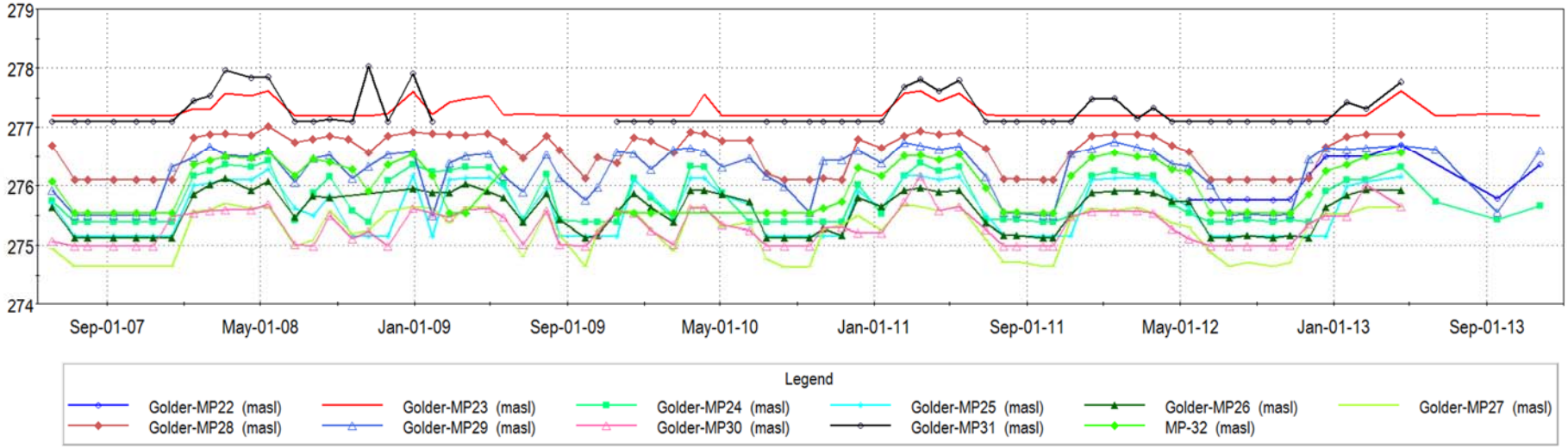
WETLAND 13022 - GRAPH 3

Shallow Groundwater Hydrographs
Wetland 13022



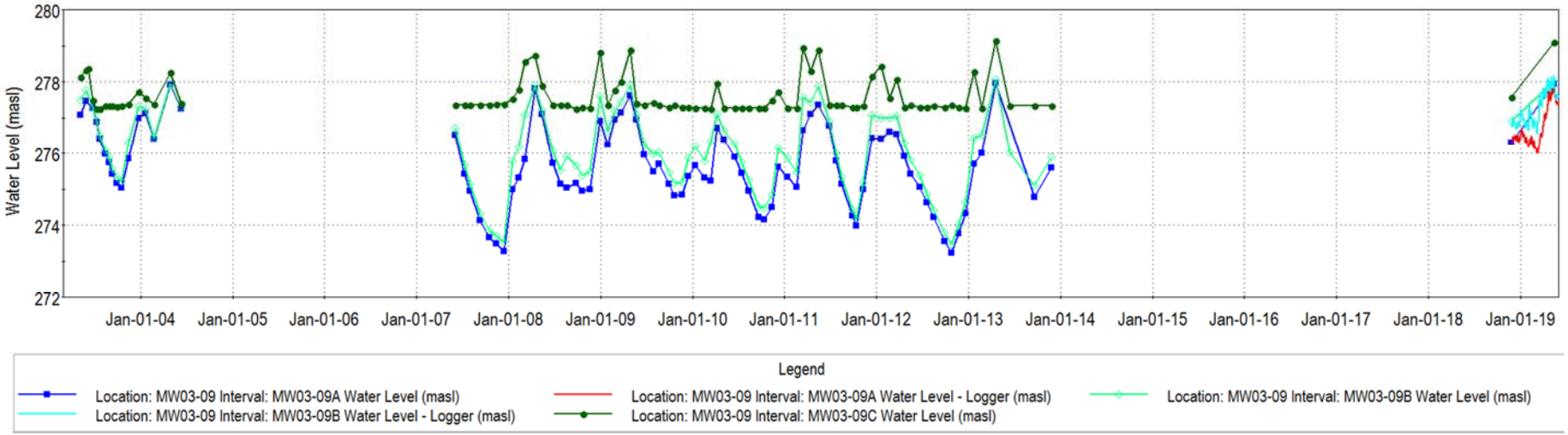
WETLAND 13022 - GRAPH 4

Shallow Groundwater Hydrographs
Wetland 13022

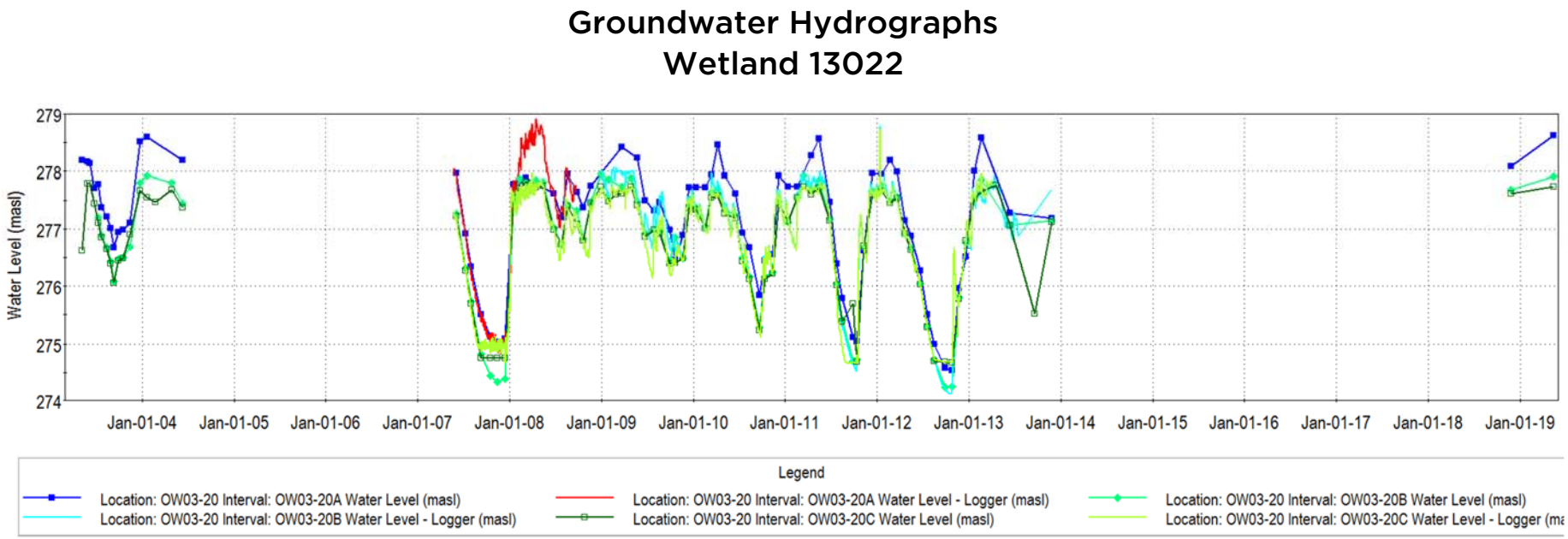


WETLAND 13022 - GRAPH 5

Groundwater Hydrographs
Wetland 13022



WETLAND 13022 - GRAPH 6



WETLAND 13022

FIGURE 2A

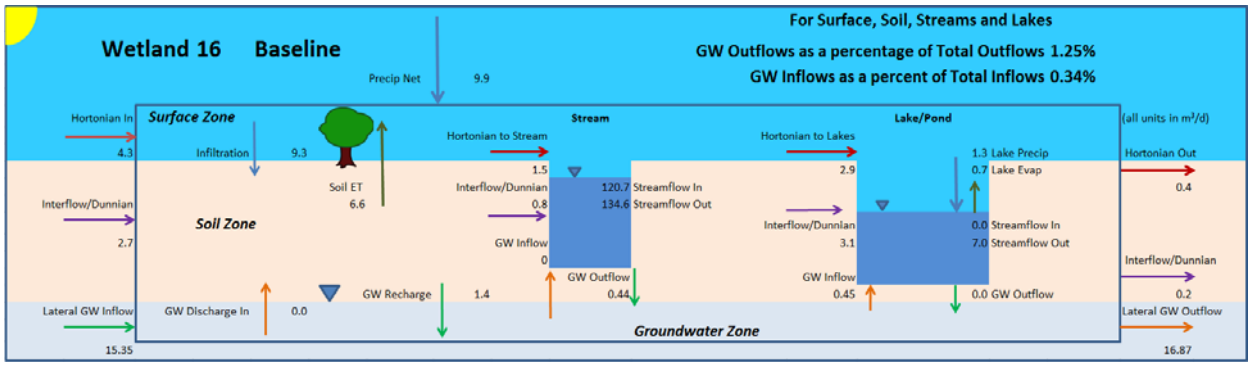


FIGURE 2B

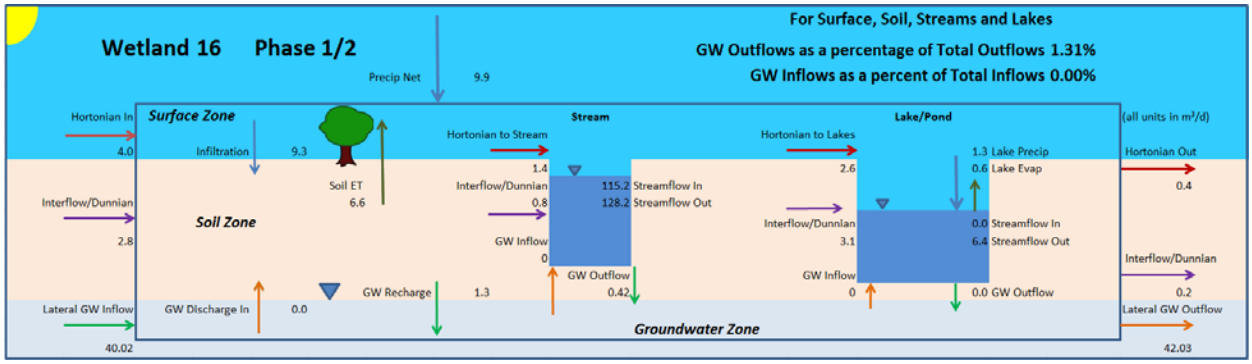


FIGURE 2C

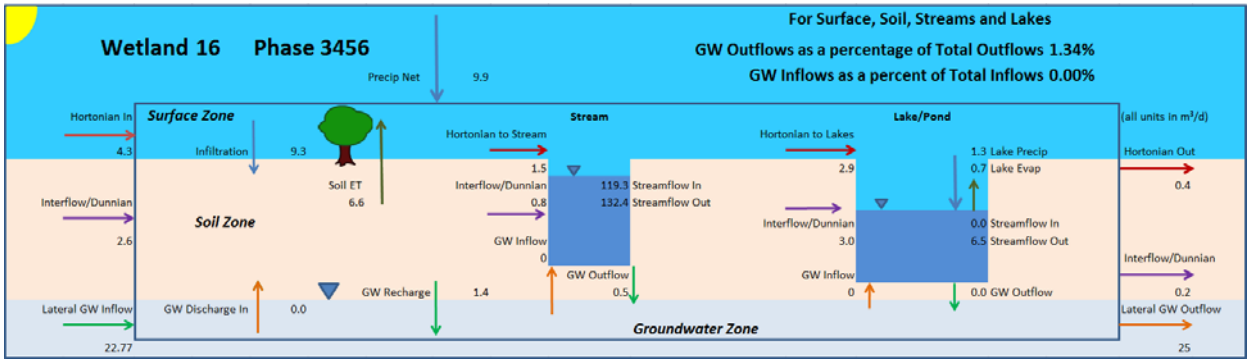


FIGURE 2D

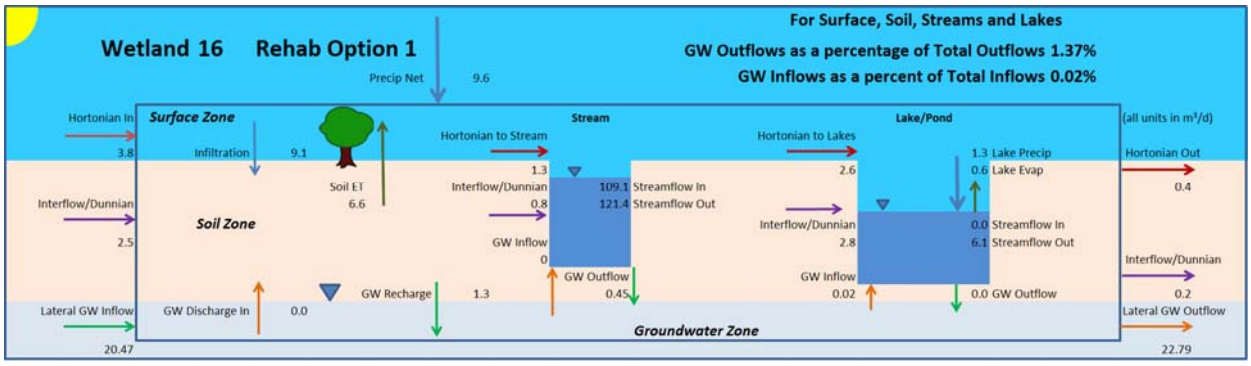
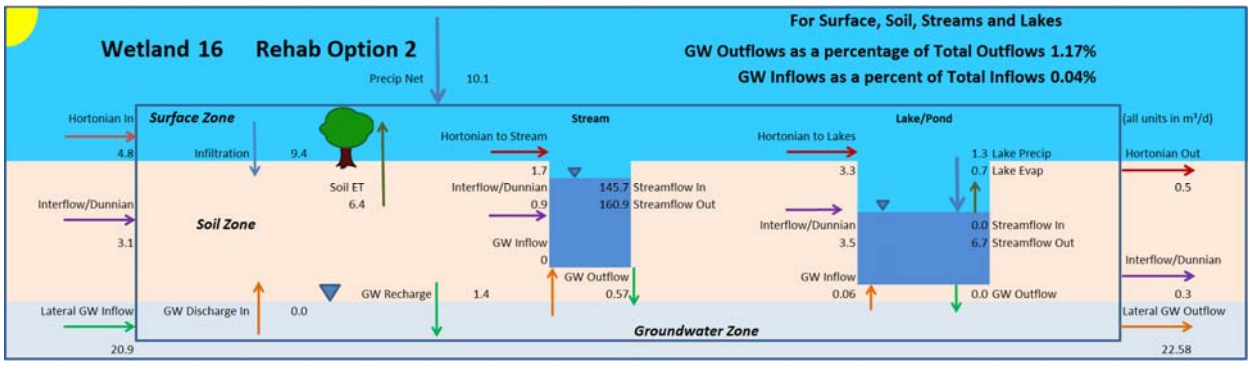
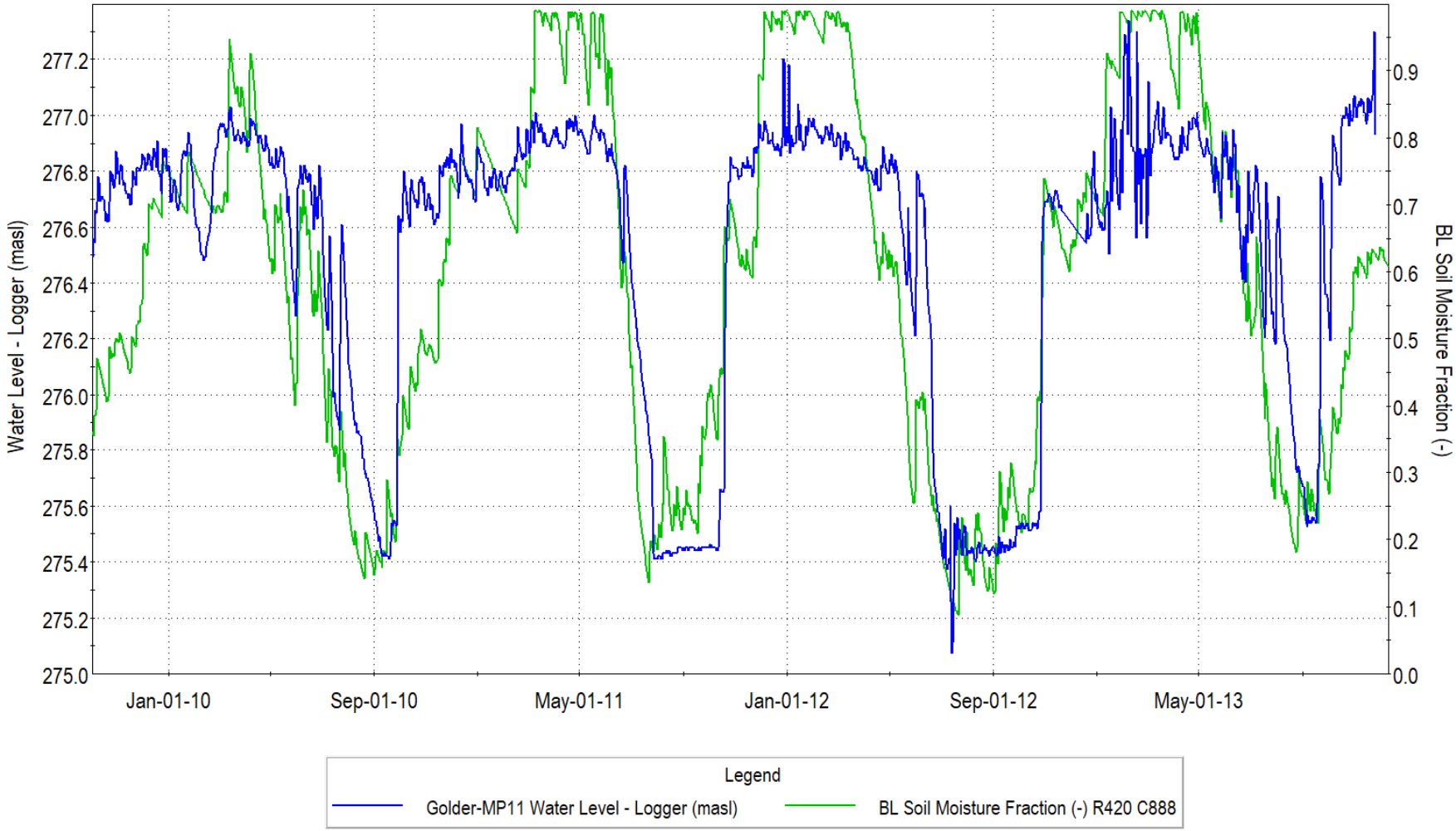


FIGURE 2E



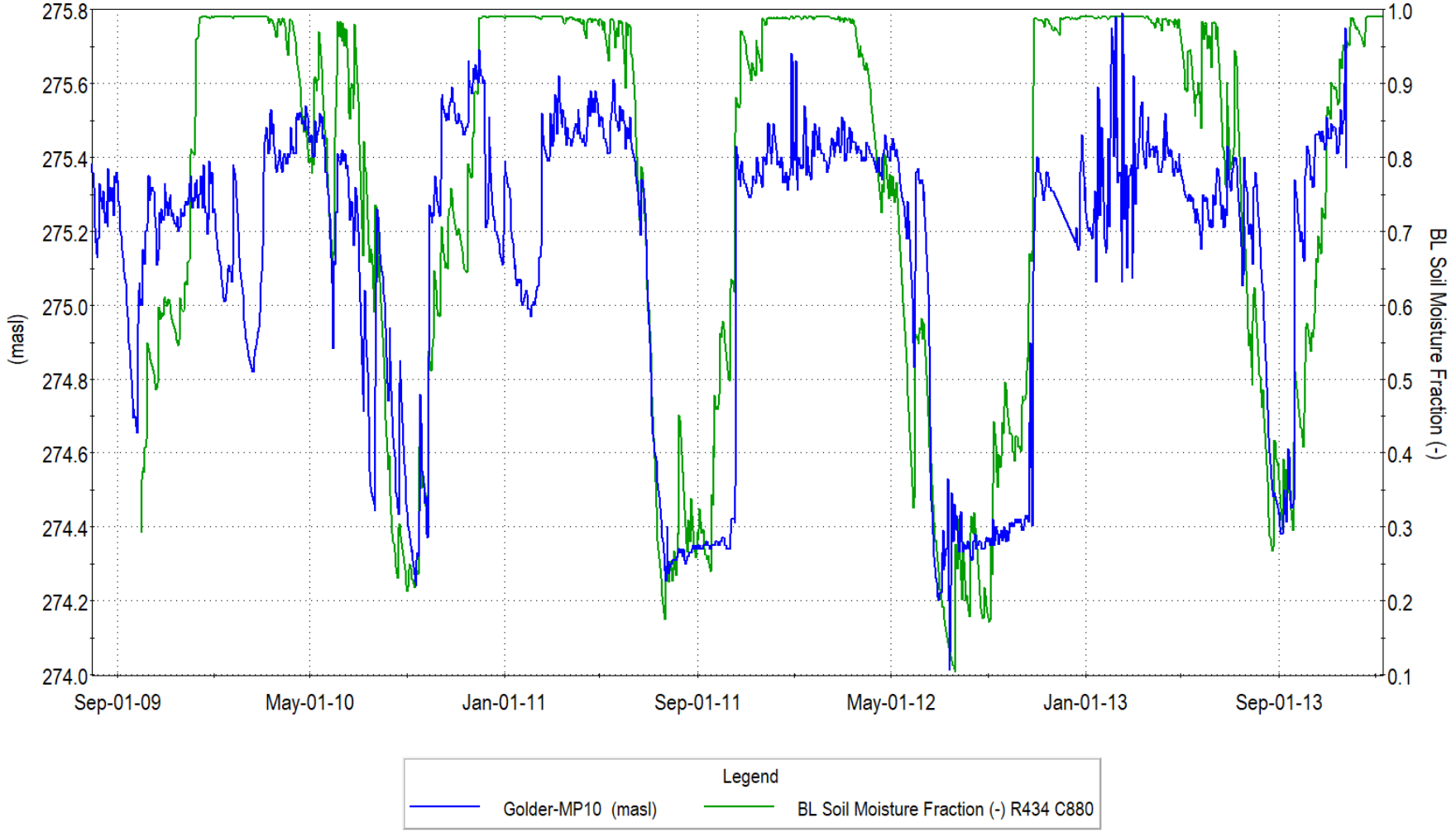
WETLAND 13022 - GRAPH 7

Integrated Model Calibration
Wetland 13022



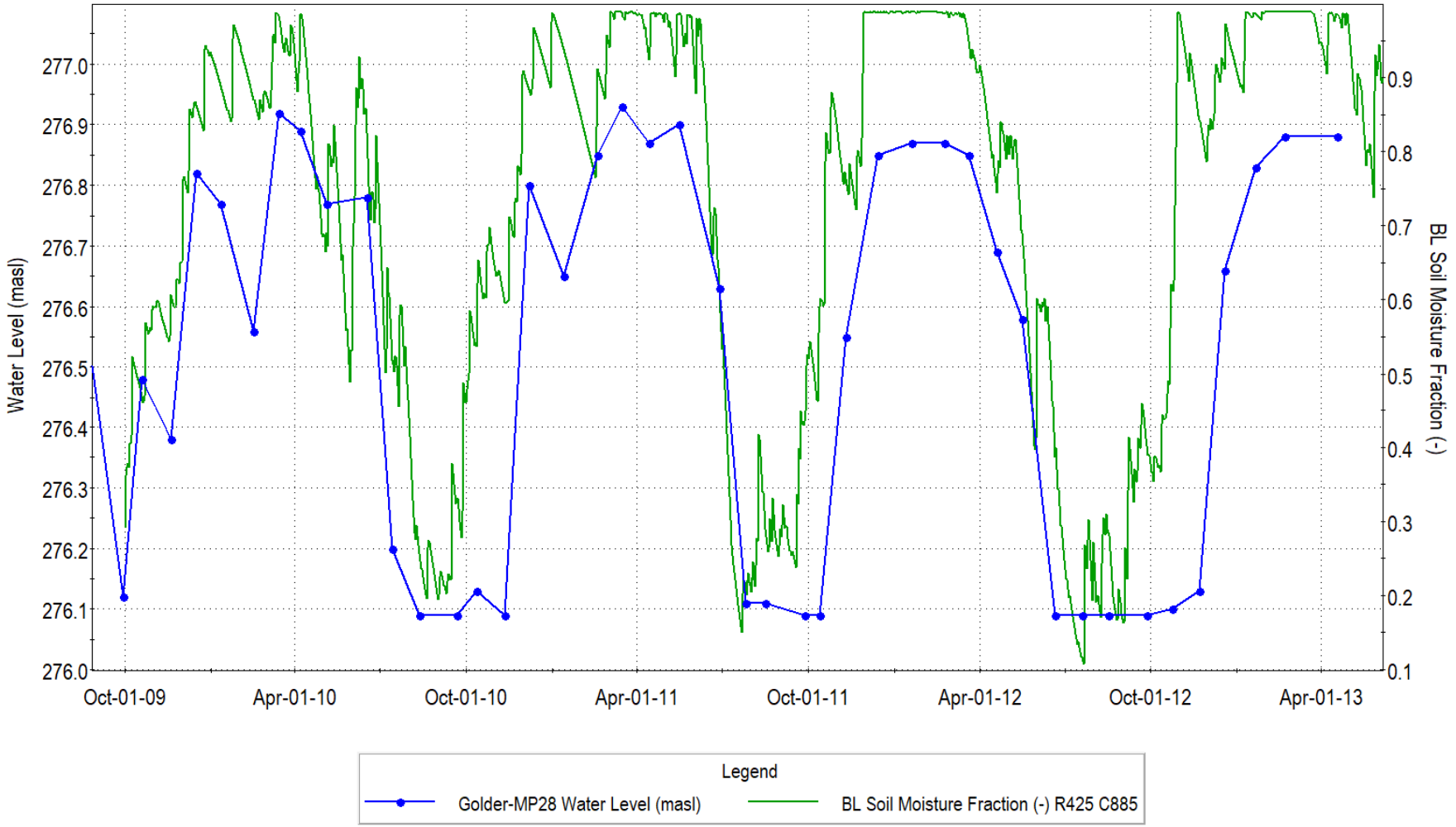
WETLAND 13022 - GRAPH 8

Integrated Model Calibration
Wetland 13022



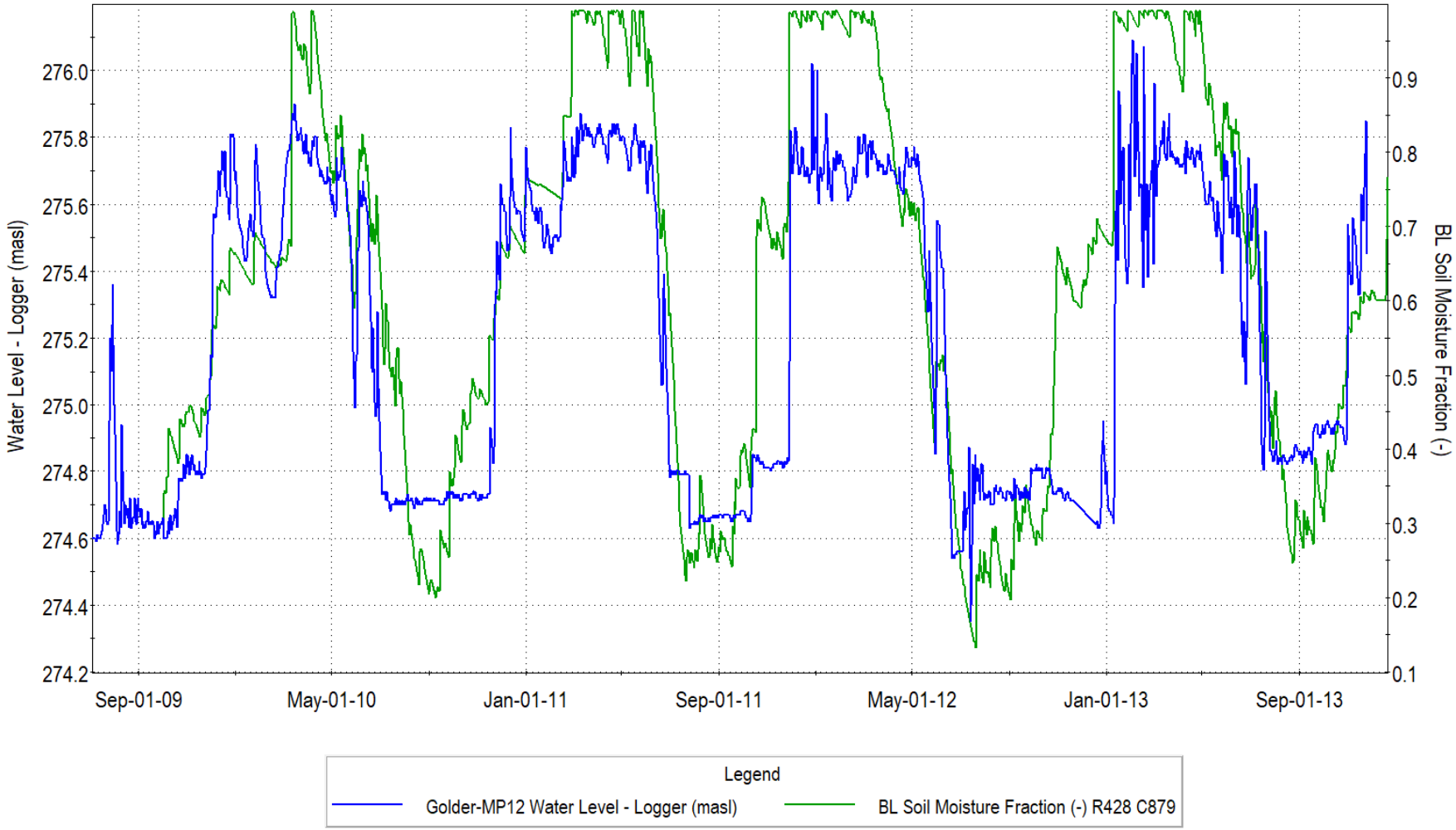
WETLAND 13022 - GRAPH 9

Integrated Model Calibration
Wetland 13022

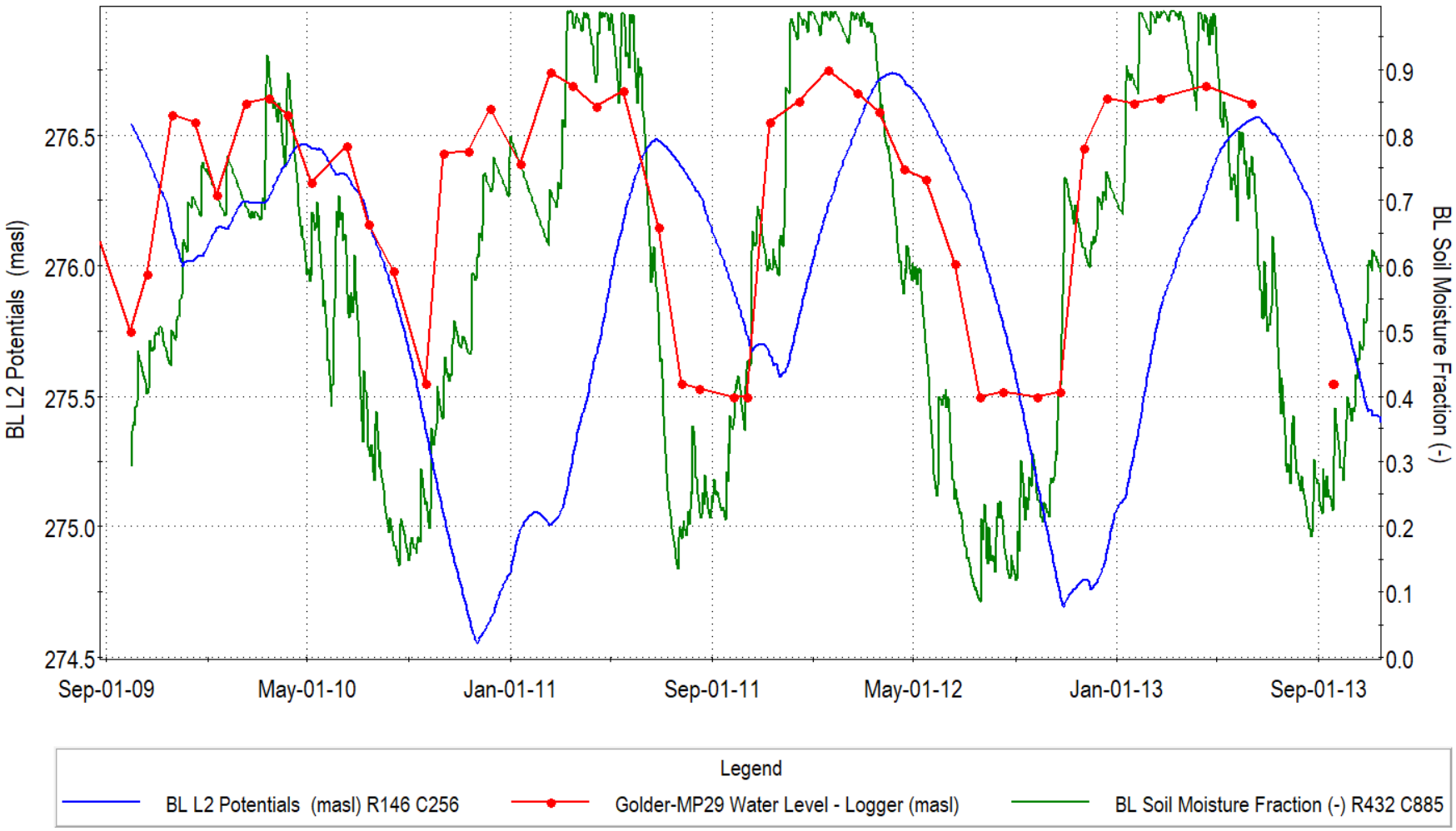


WETLAND 13022 - GRAPH 10

Integrated Model Calibration
Wetland 13022

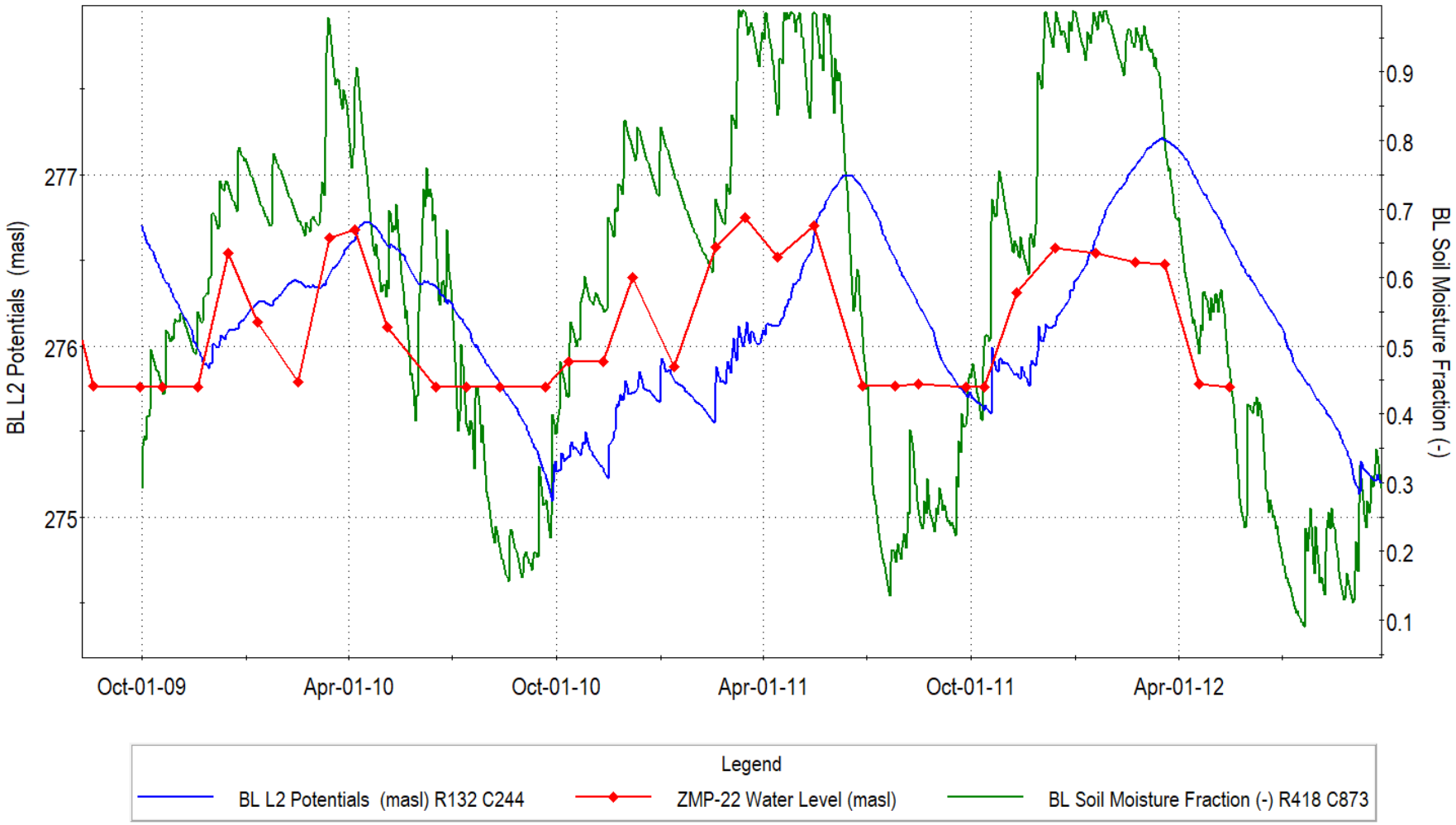


Integrated Model Calibration
Wetland 13022



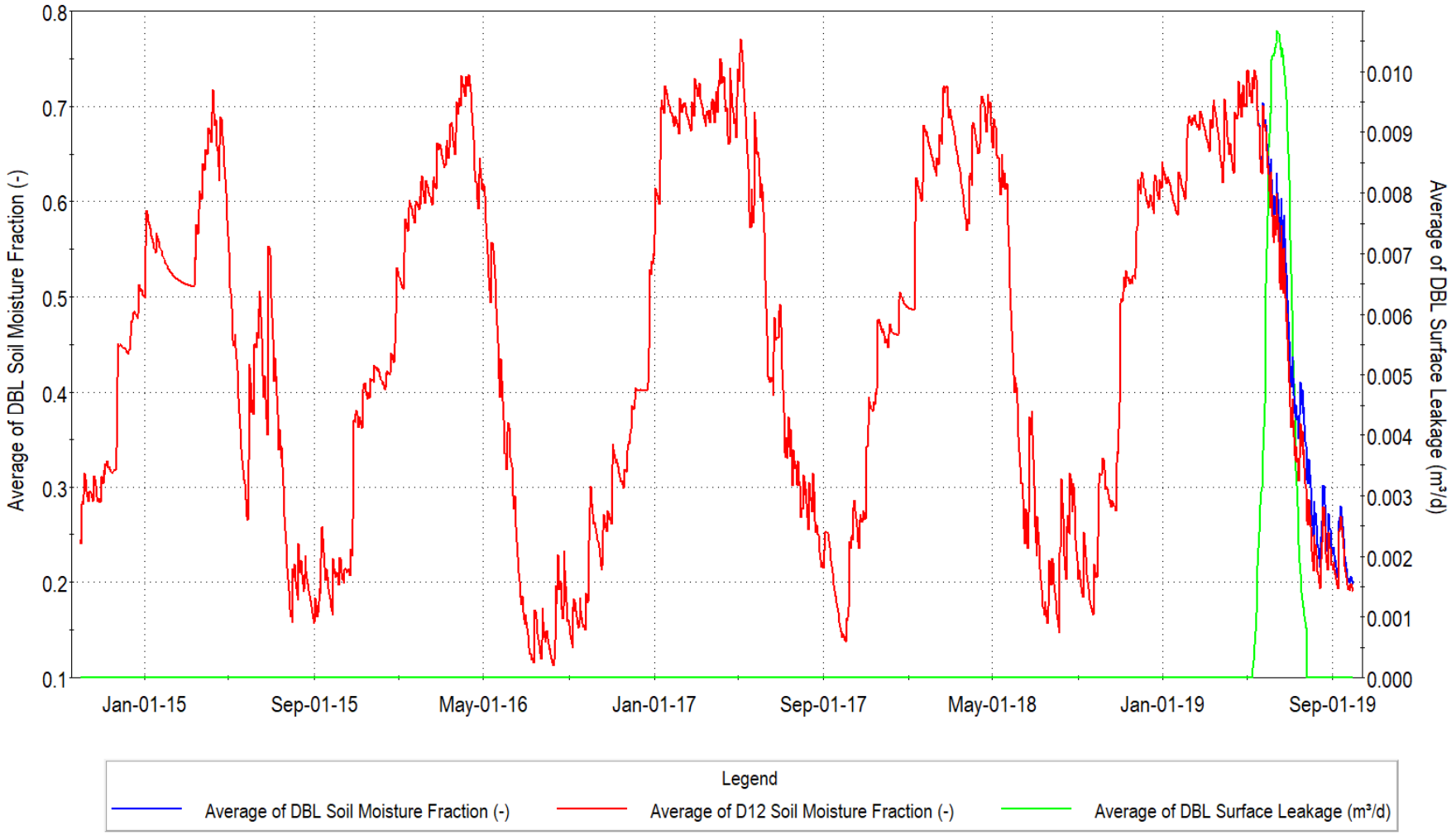
WETLAND 13022 - GRAPH 12

Integrated Model Calibration
Wetland 13022



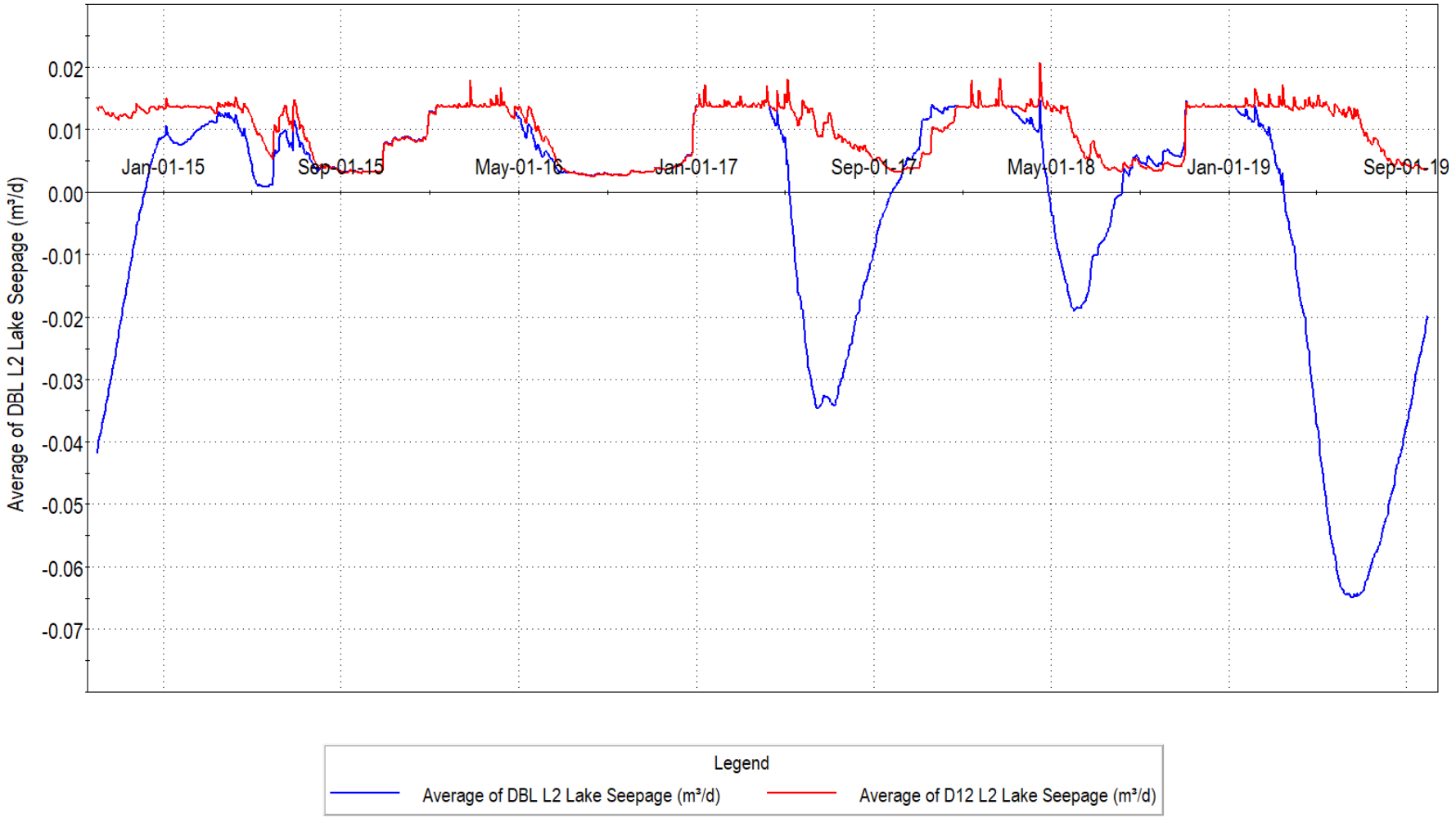
WETLAND 13022 - GRAPH 13

Change in Soil Moisture Conditions
Wetland 13022

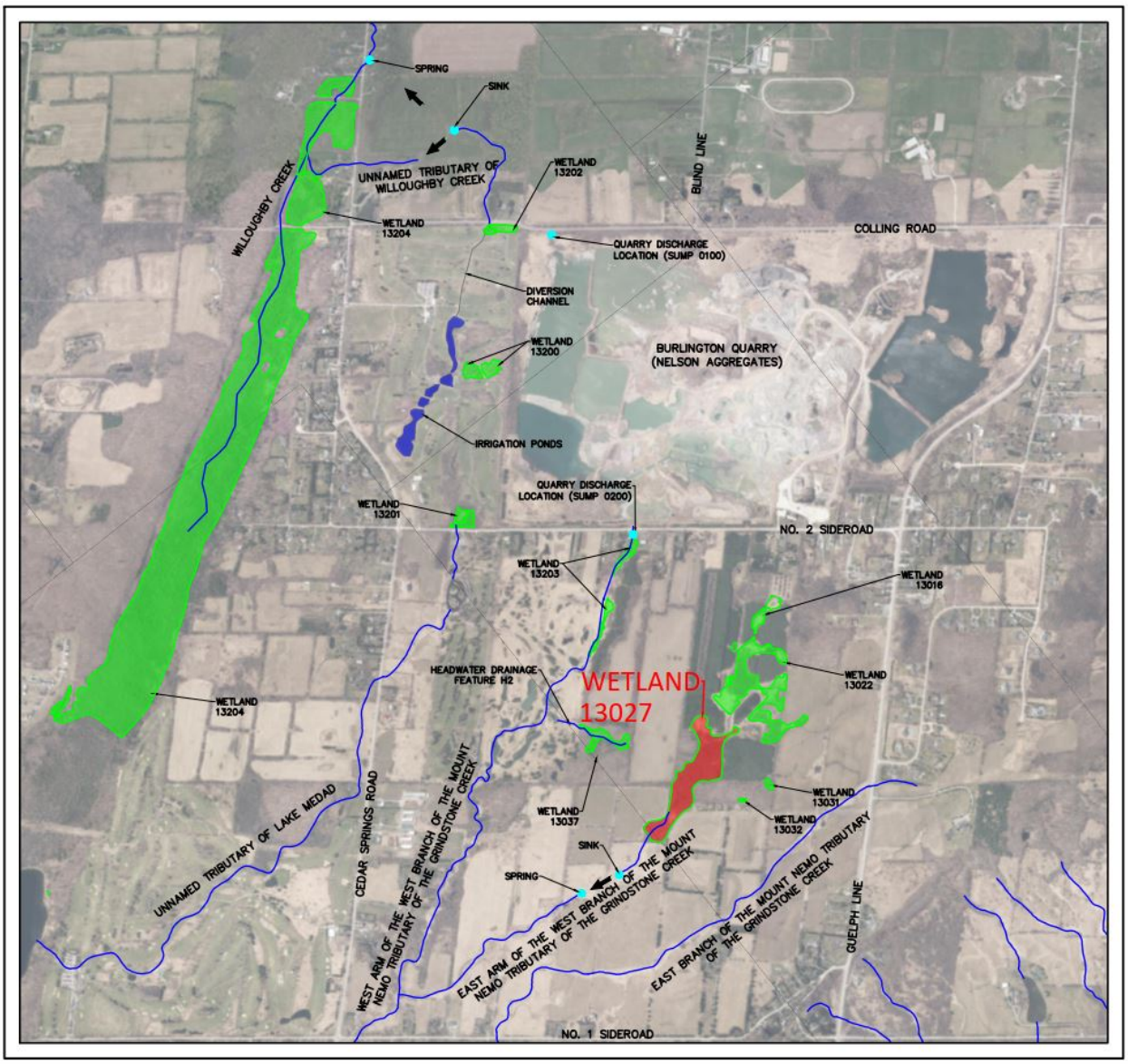


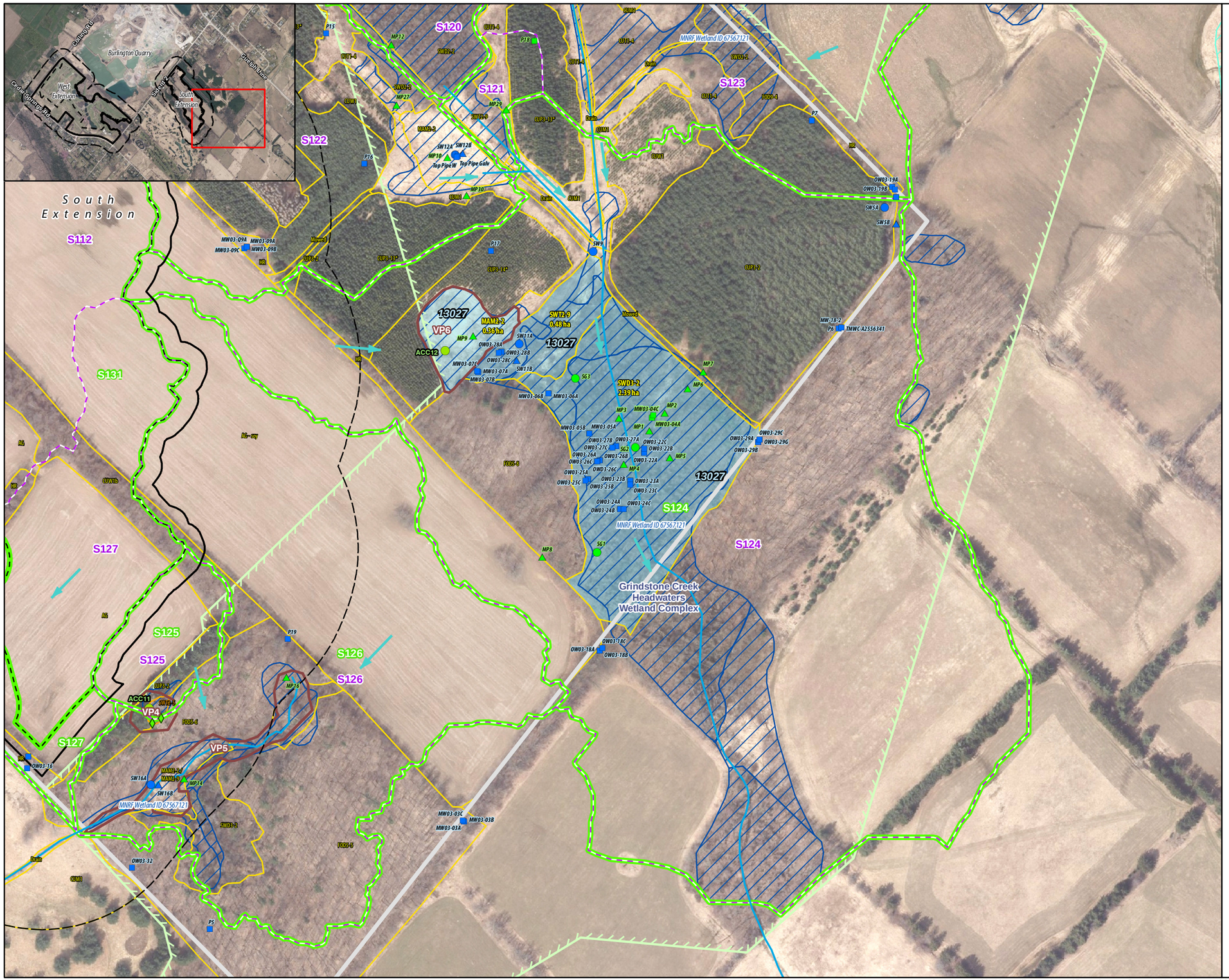
WETLAND 13022 - GRAPH 14

Change in Soil Moisture Conditions
Wetland 13022



WETLAND 13027





Legend

- Licensed Boundary
- Limit of Extraction
- 120 m Adjacent Lands
- Subject Lands
- Amphibian Call Count Station (2019)
- Salamander Trap (2019)
- Salamander Habitat Assessment (2019)
- Indirect Fish Habitat
- Existing Subcatchment Boundary (Tatham Engineering, 2020)
- Proposed Subcatchment Boundary - Operations and Post-Rehabilitation (Tatham Engineering, 2020
- Wetland (Savanta, 2020)
- Ecological Land Classification (Savanta, 2019 & 2020)
- Ecological Land Classification (Savanta, 2020)
- Provincially Significant Wetland (LIO/MNRF, 2020)
- Wetland - Not Evaluated per OWES (MNRF/LIO, 2020)
- MECP Jefferson Salamander Regulated Habitat

Current Instrumentation

- Groundwater Monitoring Station (EarthFx)
- Mini Piezometer (Tatham Engineering)
- Staff Gauge & Surface Water Monitoring Station (Tatham Engineering)

Previous Instrumentation

- Groundwater Monitoring Station (Golder)
- Mini Piezometer (Golder)
- Staff Gauge & Surface Water Monitoring Station (Golder)

ELC Legend

AG, Agriculture
CUM1, Mineral Cultural Meadow
CUP3-2, White Pine Coniferous Plantation
CUP3-6, European Larch Coniferous Plantation
CUP3-13*, White Spruce Coniferous Plantation
CUP3-14*, White Cedar Coniferous Plantation
CUT1-4, Gray Dogwood Cultural Thicket
CUW1, Mineral Cultural Woodland
FOD5-5, Dry – Fresh Sugar Maple – Hickory Deciduous Forest
FOD5-6, Dry- Fresh Sugar Maple-Basswood Deciduous Forest
FOD5-8, Dry – Fresh Sugar Maple – White Ash Deciduous Forest
FOD9-4, Fresh – Moist Shagbark Hickory Deciduous Forest
HR, Hedgerow
MAM2-2, Reed-canary Grass Mineral Meadow Marsh
MAM2-9, Jewelweed Mineral Meadow Marsh
SWD2-2, Green Ash Mineral Deciduous Swamp
SWD3-2, Silver Maple Mineral Deciduous Swamp
SWT2-5, Red-osier Dogwood Mineral Thicket Swamp
SWT2-9, Gray Dogwood Mineral Thicket Swamp

NOTES:

1. Coordinate System: NAD 1983 UTM Zone 17N.
2. Base features produced under license with the Ontario Ministry of Natural Resources and Forestry © Queen's Printer for Ontario, 2021.
3. Orthoimagery © First Base Solutions, 2021. Imagery taken in 2019.

Project 8133

Burlington Quarry Extension
Nelson Aggregates Co.

Figure 3
Wetland Characterization
Wetland 13027 - South Extension

0 50 m
1:3,000

N

GEI Consultants
Savanta Division

Path: C:\Savanta\8133 - Burlington Quarry\figures\report_figures\2021 01 21 natural feature tech summary\8133_rpt_wetland_char_mapbook.mxd Date S...uary 11, 2021

Wetland 13027

Wetland Characteristics	Description	Figure / Graph	Reference	
			Report	Section / Page
Wetland IDs:	MNRF – 67567121(OGF ID 67567149, 67567122, 67567135, 67567124, 67567123, 67567127) Earthfx – 17 Tatham – 13049, 13027, 13048, 13038, 13035, 13034 Savanta – 13027 Golder (Background) - 13049, 13027, 13048, 13038, 13035, 13034			
Wetland Area (ha):	LIO/MNRF - 6.53 (excludes wetland area on neighbouring property) Savanta - 3.23 (excludes wetland area on neighbouring property)			
Watershed:	Grindstone Creek Watershed			
Sub-Watershed:	East Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek			
Located in Proposed Limit of Extraction:	No			
Located in Proposed License Boundary:	No			
Catchment Area (ha):	22.04		SWA (Tatham, April 2020)	Drawing DP-1
Catchment ID:	S124		SWA (Tatham, April 2020)	Drawing DP-1
Closed or Connected System:	On-line (connected to downstream watercourse)			
Condition:	Natural			
Bathymetry:	A bathymetry survey of Wetland 13027 was completed by Tatham Engineering Limited and incorporated into the integrated model (see Earthfx Section 18.3, p.381). Wetland lakes were assigned to Layer 1 of the integrated model by adjusting the base of Layer 1 to correspond with the interpolated bottom elevation. Care was taken to ensure that the lowest elevation observed in the wetland was honored in the assigned elevations.	Figure 1	HHIAR (Earthfx, April 2020)	18.3 (page 381)
Outlet:	East Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek			
Hydroperiod:	Spring Hydroperiod (date wetland dries out) – April 7th – July 17th Fall Hydroperiod (start of hydroperiod) – September 4th –December 27th	Graph 1	SWA (Tatham, April 2020)	2.2.2, 3 and Appendix F
Surface Water Monitoring:	ID: SW11A (Tatham) Installation Date: October 2, 2014 Data Collection: Continuous water level and temperature and manual monthly water level measurements Coordinates of Monitoring Station: Easting 591177.323, Northing 4805244.509	Graph 1	SWA (Tatham, April 2020)	2.2.2, 3 and Appendix F

Natural Heritage and Habitat Features	Description	Figure / Graph	Reference	
			Report	Section / Page
Wetland Name & Provincial Significance Evaluation:	Grindstone Creek Headwaters Wetland Complex – Provincially Significant		NETR (Savanta, April 2020)	6.1.2
ELC Unit(s):	Reed-canary Grass Mineral Meadow Marsh: MAM2-2 Gray Dogwood Mineral Thicket Swamp: SWT2-9 Green Ash Mineral Deciduous Swamp: SWD2-2		NETR (Savanta, April 2020)	Table 2
Regulated Habitat (MECP):	Yes – Jefferson Salamander (not field verified during 2019 field program; regulated based on historical data) Hydroperiod sensitive species; water presence necessary until end of June		NETR (Savanta, April 2020)	6.7
Significant Wildlife Habitat:	Unknown – outside of 120 m adjacent lands			
Fish Habitat:	Indirect		NETR (Savanta, April 2020)	6.6
Habitat of Endangered and Threatened Species:	Unknown – outside of 120 m adjacent lands			

Groundwater Interaction	Description	Figure / Graph	Reference	
			Report	Section / Page
Lithology:	Halton Till			
Hydraulic Conductivity:	Integrated Model (Earthfx) - The harmonic mean hydraulic conductivity, based on testing by Golder (2007) of 10 mini-piezometers, was $1.2x10^{-8}$ m/s. Model value for the vertical hydraulic conductivity was $1.6x10^{-7}$ m/s, about an order of magnitude higher, to account for limited flow through fractures in the till. Wetland Water Balance (Tatham) – $8.2x10^{-9}$ m/s.			
Surface Water/Groundwater Interaction:	The low permeability of the Halton Till underlying the wetland is the dominant control on 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. This wetland receives some groundwater inflow but is relatively isolated from any changes in the water table due to quarry development.			
Shallow Groundwater (Mini-piezometer) Monitoring:	ID: SW11B (Tatham) Installation Date: October 25, 2018 Data Collection: Continuous water level and temperature and manual monthly water level measurements Coordinates of Monitoring Station: Easting 591177.323, Northing 4805244.509	Graph 2	SWA (Tatham, April 2020)	2.3 and Appendix G

Background Shallow Groundwater (Mini-piezometer) Monitoring: — Graph 3

Mini-piezometer ID	Ground Elevation	Bottom Elevation	Average WL	Logger	Manual Meas.
Golder-MP1	275.05	273.55	274.65	-	2007-2013
Golder-MP2	275.28	273.78	274.95	-	2007-2013
Golder-MP3	275.15	273.65	274.85	-	2007-2013
Golder-MP4	275.15	273.65	274.8	-	2007-2013
Golder-MP5	275.04	273.54	274.75	-	2007-2013
Golder-MP6	276.48	274.98	275.18	-	2007-2013
Golder-MP7	276.32	274.82	274.74	-	2007-2013
Golder-MP9	278.71	277.51	275.12	2006-2013	2006-2013

<table>
<tr><th>Groundwater Interaction</th><th colspan="6">Description</th><th>Figure / Graph</th><th colspan="2">Reference</th></tr>
<tr><th></th><th colspan="6"></th><th></th><th>Report</th><th>Section / Page</th></tr>
<tr><td rowspan="32">Groundwater Monitoring (Monitoring Wells):</td><td>Monitoring Well ID</td><td>Distance (Dir.)</td><td>Geologic Unit</td><td>Ground Elevation</td><td>Monitoring Elev</td><td>Average WL</td><td rowspan="32">Graphs 4, 5, 6 & 7</td><td rowspan="32"></td><td rowspan="32"></td></tr>
<tr><td>MW03-04A</td><td>16 (E)</td><td>Bedrock</td><td>274.92</td><td>257.24 - 253.28</td><td>274.79</td></tr>
<tr><td>MW03-04B</td><td>16 (E)</td><td>Bedrock</td><td>274.92</td><td>266.69 - 262.42</td><td>274.71</td></tr>
<tr><td>MW03-04C</td><td>17 (E)</td><td>Bedrock</td><td>274.86</td><td>273.46 - 271.66</td><td>274.66</td></tr>
<tr><td>MW03-05A</td><td>33 (ESE)</td><td>Bedrock</td><td>275.01</td><td>272.42 - 271.66</td><td>274.70</td></tr>
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<tr><td>MW03-06B</td><td>65 (ENE)</td><td>Overburden</td><td>275.01</td><td>273.79 - 273.33</td><td>274.82</td></tr>
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<tr><td>MW03-07B</td><td>120 (ENE)</td><td>Bedrock</td><td>275.38</td><td>269.74 - 267.46</td><td>275.03</td></tr>
<tr><td>MW03-07C</td><td>121 (ENE)</td><td>Bedrock</td><td>275.37</td><td>273.54 - 271.56</td><td>275.11</td></tr>
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<tr><td>OW03-22B</td><td>10 (SSE)</td><td>Bedrock</td><td>275.02</td><td>271.19 - 263.82</td><td>274.44</td></tr>
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<tr><td>OW03-29C</td><td>100 (ESE)</td><td>Overburden</td><td>277.02</td><td>276.72 - 275.12</td><td>275.79</td></tr>
<tr><td>OW03-29G</td><td>100 (ESE)</td><td>Overburden</td><td>277.02</td><td></td><td></td></tr>
<tr><td>Water Budget Results:</td><td colspan="6">A detailed average water budget, as simulated by the integrated model, is provided in the main report for Baseline Conditions (Earthfx Figure 7.25, p. 187). The baseline water budget is reproduced in Figure 2a. The wetland is a net provider of groundwater. Simulated groundwater levels, groundwater discharge to riparian areas, and streamflow in the vicinity of Wetland 17 for baseline conditions are discussed in Section 7 of the main report.

Wetland 13027 | GW Outflow (%) | GW Inflow (%)
Baseline (Existing) | 2.51 | 1.31</td><td>Figure 2a</td><td>HHIAR (Earthfx, April 2020)</td><td>187</td></tr>
</table>

Groundwater Interaction	Description	Figure / Graph	Reference	
			Report	Section / Page
Integrated Model Calibration:	Four mini-piezometers in Wetland 17 provide multiple years of monitoring in the soil zone and upper weathered Halton Till. These monitors correspond to the PRMS soil zone and upper-most part of Layer 1 of the GSFLOW model. A comparison of the mini-piezometer data to the simulated soil moisture conditions demonstrates that the model is closely matching both the soil moisture and hydroperiod in the shallow subsurface at this wetland (see Graphs 8 through 12).	Graphs 8, 9, 10, 11 & 12		
	Earthfx Figure 19.42 (p.442) in the Main Report shows a hydrograph for Golder SG-3 along with simulated shallow water levels. Earthfx Figure 6.31 (p.155) and Figure 19.43 (p.443) in the Main Report shows a hydrograph for Golder SG-2 and MP5 along with simulated shallow water levels. The results are reproduced in Graphs 13 and 14. A brief discussion of the Wetland 13027 (Earthfx Wetland 17) is contained in Earthfx Section 6.11.4 (p. 155). A more detailed discussion is provided in Appendix E, Section 19.6 (p. 441).	Graphs 13 & 14	HHIAR (Earthfx, April 2020)	155 and 441 - 443

<table>
<tr><th>Impact Assessment (Operations Phases 1 & 2)</th><th>Description</th><th>Figure / Graph</th><th colspan="2">Reference</th></tr>
<tr><th></th><th></th><th></th><th>Report</th><th>Section / Page</th></tr>
<tr><td>Change in Wetland Area (ha):</td><td>No change. Wetland located greater than 120 m from licensed boundary.</td><td></td><td>SWA (Tatham, April 2020)</td><td>4.2.1</td></tr>
<tr><td>Change in Wetland Catchment Area (ha):</td><td>No change. Subcatchment area protected.</td><td></td><td>SWA (Tatham, April 2020)</td><td>4.2.1 & Drawing DP-2</td></tr>
<tr><td>Change in Hydroperiod:</td><td>No Change. Wetland is perched and isolated from the groundwater system. Subcatchment area being protected.</td><td></td><td>SWA (Tatham, April 2020)</td><td>4.2.1</td></tr>
<tr><td>Change in Water Budget:</td><td>A detailed average water budget for Wetland 13027 (Earthfx Wetland 17), as simulated by the integrated model, is provided in the Earthfx report for Baseline Conditions (Figure 7.25, p. 187); Scenario P12 (Figure 8.32, p. 222); P3456 (Figure 8.64, p. 249); RHB1 (Figure 8.100, p. 278), and RHB2 (Figure 8.127, p. 300). The water budget results for Scenario P12 are reproduced in Figure 2b. Simulated change in groundwater levels (drawdowns), groundwater discharge to riparian areas, and change in streamflow in the vicinity of Wetland 13027 (Earthfx Wetland 17) for each scenario are discussed in Section 8 of the main report.
<table>
<tr><td>Wetland 13027</td><td>GW Outflow (%)</td><td>GW Inflow (%)</td><td>Δ in Outflow (%)</td><td>Δ in Inflow (%)</td></tr>
<tr><td>Baseline (Existing)</td><td>2.51</td><td>1.31</td><td>-</td><td>-</td></tr>
<tr><td>Operations Ph 1 & 2</td><td>5.71</td><td>0.00</td><td>3.20</td><td>-1.31</td></tr>
</table></td><td>Figure 2b</td><td>HHIAR (Earthfx, April 2020)</td><td>191 - 303</td></tr>
<tr><td>Change on Soil Moisture Conditions:</td><td>The effects of development can be illustrated by comparing the average soil moisture in Wetland 17 under Baseline and P12 development conditions. Graph 15 shows average daily soil moisture for Baseline conditions as a blue line. The soil moisture under P12 development is shown in red, and it overlies (covers) the Baseline for much of the time period. Under P12 development, soil moisture is essentially identical in the winter and spring, but slightly dryer in the summer and fall. The Baseline groundwater discharge into Wetland 17 (seepage or “surface leakage” in GSFLOW) is shown as a green line on the graph (right hand scale). The decline in soil moisture under P12 is due to the loss of this groundwater discharge (due to the drawdown in groundwater levels near the excavation). Under baseline conditions, groundwater seepage occurs as water levels rise in the late spring in response to snowmelt. Seepage fluctuates significantly, however, due to natural inter-annual climate variability. During a dry year (2015-2016) groundwater levels are naturally low, there is no groundwater seepage, and so there is no difference in soil moisture between Baseline and P12. During an average year (2017-2018) there is small change in the late summer soil moisture conditions due to the loss of groundwater discharge during P12 development. During a wet year there is a modest loss of soil moisture in the May-September time frame. The water budget summary for Wetland 17 indicates that groundwater inflows account for only 1.31% of all inflows, and that this will be lost with development. Graph 16 illustrates how and when that loss of groundwater inflow will occur. The loss will primarily occur during the late summer of a wet year. There will be no impact during dry years when the wetland already experiences limited groundwater inflow. Additional surface water and groundwater interaction occurs through the bottom of the ponded water portions of Wetland 17 (Graph 15). The ponded water areas within the wetland are represented in the model as MODFLOW “Lakes”. Pond seepage is positive when the lake or pond is leaking water to the deeper groundwater system. Negative seepage indicates groundwater is upwelling into the pond. The pond seepage under Baseline (Blue) and P12 conditions (Red) are shown in Graph 15. Under Baseline conditions, the ponds leak water to the groundwater system for most of the year, and only receive upwelling (negative leakage or seepage) for short periods of the wetter years when the water table is higher (generally in late spring). Under P12 conditions (red line), the ponds leak water to the groundwater system at varying rates throughout the year; generally higher in the spring and declining through the summer. Overall, the pond leakage patterns under Baseline and P12 conditions are similar to that of soil moisture response.</td><td>Graphs 15 & 16</td><td></td><td></td></tr>
<tr><td>Potential Impact to Form and Function of Feature:</td><td>No wetlands will be removed and the wetlands subcatchment will be protected. There will be no encroachment from the project into the wetland. The proposed limit of extraction is >120 m from the wetland boundary. Licensed boundary will be demarcated and fenced to ensure site construction and operations do not extend beyond the proposed limits of the project .</td><td></td><td></td><td></td></tr>
</table>

Mitigation (Operational Phases 1 & 2)	Description	Figure / Graph	Reference	
			Report	Section / Page
Proposed Mitigation Measures:	None required.			

<table>
<tr><th>Impact Assessment (Operations Phases 3 - 6)</th><th>Description</th><th>Figure / Graph</th><th colspan="2">Reference</th></tr>
<tr><th></th><th></th><th></th><th>Report</th><th>Section / Page</th></tr>
<tr><td>Change in Wetland Area (ha):</td><td>No change. Wetland located greater than 120 m from licensed boundary.</td><td></td><td>SWA (Tatham, April 2020)</td><td>4.2.1</td></tr>
<tr><td>Change in Wetland Catchment Area (ha):</td><td>No change. Subcatchment area protected.</td><td></td><td>SWA (Tatham, April 2020)</td><td>4.2.1 & Drawing DP-2</td></tr>
<tr><td>Change in Hydroperiod:</td><td>No Change. Wetland is perched and isolated from the groundwater system. Subcatchment area being protected.</td><td></td><td>SWA (Tatham, April 2020)</td><td>4.2.1</td></tr>
<tr><td>Change in Water Budget:</td><td>A detailed average water budget for Wetland 13027 (Earthfx Wetland 17), as simulated by the integrated model, is provided in the Earthfx report for Baseline Conditions (Figure 7.25, p. 187); Scenario P12 (Figure 8.32, p. 222); P3456 (Figure 8.64, p. 249); RHB1 (Figure 8.100, p. 278), and RHB2 (Figure 8.127, p. 300). The water budget results for Scenario P3456 are reproduced in Figure 2c. Simulated change in groundwater levels (drawdowns), groundwater discharge to riparian areas, and change in streamflow in the vicinity of Wetland 13027 (Earthfx Wetland 17) for each scenario are discussed in Section 8 of the main report.
<table>
<tr><td>Wetland 13027</td><td>GW Outflow (%)</td><td>GW Inflow (%)</td><td>Δ in Outflow (%)</td><td>Δ in Inflow (%)</td></tr>
<tr><td>Baseline (Existing)</td><td>2.51</td><td>1.31</td><td>-</td><td>-</td></tr>
<tr><td>Operations Ph 3 - 6</td><td>4.18</td><td>0.34</td><td>1.67</td><td>-0.97</td></tr>
</table></td><td>Figure 2c</td><td>HHIAR (Earthfx, April 2020)</td><td>191 - 303</td></tr>
<tr><td>Potential Impact to Form and Function of Feature:</td><td>No wetlands will be removed and the wetlands subcatchment will be protected. There will be no encroachment from the project into the wetland. The proposed limit of extraction is >120 m from the wetland boundary. Licensed boundary will be demarcated and fenced to ensure site construction and operations do not extend beyond the proposed limits of the project .</td><td></td><td></td><td></td></tr>
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Mitigation (Operational Phases 3 - 6)	Description	Figure / Graph	Reference	
			Report	Section / Page
Proposed Mitigation Measures:	None required.			

<table>
<tr><th>Impact Assessment (Rehabilitation)</th><th>Description</th><th>Figure / Graph</th><th colspan="2">Reference</th></tr>
<tr><th></th><th></th><th></th><th>Report</th><th>Section / Page</th></tr>
<tr><td>Change in Wetland Area (ha):</td><td>No change. Wetland located greater than 120 m from licensed boundary.</td><td></td><td>SWA (Tatham, April 2020)</td><td>5.4.1</td></tr>
<tr><td>Change in Wetland Catchment Area (ha):</td><td>No change. Subcatchment area protected.</td><td></td><td>SWA (Tatham, April 2020)</td><td>5.4.1 & Drawing DP-3</td></tr>
<tr><td>Change in Hydroperiod:</td><td>No Change. Wetland is perched and isolated from the groundwater system. Subcatchment area being protected.</td><td></td><td>SWA (Tatham, April 2020)</td><td>5.4.1</td></tr>
<tr><td>Change in Water Budget:</td><td>A detailed average water budget for Wetland 13027 (Earthfx Wetland 17), as simulated by the integrated model, is provided in the Earthfx report for Baseline Conditions (Figure 7.25, p. 187); Scenario P12 (Figure 8.32, p. 222); P3456 (Figure 8.64, p. 249); RHB1 (Figure 8.100, p. 278), and RHB2 (Figure 8.127, p. 300). The water budget results for Scenario RHB1 and RHB2 are reproduced in Figure 2d and 2e. Simulated change in groundwater levels (drawdowns), groundwater discharge to riparian areas, and change in streamflow in the vicinity of Wetland 13027 (Earthfx Wetland 17) for each scenario are discussed in Section 8 of the main report.
<table>
<tr><td>Wetland 13027</td><td>GW Outflow (%)</td><td>GW Inflow (%)</td><td>Δ in Outflow (%)</td><td>Δ in Inflow (%)</td></tr>
<tr><td>Baseline (Existing)</td><td>2.51</td><td>1.31</td><td>-</td><td>-</td></tr>
<tr><td>Rehab Scenario 1</td><td>3.65</td><td>0.55</td><td>1.14</td><td>-0.76</td></tr>
<tr><td>Rehab Scenario 2</td><td>3.38</td><td>0.45</td><td>0.87</td><td>-0.86</td></tr>
</table></td><td>Figure 2d and 2e</td><td>HHIAR (Earthfx, April 2020)</td><td>191 - 303</td></tr>
<tr><td>Potential Impact to Form and Function of Feature:</td><td>No wetlands will be removed and the wetlands subcatchment will be protected. There will be no encroachment from the project into the wetland. The proposed limit of extraction is >120 m from the wetland boundary. Licensed boundary will be demarcated and fenced to ensure site construction and operations do not extend beyond the proposed limits of the project.</td><td></td><td></td><td></td></tr>
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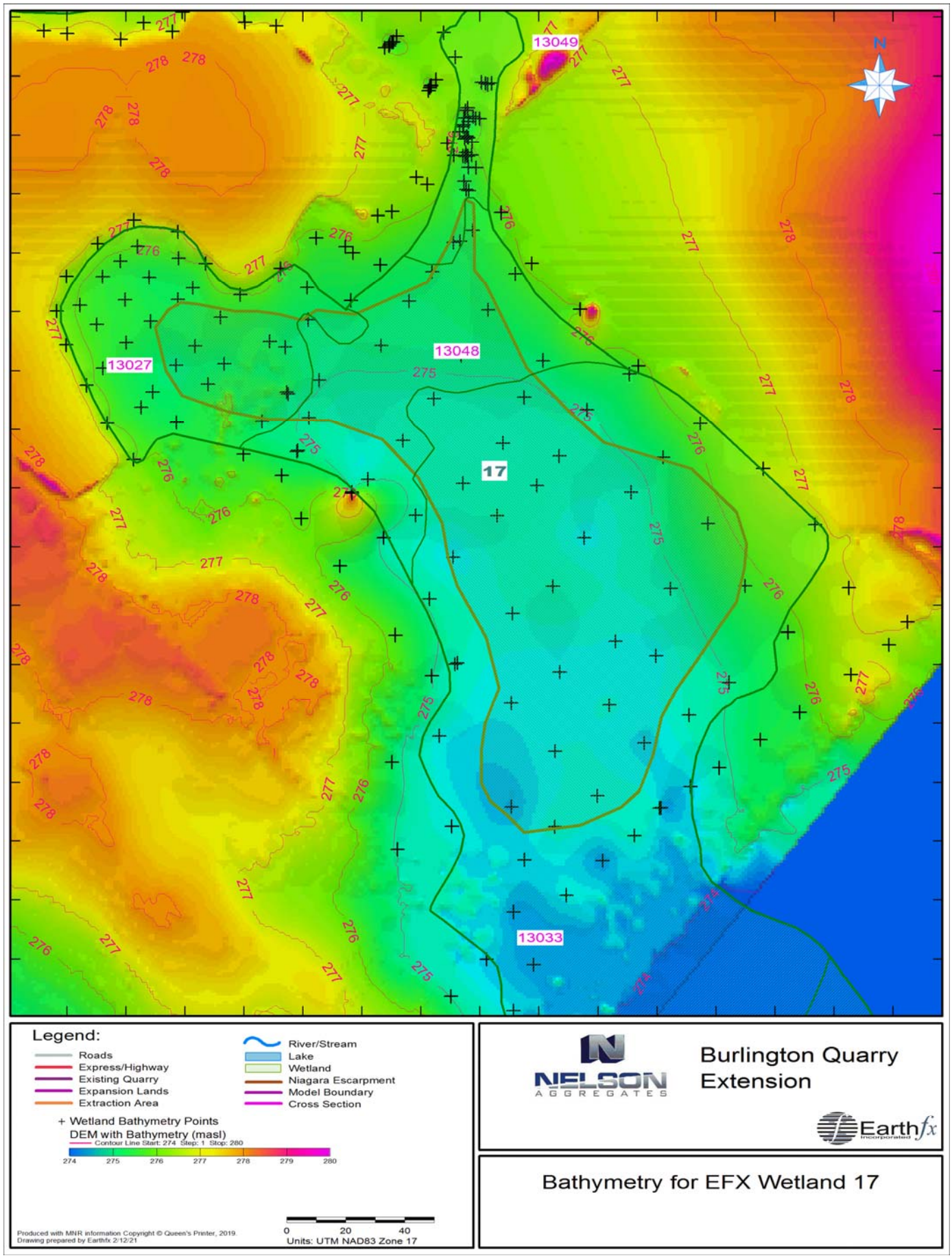
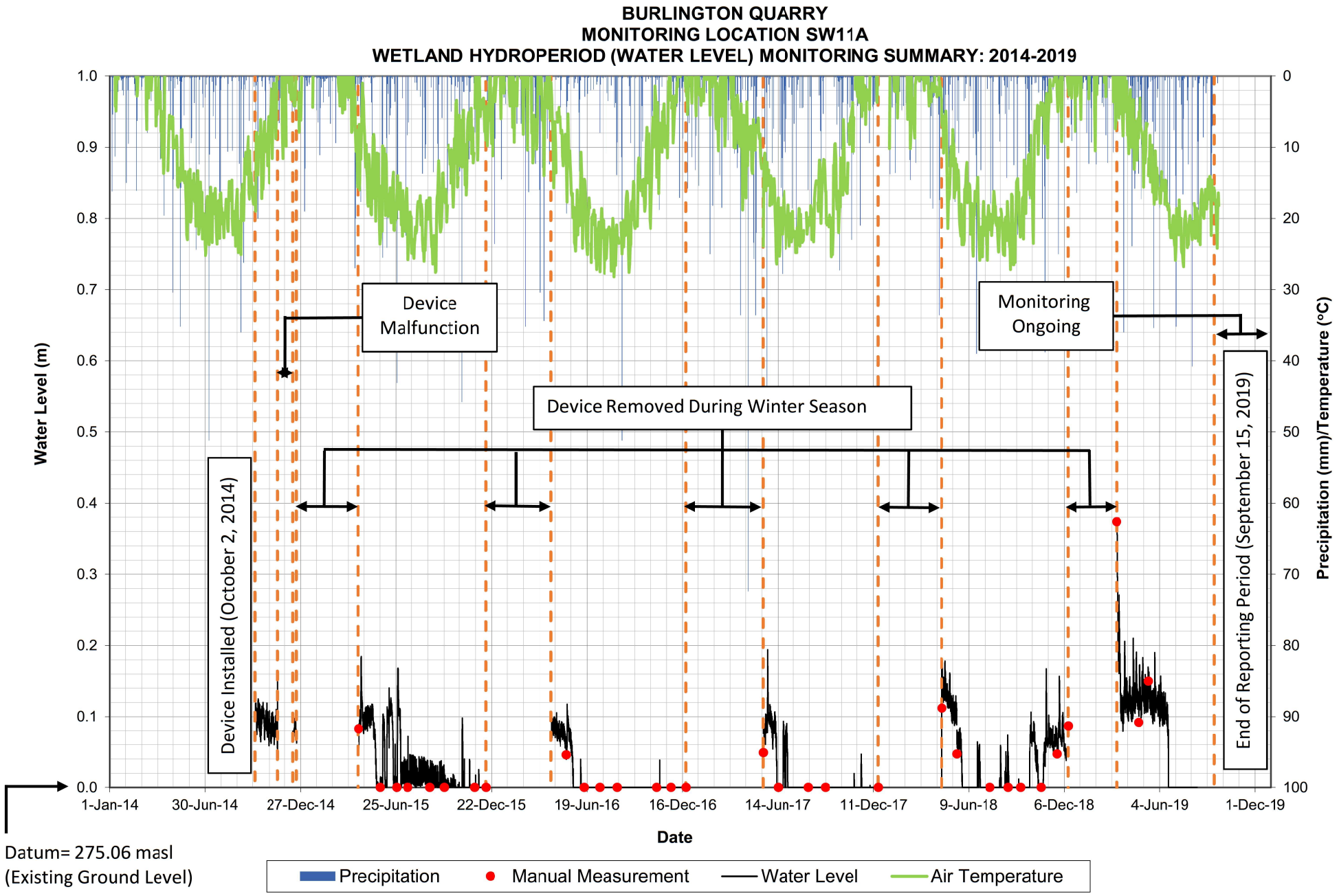
Mitigation (Rehabilitation)	Description	Figure / Graph	Reference	
			Report	Section / Page
Proposed Mitigation Measures:	None required.			

WETLAND 13027 - FIGURE 1



WETLAND 13027 - GRAPH 1



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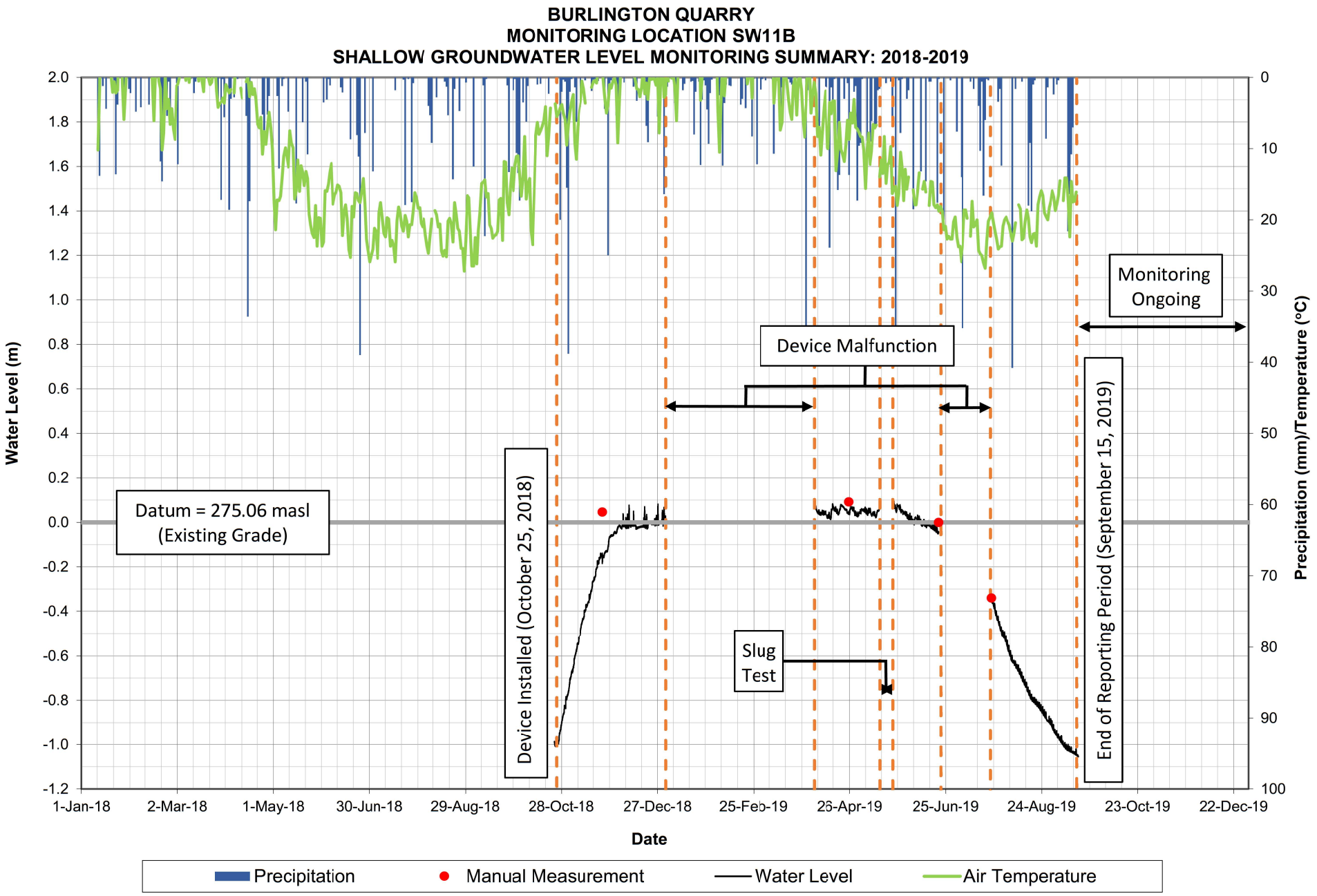
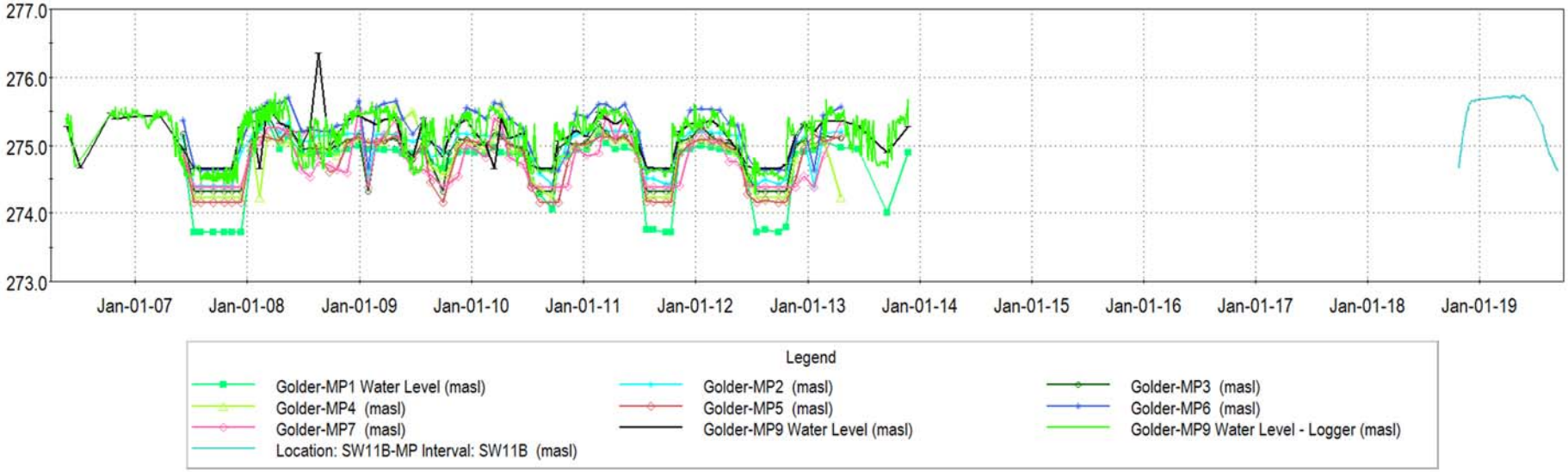


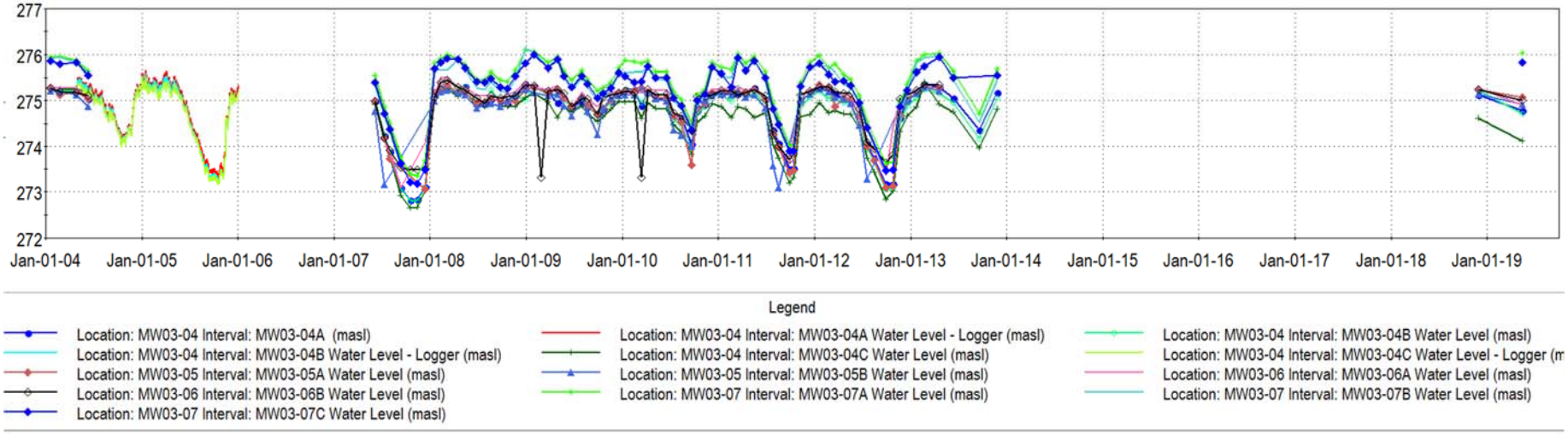
WETLAND 13027 - GRAPH 3

Shallow Groundwater Hydrographs
Wetland 13027



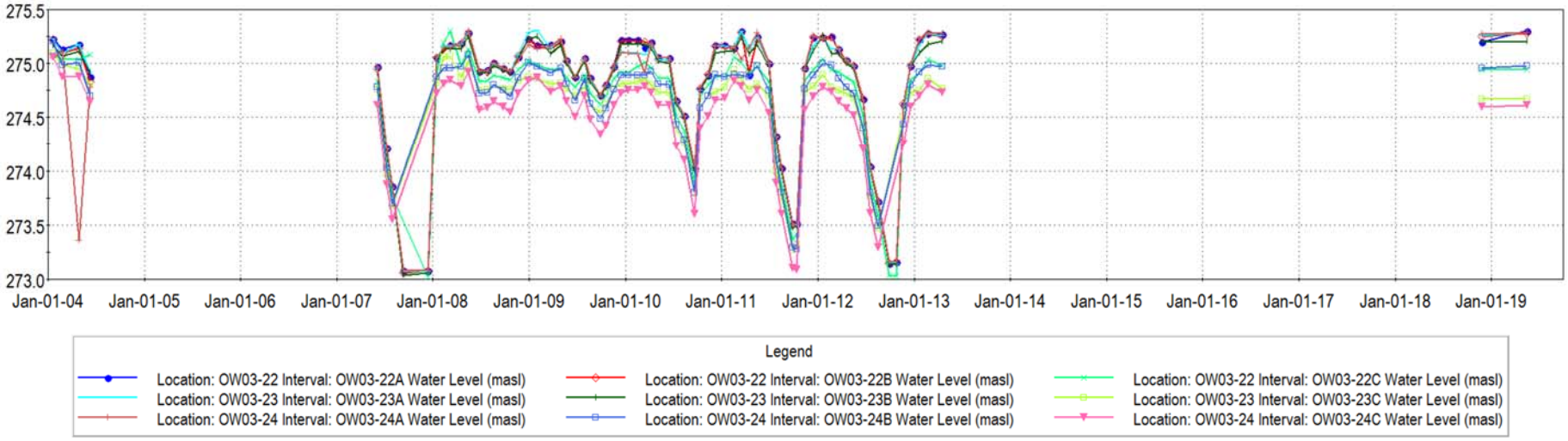
WETLAND 13027 - GRAPH 4

Groundwater Hydrographs
Wetland 13027



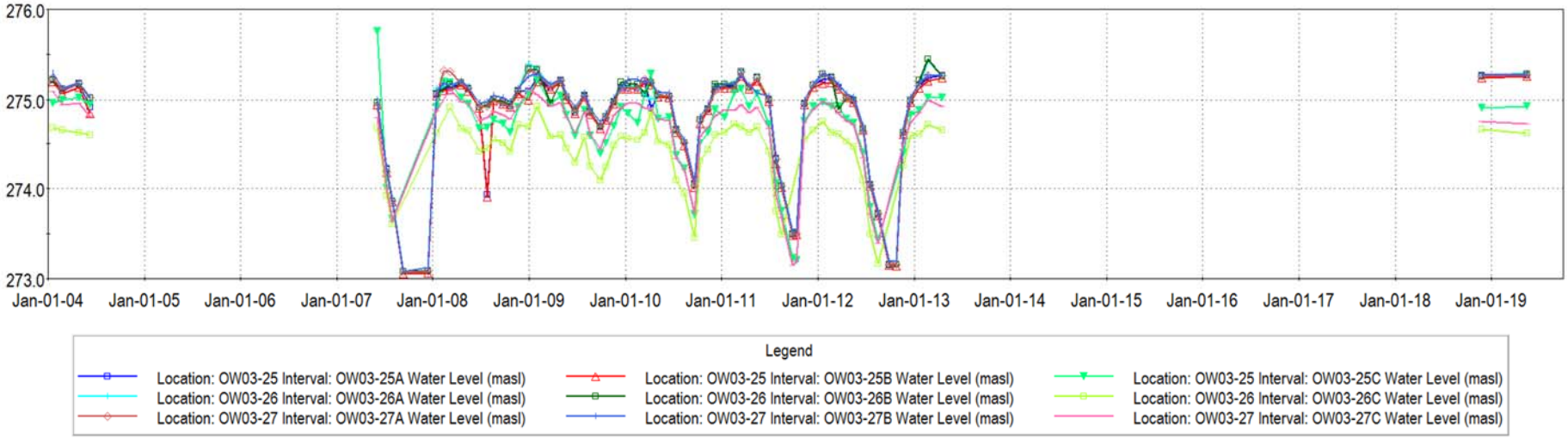
WETLAND 13027 - GRAPH 5

Groundwater Hydrographs
Wetland 13027



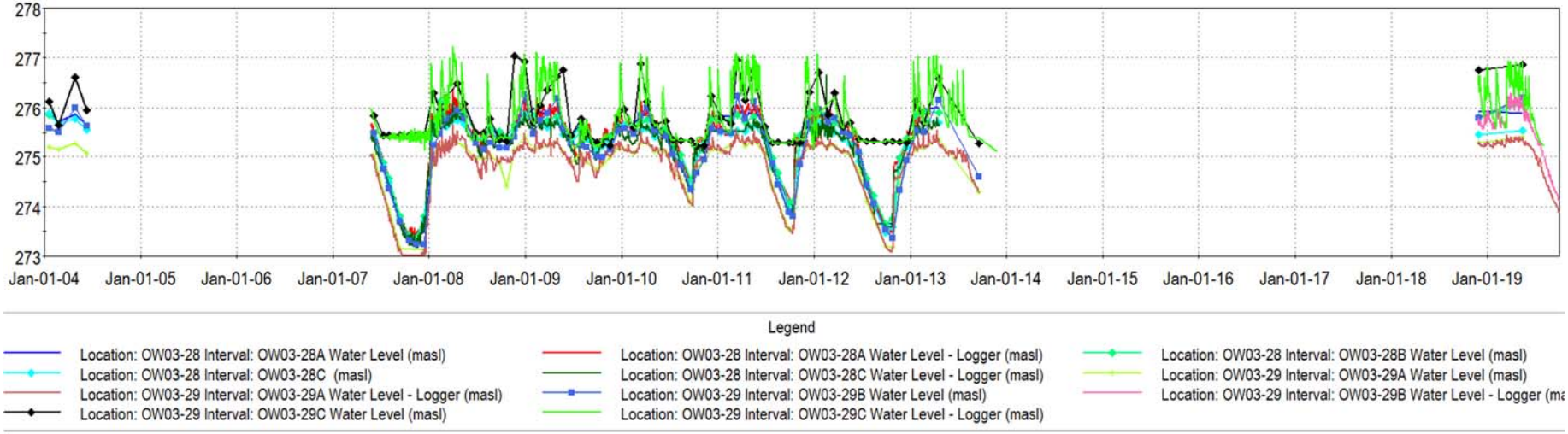
WETLAND 13027 - GRAPH 6

Groundwater Hydrographs
Wetland 13027



WETLAND 13027 - GRAPH 7

Groundwater Hydrographs
Wetland 13027



WETLAND 13027

FIGURE 2A

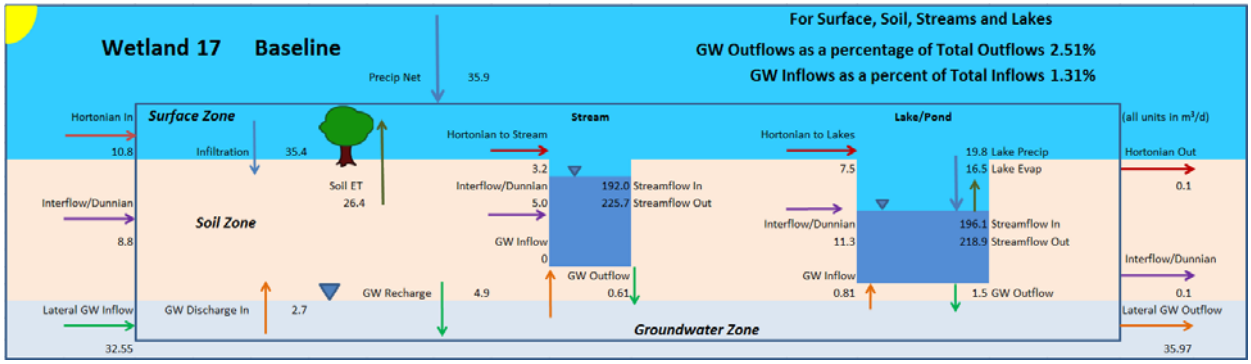


FIGURE 2B

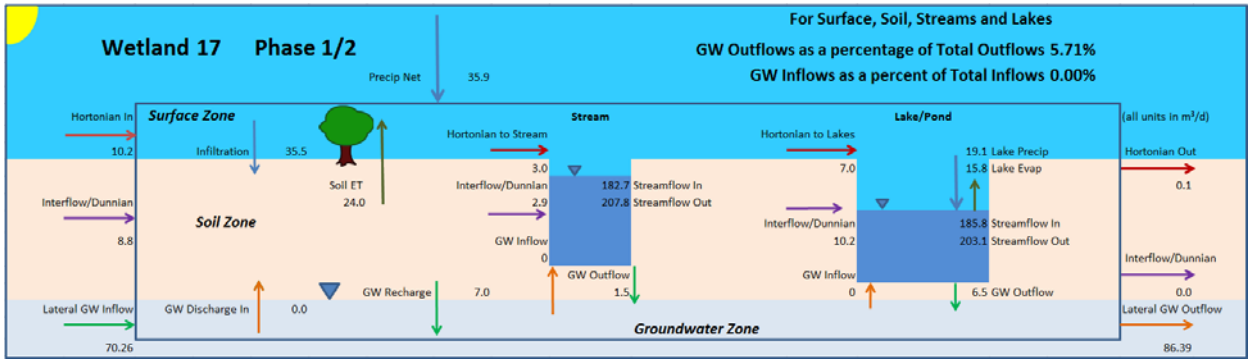


FIGURE 2C

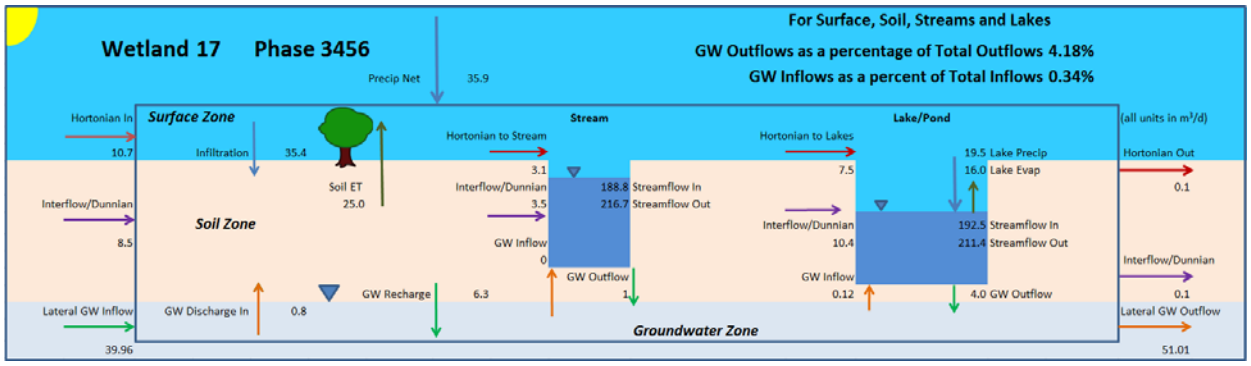


FIGURE 2D

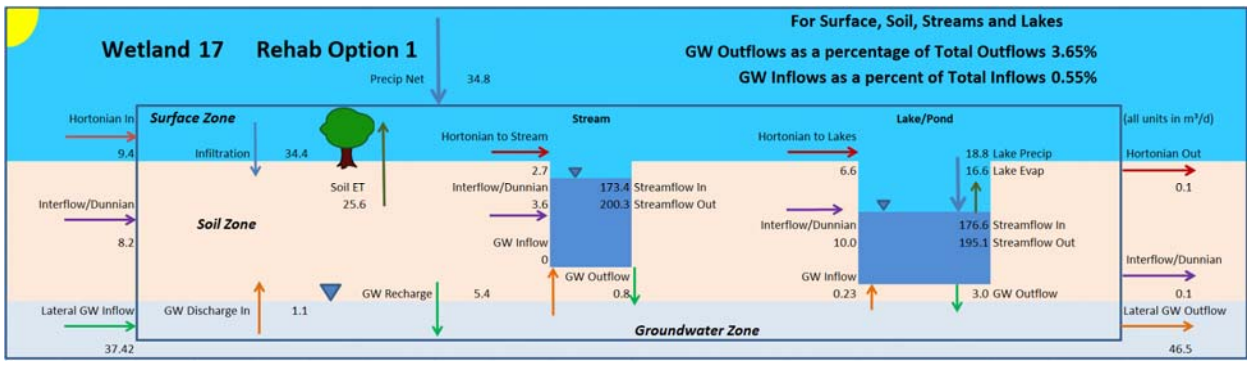
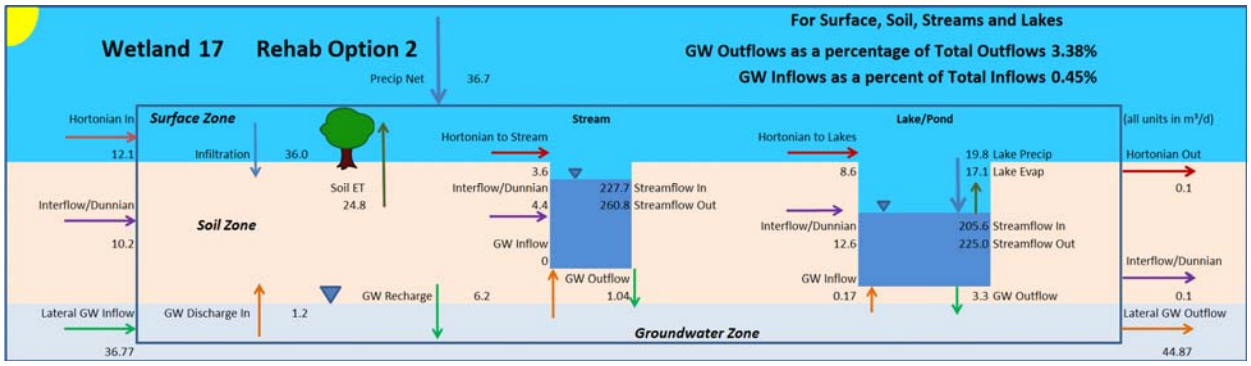
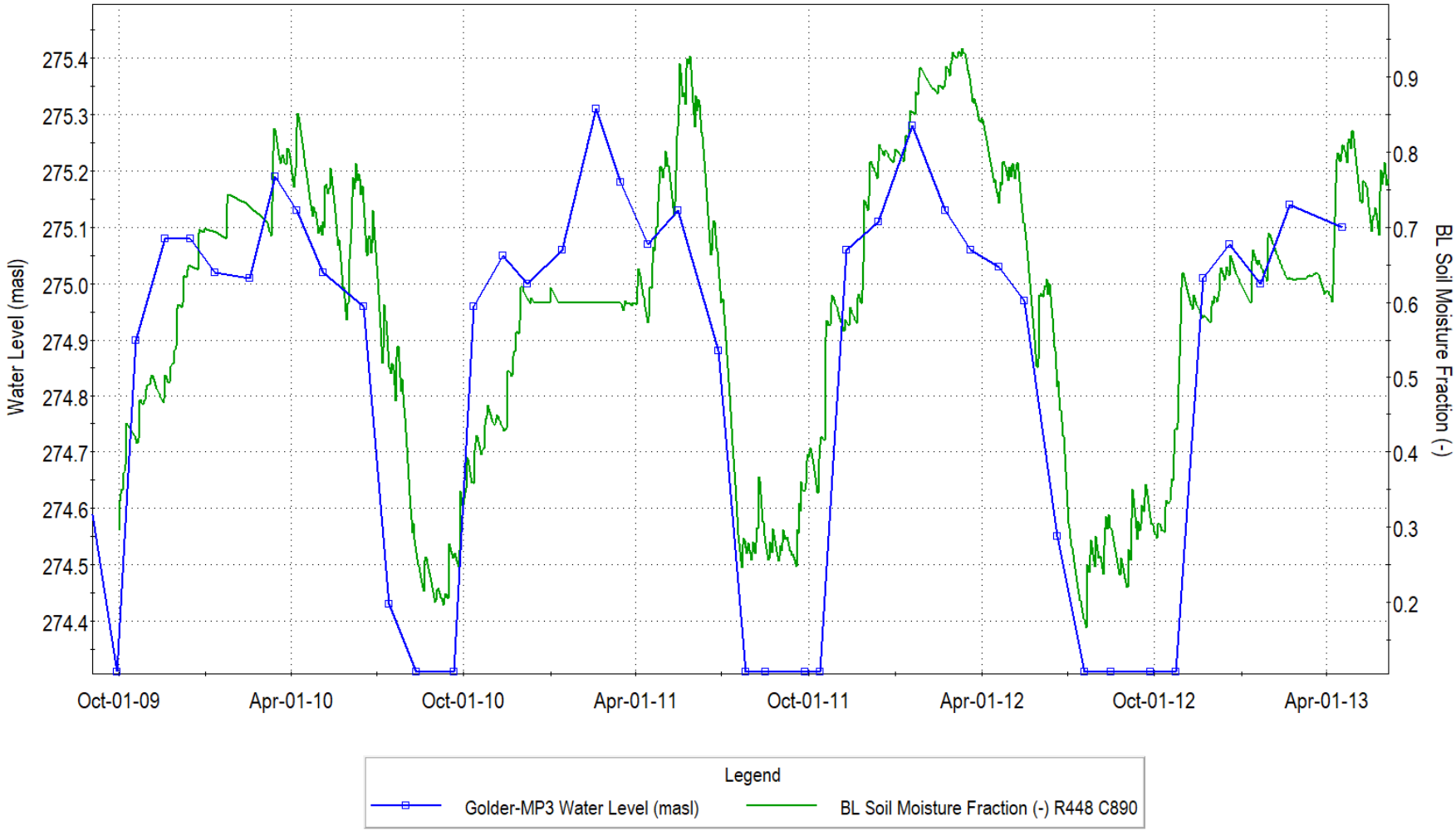


FIGURE 2E



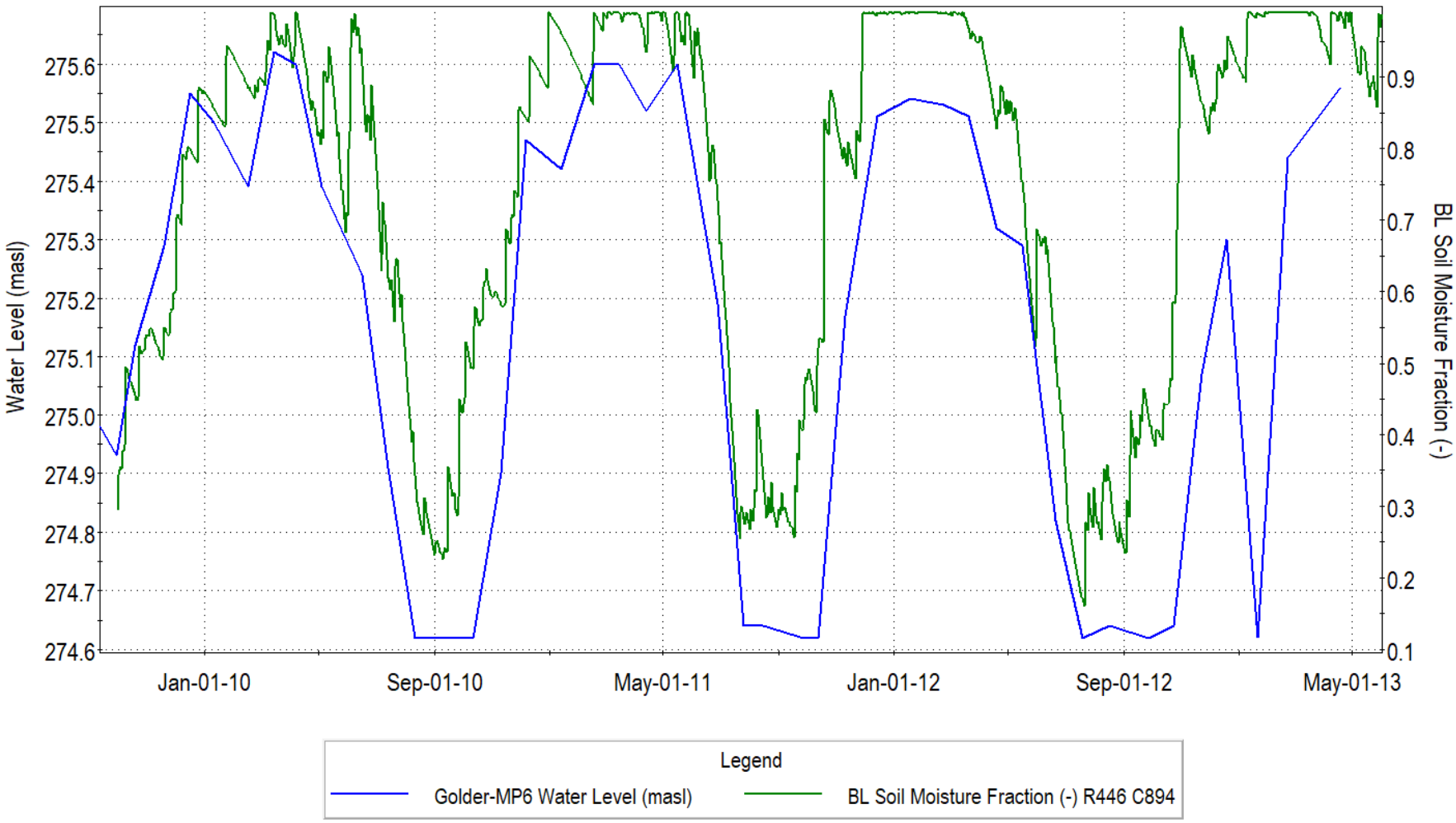
WETLAND 13027 - GRAPH 8

Integrated Model Calibration
Wetland 13027

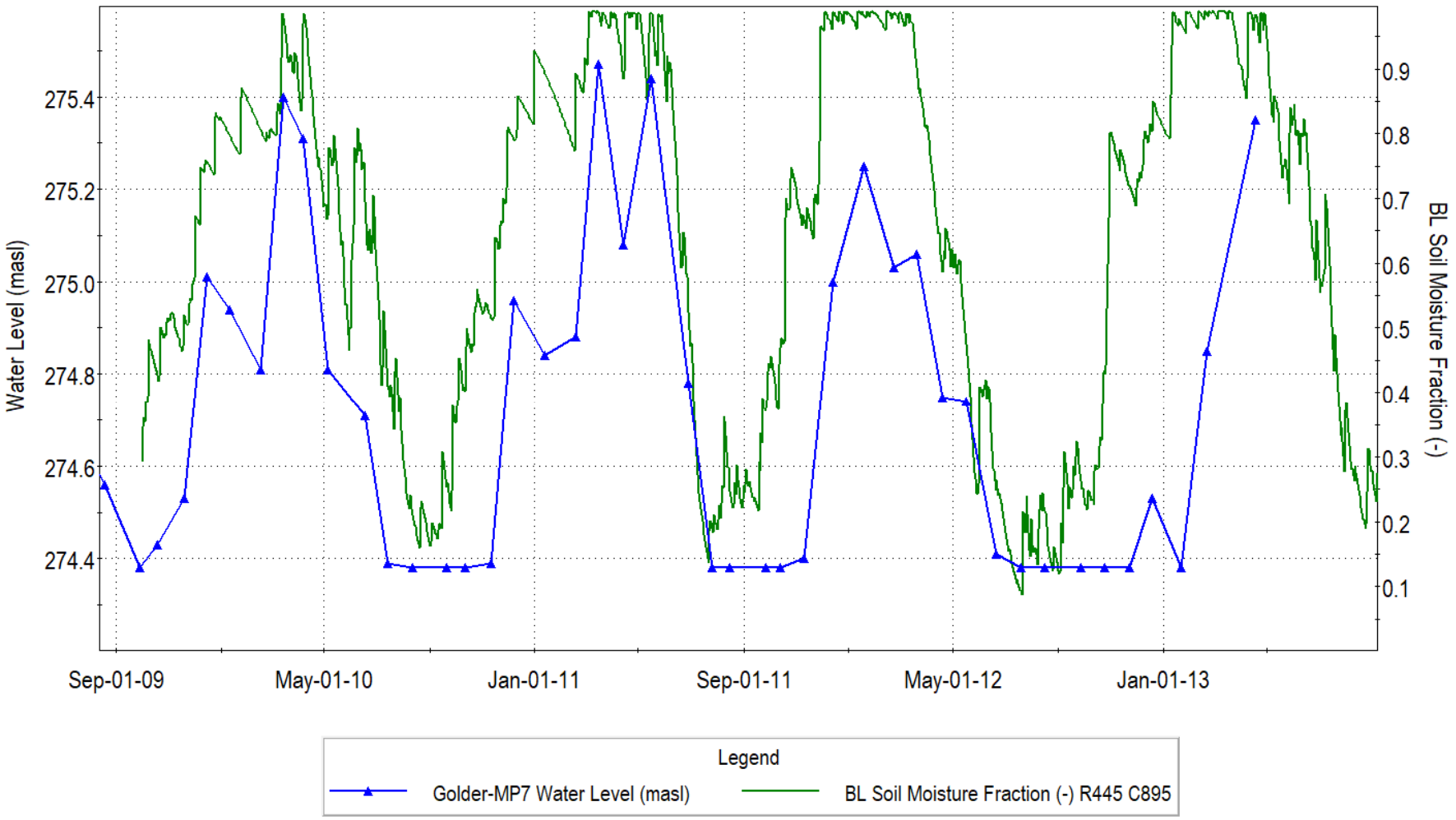


WETLAND 13027 - GRAPH 9

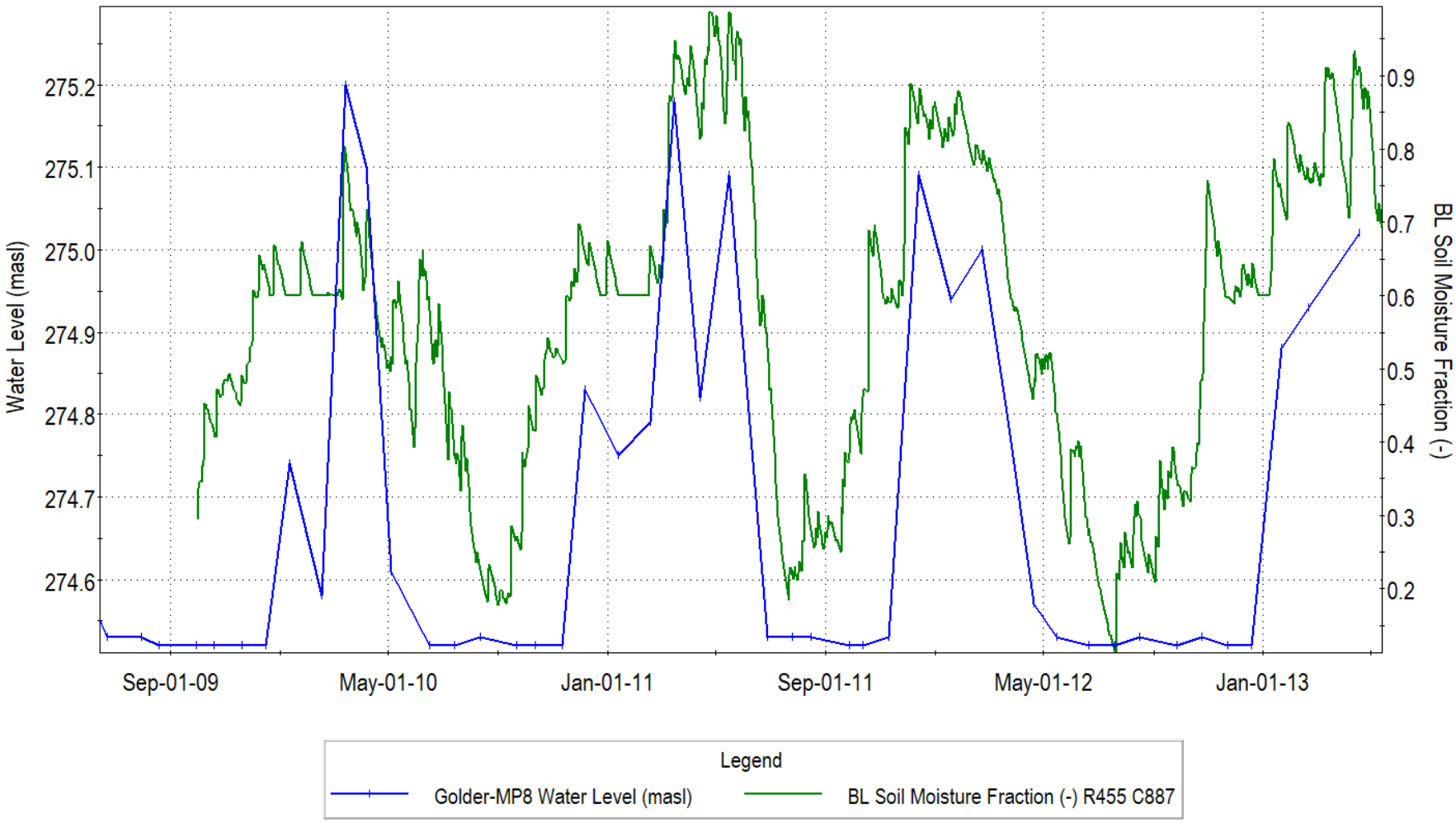
Integrated Model Calibration
Wetland 13027



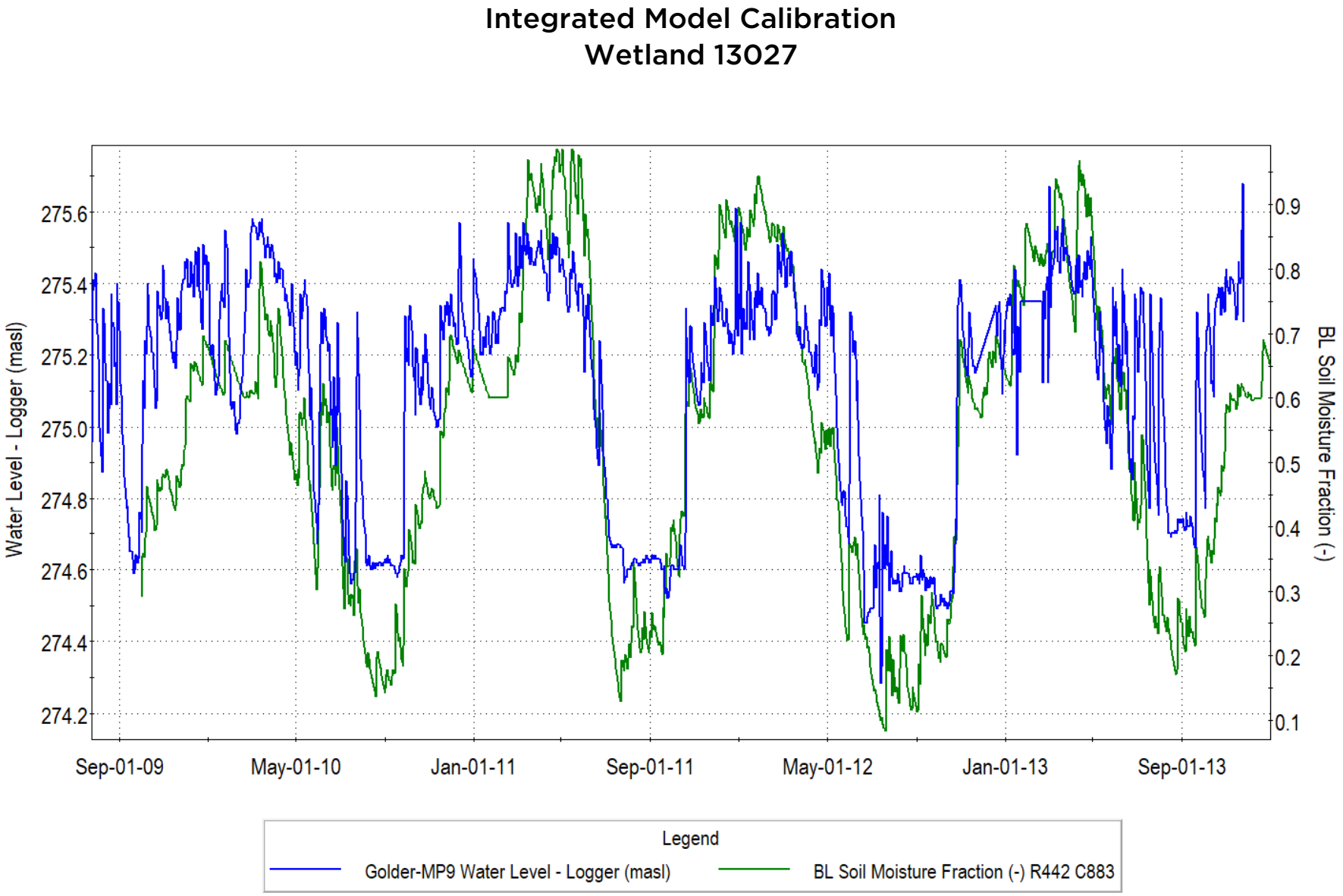
Integrated Model Calibration
Wetland 13027



Integrated Model Calibration
Wetland 13027



WETLAND 13027 - GRAPH 12



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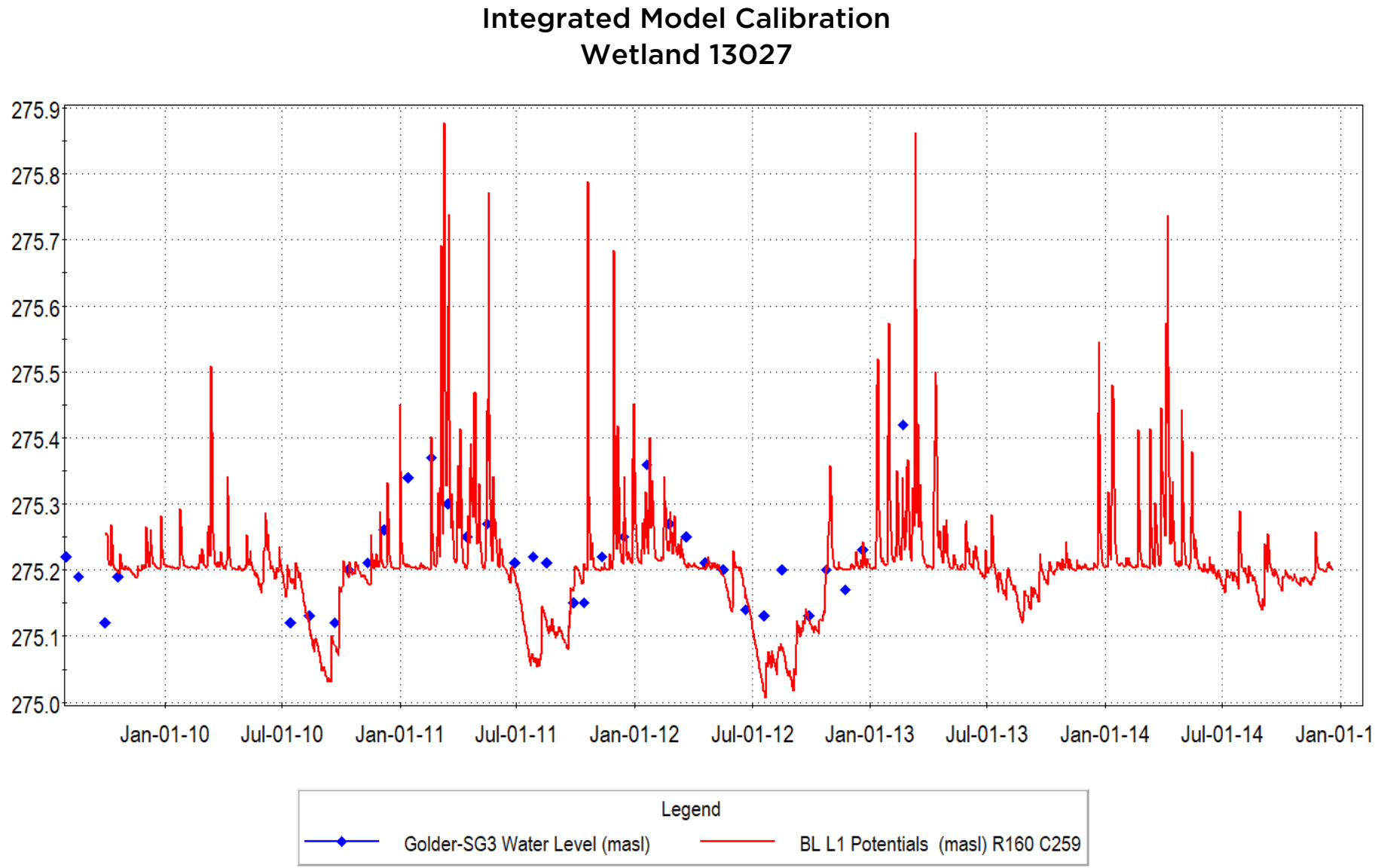
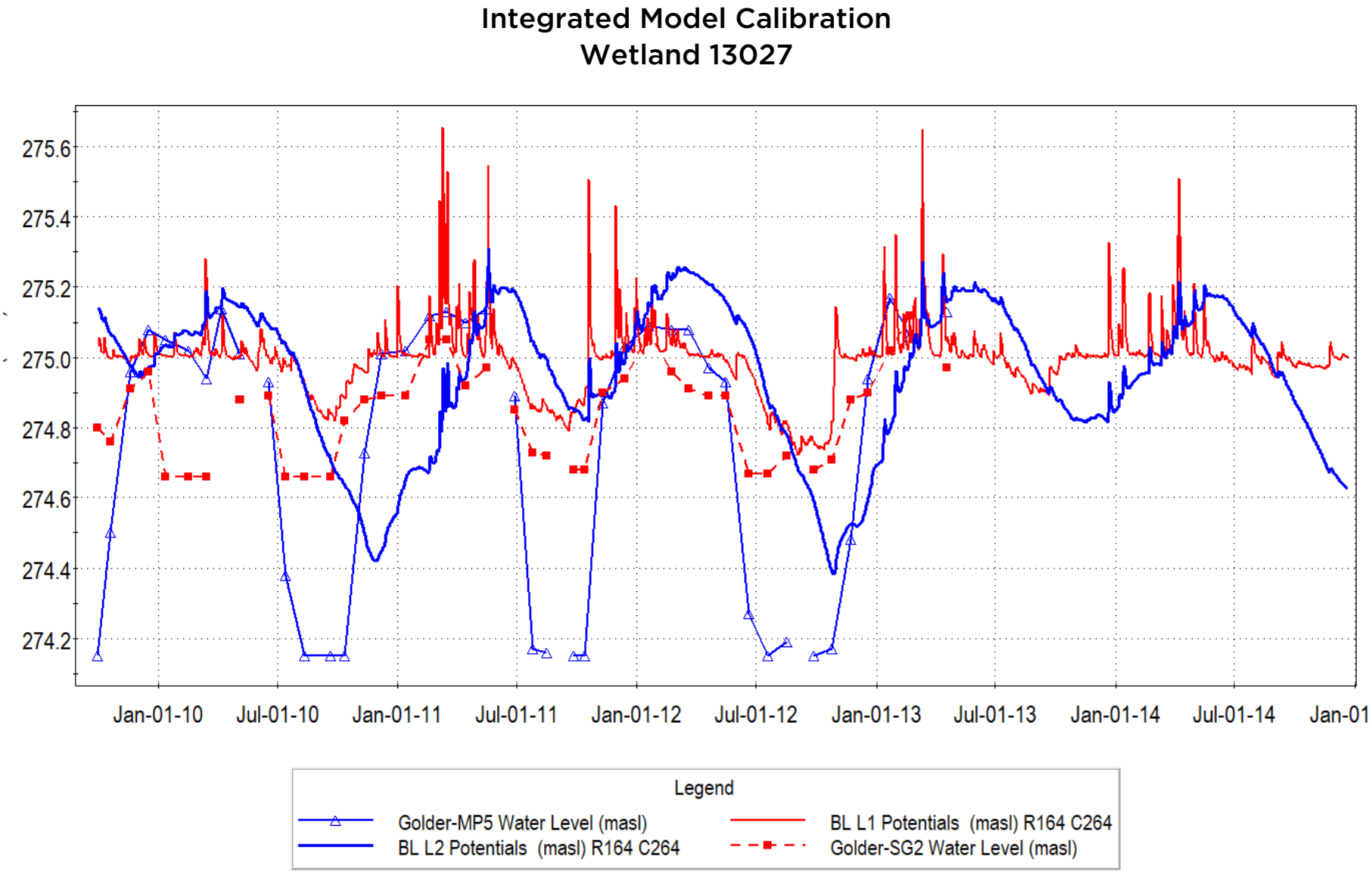
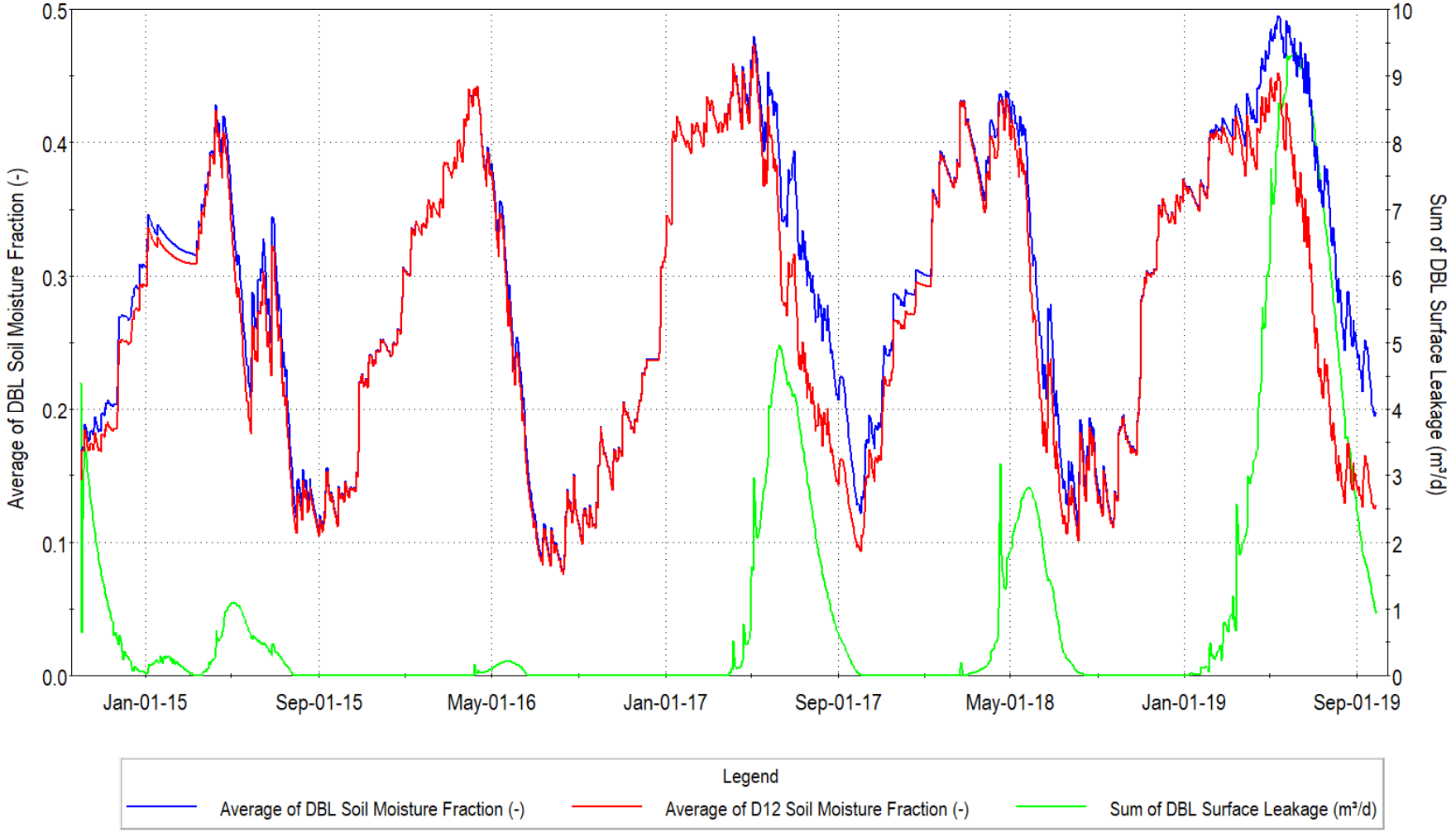


WETLAND 13027 - GRAPH 14



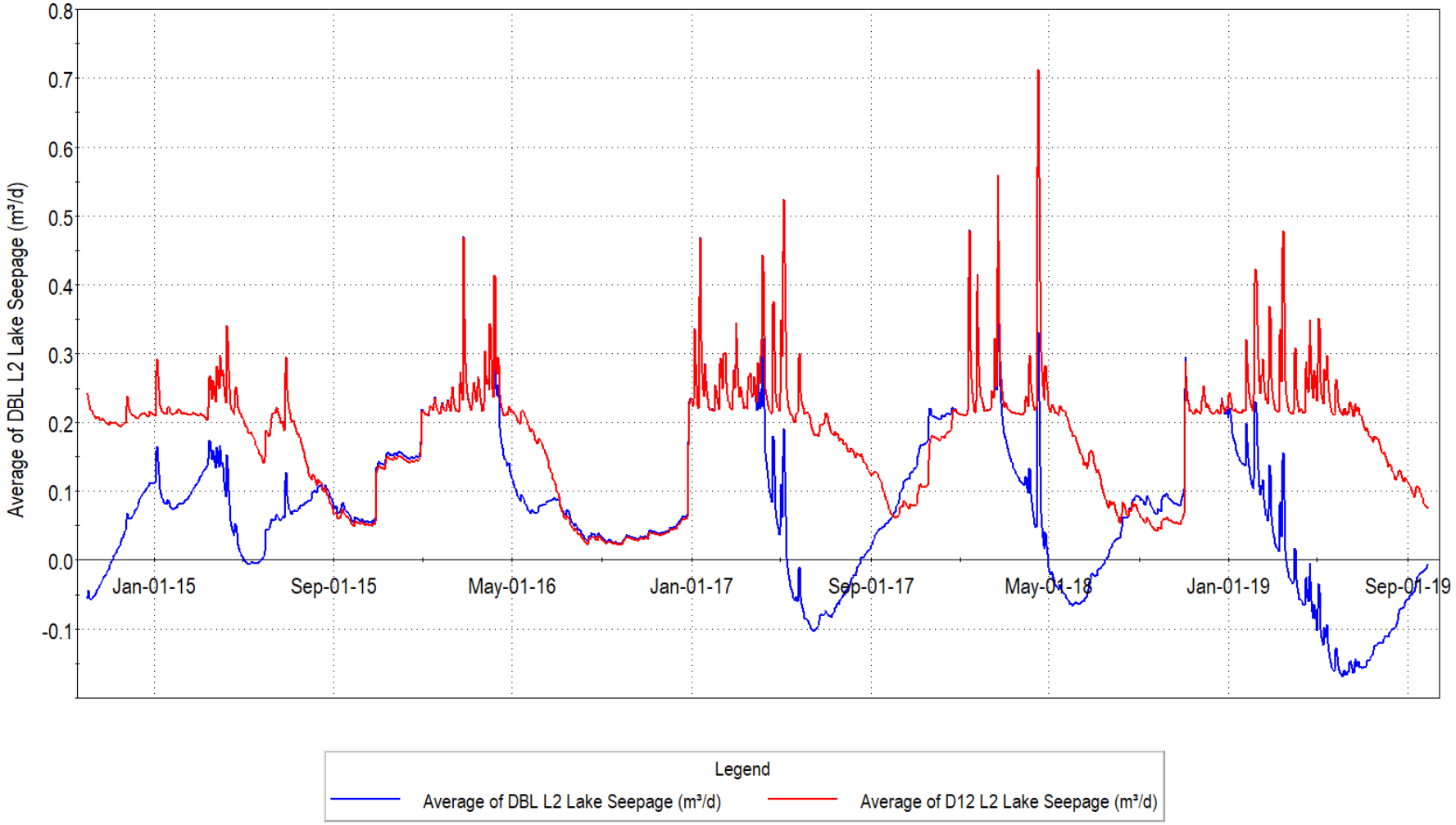
WETLAND 13027 - GRAPH 15

Change in Soil Moisture Conditions
Wetland 13027

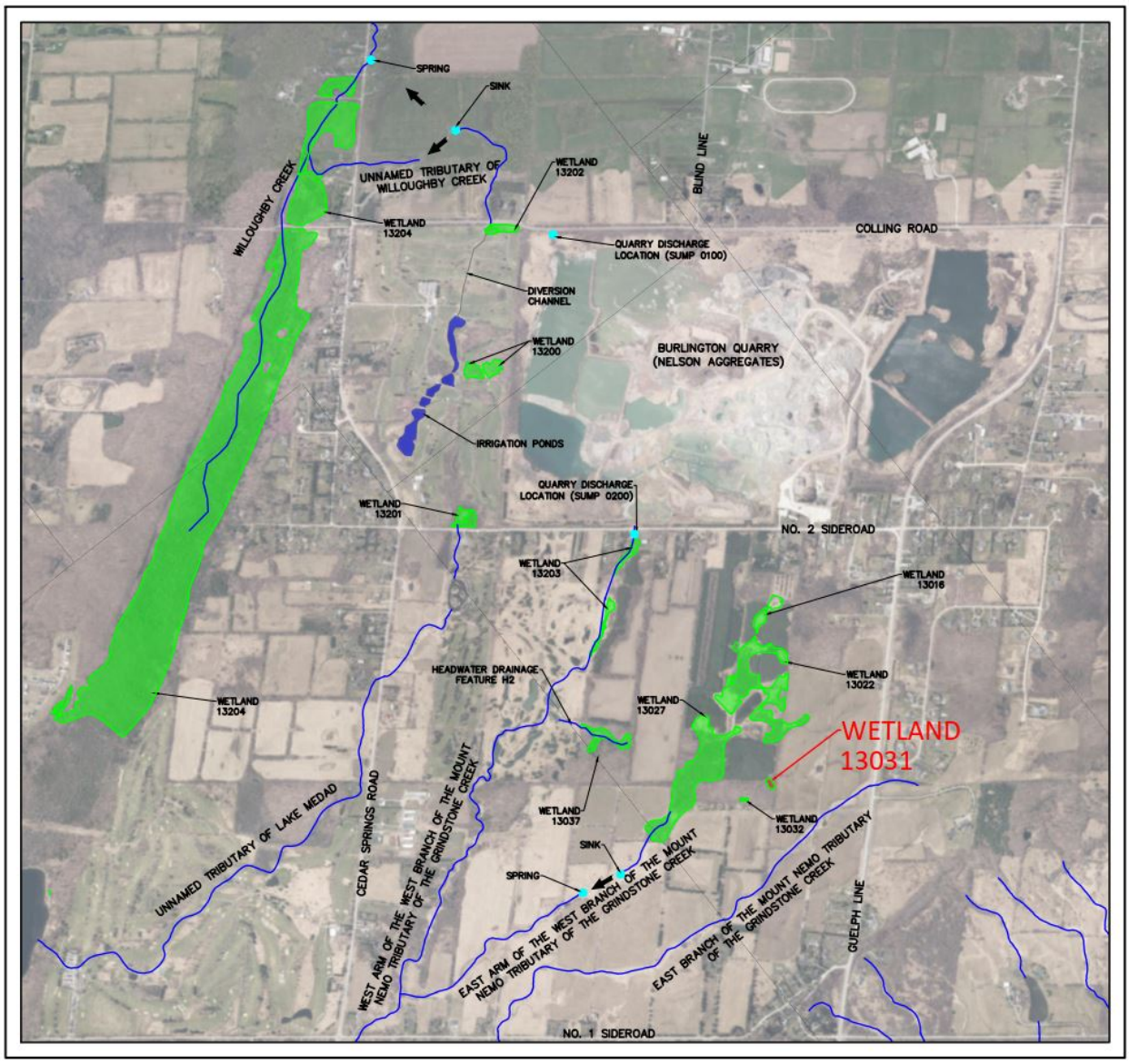


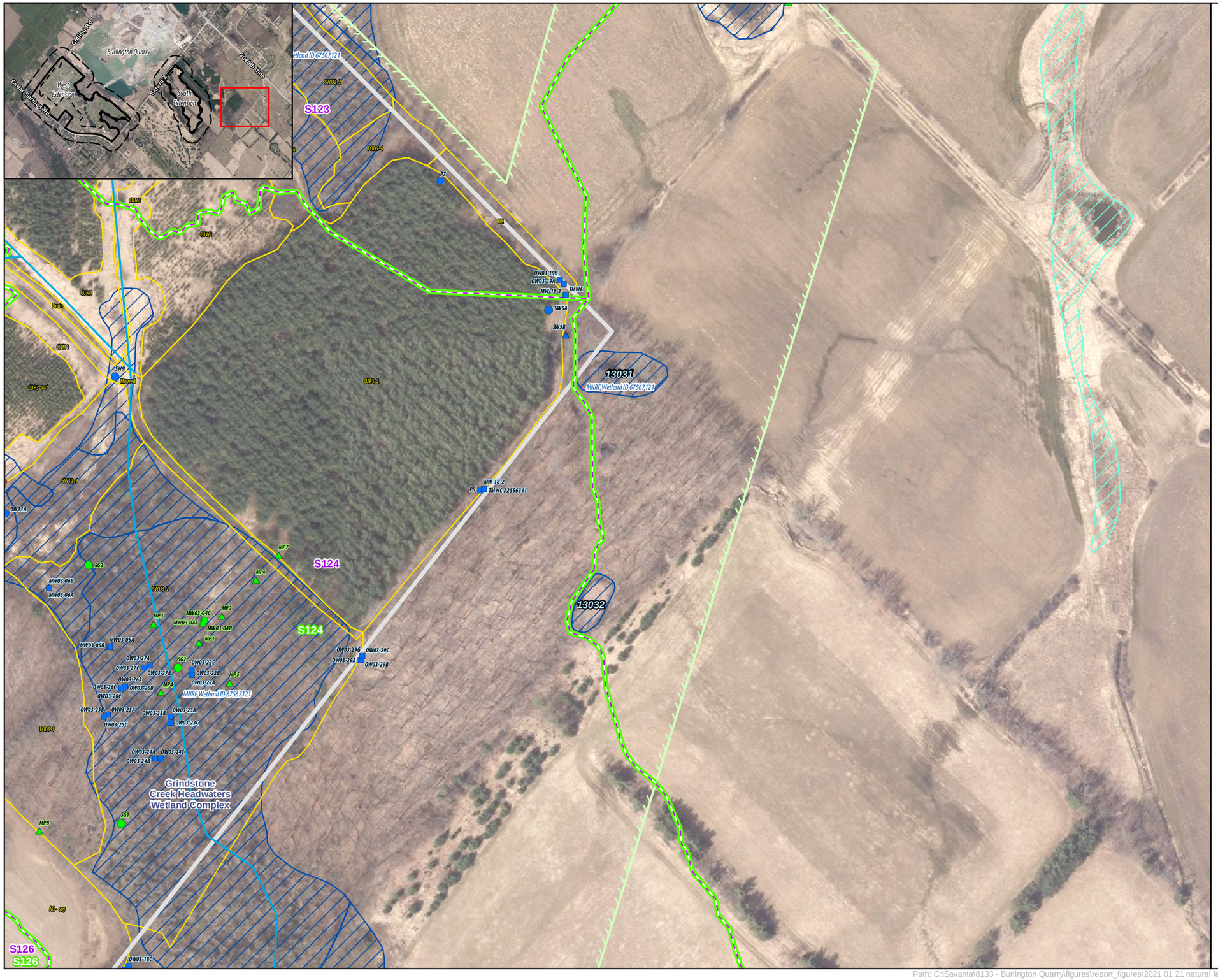
WETLAND 13027 - GRAPH 16

Change in Soil Moisture Conditions
Wetland 13027



WETLAND 13031





Legend

- Subject Lands
- Salamander Habitat Assessment (2019)
- Indirect Fish Habitat
- Existing Subcatchment Boundary (Tatham Engineering, 2020)
- Proposed Subcatchment Boundary - Operations and Post-Rehabilitation (Tatham Engineering, 2020
- Ecological Land Classification (Savanta, 2019 & 2020)
- Provincially Significant Wetland (LIO/MNRF, 2020)
- Wetland - Not Evaluated per OWES (MNRF/LIO, 2020)
- MECP Jefferson Salamander Regulated Habitat

Current Instrumentation

- Groundwater Monitoring Station (EarthFx)
- Mini Piezometer (Tatham Engineering)
- Staff Gauge & Surface Water Monitoring Station (Tatham Engineering)

Previous Instrumentation

- Groundwater Monitoring Station (Golder)
- Mini Piezometer (Golder)
- Staff Gauge & Surface Water Monitoring Station (Golder)

ELC Legend

AG, Agriculture
CUM1, Mineral Cultural Meadow
CUP3-2, White Pine Coniferous Plantation
CUP3-13*, White Spruce Coniferous Plantation
CUP3-14*, White Cedar Coniferous Plantation
CUT1-4, Gray Dogwood Cultural Thicket
CUW1, Mineral Cultural Woodland
FOD5-8, Dry – Fresh Sugar Maple – White Ash Deciduous Forest
FOD9-4, Fresh – Moist Shagbark Hickory Deciduous Forest
HR, Hedgerow
MAM2-2, Reed-canary Grass Mineral Meadow Marsh
SWD2-2, Green Ash Mineral Deciduous Swamp
SWD3-2, Silver Maple Mineral Deciduous Swamp
SWT2-9, Gray Dogwood Mineral Thicket Swamp

NOTES:

1. Coordinate System: NAD 1983 UTM Zone 17N.
2. Base features produced under license with the Ontario Ministry of Natural Resources and Forestry © Queen's Printer for Ontario, 2021.
3. Orthoimagery © First Base Solutions, 2021. Imagery taken in 2019.

Project 8133

Burlington Quarry Extension
Nelson Aggregates Co.

Figure 4
Wetland Characterization

Wetland 13031 and 13032 - South Extension

0 30 m
1:2,000

N

GEI Consultants
Savanta Division

Path: C:\Savanta\8133 - Burlington Quarry\figures\report_figures\2021 01 21 natural feature tech summary\8133_rpt_wetland_char_mapbook.mxd Date S...ary 11, 2021

Wetland 13031

Wetland Characteristics	Description	Figure / Graph	Reference	
			Report	Section / Page
Wetland IDs:	MNRF – 67567121 (OGF ID 67567125) Earthfx – N/A Tatham – 13031 Savanta – 13031 Golder (Background) - 13031			
Wetland Area (ha):	LIO/MNRF - 0.09			
Watershed:	Grindstone Creek Watershed			
Sub-Watershed:	East Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek			
Located in Proposed Limit of Extraction:	No			
Located in Proposed License Boundary:	No			
Catchment Area (ha):	N/A			
Catchment ID:	N/A			
Closed or Connected System:	Isolated Feature			
Condition:	Natural			
Bathymetry:	Bathymetry unavailable; off-site wetland without permission to survey.			
Outlet:	Isolated Feature			
Hydroperiod:	Spring Hydroperiod (date wetland dries out) – June 13th – July 24th Fall Hydroperiod (start of hydroperiod) – November 1st – N/A	Graph 1	SWA (Tatham, April 2020)	2.2.1, 3 and Appendix F
Surface Water Monitoring:	ID: SW5A (Tatham) Installation Date: October 2, 2014 Data Collection: Continuous water level and temperature and manual monthly water level measurements Coordinates of Monitoring Station: Easting 591476.534, Northing 4805331.03	Graph 1	SWA (Tatham, April 2020)	2.2.1, 3 and Appendix F

Natural Heritage and Habitat Features	Description	Figure / Graph	Reference	
			Report	Section / Page
Wetland Name & Provincial Significance Evaluation:	Grindstone Creek Headwaters Wetland Complex – Provincially Significant		NETR (Savanta, April 2020)	6.1.2
ELC Unit(s):	Unknown – outside of 120 m adjacent lands			
Regulated Habitat (MECP):	Yes – Jefferson Salamander (not field verified during 2019 field program; regulated based on historical data) Hydroperiod sensitive species; water presence necessary until end of June		NETR (Savanta, April 2020)	6.7
Significant Wildlife Habitat:	Unknown – outside of 120 m adjacent lands			
Fish Habitat:	None			
Habitat of Endangered and Threatened Species:	Unknown – outside of 120 m adjacent lands			

<table>
<tr><th>Groundwater Interaction</th><th>Description</th><th>Figure / Graph</th><th colspan="2">Reference</th></tr>
<tr><th></th><th></th><th></th><th>Report</th><th>Section / Page</th></tr>
<tr><td>Lithology:</td><td>Halton Till</td><td></td><td></td><td></td></tr>
<tr><td>Hydraulic Conductivity:</td><td>Integrated Model (Earthfx) - The harmonic mean hydraulic conductivity, based on testing by Golder (2007) of 10 mini-piezometers, was 1.2x10^{-8} m/s. Model value for the vertical hydraulic conductivity was 1.6x10^{-7} m/s, about an order of magnitude higher, to account for limited flow through fractures in the till.</td><td></td><td></td><td></td></tr>
<tr><td>Surface Water/Groundwater Interaction:</td><td>The low permeability of the Halton Till underlying the wetland is the dominant control on 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.</td><td></td><td></td><td></td></tr>
<tr><td>Shallow Groundwater (Mini-piezometer) Monitoring:</td><td>ID: SW5B (Tatham)
Installation Date: October 23, 2018
Data Collection: Continuous water level and temperature and manual monthly water level measurements
Coordinates of Monitoring Station: Easting 591476.534, Northing 4805331.03</td><td>Graph 2</td><td>SWA (Tatham, April 2020)</td><td>2.3 and Appendix G</td></tr>
<tr><td>Groundwater Monitoring (Monitoring Wells):</td><td>
<table>
<tr><th>Monitoring Well ID</th><th>Distance (Dir.)</th><th>Geologic Unit</th><th>Ground Elevation</th><th>Monitoring Elev</th><th>Average WL</th></tr>
<tr><td>OW03-19A</td><td>50(NW)</td><td>Bedrock</td><td>284.87</td><td>262.1 - 255.4</td><td>268.62</td></tr>
<tr><td>OW03-19B</td><td>50(NW)</td><td>Bedrock</td><td>284.87</td><td>273.9 – 267.3</td><td>268.64</td></tr>
<tr><td>OW03-19C</td><td>50(NW)</td><td>Overburden</td><td>284.98</td><td>276.7 – 275.1</td><td>276.91</td></tr>
</table>
</td><td>Graph 3</td><td></td><td></td></tr>
<tr><td>Water Budget Results:</td><td>A detailed water budget was not produced for this wetland. The wetland is close to Wetland 13032 (Earthfx Wetland 19) and similar in size. The water budget for this wetland should be similar. Simulated groundwater levels, groundwater discharge to riparian areas, and streamflow in the vicinity of Wetland 13032 (Earthfx Wetland 19) for baseline conditions is discussed in Section 7 of the main report.</td><td></td><td>HHIAR (Earthfx, April 2020)</td><td>165 - 190</td></tr>
<tr><td>Integrated Model Calibration:</td><td>The calibration of this wetland is not discussed in the Earthfx Main Report. Section 6.11.6.3 discusses the calibration to nearby Wetland 13032 (Earthfx Wetland 19) in great detail. The calibration to nearby well OW03-19 is shown in Graph 4. The groundwater monitors are completed in the shallow and intermediate depth bedrock and exhibit similar water level elevations and fluctuations. The model simulations match the observations closely (the ground surface and model layer tops are shown as horizontal reference lines to illustrate the thickness of the till at this location).</td><td>Graph 4</td><td></td><td></td></tr>
</table>

Impact Assessment (Operations Phases 1 & 2)	Description	Figure / Graph	Reference	
			Report	Section / Page
Change in Wetland Area (ha):	No change. Wetland located greater than 120 m from licensed boundary.		SWA (Tatham, April 2020)	4.2.1
Change in Wetland Catchment Area (ha):	No change. Subcatchment area protected.		SWA (Tatham, April 2020)	4.2.1 & Drawing DP-2
Change in Hydroperiod:	No Change. Wetland is perched and isolated from the groundwater system. Subcatchment area being protected.		SWA (Tatham, April 2020)	4.2.1
Change in Water Budget:	Detailed water budgets were not prepared for this feature. A detailed average water budget as simulated by the integrated model is provided for nearby Wetland 13032 (Earthfx Wetland 19) Simulated change in groundwater levels (drawdowns), groundwater discharge to riparian areas, and change in streamflow in the vicinity of Wetland 13032 (Earthfx Wetland 19) for each scenario are discussed in Section 8 of the main report.		HHIAR (Earthfx, April 2020)	191 - 303
Potential Impact to Form and Function of Feature:	No wetlands will be removed and the wetlands subcatchment will be protected. There will be no encroachment from the project into the wetland. The proposed limit of extraction is >120 m from the wetland boundary. Licensed boundary will be demarcated and fenced to ensure site construction and operations do not extend beyond the proposed limits of the project.			

Mitigation (Operational Phases 1 & 2)	Description	Figure / Graph	Reference	
			Report	Section / Page
Proposed Mitigation Measures:	None required.			

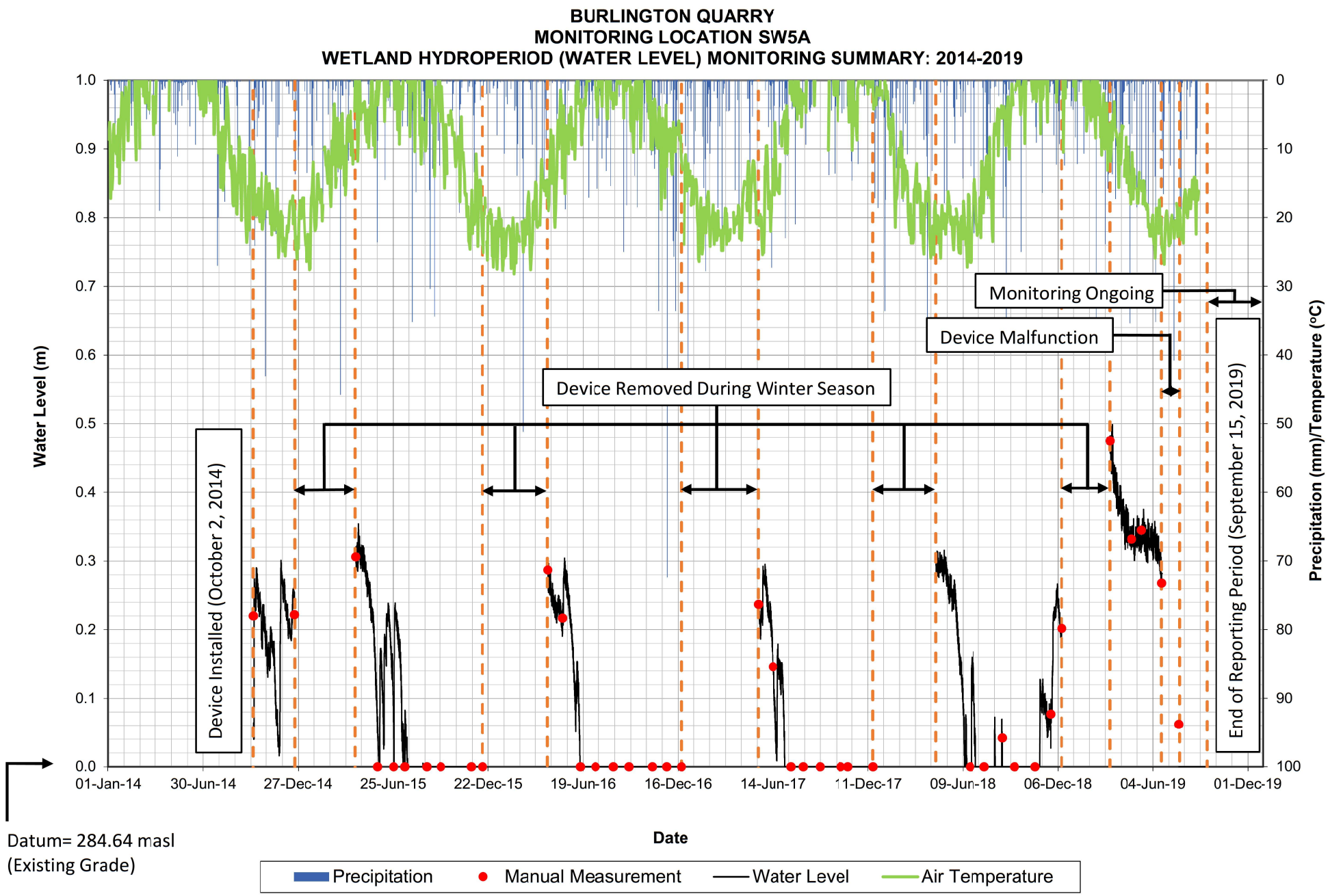
Impact Assessment (Operations Phases 3 - 6)	Description	Figure / Graph	Reference	
			Report	Section / Page
Change in Wetland Area (ha):	No change. Wetland located greater than 120 m from licensed boundary.		SWA (Tatham, April 2020)	4.2.1
Change in Wetland Catchment Area (ha):	No change. Subcatchment area protected.		SWA (Tatham, April 2020)	4.2.1 & Drawing DP-2
Change in Hydroperiod:	No Change. Wetland is perched and isolated from the groundwater system. Subcatchment area being protected.		SWA (Tatham, April 2020)	4.2.1
Change in Water Budget:	Detailed water budgets were not prepared for this feature. A detailed average water budget as simulated by the integrated model is provided for nearby Wetland 13032 (Earthfx Wetland 19) Simulated change in groundwater levels (drawdowns), groundwater discharge to riparian areas, and change in streamflow in the vicinity of Wetland 13032 (Earthfx Wetland 19) for each scenario are discussed in Section 8 of the main report.		HHIAR (Earthfx, April 2020)	191 - 303
Potential Impact to Form and Function of Feature:	No wetlands will be removed and the wetlands subcatchment will be protected. There will be no encroachment from the project into the wetland. The proposed limit of extraction is >120 m from the wetland boundary. Licensed boundary will be demarcated and fenced to ensure site construction and operations do not extend beyond the proposed limits of the project .			

Mitigation (Operational Phases 3 - 6)	Description	Figure / Graph	Reference	
			Report	Section / Page
Proposed Mitigation Measures:	None required.			

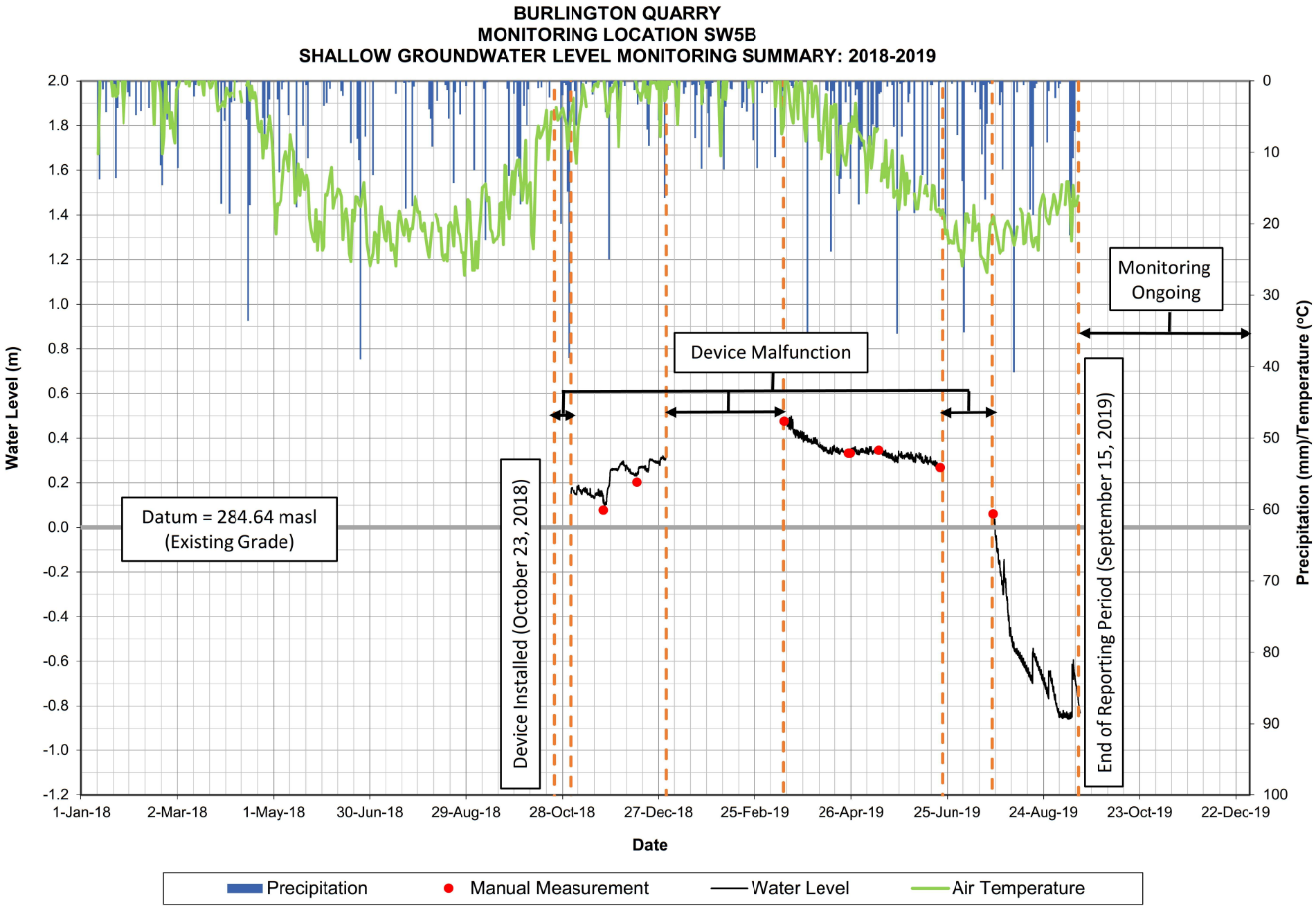
Impact Assessment (Rehabilitation)	Description	Figure / Graph	Reference	
			Report	Section / Page
Change in Wetland Area (ha):	No change. Wetland located greater than 120 m from licensed boundary.		SWA (Tatham, April 2020)	5.4.1
Change in Wetland Catchment Area (ha):	No change. Subcatchment area protected.		SWA (Tatham, April 2020)	5.4.1 & Drawing DP-3
Change in Hydroperiod:	No Change. Wetland is perched and isolated from the groundwater system. Subcatchment area being protected.		SWA (Tatham, April 2020)	5.4.1
Change in Water Budget:	Detailed water budgets were not prepared for this feature. A detailed average water budget as simulated by the integrated model is provided for nearby Wetland 13032 (Earthfx Wetland 19) Simulated change in groundwater levels (drawdowns), groundwater discharge to riparian areas, and change in streamflow in the vicinity of Wetland 13032 (Earthfx Wetland 19) for each scenario are discussed in Section 8 of the main report.		HHIAR (Earthfx, April 2020)	191 - 303
Potential Impact to Form and Function of Feature:	No wetlands will be removed and the wetlands subcatchment will be protected. There will be no encroachment from the project into the wetland. The proposed limit of extraction is >120 m from the wetland boundary. Licensed boundary will be demarcated and fenced to ensure site construction and operations do not extend beyond the proposed limits of the project .			

Mitigation (Rehabilitation)	Description	Figure / Graph	Reference	
			Report	Section / Page
Proposed Mitigation Measures:	None required.			

WETLAND 13031 - GRAPH 1

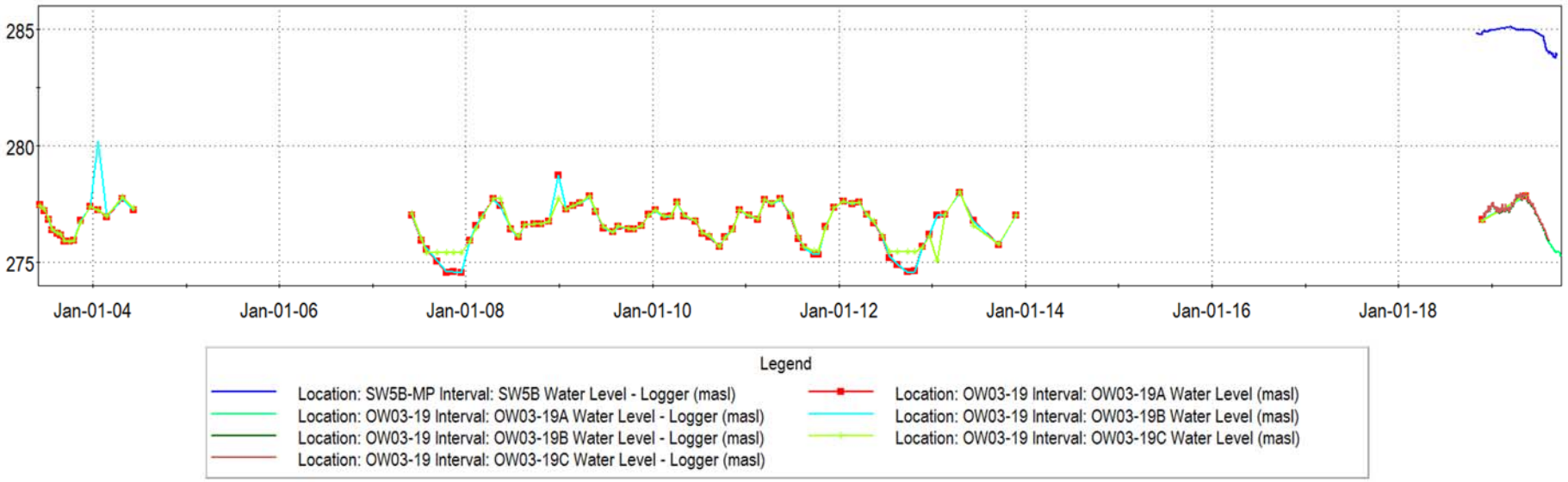


WETLAND 13031 - GRAPH 2

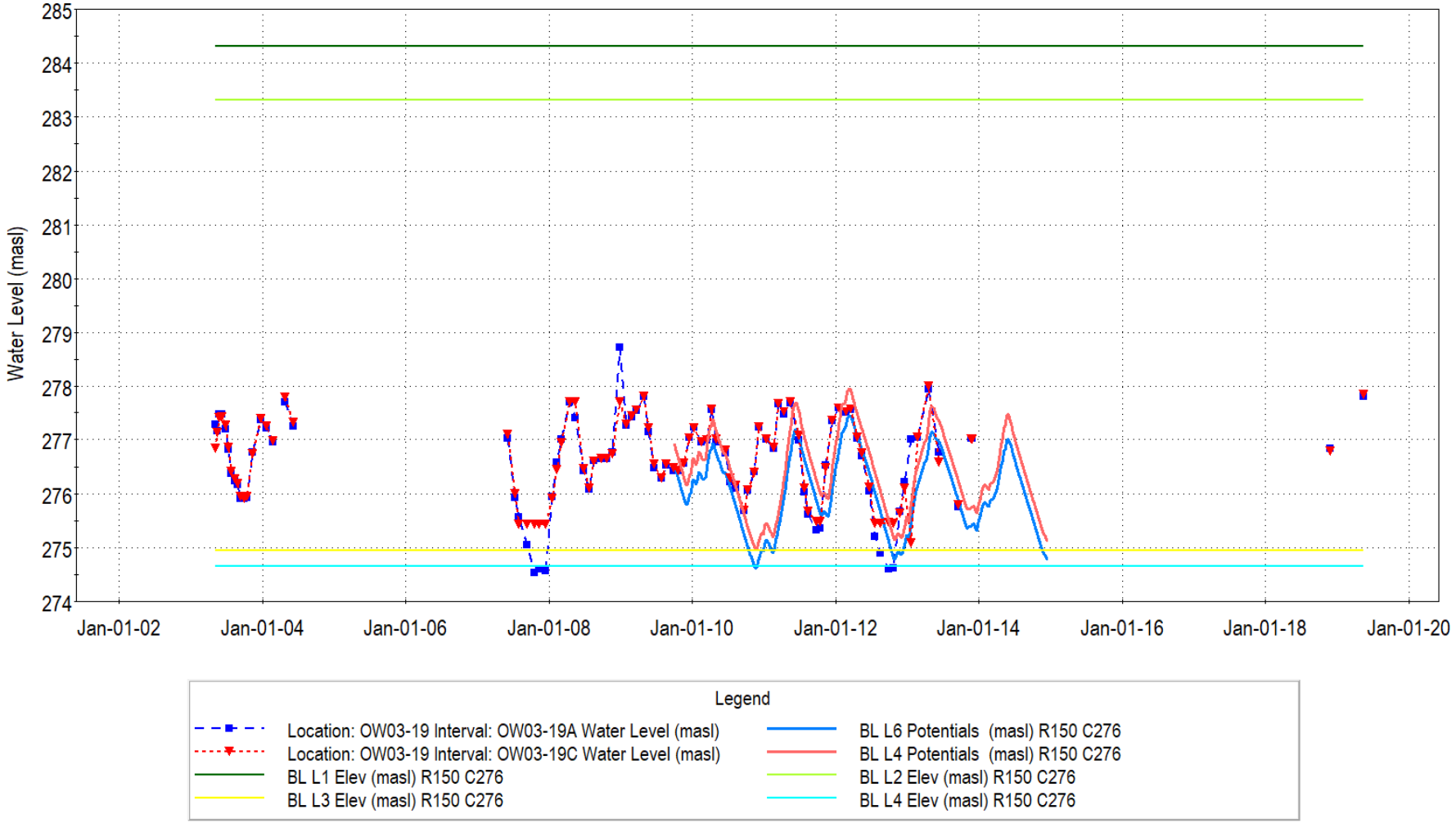


WETLAND 13031 - GRAPH 3

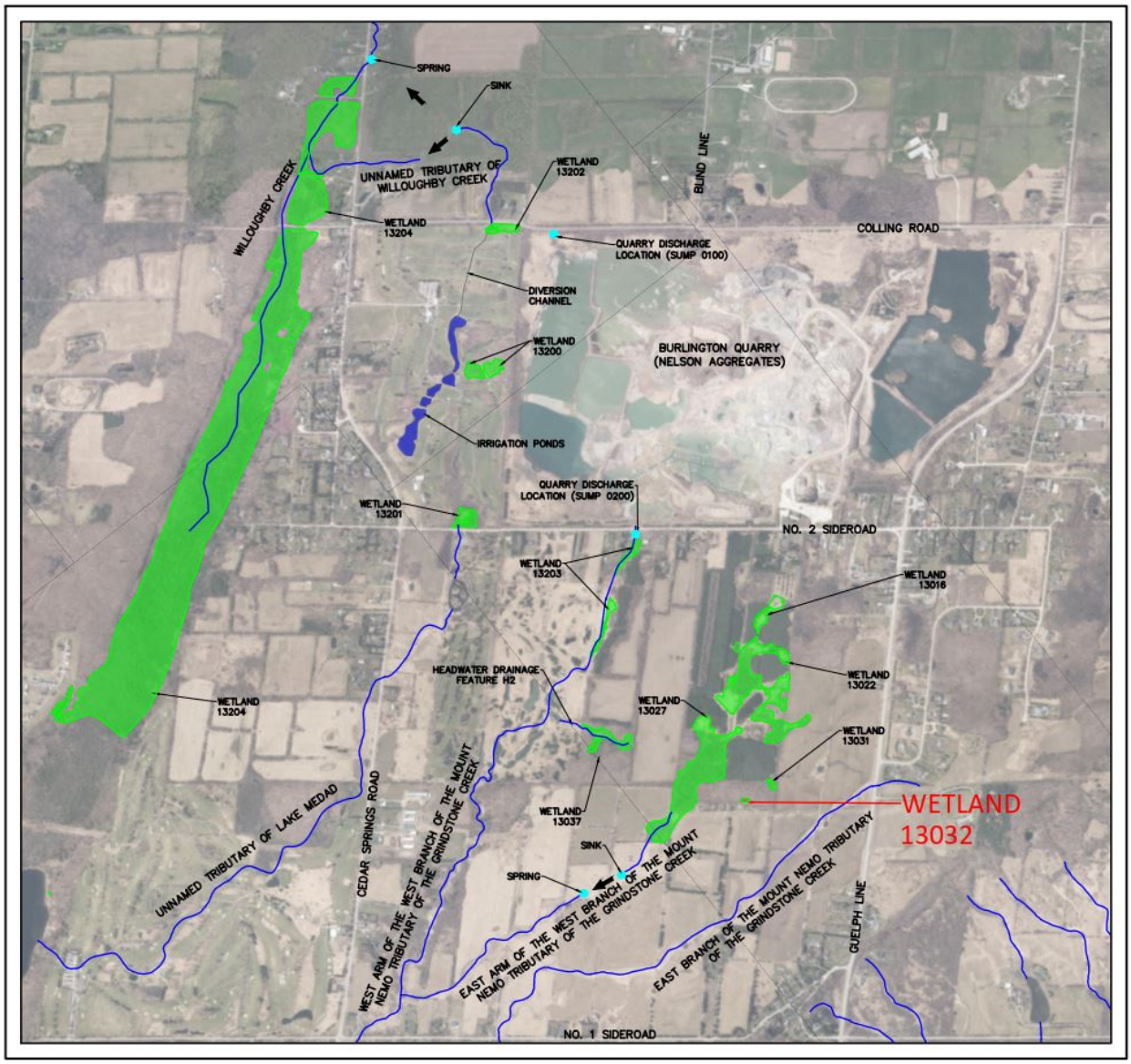
Groundwater Hydrograph
Wetland 13031

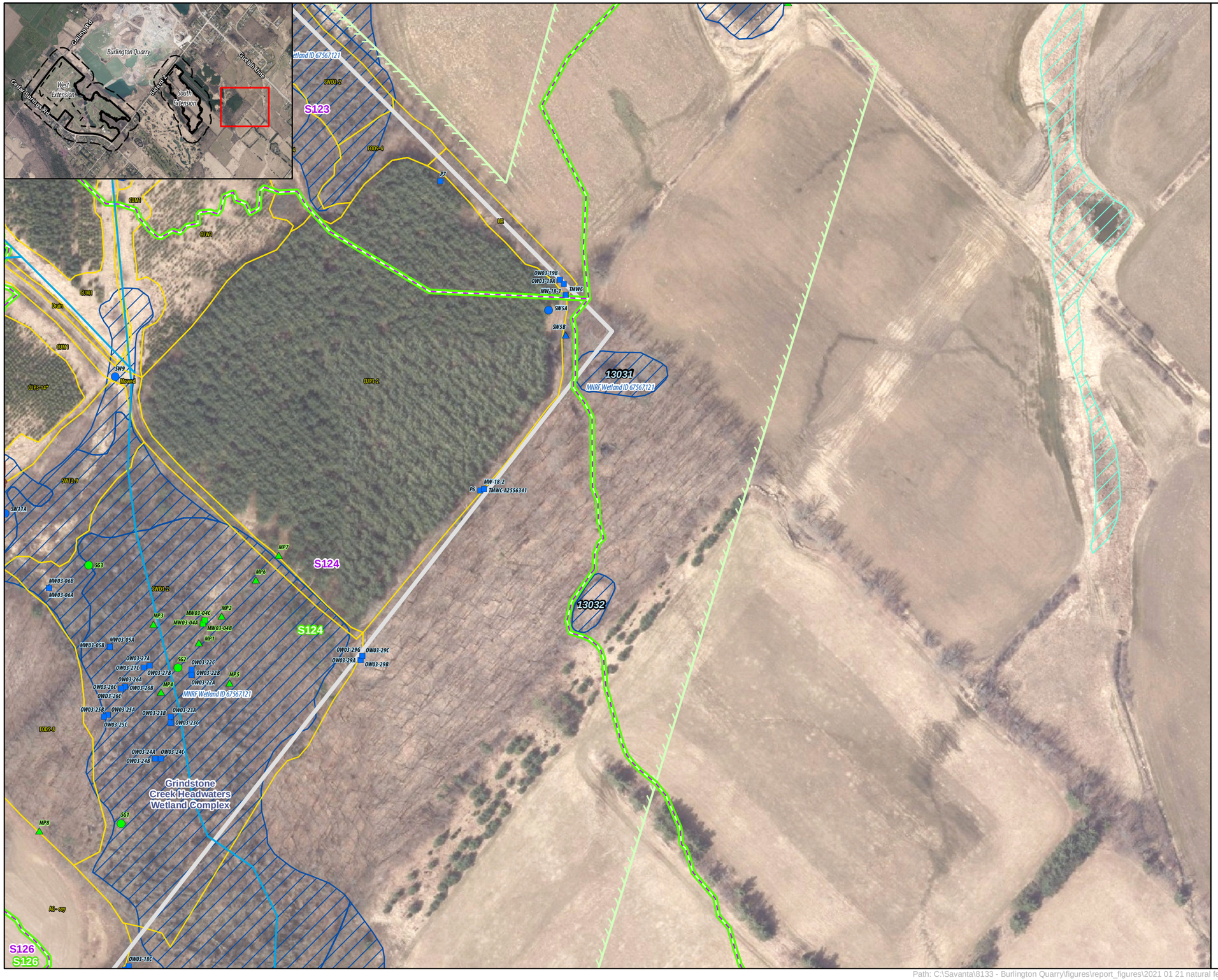


Integrated Model Calibration
Wetland 13031



WETLAND 13032





Legend

- Subject Lands
- Salamander Habitat Assessment (2019)
- Indirect Fish Habitat
- Existing Subcatchment Boundary (Tatham Engineering, 2020)
- Proposed Subcatchment Boundary - Operations and Post-Rehabilitation (Tatham Engineering, 2020
- Ecological Land Classification (Savanta, 2019 & 2020)
- Provincially Significant Wetland (LIO/MNRF, 2020)
- Wetland - Not Evaluated per OWES (MNRF/LIO, 2020)
- MECP Jefferson Salamander Regulated Habitat

Current Instrumentation

- Groundwater Monitoring Station (EarthFx)
- Mini Piezometer (Tatham Engineering)
- Staff Gauge & Surface Water Monitoring Station (Tatham Engineering)

Previous Instrumentation

- Groundwater Monitoring Station (Golder)
- Mini Piezometer (Golder)
- Staff Gauge & Surface Water Monitoring Station (Golder)

ELC Legend

AG, Agriculture
CUM1, Mineral Cultural Meadow
CUP3-2, White Pine Coniferous Plantation
CUP3-13*, White Spruce Coniferous Plantation
CUP3-14*, White Cedar Coniferous Plantation
CUT1-4, Gray Dogwood Cultural Thicket
CUW1, Mineral Cultural Woodland
FOD5-8, Dry – Fresh Sugar Maple – White Ash Deciduous Forest
FOD9-4, Fresh – Moist Shagbark Hickory Deciduous Forest
HR, Hedgerow
MAM2-2, Reed-canary Grass Mineral Meadow Marsh
SWD2-2, Green Ash Mineral Deciduous Swamp
SWD3-2, Silver Maple Mineral Deciduous Swamp
SWT2-9, Gray Dogwood Mineral Thicket Swamp

NOTES:

1. Coordinate System: NAD 1983 UTM Zone 17N.
2. Base features produced under license with the Ontario Ministry of Natural Resources and Forestry © Queen's Printer for Ontario, 2021.
3. Orthoimagery © First Base Solutions, 2021. Imagery taken in 2019.

Project 8133

Burlington Quarry Extension
Nelson Aggregates Co.

Figure 4
Wetland Characterization

Wetland 13031 and 13032 - South Extension

0 30 m
1:2,000

N

GEI Consultants
Savanta Division

Wetland 13032

Wetland Characteristics	Description	Figure / Graph	Reference	
			Report	Section / Page
Wetland IDs:	MNRF – 67567121 (OGF ID 67567150) Earthfx – 19 Tatham – 13032 Savanta – 13032 Golder (Background) - 13032			
Wetland Area (ha):	LIO/MNRF - 0.04			
Watershed:	Grindstone Creek Watershed			
Sub-Watershed:	East Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek			
Located in Proposed Limit of Extraction:	No			
Located in Proposed License Boundary:	No			
Catchment Area (ha):	N/A			
Catchment ID:	N/A			
Closed or Connected System:	Isolated Feature			
Condition:	Natural			
Bathymetry:	Bathymetry unavailable; off-site wetland without permission to survey.			
Outlet:	Isolated Feature			
Hydroperiod:	It is understood a permanent pool of water is maintained in Wetland 13032 year-round.			
Surface Water Monitoring:	MNRF Wetland 13032 was monitored in 2007 by the H Pond Staff Gauge (HPond SG). In addition to the staff gauge in the pond, two drive point mini-piezometers were installed near this pond in 2007. These drive points were always dry, indicating that the pond is perched above the water table.		HHIAR (Earthfx, April 2020)	158

Water Level Measurement Summary			
	Pond	DP1	DP2
Ref:	283.09	284.09	283.31
GS:	-	283.29	282.63
Date	Water Level Elevations		
17-May-07	283.40	N/A	N/A
11-Jul-07	283.21	282.25	281.83

Notes:
Ref: = reference point elevation
GS = ground surface elevation
DP1 is adjacent to the pond (north)
DP2 is about 20 m north (downslope) of the pond

Natural Heritage and Habitat Features	Description	Figure / Graph	Reference	
			Report	Section / Page
Wetland Name & Provincial Significance Evaluation:	Grindstone Creek Headwaters Wetland Complex – Provincially Significant		NETR (Savanta, April 2020)	6.1.2
ELC Unit(s):	Unknown – outside of 120 m adjacent lands			
Regulated Habitat (MECP):	Yes – Jefferson Salamander (not field verified during 2019 field program; regulated based on historical data) Hydroperiod sensitive species; water presence necessary until end of June		NETR (Savanta, April 2020)	6.7
Significant Wildlife Habitat:	Unknown – outside of 120 m adjacent lands			
Fish Habitat:	None			
Habitat of Endangered and Threatened Species:	Unknown – outside of 120 m adjacent lands			

<table>
<tr><th>Groundwater Interaction</th><th>Description</th><th>Figure / Graph</th><th colspan="2">Reference</th></tr>
<tr><th></th><th></th><th></th><th>Report</th><th>Section / Page</th></tr>
<tr><td>Lithology:</td><td>Halton Till</td><td></td><td></td><td></td></tr>
<tr><td>Hydraulic Conductivity:</td><td>Integrated Model (Earthfx) - The harmonic mean hydraulic conductivity, based on testing by Golder (2007) of 10 mini-piezometers, was 1.2x10^{-8} m/s. Model value for the vertical hydraulic conductivity was 1.6x10^{-7} m/s, about an order of magnitude higher, to account for limited flow through fractures in the till.</td><td></td><td></td><td></td></tr>
<tr><td>Surface Water/Groundwater Interaction:</td><td>The low permeability of the Halton Till underlying the wetland is the dominant control on 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. This wetland receives no significant groundwater inflow, and is isolated from any changes in the water table due to quarry development.</td><td></td><td></td><td></td></tr>
<tr><td>Background Shallow Groundwater (Mini-piezometer) Monitoring:</td><td>
<table>
<tr><td>Mini-piezometer ID</td><td>Ground Elevation</td><td>Bottom Elevation</td><td>Average WL</td><td>Logger</td><td>Manual Meas.</td></tr>
<tr><td>DP1</td><td>283.29</td><td>282.25</td><td>Dry</td><td>-</td><td>2007.00</td></tr>
<tr><td>DP2</td><td>282.63</td><td>281.83</td><td>Dry</td><td>-</td><td>2007.00</td></tr>
</table>
</td><td></td><td></td><td></td></tr>
<tr><td>Groundwater Monitoring (Monitoring Wells):</td><td>
<table>
<tr><td>Monitoring Well ID</td><td>Distance (Dir.)</td><td>Geologic Unit</td><td>Ground Elevation</td><td>Monitoring Elev</td><td>Average WL</td></tr>
<tr><td>OW03-29A</td><td>126 (W)</td><td>Bedrock</td><td>277.06</td><td>256.46 - 248.92</td><td>274.84</td></tr>
<tr><td>OW03-29B</td><td>126 (W)</td><td>Bedrock</td><td>277.05</td><td>273.93 - 266.83</td><td>275.47</td></tr>
<tr><td>OW03-29C</td><td>126 (W)</td><td>Overburden</td><td>277.02</td><td>276.72 - 275.12</td><td>275.79</td></tr>
<tr><td>OW03-29G</td><td>126 (W)</td><td>Overburden</td><td>277.02</td><td>-</td><td>-</td></tr>
</table>
</td><td>Graph 1</td><td></td><td></td></tr>
<tr><td>Water Budget Results:</td><td>A detailed average water budget, as simulated by the integrated model, is provided in the main report for Baseline Conditions (Earthfx Figure 7.27, p. 188). The baseline water budget is reproduced in Figure 1a. The wetland is a net provider of groundwater and never receives groundwater inflow. Simulated groundwater levels, groundwater discharge to riparian areas, and streamflow in the vicinity of Wetland 13032 (Earthfx Wetland 19) are discussed in Section 7 of the main report.
<table>
<tr><td>Wetland 13032</td><td>GW Outflow (%)</td><td>GW Inflow (%)</td></tr>
<tr><td>Baseline (Existing)</td><td>19.82</td><td>0.00</td></tr>
</table>
</td><td>Figure 1a</td><td>HHIAR (Earthfx, April 2020)</td><td>165 - 190</td></tr>
<tr><td>Integrated Model Calibration:</td><td>Earthfx Figures 6.35 and 6.36 (p.159) in the Main Report shows data for the H Pond staff gauge along with hydrographs of simulated shallow water levels. The results are reproduced in Graph 2. A discussion of Wetland 19 is contained in Earthfx Section 6.11.6.3 (p. 158).</td><td>Graph 2</td><td></td><td></td></tr>
</table>

Impact Assessment (Operations Phases 1 & 2)	Description	Figure / Graph	Reference	
			Report	Section / Page
Change in Wetland Area (ha):	No change. Wetland located greater than 120 m from licensed boundary.		SWA (Tatham, April 2020)	4.2.1
Change in Wetland Catchment Area (ha):	No change. Subcatchment area protected.		SWA (Tatham, April 2020)	4.2.1 & Drawing DP-2
Change in Hydroperiod:	No Change. Wetland is perched and isolated from the groundwater system. Subcatchment area being protected.		SWA (Tatham, April 2020)	4.2.1
Change in Water Budget:	A detailed average water budget as simulated by the integrated model is provided in the Earthfx report for Baseline Conditions (Figure 7.28, p. 188); Scenario P12 (Figure 8.34, p. 223); and P3456 (Figure 8.66, p. 250). The water budget results for Scenario P12 are reproduced in Figure 1b. Simulated change in groundwater levels (drawdowns), groundwater discharge to riparian areas, and change in streamflow in the vicinity of Wetland 13032 (Earthfx Wetland 19) for each scenario are discussed in Section 8 of the main report.	Figure 1b	HHIAR (Earthfx, April 2020)	191 - 303
Change on Soil Moisture Conditions:	The Water Budget figures indicate that there is no groundwater seepage entering the wetland under baseline conditions, so there will be no change under P12 conditions.			
Potential Impact to Form and Function of Feature:	No wetlands will be removed and the wetlands subcatchment will be protected. There will be no encroachment from the project into the wetland. The proposed limit of extraction is >120 m from the wetland boundary. Licensed boundary will be demarcated and fenced to ensure site construction and operations do not extend beyond the proposed limits of the project .			

Wetland 13032	GW Outflow (%)	GW Inflow (%)	Change in GW	Change in GW
Baseline (Existing)	19.82	0.00	-	-
Operations Ph 1 & 2	19.35	0.00	-0.47	0.00

Mitigation (Operational Phases 1 & 2)	Description	Figure / Graph	Reference	
			Report	Section / Page
Proposed Mitigation Measures:	None required.			

Impact Assessment (Operations Phases 3 - 6)	Description	Figure / Graph	Reference	
			Report	Section / Page
Change in Wetland Area (ha):	No change. Wetland located greater than 120 m from licensed boundary.		SWA (Tatham, April 2020)	4.2.1
Change in Wetland Catchment Area (ha):	No change. Subcatchment area protected.		SWA (Tatham, April 2020)	4.2.1 & Drawing DP-2
Change in Hydroperiod:	No Change. Wetland is perched and isolated from the groundwater system. Subcatchment area being protected.		SWA (Tatham, April 2020)	4.2.1
Change in Water Budget:	A detailed average water budget as simulated by the integrated model is provided in the Earthfx report for Baseline Conditions (Figure 7.28, p. 188); Scenario P12 (Figure 8.34, p. 223); and P3456 (Figure 8.66, p. 250). The water budget results for Scenario P3456 are reproduced in Figure 1c. Simulated change in groundwater levels (drawdowns), groundwater discharge to riparian areas, and change in streamflow in the vicinity of Wetland 13032 (Earthfx Wetland 19) for each scenario are discussed in Section 8 of the main report.	Figure 1c	HHIAR (Earthfx, April 2020)	191 - 303
Potential Impact to Form and Function of Feature:	No wetlands will be removed and the wetlands subcatchment will be protected. There will be no encroachment from the project into the wetland. The proposed limit of extraction is >120 m from the wetland boundary. Licensed boundary will be demarcated and fenced to ensure site construction and operations do not extend beyond the proposed limits of the project .			

Wetland 13032	GW Outflow (%)	GW Inflow (%)	Change in GW	Change in GW
Baseline (Existing)	19.82	0.00	-	-
Operations Ph 3 - 6	19.79	0.00	-0.03	0.00

Mitigation (Operational Phases 3 - 6)	Description	Figure / Graph	Reference	
			Report	Section / Page
Proposed Mitigation Measures:	None required.			

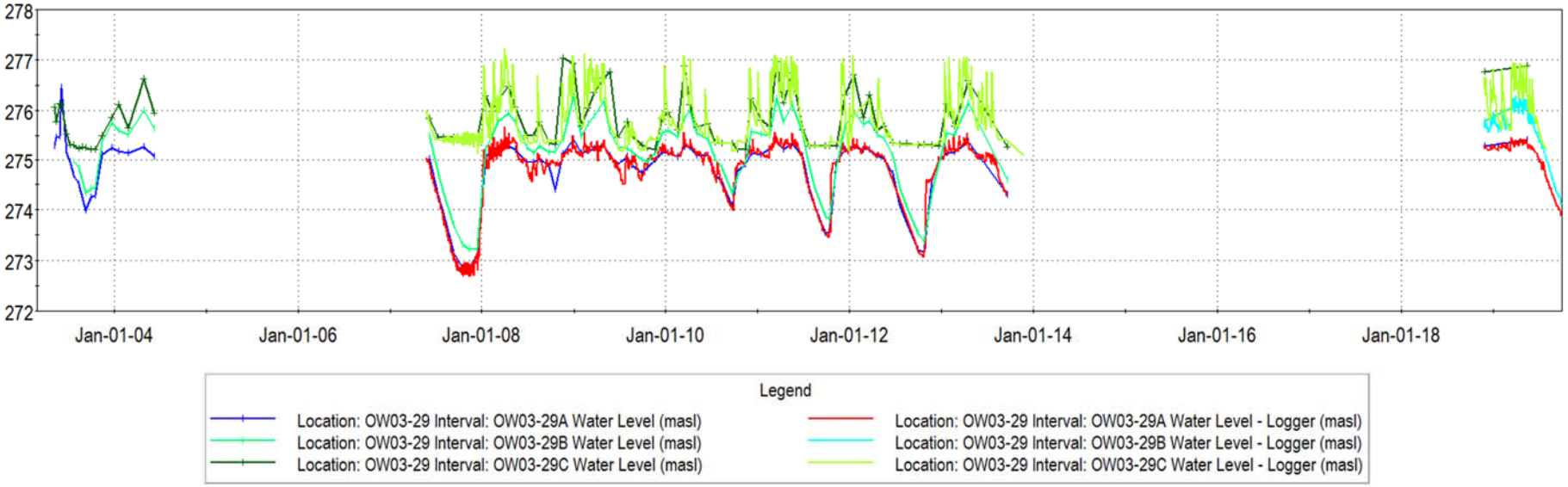
Impact Assessment (Rehabilitation)	Description	Figure / Graph	Reference	
			Report	Section / Page
Change in Wetland Area (ha):	No change. Wetland located greater than 120 m from licensed boundary.		SWA (Tatham, April 2020)	5.4.1
Change in Wetland Catchment Area (ha):	No change. Subcatchment area protected.		SWA (Tatham, April 2020)	5.4.1 & Drawing DP-3
Change in Hydroperiod:	No Change. Wetland is perched and isolated from the groundwater system. Subcatchment area being protected.		SWA (Tatham, April 2020)	5.4.1
Change in Water Budget:	A detailed average water budget as simulated by the integrated model is provided in the Earthfx report for Baseline Conditions (Figure 7.28, p. 188); Scenario P12 (Figure 8.34, p. 223); and P3456 (Figure 8.66, p. 250). The water budget results for Scenario RHB1 and RHB2 are reproduced in Figures 1d and 1e. Simulated change in groundwater levels (drawdowns), groundwater discharge to riparian areas, and change in streamflow in the vicinity of Wetland 13032 (Earthfx Wetland 19) for each scenario are discussed in Section 8 of the main report.	Figure 1d and 1e	HHIAR (Earthfx, April 2020)	191 - 303
Potential Impact to Form and Function of Feature:	No wetlands will be removed and the wetlands subcatchment will be protected. There will be no encroachment from the project into the wetland. The proposed limit of extraction is >120 m from the wetland boundary. Licensed boundary will be demarcated and fenced to ensure site construction and operations do not extend beyond the proposed limits of the project .			

Wetland 13027	GW Outflow (%)	GW Inflow (%)	Δ in Outflow (%)	Δ in Inflow (%)
Baseline (Existing)	19.82	0.00	-	-
Rehab Scenario 1	20.94	0.00	1.12	0.00
Rehab Scenario 2	20.30	0.00	0.48	0.00

Mitigation (Rehabilitation)	Description	Figure / Graph	Reference	
			Report	Section / Page
Proposed Mitigation Measures:	None required.			

WETLAND 13032 - GRAPH 1

Groundwater Hydrograph
Wetland 13032



WETLAND 13032

FIGURE 1A

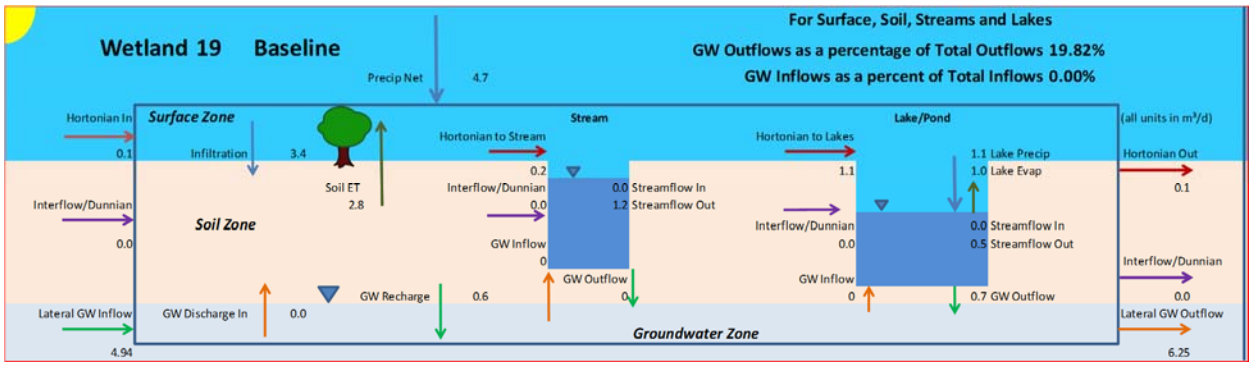


FIGURE 1B

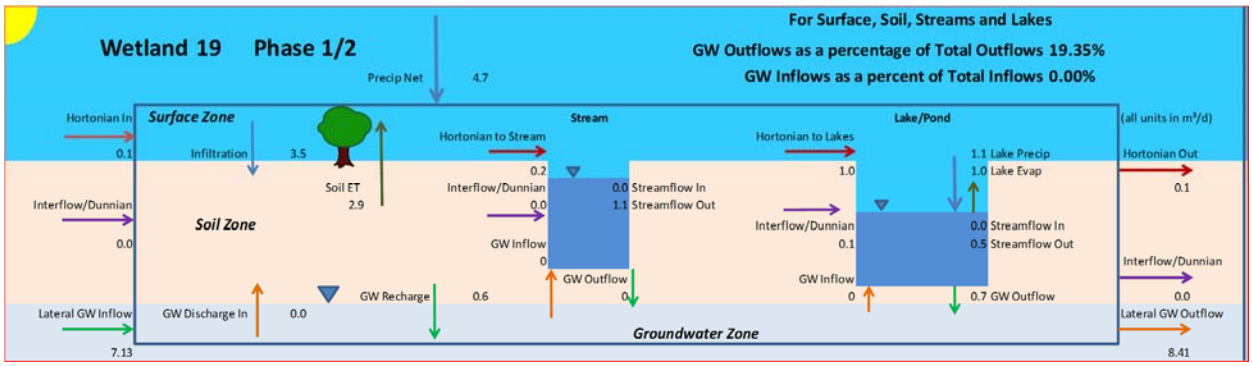


FIGURE 1C

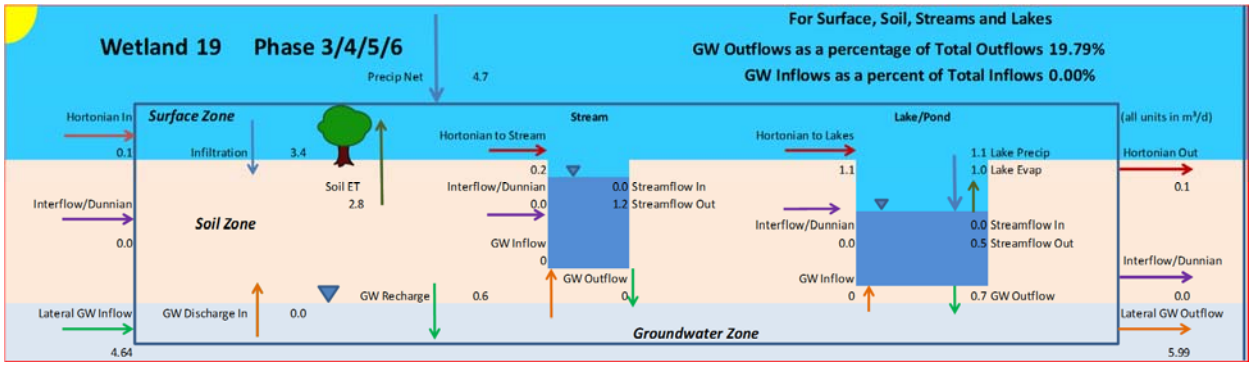


FIGURE 1D

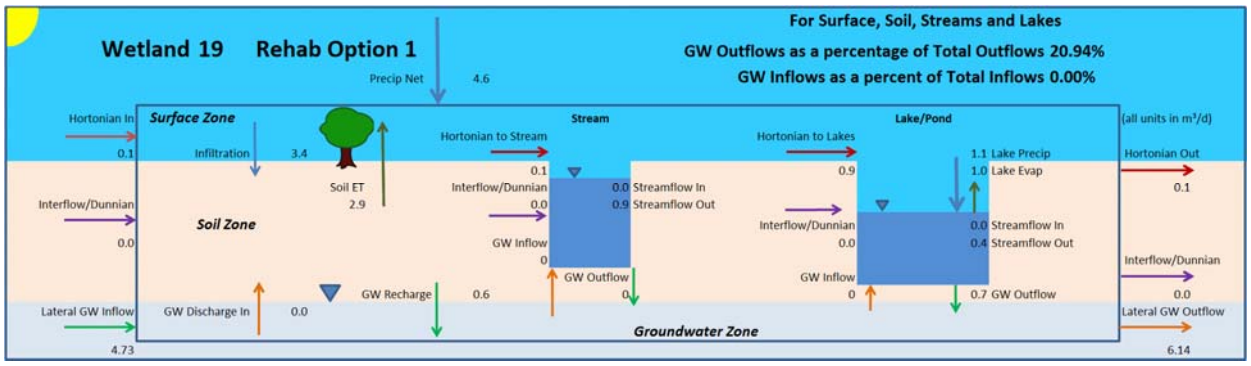
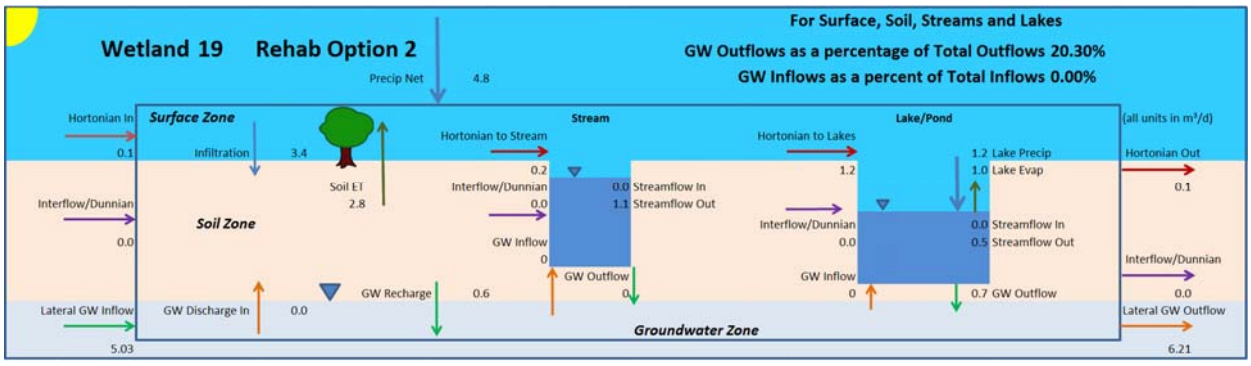
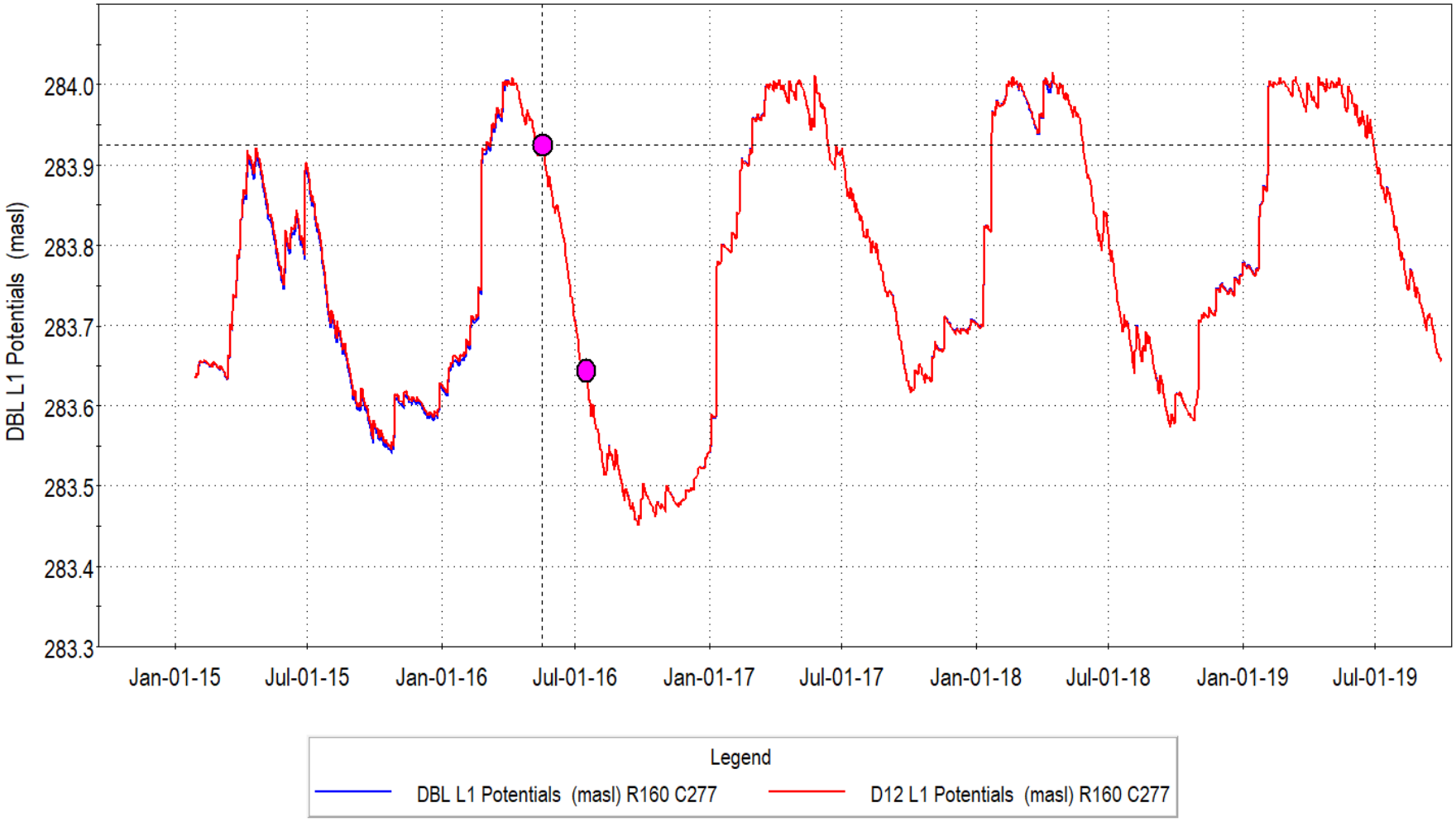


FIGURE 1E

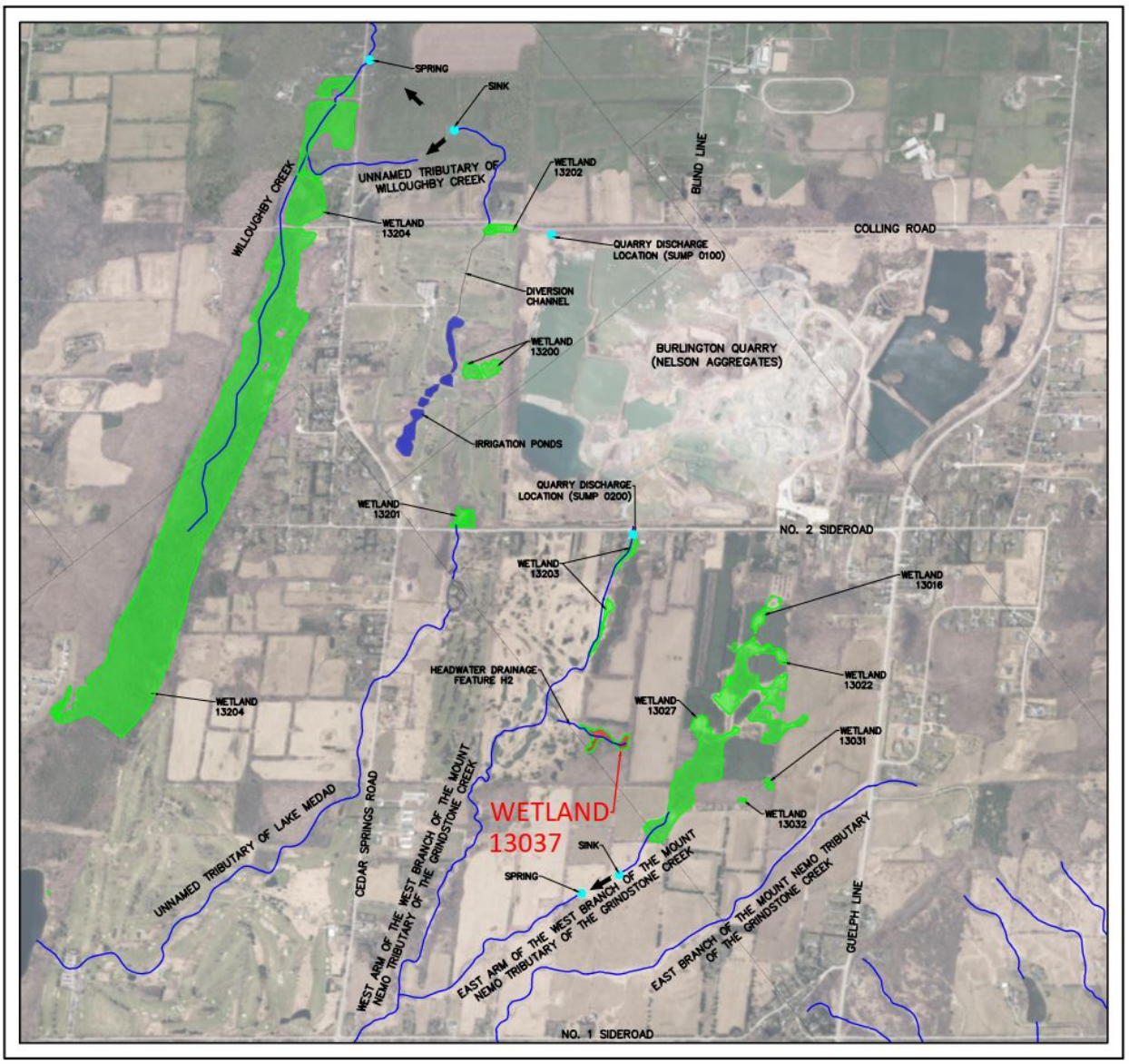


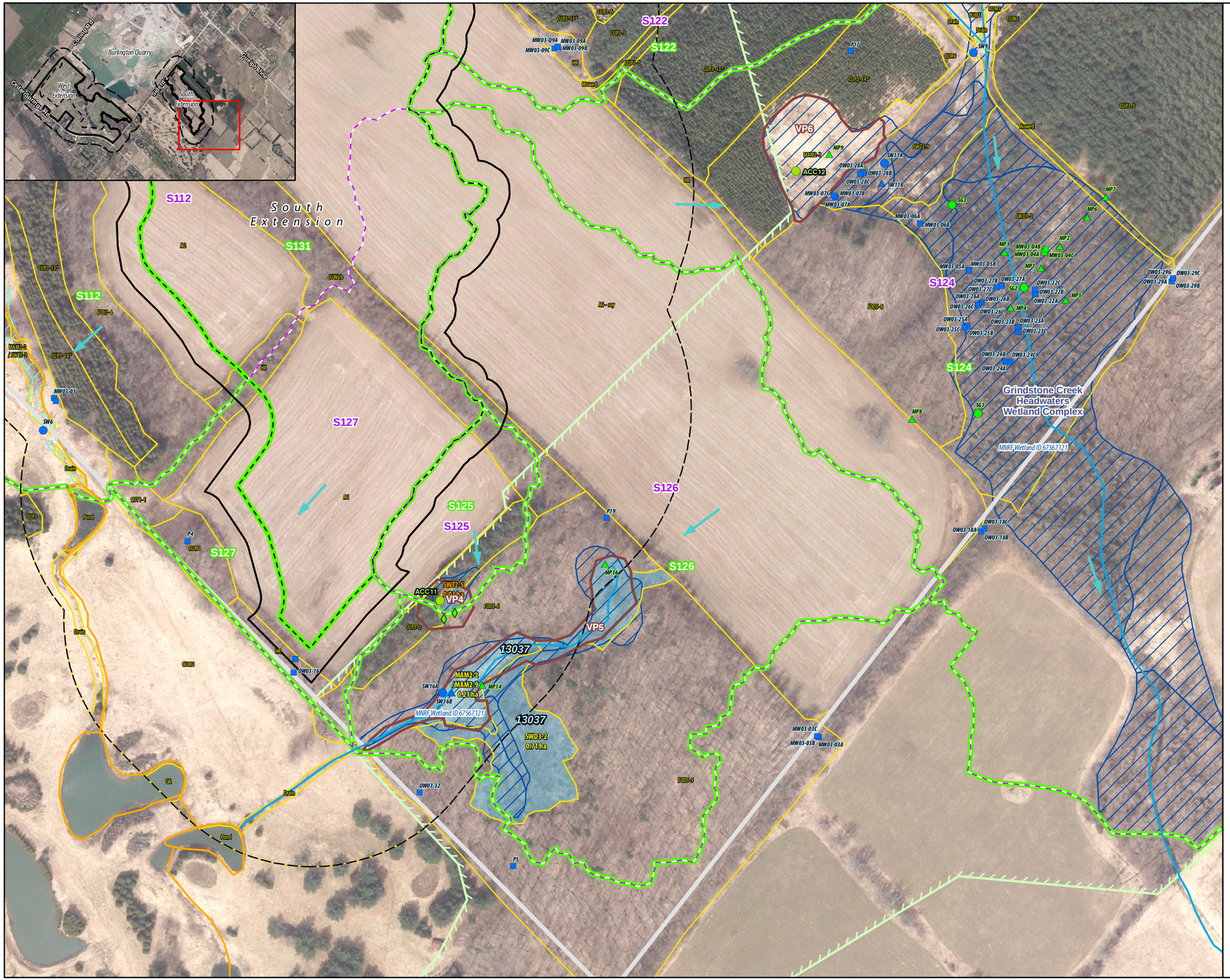
WETLAND 13032 - GRAPH 2

Integrated Model Calibration
Wetland 13032



WETLAND 13037





Legend

- Licensed Boundary
- Limit of Extraction
- 120 m Adjacent Lands
- Subject Lands
- Amphibian Call Count Station (2019)
- Salamander Trap (2019)
- Salamander Habitat Assessment (2019)
- Indirect Fish Habitat
- Direct Fish Habitat
- Existing Subcatchment Boundary (Tatham Engineering, 2020)
- Proposed Subcatchment Boundary - Operations and Post-Rehabilitation (Tatham Engineering, 2020
- Wetland (Savanta, 2020)
- Ecological Land Classification (Savanta, 2019 & 2020)
- Provincially Significant Wetland (LIO/MNRF, 2020)
- Wetland - Not Evaluated per OWES (MNRF/LIO, 2020)
- MECP Jefferson Salamander Regulated Habitat

Current Instrumentation

- Groundwater Monitoring Station (EarthFx)
- Mini Piezometer (Tatham Engineering)
- Staff Gauge & Surface Water Monitoring Station (Tatham Engineering)

Previous Instrumentation

- Groundwater Monitoring Station (Golder)
- Mini Piezometer (Golder)
- Staff Gauge & Surface Water Monitoring Station (Golder)

ELC Legend

AG, Agriculture
CUM1, Mineral Cultural Meadow
CUP3, Coniferous Plantation
CUP3-2, White Pine Coniferous Plantation
CUP3-6, European Larch Coniferous Plantation
CUP3-13*, White Spruce Coniferous Plantation
CUP3-14*, White Cedar Coniferous Plantation
CUT1-1, Sumac Cultural Thicket
CUW1, Mineral Cultural Woodland
FOD5-5, Dry – Fresh Sugar Maple – Hickory Deciduous Forest
FOD5-6, Dry- Fresh Sugar Maple-Basswood Deciduous Forest
FOD5-8, Dry – Fresh Sugar Maple – White Ash Deciduous Forest
FOD7-4, Fresh – Moist Black Walnut Lowland Deciduous Forest
HR, Hedgerow
MAM2-2, Reed-canary Grass Mineral Meadow Marsh
MAM2-9, Jewelweed Mineral Meadow Marsh
OA, Open Aquatic
SWD3-2, Silver Maple Mineral Deciduous Swamp
SWT2-2, Willow Mineral Thicket Swamp
SWT2-5, Red-osier Dogwood Mineral Thicket Swamp
SWT2-9, Gray Dogwood Mineral Thicket Swamp

NOTES:

1. Coordinate System: NAD 1983 UTM Zone 17N.
2. Base features produced under license with the Ontario Ministry of Natural Resources and Forestry © Queen's Printer for Ontario, 2021.
3. Orthoimagery © First Base Solutions, 2021. Imagery taken in 2019.

Project 8133

Burlington Quarry Extension
Nelson Aggregates Co.

Figure 5
Wetland Characterization
Wetland 13037 - South Extension

0 40 m
1:2,500

N

GEI Consultants
Savanta Division

Path: C:\Savanta\8133 - Burlington Quarry\figures\report_figures\2021 01 21 natural feature tech summary\8133_rpt_wetland_char_mapbook.mxd Date S...uary 11, 2021

Wetland 13037

Wetland Characteristics	Description	Figure / Graph	Reference	
			Report	Section / Page
Wetland IDs:	MNRF – 67567121 (OGF ID 67567139, 67567128, 67567138, 67567132) Earthfx - 20 Tatham – 13036, 13037 Savanta - 13037 Golder (Background) – 13036, 13037, 13038, 13039			
Wetland Area (ha):	LIO/MNRF - 1.05 Savanta - 0.95			
Watershed:	Grindstone Creek Watershed			
Sub-Watershed:	West Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek			
Located in Proposed Limit of Extraction:	No			
Located in Proposed License Boundary:	No			
Catchment Area (ha):	10.05		SWA (Tatham, April 2020)	Drawing DP-1
Catchment ID:	S125, S126		SWA (Tatham, April 2020)	Drawing DP-1
Closed or Connected System:	On-line (connected to downstream watercourse)			
Condition:	Natural			
Bathymetry:	A bathymetry survey of Wetland 13037 was completed by Tatham Engineering Limited and incorporated into the integrated model (see Earthfx Section 18.3, p.381). Wetland lakes were assigned to Layer 1 of the integrated model by adjusting the base of Layer 1 to correspond with the interpolated bottom elevation. Care was taken to ensure that the lowest elevation observed in the wetland was honored in the assigned elevations.	Figure 1	HHIAR (Earthfx, April 2020)	18.3 (page 381)
Outlet:	Headwater Drainage Feature H2			
Hydroperiod:	Spring Hydroperiod (date wetland dries out) – May 25th – August 26th Fall Hydroperiod (start of hydroperiod) – September 6th – December 25th	Graph 1	SWA (Tatham, April 2020)	2.2.5, 3 and Appendix F
Surface Water Monitoring:	ID: SW16A (Tatham) Installation Date: October 23, 2018 Data Collection: Continuous water level and temperature and manual monthly water level measurements Coordinates of Monitoring Station: Easting 590888.61, Northing 4804899.887	Graph 1	SWA (Tatham, April 2020)	2.2.5, 3 and Appendix F

Natural Heritage and Habitat Features	Description	Figure / Graph	Reference	
			Report	Section / Page
Wetland Name & Provincial Significance Evaluation:	Grindstone Creek Headwaters Wetland Complex – Provincially Significant		NETR (Savanta, April 2020)	6.1.2
ELC Unit(s):	Dogwood Mineral Swamp Thicket: SWT2-5 Reed-canary grass / Jewelweed Mineral Meadow Marsh: MAM2-2/MAM2-9 Silver Maple Mineral Deciduous Swamp: SWD3-2		NETR (Savanta, April 2020)	Table 2
Regulated Habitat (MECP):	Yes – Jefferson Salamander (none observed despite survey effort) Hydroperiod sensitive species; water presence necessary until end of June		NETR (Savanta, April 2020)	6.1.2
Significant Wildlife Habitat:	None confirmed for amphibian breeding, despite survey effort through salamander habitat assessments, salamander trapping and call count surveys.		NETR (Savanta, April 2020)	4.2.2; 4.2.3; 4.2.5; 5.2.2; 5.2.3; 5.2.5; 6.4; Table 19
Fish Habitat:	Indirect		NETR (Savanta, April 2020)	6.6
Habitat of Endangered and Threatened Species:	No species at risk salamanders observed, despite survey effort including salamander habitat assessment, salamander trapping and egg mass surveys.		NETR (Savanta, April 2020)	4.2.2; 4.2.3; 5.2.2; 5.2.3; 6.7

Groundwater Interaction	Description	Figure / Graph	Reference	
			Report	Section / Page
Lithology:	Halton Till			
Hydraulic Conductivity:	Integrated Model (Earthfx) - The harmonic mean hydraulic conductivity, based on testing by Golder (2007) of 10 mini-piezometers, was $1.2x10^{-8}$ m/s. Model value for the vertical hydraulic conductivity was $1.6x10^{-7}$ m/s, about an order of magnitude higher, to account for limited flow through fractures in the till. Wetland Water Balance (Tatham) – $1.2x10^{-10}$ m/s.			
Surface Water/Groundwater Interaction:	The low permeability of the Halton Till underlying the wetland is the dominant control on 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. This wetland receives some groundwater inflow but is relatively isolated from changes in the water table due to quarry development.			
Shallow Groundwater (Mini-piezometer) Monitoring:	ID: SW16B (Tatham) Installation Date: October 23, 2018 Data Collection: Continuous water level and temperature and manual monthly water level measurements Coordinates of Monitoring Station: Easting 590888.61, Northing 4804899.887	Graph 2	SWA (Tatham, April 2020)	2.3 and Appendix G

Background Shallow Groundwater (Mini-piezometer) Monitoring: — Graph 3

Mini-piezometer ID	Ground Elevation	Bottom Elevation	Average WL	Logger	Manual Meas.
Golder MP14	274.57	273.37	270.93	-	2007-2013
Golder MP16	276.37	275.17	273.45	2007-2013	2007-2013

Groundwater Monitoring (Monitoring Wells): — Graph 3

Monitoring Well ID	Distance (Dir.)	Geologic Unit	Ground Elevation	Monitoring Elev	Average WL
OW03-32A	78 (SSW)	Bedrock	278.00	265.0 - 254.4	268.62
OW03-32B	78 (SSW)	Bedrock	271.00	269.1 – 261.3	268.64
OW03-16A	114 (W)	Bedrock	272.20	254.4 – 246.6	268.28
OW03-16B	114 (W)	Bedrock	272.20	269.3 – 262.2	270.22
OW03-16C	112 (W)	Bedrock	272.30	270.0 – 268.4	270.55
MW03-03A	212 (E)	Bedrock	274.80	255.6 – 251.6	273.33
MW03-03B	212 (E)	Bedrock	274.80	264.7 – 260.8	273.69
MW03-03C	212 (E)	Overburden	274.70	274.1 – 272.1	272.93

Water Budget Results: — Figure 2a — HHIAR (Earthfx, April 2020) — 165 - 190

A detailed average water budget, as simulated by the integrated model, was not presented in the Main report but is provided in Figure 2a. The wetland is a net provider of groundwater. Simulated groundwater levels, groundwater discharge to riparian areas, and streamflow in the vicinity of Wetland 13016 (Earthfx Wetland 11) for baseline conditions is discussed in Section 7 of the main report.

Wetland 13037	GW Outflow (%)	GW Inflow (%)
Baseline (Existing)	12.84	1.76

Integrated Model Calibration: — Graphs 4 & 5

Two mini-piezometers in Wetland 20 provide multiple years of monitoring in the soil zone and upper weathered Halton Till. These monitors correspond to the PRMS soil zone and upper-most part of Layer 1 of the GSFLOW model. A comparison of the mini-piezometer data to the simulated soil moisture conditions (see Graphs 4 and 5) demonstrates that the model is closely matching both the soil moisture and hydroperiod of the shallow subsurface at this wetland. Based on recent measurements at SW16B, it appears that the historic data at MP14 may have an elevation offset. The timing of the simulated response does, however, match the recorded data.

Earthfx Figure 6.29 (p.154) and Figure 19.44 (p.444) in the Main Report shows a hydrograph for Golder MP16 along with simulated shallow water levels. The figure is reproduced in Graphs 4 and 5. Note that the total range in observed water level fluctuation is less than 40 cm. A brief discussion of the Wetland 20 is contained in Earthfx Section 6.11.4 (p. 152). A more detailed discussion is provided in Appendix E, Section 19.6 (p. 443).

Graph 6 — HHIAR (Earthfx, April 2020) — 154, 443 - 444

<table>
<tr><th>Impact Assessment (Operations Phases 1 & 2)</th><th>Description</th><th>Figure / Graph</th><th colspan="2">Reference</th></tr>
<tr><th></th><th></th><th></th><th>Report</th><th>Section / Page</th></tr>
<tr><td>Change in Wetland Area (ha):</td><td>No change. Wetland located greater than 120 m from licensed boundary.</td><td></td><td>SWA (Tatham, April 2020)</td><td>4.2.1</td></tr>
<tr><td>Change in Wetland Catchment Area (ha):</td><td>No change. Subcatchment area protected.</td><td></td><td>SWA (Tatham, April 2020)</td><td>4.2.1 & Drawing DP-2</td></tr>
<tr><td>Change in Hydroperiod:</td><td>No Change. Wetland is perched and isolated from the groundwater system. Subcatchment area being protected.</td><td></td><td>SWA (Tatham, April 2020)</td><td>4.2.1</td></tr>
<tr><td>Change in Water Budget:</td><td>A detailed average water budget as simulated by the integrated model is provided in the Earthfx report for Baseline Conditions (Figure 7.28, p. 188); Scenario P12 (Figure 8.35, p. 223); P3456 (Figure 8.67, p. 250); RHB1 (Figure 8.102, p. 279), and RHB2 (Figure 8.129, p. 300). The water budget results for Scenario P12 are reproduced in Figure 2b. Simulated change in groundwater levels (drawdowns), groundwater discharge to riparian areas, and change in streamflow in the vicinity of Wetland 13037 (Earthfx Wetland 20) for each scenario are discussed in Section 8 of the main report.
<table>
<tr><td>Wetland 13037</td><td>GW Outflow (%)</td><td>GW Inflow (%)</td><td>Δ in Outflow (%)</td><td>Δ in Inflow (%)</td></tr>
<tr><td>Baseline (Existing)</td><td>12.84</td><td>1.76</td><td>-</td><td>-</td></tr>
<tr><td>Operations Ph 1 & 2</td><td>15.90</td><td>0.00</td><td>3.45</td><td>-1.76</td></tr>
</table></td><td>Figure 2b</td><td>HHIAR (Earthfx, April 2020)</td><td>191 - 303</td></tr>
<tr><td>Change on Soil Moisture Conditions:</td><td>The soil moisture under Baseline and P12 conditions, as well as Baseline surface discharge (seepage), are shown in Graph 7. The small reduction in soil moisture under P12 conditions is due to the loss of groundwater seepage (due to the drawdown in groundwater levels near the excavation). Under baseline conditions, groundwater seepage occurs as water levels rise in the late spring in response to snowmelt. Seepage fluctuates significantly, however, due to natural inter-annual climate variability. During a dry year (2015-2016) groundwater levels are naturally low, there is limited groundwater seepage, and a very minor difference in soil moisture between Baseline and P12. During an average year (2017-2018) there is small change in the late summer soil moisture conditions due to the loss of groundwater discharge during P12 development. During a wet year there is a modest loss of soil moisture in the May-September time frame. Additional surface water and ground water interaction occurs through the bottom of the ponded water portions of Wetland 20. Pond leakage to the groundwater system is shown in Graph 8. Negative seepage indicates groundwater is upwelling into the pond. Under Baseline conditions, the ponds leak water to the groundwater system for most of the year, and only receive upwelling (negative leakage or seepage) for short periods during the wetter years when the water table is higher. Under P12 conditions (red line), the ponds leak water to the groundwater system at varying rates throughout the year; generally higher in the spring and declining through the summer.</td><td>Graphs 7 & 8</td><td></td><td></td></tr>
<tr><td>Potential Impact to Form and Function of Feature:</td><td>No wetlands will be removed and the wetlands subcatchment will be protected. There will be no encroachment from the project into the wetland. The proposed limit of extraction is >120 m from the wetland boundary. Licensed boundary will be demarcated and fenced to ensure site construction and operations do not extend beyond the proposed limits of the project .</td><td></td><td></td><td></td></tr>
</table>

Mitigation (Operational Phases 1 & 2)	Description	Figure / Graph	Reference	
			Report	Section / Page
Proposed Mitigation Measures:	None required.			

Impact Assessment (Operations Phases 3 - 6)	Description	Figure / Graph	Reference	
			Report	Section / Page
Change in Wetland Area (ha):	No change. Wetland located greater than 120 m from licensed boundary.		SWA (Tatham, April 2020)	4.2.1
Change in Wetland Catchment Area (ha):	No change. Subcatchment area protected.		SWA (Tatham, April 2020)	4.2.1 & Drawing DP-2
Change in Hydroperiod:	No Change. Wetland is perched and isolated from the groundwater system. Subcatchment area being protected.		SWA (Tatham, April 2020)	4.2.1
Change in Water Budget:	A detailed average water budget as simulated by the integrated model is provided in the Earthfx report for Baseline Conditions (Figure 7.28, p. 188); Scenario P12 (Figure 8.35, p. 223); P3456 (Figure 8.67, p. 250); RHB1 (Figure 8.102, p. 279), and RHB2 (Figure 8.129, p. 300). The water budget results for Scenario P3456 are reproduced in Figure 2c. Simulated change in groundwater levels (drawdowns), groundwater discharge to riparian areas, and change in streamflow in the vicinity of Wetland 13037 (Earthfx Wetland 20) for each scenario are discussed in Section 8 of the main report.	Figure 2c	HHIAR (Earthfx, April 2020)	191 - 303
Potential Impact to Form and Function of Feature:	No wetlands will be removed and the wetlands subcatchment will be protected. There will be no encroachment from the project into the wetland. The proposed limit of extraction is >120 m from the wetland boundary. Licensed boundary will be demarcated and fenced to ensure site construction and operations do not extend beyond the proposed limits of the project .			

Wetland 13037	GW Outflow (%)	GW Inflow (%)	Δ in Outflow (%)	Δ in Inflow (%)
Baseline (Existing)	12.84	1.76	-	-
Operations Ph 3 - 6	16.29	0.00	3.45	-1.76

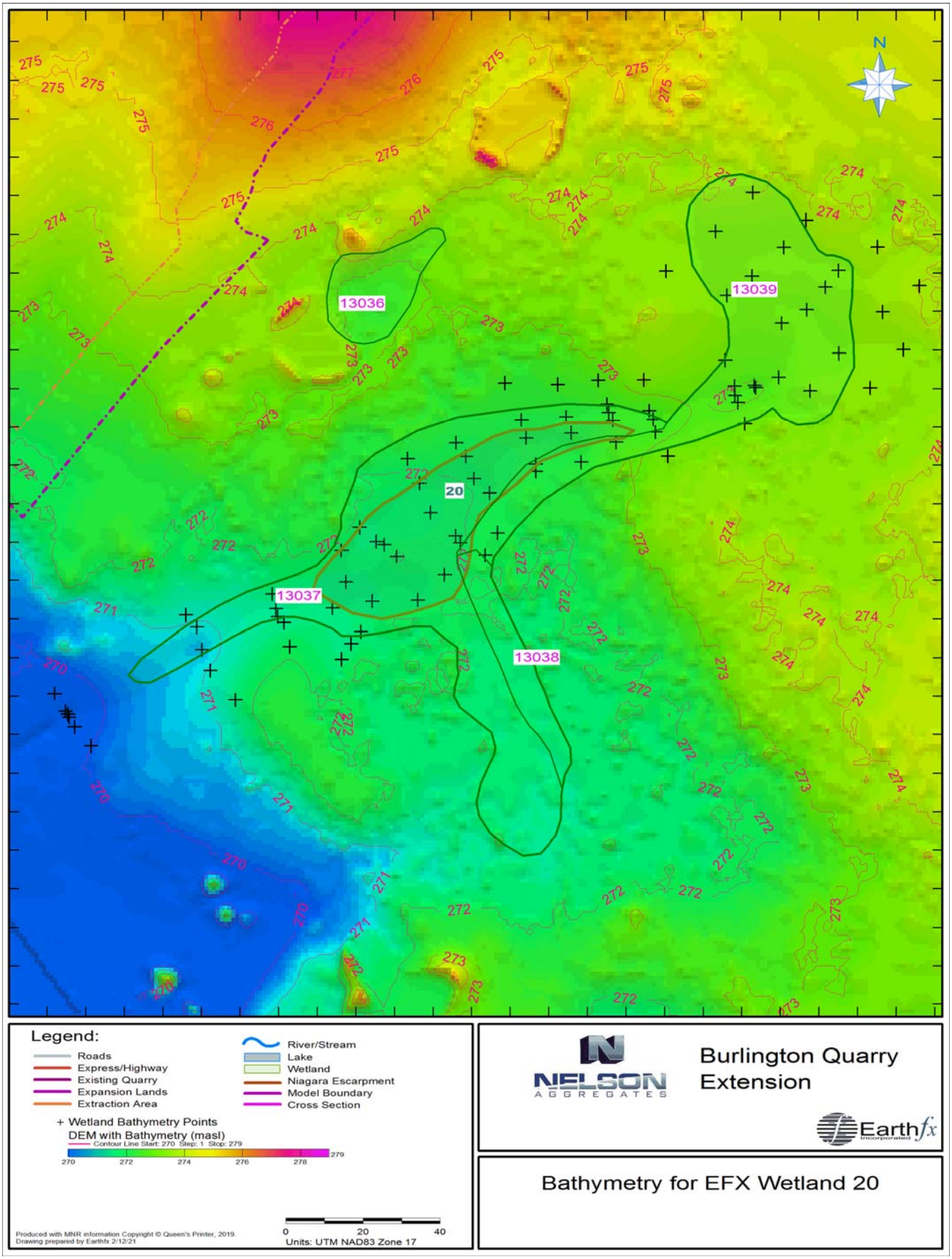
Mitigation (Operational Phases 3 - 6)	Description	Figure / Graph	Reference	
			Report	Section / Page
Proposed Mitigation Measures:	None required.			

Impact Assessment (Rehabilitation)	Description	Figure / Graph	Reference	
			Report	Section / Page
Change in Wetland Area (ha):	No change. Wetland located greater than 120 m from licensed boundary.		SWA (Tatham, April 2020)	5.4.1
Change in Wetland Catchment Area (ha):	No change. Subcatchment area protected.		SWA (Tatham, April 2020)	5.4.1 & Drawing DP-3
Change in Hydroperiod:	No Change. Wetland is perched and isolated from the groundwater system. Subcatchment area being protected.		SWA (Tatham, April 2020)	5.4.1
Change in Water Budget:	A detailed average water budget as simulated by the integrated model is provided in the Earthfx report for Baseline Conditions (Figure 7.28, p. 188); Scenario P12 (Figure 8.35, p. 223); P3456 (Figure 8.67, p. 250); RHB1 (Figure 8.102, p. 279), and RHB2 (Figure 8.129, p. 300). The water budget results for Scenarios RHB1 and RHB2 are reproduced in Figures 2d and 2e. Simulated change in groundwater levels (drawdowns), groundwater discharge to riparian areas, and change in streamflow in the vicinity of Wetland 13037 (Earthfx Wetland 20) for each scenario are discussed in Section 8 of the main report.	Figure 2d and 2e	HHIAR (Earthfx, April 2020)	191 - 303
Potential Impact to Form and Function of Feature:	No wetlands will be removed and the wetlands subcatchment will be protected. There will be no encroachment from the project into the wetland. The proposed limit of extraction is >120 m from the wetland boundary. Licensed boundary will be demarcated and fenced to ensure site construction and operations do not extend beyond the proposed limits of the project .			

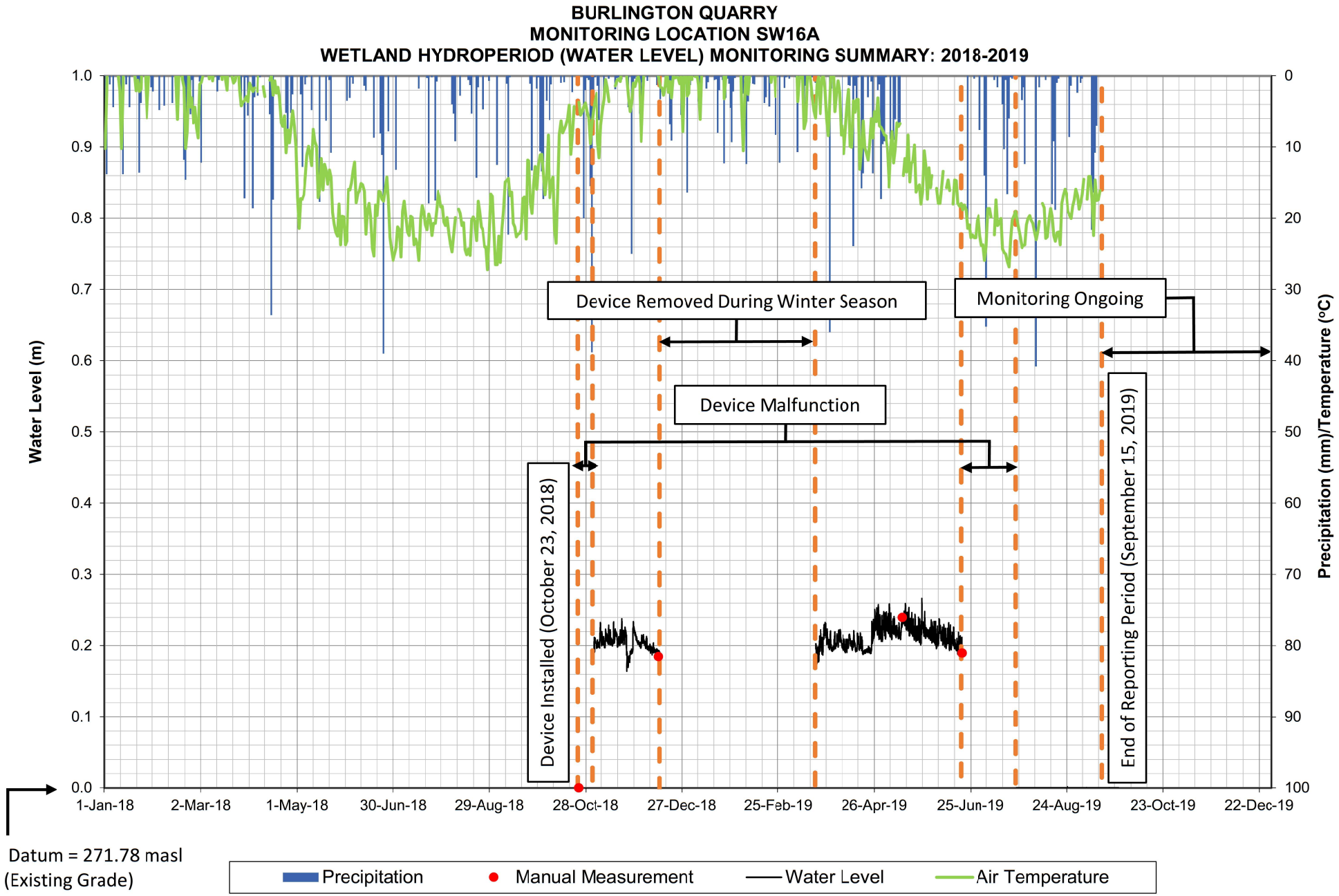
Wetland 13037	GW Outflow (%)	GW Inflow (%)	Δ in Outflow (%)	Δ in Inflow (%)
Baseline (Existing)	12.84	1.76	-	-
Rehab Scenario 1	15.85	0.17	3.01	-1.59
Rehab Scenario 2	14.91	0.22	2.07	-1.54

Mitigation (Rehabilitation)	Description	Figure / Graph	Reference	
			Report	Section / Page
Proposed Mitigation Measures:	None required.			

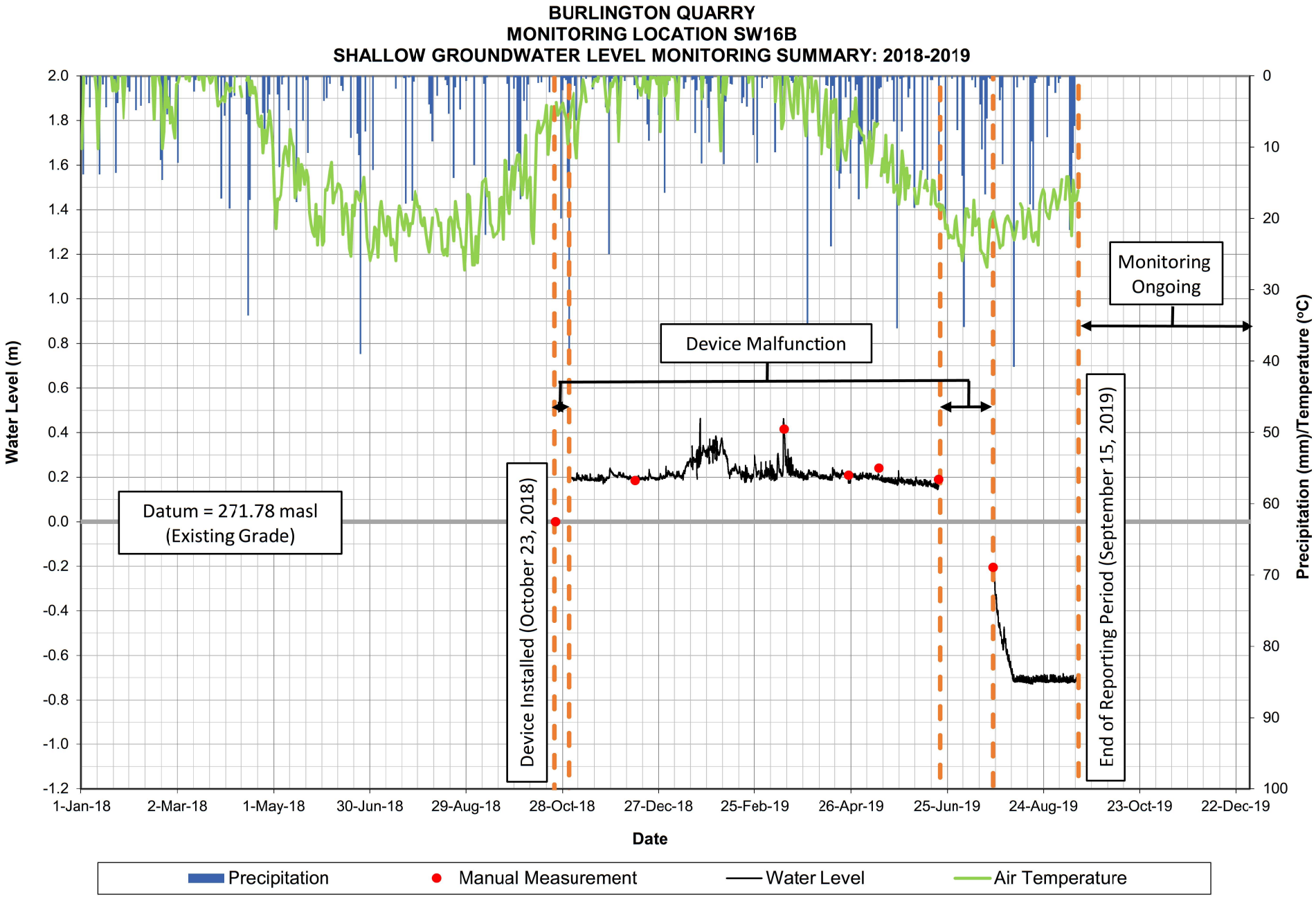
WETLAND 13037 - FIGURE 1



WETLAND 13037 - GRAPH 1

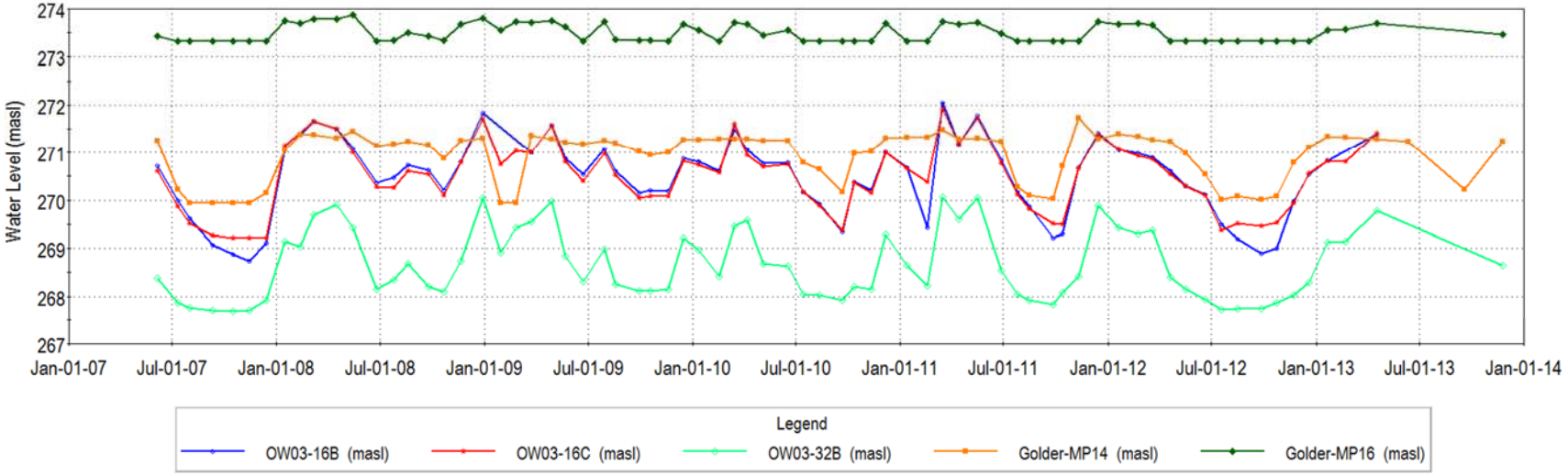


WETLAND 13037 - GRAPH 2



WETLAND 13037 - GRAPH 3

Shallow and Deep Groundwater Hydrographs
Wetland 13037



WETLAND 13037

FIGURE 2A

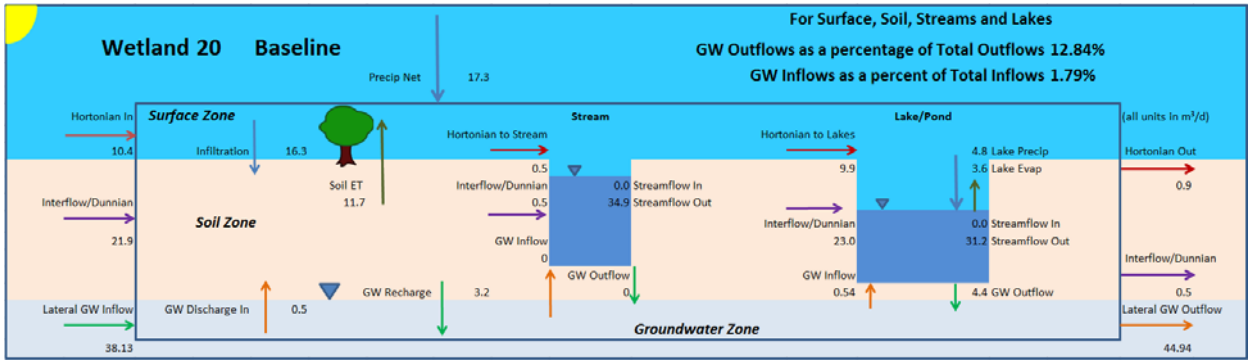


FIGURE 2B

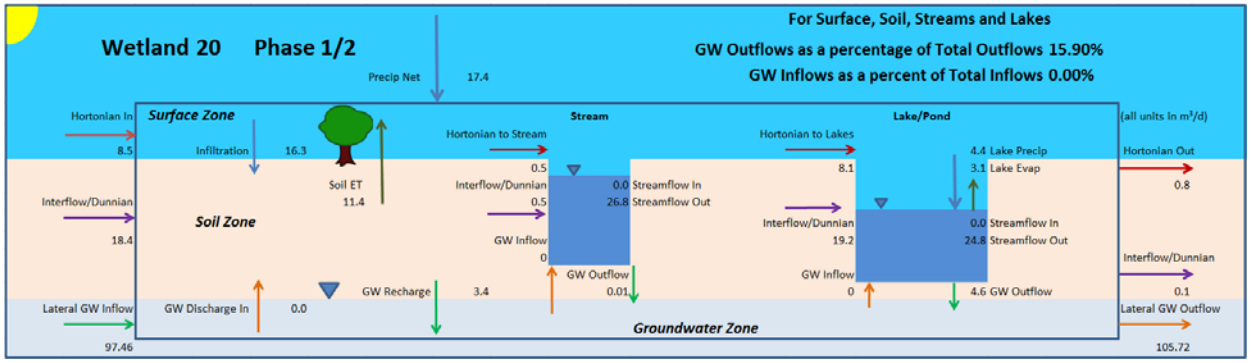


FIGURE 2C

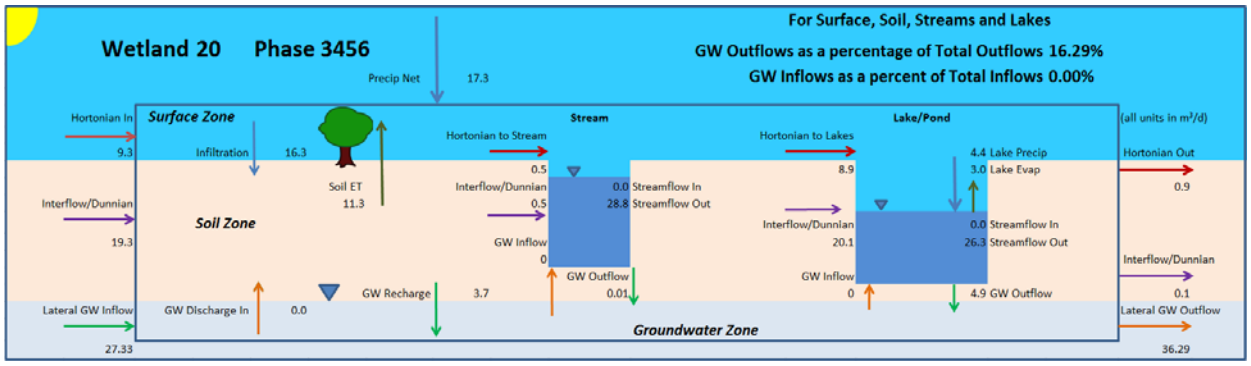


FIGURE 2D

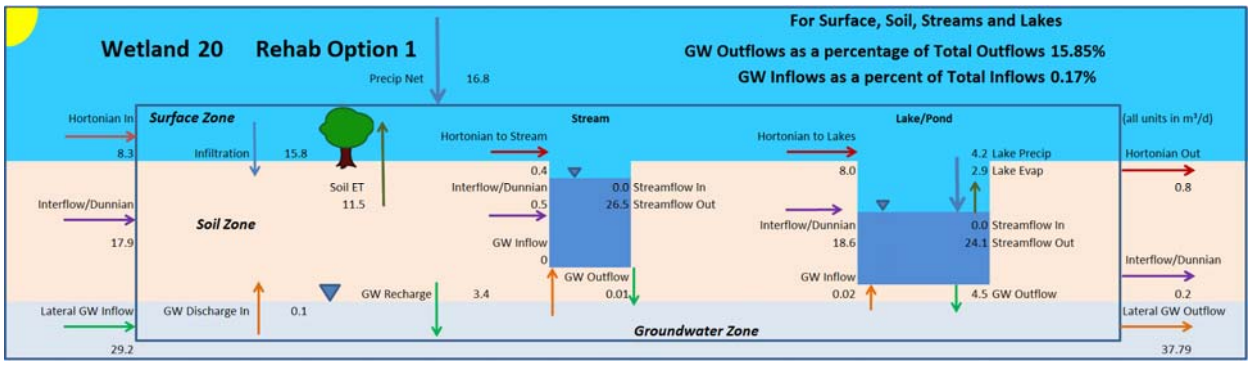
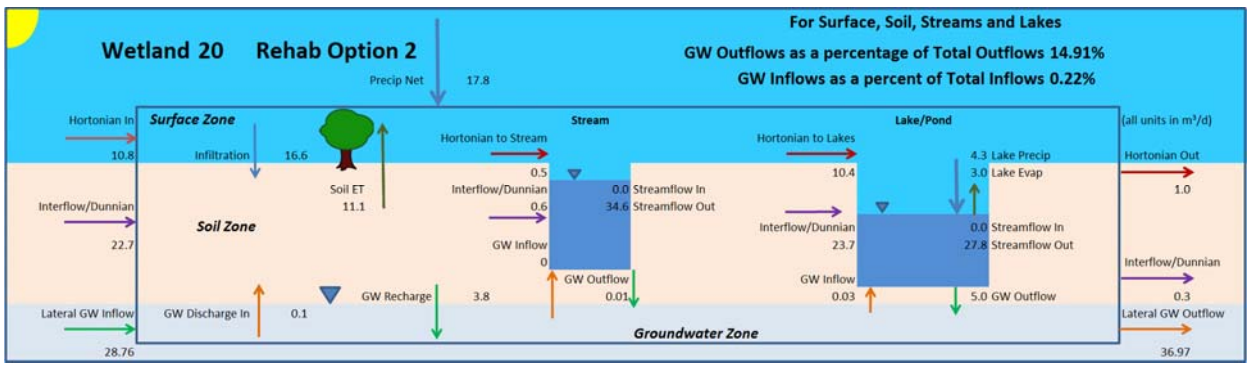
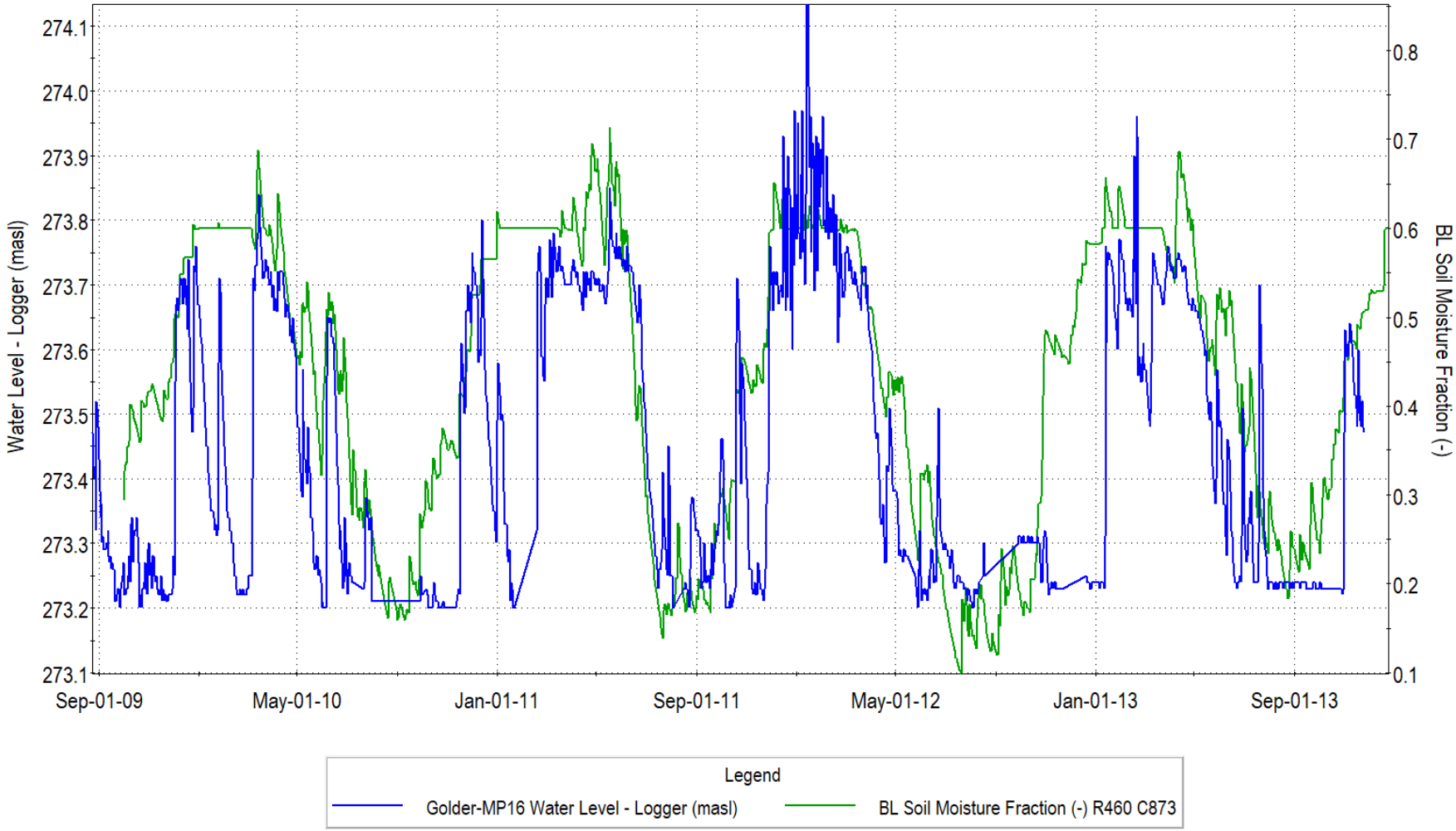


FIGURE 2E



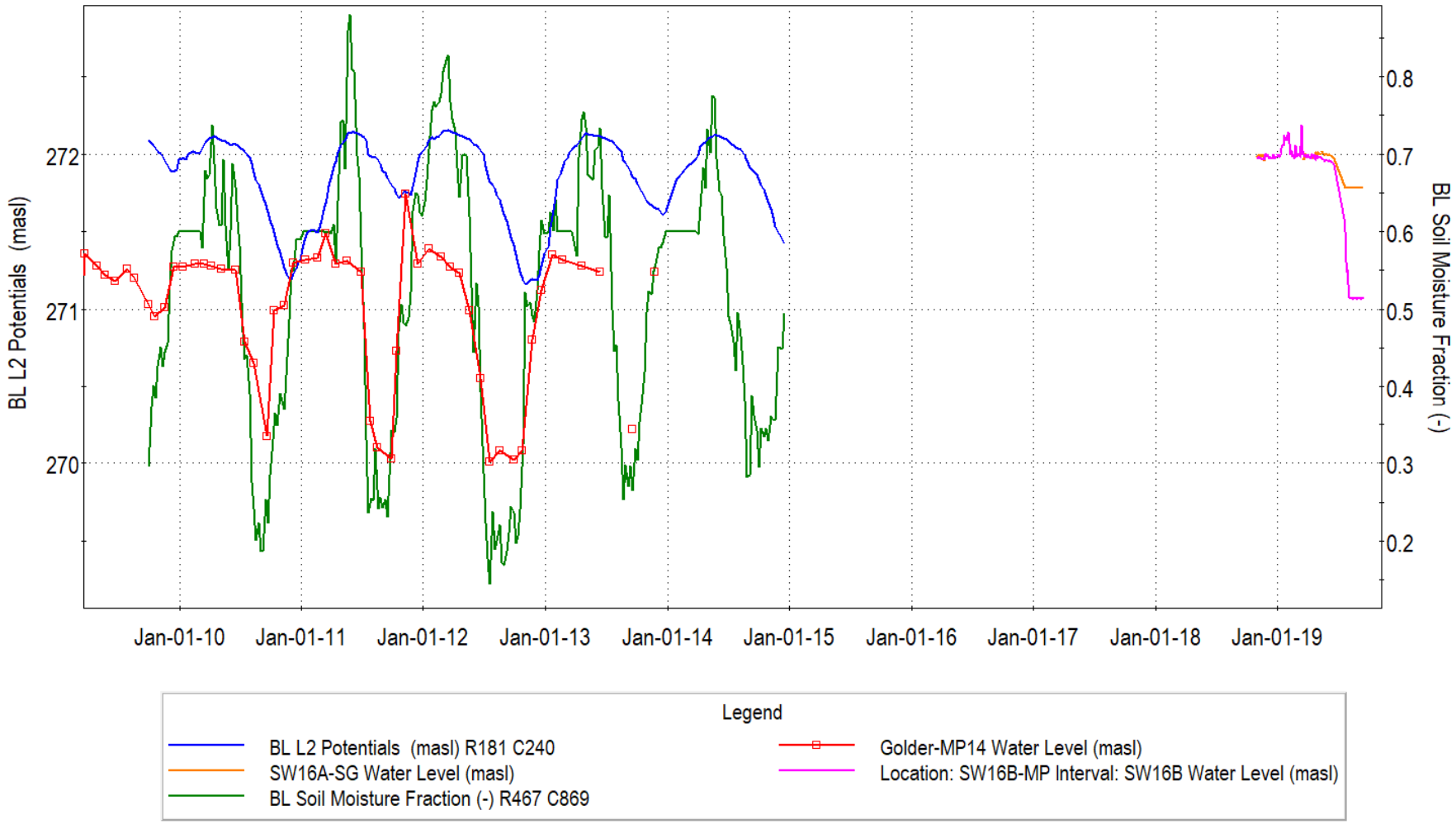
WETLAND 13037 - GRAPH 4

Integrated Model Calibration
Wetland 13037



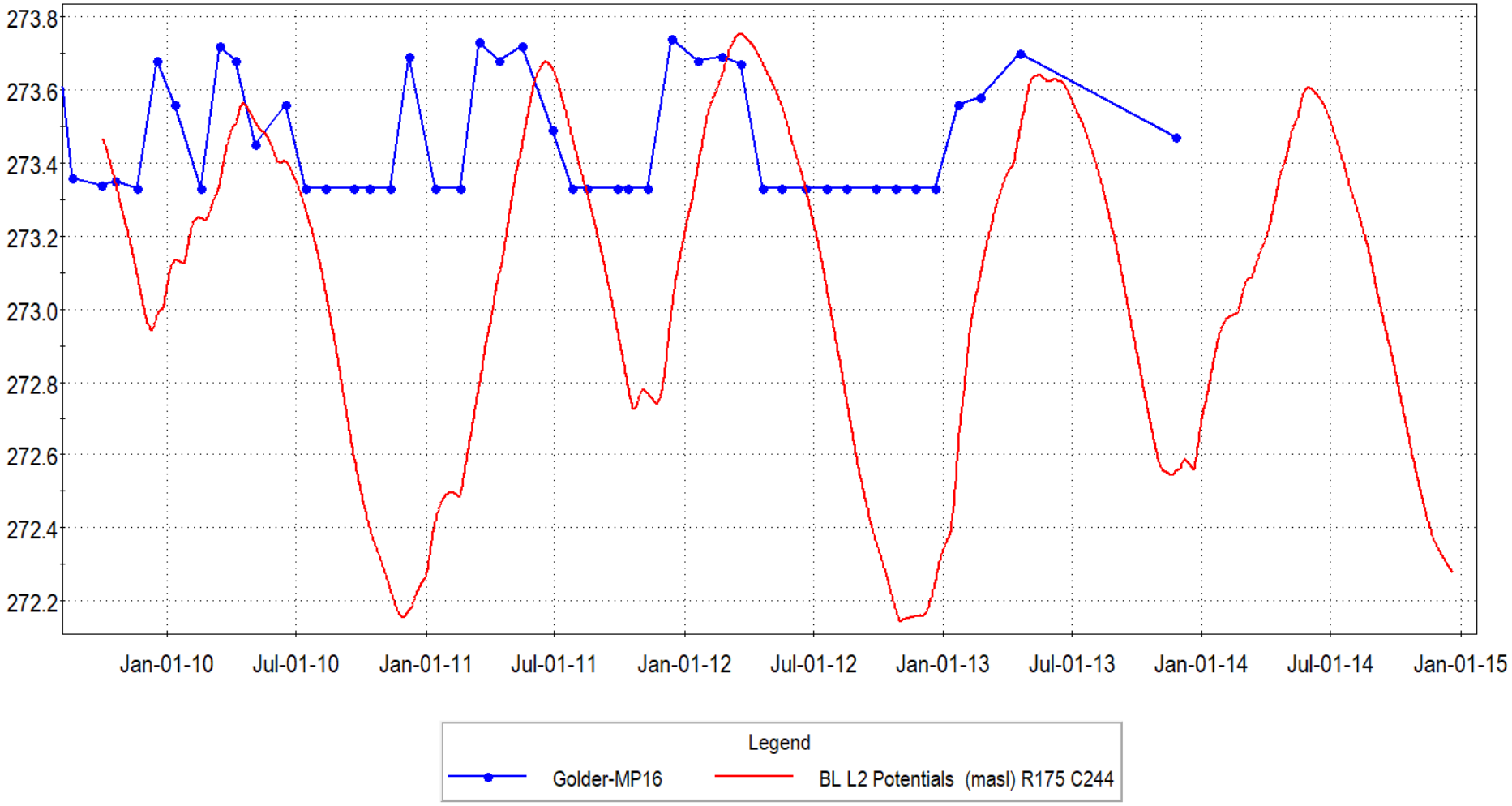
WETLAND 13037 - GRAPH 5

Integrated Model Calibration
Wetland 13037



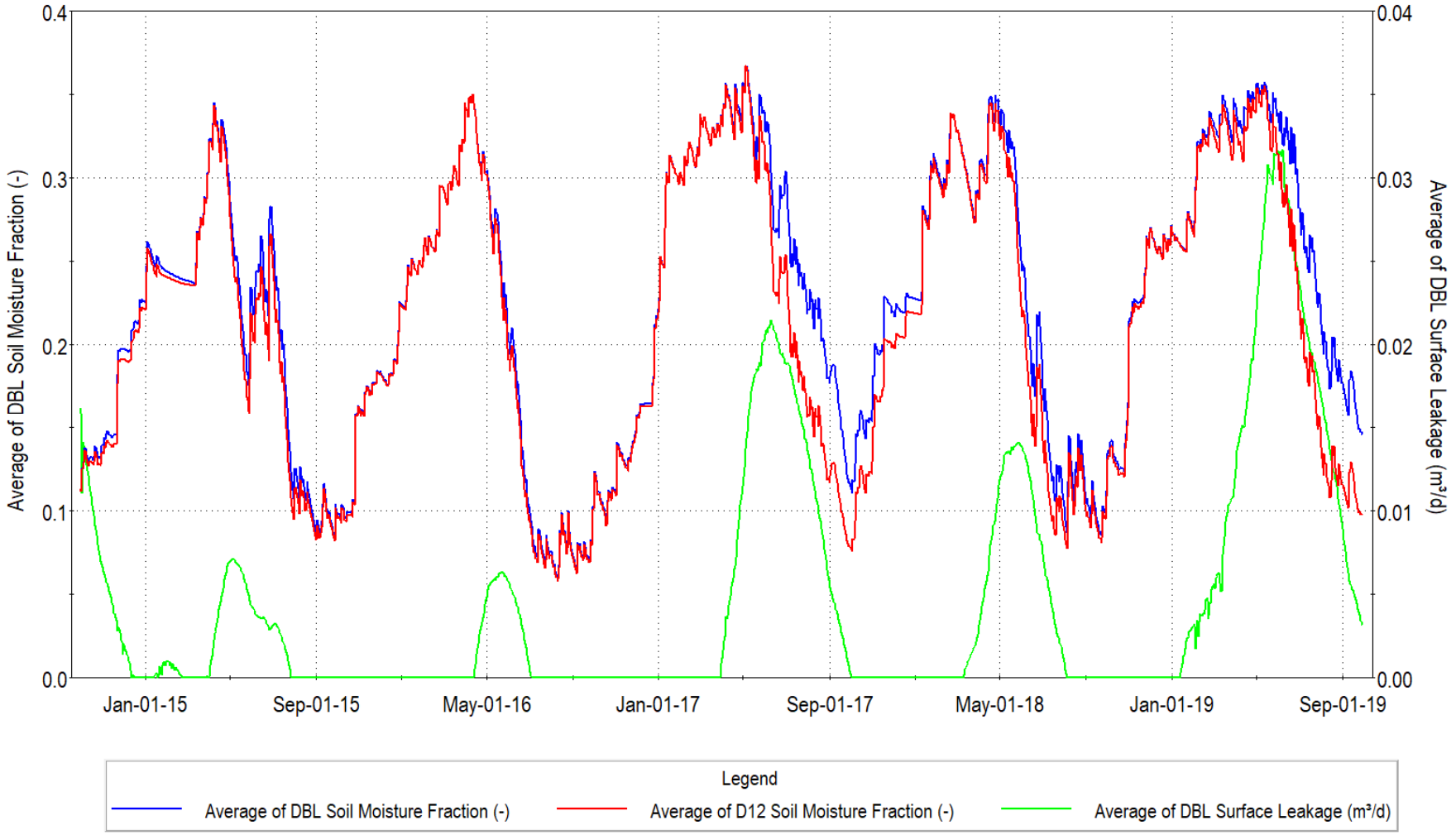
WETLAND 13037 - GRAPH 6

Integrated Model Calibration
Wetland 13037



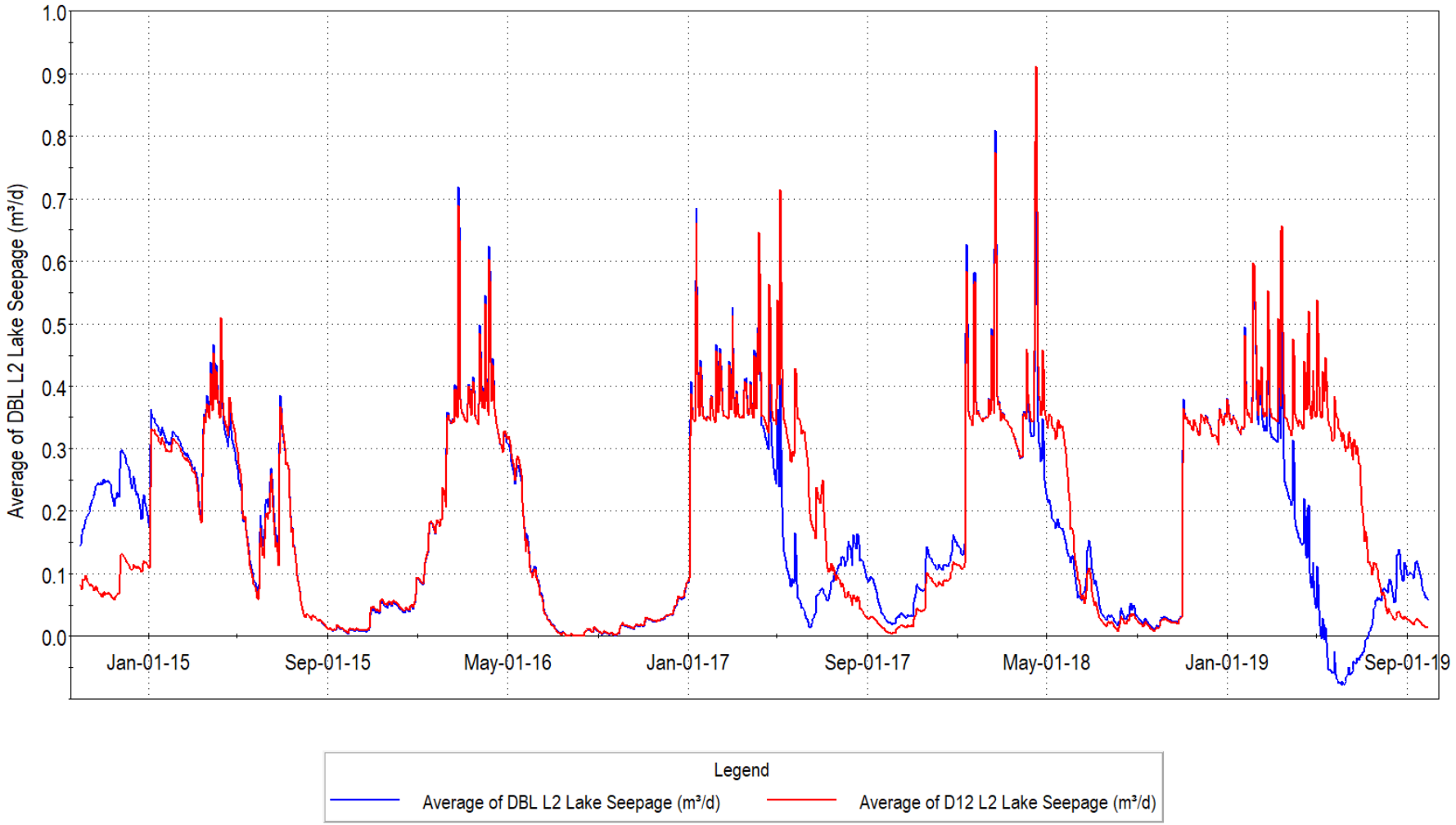
WETLAND 13037 - GRAPH 7

Change in Soil Moisture Conditions
Wetland 13037

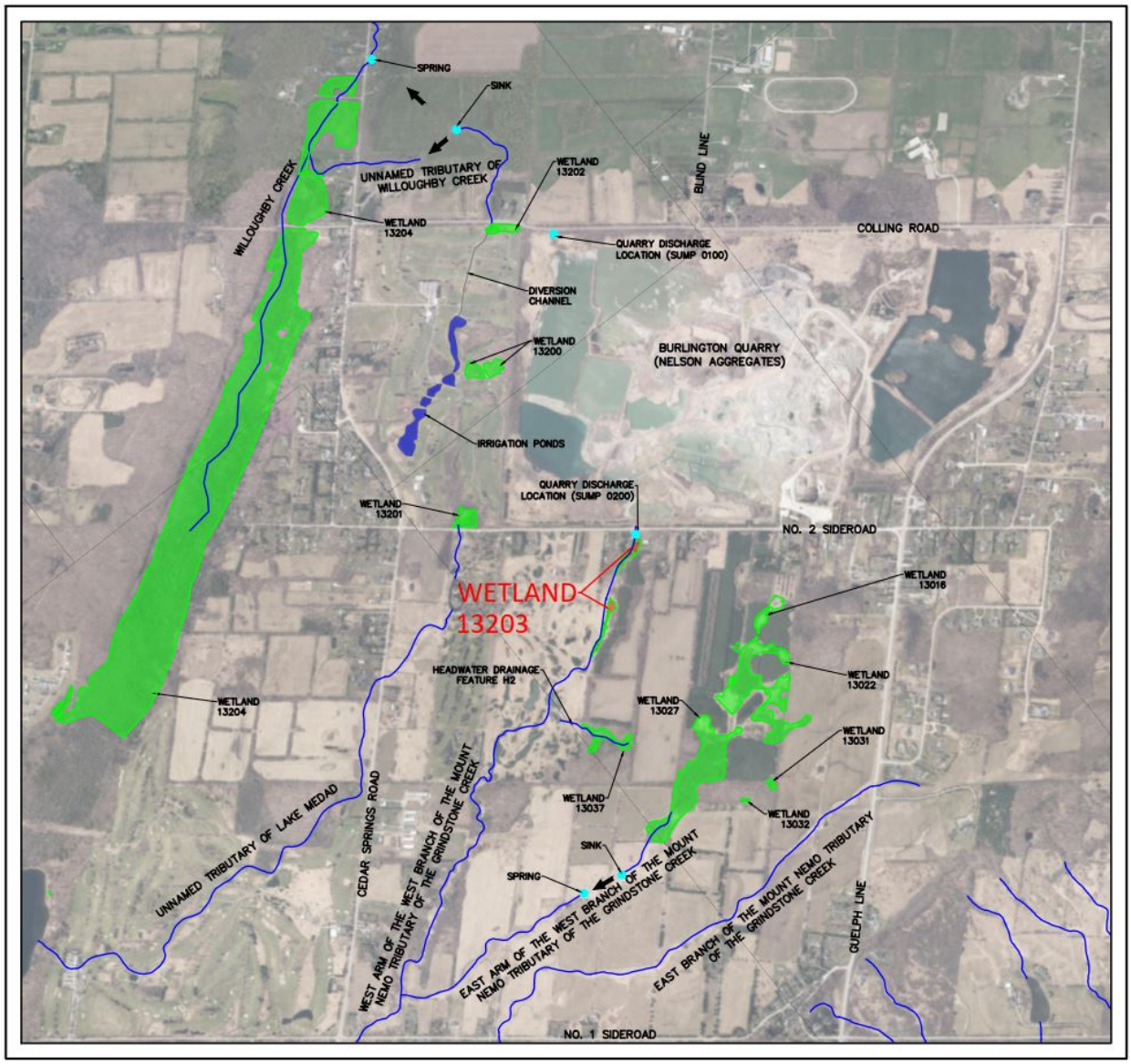


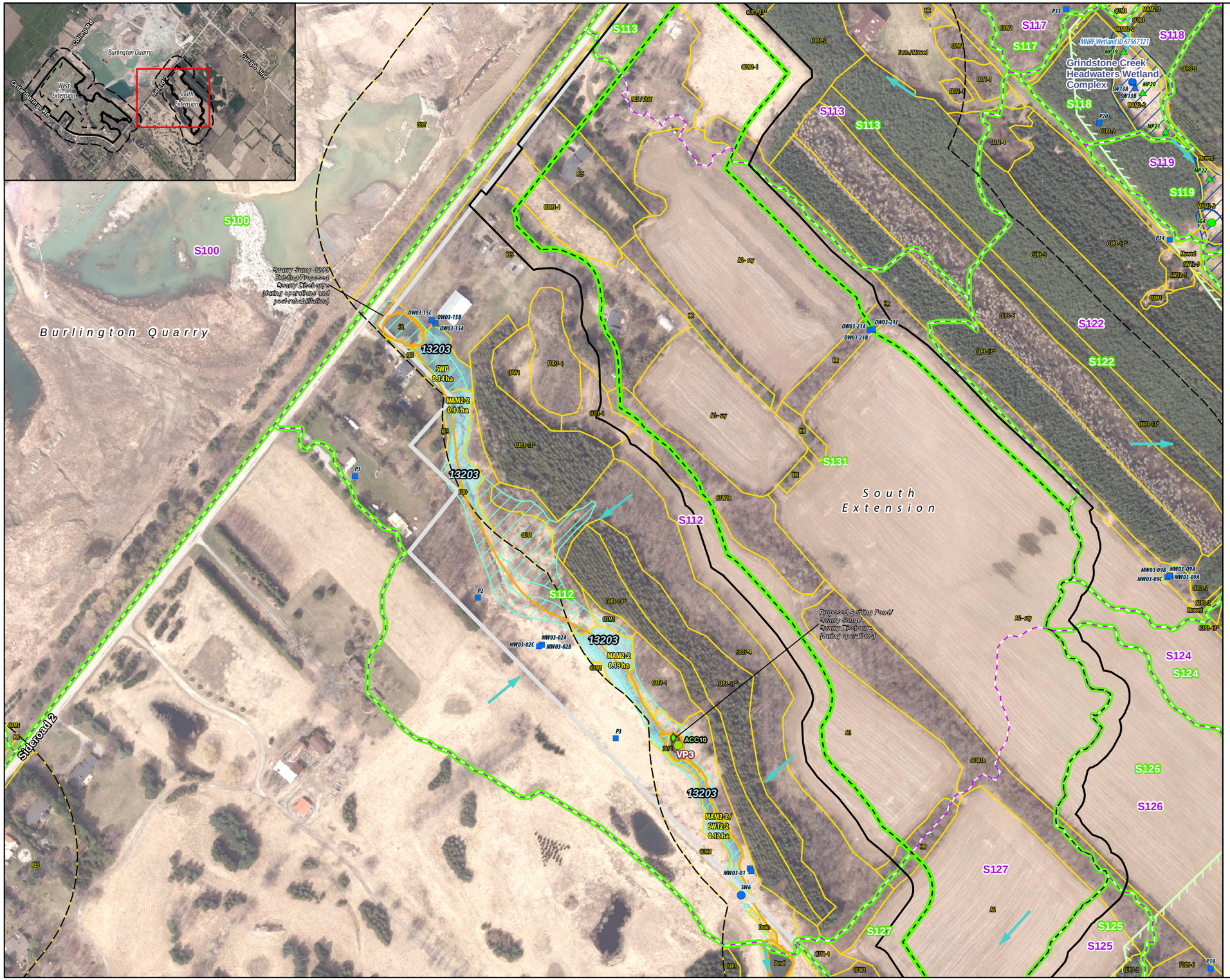
WETLAND 13037 - GRAPH 8

Change in Soil Moisture Conditions
Wetland 13037



WETLAND 13203





Legend

- Licensed Boundary
- Limit of Extraction
- 120 m Adjacent Lands
- Subject Lands
- Amphibian Call Count Station (2019)
- Salamander Trap (2019)
- Salamander Habitat Assessment (2019)
- Direct Fish Habitat
- Existing Subcatchment Boundary (Tatham Engineering, 2020)
- Proposed Subcatchment Boundary - Operations and Post-Rehabilitation (Tatham Engineering, 2020
- Wetland (Savanta, 2020)
- Ecological Land Classification (Savanta, 2019 & 2020)
- Ecological Land Classification (Savanta, 2020)
- Provincially Significant Wetland (LIO/MNRF, 2020)
- Wetland - Not Evaluated per OWES (MNRF/LIO, 2020)
- MECP Jefferson Salamander Regulated Habitat

Current Instrumentation

- Groundwater Monitoring Station (EarthFx)
- Mini Piezometer (Tatham Engineering)
- Staff Gauge & Surface Water Monitoring Station (Tatham Engineering)

Previous Instrumentation

- Mini Piezometer (Golder)
- Staff Gauge & Surface Water Monitoring Station (Golder)

ELC Legend

AG, Agriculture
CUM1, Mineral Cultural Meadow
CUM1-1, Dry Moist Old Field Meadow
CUP3, Coniferous Plantation
CUP3-2, White Pine Coniferous Plantation
CUP3-6, European Larch Coniferous Plantation
CUP3-13*, White Spruce Coniferous Plantation
CUP3-14*, White Cedar Coniferous Plantation
CUT1, Mineral Cultural Thicket
CUT1-1, Sumac Cultural Thicket
CUW1, Mineral Cultural Woodland
DIST, Disturbed
FOD, Deciduous Forest
FOD5-6, Dry- Fresh Sugar Maple-Basswood Deciduous Forest
FOD7-4, Fresh – Moist Black Walnut Lowland Deciduous Forest
HR, Hedgerow
MAM2-2, Reed-canary Grass Mineral Meadow Marsh
RES, Residential
SA, Shallow Aquatic
SAS1, Submerged Shallow Aquatic
SWD, Deciduous Swamp
SWT2-2, Willow Mineral Thicket Swamp
SWT2-5, Red-osier Dogwood Mineral Thicket Swamp
SWT2-9, Gray Dogwood Mineral Thicket Swamp

NOTES:

1. Coordinate System: NAD 1983 UTM Zone 17N.
2. Base features produced under license with the Ontario Ministry of Natural Resources and Forestry © Queen's Printer for Ontario, 2021.
3. Orthoimagery © First Base Solutions, 2021. Imagery taken in 2019.

Project 8133

Burlington Quarry Extension
Nelson Aggregates Co.

Figure 6
Wetland Characterization

Wetland 13203 - South Extension

0 50 m
1:3,000

N

GEI Consultants
Savanta Division

Wetland 13203

Wetland Characteristics	Description	Figure / Graph	Reference	
			Report	Section / Page
Wetland IDs:	MNRF – N/A (OGF ID 67196365, 67196392, 67196289) Earthfx - 18 Tatham - 13203 Savanta - 13203 Golder (Background) - N/A			
Wetland Area (ha):	LIO/MNRF – 1.84 (includes wetland area outside 120 m adjacent lands) Savanta – 0.61 (excludes wetland area outside 120 m adjacent lands)			
Watershed:	Grindstone Creek Watershed			
Sub-Watershed:	West Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek			
Located in Proposed Limit of Extraction:	No			
Located in Proposed License Boundary:	No			
Catchment Area (ha):	26.2 + quarry discharge (Sump 0200)		SWA (Tatham, April 2020)	Drawing DP-1
Catchment ID:	S112		SWA (Tatham, April 2020)	Drawing DP-1
Closed or Connected System:	On-line (connected to downstream watercourse)			
Condition:	Modified			
Bathymetry:	A bathymetric survey of Wetland 13202 has not been completed.			
Outlet:	West Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek			
Hydroperiod:	Water level in Wetland 13203 maintained by quarry discharge. When quarry discharge ceases, flow through West Arm ceases.		SWA (Tatham, April 2020)	2.1.2, 3 and Appendix C
Surface Water Monitoring:	ID: SW6 (Tatham) Installation Date: September 19, 2014 Data Collection: Continuous water level and temperature, manual monthly in-situ streamflow measurements and calibration data (water level converted to flow using rating curve) Coordinates of Monitoring Station: Easting 590629.123, Northing 4805071.124	Graph 1	SWA (Tatham, April 2020)	2.1.2 and Appendix C

Natural Heritage and Habitat Features	Description	Figure / Graph	Reference	
			Report	Section / Page
Wetland Name & Provincial Significance Evaluation:	Wetland 13203 – Other (as determined by MNRF and it is completely dependent on pumping from the existing quarry; however it has been designed to demonstrate no negative impacts.)		NETR (Savanta, April 2020)	6.1.2
ELC Unit(s):	Shallow Aquatic: SA Submerged Shallow Aquatic: SAS1 Deciduous Swamp: SWD Reed-canary Grass Mineral Meadow Marsh: MAM2-2 Reed-canary Grass Mineral Meadow Marsh / Willow Mineral Thicket Swamp: MAM2-2 / SWT2-2		NETR (Savanta, April 2020)	Table 2
Regulated Habitat (MECP):	No		NETR (Savanta, April 2020)	6.7
Significant Wildlife Habitat:	Confirmed for amphibian breeding (woodland) – SAS1. Salamander species absent, despite survey effort including salamander habitat assessment, salamander trapping and egg mass surveys.		NETR (Savanta, April 2020)	4.2.2; 4.2.3; 4.2.5; 5.2.2; 5.2.3; 5.2.5; 6.4; Table 19
Fish Habitat:	Indirect		NETR (Savanta, April 2020)	6.6
Habitat of Endangered and Threatened Species:	No species at risk salamanders observed, despite survey effort including salamander habitat assessment, salamander trapping and egg mass surveys.		NETR (Savanta, April 2020)	4.2.2; 4.2.3; 5.2.2; 5.2.3; 6.7

<table>
<tr><th>Groundwater Interaction</th><th>Description</th><th>Figure / Graph</th><th colspan="2">Reference</th></tr>
<tr><th></th><th></th><th></th><th>Report</th><th>Section / Page</th></tr>
<tr><td>Lithology:</td><td>Halton Till</td><td></td><td></td><td></td></tr>
<tr><td>Hydraulic Conductivity:</td><td>Integrated Model (Earthfx) - The harmonic mean hydraulic conductivity, based on testing by Golder (2007) of 10 mini-piezometers, was 1.2x10^{-8} m/s. Model value for the vertical hydraulic conductivity was 1.6x10^{-7} m/s, about an order of magnitude higher, to account for limited flow through fractures in the till.</td><td></td><td></td><td></td></tr>
<tr><td>Surface Water/Groundwater Interaction:</td><td>The low permeability of the Halton Till underlying the wetland is the dominant control on 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. This wetland receives some groundwater inflow but is generally isolated from any changes in the water table due to quarry development.</td><td></td><td></td><td></td></tr>
<tr><td>Groundwater Monitoring (Monitoring Wells):</td><td>
<table>
<tr><th>Monitoring Well ID</th><th>Distance (Dir.)</th><th>Geologic Unit</th><th>Ground Elevation</th><th>Monitoring Elev</th><th>Average WL</th></tr>
<tr><td>MW03-01A</td><td>227 (SW)</td><td>Bedrock</td><td>270.94</td><td>251.9 – 247.7</td><td>269.33</td></tr>
<tr><td>MW03-01B</td><td>227 (SW)</td><td>Bedrock</td><td>270.94</td><td>261.8 – 256.8</td><td>269.37</td></tr>
<tr><td>MW03-01C</td><td>227 (SW)</td><td>Bedrock</td><td>270.97</td><td>270.4 - 269.5</td><td>270.13</td></tr>
<tr><td>MW03-02A</td><td>36 (E)</td><td>Bedrock</td><td>272.48</td><td>251.8 – 247.8</td><td>259.76</td></tr>
<tr><td>MW03-02B</td><td>36 (E)</td><td>Bedrock</td><td>272.48</td><td>260.9 – 256.6</td><td>262.02</td></tr>
<tr><td>MW03-02C</td><td>36 (E)</td><td>Bedrock</td><td>272.54</td><td>270.0 – 268.4</td><td>269.89</td></tr>
<tr><td>OW03-15A</td><td>226 (NNE)</td><td>Bedrock</td><td>275.12</td><td>256.8 – 250.0</td><td>259.11</td></tr>
<tr><td>OW03-15B</td><td>226 (NNE)</td><td>Bedrock</td><td>275.12</td><td>269.2 – 264.9</td><td>268.97</td></tr>
<tr><td>OW03-15B</td><td>226 (NNE)</td><td>Bedrock</td><td>275.13</td><td>273.2 – 271.6</td><td>272.93</td></tr>
</table>
</td><td>Graphs 2, 3 & 4</td><td></td><td></td></tr>
<tr><td>Water Budget Results:</td><td>A detailed average water budget, as simulated by the integrated model, is provided in the main report for Baseline Conditions (Earthfx Figure 7.26, p. 187). The baseline water budget is reproduced in Figure 1a. The wetland is a net provider of groundwater. Simulated groundwater levels, groundwater discharge to riparian areas, and streamflow in the vicinity of Wetland 18 for baseline conditions are discussed in Section 7 of the main report.
<table>
<tr><th>Wetland 13203</th><th>GW Outflow (%)</th><th>GW Inflow (%)</th></tr>
<tr><td>Baseline (Existing)</td><td>5.98</td><td>2.42</td></tr>
</table>
</td><td>Figure 1a</td><td>HHIAR (Earthfx, April 2020)</td><td>165 - 190</td></tr>
<tr><td>Integrated Model Calibration:</td><td>No mini-piezometers for calibration. The model is replicating the dewatering effects of the existing quarry at the north end of the wetland (see Graph 5). Water level calibration at the south end of wetland is reasonable (see Graph 6). There is some uncertainty in the calibration because records and operations of south quarry discharge are intermittent. Wetland 13203 is not discussed in the Main Report. Other nearby wetlands are discussed in Appendix E, Section 19.6.</td><td>Graphs 5 & 6</td><td></td><td></td></tr>
</table>

<table>
<tr><th>Impact Assessment (Operations Phases 1 & 2)</th><th>Description</th><th>Figure / Graph</th><th colspan="2">Reference</th></tr>
<tr><th></th><th></th><th></th><th>Report</th><th>Section / Page</th></tr>
<tr><td>Change in Wetland Area (ha):</td><td>No change.</td><td></td><td></td><td></td></tr>
<tr><td>Change in Wetland Catchment Area (ha):</td><td>Reduction in catchment area. During operations in Phases 1 and 2 the catchment area will be reduced to 14.5 ha (reduction of 11.7 ha)</td><td></td><td>SWA (Tatham, April 2020)</td><td>Drawing DP-2</td></tr>
<tr><td>Change in Hydroperiod:</td><td>No change in hydroperiod expected as quarry discharge maintains wetland water levels.</td><td></td><td></td><td></td></tr>
<tr><td>Change in Water Budget:</td><td>A detailed average water budget as simulated by the integrated model is provided in the Earthfx report for Baseline Conditions (Figure 7.26, p. 187); Scenario P12 (Figure 8.33, p. 222); P3456 (Figure 8.65, p. 249); RHB1 (Figure 8.101, p. 278), and RHB2 (Figure 8.126, p. 300). The water budget results for Scenario P12 are reproduced in Figure 1b. Simulated change in groundwater levels (drawdowns), groundwater discharge to riparian areas, and change in streamflow in the vicinity of Wetland 13203 (Earthfx Wetland 18) for each scenario are discussed in Section 8 of the main report.
<table>
<tr><td>Wetland 13203</td><td>GW Outflow (%)</td><td>GW Inflow (%)</td><td>Δ in Outflow (%)</td><td>Δ in Inflow (%)</td></tr>
<tr><td>Baseline (Existing)</td><td>5.98</td><td>2.42</td><td>-</td><td>-</td></tr>
<tr><td>Operations Ph 1 & 2</td><td>9.95</td><td>0.00</td><td>3.97</td><td>-2.42</td></tr>
</table></td><td>Figure 1b</td><td>HHIAR (Earthfx, April 2020)</td><td>191 - 303</td></tr>
<tr><td>Change on Soil Moisture Conditions:</td><td>The soil moisture and surface discharge patterns in Wetland 18 are shown in Graph 7. There will only be a minimal change in soil moisture conditions under P12 conditions. Note that the Baseline groundwater inflow as a percentage of total inflows is only 2.42% (the right-hand scale range is very small).</td><td>Graph 7</td><td></td><td></td></tr>
<tr><td>Potential Impact to Form and Function of Feature:</td><td>Both the pond and the wetland will remain in place. There will be no encroachment from the project into the wetlands. Proposed limit of extraction is >30 m from the wetland boundary. The extraction limit will be demarcated and fenced to ensure site construction and operations do not extend beyond the proposed limits of the project .</td><td></td><td>NETR (Savanta, April 2020)</td><td>7.2.1; 7.1.1; 7.1.2</td></tr>
</table>

Mitigation (Operational Phases 1 & 2)	Description	Figure / Graph	Reference	
			Report	Section / Page
Proposed Mitigation Measures:	The wetland is supplied with water by pumping from the existing adjacent quarry. The proposed quarry Extension is not anticipated to have any impact on pumping or water quality related to discharge from the existing quarry. Pumping and discharge are recommended to occur at the same location at the upstream end of the tributary and in the same manner as existing pumping.		NETR (Savanta, April 2020)	7.2.1; 7.1.1; 7.1.2

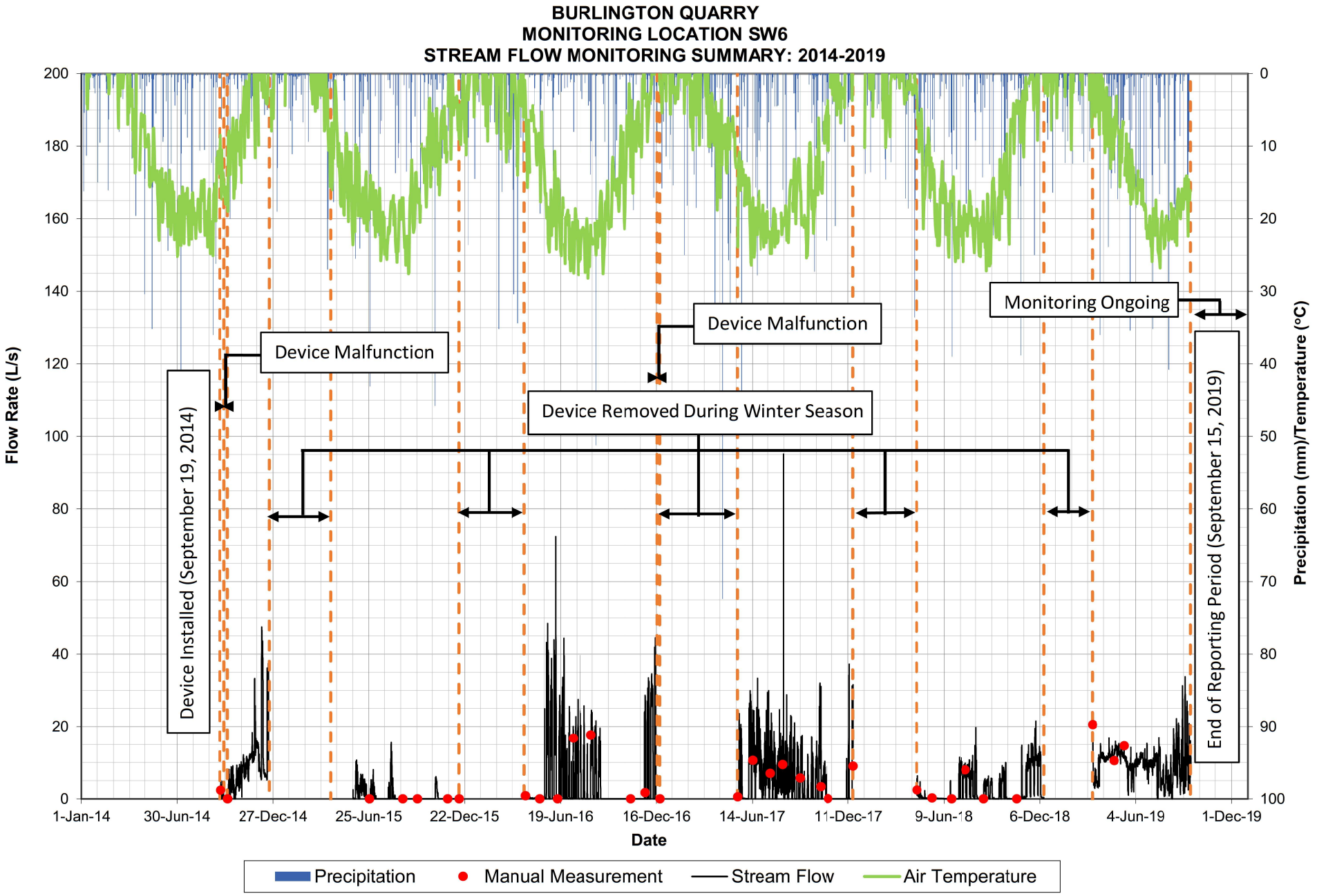
<table>
<tr><th>Impact Assessment (Operations Phases 3 - 6)</th><th>Description</th><th>Figure / Graph</th><th colspan="2">Reference</th></tr>
<tr><th></th><th></th><th></th><th>Report</th><th>Section / Page</th></tr>
<tr><td>Change in Wetland Area (ha):</td><td>No change.</td><td></td><td></td><td></td></tr>
<tr><td>Change in Wetland Catchment Area (ha):</td><td>Reduction in catchment area. During operations in Phases 1 and 2 the catchment area will be reduced to 14.5 ha (reduction of 11.7 ha). This reduction in drainage area will remain long-term.</td><td></td><td>SWA (Tatham, April 2020)</td><td>Drawing DP-2</td></tr>
<tr><td>Change in Hydroperiod:</td><td>No change in hydroperiod expected as quarry discharge maintains wetland water levels.</td><td></td><td></td><td></td></tr>
<tr><td>Change in Water Budget:</td><td>A detailed average water budget as simulated by the integrated model is provided in the Earthfx report for Baseline Conditions (Figure 7.26, p. 187); Scenario P12 (Figure 8.33, p. 222); P3456 (Figure 8.65, p. 249); RHB1 (Figure 8.101, p. 278), and RHB2 (Figure 8.126, p. 300). The water budget results for Scenario P3456 are reproduced in Figure 1c. Simulated change in groundwater levels (drawdowns), groundwater discharge to riparian areas, and change in streamflow in the vicinity of Wetland 13203 (Earthfx Wetland 18) for each scenario are discussed in Section 8 of the main report.
<table>
<tr><td>Wetland 13203</td><td>GW Outflow (%)</td><td>GW Inflow (%)</td><td>Δ in Outflow (%)</td><td>Δ in Inflow (%)</td></tr>
<tr><td>Baseline (Existing)</td><td>5.98</td><td>2.42</td><td>-</td><td>-</td></tr>
<tr><td>Operations Ph 3 - 6</td><td>7.11</td><td>0.04</td><td>1.13</td><td>-2.38</td></tr>
</table></td><td>Figure 1c</td><td>HHIAR (Earthfx, April 2020)</td><td>191 - 303</td></tr>
<tr><td>Potential Impact to Form and Function of Feature:</td><td>Both the pond and the wetland will remain in place. There will be no encroachment from the project into the wetlands. Proposed limit of extraction is >30 m from the wetland boundary. The extraction limit will be demarcated and fenced to ensure site construction and operations do not extend beyond the proposed limits of the project .</td><td></td><td>NETR (Savanta, April 2020)</td><td>7.2.1; 7.1.1; 7.1.2</td></tr>
</table>

<table>
<tr><th>Mitigation (Operational Phases 3 - 6)</th><th>Description</th><th>Figure / Graph</th><th colspan="2">Reference</th></tr>
<tr><th></th><th></th><th></th><th>Report</th><th>Section / Page</th></tr>
<tr><td>Proposed Mitigation Measures:</td><td>The wetland is supplied with water by pumping from the existing adjacent quarry. The proposed quarry Extension is not anticipated to have any impact on pumping or water quality related to discharge from the existing quarry. Pumping and discharge are recommended to occur at the same location at the upstream end of the tributary and in the same manner as existing pumping.</td><td></td><td>NETR (Savanta, April 2020)</td><td>7.2.1; 7.1.1; 7.1.2</td></tr>
</table>

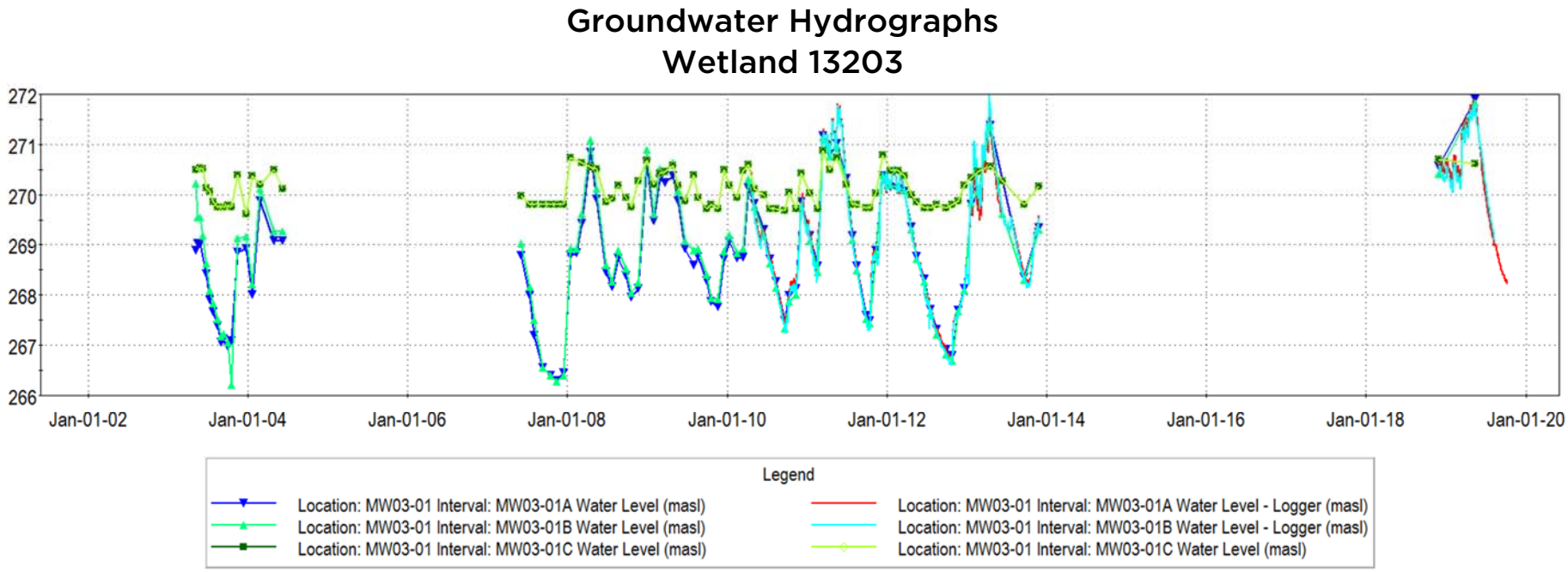
<table>
<tr><th>Impact Assessment (Rehabilitation)</th><th>Description</th><th>Figure / Graph</th><th colspan="2">Reference</th></tr>
<tr><th></th><th></th><th></th><th>Report</th><th>Section / Page</th></tr>
<tr><td>Change in Wetland Area (ha):</td><td>No change.</td><td></td><td></td><td></td></tr>
<tr><td>Change in Wetland Catchment Area (ha):</td><td>Reduction in catchment area. During operations in Phases 1 and 2 the catchment area will be reduced to 14.5 ha (reduction of 11.7 ha). This reduction in drainage area will remain long-term.</td><td></td><td>SWA (Tatham, April 2020)</td><td>Drawing DP-3</td></tr>
<tr><td>Change in Hydroperiod:</td><td>No change in hydroperiod expected as quarry discharge maintains wetland water levels.</td><td></td><td></td><td></td></tr>
<tr><td>Change in Water Budget:</td><td>A detailed average water budget as simulated by the integrated model is provided in the Earthfx report for Baseline Conditions (Figure 7.26, p. 187); Scenario P12 (Figure 8.33, p. 222); P3456 (Figure 8.65, p. 249); RHB1 (Figure 8.101, p. 278), and RHB2 (Figure 8.126, p. 300). The water budget results for Scenario RHB1 and RHB2 are reproduced below. Simulated change in groundwater levels (drawdowns), groundwater discharge to riparian areas, and change in streamflow in the vicinity of Wetland 13203 (Earthfx Wetland 18) for each scenario are discussed in Section 8 of the main report.
<table>
<tr><td>Wetland 13203</td><td>GW Outflow (%)</td><td>GW Inflow (%)</td><td>Δ in Outflow (%)</td><td>Δ in Inflow (%)</td></tr>
<tr><td>Baseline (Existing)</td><td>5.98</td><td>2.42</td><td>-</td><td>-</td></tr>
<tr><td>Rehab Scenario 1</td><td>5.19</td><td>1.36</td><td>-0.79</td><td>-1.06</td></tr>
<tr><td>Rehab Scenario 2</td><td>6.68</td><td>3.53</td><td>0.70</td><td>1.11</td></tr>
</table></td><td>Figure 1d and 1e</td><td>HHIAR (Earthfx, April 2020)</td><td>191 - 303</td></tr>
<tr><td>Potential Impact to Form and Function of Feature:</td><td>Both the pond and the wetland will remain in place. There will be no encroachment from the project into the wetlands. Proposed limit of extraction is >30 m from the wetland boundary. The extraction limit will be demarcated and fenced to ensure site construction and operations do not extend beyond the proposed limits of the project .</td><td></td><td>NETR (Savanta, April 2020)</td><td>7.2.1; 7.1.1; 7.1.2</td></tr>
</table>

Mitigation (Rehabilitation)	Description	Figure / Graph	Reference	
			Report	Section / Page
Proposed Mitigation Measures:	The wetland is supplied with water by pumping from the existing adjacent quarry. The proposed quarry Extension is not anticipated to have any impact on pumping or water quality related to discharge from the existing quarry. Pumping and discharge are recommended to occur at the same location at the upstream end of the tributary and in the same manner as existing pumping.		NETR (Savanta, April 2020)	7.2.1; 7.1.1; 7.1.2

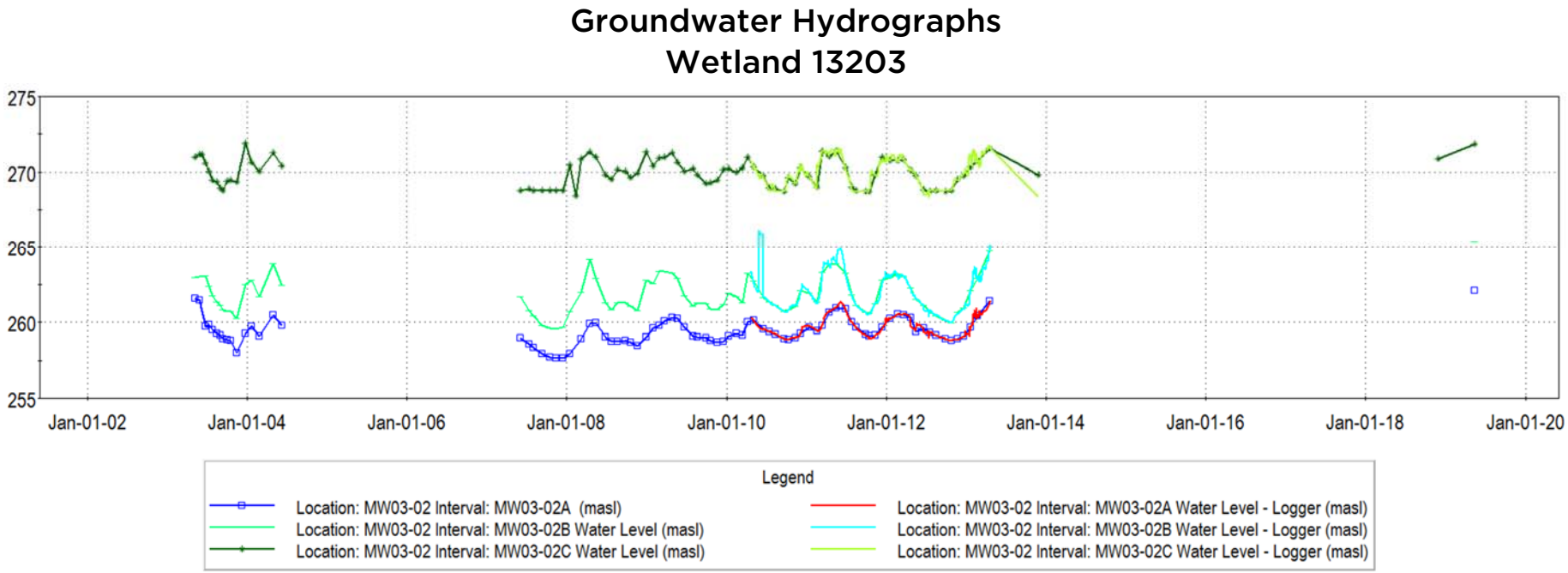
WETLAND 13203 - GRAPH 1



WETLAND 13203 - GRAPH 2

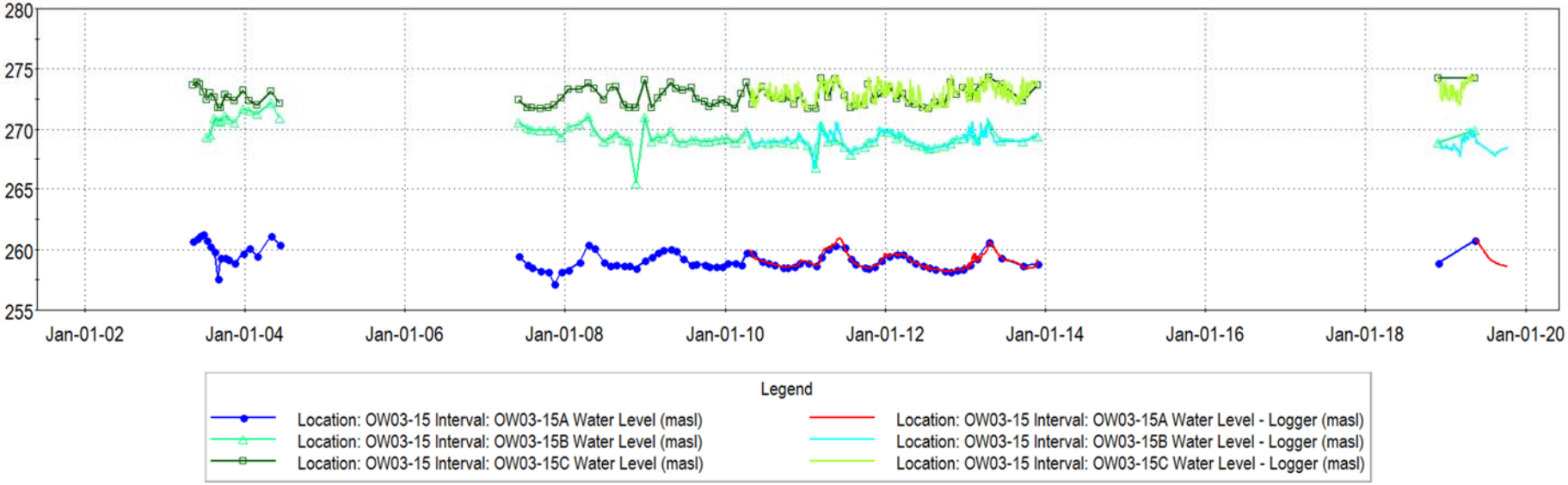


WETLAND 13203 - GRAPH 3



WETLAND 13203 - GRAPH 4

Groundwater Hydrographs
Wetland 13203



WETLAND 13203

FIGURE 1A

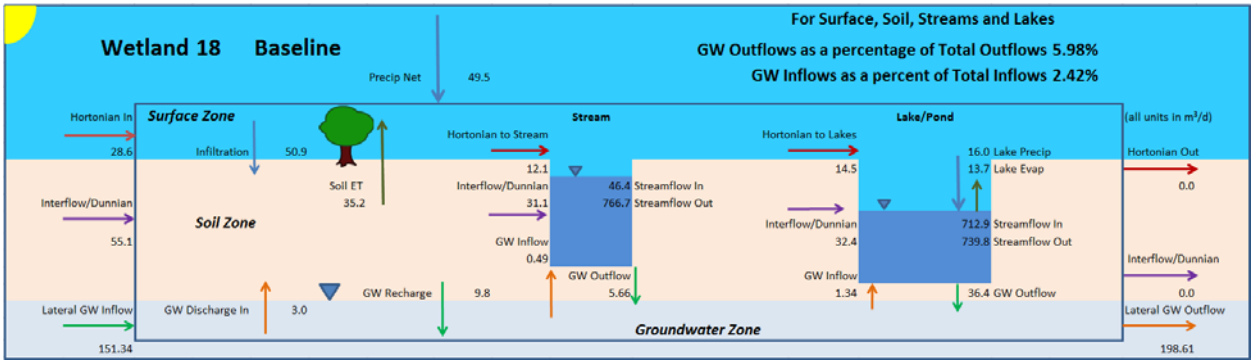


FIGURE 1B

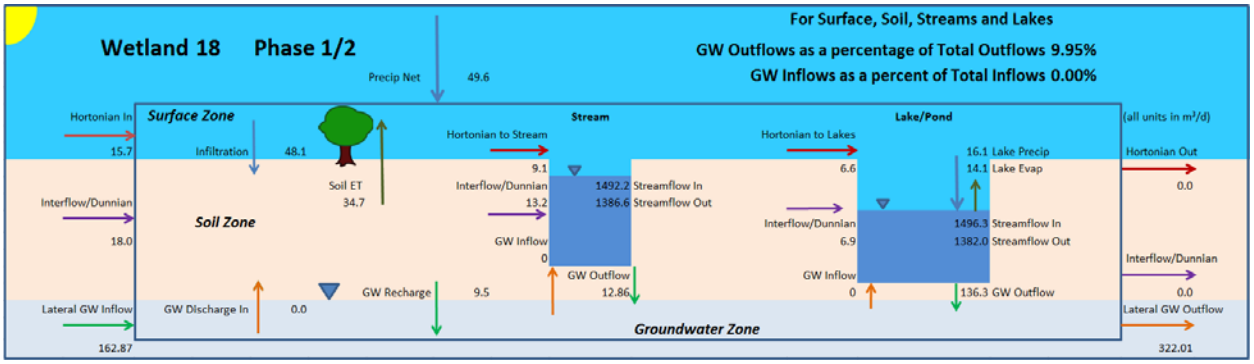


FIGURE 1C

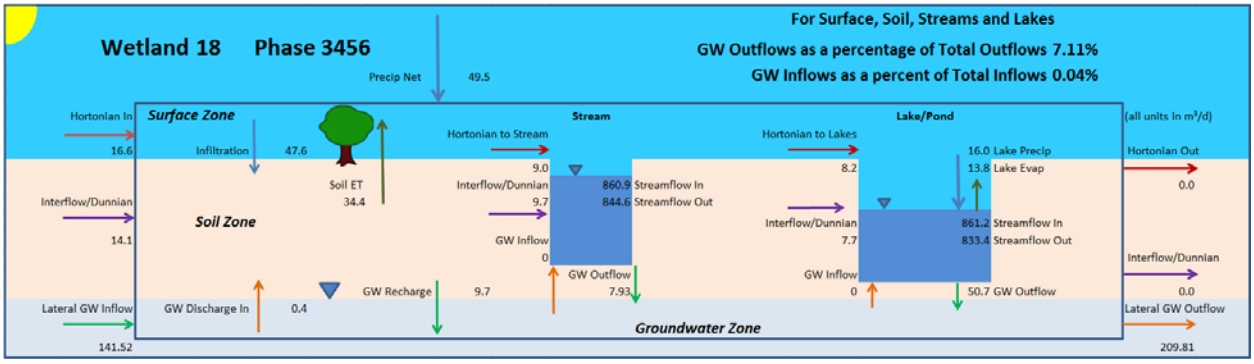


FIGURE 1D

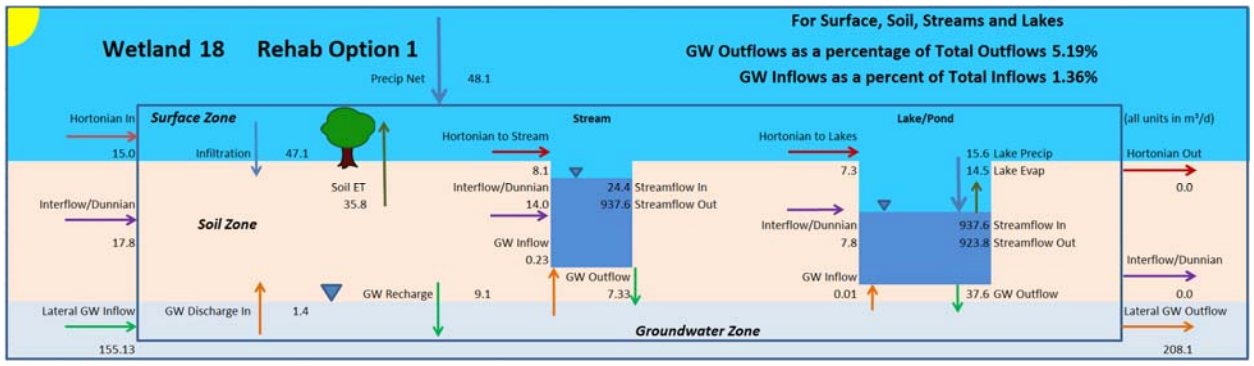
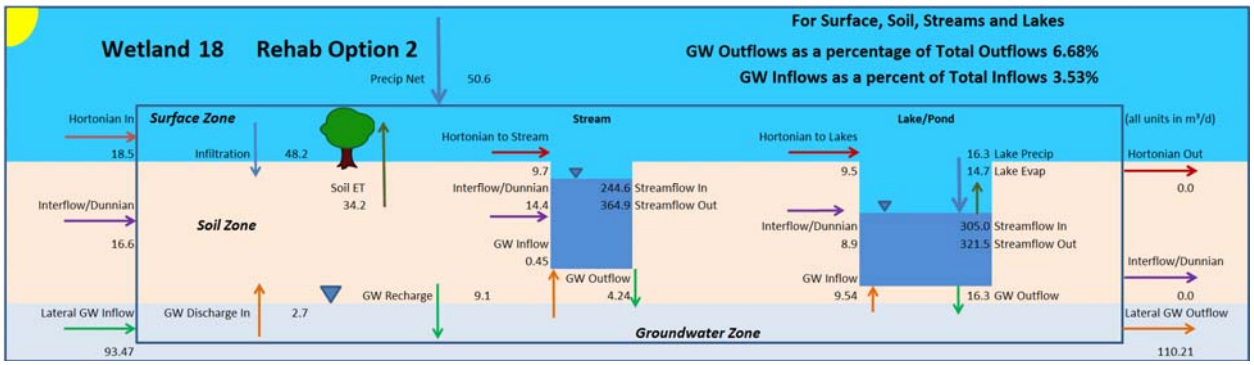
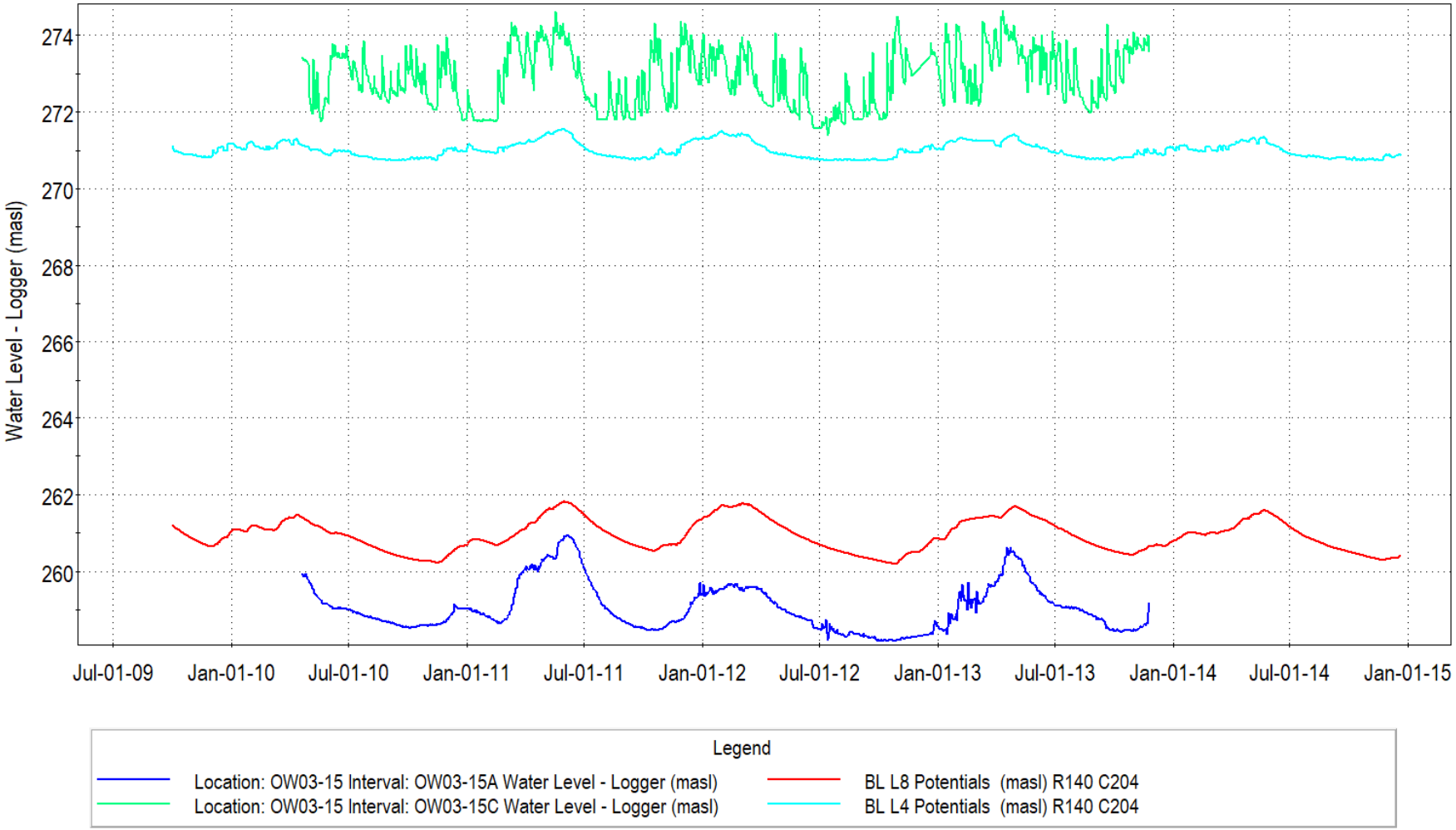


FIGURE 1E

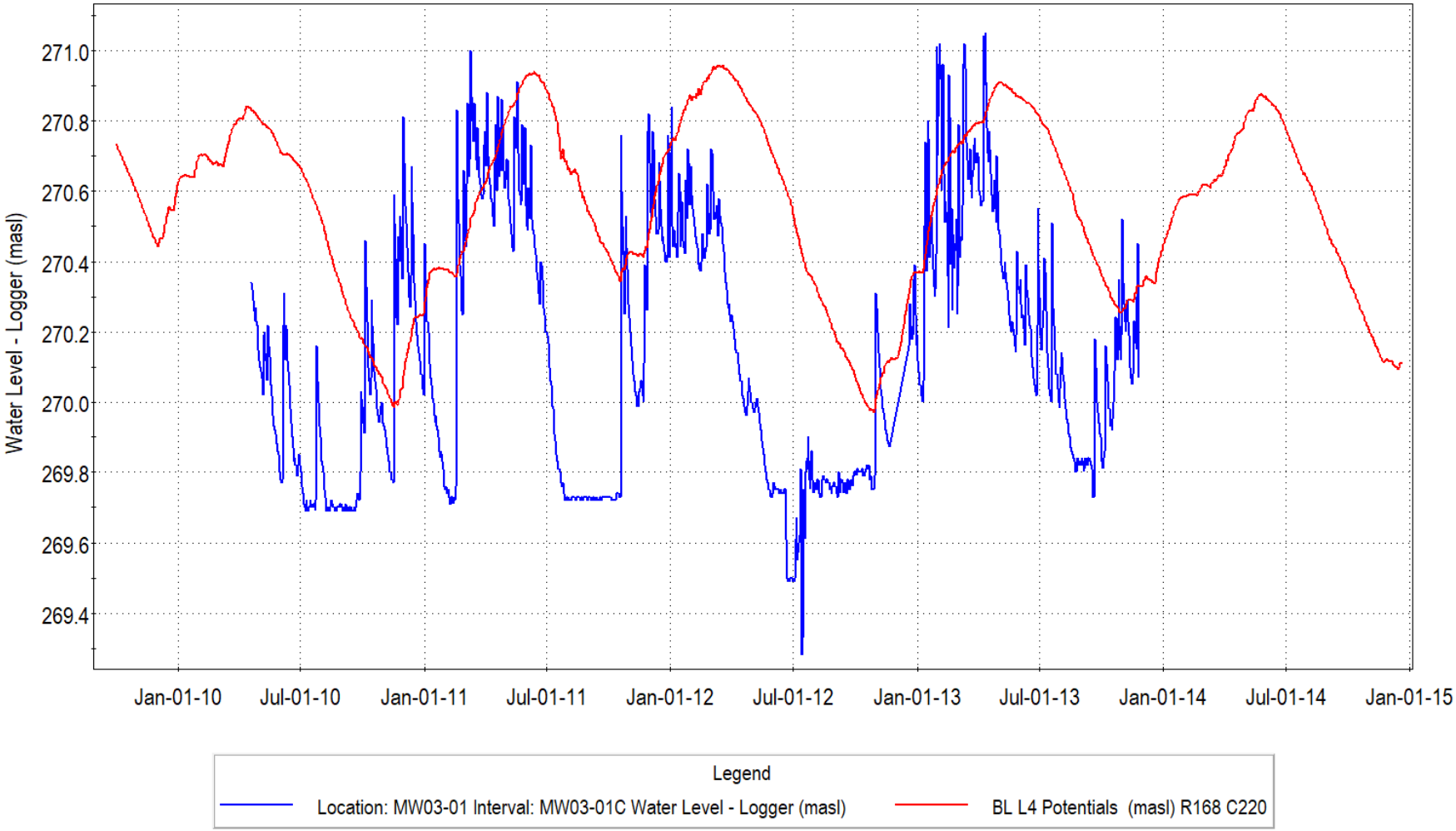


Integrated Model Calibration
Wetland 13203



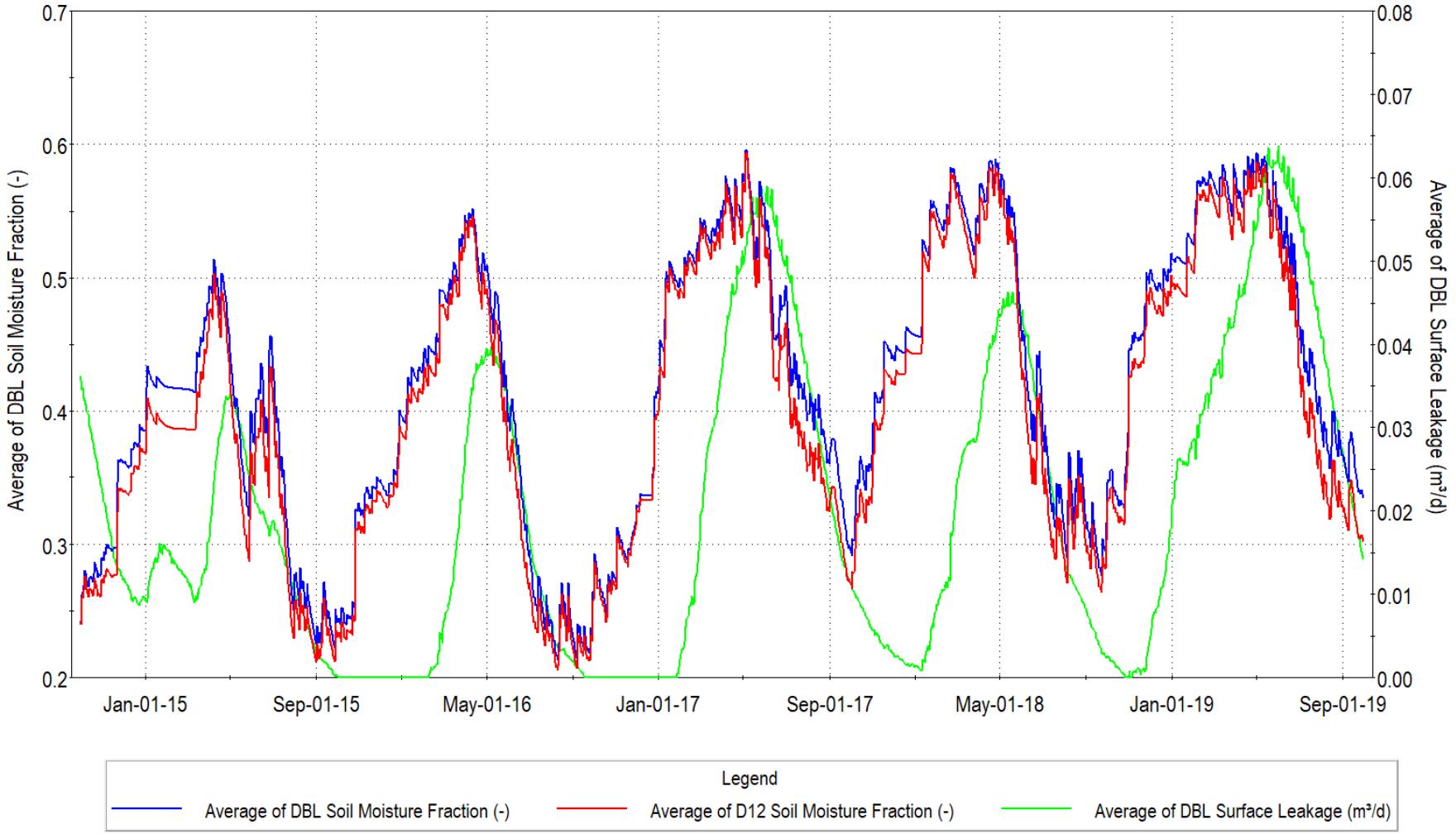
WETLAND 13203 - GRAPH 6

Integrated Model Calibration
Wetland 13203

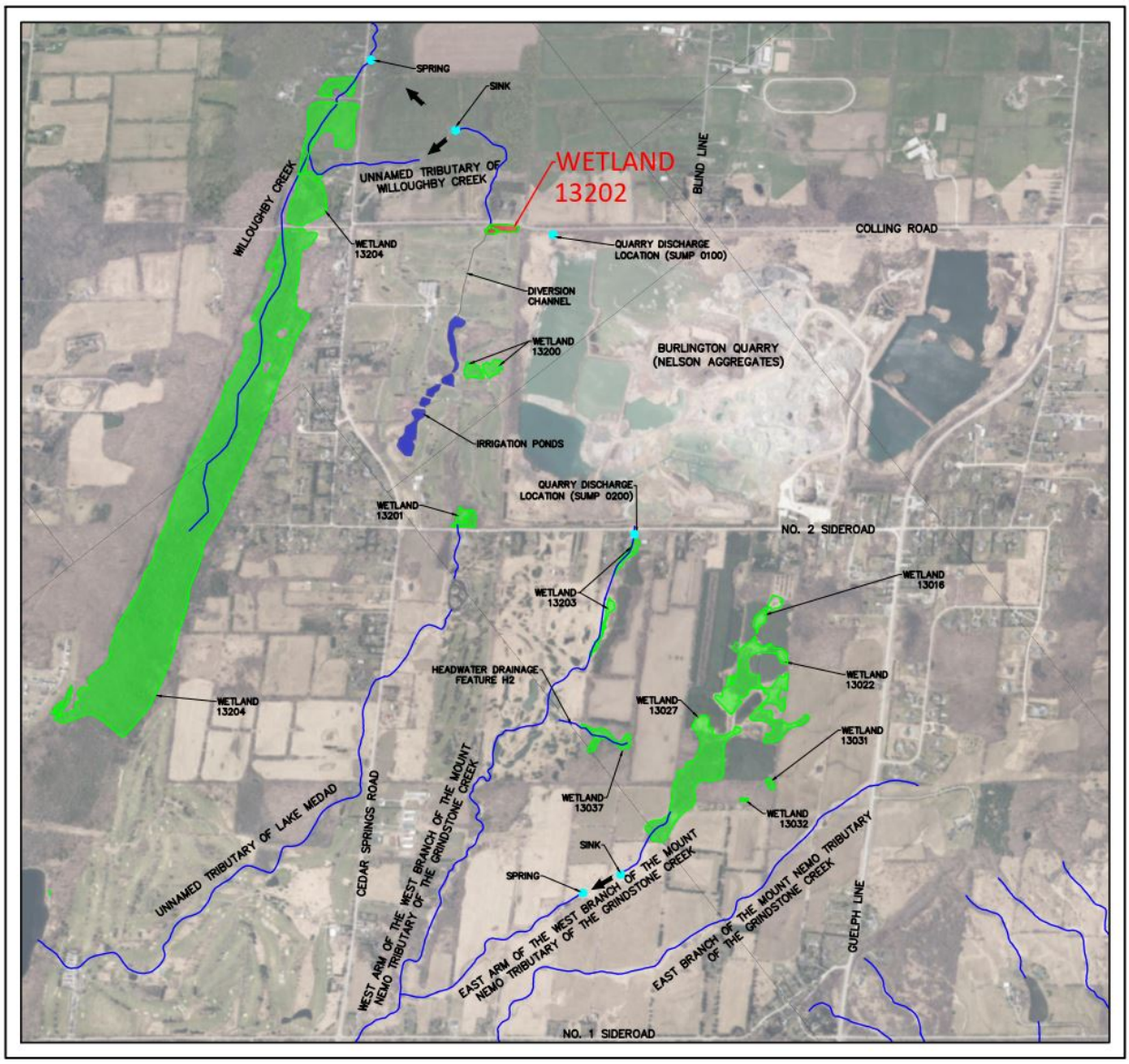


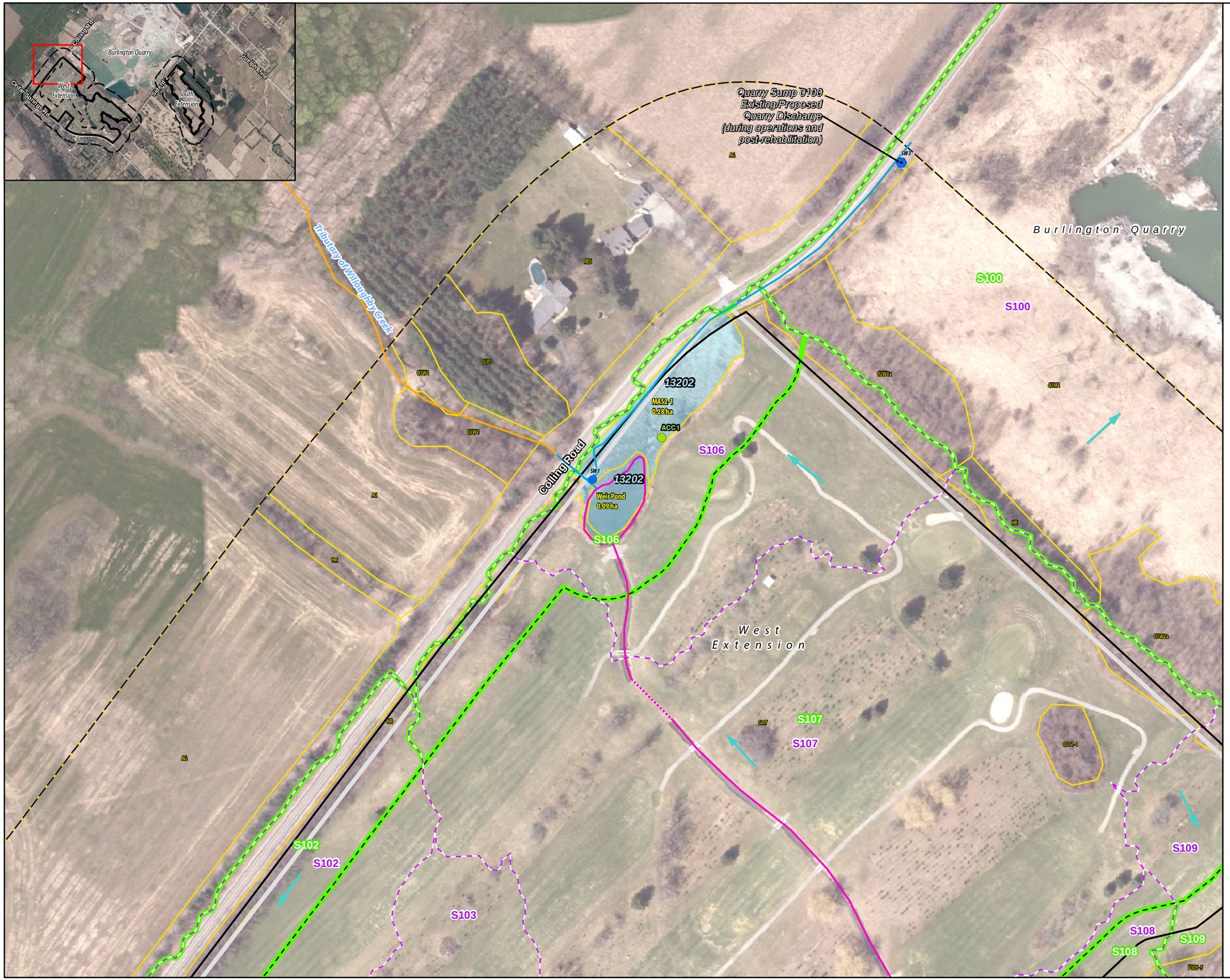
WETLAND 13203 - GRAPH 7

Change in Soil Moisture Conditions
Wetland 13203



WETLAND 13202





Legend

- Licensed Boundary
- Limit of Extraction
- 120 m Adjacent Lands
- Subject Lands
- Amphibian Call Count Station (2019)
- Golf Course Irrigation Ponds and Channel
- Indirect Fish Habitat
- Direct Fish Habitat
- Existing Subcatchment Boundary (Tatham Engineering, 2020)
- Proposed Subcatchment Boundary - Operations and Post-Rehabilitation (Tatham Engineering, 2020
- Wetland (Savanta, 2020)
- Ecological Land Classification (Savanta, 2019 & 2020)

Current Instrumentation

- Staff Gauge & Surface Water Monitoring Station (Tatham Engineering)
- Manual Stream Flow Measurement (Tatham Engineering)

ELC Legend

AG, Agriculture
CUM1, Mineral Cultural Meadow
CUP3, Coniferous Plantation
CUT1-1, Sumac Cultural Thicket
CUW1, Mineral Cultural Woodland
FOD5-5, Dry – Fresh Sugar Maple – Hickory Deciduous Forest
HR, Hedgerow
MAS2-1, Cattail Mineral Shallow Marsh
RES, Residential

NOTES:

1. Coordinate System: NAD 1983 UTM Zone 17N.
2. Base features produced under license with the Ontario Ministry of Natural Resources and Forestry © Queen's Printer for Ontario, 2021.
3. Orthoimagery © First Base Solutions, 2021. Imagery taken in 2019.

Project 8133

Burlington Quarry Extension
Nelson Aggregates Co.

Figure 7
Wetland Characterization

Wetland 13202 - West Extension

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Wetland 13202

Wetland Characteristics	Description	Figure / Graph	Reference	
			Report	Section / Page
Wetland IDs:	MNRF -N/A Earthfx - N/A Tatham - 13202 Savanta - 13202 Golder (Background) - N/A			
Wetland Area (ha):	Savanta - 0.37			
Watershed:	Bronte Creek Watershed			
Sub-Watershed:	Willoughby Creek Watershed			
Located in Proposed Limit of Extraction:	No			
Located in Proposed License Boundary:	Yes			
Catchment Area (ha):	2.32 + quarry discharge (Sump 0100)		SWA (Tatham, April 2020)	Drawing DP-1
Catchment ID:	S106		SWA (Tatham, April 2020)	Drawing DP-1
Closed or Connected System:	On-line (connected to downstream watercourse)			
Condition:	Modified			
Bathymetry:	A bathymetric survey of Wetland 13202 has not been completed.			
Outlet:	Tributary of Willoughby Creek			
Hydroperiod:	Water level in Wetland 13202 and the weir pond maintained by quarry discharge. Water levels in Wetland 13202 and the weir pond are also manipulated by a weir structure operated by the Burlington Springs Golf and Country Club for irrigation of the golf course and to maintain water levels in the on-site irrigation/hazard ponds.		SWA (Tatham, April 2020)	2.1.1, 3 and Appendix B
Surface Water Monitoring:	ID: SW1 (Tatham) Installation Date: July 17, 2015 Data Collection: Continuous water level and temperature, manual monthly in-situ streamflow measurements and calibration data (water level converted to flow using rating curve) Coordinates of Monitoring Station: Easting 589015.325, Northing 4805832.639	Graph 1	SWA (Tatham, April 2020)	2.1.1 and Appendix B

Natural Heritage and Habitat Features	Description	Figure / Graph	Reference	
			Report	Section / Page
Wetland Name & Provincial Significance Evaluation:	Wetland 13202 – Other (it is completely dependent on pumping from the existing quarry; however it has been designed to demonstrate no negative impacts.)		NETR (Savanta, April 2020)	6.1.2
ELC Unit(s):	Pond: Weir Pond Cattail Mineral Shallow Marsh: MAS2-1		NETR (Savanta, April 2020)	Table 2
Regulated Habitat (MECP):	No		NETR (Savanta, April 2020)	6.7
Significant Wildlife Habitat:	None confirmed for amphibian breeding, despite survey effort through habitat assessments and call count surveys. Confirmed for species of conservation concern – Unicorn Clubtail.		NETR (Savanta, April 2020)	4.2.2; 4.2.5; 5.2.2; 5.2.5; 6.4; Table 19
Fish Habitat:	Weir Pond – part of the golf course irrigation ponds and channel MAS2-1 – Indirect fish habitat		NETR (Savanta, April 2020)	6.6
Habitat of Endangered and Threatened Species:	No species at risk salamanders observed, despite survey effort including habitat assessment.		NETR (Savanta, April 2020)	5.2.2

Groundwater Interaction	Description	Figure / Graph	Reference	
			Report	Section / Page
Lithology:	Halton Till			
Hydraulic Conductivity:	Integrated Model (Earthfx) - The harmonic mean hydraulic conductivity, based on testing by Golder (2007) of 10 mini-piezometers, was $1.2x10^{-8}$ m/s. Model value for the vertical hydraulic conductivity was $1.6x10^{-7}$ m/s, about an order of magnitude higher, to account for limited flow through fractures in the till.			
Surface Water/Groundwater Interaction:	The low permeability of the Halton Till underlying the wetland is the dominant control on 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.			
Water Budget Results:	No detailed water budget was produced for this wetland. The wetland is close to Wetland 13032 (Earthfx Wetland 19) and similar in size. The water budget for this wetland should be similar. Simulated groundwater levels, groundwater discharge to riparian areas, and streamflow in the vicinity of Wetland 13032 (Earthfx Wetland 19) for baseline conditions is discussed in Section 7 of the main report			
Integrated Model Calibration:	The calibration of this wetland is not discussed in the Earthfx Report.			

Impact Assessment (Operations Phases 1 & 2)	Description	Figure / Graph	Reference	
			Report	Section / Page
Change in Wetland Area (ha):	No change.			
Change in Wetland Catchment Area (ha):	No change. No extraction proposed in West Extension as part of Phases 1 and 2 of extraction.		SWA (Tatham, April 2020)	Drawing DP-2
Change in Hydroperiod:	No Change.			
Change in Water Budget:	Detailed water budgets were not prepared for this feature. Changes in streamflow at SW1 were discussed in Section 8.7.6. Simulated change in groundwater levels (drawdowns), groundwater discharge to riparian areas, and change in streamflow in the vicinity of the wetland are discussed in Section 8 of the main report for each scenario a.		HHIAR (Earthfx, April 2020)	191 - 303
Potential Impact to Form and Function of Feature:	No potential impacts to Wetland 13202 and the weir pond under Phases 1 and 2 of operations.			

Mitigation (Operational Phases 1 & 2)	Description	Figure / Graph	Reference	
			Report	Section / Page
Proposed Mitigation Measures:	No mitigation required under Phase 1 and 2 of operations. Existing quarry discharge to be maintained.			

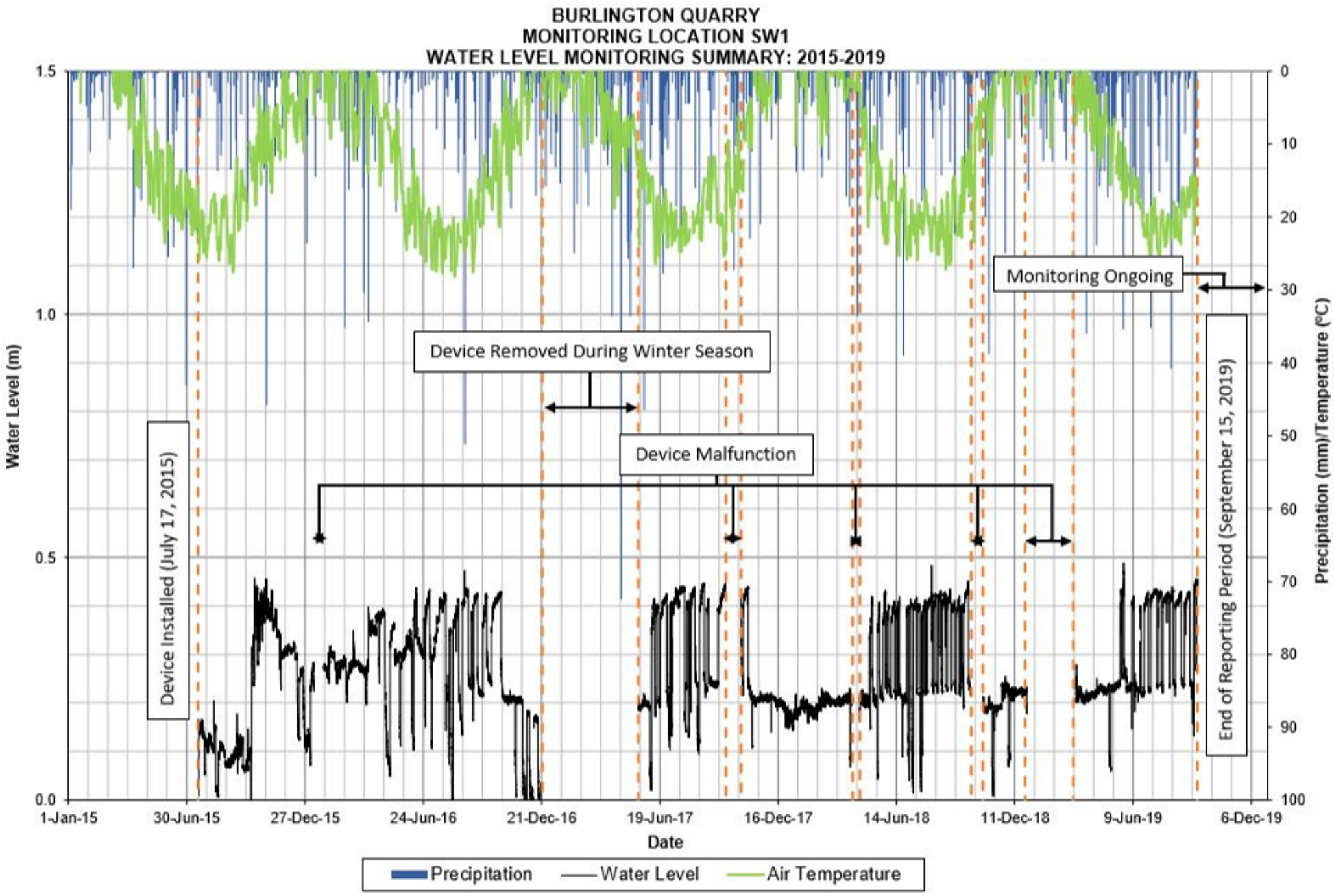
Impact Assessment (Operations Phases 3 - 6)	Description	Figure / Graph	Reference	
			Report	Section / Page
Change in Wetland Area (ha):	No change.			
Change in Wetland Catchment Area (ha):	Reduction in catchment area. During operations in Phases 3 through 6 the catchment area will be reduced to 1.6 ha (reduction of 0.72 ha)		SWA (Tatham, April 2020)	Drawing DP-2
Change in Hydroperiod:	No change in hydroperiod expected as quarry discharge maintains wetland and weir pond water levels.			
Change in Water Budget:	Detailed water budgets were not prepared for this feature. Changes in streamflow at SW1 were discussed in Section 8.7.6. Simulated change in groundwater levels (drawdowns), groundwater discharge to riparian areas, and change in streamflow in the vicinity of the wetland are discussed in Section 8 of the main report for each scenario.		HHIAR (Earthfx, April 2020)	191 - 303
Potential Impact to Form and Function of Feature:	Both the pond and the wetland will remain in place. There will be no encroachment from the project into the wetlands. Proposed limit of extraction is ≥30 m from the wetland boundary. A proposed berm will be constructed within the 30 m setback. The closest point of the berm will be 14 m from the wetland boundary. The extraction limit will be demarcated and fenced to ensure site construction and operations do not extend beyond the proposed limits of the project . The berm will be vegetated with common, native species (as approved by Conservation Halton) to ensure soil stability and prevention of erosion. The Weir Pond and the MAS2-1 are supplied with water by pumping from the existing adjacent quarry. The proposed quarry Extension is not anticipated to have any impact on pumping or water quality related to discharge from the existing quarry. Pumping and discharge are recommended to occur at the same location at the upstream end of the tributary and in the same manner as existing pumping.		NETR (Savanta, April 2020)	7.2.1; 7.1.1; 7.1.2

Mitigation (Operational Phases 3 - 6)	Description	Figure / Graph	Reference	
			Report	Section / Page
Proposed Mitigation Measures:	The Weir Pond and the MAS2-1 are supplied with water by pumping from the existing adjacent quarry. The proposed quarry Extension is not anticipated to have any impact on pumping or water quality related to discharge from the existing quarry. Pumping and discharge are recommended to occur at the same location at the upstream end of the tributary and in the same manner as existing pumping.		NETR (Savanta, April 2020)	7.2.1; 7.1.1; 7.1.2

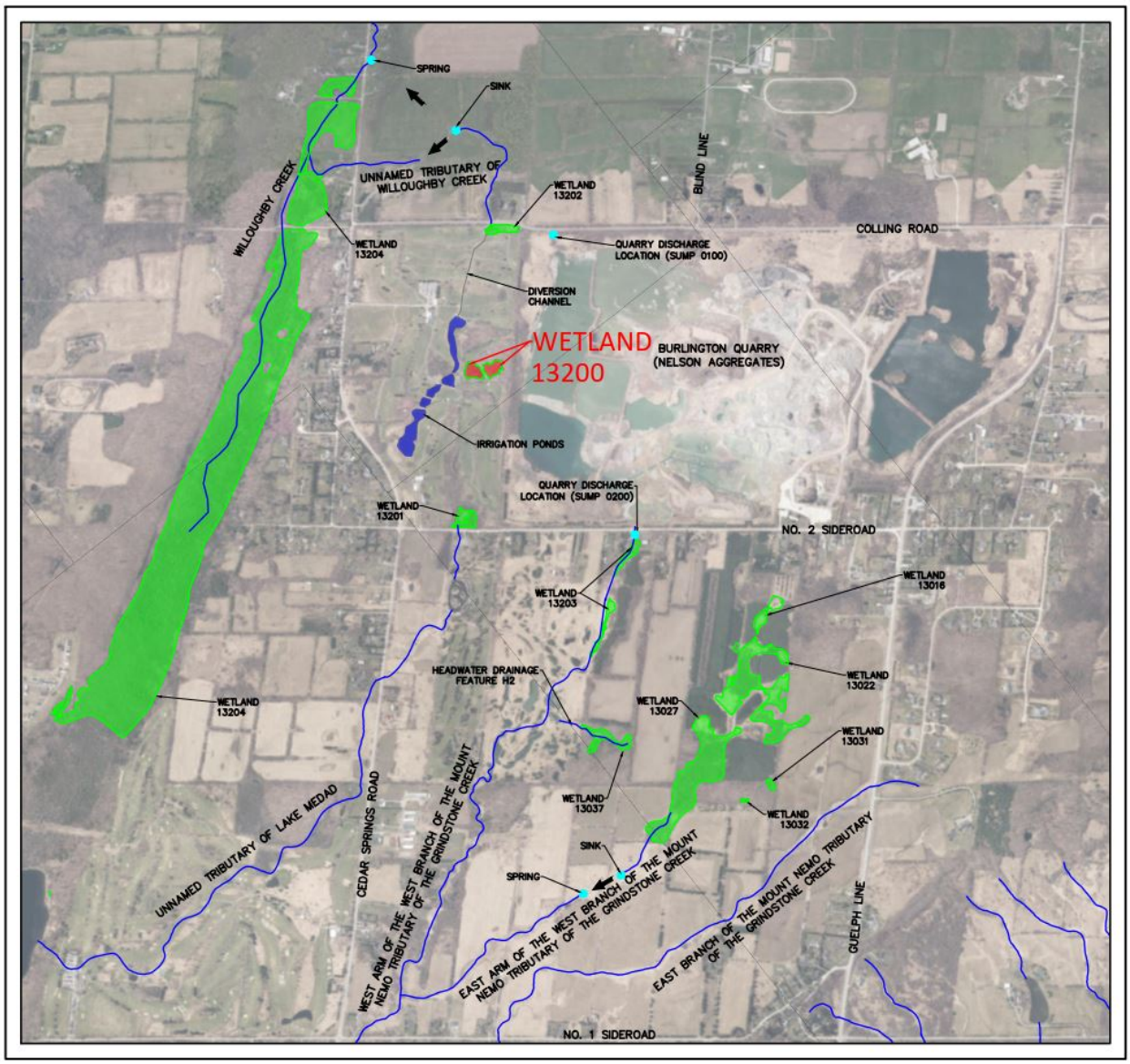
Impact Assessment (Rehabilitation)	Description	Figure / Graph	Reference	
			Report	Section / Page
Change in Wetland Area (ha):	No change.			
Change in Wetland Catchment Area (ha):	Reduction in catchment area. During operations in Phases 3 through 6 the catchment area will be reduced to 1.6 ha (reduction of 0.72 ha). Drainage area to remain 1.6 ha post rehabilitation.		SWA (Tatham, April 2020)	Drawing DP-3
Change in Hydroperiod:	Currently approved plan for Burlington Quarry is to cease discharge following operations creating a pit lake. Ceasing discharge from the quarry will adversely impact Wetland 13202 and the Tributary of Willoughby Creek. No change in hydroperiod expected if quarry discharge is maintained.			
Change in Water Budget:	Detailed water budgets were not prepared for this feature. Changes in streamflow at SW1 were discussed in Section 8.7.6. Simulated change in groundwater levels (drawdowns), groundwater discharge to riparian areas, and change in streamflow in the vicinity of the wetland are discussed in Section 8 of the main report for each scenario.		HHIAR (Earthfx, April 2020)	191 - 303
Potential Impact to Form and Function of Feature:	Both the pond and the wetland will remain in place. There will be no encroachment from the project into the wetlands. Proposed limit of extraction is ≥30 m from the wetland boundary. A proposed berm will be constructed within the 30 m setback. The closest point of the berm will be 14 m from the wetland boundary. The extraction limit will be demarcated and fenced to ensure site construction and operations do not extend beyond the proposed limits of the project . The berm will be vegetated with common, native species (as approved by Conservation Halton) to ensure soil stability and prevention of erosion. The Weir Pond and the MAS2-1 are supplied with water by pumping from the existing adjacent quarry. The proposed quarry Extension is not anticipated to have any impact on pumping or water quality related to discharge from the existing quarry. Pumping and discharge are recommended to occur long-term at the same location at the upstream end of the tributary and in the same manner as existing pumping.		NETR (Savanta, April 2020)	7.2.1; 7.1.1; 7.1.2

Mitigation (Rehabilitation)	Description	Figure / Graph	Reference	
			Report	Section / Page
Proposed Mitigation Measures:	The Weir Pond and the MAS2-1 are supplied with water by pumping from the existing adjacent quarry. The proposed quarry Extension is not anticipated to have any impact on pumping or water quality related to discharge from the existing quarry. Pumping and discharge are recommended to occur long-term at the same location at the upstream end of the tributary and in the same manner as existing pumping. The cessation of quarry discharge will adversely impact Wetland 13202 and the Unnamed Tributary of Willoughby Creek.		NETR (Savanta, April 2020)	7.2.1; 7.1.1; 7.1.2

WETLAND 13202 - GRAPH 1



WETLAND 13200





Legend

- Licensed Boundary
- Limit of Extraction
- 120 m Adjacent Lands
- Subject Lands
- Amphibian Call Count Station (2019)
- Golf Course Irrigation Ponds and Channel
- Existing Subcatchment Boundary (Tatham Engineering, 2020)
- Proposed Subcatchment Boundary - Operations and Post-Rehabilitation (Tatham Engineering, 2020
- Proposed Subcatchment Boundary - Operations (Tatham Engineering, 2020)
- Proposed Subcatchment Boundary - Post-Rehabilitation (Tatham Engineering, 2020)
- Wetland (Savanta, 2020)
- Ecological Land Classification (Savanta, 2019 & 2020)
- Ecological Land Classification (Savanta, 2020)

Current Instrumentation

- Mini Piezometer (Tatham Engineering)

Previous Instrumentation

- Groundwater Monitoring Station (Golder)

ELC Legend

CUM1, Mineral Cultural Meadow
CUT1, Mineral Cultural Thicket
CUT1-1, Sumac Cultural Thicket
CUW1, Mineral Cultural Woodland
DIST, Disturbed
FOD5-1, Dry- Fresh Sugar Maple Deciduous Forest
FOD5-2, Dry- Fresh Sugar Maple-Beech Deciduous Forest
FOD5-5, Dry – Fresh Sugar Maple – Hickory Deciduous Forest
FOD7-2, Fresh-Moist Ash Lowland Deciduous Forest
HR, Hedgerow
OA, Open Aquatic
RES, Residential
SWD3-2, Silver Maple Mineral Deciduous Swamp

NOTES:

1. Coordinate System: NAD 1983 UTM Zone 17N.
2. Base features produced under license with the Ontario Ministry of Natural Resources and Forestry © Queen's Printer for Ontario, 2021.
3. Orthoimagery © First Base Solutions, 2021. Imagery taken in 2019.

Project 8133

Burlington Quarry Extension
Nelson Aggregates Co.

Figure 8
Wetland Characterization

Wetland 13200 - West Extension

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Wetland 13200

Wetland Characteristics	Description	Figure / Graph	Reference	
			Report	Section / Page
Wetland IDs:	MNRF -N/A Earthfx - 22 Tatham - 13200 Savanta - 13200 Golder (Background) - N/A			
Wetland Area (ha):	Savanta - 0.73			
Watershed:	Bronte Creek Watershed			
Sub-Watershed:	Willoughby Creek Watershed			
Located in Proposed Limit of Extraction:	No			
Located in Proposed License Boundary:	No			
Catchment Area (ha):	7.38		SWA (Tatham, April 2020)	Drawing DP-1
Catchment ID:	S109		SWA (Tatham, April 2020)	Drawing DP-1
Closed or Connected System:	Isolated Feature			
Condition:	Natural			
Bathymetry:	A bathymetric survey of Wetland 13200 has not been completed.			
Outlet:	None			
Hydroperiod:	Monitoring station established April 22, 2020. Hydroperiod to be determined.			
Surface Water Monitoring:	ID: SW37 (Tatham) Installation Date: April 22, 2020 Data Collection: Continuous water level and temperature and manual monthly water level measurements Coordinates of Monitoring Station: Easting 589429.71, Northing 4805390.25			

Natural Heritage and Habitat Features	Description	Figure / Graph	Reference	
			Report	Section / Page
Wetland Name & Provincial Significance Evaluation:	Wetland 13200 – Other (considered not significant due to lack of amphibian breeding habitat, isolated and not connected to a PSW; however it has been designed to demonstrate no negative impacts.)		NETR (Savanta, April 2020)	6.1.2
ELC Unit(s):	Silver Maple Mineral Deciduous Swamp: SWD3-2a		NETR (Savanta, April 2020)	Table 2
Regulated Habitat (MECP):	No		NETR (Savanta, April 2020)	6.7
Significant Wildlife Habitat:	None confirmed for amphibian breeding, despite survey effort through habitat assessments. Salamander trapping and call count surveys were not completed due to absence of water.		NETR (Savanta, April 2020)	4.2.2; 5.2.2; Table 19
Fish Habitat:	None		NETR (Savanta, April 2020)	6.6
Habitat of Endangered and Threatened Species:	No species at risk salamanders observed, despite survey effort including habitat assessment.		NETR (Savanta, April 2020)	5.2.2

<table>
<tr><th>Groundwater Interaction</th><th>Description</th><th>Figure / Graph</th><th colspan="2">Reference</th></tr>
<tr><th></th><th></th><th></th><th>Report</th><th>Section / Page</th></tr>
<tr><td>Lithology:</td><td>Halton Till</td><td></td><td></td><td></td></tr>
<tr><td>Hydraulic Conductivity:</td><td>Integrated Model (Earthfx) - The harmonic mean hydraulic conductivity, based on testing by Golder (2007) of 10 mini-piezometers, was 1.2x10^{-8} m/s. Model value for the vertical hydraulic conductivity was 1.6x10^{-7} m/s, about an order of magnitude higher, to account for limited flow through fractures in the till.</td><td></td><td></td><td></td></tr>
<tr><td>Surface Water/Groundwater Interaction:</td><td>The low permeability of the Halton Till underlying the wetland is the dominant control on 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. This wetland does not receive significant groundwater inflow and is isolated from any changes in the water table due to quarry development.</td><td></td><td></td><td></td></tr>
<tr><td>Shallow Groundwater (Mini-piezometer) Monitoring:</td><td>ID: SW37 (Tatham)
Installation Date: April 22, 2020
Data Collection: Continuous water level and temperature and manual monthly water level measurements
Coordinates of Monitoring Station: Easting 589429.71, Northing 4805390.25</td><td></td><td></td><td></td></tr>
<tr><td>Groundwater Monitoring (Monitoring Wells):</td><td>
<table>
<tr><td>Monitoring Well ID</td><td>Distance (Dir.)</td><td>Geologic Unit</td><td>Ground Elevation</td><td>Monitoring Elev</td><td>Average WL</td></tr>
<tr><td>BS-03A</td><td>131 (SSW)</td><td>Bedrock</td><td>271.73</td><td>-</td><td>264.53</td></tr>
<tr><td>BS-03B</td><td>131 (SSW)</td><td>Bedrock</td><td>271.73</td><td>-</td><td>264.57</td></tr>
<tr><td>BS-03</td><td>131 (SSW)</td><td>Bedrock</td><td>271.73</td><td>-</td><td>266.05</td></tr>
</table>
</td><td>Graph 1</td><td></td><td></td></tr>
<tr><td>Water Budget Results:</td><td>A detailed average water budget, as simulated by the integrated model, is provided in the main report for Baseline Conditions (Earthfx Figure 7.30, p. 189). The baseline water budget is reproduced in Figure 1a. The wetland is a net provider of groundwater. Simulated groundwater levels, groundwater discharge to riparian areas, and streamflow in the vicinity of Wetland 13200 (Earthfx Wetland 22) for baseline conditions are discussed in Section 7 of the main report.
<table>
<tr><td>Wetland 13200</td><td>GW Outflow (%)</td><td>GW Inflow (%)</td></tr>
<tr><td>Baseline (Existing)</td><td>26.31</td><td>0.00</td></tr>
</table>
</td><td>Figure 1a</td><td>HHIAR (Earthfx, April 2020)</td><td>165 - 190</td></tr>
<tr><td>Integrated Model Calibration:</td><td>No mini-piezometers for calibration. The model calibration to the new groundwater monitoring well 100 m south west show a good calibration to the available monitoring record (see Graph 2). Wetland 22 is not discussed in the Main Report. Other nearby wetlands are discussed in Appendix E, Section 19.6.</td><td>Graph 2</td><td></td><td></td></tr>
</table>

<table>
<tr><th>Impact Assessment (Operations Phases 1 & 2)</th><th>Description</th><th>Figure / Graph</th><th colspan="2">Reference</th></tr>
<tr><th></th><th></th><th></th><th>Report</th><th>Section / Page</th></tr>
<tr><td>Change in Wetland Area (ha):</td><td>No change.</td><td></td><td></td><td></td></tr>
<tr><td>Change in Wetland Catchment Area (ha):</td><td>No change. No extraction proposed in West Extension as part of Phases 1 and 2 of extraction.</td><td></td><td>SWA (Tatham, April 2020)</td><td>Drawing DP-2</td></tr>
<tr><td>Change in Hydroperiod:</td><td>No Change</td><td></td><td></td><td></td></tr>
<tr><td>Change in Water Budget:</td><td>A detailed average water budget as simulated by the integrated model is provided in the Earthfx report for Baseline Conditions (Figure 7.30, p. 189); Scenario P12 (Figure 8.37, p. 224); P3456 (Figure 8.69, p. 251 Wetland 22); RHB1 (Figure 8.103, p. 279), and RHB2 (Figure 8.130, p. 301). The water budget results for Scenario P12 are reproduced in Figure 1b. Wetland 13200 (Earthfx 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 during Phase 1 and 2 operations because it is perched year-round and there was no change in the contributing area. Simulated change in groundwater levels (drawdowns), groundwater discharge to riparian areas, and change in streamflow in the vicinity of Wetland 13200 (Earthfx Wetland 22) for each scenario are discussed in Section 8 of the main report.
<table>
<tr><td>Wetland 13200</td><td>GW Outflow (%)</td><td>GW Inflow (%)</td><td>Δ in Outflow (%)</td><td>Δ in Inflow (%)</td></tr>
<tr><td>Baseline (Existing)</td><td>26.31</td><td>0.00</td><td>-</td><td>-</td></tr>
<tr><td>Operations Ph 1 & 2</td><td>25.24</td><td>0.00</td><td>-1.07</td><td>0.00</td></tr>
</table></td><td>Figure 1b</td><td>HHIAR (Earthfx, April 2020)</td><td>191 - 303</td></tr>
<tr><td>Potential Impact to Form and Function of Feature:</td><td>No wetlands will be removed and the wetlands subcatchment will be maintained. There will be no encroachment from the project into the wetland.</td><td></td><td></td><td></td></tr>
</table>

Mitigation (Operational Phases 1 & 2)	Description	Figure / Graph	Reference	
			Report	Section / Page
Proposed Mitigation Measures:	None required.			

Impact Assessment (Operations Phases 3 - 6)	Description	Figure / Graph	Reference	
			Report	Section / Page
Change in Wetland Area (ha):	No change.			
Change in Wetland Catchment Area (ha):	Reduction in catchment area. During operations in Phases 3 through 6 the catchment area will be reduced to 5.40 ha (reduction of 1.98 ha)		SWA (Tatham, April 2020)	Drawing DP-2
Change in Hydroperiod:	Reduction due to reduction in catchment area. Change in hydroperiod to be determined (to be mitigated).			
Change in Water Budget:	A detailed average water budget as simulated by the integrated model is provided in the Earthfx report for Baseline Conditions (Figure 7.30, p. 189); Scenario P12 (Figure 8.37, p. 224); P3456 (Figure 8.69, p. 251 Wetland 22); RHB1 (Figure 8.103, p. 279), and RHB2 (Figure 8.130, p. 301). The water budget results for Scenario P3456 are reproduced in Figure 1c. Wetland 13200 (Earthfx Wetland 22) is located between the P3456 extraction area and the existing quarry. This wetland had a minor change in the water budget compared to baseline conditions due to changes to the contributing drainage area. However the wetland remained perched. This wetland will be monitored and receive supplemental inflows as required to maintain its hydroperiod, as described in the Tatham, 2020 report. The planned supplementation has not been represented in the model, so the Wetland 13201 (Earthfx Wetland 21) water budget is not fully representative of future conditions. Simulated change in groundwater levels (drawdowns), groundwater discharge to riparian areas, and change in streamflow in the vicinity of Wetland 13200 (Earthfx Wetland 13200) for each scenario are discussed in Section 8 of the main report.	Figure 1c	HHIAR (Earthfx, April 2020)	191 - 303
Change on Soil Moisture Conditions:	The Water Budget figures indicate that there is no groundwater seepage entering the wetland under baseline conditions, so there will be no change under P3456 conditions.			
Potential Impact to Form and Function of Feature:	Both wetlands will remain in place. There will be no encroachment from the project into the wetlands. The proposed limit of extraction is >30 m from the wetland boundary. The licensed boundary/extraction limit will be demarcated and fenced to ensure site construction and operations do not extend beyond the proposed limits of the project . The drainage area to these wetland units will be reduced during operations, which has the potential to adversely impact the hydroperiods.		NETR (Savanta, April 2020)	7.2.1; 7.1.1; 7.1.2

Wetland 13200	GW Outflow (%)	GW Inflow (%)	Δ in Outflow (%)	Δ in Inflow (%)
Baseline (Existing)	26.31	0.00	-	-
Operations Ph 3 - 6	26.31	0.00	0.00	0.00

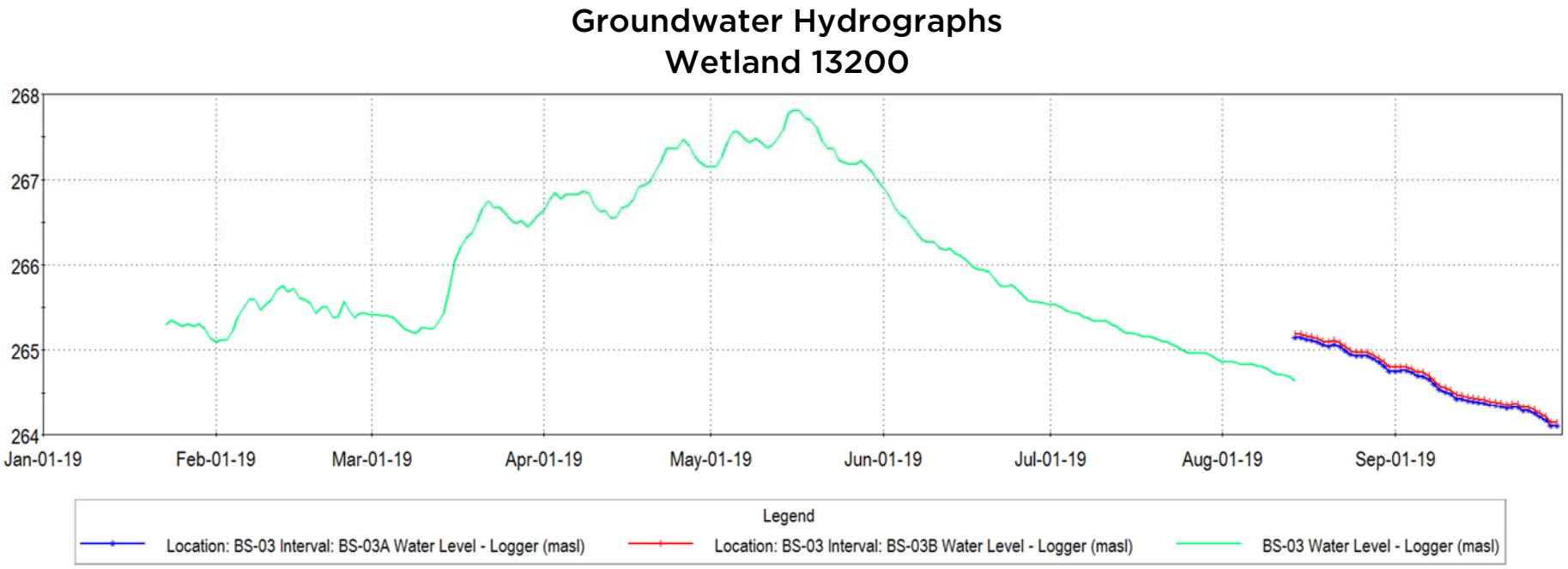
Mitigation (Operational Phases 3 - 6)	Description	Figure / Graph	Reference	
			Report	Section / Page
Proposed Mitigation Measures:	To mitigate this potential impact, flow to the wetlands will be supplemented by pumping from Quarry Sump 0100 directly into the wetland at specified rates and volumes to maintain the wetland hydroperiod. Wetland hydroperiod and shallow groundwater monitoring stations were installed in spring 2020. This data will be used to establish existing thresholds so existing conditions can be maintained throughout extraction operations.		NETR (Savanta, April 2020)	7.2.1; 7.1.1; 7.1.2

Impact Assessment (Rehabilitation)	Description	Figure / Graph	Reference	
			Report	Section / Page
Change in Wetland Area (ha):	No change.			
Change in Wetland Catchment Area (ha):	No change. Subcatchment area will be reinstated as part of rehabilitation.		SWA (Tatham, April 2020)	Drawing DP-3
Change in Hydroperiod:	No Change. Wetland is perched and isolated from the groundwater system. Subcatchment area will be reinstated as part of rehabilitation.			
Change in Water Budget:	A detailed average water budget as simulated by the integrated model is provided in the Earthfx report for Baseline Conditions (Figure 7.30, p. 189); Scenario P12 (Figure 8.37, p. 224); P3456 (Figure 8.69, p. 251 Wetland 22); RHB1 (Figure 8.103, p. 279), and RHB2 (Figure 8.130, p. 301). The water budget results for Scenarios RHB1 and RHB2 are presented in Figures 1d and 1e. Wetland 13200 (Earthfx Wetland 22) is located between the P3456 extraction area and the existing quarry. This wetland had no significant change in the water budget compared to baseline conditions because it is perched year-round and the catchment area will be reinstated as part of rehabilitation of the site. Simulated change in groundwater levels (drawdowns), groundwater discharge to riparian areas, and change in streamflow in the vicinity of Wetland 13200 (Earthfx Wetland 13200) for each scenario are discussed in Section 8 of the main report	Figure 1d and 1e	HHIAR (Earthfx, April 2020)	191 - 303
Potential Impact to Form and Function of Feature:	Both wetlands will remain in place. There will be no encroachment from the project into the wetlands. The proposed limit of extraction is >30 m from the wetland boundary. The licensed boundary/extraction limit will be demarcated and fenced to ensure site construction and operations do not extend beyond the proposed limits of the project . The drainage area to these wetland units will be reduced during operations, which has the potential to adversely impact the hydroperiods.		NETR (Savanta, April 2020)	7.2.1; 7.1.1; 7.1.2

Wetland 13200	GW Outflow (%)	GW Inflow (%)	Δ in Outflow (%)	Δ in Inflow (%)
Baseline (Existing)	26.31	0.00	-	-
Rehab Scenario 1	24.14	0.00	-2.17	0.00
Rehab Scenario 2	28.47	0.00	2.16	0.00

Mitigation (Rehabilitation)	Description	Figure / Graph	Reference	
			Report	Section / Page
Proposed Mitigation Measures:	Once operations are complete and the rehabilitation is implemented, the grade around the wetlands will be returned to existing conditions reinstating the catchment area to the wetland. Wetland hydroperiods and shallow groundwater monitoring stations were installed in spring 2020. This data will be used to establish existing thresholds so existing conditions can be maintained throughout extraction operations and replicated in post-operation / rehabilitated conditions.		NETR (Savanta, April 2020)	7.2.1; 7.1.1; 7.1.2

WETLAND 13200 - GRAPH 1



WETLAND 13200

FIGURE 1A

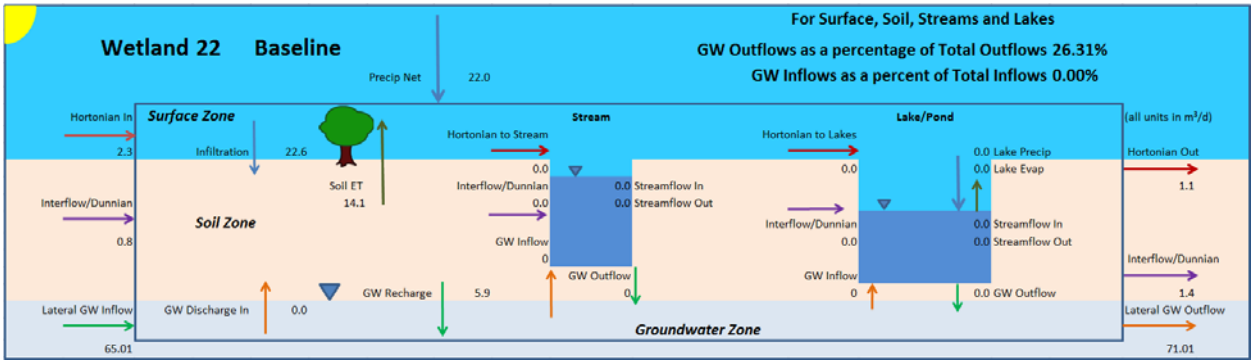


FIGURE 1B

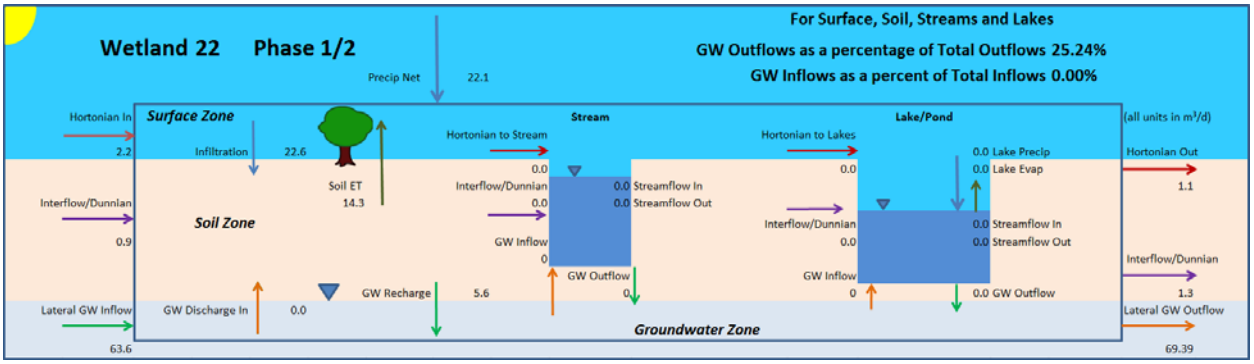


FIGURE 1C

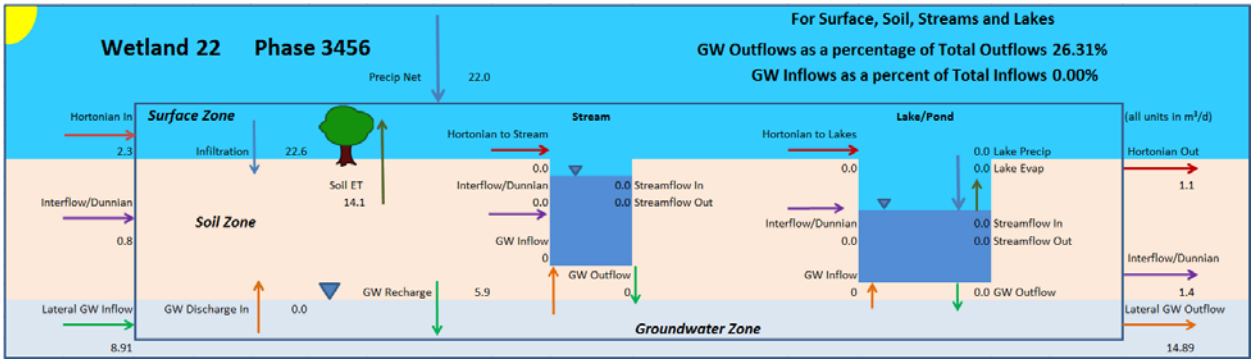


FIGURE 1D

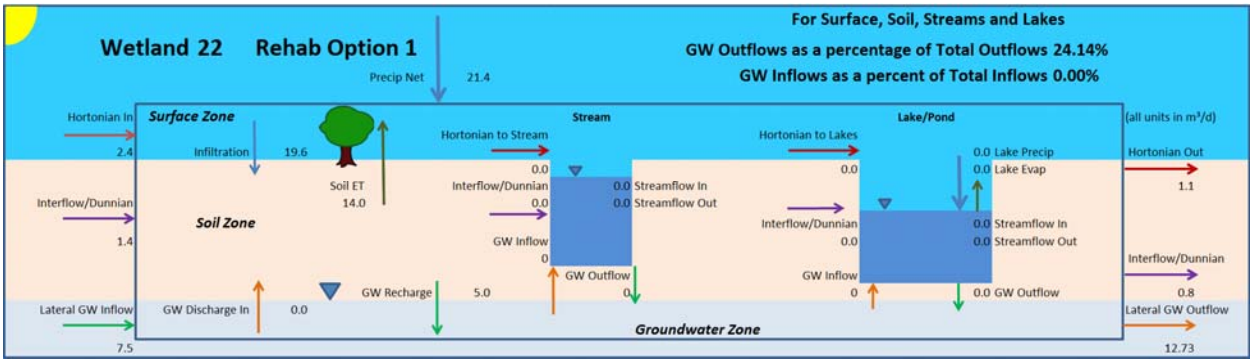
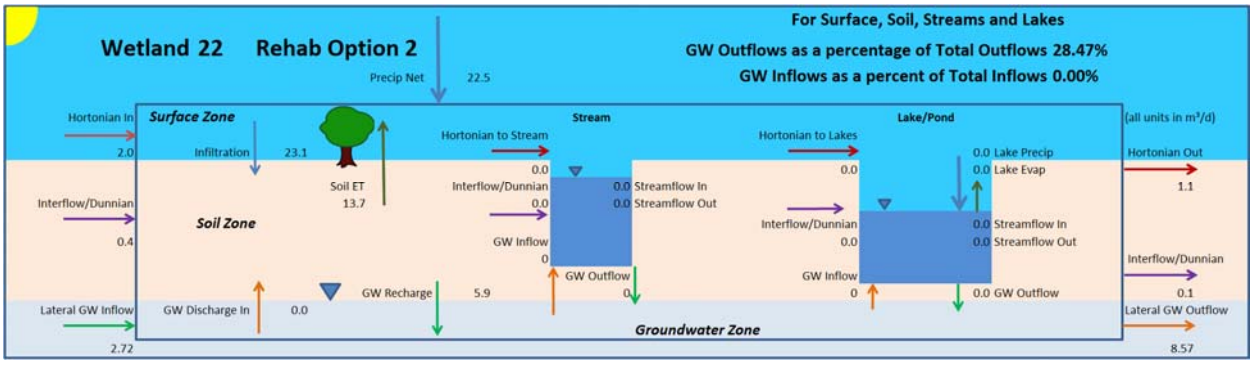
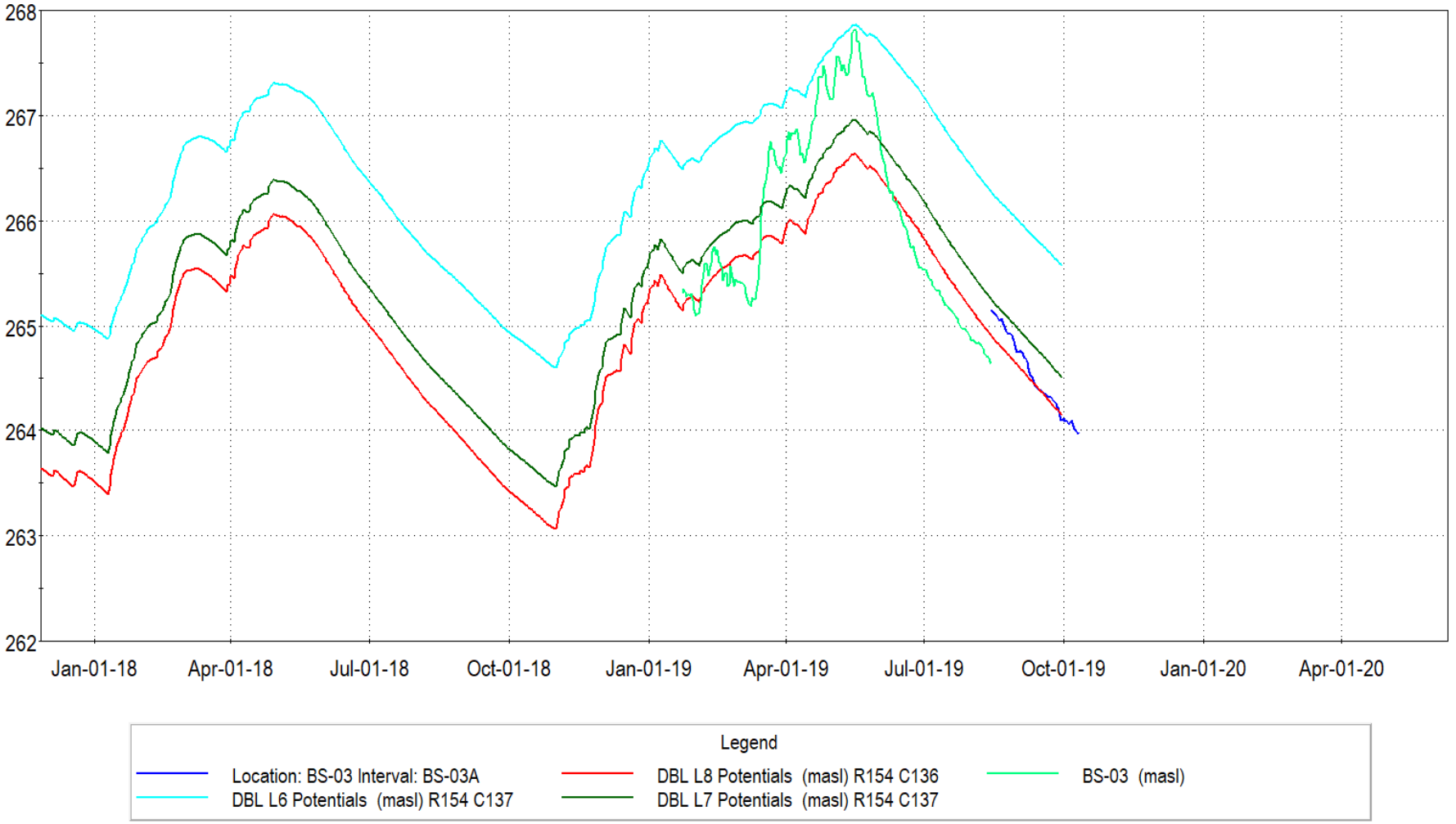


FIGURE 1E

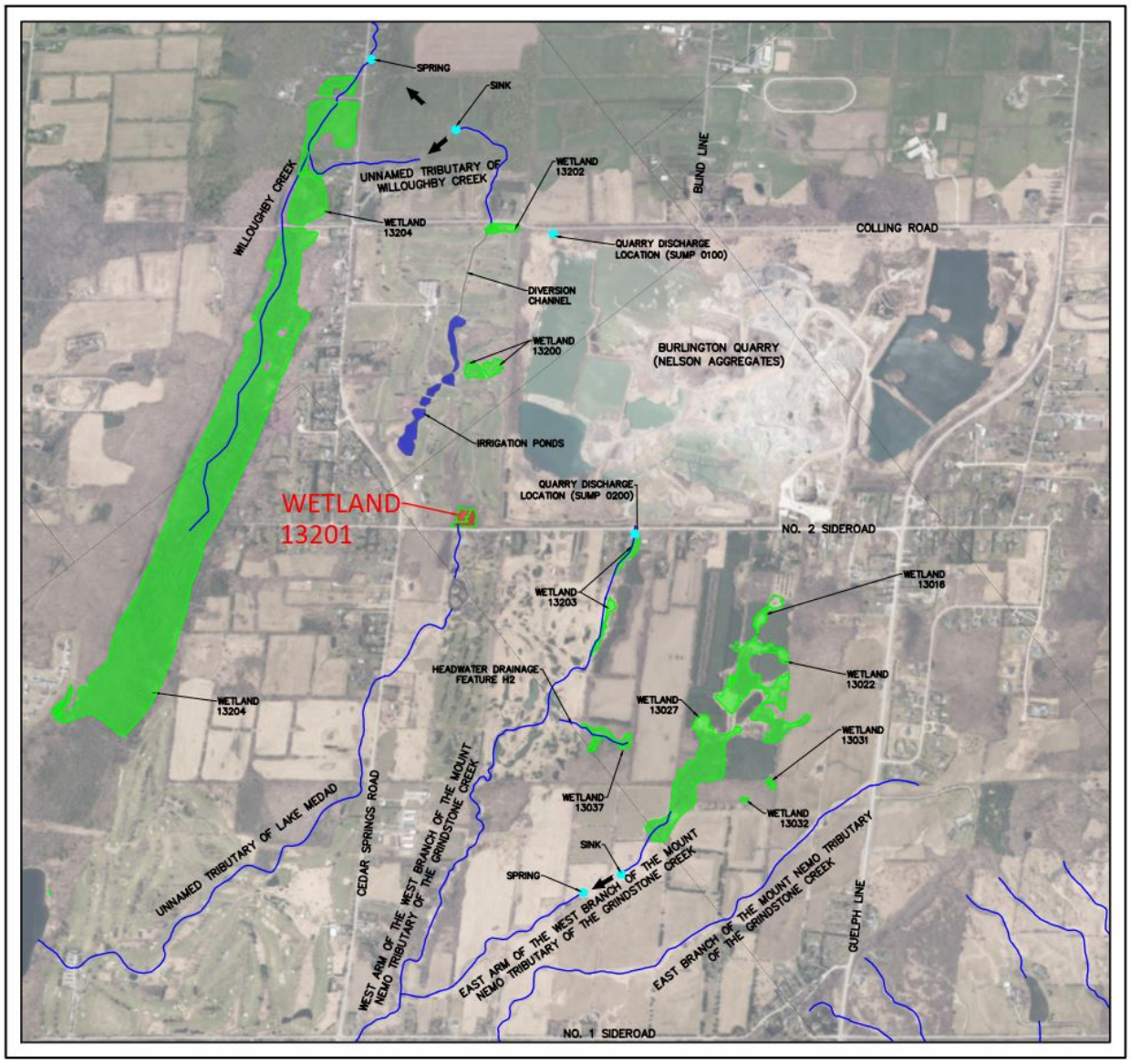


WETLAND 13200 - GRAPH 2

Integrated Model Calibration
Wetland 13200



WETLAND 13201





Legend

- Licensed Boundary
- Limit of Extraction
- 120 m Adjacent Lands
- Subject Lands
- Amphibian Call Count Station (2019)
- Salamander Trap (2019)
- Salamander Habitat Assessment (2019)
- Indirect Fish Habitat
- Direct Fish Habitat
- Existing Subcatchment Boundary (Tatham Engineering, 2020)
- Proposed Subcatchment Boundary - Operations and Post-Rehabilitation (Tatham Engineering, 2020
- Wetland (Savanta, 2020)
- Ecological Land Classification (Savanta, 2019 & 2020)

Current Instrumentation

- Groundwater Monitoring Station (EarthFx)
- Mini Piezometer (Tatham Engineering)
- Manual Stream Flow Measurement (Tatham Engineering)

ELC Legend

AG, Agriculture
CUM1, Mineral Cultural Meadow
CUT1, Mineral Cultural Thicket
CUW1, Mineral Cultural Woodland
FOD, Deciduous Forest
FOD7-2, Fresh-Moist Ash Lowland Deciduous Forest
FOD7-4, Fresh – Moist Black Walnut Lowland Deciduous Forest
HR, Hedgerow
MAM2-2, Reed-canary Grass Mineral Meadow Marsh
RES, Residential
SWD, Deciduous Swamp
SWD3-2, Silver Maple Mineral Deciduous Swamp

NOTES:

1. Coordinate System: NAD 1983 UTM Zone 17N.
2. Base features produced under license with the Ontario Ministry of Natural Resources and Forestry © Queen's Printer for Ontario, 2021.
3. Orthoimagery © First Base Solutions, 2021. Imagery taken in 2019.

Project 8133

Burlington Quarry Extension
Nelson Aggregates Co.

Figure 9
Wetland Characterization

Wetland 13201 - West Extension

0 30 m
1:2,000

N

GEI Consultants
Savanta Division

Path: C:\Savanta\8133 - Burlington Quarry\figures\report_figures\2021 01 21 natural feature tech summary\8133_rpt_wetland_char_mapbook.mxd Date: January 11, 2021

Wetland 13201

Wetland Characteristics	Description	Figure / Graph	Reference	
			Report	Section / Page
Wetland IDs:	MNRF -N/A Earthfx - 21 Tatham - 13201 Savanta - 13201 Golder (Background) - N/A			
Wetland Area (ha):	Savanta - 0.92			
Watershed:	Bronte Creek Watershed			
Sub-Watershed:	Willoughby Creek Watershed			
Located in Proposed Limit of Extraction:	No			
Located in Proposed License Boundary:	No			
Catchment Area (ha):	14.85		SWA (Tatham, April 2020)	Drawing DP-1
Catchment ID:	S111		SWA (Tatham, April 2020)	Drawing DP-1
Closed or Connected System:	Isolated Feature (culvert under No. 2 Sideroad plugged and there is no evidence of a culvert or channel connection to the Unnamed Tributary of Lake Medad).			
Condition:	Modified			
Bathymetry:	A bathymetric survey of Wetland 13201 has not been completed.			
Outlet:	None			
Hydroperiod:	Monitoring station established April 22, 2020. Hydroperiod to be determined.			
Surface Water Monitoring:	ID: SW36 (Tatham) Installation Date: April 22, 2020 Data Collection: Continuous water level and temperature and manual monthly water level measurements Coordinates of Monitoring Station: Easting 589880.52, Northing 4804990.81			

Natural Heritage and Habitat Features	Description	Figure / Graph	Reference	
			Report	Section / Page
Wetland Name & Provincial Significance Evaluation:	Wetland 13201 – Other (considered not significant due to lack of amphibian breeding habitat, isolated and not connected to a PSW; however it has been designed to demonstrate no negative impacts.)		NETR (Savanta, April 2020)	6.1.2
ELC Unit(s):	Reed-canary Grass Mineral Meadow Marsh: MAM2-2 Silver Maple Mineral Deciduous Swamp: SWD3-2b		NETR (Savanta, April 2020)	Table 2
Regulated Habitat (MECP):	No		NETR (Savanta, April 2020)	6.7
Significant Wildlife Habitat:	None confirmed for amphibian breeding, despite survey effort through salamander habitat assessments, salamander trapping and call count surveys.		NETR (Savanta, April 2020)	4.2.2; 5.2.2; Table 19
Fish Habitat:	None		NETR (Savanta, April 2020)	6.6
Habitat of Endangered and Threatened Species:	No species at risk salamanders observed, despite survey effort including salamander habitat assessment and salamander trapping.		NETR (Savanta, April 2020)	5.2.2

<table>
<tr><th>Groundwater Interaction</th><th>Description</th><th>Figure / Graph</th><th colspan="2">Reference</th></tr>
<tr><th></th><th></th><th></th><th>Report</th><th>Section / Page</th></tr>
<tr><td>Lithology:</td><td>Halton Till</td><td></td><td></td><td></td></tr>
<tr><td>Hydraulic Conductivity:</td><td>Integrated Model (Earthfx) - The harmonic mean hydraulic conductivity, based on testing by Golder (2007) of 10 mini-piezometers, was 1.2x10^{-8} m/s. Model value for the vertical hydraulic conductivity was 1.6x10^{-7} m/s, about an order of magnitude higher, to account for limited flow through fractures in the till.</td><td></td><td></td><td></td></tr>
<tr><td>Surface Water/Groundwater Interaction:</td><td>The low permeability of the Halton Till underlying the wetland is the dominant control on 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. This wetland receives some groundwater inflow but is relatively isolated from any changes in the water table due to quarry development.</td><td></td><td></td><td></td></tr>
<tr><td>Shallow Groundwater (Mini-piezometer) Monitoring:</td><td>ID: SW36 (Tatham)
Installation Date: April 22, 2020
Data Collection: Continuous water level and temperature and manual monthly water level measurements
Coordinates of Monitoring Station: Easting 589880.52, Northing 4804990.81</td><td></td><td></td><td></td></tr>
<tr><td>Background Shallow Groundwater (Mini-piezometer) Monitoring:</td><td>
<table>
<tr><td>Mini-piezometer ID</td><td>Ground Elevation</td><td>Bottom Elevation</td><td>Average WL</td><td>Logger</td><td>Manual Meas.</td></tr>
<tr><td>Golder MP34</td><td>273.66</td><td>273.15</td><td>173.26</td><td>2010 - 2013</td><td>2010 - 2013</td></tr>
</table>
</td><td></td><td></td><td></td></tr>
<tr><td>Groundwater Monitoring (Monitoring Wells):</td><td>
<table>
<tr><td>Monitoring Well ID</td><td>Distance (Dir.)</td><td>Geologic Unit</td><td>Ground Elevation</td><td>Monitoring Elev</td><td>Average WL</td></tr>
<tr><td>BS-04A</td><td>144 (SW)</td><td>Bedrock</td><td>284.87</td><td>-</td><td>264.34</td></tr>
<tr><td>BS-04B</td><td>144 (SW)</td><td>Bedrock</td><td>284.87</td><td>-</td><td>264.69</td></tr>
<tr><td>BS-04C</td><td>144 (SW)</td><td>Bedrock</td><td>284.98</td><td>-</td><td>264.70</td></tr>
</table>
</td><td>Graphs 1 & 2</td><td></td><td></td></tr>
<tr><td>Water Budget Results:</td><td>A detailed average water budget, as simulated by the integrated model, is provided in the main report for Baseline Conditions (Earthfx Figure 7.29, p. 189). The baseline water budget is reproduced in Figure 1a. The wetland is a net provider of groundwater. Simulated groundwater levels, groundwater discharge to riparian areas, and streamflow in the vicinity of Wetland 13201 (Earthfx Wetland 21) for baseline conditions are discussed in Section 7 of the main report.
<table>
<tr><td>Wetland 13201</td><td>GW Outflow (%)</td><td>GW Inflow (%)</td></tr>
<tr><td>Baseline (Existing)</td><td>29.78</td><td>2.98</td></tr>
</table>
</td><td>Figure 1a</td><td>HHIAR (Earthfx, April 2020)</td><td>165 - 190</td></tr>
<tr><td>Integrated Model Calibration:</td><td>The model calibration to Well BS02 shows a good calibration to the available monitoring record (see Graph 3). Wetland 22 is not discussed in the Main Report. Other nearby wetlands are discussed in Appendix E, Section 19.6.</td><td>Graph 3</td><td></td><td></td></tr>
</table>

<table>
<tr><th>Impact Assessment (Operations Phases 1 & 2)</th><th>Description</th><th>Figure / Graph</th><th colspan="2">Reference</th></tr>
<tr><th></th><th></th><th></th><th>Report</th><th>Section / Page</th></tr>
<tr><td>Change in Wetland Area (ha):</td><td>No change.</td><td></td><td></td><td></td></tr>
<tr><td>Change in Wetland Catchment Area (ha):</td><td>No change. No extraction proposed in West Extension as part of Phases 1 and 2 of extraction.</td><td></td><td>SWA (Tatham, April 2020)</td><td>Drawing DP-2</td></tr>
<tr><td>Change in Hydroperiod:</td><td>No Change</td><td></td><td></td><td></td></tr>
<tr><td>Change in Water Budget:</td><td>A detailed average water budget as simulated by the integrated model is provided in the Earthfx report for Baseline Conditions (Figure 7.29, p. 189); Scenario P12 (Figure 8.36, p. 224); P3456 (Figure 8.68, p. 251 Wetland 22). The water budget results for Scenario P12 are reproduced in Figure 1b. Wetland 13201 (Earthfx Wetland 21) is located at the south edge of the West Extension area. This wetland will be monitored and receive supplemental inflows as required to maintain its hydroperiod, as described in the Tatham, 2020 report. The planned supplementation has not been represented in the model, so the Wetland 13201 (Earthfx Wetland 21) water budget is not fully representative of future conditions. Simulated change in groundwater levels (drawdowns), groundwater discharge to riparian areas, and change in streamflow in the vicinity of Wetland 13201 (Earthfx Wetland 21) for each scenario are discussed in Section 8 of the main report.
<table>
<tr><td>Wetland 13201</td><td>GW Outflow (%)</td><td>GW Inflow (%)</td><td>Δ in Outflow (%)</td><td>Δ in Inflow (%)</td></tr>
<tr><td>Baseline (Existing)</td><td>29.78</td><td>2.98</td><td>-</td><td>-</td></tr>
<tr><td>Operations Ph 1 & 2</td><td>30.38</td><td>1.76</td><td>-0.60</td><td>-1.22</td></tr>
</table></td><td>Figure 1b</td><td>HHIAR (Earthfx, April 2020)</td><td>191 - 303</td></tr>
<tr><td>Potential Impact to Form and Function of Feature:</td><td>No wetlands will be removed and the wetlands subcatchment will be maintained. There will be no encroachment from the project into the wetland.</td><td></td><td></td><td></td></tr>
</table>

<table>
<tr><th>Mitigation (Operational Phases 1 & 2)</th><th>Description</th><th>Figure / Graph</th><th colspan="2">Reference</th></tr>
<tr><th></th><th></th><th></th><th>Report</th><th>Section / Page</th></tr>
<tr><td>Proposed Mitigation Measures:</td><td>None required.</td><td></td><td></td><td></td></tr>
</table>

<table>
<tr><th>Impact Assessment (Operations Phases 3 - 6)</th><th>Description</th><th>Figure / Graph</th><th colspan="2">Reference</th></tr>
<tr><th></th><th></th><th></th><th>Report</th><th>Section / Page</th></tr>
<tr><td>Change in Wetland Area (ha):</td><td>No change.</td><td></td><td></td><td></td></tr>
<tr><td>Change in Wetland Catchment Area (ha):</td><td>Reduction in catchment area. During operations in Phases 3 through 6 the catchment area will be reduced to 7.6 ha (reduction of 7.25 ha)</td><td></td><td>SWA (Tatham, April 2020)</td><td>Drawing DP-2</td></tr>
<tr><td>Change in Hydroperiod:</td><td>Reduction due to reduction in catchment area. Change in hydroperiod to be determined (to be mitigated).</td><td></td><td></td><td></td></tr>
<tr><td>Change in Water Budget:</td><td>A detailed average water budget as simulated by the integrated model is provided in the Earthfx report for Baseline Conditions (Figure 7.29, p. 189); Scenario P12 (Figure 8.36, p. 224); P3456 (Figure 8.68, p. 251 Wetland 22). The water budget results for Scenario P3456 are reproduced in Figure 1c. Wetland 13201 (Earthfx Wetland 21) is located at the south edge of the West Extension area. This wetland will be monitored and receive supplemental inflows as required to maintain its hydroperiod, as described in the Tatham, 2020 report. The planned supplementation has not been represented in the model, so the Wetland 13201 (Earthfx Wetland 21) water budget is not fully representative of future conditions. Simulated change in groundwater levels (drawdowns), groundwater discharge to riparian areas, and change in streamflow in the vicinity of Wetland 13201 (Earthfx Wetland 21) for each scenario are discussed in Section 8 of the main report.
<table>
<tr><td>Wetland 13201</td><td>GW Outflow (%)</td><td>GW Inflow (%)</td><td>Δ in Outflow (%)</td><td>Δ in Inflow (%)</td></tr>
<tr><td>Baseline (Existing)</td><td>29.78</td><td>2.98</td><td>-</td><td>-</td></tr>
<tr><td>Operations Ph 3 - 6</td><td>51.69</td><td>0.01</td><td>21.91</td><td>-2.97</td></tr>
</table></td><td>Figure 1c</td><td>HHIAR (Earthfx, April 2020)</td><td>191 - 303</td></tr>
<tr><td>Change on Soil Moisture Conditions:</td><td>The predicted soil moisture and surface discharge patterns in Wetland 21 are shown in Graph 4. The pond leakage for Wetland 21 is shown in Graph 5. The change in soil moisture and pond seepage is somewhat more complex in Wetland 21 than the other wetlands because the headwater catchment area will be reduced by the development of P3456. Under Baseline conditions, the wetland receives runoff and interflow from a larger catchment resulting in higher average soil moisture conditions. Under P3456 conditions the change in catchment area reduces the soil moisture and groundwater seepage. These changes (due to lower water availability and the drop in the water table) cause higher pond leakage in the spring, and lower leakage in the fall (Graph 5). It is important to note that groundwater inflow as a percentage of total inflows is only 2.98% under baseline conditions.</td><td>Graph 4 & 5</td><td></td><td></td></tr>
<tr><td>Potential Impact to Form and Function of Feature:</td><td>Both wetlands will remain in place. There will be no encroachment from the project into the wetlands. The proposed limit of extraction is >30 m from the wetland boundary. The licensed boundary/extraction limit will be demarcated and fenced to ensure site construction and operations do not extend beyond the proposed limits of the project . The drainage area to these wetland units will be reduced during operations, which has the potential to adversely impact the hydroperiods.</td><td></td><td>NETR (Savanta, April 2020)</td><td>7.2.1; 7.1.1; 7.1.2</td></tr>
</table>

<table>
<tr><th>Mitigation (Operational Phases 3 - 6)</th><th>Description</th><th>Figure / Graph</th><th colspan="2">Reference</th></tr>
<tr><th></th><th></th><th></th><th>Report</th><th>Section / Page</th></tr>
<tr><td>Proposed Mitigation Measures:</td><td>To mitigate this potential impact, flow to the wetlands will be supplemented by a bottom draw outlet constructed in the southeast corner of the proposed infiltration pond and an outlet pipe with a control valve will be installed to discharge water into the roadside ditch along No. 2 Sideroad, feeding the wetland. The bottom draw outlet, outlet pipe and control valve will remain post extraction as part of the rehabilitation of the site. Wetland hydroperiod and shallow groundwater monitoring stations were installed in spring 2020. This data will be used to establish existing thresholds so existing conditions can be maintained throughout extraction operations and replicated in post-operation / rehabilitated conditions.</td><td></td><td>NETR (Savanta, April 2020)</td><td>7.2.1; 7.1.1; 7.1.2</td></tr>
</table>

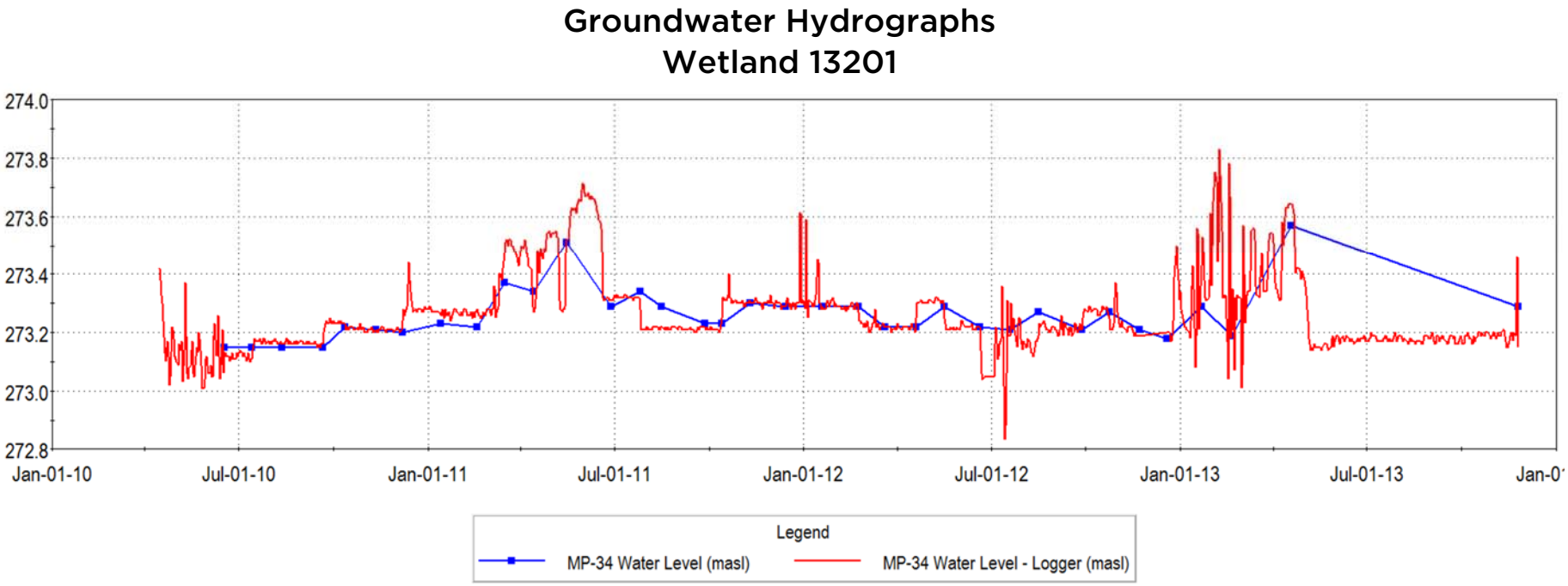
Impact Assessment (Rehabilitation)	Description	Figure / Graph	Reference	
			Report	Section / Page
Change in Wetland Area (ha):	No change.			
Change in Wetland Catchment Area (ha):	Reduction in catchment area. During operations in Phases 3 through 6 the catchment area will be reduced to 7.6 ha (reduction of 7.25 ha)		SWA (Tatham, April 2020)	Drawing DP-3
Change in Hydroperiod:	Reduction due to reduction in catchment area. Change in hydroperiod to be determined (to be mitigated).			
Change in Water Budget:	A detailed average water budget as simulated by the integrated model is provided in the Earthfx report for Baseline Conditions (Figure 7.29, p. 189); Scenario P12 (Figure 8.36, p. 224); P3456 (Figure 8.68, p. 251 Wetland 22). The water budget results for Scenario RHB1 and RHB2 are reproduced in Figures 1d and 1e. Wetland 13201 (Earthfx Wetland 21) is located at the south edge of the West Extension area. This wetland will be monitored and receive supplemental inflows as required to maintain its hydroperiod, as described in the Tatham, 2020 report. The planned supplementation has not been represented in the model, so the Wetland 13201 (Earthfx Wetland 21) water budget is not fully representative of future conditions. Simulated change in groundwater levels (drawdowns), groundwater discharge to riparian areas, and change in streamflow in the vicinity of Wetland 13201 (Earthfx Wetland 21) for each scenario are discussed in Section 8 of the main report.	Figure 1d and 1e	HHIAR (Earthfx, April 2020)	191 - 303

Wetland 13201	GW Outflow (%)	GW Inflow (%)	Δ in Outflow (%)	Δ in Inflow (%)
Baseline (Existing)	26.31	0.00	-	-
Rehab Scenario 1	49.00	0.23	19.22	-2.75
Rehab Scenario 2	2.21	15.67	-27.57	12.69

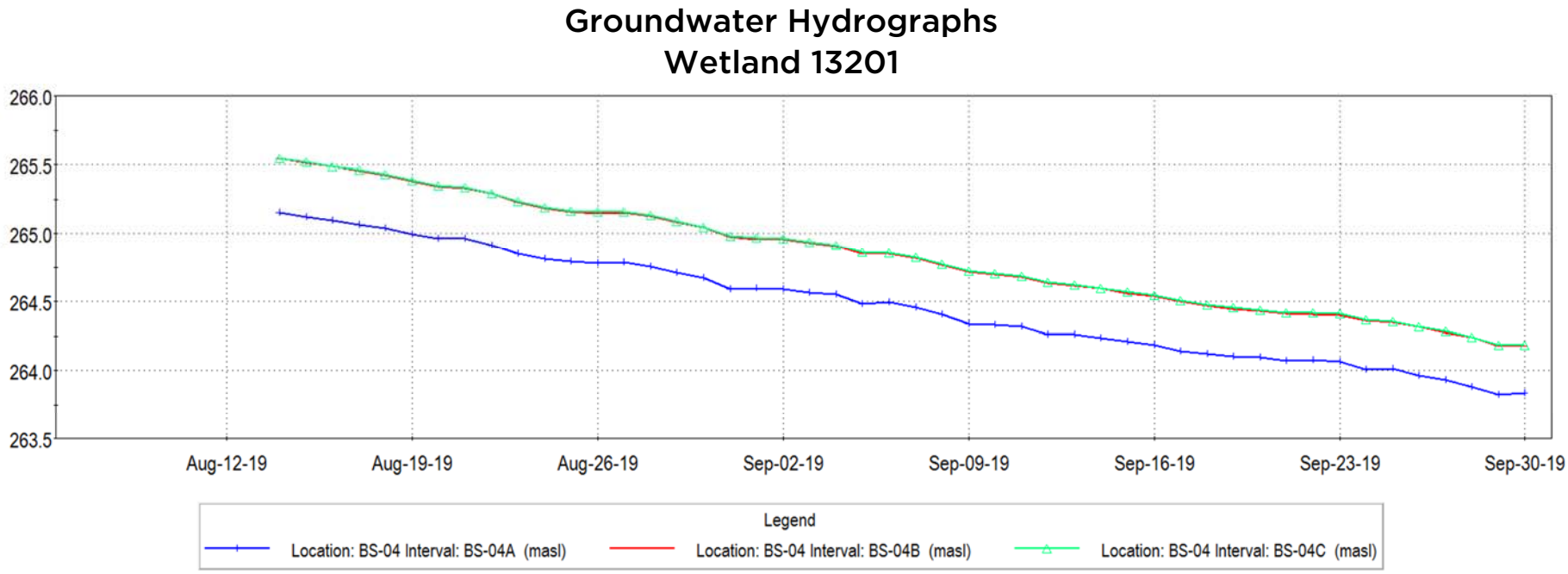
Impact Assessment (Rehabilitation)	Description	Figure / Graph	Reference	
			Report	Section / Page
Potential Impact to Form and Function of Feature:	Both wetlands will remain in place. There will be no encroachment from the project into the wetlands. The proposed limit of extraction is >30 m from the wetland boundary. The licensed boundary/extraction limit will be demarcated and fenced to ensure site construction and operations do not extend beyond the proposed limits of the project . The drainage area to these wetland units will be reduced during operations, which has the potential to adversely impact the hydroperiods.		NETR (Savanta, April 2020)	7.2.1; 7.1.1; 7.1.2

Mitigation (Rehabilitation)	Description	Figure / Graph	Reference	
			Report	Section / Page
Proposed Mitigation Measures:	To mitigate this potential impact, flow to the wetlands will be supplemented by a bottom draw outlet constructed in the southeast corner of the proposed infiltration pond and an outlet pipe with a control valve will be installed to discharge water into the roadside ditch along No. 2 Sideroad, feeding the wetland. The bottom draw outlet, outlet pipe and control valve will remain post extraction as part of the rehabilitation of the site. Wetland hydroperiods and shallow groundwater monitoring stations were installed in spring 2020. This data will be used to establish existing thresholds so existing conditions can be maintained throughout extraction operations and replicated in post-operation / rehabilitated conditions.		NETR (Savanta, April 2020)	7.2.1; 7.1.1; 7.1.2

WETLAND 13201 - GRAPH 1



WETLAND 13201 - GRAPH 2



WETLAND 13201

FIGURE 1A

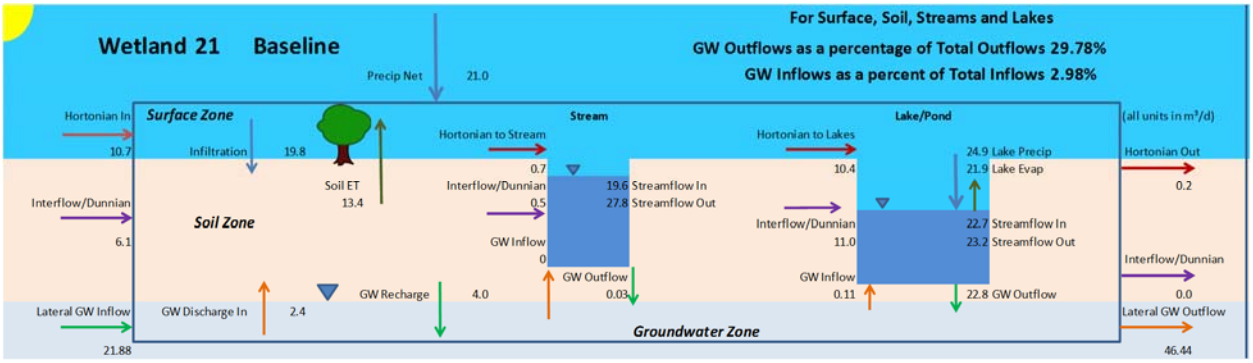


FIGURE 1B

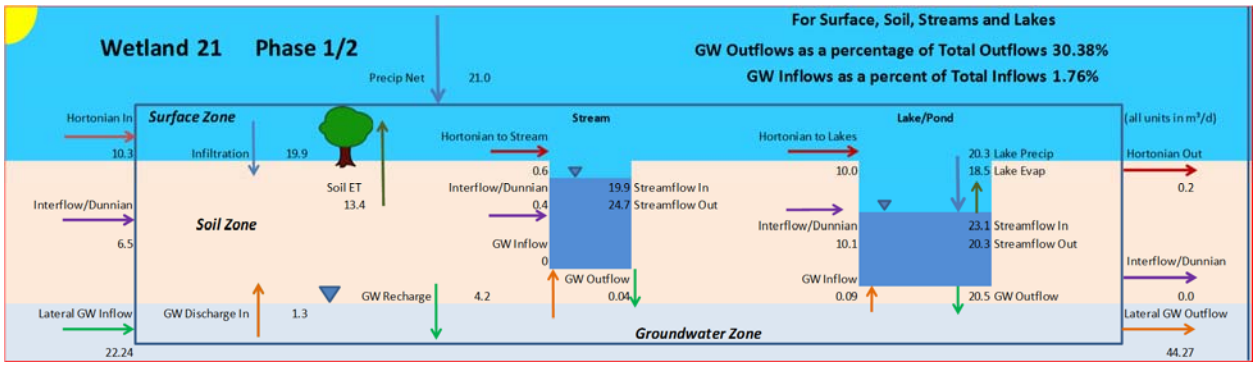


FIGURE 1C

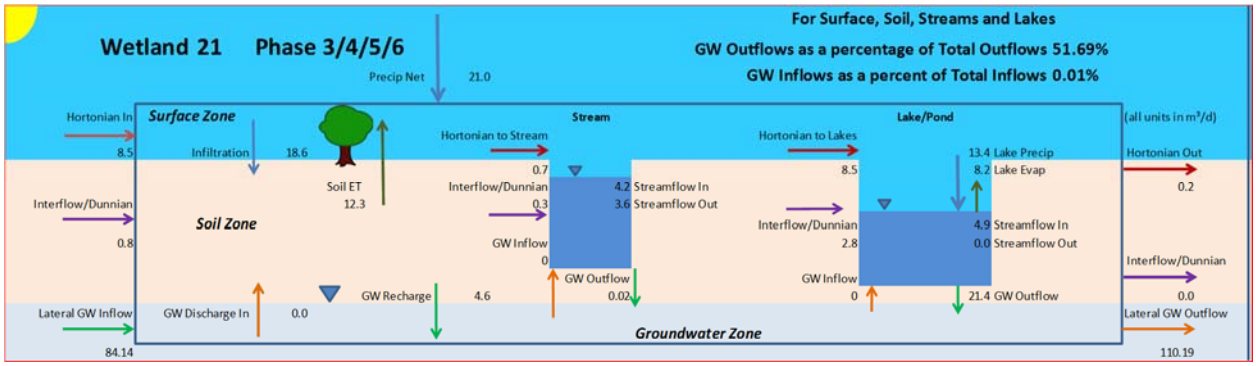


FIGURE 1D

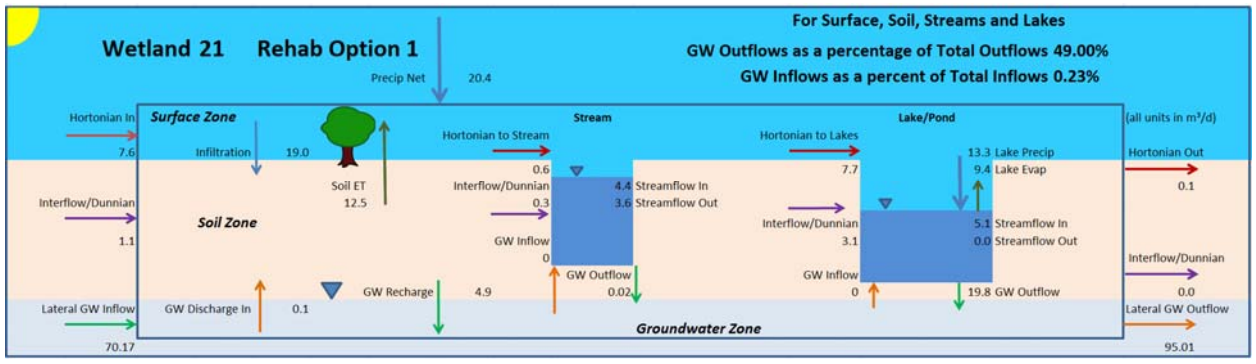
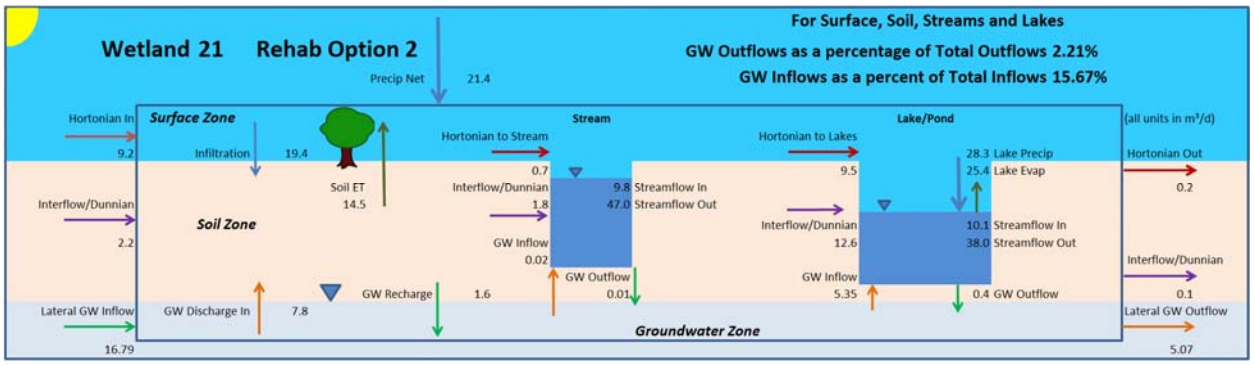
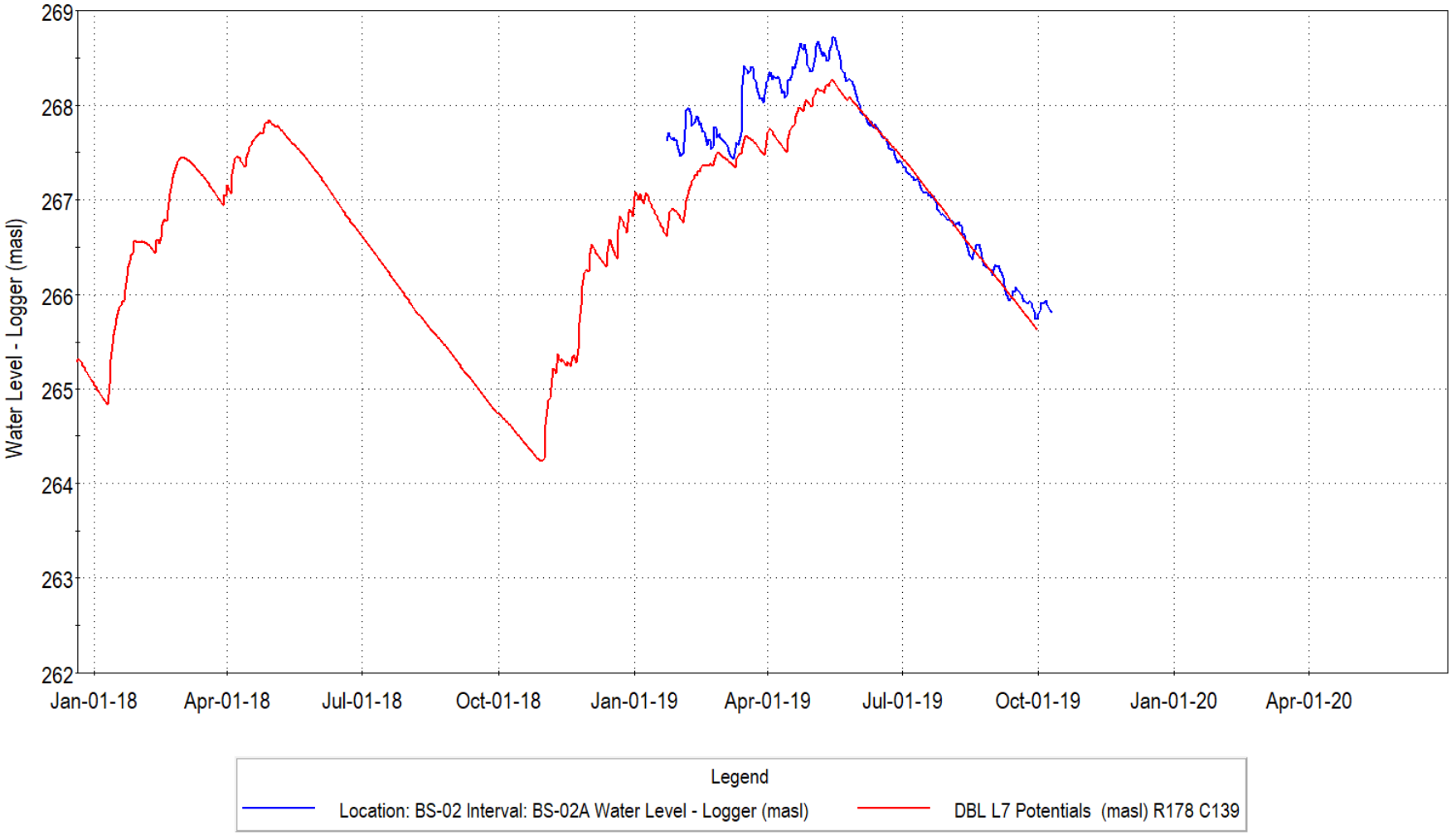


FIGURE 1E



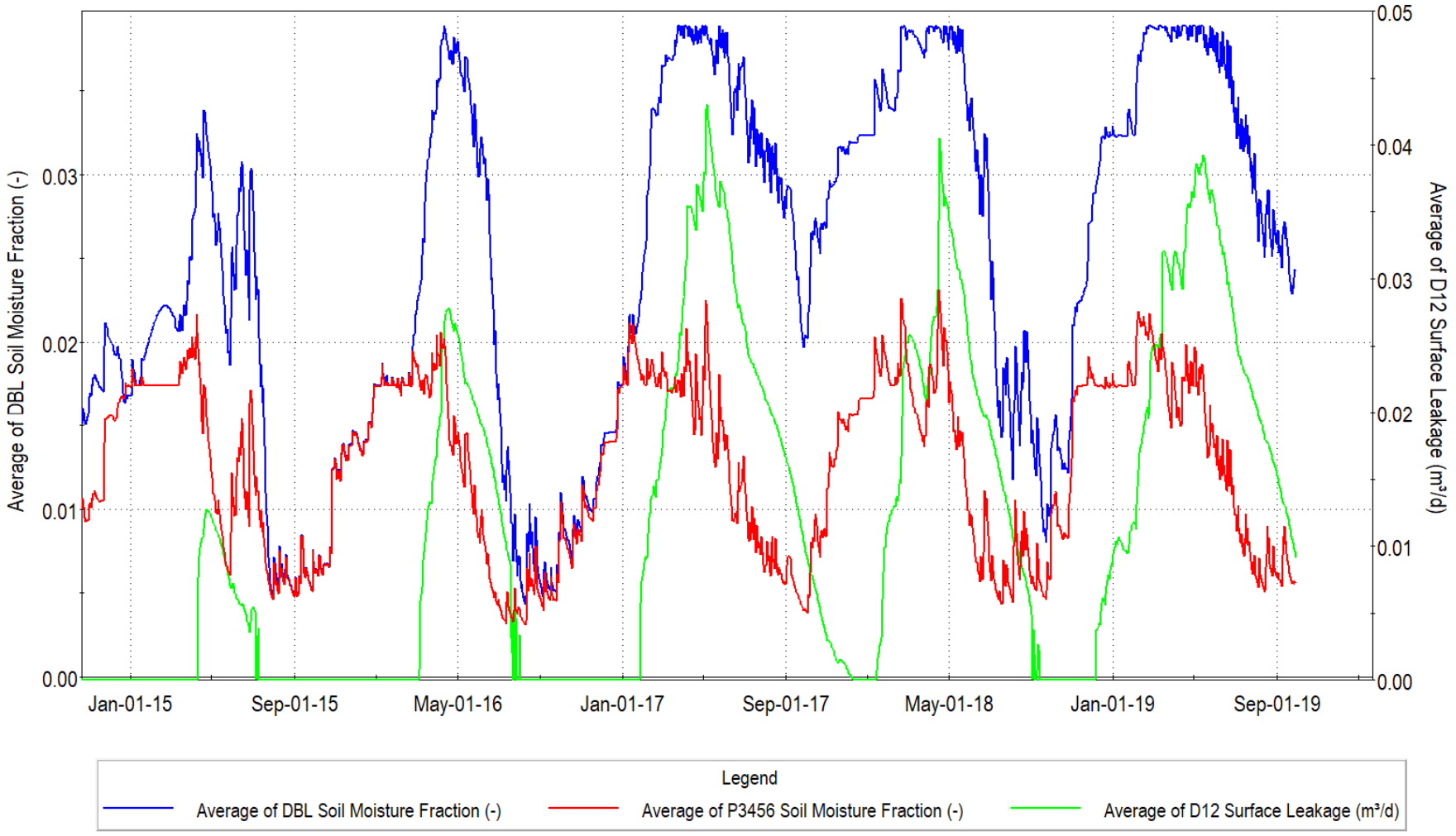
WETLAND 13201 - GRAPH 3

Integrated Model Calibration
Wetland 13201



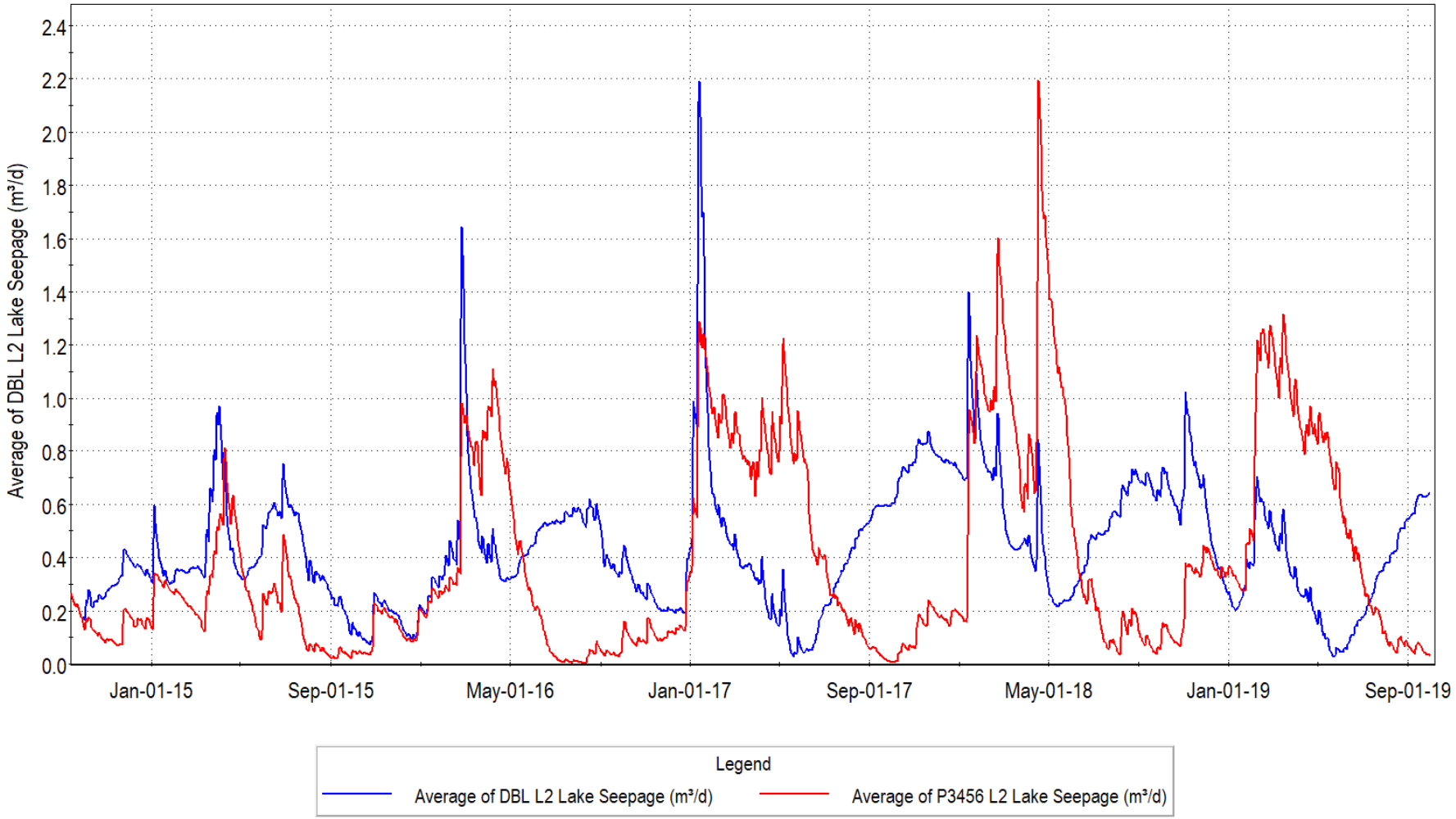
WETLAND 13201 - GRAPH 4

Change in Soil Moisture Conditions
Wetland 13201

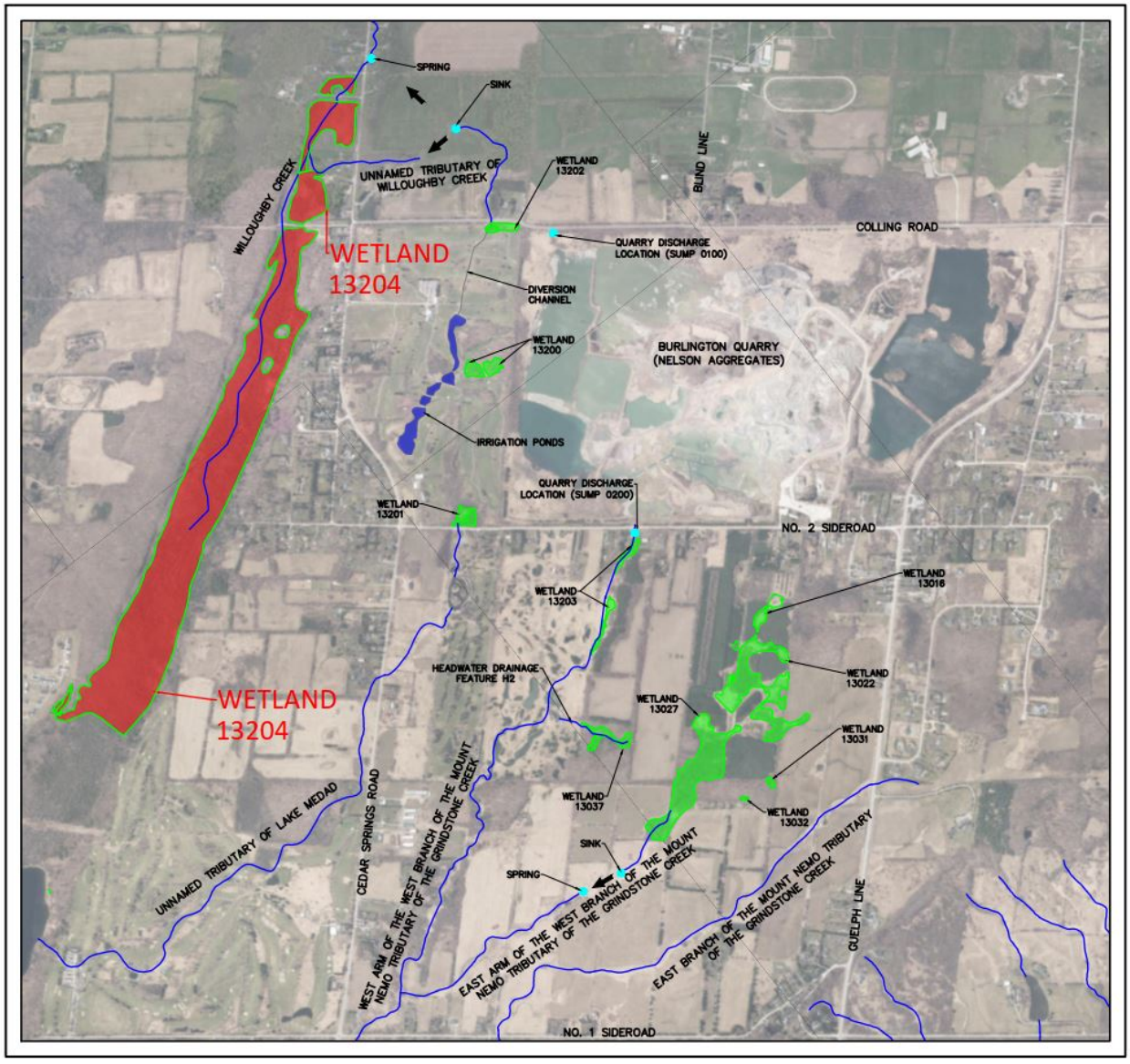


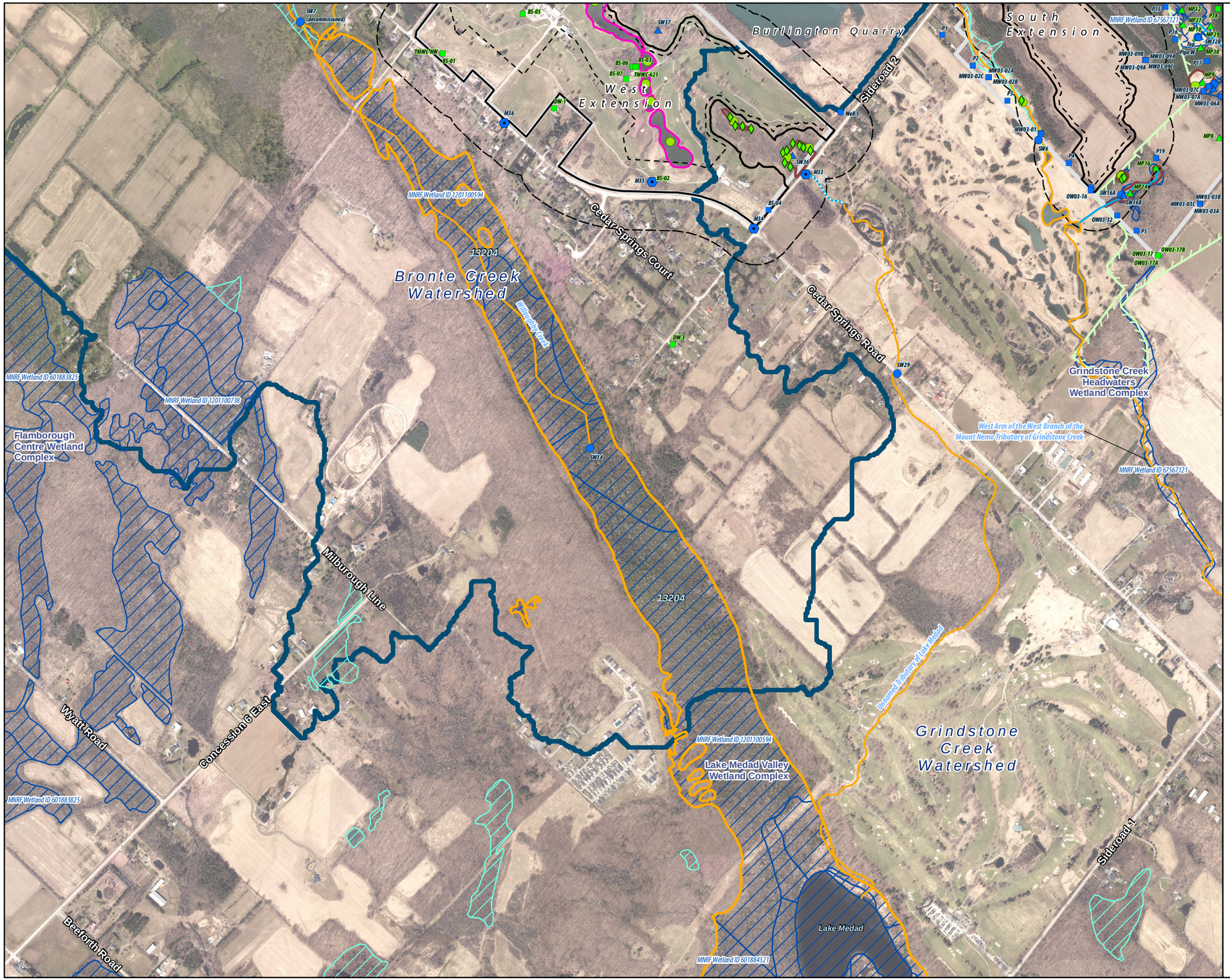
WETLAND 13201 - GRAPH 5

Change in Soil Moisture Conditions
Wetland 13201



WETLAND 13204





Legend

- Licensed Boundary
- Limit of Extraction
- 120 m Adjacent Lands
- Subject Lands
- Lake Medad Valley Wetland Complex
- Amphibian Call Count Station (2019)
- Salamander Trap (2019)
- Salamander Habitat Assessment (2019)
- Golf Course Irrigation Ponds and Channel
- Indirect Fish Habitat
- Direct Fish Habitat
- Provincially Significant Wetland (LIO/MNRF, 2020)
- Wetland - Not Evaluated per OWES (MNRF/LIO, 2020)
- MECP Jefferson Salamander Regulated Habitat
- Watershed Boundary (Conservation Halton)

Current Instrumentation

- Groundwater Monitoring Station (EarthFx)
- Mini Piezometer (Tatham Engineering)
- Staff Gauge & Surface Water Monitoring Station (Tatham Engineering)
- Manual Stream Flow Measurement (Tatham Engineering)

Previous Instrumentation

- Groundwater Monitoring Station (Golder)
- Mini Piezometer (Golder)

NOTES:

1. Coordinate System: NAD 1983 UTM Zone 17N.
2. Base features produced under license with the Ontario Ministry of Natural Resources and Forestry © Queen's Printer for Ontario, 2021; © Conservation Halton, 2021.
3. Orthoimagery © First Base Solutions, 2021. Imagery taken in 2019.

Project 8133

Burlington Quarry Extension
Nelson Aggregates Co.

Figure 10
Wetland Characterization

Wetland 13204 - Medad Valley PSW Complex

0 220 m

1:12,000

N

GEI Consultants
Savanta Division

Wetland 13204

Wetland Characteristics	Description	Figure / Graph	Reference	
			Report	Section / Page
Wetland IDs:	MNRF – 1201100594 (OGF 1200821993, 1200821992, 1200821982, 1200821988, 67340473, 1200821978, 67196301, Earthfx - Medad Valley Tatham - 13204 Savanta - Lake Medad Wetland Golder (Background) - N/A			
Wetland Area (ha):	LIO/MNRF - 48.5			
Watershed:	Bronte Creek Watershed			
Sub-Watershed:	Willoughby Creek Watershed			
Located in Proposed Limit of Extraction:	No			
Located in Proposed License Boundary:	No			
Catchment Area (ha):	844 + quarry discharge (Sump 0100)			
Catchment ID:	N/A			
Closed or Connected System:	On-line (connected to downstream watercourse)			
Condition:	Natural			
Bathymetry:	No bathymetric data available for the Lake Medad PSW.			
Outlet:	Willoughby Creek			
Hydroperiod:	Seasonal			
Surface Water Monitoring:	ID: SW14 (Tatham) Installation Date: October 2, 2014 Data Collection: Continuous water level and temperature and manual monthly water level measurements Coordinates of Monitoring Station: Easting 589226.754, Northing 4804106.857	Graph 1	SWA (Tatham, April 2020)	2.1.1, 3 and Appendix B

Natural Heritage and Habitat Features	Description	Figure / Graph	Reference	
			Report	Section / Page
Wetland Name & Provincial Significance Evaluation:	Lake Medad Valley Wetland Complex – Provincially Significant		NETR (Savanta, April 2020)	6.1.2
ELC Unit(s):	Unknown – outside of 120 m adjacent lands			
Regulated Habitat (MECP):	No			
Significant Wildlife Habitat:	Unknown – outside of 120 m adjacent lands			
Fish Habitat:	Unknown – outside of 120 m adjacent lands			
Habitat of Endangered and Threatened Species:	Unknown – outside of 120 m adjacent lands			

Groundwater Interaction	Description	Figure / Graph	Reference	
			Report	Section / Page
Lithology:	The Medad Valley is a partly-buried gorge that carried meltwater from the receding ice for a period of time (Karrow, 1987). The infill deposits are likely coarse-grained glaciofluvial deposits overlain by organic deposits. While there is limited borehole information in the Medad Valley, there is some evidence that the sand deposits are thicker in the valley to the north and south of the site.			
Hydraulic Conductivity:	Integrated Model (Earthfx) - Model values for the horizontal hydraulic conductivity of the MIS sands were $5.0x10^{-5}$ m/s and $2.5x10^{-5}$ m/s for vertical hydraulic conductivity.			
Surface Water/Groundwater Interaction:	The Medad Valley is a local groundwater discharge zone. Flow is supplemented by groundwater discharge to springs on the flanks of the valley. The GSFLOW model indicated that groundwater discharge exceeds groundwater recharge in this area. The model also indicated that lowering the water table in the quarry vicinity has limited effect on the major areas of groundwater discharge, such as the Medad Valley, which are already at a lower elevation than the quarry. The model also indicated that, while the Medad Valley is generally a groundwater discharge area, there are reaches of the main stream in the centerline of the valley that lose water to the groundwater system (see figure 7.21 in Earthfx report, reproduced below). This demonstrates that the incised Medad wetlands and streams are isolated from and behave differently than the streams and wetlands of the upland plateau (where the quarry is located). Despite these losing conditions, there is still a net gain of water in the stream between gauges SW14 and SW07.	Figure 1		
Water Budget Results:	A detailed Baseline water budget (to stream gauge SW7) was produced for this wetland and it is discussed in the Watercourse Characterization Table for Willoughby Creek.	Figure 2a		
Integrated Model Calibration:	Model calibration focused on matching observed streamflow. The calibration to streamflow is presented in Earthfx Section 19.4. The figure shows the calibration to SW2.	Graph 2	HHIAR (Earthfx, April 2020)	19.4

Impact Assessment (Operations Phases 1 & 2)	Description	Figure / Graph	Reference	
			Report	Section / Page
Change in Wetland Area (ha):	No change. Wetland located greater than 120 m from licensed boundary.			
Change in Wetland Catchment Area (ha):	No Change as a result of extraction in Phase 1. Catchment area remains unaltered.			
Change in Hydroperiod:	No Change. Subcatchment area remains unaltered.			
Change in Water Budget:	A detailed Baseline water budget (to stream gauge SW7) was produced for this wetland and it is discussed in the Watercourse Characterization Table for Willoughby Creek.	Figure 2b		
Potential Impact to Form and Function of Feature:	No wetlands will be removed and the wetlands subcatchment will be protected. There will be no encroachment from the project into the wetland. The proposed limit of extraction is >120 m from the wetland boundary. Licensed boundary will be demarcated and fenced to ensure site construction and operations do not extend beyond the proposed limits of the project.			

Mitigation (Operational Phases 1 & 2)	Description	Figure / Graph	Reference	
			Report	Section / Page
Proposed Mitigation Measures:	None required.			

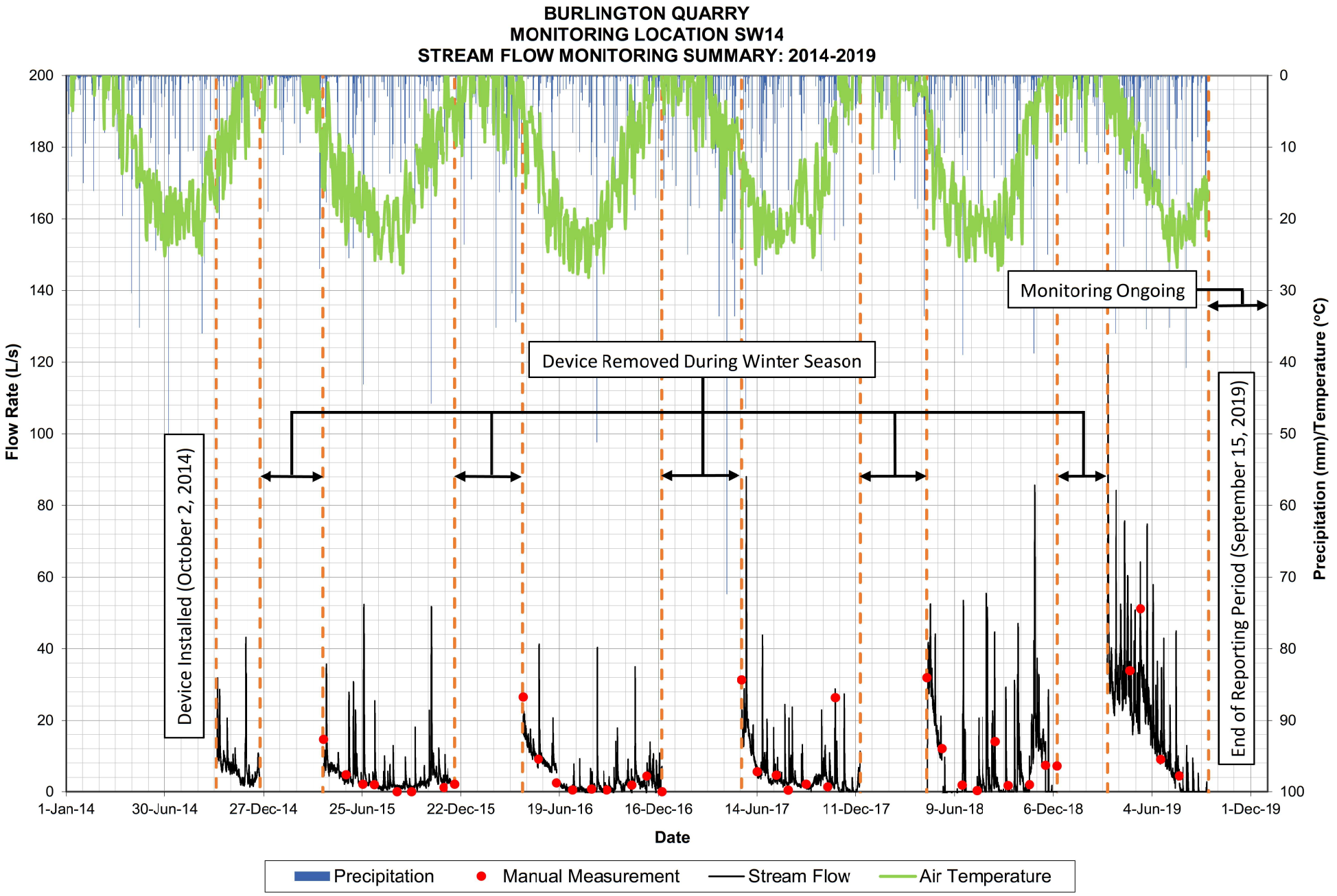
Impact Assessment (Operations Phases 3 - 6)	Description	Figure / Graph	Reference	
			Report	Section / Page
Change in Wetland Area (ha):	No change. Wetland located greater than 120 m from licensed boundary.			
Change in Wetland Catchment Area (ha):	Reduction in catchment area. During operations in Phases 3 through 6 the catchment area will be reduced by 18.6 ha (reduction of 2%).			
Change in Hydroperiod:	Insignificant reduction due to reduction in catchment area. Potential reduction due to groundwater drawdown to be mitigated through construction of infiltration pond.			
Change in Water Budget:	A detailed Baseline water budget (to stream gauge SW7) was produced for this wetland and it is discussed in the Watercourse Characterization Table for Willoughby Creek. Changes in streamflow at SW7 in the Medad Valley were generally small. Figures 8.11 (p. 203) and Figure 8.49 (p. 237) compare streamflow under Phase 12 and Phase 3456, respectively, to baseline flows. The figures are reproduced in Graphs 3 and 4. The small changes indicate that changes to the Medad wetland are also likely to be small.	Figure 2c and Graphs 3 & 4		
Change on Soil Moisture Conditions:	The total change in surface leakage between Baseline and P3456 in catchment SW7 is shown in Graph 5. A small amount of groundwater seepage will be intercepted by P3456 and discharged to the Medad Valley just downstream of SW7. This change in seepage is relatively uniform over time and will not be observable because it is highly diffuse.	Graph 5		
Potential Impact to Form and Function of Feature:	Potential adverse impacts to wetland hydroperiod due to reduction in catchment area and groundwater drawdown to be mitigated.			

Mitigation (Operational Phases 3 - 6)	Description	Figure / Graph	Reference	
			Report	Section / Page
Proposed Mitigation Measures:	Construction of infiltration pond is intended to maintain seepage to GW in the vicinity West Extension to maintain GW levels and GW discharge to the Medad Valley.			

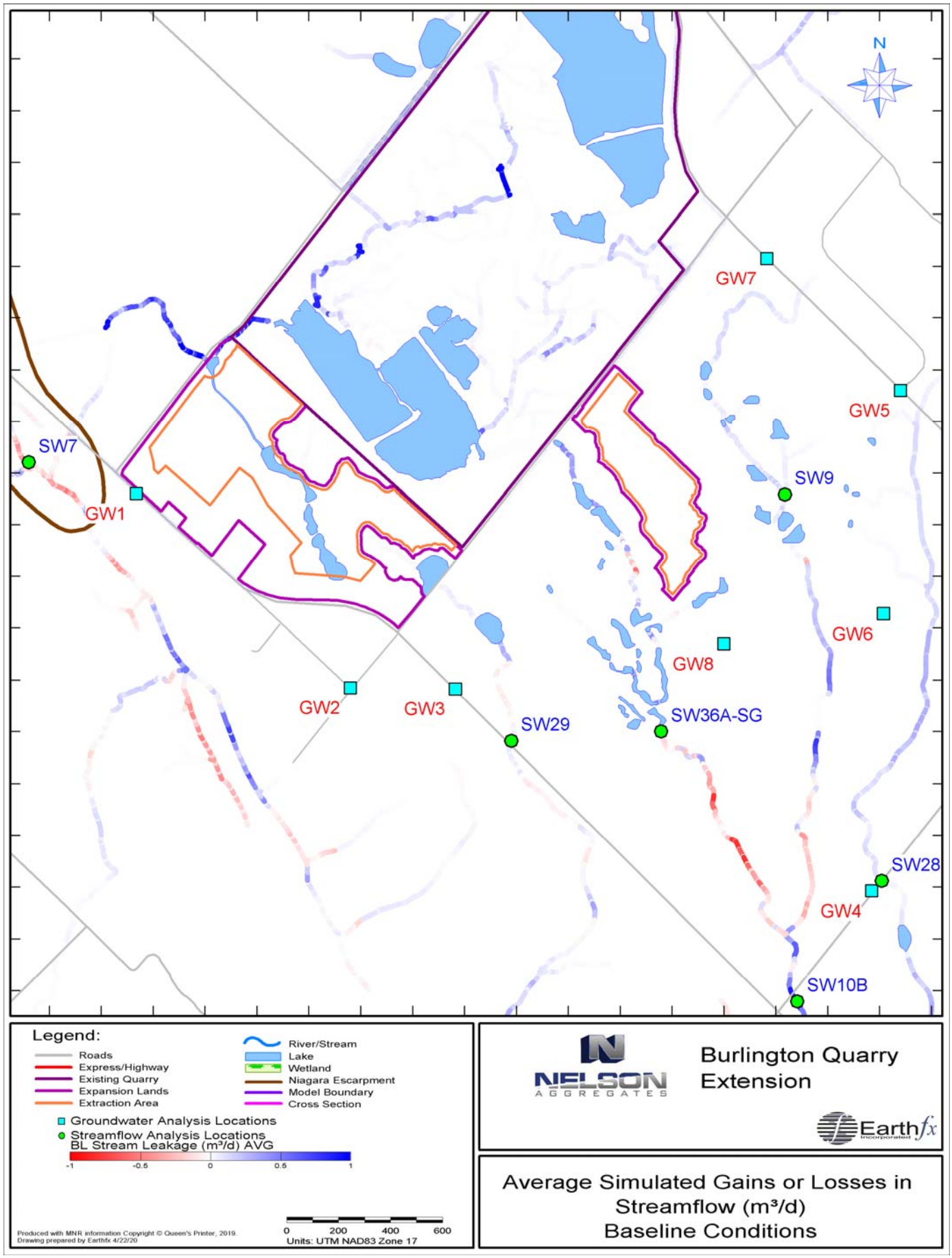
Impact Assessment (Rehabilitation)	Description	Figure / Graph	Reference	
			Report	Section / Page
Change in Wetland Area (ha):	No change. Wetland located greater than 120 m from licensed boundary.			
Change in Wetland Catchment Area (ha):	Reduction in catchment area. During operations in Phases 3 through 6 the catchment area will be reduced by 18.6 ha (reduction of 2%).			
Change in Hydroperiod:	Insignificant reduction due to reduction in catchment area. Potential reduction due to groundwater drawdown to be mitigated through construction of infiltration pond.			
Change in Water Budget:	See Change in Water Budget described under Impact Assessment (Phases 3 through 6).			
Potential Impact to Form and Function of Feature:	Potential adverse impacts to wetland hydroperiod due to reduction in catchment area and groundwater drawdown to be mitigated.			

Mitigation (Rehabilitation)	Description	Figure / Graph	Reference	
			Report	Section / Page
Proposed Mitigation Measures:	Construction of infiltration pond is intended to maintain seepage to GW in the vicinity West Extension to maintain GW levels and GW discharge to the Medad Valley.			

WETLAND 13204 - GRAPH 1



WETLAND 13204 - FIGURE 1



WETLAND 13204

FIGURE 2A

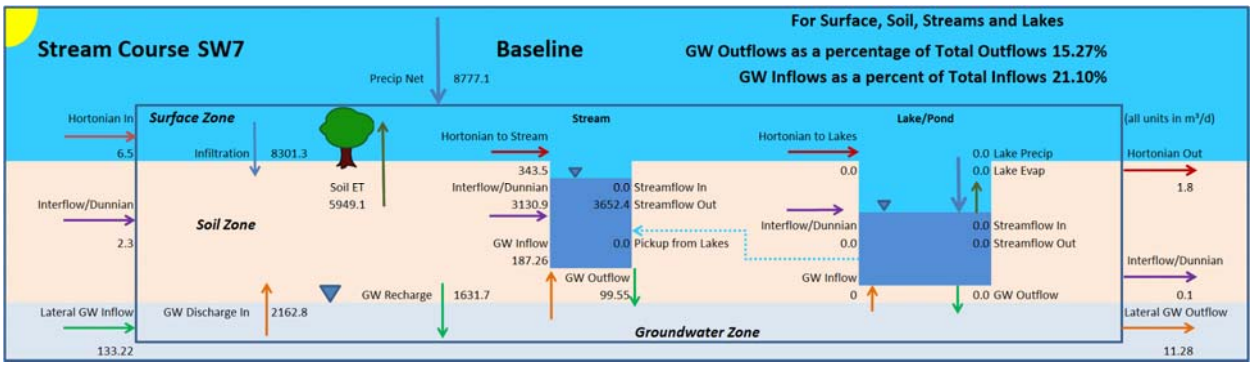


FIGURE 2B

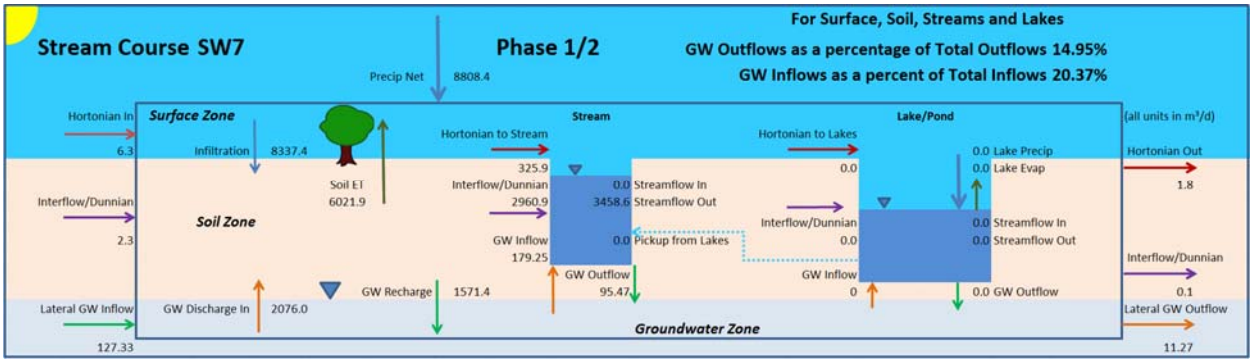


FIGURE 2C

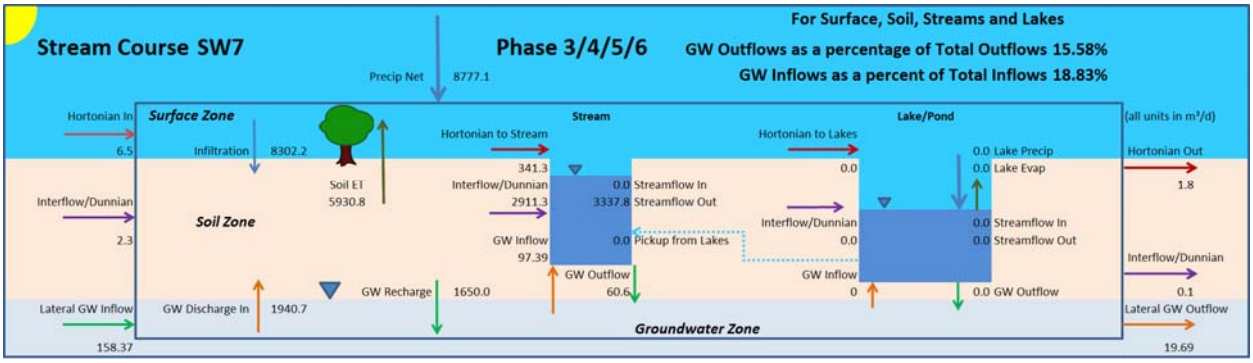


FIGURE 2D

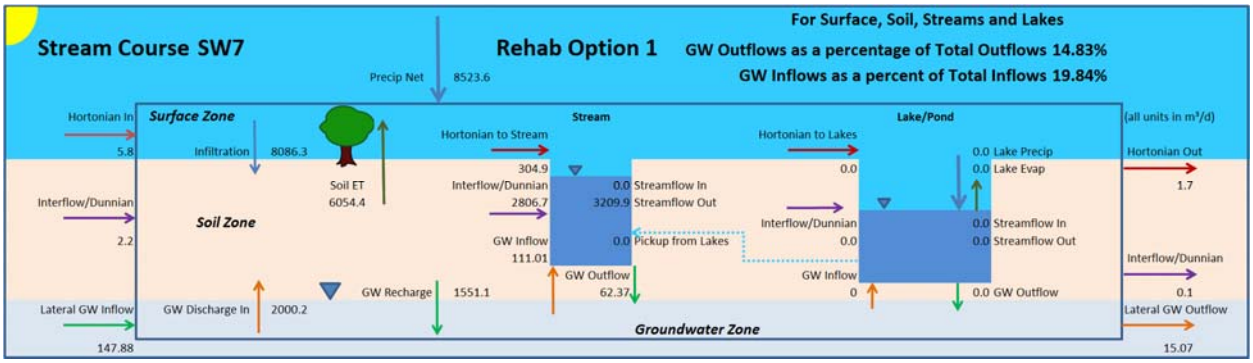
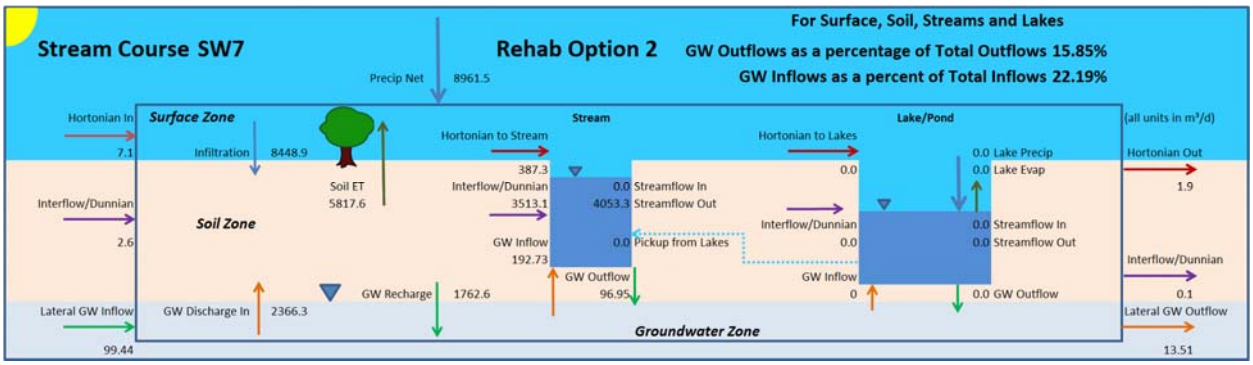
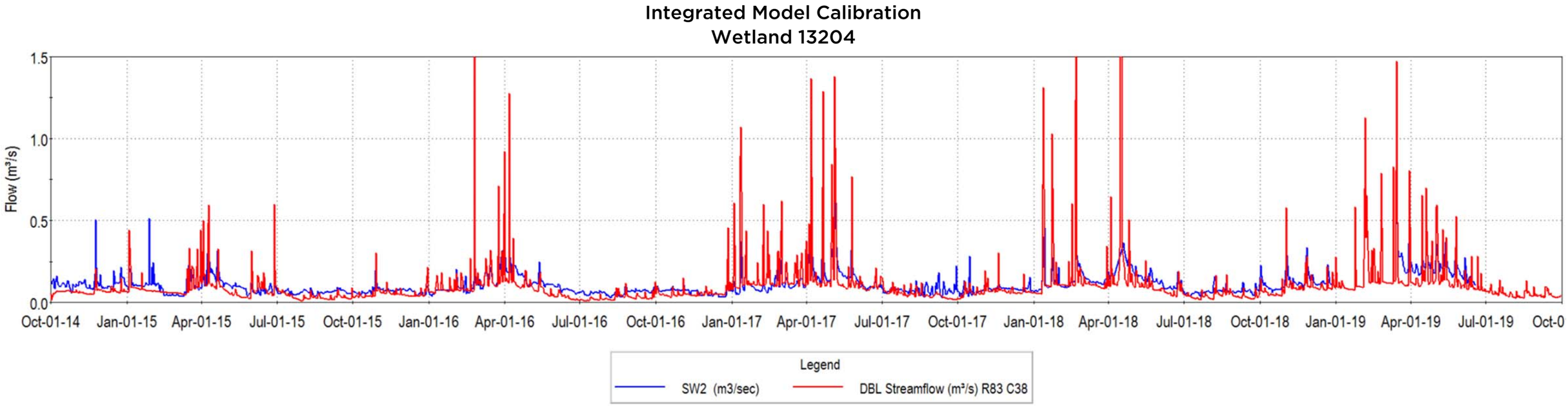


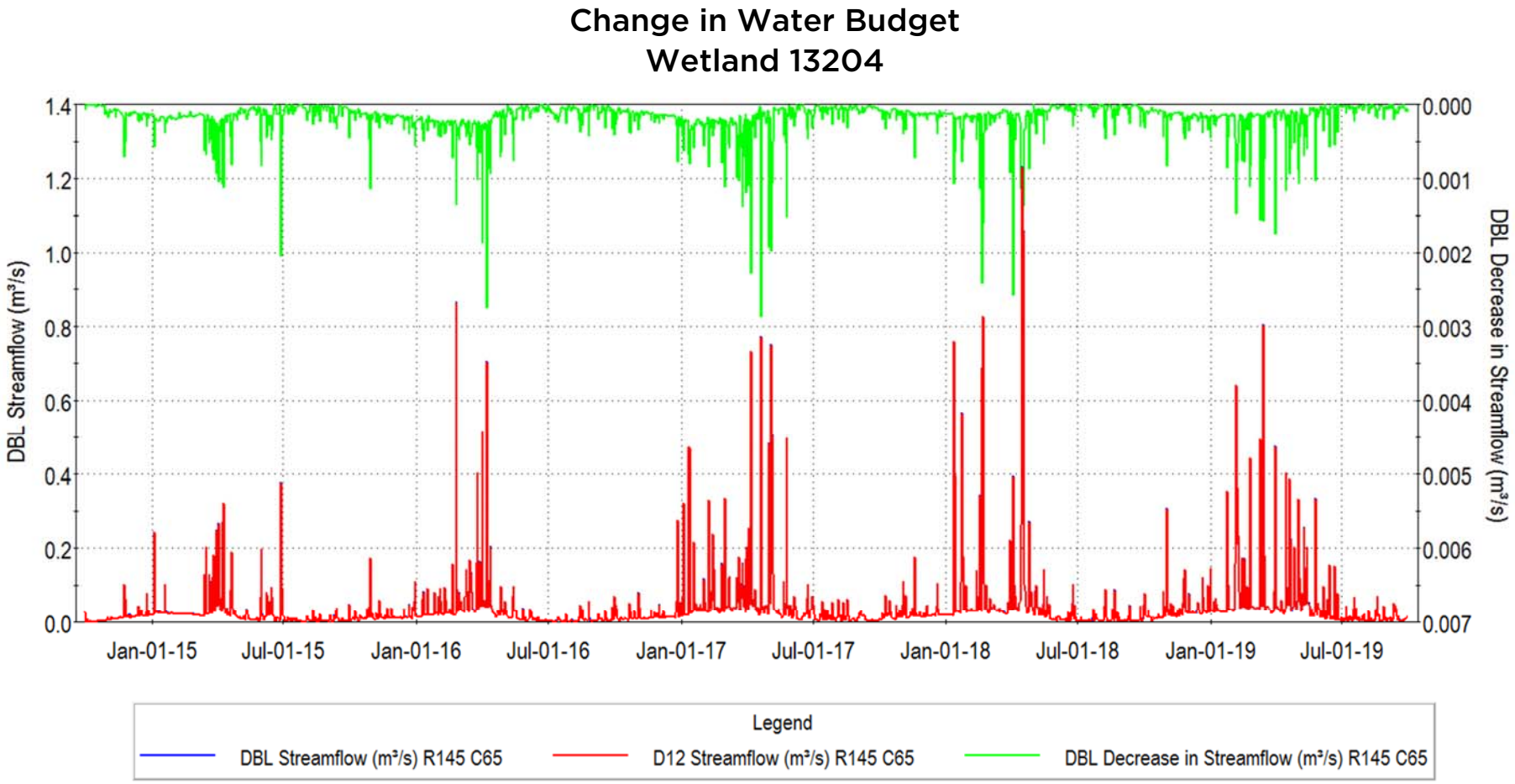
FIGURE 2E



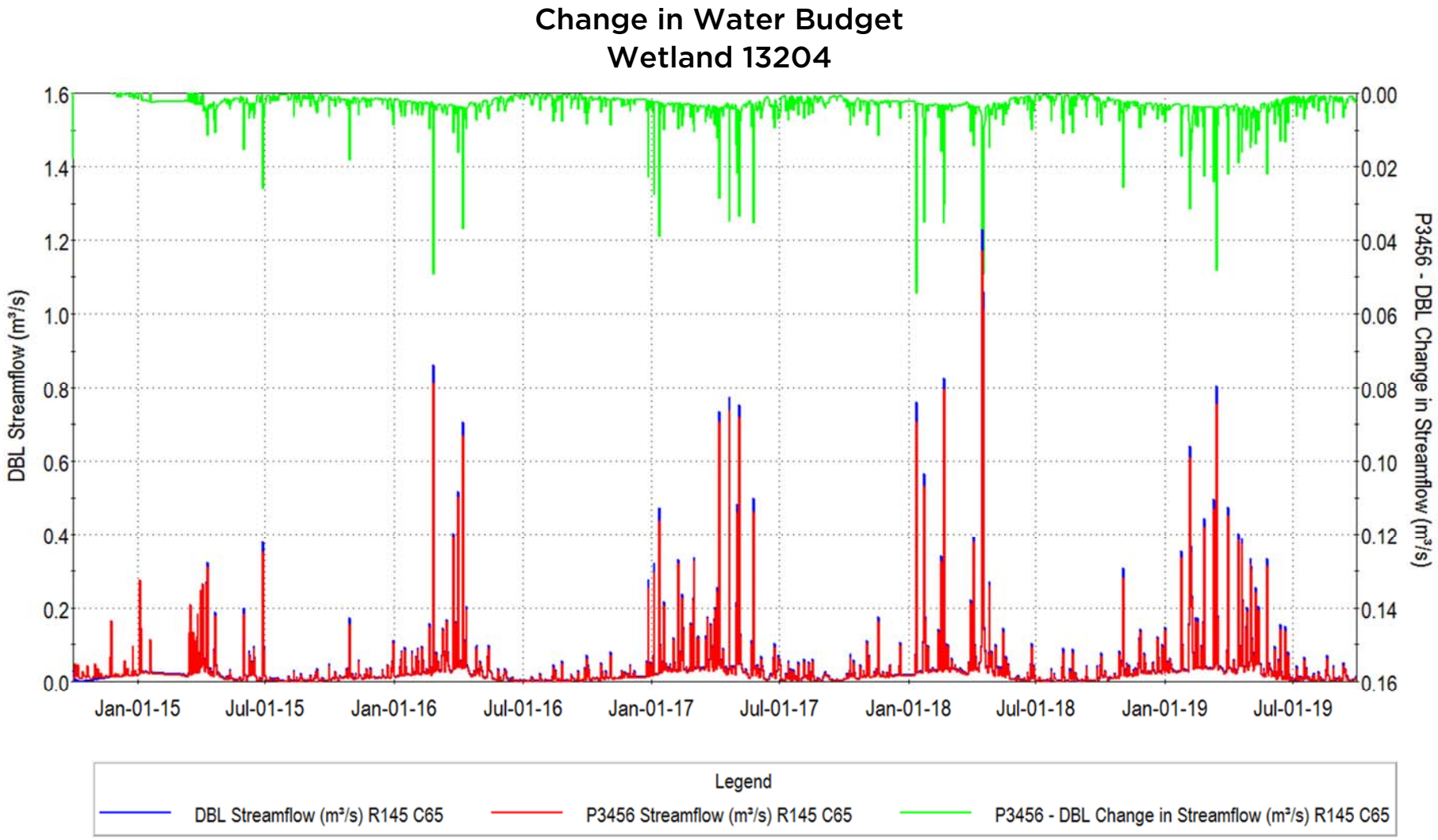
WETLAND 13204 - GRAPH 2



WETLAND 13204 - GRAPH 3

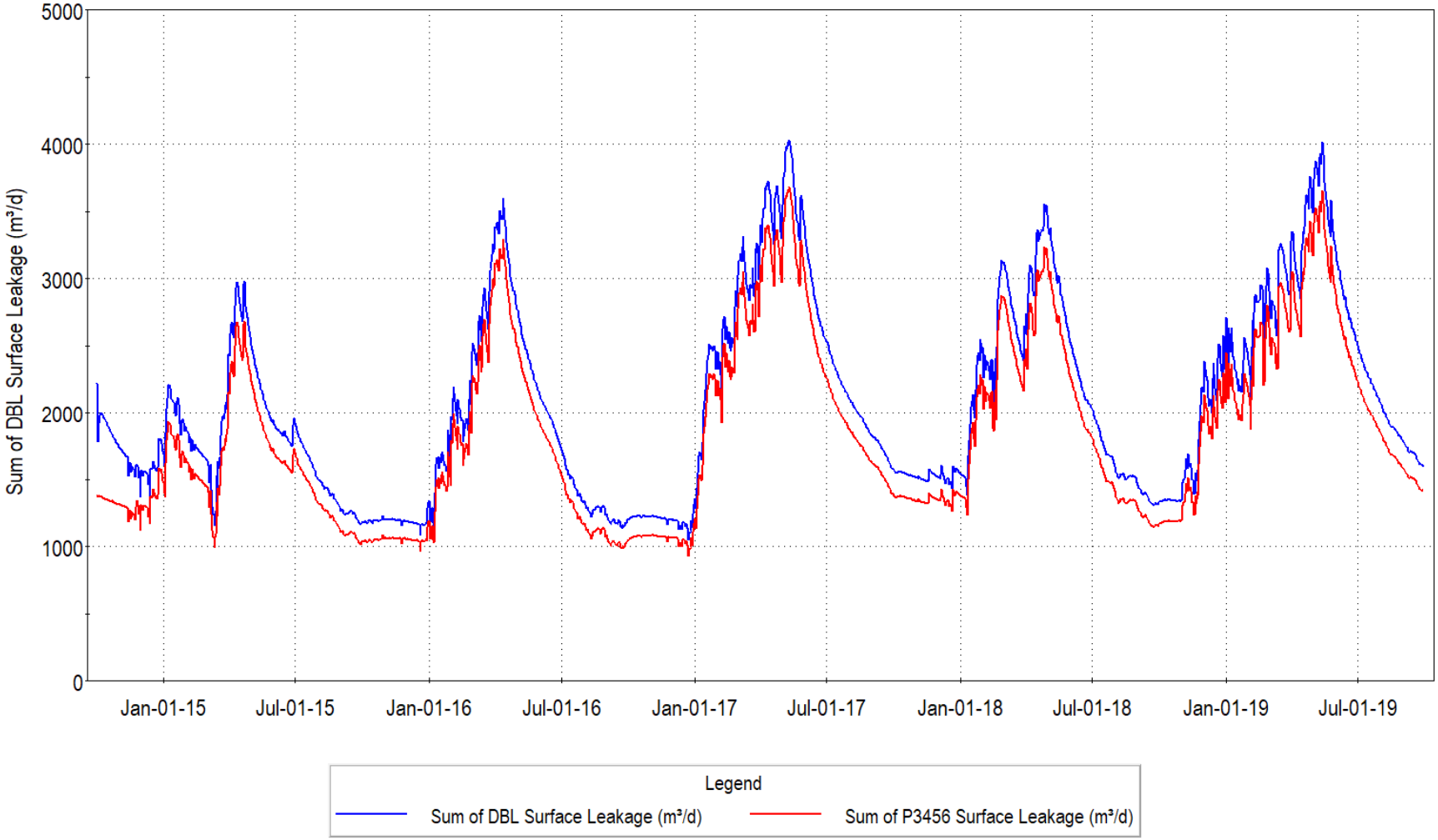


WETLAND 13204 - GRAPH 4

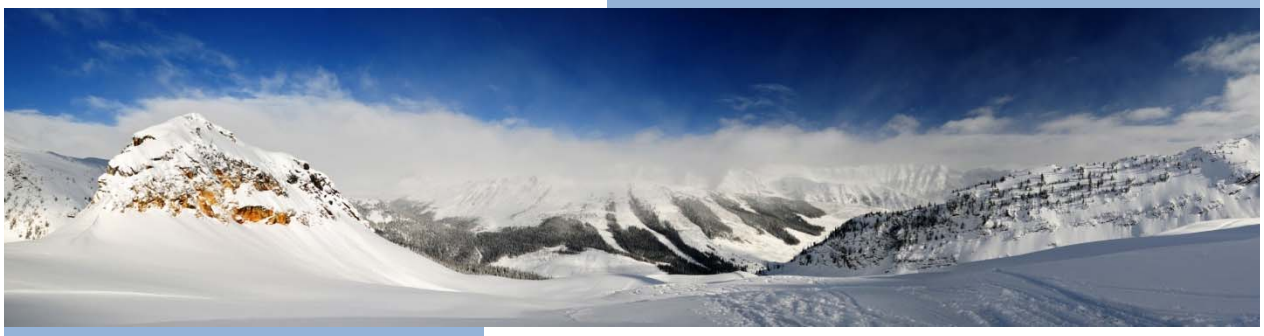


WETLAND 13204 - GRAPH 5

Change in Soil Moisture Conditions
Wetland 13204



Whitewater
Hydrogeology Ltd.



BURLINGTON QUARRY

2019 Compliance Groundwater and Surface Water Monitoring Report

Completed in Compliance with:

Environmental Compliance Approval No.: 5203-AN6NGV

Prepared for:

NELSON AGGREGATE CO.

Whitewater Hydrogeology Ltd
Phone: 705.888.7064
Email: tecia@white-water.ca

Date: March 2020

Whitewater
Hydrogeology Ltd.

80 Chamberlain Cres
Collingwood, ON L9Y 0C8
Phone: 705-888-7064
Email: tecia@white-water.ca

March 18, 2020

Ministry of the Environment, Conservation and Parks
Halton-Peel District Office
4145 North Service Rd,
Burlington, ON
L7L 6A3

Attention: Tina Dufresne, Manager

Re: 2019 Compliance Monitoring Results
Environmental Compliance Approval for Industrial Sewage Works (No.: 5203-AN6NGV)

Whitewater Hydrogeology Ltd. (Whitewater) is pleased to present the results of the 2019 compliance monitoring program, which was carried out under the Environmental Compliance Approval (ECA) for Industrial Sewage Works (No.: 5203-AN6NGV) for the Burlington Quarry.

A copy of the ECA is provided in Appendix A.

If you have any questions, please do not hesitate to contact the undersigned.

Yours truly,

Tecia White, M.Sc., P.Geo. (License 0701)
Senior Hydrogeologist
Whitewater Hydrogeology Ltd.

Cc: District Manager, MECP (email)

Table of Contents

1.0 INTRODUCTION 3
1.1 Description of Sewage Works 3
1.2 Compliance Monitoring Program 6
2.0 2019 MONITORING RESULTS AND REPORTING 6
2.1 Effluent Monitoring Results 6
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2.5 Effluent Quality Assurance or Control Measures 8
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2.10 Notifications and Contingency Plan 9
3.0 CONCLUSION 9

List of Appendices

Appendix A Copy of Environmental Compliance Approval
Appendix B Water Quality Results
Appendix C Meter Calibration Reports
Appendix D Water Takings (Flow Measurements)

1.0 INTRODUCTION

The Nelson Aggregate Company (Nelson) owns and operates the Burlington Quarry, located at 2433 No. 2 Side Rd, City of Burlington, Regional Municipality of Halton (Figure 1). On June 29, 2017, the Ministry of the Environment, Conservation and Parks (MECP) issued Nelson an Ontario Water Resources Act Section 53 Environmental Compliance Approval for Industrial Sewage Works (ECA No.: 5203-AN6NGV) for the site. The ECA allows for the site to operate a water management program to control the incidental water that enters the quarry footprint.

As a condition of the ECA, Nelson is required to complete an annual compliance report that contains the following information:

a) a summary and interpretation of all monitoring data and a comparison to the effluent limits outlined in Condition 4, including an overview of the success and adequacy of the Works;
b) a description of any operating problems encountered, and corrective actions taken;
c) a summary of all inspection, maintenance, and clean-out carried out on any major structure, equipment, apparatus, mechanism, or thing forming part of the Works;
d) a summary of any effluent quality assurance or control measures undertaken;
e) a summary of the calibration and maintenance carried out on all effluent monitoring equipment;
f) a summary of any complaints received during the reporting period and any steps taken to address the complaints;
g) a summary of all spill or abnormal discharge events; and,
h) a summary of any Notifications and Contingency Plan undertook during the reporting period and a discussion regarding their adequacy.

Whitewater Hydrogeology Ltd (Whitewater) has been retained to undertake the 2019 ECA reporting requirements. A copy of the ECA is provided in Appendix A.

1.1 Description of Sewage Works

Nelson has established sewage works at the Uhthoff Quarry for the collection, transmission, treatment, and disposal of groundwater and stormwater runoff collecting within the confines of the quarry. The sewage works consist of:

- one (1) settling pond (North Pond), collecting groundwater and surface water runoff from the active area of the quarry, with an estimated storage volume of 230,000 m at an average depth of 2.4 m, equipped with a discharge sump within the pond and submersible pump (North Discharge), discharging at a maximum release rate of 4,090 L/min to the roadside ditch of Colling Road and a tributary watercourse of Bronte Creek;
- one (1) settling pond (South Pond), collecting groundwater and surface water runoff from the active area of the quarry, with an estimated storage volume of 204,800 m at an average depth of 1.8 m, equipped with a discharge sump within the pond and submersible pump (South Discharge), discharging at a maximum release rate of 945 L/min to the West Mount Nemo Tributary; and
- all other controls, electrical equipment, instrumentation, piping, pumps, valves and associated appurtenances for the proper operations of the aforementioned sewage works.

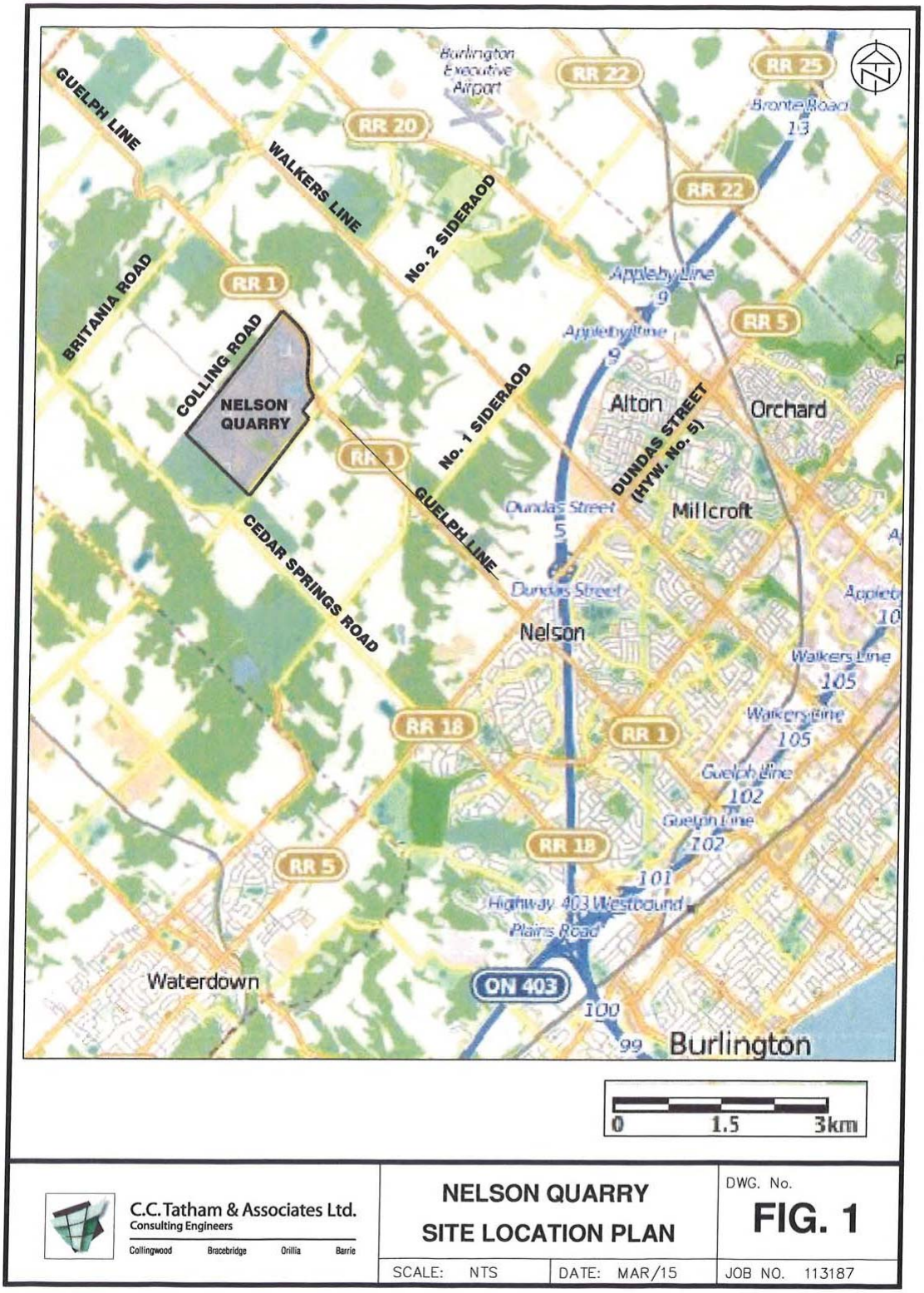

FIGURE 1: SITE LOCATION MAP

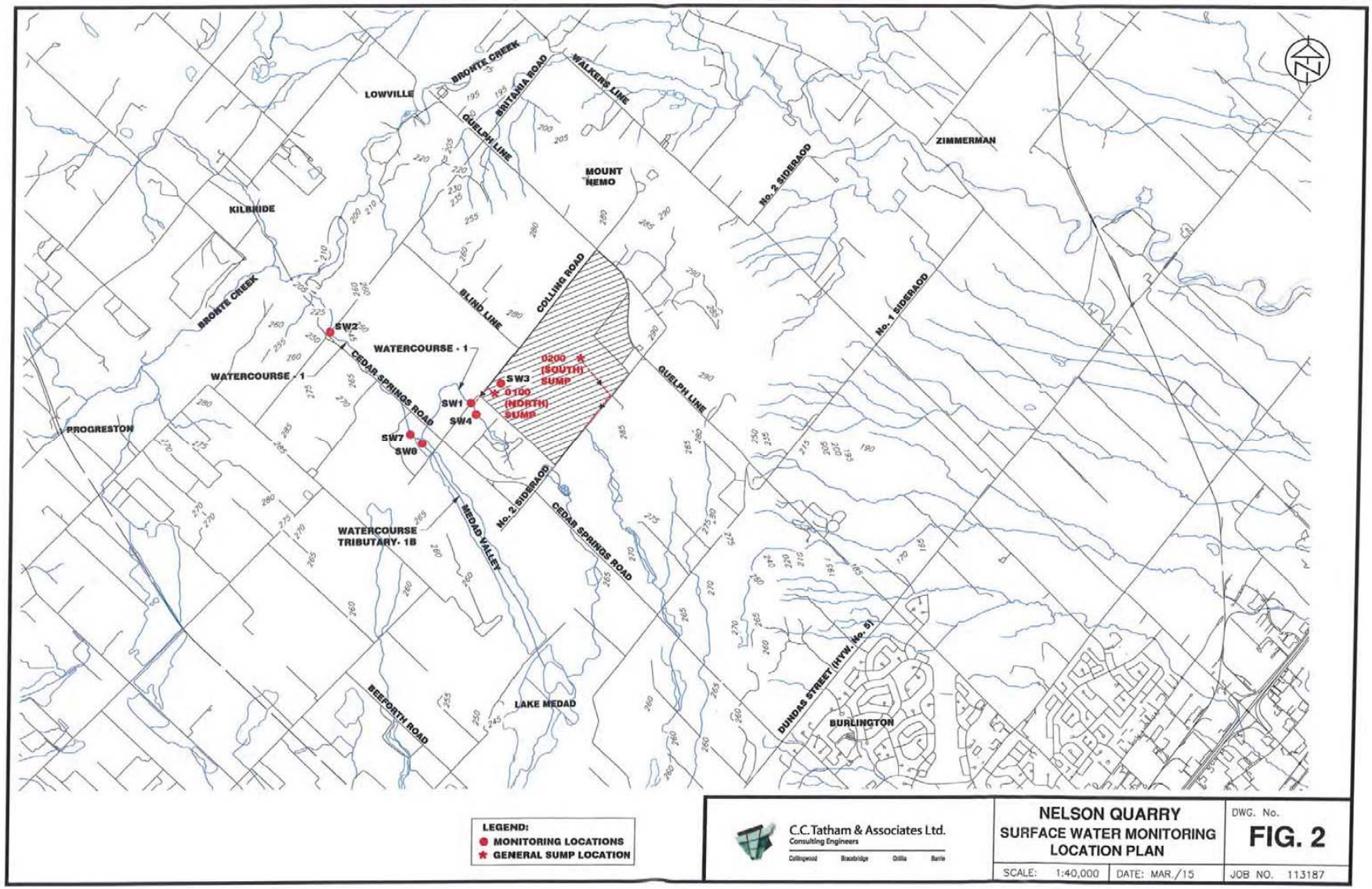

FIGURE 2: MONITORING LOCATIONS

1.2 Compliance Monitoring Program

The effluent monitoring is completed at two sampling locations. The North Discharge pipe, which is located along Collins Road and South Discharge pipe, which is located along the 2nd line (Figure 1 and Figure 2). Sampling is to be completed monthly and quarterly during operations. The sampling details are provided in Table 1.

TABLE 1: WATER QUALITY PARAMETERS

Frequency	Parameters
Monthly	pH (field), Temperature (field), Dissolved Oxygen (field), Conductivity (field), Total Suspended Solids, Total Dissolved Solids, Alkalinity, Hardness, Total Ammonia, calculated Unionized Ammonia, Oil, and Grease
Quarterly	Chloride, Sulphate, Total Kjeldahl Nitrogen, Dissolved Organic Carbon, Total Phosphorus, Nitrate, Nitrite, Phenols, PAHs, Metals (Total Aluminum, Antimony, Arsenic, Barium, Boron, Cadmium, Chromium, Copper, Iron, Lead, Manganese, Mercury, Selenium, Silver, and Zinc)

Note: the effluent from the works shall be essentially free of floating and settleable solids and does not contain oil or any other substance in amounts enough to create a visible film, sheen or foam on the receiving waters.

Also, quarterly field temperature monitoring (four times per year representing seasonal changes) is to be completed at the following locations:

- SW1: Outlet of the North Discharge;
- SW14: second tributary upstream of the quarry discharge;
- SW7: downstream of the SW1 tributary's confluence with a second tributary;
- SW2: a tributary of Bronte Creek downstream of the Britannia Rd crossing;

2.0 2019 MONITORING RESULTS AND REPORTING

2.1 Effluent Monitoring Results

For the purposes of determining compliance with and enforcing the effluent limits, non-compliance is deemed to have occurred when the concentration limit of any single (grab) sample analyzed for a parameter named in Column 1 is greater than the corresponding maximum concentration set out in Column 2, and/or the pH is deemed to have occurred when any single measurement is outside of the indicated range. The 2019 results are presented in the following tables.

Parameter	Limit (mg/L)	WATER QUALITY RESULTS 2019										
Column 1	Column 2	Jan 31	Feb 26	Mar 21	Apr 23	May 8	Jun 13	July 12	Aug 21	Sept 25	Oct 22	Nov. 11
North-West Water Quality Results												
TSS	25	1.7	1.7	2.3	2.7	3.3	<0.7	2.3	4.7	1.7	<0.67	<0.67
Oil & Grease	15	<1	2	9	<1	1	1	3	5	<1	<1	<
pH (field)	6.5 to 8.5	7.8	7.7	7.6	8.1	8.3	7.8	7.8	7.9	8.0	8.1	8.2
TSS	25	2.5	2	4.5	7	8.7	1.5	4.3	1.0	NA	NA	18.7
Oil & Grease	15	<1	1	6	<1	<1	1	2	<1	NA	NA	<
pH (field)	6.5 to 8.5	7.8	7.8	7.7	8.2	8.2	8.1	8.0	8.0	NA	NA	8.0

The results indicate that the water quality is representative of historical conditions. In September and October, pumping from the South-Central Sump was redirected and pumped into the larger North West

settling ponds to all for repairs to the berms. Samples were collected from the South-Central sump to characterize the water prior to discharge into the North-West Sump (Appendix B). Samples were not collected in December 2019 due to safety concerns (ice and snow).

The quarterly sampling occurred on March 21, May 8, August 21, and November 12, 2019. The complete laboratory reports are provided in Appendix B.

2.2 Field Parameters – General Water Quality

The sampling protocol for the collection of effluent samples includes the measurements for field parameters (pH, conductivity, temperature, and dissolved oxygen). The concentration of un-ionized ammonia has been calculated using the total ammonia concentration, pH and temperature. The results of field measurements for 2019 are provided in tables below.

Parameter	North-West Sump Field Parameters									
	Jan 31	Feb 26	Mar 21	Apr 23	May 8	June 13	July 12	Aug 21	Sept 25	Oct 22
Temperature (°C)	3	3.3	4	9	12	18	23	23	20	13
Conductivity (µS/cm)	N/A	889	891	768	751	800	768	730	763	479
Dissolved Oxygen (mg/L)	N/A	11.2	10.6	11.5	9.9	8.3	10.8	9.5	8.6	9.6
pH	7.8	7.7	8.0	8.1	8.2	8.0	7.9	8.0	8.0	8.4
Total Ammonia (mg/L)	0.03	0.1	0.17	<0.01	0.05	0.08	0.03	N/A	0.02	0.07
Un-ionized Ammonia (mg/L)	<0.002	<0.002	<0.002	<0.002	0.002	<0.002	<0.002	N/A	<0.002	<0.002

Parameter	South-Central Sump Field Parameters									
	Jan 31	Feb 26	Mar 21	Apr 23	May 8	June 13	July 12	Aug 21	Sept 25	Oct 22
Temperature (°C)	3	2	4	12	13	19	25	26	19	13
Conductivity (µS/cm)	N/A	933	823	877	869	842	817	832	915	975
Dissolved Oxygen (mg/L)	N/A	11.6	11.1	11.7	9.8	9.2	10.5	9.4	7.8	9.4
pH	7.8	8.0	7.7	8.1	8.0	8.0	8.0	8.1	7.8	8.4
Total Ammonia (mg/L)	0.13	0.26	0.19	0.02	0.07	0.1	0.06	N/A	0.06	0.13
Un-ionized Ammonia (mg/L)	<0.002	<0.002	<0.002	<0.002	0.003	0.005	0.003	N/A	<0.002	0.003

2.3 Surface Water Temperature Monitoring

Quarterly field temperature monitoring (four times per year representing seasonal changes) is required at SW1, SW2, SW7, and SW14. Water temperature was collected continuously at these locations. The results are presented on Figure 3.

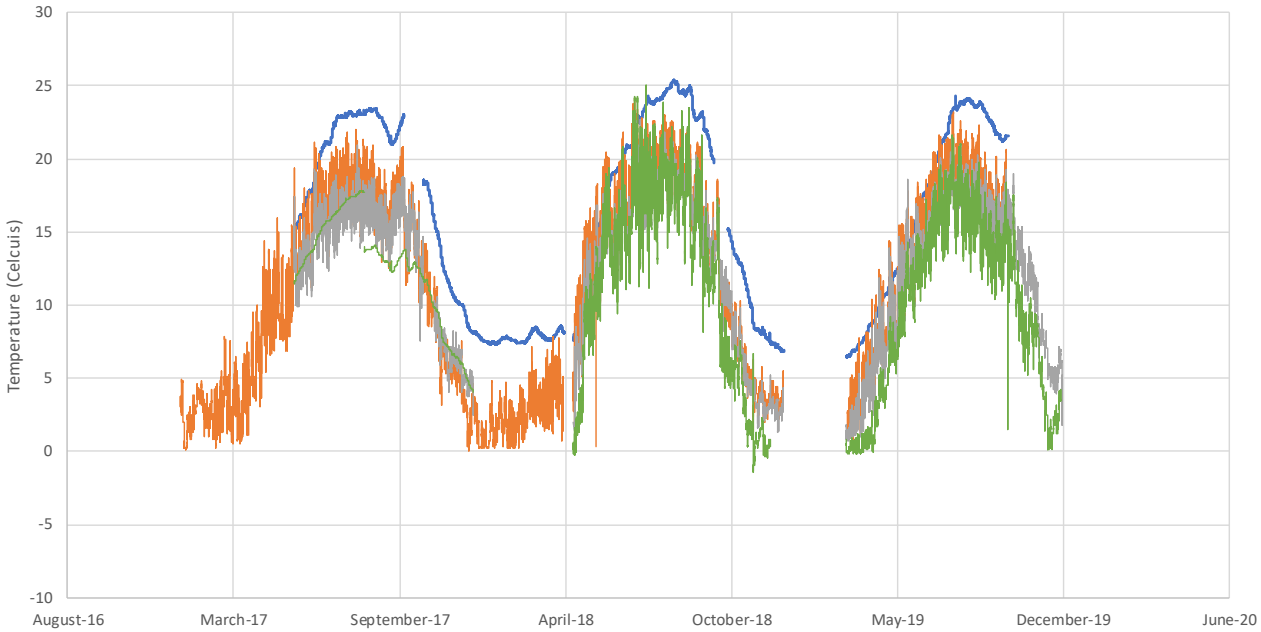

FIGURE 3: SURFACE WATER TEMPERATURE

2.4 Inspection Results and Operational Issues

There were no operational issues in 2019.

2.5 Effluent Quality Assurance or Control Measures

No effluent quality assurance or control measures were required in 2019.

2.6 Calibration and Maintenance

Wajax was retained in 2019 to complete the certification/calibration of the metering equipment at the Burlington Quarry. Seametrics FT430M-126 Mag Meters are used to measure the discharge rates at the north and south discharge locations. The results indicate that the flows are 778 L/min and 3,780 L/min, for the south and north locations, respectively. These rates were slightly over the maximum permitted instantaneous rate listed on the Permit to Take Water. Therefore, the pumps are throttled back to ensure compliance with the water taking limits.

Copies of the calibration reports are provided in Appendix C.

Nelson inspected the depth of sediment in the settling ponds in October, 2019 to comply with Condition 6 of the ECA. The size of the ponds provides a large settling area. It is anticipated that the ponds will not require to be cleaned out for several years. Nelson will continue to inspect the Works at least once a year and periodically measure the amount of sediment accumulating in the settling ponds and remove the sediment, if necessary, to ensure continued suspended solids removal performance of the ponds.

2.7 Flow Monitoring to the North and South Discharge Locations

As per Condition 7(7) of the ECA, Nelson conducts continuous flow monitoring for the North Discharge and South Discharge during operation. This flow equals the discharge rate from the quarry sumps (North-West and South-Central). The total daily flows reported in 2019 are provided in Appendix D. This information has been submitted to the Water Taking Reporting System.

2.8 Complaints

There were no complaints in 2019.

2.9 Spill Occurrence

There were no spills in 2019.

2.10 Notifications and Contingency Plan

There was no need to undertaken notifications or the contingency plan in 2019.

3.0 CONCLUSION

In 2019, the Burlington Quarry complied with the requirements stipulated in ECA No.: 5203-AN6NGV.

APPENDIX A

ENVIRONMENTAL COMPLIANCE APPROVAL

Ontario

Ministry of the Environment and Climate Change
Ministère de l'Environnement et de l'Action en matière de changement climatique

ENVIRONMENTAL COMPLIANCE APPROVAL

NUMBER 5203-AN6NGV
Issue Date: June 29, 2017

Lafarge Canada Inc. and Steed & Evans Holdings Inc.
operating as Nelson Aggregate Co.
Post Office Box, No. 1070
Burlington, Ontario
L7R 4L8

Site Location: Burlington Quarry - Nelson Aggregates
2433 No. 2 Side Rd
City of Burlington, Regional Municipality of Halton
L7P 0G8

You have applied under section 20.2 of Part II.1 of the Environmental Protection Act, R.S.O. 1990, c. E. 19 (Environmental Protection Act) for approval of:

Existing sewage works for the collection, transmission, treatment and disposal of surface water and quarry water from Burlington Quarry - Nelson Aggregates located in City of Burlington, Ontario, Consisting of the following:

- one (1) settling pond (North Pond), collecting groundwater and surface water runoff from the active area of the quarry, with an estimated storage volume of 230,000 m^3 at an average depth of 2.4 m, equipped with a discharge sump within the pond and submersible pump (North Discharge), discharging at a maximum release rate of 4,090 L/min to the roadside ditch of Colling Road and a tributary watercourse of Bronte Creek;

- one (1) settling pond (South Pond), collecting groundwater and surface water runoff from the active area of the quarry, with an estimated storage volume of 204,800 m^3 at an average depth of 1.8 m, equipped with a discharge sump within the pond and submersible pump (South Discharge), discharging at a maximum release rate of 945 L/min to the West Mount Nemo Tributary;

including all other controls, electrical equipment, instrumentation, piping, pumps, valves and associated appurtenances for the proper operations of the aforementioned sewage works;

all in accordance with the submitted supporting documents listed in Schedule "A" forming part of this Approval.

For the purpose of this environmental compliance approval, the following definitions apply:

"Approval" means this entire document including the application and any supporting documents listed in any schedules in this Approval;

"Director" means a person appointed by the Minister pursuant to section 5 of the EPA for the purposes of Part II.1 of the EPA;

"District Manager" means the District Manager of the Halton-Peel District Office of the Ministry*;*

"EPA" means the *Environmental Protection Act* , R.S.O. 1990, c.E.19, as amended;

"Ministry" means the ministry of the government of Ontario responsible for the EPA and OWRA and includes all officials, employees or other persons acting on its behalf;

"Owner" means Lafarge Canada Inc. and Steed & Evans Holdings Inc. operating as Nelson Aggregate Co. and its successors and assignees;

"OWRA" means the *Ontario Water Resources Act* , R.S.O. 1990, c. O.40, as amended;

"Works" means the sewage works described in the Owner's application, and this Approval.

You are hereby notified that this environmental compliance approval is issued to you subject to the terms and conditions outlined below:

TERMS AND CONDITIONS

1. GENERAL PROVISIONS

(1) The Owner shall ensure that any person authorized to carry out work on or operate any aspect of the Works is notified of this Approval and the terms and conditions herein and shall take all reasonable measures to ensure any such person complies with the same.

(2) Except as otherwise provided by these terms and conditions, the Owner shall design, build, install, operate and maintain the Works in accordance with this Approval.

(3) Where there is a conflict between a provision of this environmental compliance approval and any document submitted by the Owner, the conditions in this environmental compliance approval shall take precedence. Where there is a conflict between one or more of the documents submitted by the Owner, the Application shall take precedence unless it is clear that the purpose of the document was to amend the application.

(4) Where there is a conflict between the documents listed in the Schedule A, and the application, the application shall take precedence unless it is clear that the purpose of the document was to amend the application.

(5) The terms and conditions of this Approval are severable. If any term and condition of this environmental compliance approval, or the application of any requirement of this environmental compliance approval to any circumstance, is held invalid or unenforceable, the application of such condition to other circumstances and the remainder of this Approval shall not be affected thereby.

(6) The issuance of, and compliance with the Conditions of this Approval does not:

(a) relieve any person of any obligation to comply with any provision of any applicable statute, regulation or other legal requirement, including, but not limited to, the obligation to obtain approval from the local conservation authority necessary to construct or operate the sewage Works; or

(b) limit in any way the authority of the Ministry to require certain steps be taken to require the Owner to furnish any further information related to compliance with this Approval.

2. CHANGE OF OWNER

(1) The Owner shall notify the District Manager and the Director, in writing, of any of the following changes within **thirty (30) days** of the change occurring:

(a) change of Owner;

(b) change of address of the Owner;

(c) change of partners where the Owner is or at any time becomes a partnership, and a copy of the most recent declaration filed under the Business Names Act, R.S.O. 1990, c. B17 shall be included in the notification to the District Manager;

(d) change of name of the corporation where the Owner is or at any time becomes a corporation, and a copy of the most current information filed under the Corporations Information Act, R.S.O. 1990, c. C39 shall be included in the notification to the District Manager.

(2) In the event of any change in ownership of the Works, other than a change in ownership to the municipal, i.e. assumption of the Works, the Owner shall notify the succeeding owner in writing of the existence of this Approval, and a cop

3. OPERATIONS MANUAL

(1) The Owner shall prepare an operations manual for the sewage works described in this Approval within three months of the date of its issuance including, but not necessarily limited to, the following information:

(a) operating procedures for routine operation of the works;

(b) inspection programs, including frequency of inspection, for the works and the methods or tests employed to detect when maintenance is necessary;

(c) repair and maintenance programs, including the frequency of repair and maintenance for the works;

(d) contingency plans and procedures for dealing with potential spill, bypasses and any other abnormal situations and for notifying the District Manager; and

(e) complaint procedures for receiving and responding to public complaints.

(2) The Owner shall maintain the operations manual up to date through revisions undertaken from time to time and retain a copy at the location of the sewage works. Upon request, the Owner shall make the manual available for inspection and copying by Ministry personnel.

4. EFFLUENT LIMITS

(1) The Owner shall operate and maintain the Works such that the compliance limits of the materials named below as effluent parameters are not exceeded in the effluent from the works.

Table 1 - Effluent Limits	
Effluent Parameter	**Concentration Limit** (milligrams per litre unless otherwise indicated)
Column 1	Column 2
Total Suspended Solids	25.0
Oil and Grease	15.0
pH of the effluent maintained between 6.5 to 8.5, inclusive, at all times	

(2) For the purposes of determining compliance with and enforcing subsection (1):

(a) non-compliance with respect to a Concentration Limit is deemed to have occurred when any single (grab) sample analyzed for a parameter named in Column 1 of subsection (1) is greater than the corresponding maximum concentration set out in Column 2 of subsection (1);

(b) non-compliance with respect to pH is deemed to have occurred when any single measurement is outside of the indicated range.

5. EFFLUENT - VISUAL OBSERVATIONS

Notwithstanding any other condition in this certificate, the Owner shall ensure that the effluent from the works is essentially free of floating and settleable solids and does not contain oil or any other substance in amounts sufficient to create a visible film, sheen or foam on the receiving waters.

6. OPERATION AND MAINTENANCE

(1) The Owner shall inspect the Works at least once a year and periodically measure the amount of sediment accumulating in the settling ponds and remove the sediment, if necessary, to ensure continued suspended solids removal performance of the ponds.

(2) The Owner shall record, in a log book, the day measurement of sediment was undertaken, the amount of sediment measured, if sediment removal was undertaken and where any removed sediment

was disposed.

(3) The log book shall be retained at the site and be made available for Ministry inspection upon request.

7. MONITORING AND RECORDING

The Owner shall, upon the issuance of the Approval, carry out the following monitoring program:

(1) All samples and measurements taken for the purposes of this Approval are to be taken at a time and in a location characteristic of the quality and quantity of the effluent stream over the time period being monitored.

(2) For the purposes of this condition, the following definitions apply:

a. Monthly means once every month;
b. Quarterly means once every three months.

(3) Samples shall be collected at the following sampling points, at the frequency specified, by means of the specified sample type and analyzed for each parameter listed and all results recorded.

Table 2 - Effluent Monitoring	
Sampling Locations	1. at the end of the North Discharge pipe 2. at the end of the South Discharge pipe
Sampling Frequency	Monthly and Quarterly during Operation (see below)
Sample Type	Grab
Parameters	Monthly Monitoring Parameters pH (field), Temperature (field), Dissolved Oxygen (field), Conductivity (field), Total Suspended Solids, Total Dissolved Solids, Alkalinity, Hardness, Total Ammonia, calculated Unionized Ammonia, Oil and Grease Quarterly Monitoring Parameters Chloride, Sulphate, Total Kjeldahl Nitrogen, Dissolved Organic Carbon, Total Phosphorus, Nitrate, Nitrite, Phenols, PAHs, Metals (Total Aluminum, Antimony, Arsenic, Barium, Boron, Cadmium, Chromium, Copper, Iron, Lead, Manganese, Mercury, Selenium, Silver and Zinc)

(4) The Owner shall conduct **quarterly field temperature monitoring** (four times per year representing seasonal changes) at the following locations identified in the submitted documents of this application:

a. SW1: Outlet of the North Discharge;

b. SW14: second tributary upstream of the quarry discharge;

c. SW7: downstream of the SW1 tributary's confluence with a second tributary;

d. SW2: tributary of Bronte Creek downstream of the Britannia Rd crossing;

(5) The methods and protocols for sampling, analysis, and recording shall conform, in order of precedence, to the methods and protocols specified in the following:

(a) the Ministry's publication "Protocol for the Sampling and Analysis of Industrial/Municipal Wastewater" (August 1994), ISBN 0-7778-1880-9, as amended from time to time by more recently published editions;

(b) the publication "Standard Methods for the Examination of Water and Wastewater" (21st edition) as amended from time to time by more recently published editions; and,

(c) in respect of any parameters not mentioned in (a) or (b), the written approval of the District Manager, which approval shall be obtained prior to sampling.

(6) The temperature and pH of the effluent from the works shall be determined in the field at the time of sampling for total ammonia. The concentration of un-ionized ammonia shall be calculated using the total ammonia concentration, pH and temperature using the methodology stipulated in "Ontario's Provincial Water Quality Objectives" dated July 1994, as amended, for ammonia (un-ionized).

(7) The Owner shall conduct flow monitoring for the North Discharge and South Discharge during operation.

(8) The measurement frequencies and parameters specified in subsection (3) are minimum requirements which may, after two (2) years of monitoring in accordance with this Condition, be modified by the Director in writing from time to time.

(9) The Owner shall retain for a minimum of five (5) years from the date of their creation, all records and information related to or resulting from the monitoring activities required by this Approval.

8. SPILL CONTINGENCY AND POLLUTION PREVENTION PLAN

(1) Before the commencement of operation of the Works, the Owner shall prepare a Spill Contingency and Pollution Prevention Plan that outlines procedures as to how to mitigate the impacts of a spill within the drainage areas serviced by the Works and prevent pollution incidents, and provide a copy to the District Manager. The said plan shall include as a minimum, but not limited to:

(a) the name, job title and 24-hour telephone number of the person(s) responsible for activating the Spill Contingency and Pollution Prevention Plan;

(b) a site plan drawn to scale showing the types of business, streets, catch basins and/or manholes

and/or ditches and/or drainage channels , drainage patterns (including direction(s) of flow in storm sewers) and any features which need to be taken into account in terms of potential impacts on access and response (including physical obstructions and location of response and clean-up equipment);

(c) steps to be taken to report, contain, clean up and dispose of contaminants following a spill;

(d) a listing of telephone numbers for: local clean-up companies who may be called upon to assist in responding to spills; local emergency responders including health institution(s); and Ministry of the Environment and Climate Change (MOECC) Spills Action Centre 1-800-268-6060;

(e) Materials Safety Data Sheets (MSDS) for each and every hazardous material which may be transported or stored within the area serviced by the Works;

(f) a description of the spill response and pollution prevention training provided to employees assigned to work in the area serviced by the Works, the date(s) on which the training was provided and to whom;

(g) an inventory of response and clean-up equipment available to implement the Spill Contingency and Pollution Prevention Plan, location and date of maintenance/replacement if warranted, including testing and calibration of the equipment; and

(h) the date on which the Spill Contingency and Pollution Prevention Plan was prepared and subsequently, amended.

(2) The Spill Contingency and Pollution Prevention Plan shall be kept in a conspicuous place near the reception area on site.

(3) The Spill Contingency and Pollution Prevention Plan will be amended from time to time as needed by changes in the operation of the facility or to reflect updates in the Municipal By-Laws, or improved Best Management Practices by the Owner.

9. REPORTING

(1) The Owner shall report to the District Manager or designate, any exceedance of any parameter specified in Condition 4 orally, as soon as reasonably possible, and in writing within seven (7) days of the exceedance.

(2) The Owner shall, upon request, make all manuals, plans, records, data, procedures and supporting documentation available to Ministry staff.

(3) In addition to the obligations under Part X of the *Environmental Protection Act* , the Owner shall, within ten (10) working days of the occurrence of any reportable spill as defined in Ontario Regulation 675/98, bypass or loss of any product, by-product, intermediate product, oil, solvent, waste material or any other polluting substance into the environment, submit a full written report of the occurrence to the District Manager describing the cause and discovery of the spill or loss, clean-up and recovery measures

taken, preventative measures to be taken and schedule of implementation.

(4) The Owner shall prepare and submit a performance report to the District Manager on an annual basis within 60 days following the end of the period being reported upon. The first such report shall cover the first annual period following the commencement of operation of the works and subsequent reports shall be submitted to cover successive annual periods following thereafter. The reports shall contain, but shall not be limited to, the following information:

(a) a summary and interpretation of all monitoring data and a comparison to the effluent limits outlined in Condition 4, including an overview of the success and adequacy of the Works;

(b) a description of any operating problems encountered and corrective actions taken;

(c) a summary of all inspection, maintenance and clean-out carried out on any major structure, equipment, apparatus, mechanism or thing forming part of the Works;

(d) a summary of any effluent quality assurance or control measures undertaken in the reporting period;

(e) a summary of the calibration and maintenance carried out on all effluent monitoring equipment;

(f) a summary of any complaints received during the reporting period and any steps taken to address the complaints;

(g) a summary of all spill or abnormal discharge events; and,

(h) a summary of any Notifications and Contingency Plan undertaken during the reporting period and a discussion regarding their adequacy.

Schedule "A"

1. Application for Approval of Industrial Sewage Works, dated March 10, 2016, submitted by Daniel Twigger, C.C. Tatham & Associates Ltd.;

2. Environmental Compliance Application Report dated March 10, 2016, prepared by C.C. Tatham & Associates Ltd.;

3. Supplemental Information memo dated April 21, 2017, prepared by Dan Hurley from C.C. Tatham & Associates Ltd.;

4. All additional supporting information submitted by Daniel Twigger and Dan Hurley from C.C. Tatham & Associates Ltd. from July 2016 to June, 2017.

The reasons for the imposition of these terms and conditions are as follows:

1. Condition 1 is imposed to ensure that the Works are constructed and operated in the manner in which they were described and upon which approval was granted. This condition is also included to emphasize the precedence of Conditions in the Approval and the practice that the Approval is based on the most current document, if several conflicting documents are submitted for review.

2. Condition 2 is included to ensure that the Ministry records are kept accurate and current with respect to approved Works and to ensure that subsequent owners of the Works are made aware of the Approval and continue to operate the Works in compliance with it.

3. Condition 3 is included to ensure that a comprehensive operations manual governing all significant areas of operation, maintenance and repair is prepared, implemented and kept up-to-date by the owner and made available to the Ministry. Such a manual is an integral part of the operation of the works. Its compilation and use should assist the owner in staff training, in proper plant operation and in identifying and planning for contingencies during possible abnormal conditions. The manual will also act as a benchmark for Ministry staff when reviewing the owner's operation of the work.

4. Conditions 4 and 5 are imposed to ensure that the effluent discharged from the Works to the environment meets the Ministry's effluent quality requirements thus minimizing environmental impact on the receiver and to protect water quality, fish and other aquatic life in the receiving water body.

5. Condition 6 is included to require that the Works be properly operated and maintained such that the environment is protected.

6. Condition 7 is included to enable the Owner to evaluate and demonstrate the performance of the Works, on a continual basis, so that the Works are properly operated and maintained at a level which is consistent with the design objectives specified in the Approval and that the Works do not cause any impairment to the receiving watercourse.

7. Condition 8 is included to ensure that the Ministry is immediately informed of the occurrence of an emergency or otherwise abnormal situation so that appropriate steps are taken to address the immediate concerns regarding the protection of public health and minimizing environmental damage and to be able to devise an overall abatement strategy to prevent long term degradation and the re-occurrence of the situation.

8. Condition 9 is included to provide a performance record for future references, to ensure that the Ministry is made aware of problems as they arise, and to provide a compliance record for all the terms and conditions outlined in this Approval,so that the Ministry can work with the Owner in resolving any problems in a timely manner.

In accordance with Section 139 of the Environmental Protection Act, you may by written Notice served upon me, the Environmental Review Tribunal and in accordance with Section 47 of the Environmental Bill of Rights, 1993, S.O. 1993, c. 28 (Environmental Bill of Rights), the Environmental Commissioner, within 15

days after receipt of this Notice, require a hearing by the Tribunal. The Environmental Commissioner will place notice of your appeal on the Environmental Registry. Section 142 of the Environmental Protection Act provides that the Notice requiring the hearing shall state:

a. The portions of the environmental compliance approval or each term or condition in the environmental compliance approval in respect of which the hearing is required, and;
b. The grounds on which you intend to rely at the hearing in relation to each portion appealed.

The Notice should also include:

1. The name of the appellant;
2. The address of the appellant;
3. The environmental compliance approval number;
4. The date of the environmental compliance approval;
5. The name of the Director, and;
6. The municipality or municipalities within which the project is to be engaged in.

And the Notice should be signed and dated by the appellant.

This Notice must be served upon:

The Secretary*****
Environmental Review Tribunal
655 Bay Street, Suite 1500
Toronto, Ontario
M5G 1E5

AND

The Environmental Commissioner
1075 Bay Street, Suite 605
Toronto, Ontario
M5S 2B1

AND

The Director appointed for the purposes of
Part II.1 of the Environmental Protection Act
Ministry of the Environment and
Climate Change
135 St. Clair Avenue West, 1st Floor
Toronto, Ontario
M4V 1P5

*** Further information on the Environmental Review Tribunal's requirements for an appeal can be obtained directly from the Tribunal at: Tel: (416) 212-6349, Fax: (416) 326-5370 or www.ert.gov.on.ca**

This instrument is subject to Section 38 of the Environmental Bill of Rights, 1993, that allows residents of Ontario to seek leave to appeal the decision on this instrument. Residents of Ontario may seek leave to appeal within 15 days from the date this decision is placed on the Environmental Registry. By accessing the Environmental Registry at www.ebr.gov.on.ca , you can determine when the leave to appeal period ends.

The above noted activity is approved under s.20.3 of Part II.1 of the Environmental Protection Act.

DATED AT TORONTO this 29th day of June, 2017



Fariha Pannu, P.Eng.
Director
appointed for the purposes of Part II.1 of the
Environmental Protection Act

YZ/
c: District Manager, MOECC Halton-Peel District Office
Daniel Twigger, C.C. Tatham & Associates Ltd.

APPENDIX B

WATER QUALITY RESULTS

TESTMARK Laboratories Ltd.
Committed to Quality and Service

CERTIFICATE OF ANALYSIS

Client:	Lauren McKenzie	Work Order Number:	370134
Company:	Nelson Aggregate Co	PO #:	Nelson Aggregates
Address:	2433 No. 2 Side Road Burlington, ON, L7P 0G8	Regulation:	Information not provided
		Project #:	Burlington Quarry Monthly ECA
Phone:		DWS #:	
Email:	lauren.mckenzie@nelsonaggregate.com	Sampled By:	Stephen Vanderhorst
Date Order Received:	4/23/2019	Analysis Started:	4/23/2019
Arrival Temperature:	11.6 °C	Analysis Completed:	4/29/2019

WORK ORDER SUMMARY

ANALYSES WERE PERFORMED ON THE FOLLOWING SAMPLES. THE RESULTS RELATE ONLY TO THE ITEMS TESTED.

Sample Description	Lab ID	Matrix	Type	Comments	Date Collected	Time Collected
Burlington SC Pump - Month (Apr 23, 2019)	1431202	Surface Water	None		4/23/2019	1:00 PM
Burlington NW Pump - Month (Apr 23, 2019)	1431203	Surface Water	None		4/23/2019	1:30 PM

METHODS AND INSTRUMENTATION

THE FOLLOWING METHODS WERE USED FOR YOUR SAMPLE(S):

Method	Lab	Description	Reference
Alkalinity (A1.0)	Mississauga	Determination of Alkalinity by Titration	Modified from APHA-2320B
Ammonia Water (A42)	Mississauga	Determination of Ammonia/Ammonium in Water	Modified from EPA 350.1
Conductivity of Water (A12)	Mississauga	Determination of Conductivity in Water at 25°C	Modified from SM 2510 B
Dissolved Oxygen (A3)	Mississauga	Determination of Dissolved Oxygen in Water	Modified from APHA-5210
Field pH (R112)	Mississauga	Client Supplied Field Determination of pH of Water	Field Test
Field Temp (R113)	Mississauga	Client Supplied Field Determination of Temperature of Water	Field Test
Oil and Grease (A54)	Mississauga	Determination of Oil and Grease in Water	Modified from EPA 1664
pH of Water (A2.0)	Mississauga	Determination of Water pH by Ion Selective Electrode	Modified from APHA-4500H+ B
Reg. Hardness (A13)	Mississauga	Determination of Total Hardness	Modified from APHA-2340B

6820 Kitimat Road Unit 4, Mississauga, ON, L5N 5M3
Phone: (905) 821-1112 Fax: (905) 821-2095 Web: www.testmark.ca

CERTIFICATE OF ANALYSIS

Nelson Aggregate Co

Work Order Number: 370134

Method	Lab	Description	Reference
TDS (A27)	Mississauga	Determination of Total Dissolved Solids in water by gravimetry	Modified from SM-2540
TSS (A27)	Mississauga	Determination of Total Suspended Solids in water by gravimetry	Modified from SM-2540
Un-Ionized NH3 (A42.4)	Mississauga	Calculation of Un-Ionized Ammonia	Modified from APHA-4500

This report has been approved by:



Marc Creighton
Laboratory Director

6820 Kitimat Road Unit 4, Mississauga, ON, L5N 5M3
Phone: (905) 821-1112 Fax: (905) 821-2095 Web: www.testmark.ca

CERTIFICATE OF ANALYSIS

Nelson Aggregate Co

Work Order Number: 370134

WORK ORDER RESULTS

Sample Description	Burlington SC Pump - Month (Apr 23, 2019)		Burlington NW Pump - Month (Apr 23, 2019)		
Lab ID	1431202		1431203		
Field Parameters	Result	MDL	Result	MDL	Units
Field pH	8.2	N/A	8.1	N/A	pH
Field Temp	12	N/A	9	N/A	°C

Sample Description	Burlington SC Pump - Month (Apr 23, 2019)		Burlington NW Pump - Month (Apr 23, 2019)		
Lab ID	1431202		1431203		
General Chemistry	Result	MDL	Result	MDL	Units
Ammonia (as N)	0.02	0.01	<0.01	0.01	mg/L
Conductivity	877	1	768	1	µS/cm
Dissolved Oxygen	11.7	0.2	11.5	0.2	mg/L
M-Alkalinity (pH 4.5)	144	2	176	2	mg/L as CaCO3
Oil and Grease, Animal (Calc.)	<1	1	<1	1	mg/L
Oil and Grease, Mineral	<1	1	<1	1	mg/L
Oil and Grease, Total	<1	1	<1	1	mg/L
pH	8.14	N/A	8.13	N/A	pH
Total Hardness (as CaCO3) (Calc.)	412 [408]	0.1	377	0.1	mg/L
Un-Ionized Ammonia (Calc.)	<0.002	0.002	<0.002	0.002	mg/L

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CERTIFICATE OF ANALYSIS

Nelson Aggregate Co

Work Order Number: 370134

Sample Description	Burlington SC Pump - Month (Apr 23, 2019)		Burlington NW Pump - Month (Apr 23, 2019)		
Lab ID	1431202		1431203		
Solids	Result	MDL	Result	MDL	Units
Total Dissolved Solids	625	3	520	3	mg/L
Total Suspended Solids	7	0.67	2.67	0.67	mg/L

LEGEND

Dates: Dates are formatted as mm/dd/year throughout this report.

[rr]: After a parameter name indicates a re-run of that parameter. Sample may not have been handled according to the recommended temperature, hold time and head space requirements of the method after the initial analysis.

MDL: Method detection limit or minimum reporting limit.

[ ]: Results for laboratory replicates are shown in square brackets immediately below the associated sample result for ease of comparison.

Quality Control: All associated Quality Control data is available on request.

Exceedences: HIGHLIGHTED CELLS INDICATE THAT THE RESULT EXCEEDS A REGULATORY LIMIT. CALCULATED UNCERTAINTY ESTIMATIONS ARE NOT APPLIED FOR DETERMINING SAMPLE EXCEEDANCES.

Benzo(b)fluoranthene: Results for benzo(b)fluoranthene may include contributions from benzo(j)fluoranthene.

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CERTIFICATE OF ANALYSIS

Client:	Tecia White	Work Order Number:	380721
Company:	Nelson Aggregate Co	PO #:	
Address:	2433 No. 2 Side Road Burlington, ON, L7P 0G8	Regulation: Project #:	PWQO Nelson Aggregates Uhtoff Quarry Monthly
Phone:	(705) 888-7064	DWS #:	
Email:	tecia@white-water.ca	Sampled By:	Stephen Vanderhorst
Date Order Received:	8/21/2019	Analysis Started:	8/21/2019
Arrival Temperature:	24.7 °C	Analysis Completed:	8/28/2019

WORK ORDER SUMMARY

ANALYSES WERE PERFORMED ON THE FOLLOWING SAMPLES. THE RESULTS RELATE ONLY TO THE ITEMS TESTED.

Sample Description	Lab ID	Matrix	Type	Comments	Date Collected	Time Collected
NW Burlington Monthly (Aug 21, 2019)	1468385	Surface Water	None		8/21/2019	2:00 PM
SE Burlington Monthly (Aug 21, 2019)	1468386	Surface Water	None		8/21/2019	2:00 PM

METHODS AND INSTRUMENTATION

THE FOLLOWING METHODS WERE USED FOR YOUR SAMPLE(S):

Method	Lab	Description	Reference
Conductivity of Water (A12)	Mississauga	Determination of Conductivity in Water at 25°C	Modified from SM 2510 B
Dissolved Oxygen (A3)	Mississauga	Determination of Dissolved Oxygen in Water	Modified from APHA-5210
Field pH (R112)	Mississauga	Client Supplied Field Determination of pH of Water	Field Test
Field Temp (R113)	Mississauga	Client Supplied Field Determination of Temperature of Water	Field Test
Oil and Grease (A54)	Mississauga	Determination of Oil and Grease in Water	Modified from EPA 1664
pH of Water (A2.0)	Mississauga	Determination of Water pH by Ion Selective Electrode	Modified from APHA-4500H+ B
TSS (A27)	Mississauga	Determination of Total Suspended Solids in water by gravimetry	Modified from SM-2540

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CERTIFICATE OF ANALYSIS

Nelson Aggregate Co

Work Order Number: 380721

This report has been approved by:

Marc Creighton
Laboratory Director

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CERTIFICATE OF ANALYSIS

Nelson Aggregate Co

Work Order Number: 380721

WORK ORDER RESULTS

Sample Description	NW Burlington Monthly (Aug 21, 2019)		SE Burlington Monthly (Aug 21, 2019)			
Sample Date	08/21/2019		08/21/2019			
Lab ID	1468385		1468386			
Field Parameters	Result	MDL	Result	MDL	Units	Criteria: PWQO
Field pH	7.9	N/A	8	N/A	pH	~
Field Temp	23	N/A	26	N/A	°C	~

Sample Description	NW Burlington Monthly (Aug 21, 2019)		SE Burlington Monthly (Aug 21, 2019)			
Sample Date	08/21/2019		08/21/2019			
Lab ID	1468385		1468386			
General Chemistry	Result	MDL	Result	MDL	Units	Criteria: PWQO
Conductivity	730	1	832	1	µS/cm	~
Dissolved Oxygen	9.5	0.2	9.4	0.2	mg/L	~
Oil and Grease, Total	5	1	<1	1	mg/L	~
pH	8.02	N/A	8.13	N/A	pH	~

Sample Description	NW Burlington Monthly (Aug 21, 2019)		SE Burlington Monthly (Aug 21, 2019)			
Sample Date	08/21/2019		08/21/2019			
Lab ID	1468385		1468386			
Solids	Result	MDL	Result	MDL	Units	Criteria: PWQO
Total Suspended Solids	4.70	0.67	1.00	0.67	mg/L	~

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CERTIFICATE OF ANALYSIS

Nelson Aggregate Co

Work Order Number: 380721

LEGEND

Dates: Dates are formatted as mm/dd/year throughout this report.

[rr]: After a parameter name indicates a re-run of that parameter. If multiple re-runs exist they are suffixed by a number. Sample may not have been handled according to the recommended temperature, hold time and head space requirements of the method after the initial analysis.

MDL: Method detection limit or minimum reporting limit.

~: In a criteria column indicates the criteria is not applicable for the parameter row.

Quality Control: All associated Quality Control data is available on request.

Exceedences: HIGHLIGHTED CELLS INDICATE THAT THE RESULT EXCEEDS A REGULATORY LIMIT. CALCULATED UNCERTAINTY ESTIMATIONS ARE NOT APPLIED FOR DETERMINING SAMPLE EXCEEDANCES.

Benzo(b)fluoranthene: Results for benzo(b)fluoranthene may include contributions from benzo(j)fluoranthene.

Field Data: Reports containing Field Parameters represent data that has been collected and provided by the client. Testmark is not responsible for the validity of this data which may be used in subsequent calculations.

Sample Condition Deviations: A noted sample condition deviation may affect the validity of the result.

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CERTIFICATE OF ANALYSIS

Client:	Tecia White	Work Order Number:	366344
Company:	Whitewater Hydrogeology Ltd.	PO #:	
Address:	80 Chamberlain Cres Collingwood, ON, L9Y 0C8	Regulation: Project #:	Information not provided Nelson Aggregates - Burlington Quarry Monthly ECA
Phone:	(705) 888-7064	DWS #:	
Email:	tecia@white-water.ca	Sampled By:	Stephen Vanderhorst
Date Order Received:	2/26/2019	Analysis Started:	2/26/2019
Arrival Temperature:	8.9 °C	Analysis Completed:	3/5/2019

WORK ORDER SUMMARY

ANALYSES WERE PERFORMED ON THE FOLLOWING SAMPLES. THE RESULTS RELATE ONLY TO THE ITEMS TESTED.

Sample Description	Lab ID	Matrix	Type	Comments	Date Collected	Time Collected
Burlington SC Pump - Month (Feb 26, 2019)	1419201	Surface Water	None		2/26/2019	10:00 AM
Burlington NW Pump - Month (Feb 26, 2019)	1419202	Surface Water	None		2/26/2019	11:30 AM

METHODS AND INSTRUMENTATION

THE FOLLOWING METHODS WERE USED FOR YOUR SAMPLE(S):

Method	Lab	Description	Reference
Alkalinity (A1.0)	Mississauga	Determination of Alkalinity by Titration	Modified from APHA-2320B
Ammonia Water (A42)	Mississauga	Determination of Ammonia/Ammonium in Water	Modified from EPA 350.1
Conductivity of Water (A12)	Mississauga	Determination of Conductivity in Water at 25°C	Modified from SM 2510 B
Dissolved Oxygen (A3)	Mississauga	Determination of Dissolved Oxygen in Water	Modified from APHA-5210
Field pH (R112)	Mississauga	Client Supplied Field Determination of pH of Water	Field Test
Field Temp (R113)	Mississauga	Client Supplied Field Determination of Temperature of Water	Field Test
Oil and Grease (A54)	Mississauga	Determination of Oil and Grease in Water	Modified from EPA 1664
pH of Water (A2.0)	Mississauga	Determination of Water pH by Ion Selective Electrode	Modified from APHA-4500H+ B

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CERTIFICATE OF ANALYSIS

Whitewater Hydrogeology Ltd.

Work Order Number: 366344

Method	Lab	Description	Reference
Reg. Hardness (A13)	Mississauga	Determination of Total Hardness	Modified from APHA-2340B
TDS (A27)	Mississauga	Determination of Total Dissolved Solids in water by gravimetry	Modified from SM-2540
TSS (A27)	Mississauga	Determination of Total Suspended Solids in water by gravimetry	Modified from SM-2540
Un-Ionized NH3 (A42.4)	Mississauga	Calculation of Un-Ionized Ammonia	Modified from APHA-4500

This report has been approved by:



Marc Creighton
Laboratory Director

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CERTIFICATE OF ANALYSIS

Whitewater Hydrogeology Ltd.

Work Order Number: 366344

WORK ORDER RESULTS

Sample Description	Burlington SC Pump - Month (Feb 26, 2019)		Burlington NW Pump - Month (Feb 26, 2019)		
Lab ID	1419201		1419202		
Field Parameters	Result	MDL	Result	MDL	Units
Field pH	7.8	N/A	7.7	N/A	pH
Field Temp	2	N/A	3.3	N/A	°C

Sample Description	Burlington SC Pump - Month (Feb 26, 2019)		Burlington NW Pump - Month (Feb 26, 2019)		
Lab ID	1419201		1419202		
General Chemistry	Result	MDL	Result	MDL	Units
Ammonia (as N)	0.26 [0.26]	0.01	0.1	0.01	mg/L
Conductivity	933	1	889	1	µS/cm
Dissolved Oxygen	11.6	0.2	11.2	0.2	mg/L
M-Alkalinity (pH 4.5)	189	2	203	2	mg/L as CaCO3
Oil and Grease, Animal (Calc.)	1	1	<1	1	mg/L
Oil and Grease, Mineral	<1	1	1	1	mg/L
Oil and Grease, Total	1	1	2	1	mg/L
pH	7.95	N/A	7.7	N/A	pH
Total Hardness (as CaCO3) (Calc.)	376 [387]	0.1	356	0.1	mg/L
Un-Ionized Ammonia (Calc.)	<0.002	0.002	<0.002	0.002	mg/L

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Whitewater Hydrogeology Ltd.

Work Order Number: 366344

Sample Description	Burlington SC Pump - Month (Feb 26, 2019)		Burlington NW Pump - Month (Feb 26, 2019)		
Lab ID	1419201		1419202		
Solids	Result	MDL	Result	MDL	Units
Total Dissolved Solids	683 [663]	3	631	3	mg/L
Total Suspended Solids	2 [2]	1	1.67	0.67	mg/L

LEGEND

Dates: Dates are formatted as mm/dd/year throughout this report.

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MDL: Method detection limit or minimum reporting limit.

[ ]: Results for laboratory replicates are shown in square brackets immediately below the associated sample result for ease of comparison.

Quality Control: All associated Quality Control data is available on request.

Exceedences: HIGHLIGHTED CELLS INDICATE THAT THE RESULT EXCEEDS A REGULATORY LIMIT. CALCULATED UNCERTAINTY ESTIMATIONS ARE NOT APPLIED FOR DETERMINING SAMPLE EXCEEDANCES.

Benzo(b)fluoranthene: Results for benzo(b)fluoranthene may include contributions from benzo(j)fluoranthene.

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CERTIFICATE OF ANALYSIS

Client:	Tecia White	Work Order Number:	364922
Company:	Nelson Aggregate Co	PO #:	
Address:	2433 No. 2 Side Road Burlington, ON, L7P 0G8	Regulation: Project #:	Information not provided Nelson Aggregates - Burlington Quarry
Phone:	(705) 888-7064	DWS #:	
Email:	tecia@white-water.ca	Sampled By:	Stephen Vanderhorst
Date Order Received:	1/31/2019	Analysis Started:	1/31/2019
Arrival Temperature:	6.6 °C	Analysis Completed:	2/7/2019

WORK ORDER SUMMARY

ANALYSES WERE PERFORMED ON THE FOLLOWING SAMPLES. THE RESULTS RELATE ONLY TO THE ITEMS TESTED.

Sample Description	Lab ID	Matrix	Type	Comments	Date Collected	Time Collected
NW Sump - Jan 31, 2019	1414616	Surface Water	None		1/31/2019	12:00 PM
SC Sump - Jan 31, 2019	1414617	Surface Water	None		1/31/2019	12:15 PM

METHODS AND INSTRUMENTATION

THE FOLLOWING METHODS WERE USED FOR YOUR SAMPLE(S):

Method	Lab	Description	Reference
Alkalinity (A1.0)	Mississauga	Determination of Alkalinity by Titration	Modified from APHA-2320B
Ammonia Water (A42)	Mississauga	Determination of Ammonia/Ammonium in Water	Modified from EPA 350.1
Field pH (R112)	Mississauga	Client Supplied Field Determination of pH of Water	Field Test
Field Temp (R113)	Mississauga	Client Supplied Field Determination of Temperature of Water	Field Test
ICPMS Reg. Water (A13)	Mississauga	Determination of Metals in Water by ICP/MS	Modified from SW846-6020
Oil and Grease (A54)	Garson	Determination of Oil and Grease in Water	Modified from EPA 1664
Reg. Hardness (A13)	Mississauga	Determination of Total Hardness	Modified from APHA-2340B
TDS (A27)	Mississauga	Determination of Total Dissolved Solids in water by gravimetry	Modified from SM-2540
TSS (A27)	Mississauga	Determination of Total Suspended Solids in water by gravimetry	Modified from SM-2540
Un-Ionized NH3 (A42.4)	Mississauga	Calculation of Un-Ionized Ammonia	Modified from APHA-4500

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CERTIFICATE OF ANALYSIS

Nelson Aggregate Co

Work Order Number: 364922

This report has been approved by:

Marc Creighton
Laboratory Director

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CERTIFICATE OF ANALYSIS

Nelson Aggregate Co

Work Order Number: 364922

WORK ORDER RESULTS

Sample Description	NW Sump - Jan 31, 2019		SC Sump - Jan 31, 2019		
Lab ID	1414616		1414617		
Field Parameters	Result	MDL	Result	MDL	Units
Field pH	7.8	N/A	7.8	N/A	pH
Field Temp	3	N/A	3	N/A	°C

Sample Description	NW Sump - Jan 31, 2019		SC Sump - Jan 31, 2019		
Lab ID	1414616		1414617		
General Chemistry	Result	MDL	Result	MDL	Units
Ammonia (as N)	0.03	0.01	0.13	0.01	mg/L
M-Alkalinity (pH 4.5)	207	2	284	2	mg/L as CaCO3
Oil and Grease, Animal (Calc.)	<1	1	<1	1	mg/L
Oil and Grease, Mineral	<1	1	<1	1	mg/L
Oil and Grease, Total	<1	1	<1	1	mg/L
Total Hardness (as CaCO3) (Calc.)	345	0.1	458	0.1	mg/L
Un-Ionized Ammonia (Calc.)	<0.002	0.002	<0.002	0.002	mg/L

Sample Description	NW Sump - Jan 31, 2019		SC Sump - Jan 31, 2019		
Lab ID	1414616		1414617		
Metals	Result	MDL	Result	MDL	Units
Calcium	83.9	0.5	118	0.5	mg/L
Magnesium	33	0.004	39.7	0.004	mg/L

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Work Order Number: 364922

Sample Description	NW Sump - Jan 31, 2019		SC Sump - Jan 31, 2019		
Lab ID	1414616		1414617		
Solids	Result	MDL	Result	MDL	Units
Total Dissolved Solids	670	3	836 [838]	3	mg/L
Total Suspended Solids	1.7	0.67	2.5 [2.5]	1	mg/L

LEGEND

Dates: Dates are formatted as mm/dd/year throughout this report.

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MDL: Method detection limit or minimum reporting limit.

[ ]: Results for laboratory replicates are shown in square brackets immediately below the associated sample result for ease of comparison.

Quality Control: All associated Quality Control data is available on request.

LCL: Lower Control Limit.

UCL: Upper Control Limit.

QAQCID: This is a unique reference to the quality control data set used to generate the reported value. Contact our lab for this information, as it is traceable through our LIMS.

Exceedences: HIGHLIGHTED CELLS INDICATE THAT THE RESULT EXCEEDS A REGULATORY LIMIT. CALCULATED UNCERTAINTY ESTIMATIONS ARE NOT APPLIED FOR DETERMINING SAMPLE EXCEEDANCES.

Benzo(b)fluoranthene: Results for benzo(b)fluoranthene may include contributions from benzo(j)fluoranthene.

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CERTIFICATE OF ANALYSIS

Nelson Aggregate Co

Work Order Number: 364922

QUALITY CONTROL DATA

THIS SECTION REPORTS QC RESULTS ASSOCIATED WITH THE TEST BATCH; THESE ARE NOT YOUR SAMPLE RESULTS.
QAQC details include only values where sufficient sample data allowed measurement.

General Chemistry

Blank: LRB-6 (6)

Parameter	MDL	Units	LCL	Result	UCL	QAQCID
Ammonia (as N)	0.01	mg/L	0	<0.01	0.03	20190131.TM-M.A42B

Blank: LRB-6 (Blank) (6)

Parameter	MDL	Units	LCL	Result	UCL	QAQCID
Oil and Grease, Total	1	mg/L	0	<1	3	20190205.TM-G.A54B

Method Blank: LRB-6 (Blank) (6)

Parameter	MDL	Units	LCL	Result	UCL	QAQCID
M-Alkalinity (pH 4.5)	2	mg/L as CaCO3	0	2.45	6	20190204.A1.0C

Positive Control: LFB-4 (100 mg/L CaCO3) (4)

Parameter	MDL	Units	LCL	Result	UCL	QAQCID
M-Alkalinity (pH 4.5)	2	mg/L as CaCO3	80	101	120	20190204.A1.0C

Positive Control: LFB-7 (0.25 mg/L) (7)

Parameter	MDL	Units	LCL	Result	UCL	QAQCID
Ammonia (as N)	0.01	mg/L	0.2	0.219	0.3	20190131.TM-M.A42B

Positive Control: LFRB-7 (20 mg/L) (7)

Parameter	MDL	Units	LCL	Result	UCL	QAQCID
Oil and Grease, Total	1	mg/L	16	18.9	24	20190205.TM-G.A54B

Sample Replicate: % RPD (9)

Parameter	MDL	Units	LCL	Result	UCL	QAQCID
M-Alkalinity (pH 4.5)	N/A	%	0	2.7	20	20190204.A1.0C

Sample Spike: LFS-9 (Sample Spike) (9)

Parameter	MDL	Units	LCL	Result	UCL	QAQCID
Ammonia (as N)	N/A	% Rec	75	84	125	20190131.TM-M.A42B

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CERTIFICATE OF ANALYSIS

Nelson Aggregate Co

Work Order Number: 364922

Metals

Method Blank: LRB-6 (Blank- µg/L) (6)

Parameter	MDL	Units	LCL	Result	UCL	QAQCID
Calcium	0.05	mg/L	0	<0.05	0.15	20190207.TM-M.A13.1B
Magnesium	0.004	mg/L	0	<0.004	0.004	20190207.TM-M.A13.1B

Positive Control: LFB-7 (N 100 µg/L) (7)

Parameter	MDL	Units	LCL	Result	UCL	QAQCID
Calcium	N/A	%	80	94.6	120	20190207.TM-M.A13.1B
Magnesium	N/A	%	80	91.9	120	20190207.TM-M.A13.1B

Reference Sample: CRM-12 (EP-L-3) (12)

Parameter	MDL	Units	LCL	Result	UCL	QAQCID
Calcium	0.05	mg/L	0.365	0.396	0.599	20190207.TM-M.A13.1B
Magnesium	0.004	mg/L	0.0415	0.0346	0.0501	20190207.TM-M.A13.1B

Solids

Blank: LRB-6 (Blank) (6)

Parameter	MDL	Units	LCL	Result	UCL	QAQCID
Total Suspended Solids	2	mg/L	0	<2	10	20190205.TM-M.A27A

Method Blank: LRB-6 (Blank) (6)

Parameter	MDL	Units	LCL	Result	UCL	QAQCID
Total Dissolved Solids	3	mg/L	0	11	50	20190207.TM-M.A27A

Positive Control: LFB-7 (250 mg/L) (7)

Parameter	MDL	Units	LCL	Result	UCL	QAQCID
Total Dissolved Solids	3	mg/L	225	260	275	20190207.TM-M.A27A
Total Suspended Solids	2	mg/L	225	255	275	20190205.TM-M.A27A

Sample Replicate: % RPD (8)

Parameter	MDL	Units	LCL	Result	UCL	QAQCID
Total Dissolved Solids		%	0	0.2	20	20190207.TM-M.A27A
Total Suspended Solids	N/A	%	0	0	20	20190205.TM-M.A27A

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CERTIFICATE OF ANALYSIS

Nelson Aggregate Co

Work Order Number: 364922

THIS INDEX SHOWS HOW YOUR SAMPLES ARE ASSOCIATED TO THE CONTROLS INCLUDED IN THE IDENTIFIED BATCHES.

Sample Description	Lab ID	Method	QAQCID	Prep QAQCID
NW Sump - Jan 31, 2019	1414616	Alkalinity (A1.0)	20190204.A1.0C	
NW Sump - Jan 31, 2019	1414616	Ammonia Water (A42)	20190131.TM-M.A42B	
NW Sump - Jan 31, 2019	1414616	Field pH (R112)	20190131.R112P	
NW Sump - Jan 31, 2019	1414616	Field Temp (R113)	20190131.R113P	
NW Sump - Jan 31, 2019	1414616	ICPMS Reg. Water (A13)	20190207.TM-M.A13.1B	20190204.TM-M.A52B
NW Sump - Jan 31, 2019	1414616	Oil and Grease (A54)	20190205.TM-G.A54B	
NW Sump - Jan 31, 2019	1414616	Reg. Hardness (A13)	20190207.TM-M.A13.1C	
NW Sump - Jan 31, 2019	1414616	TDS (A27)	20190207.TM-M.A27A	
NW Sump - Jan 31, 2019	1414616	TSS (A27)	20190205.TM-M.A27A	
NW Sump - Jan 31, 2019	1414616	Un-Ionized NH3 (A42.4)	20190207.TM-M.A42.4B	
SC Sump - Jan 31, 2019	1414617	Alkalinity (A1.0)	20190204.A1.0C	
SC Sump - Jan 31, 2019	1414617	Ammonia Water (A42)	20190131.TM-M.A42B	
SC Sump - Jan 31, 2019	1414617	Field pH (R112)	20190131.R112P	
SC Sump - Jan 31, 2019	1414617	Field Temp (R113)	20190131.R113P	
SC Sump - Jan 31, 2019	1414617	ICPMS Reg. Water (A13)	20190207.TM-M.A13.1B	20190204.TM-M.A52B
SC Sump - Jan 31, 2019	1414617	Oil and Grease (A54)	20190205.TM-G.A54B	
SC Sump - Jan 31, 2019	1414617	Reg. Hardness (A13)	20190207.TM-M.A13.1C	
SC Sump - Jan 31, 2019	1414617	TDS (A27)	20190207.TM-M.A27A	
SC Sump - Jan 31, 2019	1414617	TSS (A27)	20190205.TM-M.A27A	
SC Sump - Jan 31, 2019	1414617	Un-Ionized NH3 (A42.4)	20190207.TM-M.A42.4B	
SC Sump - Jan 31, 2019	1414617r	TDS (A27)	20190207.TM-M.A27A	
SC Sump - Jan 31, 2019	1414617r	TSS (A27)	20190205.TM-M.A27A	

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CERTIFICATE OF ANALYSIS

Client:	Tecia White	Work Order Number:	377467
Company:	Nelson Aggregate Co	PO #:	
Address:	2433 No. 2 Side Road Burlington, ON, L7P 0G8	Regulation: Project #:	Information not provided Nelson Aggregates - Burlington Quarry Monthly ECA
Phone:	(705) 888-7064	DWS #:	
Email:	tecia@white-water.ca	Sampled By:	Stephen Vanderhorst
Date Order Received:	7/12/2019	Analysis Started:	7/12/2019
Arrival Temperature:	22.7 °C	Analysis Completed:	7/18/2019

WORK ORDER SUMMARY

ANALYSES WERE PERFORMED ON THE FOLLOWING SAMPLES. THE RESULTS RELATE ONLY TO THE ITEMS TESTED.

Sample Description	Lab ID	Matrix	Type	Comments	Date Collected	Time Collected
Burlington Monthly SC (July 12, 2019)	1456896	Surface Water	None		7/12/2019	11:00 AM
Burlington Monthly NW (July 12, 2019)	1456897	Surface Water	None		7/12/2019	11:30 AM

METHODS AND INSTRUMENTATION

THE FOLLOWING METHODS WERE USED FOR YOUR SAMPLE(S):

Method	Lab	Description	Reference
Alkalinity (A1.0)	Mississauga	Determination of Alkalinity by Titration	Modified from APHA-2320B
Ammonia Water (A42)	Mississauga	Determination of Ammonia/Ammonium in Water	Modified from EPA 350.1
Conductivity of Water (A12)	Mississauga	Determination of Conductivity in Water at 25°C	Modified from SM 2510 B
Dissolved Oxygen (A3)	Mississauga	Determination of Dissolved Oxygen in Water	Modified from APHA-5210
Field pH (R112)	Mississauga	Client Supplied Field Determination of pH of Water	Field Test
Field Temp (R113)	Mississauga	Client Supplied Field Determination of Temperature of Water	Field Test
ICPMS Reg. Water (A13)	Mississauga	Determination of Metals in Water by ICP/MS	Modified from SW846-6020
Oil and Grease (A54)	Mississauga	Determination of Oil and Grease in Water	Modified from EPA 1664
pH of Water (A2.0)	Mississauga	Determination of Water pH by Ion Selective Electrode	Modified from APHA-4500H+ B

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Method	Lab	Description	Reference
Reg. Hardness (A13)	Mississauga	Determination of Total Hardness	Modified from APHA-2340B
TDS (A27)	Mississauga	Determination of Total Dissolved Solids in water by gravimetry	Modified from SM-2540
TSS (A27)	Mississauga	Determination of Total Suspended Solids in water by gravimetry	Modified from SM-2540
Un-Ionized NH3 (A42.4)	Mississauga	Calculation of Un-Ionized Ammonia	Modified from APHA-4500

This report has been approved by:



Marc Creighton
Laboratory Director

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CERTIFICATE OF ANALYSIS

Nelson Aggregate Co

Work Order Number: 377467

WORK ORDER RESULTS

Sample Description	Burlington Monthly SC (July 12, 2019)		Burlington Monthly NW (July 12, 2019)		
Lab ID	1456896		1456897		
Field Parameters	Result	MDL	Result	MDL	Units
Field pH	8	N/A	7.8	N/A	pH
Field Temp	25	N/A	23	N/A	°C

Sample Description	Burlington Monthly SC (July 12, 2019)		Burlington Monthly NW (July 12, 2019)		
Lab ID	1456896		1456897		
General Chemistry	Result	MDL	Result	MDL	Units
Ammonia (as N)	0.06	0.01	0.03	0.01	mg/L
Conductivity	817	1	768	1	µS/cm
Dissolved Oxygen	10.5	0.2	10.8	0.2	mg/L
M-Alkalinity (pH 4.5)	138	2	158	2	mg/L as CaCO3
Oil and Grease, Animal (Calc.)	2	1	3	1	mg/L
Oil and Grease, Mineral	<1	1	<1	1	mg/L
Oil and Grease, Total	2	1	3	1	mg/L
pH	8.01	N/A	7.93	N/A	pH
Total Hardness (as CaCO3) (Calc.)	317	0.1	309	0.1	mg/L
Un-Ionized Ammonia (Calc.)	0.003	0.002	<0.002	0.002	mg/L

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Work Order Number: 377467

Sample Description	Burlington Monthly SC (July 12, 2019)		Burlington Monthly NW (July 12, 2019)		
Lab ID	1456896		1456897		
Metals	Result	MDL	Result	MDL	Units
Calcium	66.1	0.5	66	0.5	mg/L
Magnesium	37	0.05	34.9	0.05	mg/L
Sodium	40	1	37	1	mg/L

Sample Description	Burlington Monthly SC (July 12, 2019)		Burlington Monthly NW (July 12, 2019)		
Lab ID	1456896		1456897		
Solids	Result	MDL	Result	MDL	Units
Total Dissolved Solids	628	2	582	2	mg/L
Total Suspended Solids	4.33	0.67	2.33	0.67	mg/L

LEGEND

Dates: Dates are formatted as mm/dd/year throughout this report.

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MDL: Method detection limit or minimum reporting limit.

Quality Control: All associated Quality Control data is available on request.

Exceedences: HIGHLIGHTED CELLS INDICATE THAT THE RESULT EXCEEDS A REGULATORY LIMIT. CALCULATED UNCERTAINTY ESTIMATIONS ARE NOT APPLIED FOR DETERMINING SAMPLE EXCEEDANCES.

Benzo(b)fluoranthene: Results for benzo(b)fluoranthene may include contributions from benzo(j)fluoranthene.

Field Data: Reports containing Field Parameters represent data that has been collected and provided by the client. Testmark is not responsible for the validity of this data which may be used in subsequent calculations.

Sample Condition Deviations: A noted sample condition deviation may affect the validity of the result.

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CERTIFICATE OF ANALYSIS

Client:	Tecia White	Work Order Number:	374732
Company:	Nelson Aggregate Co	PO #:	
Address:	2433 No. 2 Side Road Burlington, ON, L7P 0G8	Regulation: Project #:	Information not provided Nelson Aggregates - Burlington Quarry Monthly ECA
Phone:	(705) 888-7064	DWS #:	
Email:	tecia@white-water.ca	Sampled By:	Stephen Vanderhorst
Date Order Received:	6/13/2019	Analysis Started:	6/13/2019
Arrival Temperature:	18.1 °C	Analysis Completed:	6/19/2019

WORK ORDER SUMMARY

ANALYSES WERE PERFORMED ON THE FOLLOWING SAMPLES. THE RESULTS RELATE ONLY TO THE ITEMS TESTED.

Sample Description	Lab ID	Matrix	Type	Comments	Date Collected	Time Collected
Burlington NW Monthly (June 13, 2019)	1446768	Surface Water	None		6/13/2019	11:00 AM
Burlington SC Monthly (June 13, 2019)	1446769	Surface Water	None		6/13/2019	11:00 AM

METHODS AND INSTRUMENTATION

THE FOLLOWING METHODS WERE USED FOR YOUR SAMPLE(S):

Method	Lab	Description	Reference
Alkalinity (A1.0)	Mississauga	Determination of Alkalinity by Titration	Modified from APHA-2320B
Ammonia Water (A42)	Mississauga	Determination of Ammonia/Ammonium in Water	Modified from EPA 350.1
Conductivity of Water (A12)	Mississauga	Determination of Conductivity in Water at 25°C	Modified from SM 2510 B
Dissolved Oxygen (A3)	Mississauga	Determination of Dissolved Oxygen in Water	Modified from APHA-5210
Field pH (R112)	Mississauga	Client Supplied Field Determination of pH of Water	Field Test
Field Temp (R113)	Mississauga	Client Supplied Field Determination of Temperature of Water	Field Test
ICPMS Reg. Water (A13)	Mississauga	Determination of Metals in Water by ICP/MS	Modified from SW846-6020
Oil and Grease (A54)	Mississauga	Determination of Oil and Grease in Water	Modified from EPA 1664
pH of Water (A2.0)	Mississauga	Determination of Water pH by Ion Selective Electrode	Modified from APHA-4500H+ B

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Work Order Number: 374732

Method	Lab	Description	Reference
Reg. Hardness (A13)	Mississauga	Determination of Total Hardness	Modified from APHA-2340B
TDS (A27)	Mississauga	Determination of Total Dissolved Solids in water by gravimetry	Modified from SM-2540
TSS (A27)	Mississauga	Determination of Total Suspended Solids in water by gravimetry	Modified from SM-2540
Un-Ionized NH3 (A42.4)	Mississauga	Calculation of Un-Ionized Ammonia	Modified from APHA-4500

This report has been approved by:



Marc Creighton
Laboratory Director

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CERTIFICATE OF ANALYSIS

Nelson Aggregate Co

Work Order Number: 374732

WORK ORDER RESULTS

Sample Description	Burlington NW Monthly (June 13, 2019)		Burlington SC Monthly (June 13, 2019)		
Lab ID	1446768		1446769		
Field Parameters	Result	MDL	Result	MDL	Units
Field pH	7.8	N/A	8.1	N/A	pH
Field Temp	18	N/A	19	N/A	°C

Sample Description	Burlington NW Monthly (June 13, 2019)		Burlington SC Monthly (June 13, 2019)		
Lab ID	1446768		1446769		
General Chemistry	Result	MDL	Result	MDL	Units
Ammonia (as N)	0.08	0.01	0.1	0.01	mg/L
Conductivity	800	1	842	1	µS/cm
Dissolved Oxygen	8.3	0.2	9.2	0.2	mg/L
M-Alkalinity (pH 4.5)	186	2	172	2	mg/L as CaCO3
Oil and Grease, Animal (Calc.)	1	1	1	1	mg/L
Oil and Grease, Mineral	<1	1	<1	1	mg/L
Oil and Grease, Total	1	1	1	1	mg/L
pH	7.95	N/A	8.06	N/A	pH
Total Hardness (as CaCO3) (Calc.)	337	0.1	363 [366]	0.1	mg/L
Un-Ionized Ammonia (Calc.)	<0.002	0.002	0.005	0.002	mg/L

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Nelson Aggregate Co

Work Order Number: 374732

Sample Description	Burlington NW Monthly (June 13, 2019)		Burlington SC Monthly (June 13, 2019)		
Lab ID	1446768		1446769		
Metals	Result	MDL	Result	MDL	Units
Calcium	80.7	0.05	84.8 [84.9]	0.05	mg/L
Magnesium	32.8	0.005	36.8 [37.4]	0.005	mg/L

Sample Description	Burlington NW Monthly (June 13, 2019)		Burlington SC Monthly (June 13, 2019)		
Lab ID	1446768		1446769		
Solids	Result	MDL	Result	MDL	Units
Total Dissolved Solids	560	3	585 [596]	3	mg/L
Total Suspended Solids	<0.67	0.67	1.5 [1.5]	1	mg/L

LEGEND

Dates: Dates are formatted as mm/dd/year throughout this report.

[rr]: After a parameter name indicates a re-run of that parameter. If multiple re-runs exist they are suffixed by a number. Sample may not have been handled according to the recommended temperature, hold time and head space requirements of the method after the initial analysis.

MDL: Method detection limit or minimum reporting limit.

[ ]: Results for laboratory replicates are shown in square brackets immediately below the associated sample result for ease of comparison.

Quality Control: All associated Quality Control data is available on request.

Exceedences: HIGHLIGHTED CELLS INDICATE THAT THE RESULT EXCEEDS A REGULATORY LIMIT. CALCULATED UNCERTAINTY ESTIMATIONS ARE NOT APPLIED FOR DETERMINING SAMPLE EXCEEDANCES.

Benzo(b)fluoranthene: Results for benzo(b)fluoranthene may include contributions from benzo(j)fluoranthene.

Field Data: Reports containing Field Parameters represent data that has been collected and provided by the client. Testmark is not responsible for the validity of this data which may be used in subsequent calculations.

Sample Condition Deviations: A noted sample condition deviation may affect the validity of the result.

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CERTIFICATE OF ANALYSIS

Client:	Tecia White	Work Order Number:	371428
Company:	Nelson Aggregate Co	PO #:	
Address:	2433 No. 2 Side Road Burlington, ON, L7P 0G8	Regulation: Project #:	Information not provided Nelson Aggregates - Burlington Quarry Monthly ECA
Phone:	(705) 888-7064	DWS #:	
Email:	tecia@white-water.ca	Sampled By:	Stephen Vanderhorst
Date Order Received:	5/8/2019	Analysis Started:	5/8/2019
Arrival Temperature:	14.9 °C	Analysis Completed:	5/15/2019

WORK ORDER SUMMARY

ANALYSES WERE PERFORMED ON THE FOLLOWING SAMPLES. THE RESULTS RELATE ONLY TO THE ITEMS TESTED.

Sample Description	Lab ID	Matrix	Type	Comments	Date Collected	Time Collected
Burlington SC Pump - Month (May 8, 2019)	1435417	Surface Water	None		5/8/2019	1:00 PM
Burlington NW Pump - Month (May 8, 2019)	1435418	Surface Water	None		5/8/2019	1:30 PM

METHODS AND INSTRUMENTATION

THE FOLLOWING METHODS WERE USED FOR YOUR SAMPLE(S):

Method	Lab	Description	Reference
Alkalinity (A1.0)	Mississauga	Determination of Alkalinity by Titration	Modified from APHA-2320B
Ammonia Water (A42)	Mississauga	Determination of Ammonia/Ammonium in Water	Modified from EPA 350.1
Conductivity of Water (A12)	Mississauga	Determination of Conductivity in Water at 25°C	Modified from SM 2510 B
Dissolved Oxygen (A3)	Mississauga	Determination of Dissolved Oxygen in Water	Modified from APHA-5210
Field pH (R112)	Mississauga	Client Supplied Field Determination of pH of Water	Field Test
Field Temp (R113)	Mississauga	Client Supplied Field Determination of Temperature of Water	Field Test
Oil and Grease (A54)	Mississauga	Determination of Oil and Grease in Water	Modified from EPA 1664
pH of Water (A2.0)	Mississauga	Determination of Water pH by Ion Selective Electrode	Modified from APHA-4500H+ B
Reg. Hardness (A13)	Mississauga	Determination of Total Hardness	Modified from APHA-2340B

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Method	Lab	Description	Reference
TDS (A27)	Mississauga	Determination of Total Dissolved Solids in water by gravimetry	Modified from SM-2540
TSS (A27)	Mississauga	Determination of Total Suspended Solids in water by gravimetry	Modified from SM-2540
Un-Ionized NH3 (A42.4)	Mississauga	Calculation of Un-Ionized Ammonia	Modified from APHA-4500

This report has been approved by:



Marc Creighton
Laboratory Director

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CERTIFICATE OF ANALYSIS

Nelson Aggregate Co

Work Order Number: 371428

WORK ORDER RESULTS

Sample Description	Burlington SC Pump - Month (May 8, 2019)		Burlington NW Pump - Month (May 8, 2019)		
Lab ID	1435417		1435418		
Field Parameters	Result	MDL	Result	MDL	Units
Field pH	8.2	N/A	8.3	N/A	pH
Field Temp	13	N/A	12	N/A	°C

Sample Description	Burlington SC Pump - Month (May 8, 2019)		Burlington NW Pump - Month (May 8, 2019)		
Lab ID	1435417		1435418		
General Chemistry	Result	MDL	Result	MDL	Units
Ammonia (as N)	0.07	0.01	0.05	0.01	mg/L
Conductivity	869	1	751	1	µS/cm
Dissolved Oxygen	9.8	0.2	9.9	0.2	mg/L
M-Alkalinity (pH 4.5)	166	2	179	2	mg/L as CaCO3
Oil and Grease, Animal (Calc.)	<1	1	1	1	mg/L
Oil and Grease, Mineral	<1	1	<1	1	mg/L
Oil and Grease, Total	<1	1	1	1	mg/L
pH	8.07	N/A	8.19	N/A	pH
Total Hardness (as CaCO3) (Calc.)	393	0.1	319	0.1	mg/L
Un-Ionized Ammonia (Calc.)	0.003	0.002	0.002	0.002	mg/L

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Work Order Number: 371428

Sample Description	Burlington SC Pump - Month (May 8, 2019)		Burlington NW Pump - Month (May 8, 2019)		
Lab ID	1435417		1435418		
Solids	Result	MDL	Result	MDL	Units
Total Dissolved Solids	642	3	534	3	mg/L
Total Suspended Solids	8.67	0.67	3.33	0.67	mg/L

LEGEND

Dates: Dates are formatted as mm/dd/year throughout this report.

[rr]: After a parameter name indicates a re-run of that parameter. Sample may not have been handled according to the recommended temperature, hold time and head space requirements of the method after the initial analysis.

MDL: Method detection limit or minimum reporting limit.

Quality Control: All associated Quality Control data is available on request.

Exceedences: HIGHLIGHTED CELLS INDICATE THAT THE RESULT EXCEEDS A REGULATORY LIMIT. CALCULATED UNCERTAINTY ESTIMATIONS ARE NOT APPLIED FOR DETERMINING SAMPLE EXCEEDANCES.

Benzo(b)fluoranthene: Results for benzo(b)fluoranthene may include contributions from benzo(j)fluoranthene.

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CERTIFICATE OF ANALYSIS

Client:	Lauren McKenzie	Work Order Number:	386227
Company:	Nelson Aggregate Co	PO #:	
Address:	2433 No. 2 Side Road Burlington, ON, L7P 0G8	Regulation:	None
		Project #:	Nelson Aggregates - Burlington Quarry Monthly ECA
Phone:		DWS #:	
Email:	lauren.mckenzie@nelsonaggregate.com	Sampled By:	
Date Order Received:	10/22/2019	Analysis Started:	10/23/2019
Arrival Temperature:	15.2 °C	Analysis Completed:	10/29/2019

WORK ORDER SUMMARY

ANALYSES WERE PERFORMED ON THE FOLLOWING SAMPLES. THE RESULTS RELATE ONLY TO THE ITEMS TESTED.

Sample Description	Lab ID	Matrix	Type	Comments	Date Collected	Time Collected
SC- Burlington Monthly (OCT 22, 2019)	1489371	Surface Water	None		10/22/2019	11:30 AM
NW- Burlington Monthly (OCT22, 2019)	1489372	Surface Water	None		10/22/2019	12:00 PM

METHODS AND INSTRUMENTATION

THE FOLLOWING METHODS WERE USED FOR YOUR SAMPLE(S):

Method	Lab	Description	Reference
Alkalinity (A1.0)	Mississauga	Determination of Alkalinity by Titration	Modified from APHA-2320B
Ammonia Water (A42)	Mississauga	Determination of Ammonia/Ammonium in Water	Modified from EPA 350.1
Conductivity of Water (A12)	Mississauga	Determination of Conductivity in Water at 25°C	Modified from SM 2510 B
Dissolved Oxygen (A3)	Mississauga	Determination of Dissolved Oxygen in Water	Modified from APHA-5210
Field pH (R112)	Mississauga	Client Supplied Field Determination of pH of Water	Field Test
Field Temp (R113)	Mississauga	Client Supplied Field Determination of Temperature of Water	Field Test
ICPMS Reg. Water (A13)	Mississauga	Determination of Metals in Water by ICP/MS	Modified from SW846-6020
Oil and Grease (A54)	Mississauga	Determination of Oil and Grease in Water	Modified from EPA 1664
pH of Water (A2.0)	Mississauga	Determination of Water pH by Ion Selective Electrode	Modified from APHA-4500H+ B
Reg. Hardness (A13)	Mississauga	Determination of Total Hardness	Modified from APHA-2340B

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Nelson Aggregate Co

Work Order Number: 386227

Method	Lab	Description	Reference
TDS (A27)	Mississauga	Determination of Total Dissolved Solids in water by gravimetry	Modified from SM-2540
TSS (A27)	Mississauga	Determination of Total Suspended Solids in water by gravimetry	Modified from SM-2540
Un-Ionized NH3 (A42.4)	Mississauga	Calculation of Un-Ionized Ammonia	Modified from APHA-4500

This report has been approved by:



Marc Creighton
Laboratory Director

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CERTIFICATE OF ANALYSIS

Nelson Aggregate Co

Work Order Number: 386227

WORK ORDER RESULTS

Sample Description	SC - Burlington Monthly (OCT 22, 2019)		NW - Burlington Monthly (OCT22, 2019)		
Sample Date	10/22/2019 11:30 AM		10/22/2019 12:00 PM		
Lab ID	1489371		1489372		
Field Parameters	Result	MDL	Result	MDL	Units
Field pH	8	N/A	8.1	N/A	pH
Field Temp	13	N/A	13	N/A	°C

Sample Description	SC - Burlington Monthly (OCT 22, 2019)		NW - Burlington Monthly (OCT22, 2019)		
Sample Date	10/22/2019 11:30 AM		10/22/2019 12:00 PM		
Lab ID	1489371		1489372		
General Chemistry	Result	MDL	Result	MDL	Units
Ammonia (as N)	0.13 [0.13]	0.01	0.07	0.01	mg/L
Conductivity	975	1	479	1	µS/cm
Dissolved Oxygen	9.4	0.2	9.6	0.2	mg/L
M-Alkalinity (pH 4.5)	139	2	135	2	mg/L as CaCO3
Oil and Grease, Animal (Calc.)	2	1	<1	1	mg/L
Oil and Grease, Mineral	<1	1	<1	1	mg/L
Oil and Grease, Total	2	1	<1	1	mg/L
P-Alkalinity (pH 8.3)	2	2			mg/L as CaCO3
pH	8.37	N/A	8.36	N/A	pH
Total Hardness (as CaCO3) (Calc.)	424.0	0.1	314.0	0.1	mg/L
Un-Ionized Ammonia (Calc.)	0.003	0.002	<0.002	0.002	mg/L

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CERTIFICATE OF ANALYSIS

Nelson Aggregate Co

Work Order Number: 386227

Sample Description	SC - Burlington Monthly (OCT 22, 2019)		NW - Burlington Monthly (OCT22, 2019)		
Sample Date	10/22/2019 11:30 AM		10/22/2019 12:00 PM		
Lab ID	1489371		1489372		
Metals	Result	MDL	Result	MDL	Units
Calcium	88.4	0.5	61.0	0.5	mg/L
Magnesium	49.300	0.005	39.200	0.005	mg/L

Sample Description	SC - Burlington Monthly (OCT 22, 2019)		NW - Burlington Monthly (OCT22, 2019)		
Sample Date	10/22/2019 11:30 AM		10/22/2019 12:00 PM		
Lab ID	1489371		1489372		
Solids	Result	MDL	Result	MDL	Units
Total Dissolved Solids	755	10	605	10	mg/L
Total Suspended Solids	36	1	<0.67	0.67	mg/L

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CERTIFICATE OF ANALYSIS

Nelson Aggregate Co

Work Order Number: 386227

LEGEND

Dates: Dates are formatted as mm/dd/year throughout this report.

[rr]: After a parameter name indicates a re-run of that parameter. If multiple re-runs exist they are suffixed by a number. Sample may not have been handled according to the recommended temperature, hold time and head space requirements of the method after the initial analysis.

MDL: Method detection limit or minimum reporting limit.

[ ]: Results for laboratory replicates are shown in square brackets immediately below the associated sample result for ease of comparison.

Quality Control: All associated Quality Control data is available on request.

Exceedences: HIGHLIGHTED CELLS INDICATE THAT THE RESULT EXCEEDS A REGULATORY LIMIT. CALCULATED UNCERTAINTY ESTIMATIONS ARE NOT APPLIED FOR DETERMINING SAMPLE EXCEEDANCES.

Benzo(b)fluoranthene: Results for benzo(b)fluoranthene may include contributions from benzo(j)fluoranthene.

Field Data: Reports containing Field Parameters represent data that has been collected and provided by the client. Testmark is not responsible for the validity of this data which may be used in subsequent calculations.

Sample Condition Deviations: A noted sample condition deviation may affect the validity of the result.

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CERTIFICATE OF ANALYSIS

Client:	Tecia White	Work Order Number:	383814
Company:	Nelson Aggregate Co	PO #:	
Address:	2433 No. 2 Side Road Burlington, ON, L7P 0G8	Regulation: Project #:	Information not provided Nelson Aggregates - Burlington Quarry Monthly ECA
Phone:	(705) 888-7064	DWS #:	
Email:	tecia@white-water.ca	Sampled By:	Stephen Vanderhorst
Date Order Received:	9/25/2019	Analysis Started:	9/25/2019
Arrival Temperature:	22 °C	Analysis Completed:	10/2/2019

WORK ORDER SUMMARY

ANALYSES WERE PERFORMED ON THE FOLLOWING SAMPLES. THE RESULTS RELATE ONLY TO THE ITEMS TESTED.

Sample Description	Lab ID	Matrix	Type	Comments	Date Collected	Time Collected
SC- Burlington Monthly (Sept 25, 2019)	1480021	Surface Water	None		9/25/2019	9:00 AM
NW- Burlington Monthly (Sept 25, 2019)	1480022	Surface Water	None		9/25/2019	9:30 AM

METHODS AND INSTRUMENTATION

THE FOLLOWING METHODS WERE USED FOR YOUR SAMPLE(S):

Method	Lab	Description	Reference
Alkalinity (A1.0)	Mississauga	Determination of Alkalinity by Titration	Modified from APHA-2320B
Ammonia Water (A42)	Mississauga	Determination of Ammonia/Ammonium in Water	Modified from EPA 350.1
Conductivity of Water (A12)	Mississauga	Determination of Conductivity in Water at 25°C	Modified from SM 2510 B
Dissolved Oxygen (A3)	Mississauga	Determination of Dissolved Oxygen in Water	Modified from APHA-5210
Field pH (R112)	Mississauga	Client Supplied Field Determination of pH of Water	Field Test
Field Temp (R113)	Mississauga	Client Supplied Field Determination of Temperature of Water	Field Test
ICPMS Reg. Water (A13)	Mississauga	Determination of Metals in Water by ICP/MS	Modified from SW846-6020
Oil and Grease (A54)	Mississauga	Determination of Oil and Grease in Water	Modified from EPA 1664
pH of Water (A2.0)	Mississauga	Determination of Water pH by Ion Selective Electrode	Modified from APHA-4500H+ B
Reg. Hardness (A13)	Mississauga	Determination of Total Hardness	Modified from APHA-2340B

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Nelson Aggregate Co

Work Order Number: 383814

Method	Lab	Description	Reference
TDS (A27)	Mississauga	Determination of Total Dissolved Solids in water by gravimetry	Modified from SM-2540
TSS (A27)	Mississauga	Determination of Total Suspended Solids in water by gravimetry	Modified from SM-2540
Un-Ionized NH3 (A42.4)	Mississauga	Calculation of Un-Ionized Ammonia	Modified from APHA-4500

This report has been approved by:



Marc Creighton
Laboratory Director

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CERTIFICATE OF ANALYSIS

Nelson Aggregate Co

Work Order Number: 383814

WORK ORDER RESULTS

Sample Description	SC - Burlington Monthly (Sept 25, 2019)		NW - Burlington Monthly (Sept 25, 2019)		
Sample Date	9/25/2019 9:00 AM		9/25/2019 9:30 AM		
Lab ID	1480021		1480022		
Field Parameters	Result	MDL	Result	MDL	Units
Field pH	7.9	N/A	8	N/A	pH
Field Temp	19	N/A	20	N/A	°C

Sample Description	SC - Burlington Monthly (Sept 25, 2019)		NW - Burlington Monthly (Sept 25, 2019)		
Sample Date	9/25/2019 9:00 AM		9/25/2019 9:30 AM		
Lab ID	1480021		1480022		
General Chemistry	Result	MDL	Result	MDL	Units
Ammonia (as N)	0.06 [0.06]	0.01	0.02	0.01	mg/L
Conductivity	915 [931]	1	763	1	µS/cm
Dissolved Oxygen	7.8	0.2	8.6	0.2	mg/L
M-Alkalinity (pH 4.5)	133	2	111	2	mg/L as CaCO3
Oil and Grease, Animal (Calc.)	<1	1	<1	1	mg/L
Oil and Grease, Mineral	<1	1	<1	1	mg/L
Oil and Grease, Total	<1	1	<1	1	mg/L
pH	7.8	N/A	7.99	N/A	pH
Total Hardness (as CaCO3) (Calc.)	372.0	0.1	286.0	0.1	mg/L
Un-Ionized Ammonia (Calc.)	<0.002	0.002	<0.002	0.002	mg/L

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Nelson Aggregate Co

Work Order Number: 383814

Sample Description	SC - Burlington Monthly (Sept 25, 2019)		NW - Burlington Monthly (Sept 25, 2019)		
Sample Date	9/25/2019 9:00 AM		9/25/2019 9:30 AM		
Lab ID	1480021		1480022		
Metals	Result	MDL	Result	MDL	Units
Calcium	78.6	0.5	53.4	0.5	mg/L
Magnesium	42.700	0.005	37.100	0.005	mg/L

Sample Description	SC - Burlington Monthly (Sept 25, 2019)		NW - Burlington Monthly (Sept 25, 2019)		
Sample Date	9/25/2019 9:00 AM		9/25/2019 9:30 AM		
Lab ID	1480021		1480022		
Solids	Result	MDL	Result	MDL	Units
Total Dissolved Solids	631	2	559	2	mg/L
Total Suspended Solids	37.00	0.67	1.70	0.67	mg/L

6820 Kitimat Road Unit 4, Mississauga, ON, L5N 5M3
Phone: (905) 821-1112 Fax: (905) 821-2095 Web: www.testmark.ca

CERTIFICATE OF ANALYSIS

Nelson Aggregate Co

Work Order Number: 383814

LEGEND

Dates: Dates are formatted as mm/dd/year throughout this report.

[rr]: After a parameter name indicates a re-run of that parameter. If multiple re-runs exist they are suffixed by a number. Sample may not have been handled according to the recommended temperature, hold time and head space requirements of the method after the initial analysis.

MDL: Method detection limit or minimum reporting limit.

[ ]: Results for laboratory replicates are shown in square brackets immediately below the associated sample result for ease of comparison.

Quality Control: All associated Quality Control data is available on request.

Exceedences: HIGHLIGHTED CELLS INDICATE THAT THE RESULT EXCEEDS A REGULATORY LIMIT. CALCULATED UNCERTAINTY ESTIMATIONS ARE NOT APPLIED FOR DETERMINING SAMPLE EXCEEDANCES.

Benzo(b)fluoranthene: Results for benzo(b)fluoranthene may include contributions from benzo(j)fluoranthene.

Field Data: Reports containing Field Parameters represent data that has been collected and provided by the client. Testmark is not responsible for the validity of this data which may be used in subsequent calculations.

Sample Condition Deviations: A noted sample condition deviation may affect the validity of the result.

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CERTIFICATE OF ANALYSIS

Client:	Tecia White	Work Order Number:	371427
Company:	Nelson Aggregate Co	PO #:	
Address:	2433 No. 2 Side Road Burlington, ON, L7P 0G8	Regulation: Project #:	Information not provided Nelson Aggregates - Burlington Quarry Quarterly/Monthly
Phone:	(705) 888-7064	DWS #:	
Email:	tecia@white-water.ca	Sampled By:	Stephen Vanderhorst
Date Order Received:	5/8/2019	Analysis Started:	5/8/2019
Arrival Temperature:	14.6 °C	Analysis Completed:	5/15/2019

WORK ORDER SUMMARY

ANALYSES WERE PERFORMED ON THE FOLLOWING SAMPLES. THE RESULTS RELATE ONLY TO THE ITEMS TESTED.

Sample Description	Lab ID	Matrix	Type	Comments	Date Collected	Time Collected
Burlington SC Pump - Quart (May 8, 2019)	1435378	Surface Water	None		5/8/2019	1:00 PM
Burlington NW Pump - Quart (May 8, 2019)	1435379	Surface Water	None		5/8/2019	1:30 PM

METHODS AND INSTRUMENTATION

THE FOLLOWING METHODS WERE USED FOR YOUR SAMPLE(S):

Method	Lab	Description	Reference
Alkalinity (A1.0)	Mississauga	Determination of Alkalinity by Titration	Modified from APHA-2320B
Ammonia Water (A42)	Mississauga	Determination of Ammonia/Ammonium in Water	Modified from EPA 350.1
Anions Water (mg/L by IC) (A5)	Mississauga	Determination of Anions in Water by Ion Chromatography	Modified from SW846-9056A
Conductivity of Water (A12)	Mississauga	Determination of Conductivity in Water at 25°C	Modified from SM 2510 B
Dissolved Oxygen (A3)	Mississauga	Determination of Dissolved Oxygen in Water	Modified from APHA-5210
DOC Water (A55.1)	Mississauga	Determination of Dissolved Organic Carbon in Water	Modified from SM-5310 C
Field pH (R112)	Mississauga	Client Supplied Field Determination of pH of Water	Field Test
Field Temp (R113)	Mississauga	Client Supplied Field Determination of Temperature of Water	Field Test
ICPMS Tot. Water (A13)	Mississauga	Determination of Total Metals in Water by ICP/MS with Digestion	Modified from SW846-6020

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Work Order Number: 371427

Method	Lab	Description	Reference
Oil and Grease (A54)	Mississauga	Determination of Oil and Grease in Water	Modified from EPA 1664
PAH Water SIM (A41)	Garson	Determination of PAH in Water by GC/MS	Modified from SW846-8270D
pH of Water (A2.0)	Mississauga	Determination of Water pH by Ion Selective Electrode	Modified from APHA-4500H+ B
Reg. Hardness (A13)	Mississauga	Determination of Total Hardness	Modified from APHA-2340B
T38-Phenols 4AAP	Mississauga	Determination of Total Phenols by 4AAP	Modified from APHA-5530
TDS (A27)	Mississauga	Determination of Total Dissolved Solids in water by gravimetry	Modified from SM-2540
TKN Water Dig. (A58)	Kirkland Lake	Determination of Total Kjeldahl Nitrogen in Waters with Block Digestion.	Modified from SM-4500 NORG-D
TP Water (A23.2)	Kirkland Lake	Determination of Total Phosphorus in Water.	Modified from EPA 365.3 and ESS 310.2,
TSS (A27)	Mississauga	Determination of Total Suspended Solids in water by gravimetry	Modified from SM-2540
Un-Ionized NH3 (A42.4)	Mississauga	Calculation of Un-Ionized Ammonia	Modified from APHA-4500

This report has been approved by:



Marc Creighton
Laboratory Director

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CERTIFICATE OF ANALYSIS

Nelson Aggregate Co

Work Order Number: 371427

WORK ORDER RESULTS

Sample Description	Burlington SC Pump - Quart (May 8, 2019)		Burlington NW Pump - Quart (May 8, 2019)		
Lab ID	1435378		1435379		
Anions	Result	MDL	Result	MDL	Units
Bromide	0.6	0.1	<0.1	0.1	mg/L
Chloride	76.9	0.2	68.9	0.2	mg/L
Fluoride	0.28	0.06	0.21	0.06	mg/L
Nitrate (as N)	0.37	0.05	0.19	0.05	mg/L
Nitrite (as N)	<0.05	0.05	<0.05	0.05	mg/L
Sulphate	220	0.3	142	0.3	mg/L

Sample Description	Burlington SC Pump - Quart (May 8, 2019)		Burlington NW Pump - Quart (May 8, 2019)		
Lab ID	1435378		1435379		
Field Parameters	Result	MDL	Result	MDL	Units
Field pH	8.2	N/A	8.3	N/A	pH
Field Temp	13	N/A	12	N/A	°C

Sample Description	Burlington SC Pump - Quart (May 8, 2019)		Burlington NW Pump - Quart (May 8, 2019)		
Lab ID	1435378		1435379		
General Chemistry	Result	MDL	Result	MDL	Units
Ammonia (as N)	0.06	0.01	0.04	0.01	mg/L
Conductivity	866	1	749	1	µS/cm
Dissolved Organic Carbon	2.5 [2.5]	0.4	3.6	0.4	mg/L
Dissolved Oxygen	9.7	0.2	9.8	0.2	mg/L

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Nelson Aggregate Co

Work Order Number: 371427

Sample Description	Burlington SC Pump - Quart (May 8, 2019)		Burlington NW Pump - Quart (May 8, 2019)		
Lab ID	1435378		1435379		
General Chemistry	Result	MDL	Result	MDL	Units
M-Alkalinity (pH 4.5)	156	2	182	2	mg/L as CaCO3
Oil and Grease, Animal (Calc.)	<1	1	<1	1	mg/L
Oil and Grease, Mineral	1	1	1	1	mg/L
Oil and Grease, Total	1	1	1	1	mg/L
pH	8.08	N/A	8.12	N/A	pH
Total Hardness (as CaCO3) (Calc.)	386	0.1	322	0.1	mg/L
Total Kjeldahl Nitrogen	2.6	0.4	6	0.4	mg/L
Total Phenols	0.001	0.001	<0.001	0.001	mg/L
Total Phosphorus (as P)	0.004	0.002	0.004	0.002	mg/L
Un-Ionized Ammonia (Calc.)	<0.002	0.002	<0.002	0.002	mg/L

Sample Description	Burlington SC Pump - Quart (May 8, 2019)		Burlington NW Pump - Quart (May 8, 2019)		
Lab ID	1435378		1435379		
Metals (Total)	Result	MDL	Result	MDL	Units
Total Aluminum	196	1	88	1	ug/L
Total Antimony	<0.5	0.5	<0.5	0.5	ug/L
Total Arsenic	2	1	2	1	ug/L
Total Barium	33	1	32	1	ug/L
Total Beryllium	<0.5	0.5	<0.5	0.5	ug/L
Total Bismuth	<1	1	<1	1	ug/L
Total Boron	70	2	41	2	ug/L
Total Cadmium	<0.1	0.1	<0.1	0.1	ug/L

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CERTIFICATE OF ANALYSIS

Nelson Aggregate Co

Work Order Number: 371427

Sample Description	Burlington SC Pump - Quart (May 8, 2019)		Burlington NW Pump - Quart (May 8, 2019)		
Lab ID	1435378		1435379		
Metals (Total)	Result	MDL	Result	MDL	Units
Total Calcium	72300	500	60300	500	ug/L
Total Cerium	<1	1	<1	1	ug/L
Total Cesium	<1	1	<1	1	ug/L
Total Chromium	<1	1	<1	1	ug/L
Total Cobalt	0.8	0.1	0.3	0.1	ug/L
Total Copper	2	1	1	1	ug/L
Total Europium	<1	1	<1	1	ug/L
Total Gallium	<1	1	<1	1	ug/L
Total Iron	555	20	383	20	ug/L
Total Lanthanum	<1	1	<1	1	ug/L
Total Lead	1	0.1	0.2	0.1	ug/L
Total Lithium	13	5	8	5	ug/L
Total Magnesium	32600	4	24700	4	ug/L
Total Manganese	32	1	14	1	ug/L
Total Mercury	<0.1	0.1	<0.1	0.1	ug/L
Total Molybdenum	4	1	2	1	ug/L
Total Nickel	6	1	5	1	ug/L
Total Niobium	<1	1	<1	1	ug/L
Total Potassium	4270	100	3750	100	ug/L
Total Rubidium	2	1	2	1	ug/L
Total Scandium	<1	1	<1	1	ug/L
Total Selenium	1.6	0.5	1.7	0.5	ug/L
Total Silicon	881	2	1180	2	ug/L
Total Silver	<0.1	0.1	<0.1	0.1	ug/L

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CERTIFICATE OF ANALYSIS

Nelson Aggregate Co

Work Order Number: 371427

Sample Description	Burlington SC Pump - Quart (May 8, 2019)		Burlington NW Pump - Quart (May 8, 2019)		
Lab ID	1435378		1435379		
Metals (Total)	Result	MDL	Result	MDL	Units
Total Sodium	32200	1000	30700	1000	ug/L
Total Strontium	1290	10	820	1	ug/L
Total Sulphur	63500	800	39200	800	ug/L
Total Tellurium	<1	1	<1	1	ug/L
Total Thallium	<0.1	0.1	<0.1	0.1	ug/L
Total Thorium	<1	1	<1	1	ug/L
Total Tin	<1	1	<1	1	ug/L
Total Titanium	12	1	2	1	ug/L
Total Tungsten	<1	1	<1	1	ug/L
Total Uranium	1	1	<1	1	ug/L
Total Vanadium	<1	1	<1	1	ug/L
Total Yttrium	<1	1	<1	1	ug/L
Total Zinc	302	1	<1	1	ug/L
Total Zirconium	<1	1	<1	1	ug/L

Sample Description	Burlington SC Pump - Quart (May 8, 2019)		Burlington NW Pump - Quart (May 8, 2019)		
Lab ID	1435378		1435379		
PAH	Result	MDL	Result	MDL	Units
1+2-Methylnaphthalene (Calc.)	<0.04	0.04	<0.05	0.05	ug/L
1-Methylnaphthalene	<0.03	0.03	<0.03	0.03	ug/L
2-Methylnaphthalene	<0.02	0.02	<0.02	0.02	ug/L
3,3'-Dichlorobenzidine	<0.06	0.06	<0.06	0.06	ug/L
Acenaphthene	<0.04	0.04	<0.05	0.05	ug/L

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CERTIFICATE OF ANALYSIS

Nelson Aggregate Co

Work Order Number: 371427

Sample Description	Burlington SC Pump - Quart (May 8, 2019)		Burlington NW Pump - Quart (May 8, 2019)		
Lab ID	1435378		1435379		
PAH	Result	MDL	Result	MDL	Units
Acenaphthylene	<0.04	0.04	<0.05	0.05	ug/L
Anthracene	<0.02	0.02	<0.02	0.02	ug/L
Benzo(a)anthracene	<0.02	0.02	<0.02	0.02	ug/L
Benzo(a)pyrene	<0.009	0.009	<0.009	0.009	ug/L
Benzo(b)fluoranthene	<0.07	0.07	<0.07	0.07	ug/L
Benzo(ghi)perylene	<0.04	0.04	<0.05	0.05	ug/L
Benzo(k)fluoranthene	<0.04	0.04	<0.05	0.05	ug/L
Biphenyl	<0.1	0.1	<0.1	0.1	ug/L
Chrysene	<0.06	0.06	<0.06	0.06	ug/L
Dibenz(a,h)anthracene	<0.04	0.04	<0.05	0.05	ug/L
Fluoranthene	<0.03	0.03	<0.03	0.03	ug/L
Fluorene	<0.04	0.04	<0.05	0.05	ug/L
Fluorobiphenyl (Surr.)	78.9	N/A	78.9	N/A	% Rec
Indeno(1,2,3-c,d)pyrene	<0.03	0.03	<0.03	0.03	ug/L
Naphthalene	<0.06	0.06	<0.06	0.06	ug/L
Phenanthrene	<0.03	0.03	<0.03	0.03	ug/L
p-Terphenyl-d14 (Surr.)	112	N/A	109	N/A	% Rec
Pyrene	<0.06	0.06	<0.06	0.06	ug/L

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CERTIFICATE OF ANALYSIS

Nelson Aggregate Co

Work Order Number: 371427

Sample Description	Burlington SC Pump - Quart (May 8, 2019)		Burlington NW Pump - Quart (May 8, 2019)		
Lab ID	1435378		1435379		
Solids	Result	MDL	Result	MDL	Units
Total Dissolved Solids	621 [637]	3	521	3	mg/L
Total Suspended Solids	9.5 [10]	1	3.33	0.67	mg/L

LEGEND

Dates: Dates are formatted as mm/dd/year throughout this report.

[rr]: After a parameter name indicates a re-run of that parameter. Sample may not have been handled according to the recommended temperature, hold time and head space requirements of the method after the initial analysis.

MDL: Method detection limit or minimum reporting limit.

[ ]: Results for laboratory replicates are shown in square brackets immediately below the associated sample result for ease of comparison.

Quality Control: All associated Quality Control data is available on request.

Exceedences: HIGHLIGHTED CELLS INDICATE THAT THE RESULT EXCEEDS A REGULATORY LIMIT. CALCULATED UNCERTAINTY ESTIMATIONS ARE NOT APPLIED FOR DETERMINING SAMPLE EXCEEDANCES.

Benzo(b)fluoranthene: Results for benzo(b)fluoranthene may include contributions from benzo(j)fluoranthene.

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CERTIFICATE OF ANALYSIS

Client:	Tecia White	Work Order Number:	380723
Company:	Nelson Aggregate Co	PO #:	
Address:	2433 No. 2 Side Road Burlington, ON, L7P 0G8	Regulation: Project #:	Information not provided Nelson Aggregates - Burlington Quarry Quarterly ECA
Phone:	(705) 888-7064	DWS #:	
Email:	tecia@white-water.ca	Sampled By:	Stephen Vanderhorst
Date Order Received:	8/21/2019	Analysis Started:	8/21/2019
Arrival Temperature:	24.6 °C	Analysis Completed:	8/29/2019

WORK ORDER SUMMARY

ANALYSES WERE PERFORMED ON THE FOLLOWING SAMPLES. THE RESULTS RELATE ONLY TO THE ITEMS TESTED.

Sample Description	Lab ID	Matrix	Type	Comments	Date Collected	Time Collected
NW Quarterly Burlington (Aug 21, 2019)	1468391	Surface Water	None		8/21/2019	2:00 PM
SC Quarterly Burlington (Aug 21, 2019)	1468392	Surface Water	None		8/21/2019	2:00 PM

METHODS AND INSTRUMENTATION

THE FOLLOWING METHODS WERE USED FOR YOUR SAMPLE(S):

Method	Lab	Description	Reference
Alkalinity (A1.0)	Mississauga	Determination of Alkalinity by Titration	Modified from APHA-2320B
Ammonia Water (A42)	Mississauga	Determination of Ammonia/Ammonium in Water	Modified from EPA 350.1
Anions Water (mg/L by IC) (A5)	Mississauga	Determination of Anions in Water by Ion Chromatography	Modified from SW846-9056A
Conductivity of Water (A12)	Mississauga	Determination of Conductivity in Water at 25°C	Modified from SM 2510 B
Dissolved Oxygen (A3)	Mississauga	Determination of Dissolved Oxygen in Water	Modified from APHA-5210
DOC Water (A55.1)	Mississauga	Determination of Dissolved Organic Carbon in Water	Modified from SM-5310 C
Field pH (R112)	Mississauga	Client Supplied Field Determination of pH of Water	Field Test
Field Temp (R113)	Mississauga	Client Supplied Field Determination of Temperature of Water	Field Test
ICPMS Reg. Water (A13)	Mississauga	Determination of Metals in Water by ICP/MS	Modified from SW846-6020
ICPMS Tot. Water (A13)	Mississauga	Determination of Total Metals in Water by ICP/MS with Digestion	Modified from SW846-6020

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Method	Lab	Description	Reference
Oil and Grease (A54)	Mississauga	Determination of Oil and Grease in Water	Modified from EPA 1664
PAH Water SIM (A41)	Garson	Determination of PAH in Water by GC/MS	Modified from SW846-8270D
pH of Water (A2.0)	Mississauga	Determination of Water pH by Ion Selective Electrode	Modified from APHA-4500H+ B
Phenols 4AAP (T38)	Mississauga	Determination of Total Phenols by 4AAP	Modified from APHA-5530
Reg. Hardness (A13)	Mississauga	Determination of Total Hardness	Modified from APHA-2340B
TDS (A27)	Mississauga	Determination of Total Dissolved Solids in water by gravimetry	Modified from SM-2540
TKN Water Dig. (A58)	Kirkland Lake	Determination of Total Kjeldahl Nitrogen in Waters with Block Digestion.	Modified from SM-4500 NORG-D
TP Water (A23.2)	Kirkland Lake	Determination of Total Phosphorus in Water.	Modified from EPA 365.3 and ESS 310.2,
TSS (A27)	Mississauga	Determination of Total Suspended Solids in water by gravimetry	Modified from SM-2540
Un-Ionized NH3 (A42.4)	Mississauga	Calculation of Un-Ionized Ammonia	Modified from APHA-4500

This report has been approved by:



Marc Creighton
Laboratory Director

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Work Order Number: 380723

WORK ORDER RESULTS

Sample Description	NW Quarterly Burlington (Aug 21, 2019)		SC Quarterly Burlington (Aug 21, 2019)		
Sample Date	08/21/2019		08/21/2019		
Lab ID	1468391		1468392		
Anions	Result	MDL	Result	MDL	Units
Bromide	<0.1	0.1	<0.1	0.1	mg/L
Chloride	75.4	0.2	85.0	0.2	mg/L
Fluoride	0.21	0.06	0.27	0.06	mg/L
Nitrate (as N)	<0.05	0.05	<0.05	0.05	mg/L
Nitrite (as N)	<0.05	0.05	<0.05	0.05	mg/L
Sulphate	167.0	0.3	216.0	0.3	mg/L

Sample Description	NW Quarterly Burlington (Aug 21, 2019)		SC Quarterly Burlington (Aug 21, 2019)		
Sample Date	08/21/2019		08/21/2019		
Lab ID	1468391		1468392		
Field Parameters	Result	MDL	Result	MDL	Units
Field pH	7.9	N/A	8	N/A	pH
Field Temp	23	N/A	26	N/A	°C

Sample Description	NW Quarterly Burlington (Aug 21, 2019)		SC Quarterly Burlington (Aug 21, 2019)		
Sample Date	08/21/2019		08/21/2019		
Lab ID	1468391		1468392		
General Chemistry	Result	MDL	Result	MDL	Units
Ammonia (as N)	0.05 [0.04]	0.01	0.03	0.01	mg/L

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Sample Description	NW Quarterly Burlington (Aug 21, 2019)		SC Quarterly Burlington (Aug 21, 2019)		
Sample Date	08/21/2019		08/21/2019		
Lab ID	1468391		1468392		
General Chemistry	Result	MDL	Result	MDL	Units
Conductivity	729	1	832	1	µS/cm
Dissolved Organic Carbon	4.6 [4.6]	0.4	5.2	0.4	mg/L
Dissolved Oxygen	9.6	0.2	9.3	0.2	mg/L
M-Alkalinity (pH 4.5)	117	2	116	2	mg/L as CaCO3
Oil and Grease, Animal (Calc.)	2	1	<1	1	mg/L
Oil and Grease, Mineral	1	1	<1	1	mg/L
Oil and Grease, Total	3	1	<1	1	mg/L
pH	8.02	N/A	8.1	N/A	pH
Total Hardness (as CaCO3) (Calc.)	269.0	0.1	303.0	0.1	mg/L
Total Kjeldahl Nitrogen	1.6	0.4	0.9	0.4	mg/L
Total Phenols	0.0010	0.0004	<0.0004	0.0004	mg/L
Total Phosphorus (as P)	0.006	0.002	0.007	0.002	mg/L
Un-Ionized Ammonia (Calc.)	<0.002	0.002	<0.002	0.002	mg/L

Sample Description	NW Quarterly Burlington (Aug 21, 2019)		SC Quarterly Burlington (Aug 21, 2019)		
Sample Date	08/21/2019		08/21/2019		
Lab ID	1468391		1468392		
Metals	Result	MDL	Result	MDL	Units
Calcium	54.4	0.5	58.9	0.5	mg/L
Magnesium	32.300	0.005	37.800	0.005	mg/L

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Sample Description	NW Quarterly Burlington (Aug 21, 2019)		SC Quarterly Burlington (Aug 21, 2019)		
Sample Date	08/21/2019		08/21/2019		
Lab ID	1468391		1468392		
Metals (Total)	Result	MDL	Result	MDL	Units
Total Aluminum	25 [27]	1	55	1	ug/L
Total Antimony	<0.5 [<0.5]	0.5	<0.5	0.5	ug/L
Total Arsenic	4 [4]	1	6	1	ug/L
Total Barium	29 [29]	1	30	1	ug/L
Total Beryllium	<0.5 [<0.5]	0.5	<0.5	0.5	ug/L
Total Bismuth	<1 [<1]	1	<1	1	ug/L
Total Boron	86 [87]	2	145	2	ug/L
Total Cadmium	<0.1 [<0.1]	0.1	<0.1	0.1	ug/L
Total Calcium	52200 [51800]	500	63100	500	ug/L
Total Cerium	<1 [<1]	1	<1	1	ug/L
Total Cesium	<1 [<1]	1	<1	1	ug/L
Total Chromium	<1 [<1]	1	<1	1	ug/L
Total Cobalt	0.2 [0.2]	0.1	0.2	0.1	ug/L
Total Copper	1 [1]	1	1	1	ug/L
Total Europium	<1 [<1]	1	<1	1	ug/L
Total Gallium	<1 [<1]	1	<1	1	ug/L
Total Iron	120 [120]	20	170	20	ug/L

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Sample Description	NW Quarterly Burlington (Aug 21, 2019)		SC Quarterly Burlington (Aug 21, 2019)		
Sample Date	08/21/2019		08/21/2019		
Lab ID	1468391		1468392		
Metals (Total)	Result	MDL	Result	MDL	Units
Total Lanthanum	<1 [<1]	1	<1	1	ug/L
Total Lead	<0.1 [<0.1]	0.1	<0.1	0.1	ug/L
Total Lithium	8 [9]	5	12	5	ug/L
Total Magnesium	35000 [35300]	4	41000	4	ug/L
Total Manganese	21 [22]	1	16	1	ug/L
Total Mercury	<0.1 [<0.1]	0.1	<0.1	0.1	ug/L
Total Molybdenum	1 [<1]	1	2	1	ug/L
Total Nickel	2 [2]	1	3	1	ug/L
Total Niobium	<1 [<1]	1	<1	1	ug/L
Total Potassium	5360 [5250]	100	5980	100	ug/L
Total Rubidium	3 [3]	1	3	1	ug/L
Total Scandium	<1 [<1]	1	<1	1	ug/L
Total Selenium	0.7 [0.7]	0.5	0.8	0.5	ug/L
Total Silicon	774 [795]	2	817	2	ug/L
Total Silver	<0.1 [<0.1]	0.1	<0.1	0.1	ug/L
Total Sodium	41800 [42000]	1000	45300	1000	ug/L
Total Strontium	818 [821]	1	1170	1	ug/L

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Sample Description	NW Quarterly Burlington (Aug 21, 2019)		SC Quarterly Burlington (Aug 21, 2019)		
Sample Date	08/21/2019		08/21/2019		
Lab ID	1468391		1468392		
Metals (Total)	Result	MDL	Result	MDL	Units
Total Sulphur	57800 [56500]	800	72700	800	ug/L
Total Tellurium	<1 [<1]	1	<1	1	ug/L
Total Thallium	<0.1 [<0.1]	0.1	<0.1	0.1	ug/L
Total Thorium	<1 [<1]	1	<1	1	ug/L
Total Tin	<1 [<1]	1	<1	1	ug/L
Total Titanium	<1 [<1]	1	<1	1	ug/L
Total Tungsten	<1 [<1]	1	<1	1	ug/L
Total Uranium	<1 [<1]	1	<1	1	ug/L
Total Vanadium	<1 [<1]	1	<1	1	ug/L
Total Yttrium	<1 [<1]	1	<1	1	ug/L
Total Zinc	13 [13]	1	5	1	ug/L
Total Zirconium	<1 [<1]	1	<1	1	ug/L

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Work Order Number: 380723

Sample Description	NW Quarterly Burlington (Aug 21, 2019)		SC Quarterly Burlington (Aug 21, 2019)		
Sample Date	08/21/2019		08/21/2019		
Lab ID	1468391		1468392		
PAH	Result	MDL	Result	MDL	Units
1+2-Methylnaphthalene (Calc.)	<0.05	0.05	<0.05	0.05	ug/L
1-Methylnaphthalene	<0.04	0.04	<0.03	0.03	ug/L
2-Methylnaphthalene	<0.02	0.02	<0.02	0.02	ug/L
3,3'-Dichlorobenzidine	<0.06	0.06	<0.06	0.06	ug/L
Acenaphthene	<0.05	0.05	<0.05	0.05	ug/L
Acenaphthylene	<0.05	0.05	<0.05	0.05	ug/L
Anthracene	<0.02	0.02	<0.02	0.02	ug/L
Benzo(a)anthracene	<0.02	0.02	<0.02	0.02	ug/L
Benzo(a)pyrene	<0.01	0.01	<0.01	0.01	ug/L
Benzo(b)fluoranthene	<0.07	0.07	<0.07	0.07	ug/L
Benzo(ghi)perylene	<0.05	0.05	<0.05	0.05	ug/L
Benzo(k)fluoranthene	<0.05	0.05	<0.05	0.05	ug/L
Biphenyl	<0.1	0.1	<0.1	0.1	ug/L
Chrysene	<0.06	0.06	<0.06	0.06	ug/L
Dibenz(a,h)anthracene	<0.05	0.05	<0.05	0.05	ug/L
Fluoranthene	<0.04	0.04	<0.03	0.03	ug/L
Fluorene	<0.05	0.05	<0.05	0.05	ug/L
Fluorobiphenyl (Surr.)	50.8	N/A	52.4	N/A	% Rec
Indeno(1,2,3-c,d)pyrene	<0.04	0.04	<0.03	0.03	ug/L
Naphthalene	<0.06	0.06	<0.06	0.06	ug/L
Phenanthrene	<0.04	0.04	<0.03	0.03	ug/L
p-Terphenyl-d14 (Surr.)	67.4	N/A	67.2	N/A	% Rec
Pyrene	<0.05	0.05	<0.05	0.05	ug/L

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Nelson Aggregate Co

Work Order Number: 380723

Sample Description	NW Quarterly Burlington (Aug 21, 2019)		SC Quarterly Burlington (Aug 21, 2019)		
Sample Date	08/21/2019		08/21/2019		
Lab ID	1468391		1468392		
Solids	Result	MDL	Result	MDL	Units
Total Dissolved Solids	529	2	618	2	mg/L
Total Suspended Solids	1.70	0.67	1.30	0.67	mg/L

LEGEND

Dates: Dates are formatted as mm/dd/year throughout this report.

[rr]: After a parameter name indicates a re-run of that parameter. If multiple re-runs exist they are suffixed by a number. Sample may not have been handled according to the recommended temperature, hold time and head space requirements of the method after the initial analysis.

MDL: Method detection limit or minimum reporting limit.

[ ]: Results for laboratory replicates are shown in square brackets immediately below the associated sample result for ease of comparison.

Quality Control: All associated Quality Control data is available on request.

Exceedences: HIGHLIGHTED CELLS INDICATE THAT THE RESULT EXCEEDS A REGULATORY LIMIT. CALCULATED UNCERTAINTY ESTIMATIONS ARE NOT APPLIED FOR DETERMINING SAMPLE EXCEEDANCES.

Benzo(b)fluoranthene: Results for benzo(b)fluoranthene may include contributions from benzo(j)fluoranthene.

Field Data: Reports containing Field Parameters represent data that has been collected and provided by the client. Testmark is not responsible for the validity of this data which may be used in subsequent calculations.

Sample Condition Deviations: A noted sample condition deviation may affect the validity of the result.

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CERTIFICATE OF ANALYSIS

Client:	Tecia White	Work Order Number:	367972
Company:	Whitewater Hydrogeology Ltd.	PO #:	
Address:	80 Chamberlain Cres Collingwood, ON, L9Y 0C8	Regulation: Project #:	Information not provided Nelson Aggregates - Burlington Quarry Quaterly ECA
Phone:	(705) 888-7064	DWS #:	
Email:	tecia@white-water.ca	Sampled By:	Stephen Vanderhorst
Date Order Received:	3/21/2019	Analysis Started:	3/21/2019
Arrival Temperature:	7.7 °C	Analysis Completed:	3/29/2019

WORK ORDER SUMMARY

ANALYSES WERE PERFORMED ON THE FOLLOWING SAMPLES. THE RESULTS RELATE ONLY TO THE ITEMS TESTED.

Sample Description	Lab ID	Matrix	Type	Comments	Date Collected	Time Collected
Burlington SC Pump - Quart (Mar 21, 2019)	1424299	Surface Water	None		3/21/2019	1:00 PM
Burlington NW Pump - Quart (Mar 21, 2019)	1424300	Surface Water	None		3/21/2019	1:30 PM

METHODS AND INSTRUMENTATION

THE FOLLOWING METHODS WERE USED FOR YOUR SAMPLE(S):

Method	Lab	Description	Reference
Alkalinity (A1.0)	Mississauga	Determination of Alkalinity by Titration	Modified from APHA-2320B
Ammonia Water (A42)	Mississauga	Determination of Ammonia/Ammonium in Water	Modified from EPA 350.1
Anions Water (mg/L by IC) (A5)	Mississauga	Determination of Anions in Water by Ion Chromatography	Modified from SW846-9056A
Conductivity of Water (A12)	Mississauga	Determination of Conductivity in Water at 25°C	Modified from SM 2510 B
Dissolved Oxygen (A3)	Mississauga	Determination of Dissolved Oxygen in Water	Modified from APHA-5210
DOC Water (A55.1)	Mississauga	Determination of Dissolved Organic Carbon in Water	Modified from SM-5310 C
Field pH (R112)	Mississauga	Client Supplied Field Determination of pH of Water	Field Test
Field Temp (R113)	Mississauga	Client Supplied Field Determination of Temperature of Water	Field Test
ICPMS Tot. Water (A13)	Mississauga	Determination of Total Metals in Water by ICP/MS with Digestion	Modified from SW846-6020

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CERTIFICATE OF ANALYSIS

Whitewater Hydrogeology Ltd.

Work Order Number: 367972

Method	Lab	Description	Reference
Oil and Grease (A54)	Mississauga	Determination of Oil and Grease in Water	Modified from EPA 1664
PAH TO SU Water SIM (A41)	Garson	Determination of PAH in Water by GC/MS	Modified from SW846-8270D
pH of Water (A2.0)	Mississauga	Determination of Water pH by Ion Selective Electrode	Modified from APHA-4500H+ B
Reg. Hardness (A13)	Mississauga	Determination of Total Hardness	Modified from APHA-2340B
T38-Phenols 4AAP	Mississauga	Determination of Total Phenols by 4AAP	Modified from APHA-5530
TDS (A27)	Mississauga	Determination of Total Dissolved Solids in water by gravimetry	Modified from SM-2540
TKN Water Dig. (A58)	Kirkland Lake	Determination of Total Kjeldahl Nitrogen in Waters with Block Digestion.	Modified from SM-4500 NORG-D
TP Water (A23.2)	Kirkland Lake	Determination of Total Phosphorus in Water.	Modified from EPA 365.3 and ESS 310.2,
TSS (A27)	Mississauga	Determination of Total Suspended Solids in water by gravimetry	Modified from SM-2540
Un-Ionized NH3 (A42.4)	Mississauga	Calculation of Un-Ionized Ammonia	Modified from APHA-4500

This report has been approved by:



Marc Creighton
Laboratory Director

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CERTIFICATE OF ANALYSIS

Whitewater Hydrogeology Ltd.

Work Order Number: 367972

WORK ORDER RESULTS

Sample Description	Burlington SC Pump - Quart (Mar 21, 2019)		Burlington NW Pump - Quart (Mar 21, 2019)		
Lab ID	1424299		1424300		
Anions	Result	MDL	Result	MDL	Units
Bromide	<0.1 [<0.1]	0.1	<0.1	0.1	mg/L
Chloride	77.7 [76.4]	0.2	85.4	0.2	mg/L
Fluoride	0.22 [0.23]	0.06	0.19	0.06	mg/L
Nitrate (as N)	0.4 [0.4]	0.05	0.24	0.05	mg/L
Nitrite (as N)	<0.05 [<0.05]	0.05	<0.05	0.05	mg/L
Sulphate	193 [190]	0.3	173	0.3	mg/L

Sample Description	Burlington SC Pump - Quart (Mar 21, 2019)		Burlington NW Pump - Quart (Mar 21, 2019)		
Lab ID	1424299		1424300		
Field Parameters	Result	MDL	Result	MDL	Units
Field pH	7.7	N/A	7.6	N/A	pH
Field Temp	4	N/A	4	N/A	°C

Sample Description	Burlington SC Pump - Quart (Mar 21, 2019)		Burlington NW Pump - Quart (Mar 21, 2019)		
Lab ID	1424299		1424300		
General Chemistry	Result	MDL	Result	MDL	Units
Ammonia (as N)	<0.01	0.01	0.11	0.01	mg/L
Conductivity	845	1	897	1	µS/cm

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CERTIFICATE OF ANALYSIS

Whitewater Hydrogeology Ltd.

Work Order Number: 367972

Sample Description	Burlington SC Pump - Quart (Mar 21, 2019)		Burlington NW Pump - Quart (Mar 21, 2019)		
Lab ID	1424299		1424300		
General Chemistry	Result	MDL	Result	MDL	Units
Dissolved Organic Carbon	2.7 [2.6]	0.4	3.3	0.4	mg/L
Dissolved Oxygen	9.5	0.2	9.6	0.2	mg/L
M-Alkalinity (pH 4.5)	170	2	208	2	mg/L as CaCO3
Oil and Grease, Animal (Calc.)	<1	1	2	1	mg/L
Oil and Grease, Mineral	1	1	<1	1	mg/L
Oil and Grease, Total	2	1	2	1	mg/L
pH	7.8	N/A	7.79	N/A	pH
Total Hardness (as CaCO3) (Calc.)	363	0.1	393	0.1	mg/L
Total Kjeldahl Nitrogen	2.6 [2.8]	0.4	2.7	0.4	mg/L
Total Phenols	<0.001	0.001	0.001	0.001	mg/L
Total Phosphorus (as P)	0.014	0.002	0.017	0.002	mg/L
Un-Ionized Ammonia (Calc.)	<0.002	0.002	<0.002	0.002	mg/L

Sample Description	Burlington SC Pump - Quart (Mar 21, 2019)		Burlington NW Pump - Quart (Mar 21, 2019)		
Lab ID	1424299		1424300		
Metals (Total)	Result	MDL	Result	MDL	Units
Total Aluminum	241	1	148	1	ug/L
Total Antimony	<0.5	0.5	<0.5	0.5	ug/L
Total Arsenic	2	1	4	1	ug/L
Total Barium	35	1	35	1	ug/L
Total Beryllium	<0.5	0.5	<0.5	0.5	ug/L
Total Bismuth	<1	1	<1	1	ug/L

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CERTIFICATE OF ANALYSIS

Whitewater Hydrogeology Ltd.

Work Order Number: 367972

Sample Description	Burlington SC Pump - Quart (Mar 21, 2019)		Burlington NW Pump - Quart (Mar 21, 2019)		
Lab ID	1424299		1424300		
Metals (Total)	Result	MDL	Result	MDL	Units
Total Boron	134	2	113	2	ug/L
Total Cadmium	<0.1	0.1	<0.1	0.1	ug/L
Total Calcium	112000	50	113000	50	ug/L
Total Cerium	<1	1	<1	1	ug/L
Total Cesium	<1	1	<1	1	ug/L
Total Chromium	1	1	<1	1	ug/L
Total Cobalt	0.8	0.1	0.4	0.1	ug/L
Total Copper	2	1	2	1	ug/L
Total Europium	<1	1	<1	1	ug/L
Total Gallium	<1	1	<1	1	ug/L
Total Iron	383	20	386	20	ug/L
Total Lanthanum	<1	1	<1	1	ug/L
Total Lead	0.3	0.1	0.2	0.1	ug/L
Total Lithium	11	5	9	5	ug/L
Total Magnesium	42300	4	44000	4	ug/L
Total Manganese	58	1	66	1	ug/L
Total Mercury	<0.1	0.1	<0.1	0.1	ug/L
Total Molybdenum	3	1	2	1	ug/L
Total Nickel	6	1	5	1	ug/L
Total Niobium	<1	1	<1	1	ug/L
Total Potassium	5230	100	5660	100	ug/L
Total Rubidium	2	1	2	1	ug/L
Total Scandium	<1	1	<1	1	ug/L
Total Selenium	1.3	0.5	1	0.5	ug/L

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CERTIFICATE OF ANALYSIS

Whitewater Hydrogeology Ltd.

Work Order Number: 367972

Sample Description	Burlington SC Pump - Quart (Mar 21, 2019)		Burlington NW Pump - Quart (Mar 21, 2019)		
Lab ID	1424299		1424300		
Metals (Total)	Result	MDL	Result	MDL	Units
Total Silicon	2290	2	2380	2	ug/L
Total Silver	<0.1	0.1	<0.1	0.1	ug/L
Total Sodium	46600	100	55900	100	ug/L
Total Strontium	1340	1	1130	1	ug/L
Total Sulphur	71500	800	65400	800	ug/L
Total Tellurium	<1	1	<1	1	ug/L
Total Thallium	<0.1	0.1	<0.1	0.1	ug/L
Total Thorium	<1	1	<1	1	ug/L
Total Tin	<1	1	<1	1	ug/L
Total Titanium	7	1	8	1	ug/L
Total Tungsten	<1	1	<1	1	ug/L
Total Uranium	<1	1	<1	1	ug/L
Total Vanadium	<1	1	<1	1	ug/L
Total Yttrium	<1	1	<1	1	ug/L
Total Zinc	11	1	20	1	ug/L
Total Zirconium	<1	1	<1	1	ug/L

Sample Description	Burlington SC Pump - Quart (Mar 21, 2019)		Burlington NW Pump - Quart (Mar 21, 2019)		
Lab ID	1424299		1424300		
PAH	Result	MDL	Result	MDL	Units
1,6-dinitropyrene	<1	1	<1	1	ug/L
1,8-dinitropyrene	<1	1	<1	1	ug/L
13dinitropyrene	<1	1	<1	1	ug/L

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CERTIFICATE OF ANALYSIS

Whitewater Hydrogeology Ltd.

Work Order Number: 367972

Sample Description	Burlington SC Pump - Quart (Mar 21, 2019)		Burlington NW Pump - Quart (Mar 21, 2019)		
Lab ID	1424299		1424300		
PAH	Result	MDL	Result	MDL	Units
7H-Dibenzo(c,g)carbazole	<0.1	0.1	<0.1	0.1	ug/L
Anthracene	<0.1	0.1	<0.1	0.1	ug/L
Benzo(a)anthracene	<0.1	0.1	<0.1	0.1	ug/L
Benzo(a)pyrene	<0.1	0.1	<0.1	0.1	ug/L
Benzo(b)fluoranthene	<0.1	0.1	<0.1	0.1	ug/L
Benzo(e)pyrene	<0.1	0.1	<0.1	0.1	ug/L
Benzo(ghi)perylene	<0.1	0.1	<0.1	0.1	ug/L
Benzo(j)fluoranthene	<0.1	0.1	<0.1	0.1	ug/L
Benzo(k)fluoranthene	<0.1	0.1	<0.1	0.1	ug/L
Chrysene	<0.1	0.1	<0.1	0.1	ug/L
Dibenz(a,h)anthracene	<0.1	0.1	<0.1	0.1	ug/L
Dibenzo(a,i)pyrene	<0.1	0.1	<0.1	0.1	ug/L
Dibenzo(a,j)acridine	<0.1	0.1	<0.1	0.1	ug/L
Fluoranthene	<0.1	0.1	<0.1	0.1	ug/L
Indeno(1,2,3-c,d)pyrene	<0.1	0.1	<0.1	0.1	ug/L
Perylene	<0.1	0.1	<0.1	0.1	ug/L
Phenanthrene	<0.1	0.1	<0.1	0.1	ug/L
Pyrene	<0.1	0.1	<0.1	0.1	ug/L
Total PAH	<2	2	<2	2	ug/L

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CERTIFICATE OF ANALYSIS

Whitewater Hydrogeology Ltd.

Work Order Number: 367972

Sample Description	Burlington SC Pump - Quart (Mar 21, 2019)		Burlington NW Pump - Quart (Mar 21, 2019)		
Lab ID	1424299		1424300		
Solids	Result	MDL	Result	MDL	Units
Total Dissolved Solids	644	6	662	6	mg/L
Total Suspended Solids	3.67	0.67	1.67	0.67	mg/L

LEGEND

Dates: Dates are formatted as mm/dd/year throughout this report.

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MDL: Method detection limit or minimum reporting limit.

[ ]: Results for laboratory replicates are shown in square brackets immediately below the associated sample result for ease of comparison.

Quality Control: All associated Quality Control data is available on request.

Exceedences: HIGHLIGHTED CELLS INDICATE THAT THE RESULT EXCEEDS A REGULATORY LIMIT. CALCULATED UNCERTAINTY ESTIMATIONS ARE NOT APPLIED FOR DETERMINING SAMPLE EXCEEDANCES.

Benzo(b)fluoranthene: Results for benzo(b)fluoranthene may include contributions from benzo(j)fluoranthene.

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CERTIFICATE OF ANALYSIS

Client:	Tecia White	Work Order Number:	367952
Company:	Whitewater Hydrogeology Ltd.	PO #:	
Address:	80 Chamberlain Cres Collingwood, ON, L9Y 0C8	Regulation:	Information not provided
		Project #:	Nelson Aggregates - Burlington Quarry Monthly ECA
Phone:	(705) 888-7064	DWS #:	
Email:	tecia@white-water.ca	Sampled By:	
Date Order Received:	3/21/2019	Analysis Started:	3/21/2019
Arrival Temperature:	6.6 °C	Analysis Completed:	3/25/2019

WORK ORDER SUMMARY

ANALYSES WERE PERFORMED ON THE FOLLOWING SAMPLES. THE RESULTS RELATE ONLY TO THE ITEMS TESTED.

Sample Description	Lab ID	Matrix	Type	Comments	Date Collected	Time Collected
Burlington SC Sump Pump - Month (Mar 21, 2019)	1424218	Water	None		3/21/2019	1:00 PM
Burlington NW- Sump Pump - Month (Mar 21, 2019)	1424219	Water	None		3/21/2019	1:30 PM

METHODS AND INSTRUMENTATION

THE FOLLOWING METHODS WERE USED FOR YOUR SAMPLE(S):

Method	Lab	Description	Reference
Alkalinity (A1.0)	Mississauga	Determination of Alkalinity by Titration	Modified from APHA-2320B
Ammonia Water (A42)	Mississauga	Determination of Ammonia/Ammonium in Water	Modified from EPA 350.1
Conductivity of Water (A12)	Mississauga	Determination of Conductivity in Water at 25°C	Modified from SM 2510 B
Dissolved Oxygen (A3)	Mississauga	Determination of Dissolved Oxygen in Water	Modified from APHA-5210
Field pH (R112)	Mississauga	Client Supplied Field Determination of pH of Water	Field Test
Field Temp (R113)	Mississauga	Client Supplied Field Determination of Temperature of Water	Field Test
ICPMS Reg. Water (A13)	Mississauga	Determination of Metals in Water by ICP/MS	Modified from SW846-6020
Oil and Grease (A54)	Mississauga	Determination of Oil and Grease in Water	Modified from EPA 1664

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Method	Lab	Description	Reference
pH of Water (A2.0)	Mississauga	Determination of Water pH by Ion Selective Electrode	Modified from APHA-4500H+ B
Reg. Hardness (A13)	Mississauga	Determination of Total Hardness	Modified from APHA-2340B
TDS (A27)	Mississauga	Determination of Total Dissolved Solids in water by gravimetry	Modified from SM-2540
TSS (A27)	Mississauga	Determination of Total Suspended Solids in water by gravimetry	Modified from SM-2540
Un-Ionized NH3 (A42.4)	Mississauga	Calculation of Un-Ionized Ammonia	Modified from APHA-4500

This report has been approved by:



Marc Creighton
Laboratory Director

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CERTIFICATE OF ANALYSIS

Whitewater Hydrogeology Ltd.

Work Order Number: 367952

WORK ORDER RESULTS

Sample Description	Burlington SC Sump Pump - Month (Mar 21, 2019)		Burlington NW - Sump Pump - Month (Mar 21, 2019)		
Lab ID	1424218		1424219		
Field Parameters	Result	MDL	Result	MDL	Units
Field pH	7.7	N/A	7.6	N/A	pH
Field Temp	4	N/A	4	N/A	°C

Sample Description	Burlington SC Sump Pump - Month (Mar 21, 2019)		Burlington NW - Sump Pump - Month (Mar 21, 2019)		
Lab ID	1424218		1424219		
General Chemistry	Result	MDL	Result	MDL	Units
Ammonia (as N)	0.19 [0.19]	0.01	0.17	0.01	mg/L
Conductivity	823	1	891	1	µS/cm
Dissolved Oxygen	11.1	0.2	10.6	0.2	mg/L
M-Alkalinity (pH 4.5)	169	2	207	2	mg/L as CaCO3
Oil and Grease, Animal (Calc.)	<1	1	3	1	mg/L
Oil and Grease, Mineral	5	1	6	1	mg/L
Oil and Grease, Total	6	1	9	1	mg/L
pH	7.74	N/A	8.02	N/A	pH
Total Hardness (as CaCO3) (Calc.)	345	0.1	368	0.1	mg/L
Un-Ionized Ammonia (Calc.)	<0.002	0.002	<0.002	0.002	mg/L

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Whitewater Hydrogeology Ltd.

Work Order Number: 367952

Sample Description	Burlington SC Sump Pump - Month (Mar 21, 2019)		Burlington NW - Sump Pump - Month (Mar 21, 2019)		
Lab ID	1424218		1424219		
Metals	Result	MDL	Result	MDL	Units
Calcium	82.7	0.5	84.1	0.5	mg/L
Magnesium	33.7	0.005	38.4	0.005	mg/L

Sample Description	Burlington SC Sump Pump - Month (Mar 21, 2019)		Burlington NW - Sump Pump - Month (Mar 21, 2019)		
Lab ID	1424218		1424219		
Solids	Result	MDL	Result	MDL	Units
Total Dissolved Solids	608 [582]	6	664	6	mg/L
Total Suspended Solids	4.5 [5]	1	2.33	0.67	mg/L

LEGEND

Dates: Dates are formatted as mm/dd/year throughout this report.

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MDL: Method detection limit or minimum reporting limit.

[ ]: Results for laboratory replicates are shown in square brackets immediately below the associated sample result for ease of comparison.

Quality Control: All associated Quality Control data is available on request.

Exceedences: HIGHLIGHTED CELLS INDICATE THAT THE RESULT EXCEEDS A REGULATORY LIMIT. CALCULATED UNCERTAINTY ESTIMATIONS ARE NOT APPLIED FOR DETERMINING SAMPLE EXCEEDANCES.

Benzo(b)fluoranthene: Results for benzo(b)fluoranthene may include contributions from benzo(j)fluoranthene.

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CERTIFICATE OF ANALYSIS

Client:	Tecia White	Work Order Number:	388240
Company:	Nelson Aggregate Co	PO #:	
Address:	2433 No. 2 Side Road Burlington, ON, L7P 0G8	Regulation: Project #:	Information not provided Nelson Aggregates - Burlington Quarry Monthly ECA
Phone:	(705) 888-7064	DWS #:	
Email:	tecia@white-water.ca	Sampled By:	Stephen Vanderhorst
Date Order Received:	11/14/2019	Analysis Started:	11/14/2019
Arrival Temperature:	1.6 °C	Analysis Completed:	11/22/2019

WORK ORDER SUMMARY

ANALYSES WERE PERFORMED ON THE FOLLOWING SAMPLES. THE RESULTS RELATE ONLY TO THE ITEMS TESTED.

Sample Description	Lab ID	Matrix	Type	Comments	Date Collected	Time Collected
SC- Burlington Monthly (Nov 12, 2019)	1496798	Surface Water	None		11/12/2019	11:30 AM
NW- Burlington Monthly (Nov 12, 2019)	1496799	Surface Water	None		11/12/2019	11:30 AM

METHODS AND INSTRUMENTATION

THE FOLLOWING METHODS WERE USED FOR YOUR SAMPLE(S):

Method	Lab	Description	Reference
Alkalinity (A1.0)	Mississauga	Determination of Alkalinity by Titration	Modified from APHA-2320B
Ammonia Water (A42)	Mississauga	Determination of Ammonia/Ammonium in Water	Modified from EPA 350.1
Conductivity of Water (A12)	Mississauga	Determination of Conductivity in Water at 25°C	Modified from SM 2510 B
Dissolved Oxygen (A3)	Mississauga	Determination of Dissolved Oxygen in Water	Modified from APHA-5210
Field pH (R112)	Mississauga	Client Supplied Field Determination of pH of Water	Field Test
Field Temp (R113)	Mississauga	Client Supplied Field Determination of Temperature of Water	Field Test
ICPMS Reg. Water (A13)	Mississauga	Determination of Metals in Water by ICP/MS	Modified from SW846-6020
Oil and Grease (A54)	Mississauga	Determination of Oil and Grease in Water	Modified from EPA 1664
pH of Water (A2.0)	Mississauga	Determination of Water pH by Ion Selective Electrode	Modified from APHA-4500H+ B
Reg. Hardness (A13)	Mississauga	Determination of Total Hardness	Modified from APHA-2340B

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Nelson Aggregate Co

Work Order Number: 388240

Method	Lab	Description	Reference
TDS (A27)	Mississauga	Determination of Total Dissolved Solids in water by gravimetry	Modified from SM-2540
TSS (A27)	Mississauga	Determination of Total Suspended Solids in water by gravimetry	Modified from SM-2540
Un-Ionized NH3 (A42.4)	Mississauga	Calculation of Un-Ionized Ammonia	Modified from APHA-4500

This report has been approved by:



Marc Creighton
Laboratory Director

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CERTIFICATE OF ANALYSIS

Nelson Aggregate Co

Work Order Number: 388240

WORK ORDER RESULTS

Sample Description	SC - Burlington Monthly (Nov 12, 2019)		NW - Burlington Monthly (Nov 12, 2019)		
Sample Date	11/12/2019 11:30 AM		11/12/2019 11:30 AM		
Lab ID	1496798		1496799		
Field Parameters	Result	MDL	Result	MDL	Units
Field pH	8.31	N/A	8.2	N/A	pH
Field Temp	2	N/A	5	N/A	°C

Sample Description	SC - Burlington Monthly (Nov 12, 2019)		NW - Burlington Monthly (Nov 12, 2019)		
Sample Date	11/12/2019 11:30 AM		11/12/2019 11:30 AM		
Lab ID	1496798		1496799		
General Chemistry	Result	MDL	Result	MDL	Units
Ammonia (as N)	0.25 [0.22]	0.01	0.04	0.01	mg/L
Conductivity	1040	1	1090	1	µS/cm
Dissolved Oxygen	11.8	0.2	11.6	0.2	mg/L
M-Alkalinity (pH 4.5)	140	2	185	2	mg/L as CaCO3
Oil and Grease, Animal (Calc.)	<1	1	<1	1	mg/L
Oil and Grease, Mineral	<1	1	<1	1	mg/L
Oil and Grease, Total	<1	1	<1	1	mg/L
pH	8.08	N/A	8.06	N/A	pH
Total Hardness (as CaCO3) (Calc.)	479.0	0.1	328.0	0.1	mg/L
Un-Ionized Ammonia (Calc.)	0.005	0.002	<0.002	0.002	mg/L

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Nelson Aggregate Co

Work Order Number: 388240

Sample Description	SC - Burlington Monthly (Nov 12, 2019)		NW - Burlington Monthly (Nov 12, 2019)		
Sample Date	11/12/2019 11:30 AM		11/12/2019 11:30 AM		
Lab ID	1496798		1496799		
Metals	Result	MDL	Result	MDL	Units
Calcium	106.0	0.5	68.7	0.5	mg/L
Magnesium	52.00	0.05	38.10	0.05	mg/L

Sample Description	SC - Burlington Monthly (Nov 12, 2019)		NW - Burlington Monthly (Nov 12, 2019)		
Sample Date	11/12/2019 11:30 AM		11/12/2019 11:30 AM		
Lab ID	1496798		1496799		
Solids	Result	MDL	Result	MDL	Units
Total Dissolved Solids	722	2	511	2	mg/L
Total Suspended Solids	18.70	0.67	<0.67	0.67	mg/L

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CERTIFICATE OF ANALYSIS

Nelson Aggregate Co

Work Order Number: 388240

LEGEND

Dates: Dates are formatted as mm/dd/year throughout this report.

[rr]: After a parameter name indicates a re-run of that parameter. If multiple re-runs exist they are suffixed by a number. Sample may not have been handled according to the recommended temperature, hold time and head space requirements of the method after the initial analysis.

MDL: Method detection limit or minimum reporting limit.

[ ]: Results for laboratory replicates are shown in square brackets immediately below the associated sample result for ease of comparison.

Quality Control: All associated Quality Control data is available on request.

Exceedences: HIGHLIGHTED CELLS INDICATE THAT THE RESULT EXCEEDS A REGULATORY LIMIT. CALCULATED UNCERTAINTY ESTIMATIONS ARE NOT APPLIED FOR DETERMINING SAMPLE EXCEEDANCES.

Benzo(b)fluoranthene: Results for benzo(b)fluoranthene may include contributions from benzo(j)fluoranthene.

Field Data: Reports containing Field Parameters represent data that has been collected and provided by the client. Testmark is not responsible for the validity of this data which may be used in subsequent calculations.

Sample Condition Deviations: A noted sample condition deviation may affect the validity of the result.

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CERTIFICATE OF ANALYSIS

Client:	Tecia White	Work Order Number:	388241
Company:	Nelson Aggregate Co	PO #:	
Address:	2433 No. 2 Side Road Burlington, ON, L7P 0G8	Regulation: Project #:	Information not provided Nelson Aggregates - Burlington Quarry Quarterly ECA
Phone:	(705) 888-7064	DWS #:	
Email:	tecia@white-water.ca	Sampled By:	Stephen Vanderhorst
Date Order Received:	11/14/2019	Analysis Started:	11/14/2019
Arrival Temperature:	3.2 °C	Analysis Completed:	11/22/2019

WORK ORDER SUMMARY

ANALYSES WERE PERFORMED ON THE FOLLOWING SAMPLES. THE RESULTS RELATE ONLY TO THE ITEMS TESTED.

Sample Description	Lab ID	Matrix	Type	Comments	Date Collected	Time Collected
SC- Burlington Quarterly (Nov 12, 2019)	1496800	Surface Water	None		11/12/2019	11:30 AM
NW- Burlington Quarterly (Nov 12, 2019)	1496801	Surface Water	None		11/12/2019	11:30 AM

METHODS AND INSTRUMENTATION

THE FOLLOWING METHODS WERE USED FOR YOUR SAMPLE(S):

Method	Lab	Description	Reference
Alkalinity (A1.0)	Mississauga	Determination of Alkalinity by Titration	Modified from APHA-2320B
Ammonia Water (A42)	Mississauga	Determination of Ammonia/Ammonium in Water	Modified from EPA 350.1
Anions Water (mg/L by IC) (A5)	Mississauga	Determination of Anions in Water by Ion Chromatography	Modified from SW846-9056A
Conductivity of Water (A12)	Mississauga	Determination of Conductivity in Water at 25°C	Modified from SM 2510 B
Dissolved Oxygen (A3)	Mississauga	Determination of Dissolved Oxygen in Water	Modified from APHA-5210
DOC Water (A55.1)	Mississauga	Determination of Dissolved Organic Carbon in Water	Modified from SM-5310 C
Field pH (R112)	Mississauga	Client Supplied Field Determination of pH of Water	Field Test
Field Temp (R113)	Mississauga	Client Supplied Field Determination of Temperature of Water	Field Test
ICPMS Reg. Water (A13)	Mississauga	Determination of Metals in Water by ICP/MS	Modified from SW846-6020
ICPMS Tot. Water (A13)	Mississauga	Determination of Total Metals in Water by ICP/MS with Digestion	Modified from SW846-6020

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Nelson Aggregate Co

Work Order Number: 388241

Method	Lab	Description	Reference
Oil and Grease (A54)	Mississauga	Determination of Oil and Grease in Water	Modified from EPA 1664
PAH Water SIM (A41)	Garson	Determination of PAH in Water by GC/MS	Modified from SW846-8270D
pH of Water (A2.0)	Mississauga	Determination of Water pH by Ion Selective Electrode	Modified from APHA-4500H+ B
Phenols 4AAP (T38)	Mississauga	Determination of Total Phenols by 4AAP	Modified from APHA-5530
Reg. Hardness (A13)	Mississauga	Determination of Total Hardness	Modified from APHA-2340B
TDS (A27)	Mississauga	Determination of Total Dissolved Solids in water by gravimetry	Modified from SM-2540
TKN Water Dig. (A58)	Kirkland Lake	Determination of Total Kjeldahl Nitrogen in Waters with Block Digestion.	Modified from SM-4500 NORG-D
TP Water (A23.2)	Kirkland Lake	Determination of Total Phosphorus in Water.	Modified from EPA 365.3 and ESS 310.2,
TSS (A27)	Mississauga	Determination of Total Suspended Solids in water by gravimetry	Modified from SM-2540
Un-Ionized NH3 (A42.4)	Mississauga	Calculation of Un-Ionized Ammonia	Modified from APHA-4500

This report has been approved by:



Marc Creighton
Laboratory Director

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CERTIFICATE OF ANALYSIS

Nelson Aggregate Co

Work Order Number: 388241

WORK ORDER RESULTS

Sample Description	SC - Burlington Quarterly (Nov 12, 2019)		NW - Burlington Quarterly (Nov 12, 2019)		
Sample Date	11/12/2019 11:30 AM		11/12/2019 11:30 AM		
Lab ID	1496800		1496801		
Anions	Result	MDL	Result	MDL	Units
Bromide	1.5	0.1	0.2 [0.1]	0.1	mg/L
Chloride	94.8	0.2	85.7 [83.7]	0.2	mg/L
Fluoride	0.24	0.06	0.24 [0.22]	0.06	mg/L
Nitrate (as N)	0.48	0.05	<0.05 [<0.05]	0.05	mg/L
Nitrite (as N)	<0.05	0.05	<0.05 [<0.05]	0.05	mg/L
Sulphate	287.0	0.3	186.0 [184.0]	0.3	mg/L

Sample Description	SC - Burlington Quarterly (Nov 12, 2019)		NW - Burlington Quarterly (Nov 12, 2019)		
Sample Date	11/12/2019 11:30 AM		11/12/2019 11:30 AM		
Lab ID	1496800		1496801		
Field Parameters	Result	MDL	Result	MDL	Units
Field pH	8.3	N/A	8.2	N/A	pH
Field Temp	2	N/A	5	N/A	°C

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CERTIFICATE OF ANALYSIS

Nelson Aggregate Co

Work Order Number: 388241

Sample Description	SC - Burlington Quarterly (Nov 12, 2019)		NW - Burlington Quarterly (Nov 12, 2019)		
Sample Date	11/12/2019 11:30 AM		11/12/2019 11:30 AM		
Lab ID	1496800		1496801		
General Chemistry	**Result**	**MDL**	**Result**	**MDL**	**Units**
Ammonia (as N)	0.18	0.01	0.02	0.01	mg/L
Conductivity	1040	1	863	1	µS/cm
Dissolved Organic Carbon	3.1 [2.9]	0.4	3.2	0.4	mg/L
Dissolved Oxygen	11.7	0.2	11.4	0.2	mg/L
M-Alkalinity (pH 4.5)	139	2	154	2	mg/L as CaCO3
Oil and Grease, Animal (Calc.)	2	1	<1	1	mg/L
Oil and Grease, Mineral	<1	1	<1	1	mg/L
Oil and Grease, Total	2	1	<1	1	mg/L
pH	8.06	N/A	8.09	N/A	pH
Total Hardness (as CaCO3) (Calc.)	472.0	0.1	335.0	0.1	mg/L
Total Kjeldahl Nitrogen	5.2 [5.2]	0.4	2.3	0.4	mg/L
Total Phenols	<0.0004	0.0004	<0.0004	0.0004	mg/L
Total Phosphorus (as P)	0.016 [0.015]	0.002	0.010	0.002	mg/L
Un-Ionized Ammonia (Calc.)	0.004	0.002	<0.002	0.002	mg/L

Sample Description	SC - Burlington Quarterly (Nov 12, 2019)		NW - Burlington Quarterly (Nov 12, 2019)		
Sample Date	11/12/2019 11:30 AM		11/12/2019 11:30 AM		
Lab ID	1496800		1496801		
Metals	**Result**	**MDL**	**Result**	**MDL**	**Units**
Calcium	106.0	0.5	70.0	0.5	mg/L

6820 Kitimat Road Unit 4, Mississauga, ON, L5N 5M3
Phone: (905) 821-1112 Fax: (905) 821-2095 Web: www.testmark.ca

CERTIFICATE OF ANALYSIS

Nelson Aggregate Co

Work Order Number: 388241

Sample Description	SC - Burlington Quarterly (Nov 12, 2019)		NW - Burlington Quarterly (Nov 12, 2019)		
Sample Date	11/12/2019 11:30 AM		11/12/2019 11:30 AM		
Lab ID	1496800		1496801		
Metals	Result	MDL	Result	MDL	Units
Magnesium	50.40	0.05	38.80	0.05	mg/L

Sample Description	SC - Burlington Quarterly (Nov 12, 2019)		NW - Burlington Quarterly (Nov 12, 2019)		
Sample Date	11/12/2019 11:30 AM		11/12/2019 11:30 AM		
Lab ID	1496800		1496801		
Metals (Total)	Result	MDL	Result	MDL	Units
Total Aluminum	66 [63]	1	8	1	ug/L
Total Antimony	<0.5 [<0.5]	0.5	1.2	0.5	ug/L
Total Arsenic	4 [4]	1	3	1	ug/L
Total Barium	35 [34]	1	37	1	ug/L
Total Beryllium	<0.5 [<0.5]	0.5	<0.5	0.5	ug/L
Total Bismuth	<1 [<1]	1	<1	1	ug/L
Total Boron	176 [181]	2	89	2	ug/L
Total Cadmium	<0.02 [0.02]	0.02	0.02	0.02	ug/L
Total Calcium	98300 [105000]	500	65400	500	ug/L
Total Cerium	<1 [<1]	1	<1	1	ug/L
Total Cesium	<1 [<1]	1	<1	1	ug/L

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CERTIFICATE OF ANALYSIS

Nelson Aggregate Co

Work Order Number: 388241

Sample Description	SC - Burlington Quarterly (Nov 12, 2019)		NW - Burlington Quarterly (Nov 12, 2019)		
Sample Date	11/12/2019 11:30 AM		11/12/2019 11:30 AM		
Lab ID	1496800		1496801		
Metals (Total)	Result	MDL	Result	MDL	Units
Total Chromium	<1 [<1]	1	<1	1	ug/L
Total Cobalt	0.8 [0.8]	0.1	0.1	0.1	ug/L
Total Copper	2 [2]	1	2	1	ug/L
Total Europium	<1 [<1]	1	<1	1	ug/L
Total Gallium	<1 [<1]	1	<1	1	ug/L
Total Iron	309 [316]	20	170	20	ug/L
Total Lanthanum	<1 [<1]	1	<1	1	ug/L
Total Lead	0.3 [0.3]	0.1	<0.1	0.1	ug/L
Total Lithium	15 [15]	5	7	5	ug/L
Total Magnesium	44300 [45100]	4	34700	4	ug/L
Total Manganese	16 [16]	1	6	1	ug/L
Total Mercury	<0.1 [<0.1]	0.1	<0.1	0.1	ug/L
Total Molybdenum	6 [6]	1	3	1	ug/L
Total Nickel	5 [5]	1	2	1	ug/L
Total Niobium	<1 [<1]	1	<1	1	ug/L
Total Potassium	6800 [6850]	100	5420	100	ug/L

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CERTIFICATE OF ANALYSIS

Nelson Aggregate Co

Work Order Number: 388241

Sample Description	SC - Burlington Quarterly (Nov 12, 2019)		NW - Burlington Quarterly (Nov 12, 2019)		
Sample Date	11/12/2019 11:30 AM		11/12/2019 11:30 AM		
Lab ID	1496800		1496801		
Metals (Total)	Result	MDL	Result	MDL	Units
Total Rubidium	4 [4]	1	3	1	ug/L
Total Scandium	<1 [<1]	1	<1	1	ug/L
Total Selenium	1.5 [1.3]	0.5	1.0	0.5	ug/L
Total Silicon	734 [731]	2	525	2	ug/L
Total Silver	<0.1 [<0.1]	0.1	<0.1	0.1	ug/L
Total Sodium	46300 [47100]	1000	41900	1000	ug/L
Total Strontium	1370 [1670]	10	841	10	ug/L
Total Sulphur	93300 [93400]	800	57500	800	ug/L
Total Tellurium	<1 [<1]	1	<1	1	ug/L
Total Thallium	<0.1 [<0.1]	0.1	<0.1	0.1	ug/L
Total Thorium	<1 [<1]	1	<1	1	ug/L
Total Tin	<1 [<1]	1	<1	1	ug/L
Total Titanium	2 [2]	1	<1	1	ug/L
Total Tungsten	<1 [<1]	1	<1	1	ug/L
Total Uranium	<1 [1]	1	<1	1	ug/L
Total Vanadium	<1 [<1]	1	<1	1	ug/L

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CERTIFICATE OF ANALYSIS

Nelson Aggregate Co

Work Order Number: 388241

Sample Description	SC - Burlington Quarterly (Nov 12, 2019)		NW - Burlington Quarterly (Nov 12, 2019)		
Sample Date	11/12/2019 11:30 AM		11/12/2019 11:30 AM		
Lab ID	1496800		1496801		
Metals (Total)	Result	MDL	Result	MDL	Units
Total Yttrium	<1 [<1]	1	<1	1	ug/L
Total Zinc	2 [2]	1	3	1	ug/L
Total Zirconium	<1 [<1]	1	<1	1	ug/L

Sample Description	SC - Burlington Quarterly (Nov 12, 2019)		NW - Burlington Quarterly (Nov 12, 2019)		
Sample Date	11/12/2019 11:30 AM		11/12/2019 11:30 AM		
Lab ID	1496800		1496801		
PAH	Result	MDL	Result	MDL	Units
1+2-Methylnaphthalene (Calc.)	<0.04	0.04	<0.04	0.04	ug/L
1-Methylnaphthalene	<0.03	0.03	<0.03	0.03	ug/L
2-Methylnaphthalene	<0.02	0.02	<0.02	0.02	ug/L
3,3'-Dichlorobenzidine	<0.05	0.05	<0.06	0.06	ug/L
Acenaphthene	<0.04	0.04	<0.04	0.04	ug/L
Acenaphthylene	<0.04	0.04	<0.04	0.04	ug/L
Anthracene	<0.02	0.02	<0.02	0.02	ug/L
Benzo(a)anthracene	<0.02	0.02	<0.02	0.02	ug/L
Benzo(a)pyrene	<0.009	0.009	<0.009	0.009	ug/L
Benzo(b)fluoranthene	<0.06	0.06	<0.07	0.07	ug/L
Benzo(ghi)perylene	<0.04	0.04	<0.04	0.04	ug/L
Benzo(k)fluoranthene	<0.04	0.04	<0.04	0.04	ug/L

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CERTIFICATE OF ANALYSIS

Nelson Aggregate Co

Work Order Number: 388241

Sample Description	SC - Burlington Quarterly (Nov 12, 2019)		NW - Burlington Quarterly (Nov 12, 2019)		
Sample Date	11/12/2019 11:30 AM		11/12/2019 11:30 AM		
Lab ID	1496800		1496801		
PAH	Result	MDL	Result	MDL	Units
Biphenyl	<0.1	0.1	<0.1	0.1	ug/L
Chrysene	<0.05	0.05	<0.06	0.06	ug/L
Dibenz(a,h)anthracene	<0.04	0.04	<0.04	0.04	ug/L
Fluoranthene	<0.03	0.03	<0.03	0.03	ug/L
Fluorene	<0.04	0.04	<0.04	0.04	ug/L
Fluorobiphenyl (Surr.)	110	N/A	98.4	N/A	% Rec
Indeno(1,2,3-c,d)pyrene	<0.03	0.03	<0.03	0.03	ug/L
Naphthalene	<0.05	0.05	<0.06	0.06	ug/L
Phenanthrene	<0.03	0.03	<0.03	0.03	ug/L
p-Terphenyl-d14 (Surr.)	121	N/A	79.4	N/A	% Rec
Pyrene	<0.05	0.05	<0.06	0.06	ug/L

Sample Description	SC - Burlington Quarterly (Nov 12, 2019)		NW - Burlington Quarterly (Nov 12, 2019)		
Sample Date	11/12/2019 11:30 AM		11/12/2019 11:30 AM		
Lab ID	1496800		1496801		
Solids	Result	MDL	Result	MDL	Units
Total Dissolved Solids	698	2	526	2	mg/L
Total Suspended Solids	10.00	0.67	<0.67	0.67	mg/L

6820 Kitimat Road Unit 4, Mississauga, ON, L5N 5M3
Phone: (905) 821-1112 Fax: (905) 821-2095 Web: www.testmark.ca

CERTIFICATE OF ANALYSIS

Nelson Aggregate Co

Work Order Number: 388241

LEGEND

Dates: Dates are formatted as mm/dd/year throughout this report.

[rr]: After a parameter name indicates a re-run of that parameter. If multiple re-runs exist they are suffixed by a number. Sample may not have been handled according to the recommended temperature, hold time and head space requirements of the method after the initial analysis.

MDL: Method detection limit or minimum reporting limit.

[ ]: Results for laboratory replicates are shown in square brackets immediately below the associated sample result for ease of comparison.

Quality Control: All associated Quality Control data is available on request.

Exceedences: HIGHLIGHTED CELLS INDICATE THAT THE RESULT EXCEEDS A REGULATORY LIMIT. CALCULATED UNCERTAINTY ESTIMATIONS ARE NOT APPLIED FOR DETERMINING SAMPLE EXCEEDANCES.

Benzo(b)fluoranthene: Results for benzo(b)fluoranthene may include contributions from benzo(j)fluoranthene.

Field Data: Reports containing Field Parameters represent data that has been collected and provided by the client. Testmark is not responsible for the validity of this data which may be used in subsequent calculations.

Sample Condition Deviations: A noted sample condition deviation may affect the validity of the result.

6820 Kitimat Road Unit 4, Mississauga, ON, L5N 5M3
Phone: (905) 821-1112 Fax: (905) 821-2095 Web: www.testmark.ca

APPENDIX C

METER CALIBRATION REPORTS

2250 Argentia Road,
Mississauga Ontario L5N 6A5
Telephone (905) 813-8310
Fax (905)812-1397

ISO 9001 Quality

Certified Test Report

Report #:	**22389**	**Cert Date:**	June 7, 2019
Description:	Seametrics FT430M-126 Mag Meter	**Recert Date:**	June 7, 2020
Pulse Output:	1000 L/P	**Serial #:** 072016000966	**Tolerance:** See Manual
Customer:	Nelson Aggregate Burlington	**Location:** 2433 #2 Side Road South Central	**P.O.#** 3258

Calibration Test Equipment Used

Standard used:	Flexim Ultra Sonic Flow Meter	**Our Order No.:**	CSW09154428
Type:	CDK1NZ7	**Serial No:** 13018	**Accuracy:** 0.5% of Rdg
Traceability to:	N.I.S.T		**Report #:** F14-368
Position:	Vertical		**Temperature:** 23°C ± 2°

Master	Indication
770 L/M	778 L/M

Frequency Output = 1 pules /1000 Liters

Wajax Industrial Components certifies that the above item has been inspected and tested to comply in every way with the relevant specifications in accordance with the requirements of the above purchase order.

Signed: _____
Chene Middleton

Approved: _____

2250 Argentia Road,
Mississauga Ontario L5N 6A5
Telephone (905) 813-8310
Fax (905)812-1397

ISO 9001 Quality

Certified Test Report

Report #: 22387
Description: Seametrics FT430M-126 Mag Meter
Pulse Output: 1000 L/P
Customer: Nelson Aggregate Burlington

Serial #: 072016000967
Location: 2433 #2 Side Road North Sump

Cert Date: June 7, 2019
Recert Date: June 7, 2020
Tolerance: See Manual
P.O.# 3258

Calibration Test Equipment Used

Standard used: Flexim Ultra Sonic Flow Meter
Type: CDK1NZ7
Traceability to: N.I.S.T
Position: Vertical

Serial No: 13018

Our Order No.: CSW09154428
Accuracy: 0.5% of Rdg
Report #: F14-368
Temperature: 23°C ± 2°

Master	Indication
3750 L/M	3780 L/M

Frequency Output = 1 pules /1000 Liters

Wajax Industrial Components certifies that the above item has been inspected and tested to comply in every way with the relevant specifications in accordance with the requirements of the above purchase order.

Signed: _____
Chene Middleton

Approved: _____

APPENDIX D

WATER TAKINGS

96-P-3009				
Quarry Sump 0200 SC			Quarry Sump 0100 NW	
Date	Taking Amount	Method	Taking Amount	Method
1-Jan-19	0	metered	0	metered
2-Jan-19	0	metered	0	metered
3-Jan-19	0	metered	0	metered
4-Jan-19	0	metered	0	metered
5-Jan-19	0	metered	0	metered
6-Jan-19	0	metered	0	metered
7-Jan-19	0	metered	0	metered
8-Jan-19	0	metered	0	metered
9-Jan-19	0	metered	0	metered
10-Jan-19	0	metered	0	metered
11-Jan-19	0	metered	0	metered
12-Jan-19	0	metered	0	metered
13-Jan-19	0	metered	0	metered
14-Jan-19	0	metered	0	metered
15-Jan-19	0	metered	0	metered
16-Jan-19	0	metered	0	metered
17-Jan-19	591,000	metered	2,280,000	metered
18-Jan-19	1,484,000	metered	5,760,000	metered
19-Jan-19	578,000	metered	5,760,000	metered
20-Jan-19	0	metered	5,760,000	metered
21-Jan-19	0	metered	5,760,000	metered
22-Jan-19	765,000	metered	5,760,000	metered
23-Jan-19	1,629,000	metered	5,760,000	metered
24-Jan-19	1,598,000	metered	5,760,000	metered
25-Jan-19	1,614,000	metered	5,760,000	metered
26-Jan-19	1,598,000	metered	5,760,000	metered
27-Jan-19	1,544,000	metered	5,760,000	metered
28-Jan-19	943,000	metered	5,760,000	metered
29-Jan-19	1,725,000	metered	5,760,000	metered
30-Jan-19	1,728,000	metered	5,760,000	metered
31-Jan-19	834,000	metered	5,760,000	metered
1-Feb-19	0	metered	5,760,000	metered
2-Feb-19	3,000	metered	5,760,000	metered
3-Feb-19	8,000	metered	5,760,000	metered
4-Feb-19	0	metered	5,760,000	metered
5-Feb-19	0	metered	5,760,000	metered
6-Feb-19	0	metered	5,760,000	metered
7-Feb-19	0	metered	5,760,000	metered
8-Feb-19	0	metered	5,760,000	metered
9-Feb-19	0	metered	5,760,000	metered
10-Feb-19	0	metered	5,760,000	metered
11-Feb-19	0	metered	5,760,000	metered
12-Feb-19	0	metered	5,760,000	metered
13-Feb-19	0	metered	5,760,000	metered
14-Feb-19	0	metered	5,760,000	metered
15-Feb-19	0	metered	5,760,000	metered
16-Feb-19	0	metered	5,760,000	metered
17-Feb-19	0	metered	5,760,000	metered
18-Feb-19	0	metered	5,760,000	metered
19-Feb-19	0	metered	5,760,000	metered
20-Feb-19	0	metered	5,760,000	metered
21-Feb-19	0	metered	5,760,000	metered
22-Feb-19	0	metered	5,760,000	metered
23-Feb-19	0	metered	5,760,000	metered
24-Feb-19	0	metered	5,760,000	metered
25-Feb-19	0	metered	5,760,000	metered
26-Feb-19	0	metered	5,760,000	metered
27-Feb-19	0	metered	5,760,000	metered
28-Feb-19	0	metered	5,760,000	metered
1-Mar-19	0	metered	5,760,000	metered
2-Mar-19	0	metered	5,760,000	metered
3-Mar-19	0	metered	5,760,000	metered
4-Mar-19	0	metered	5,760,000	metered
5-Mar-19	0	metered	5,760,000	metered
6-Mar-19	0	metered	5,760,000	metered
7-Mar-19	0	metered	5,760,000	metered
8-Mar-19	0	metered	5,760,000	metered
9-Mar-19	0	metered	5,760,000	metered
10-Mar-19	0	metered	5,760,000	metered
11-Mar-19	0	metered	5,760,000	metered
12-Mar-19	0	metered	5,760,000	metered
13-Mar-19	0	metered	5,760,000	metered
14-Mar-19	0	metered	5,760,000	metered
15-Mar-19	0	metered	5,760,000	metered
16-Mar-19	0	metered	5,760,000	metered

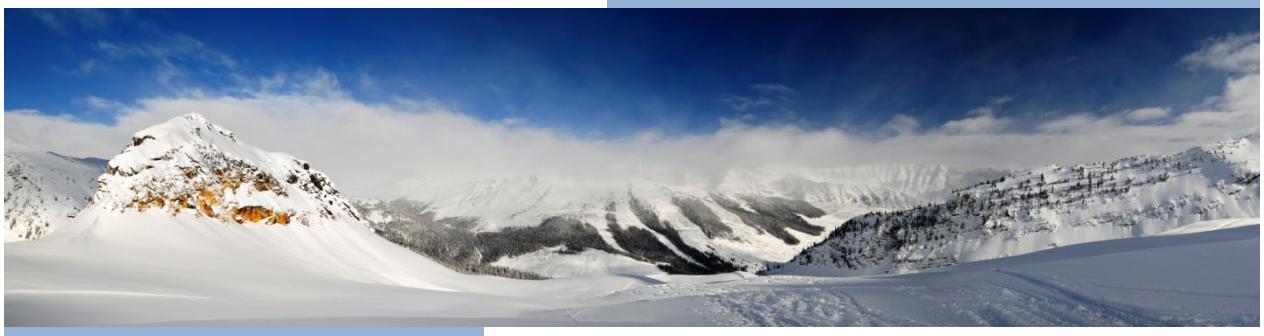
96-P-3009				
Quarry Sump 0200 SC			Quarry Sump 0100 NW	
Date	Taking Amount	Method	Taking Amount	Method
17-Mar-19	0	metered	5,760,000	metered
18-Mar-19	0	metered	5,760,000	metered
19-Mar-19	0	metered	5,760,000	metered
20-Mar-19	0	metered	5,760,000	metered
21-Mar-19	0	metered	5,760,000	metered
22-Mar-19	44,000	metered	5,760,000	metered
23-Mar-19	187,000	metered	5,760,000	metered
24-Mar-19	0	metered	5,760,000	metered
25-Mar-19	28,000	metered	5,760,000	metered
26-Mar-19	862,000	metered	5,760,000	metered
27-Mar-19	927,000	metered	5,760,000	metered
28-Mar-19	951,000	metered	5,760,000	metered
29-Mar-19	1,197,000	metered	5,760,000	metered
30-Mar-19	1,258,000	metered	5,760,000	metered
31-Mar-19	1,251,200	metered	5,760,000	metered
1-Apr-19	1,301,000	metered	5,760,000	metered
2-Apr-19	1,296,000	metered	5,760,000	metered
3-Apr-19	1,286,000	metered	5,760,000	metered
4-Apr-19	1,305,000	metered	5,760,000	metered
5-Apr-19	1,222,000	metered	5,760,000	metered
6-Apr-19	1,167,000	metered	5,760,000	metered
7-Apr-19	1,160,000	metered	5,760,000	metered
8-Apr-19	1,159,000	metered	5,760,000	metered
9-Apr-19	1,161,000	metered	5,760,000	metered
10-Apr-19	1,212,000	metered	5,760,000	metered
11-Apr-19	1,261,000	metered	5,760,000	metered
12-Apr-19	1,204,000	metered	5,760,000	metered
13-Apr-19	1,293,000	metered	5,760,000	metered
14-Apr-19	1,060,000	metered	5,760,000	metered
15-Apr-19	1,300,000	metered	5,760,000	metered
16-Apr-19	1,275,000	metered	5,760,000	metered
17-Apr-19	1,218,000	metered	5,760,000	metered
18-Apr-19	1,158,000	metered	5,760,000	metered
19-Apr-19	1,307,000	metered	5,760,000	metered
20-Apr-19	1,307,000	metered	5,760,000	metered
21-Apr-19	1,307,000	metered	5,760,000	metered
22-Apr-19	1,307,000	metered	5,760,000	metered
23-Apr-19	1,307,000	metered	5,760,000	metered
24-Apr-19	1,307,000	metered	5,760,000	metered
25-Apr-19	1,307,000	metered	5,760,000	metered
26-Apr-19	1,307,000	metered	5,760,000	metered
27-Apr-19	1,307,000	metered	5,760,000	metered
28-Apr-19	1,307,000	metered	5,760,000	metered
29-Apr-19	1,307,000	metered	5,760,000	metered
30-Apr-19	1,307,000	metered	5,760,000	metered
1-May-19	1,307,000	metered	5,760,000	metered
2-May-19	1,307,000	metered	5,760,000	metered
3-May-19	1,307,000	metered	5,760,000	metered
4-May-19	1,246,000	metered	5,760,000	metered
5-May-19	1,220,000	metered	5,760,000	metered
6-May-19	1,272,000	metered	5,760,000	metered
7-May-19	1,307,000	metered	5,760,000	metered
8-May-19	1,307,000	metered	5,760,000	metered
9-May-19	1,307,000	metered	5,760,000	metered
10-May-19	1,307,000	metered	5,760,000	metered
11-May-19	1,289,000	metered	5,760,000	metered
12-May-19	1,278,000	metered	5,760,000	metered
13-May-19	1,307,000	metered	5,760,000	metered
14-May-19	1,307,000	metered	5,760,000	metered
15-May-19	1,301,000	metered	5,760,000	metered
16-May-19	1,307,000	metered	5,760,000	metered
17-May-19	1,243,000	metered	5,760,000	metered
18-May-19	1,184,000	metered	5,760,000	metered
19-May-19	714,000	metered	5,760,000	metered
20-May-19	0	metered	5,760,000	metered
21-May-19	732,000	metered	5,760,000	metered
22-May-19	1,110,000	metered	5,760,000	metered
23-May-19	1,037,000	metered	5,760,000	metered
24-May-19	1,061,000	metered	5,760,000	metered
25-May-19	966,000	metered	5,760,000	metered
26-May-19	514,000	metered	5,760,000	metered
27-May-19	673,000	metered	5,760,000	metered
28-May-19	1,281,000	metered	5,760,000	metered
29-May-19	1,267,000	metered	5,760,000	metered
30-May-19	586,000	metered	5,760,000	metered

96-P-3009				
Quarry Sump 0200 SC			Quarry Sump 0100 NW	
Date	Taking Amount	Method	Taking Amount	Method
31-May-19	828,000	metered	5,760,000	metered
1-Jun-19	1,211,000	metered	5,760,000	metered
2-Jun-19	1,240,000	metered	5,760,000	metered
3-Jun-19	1,300,000	metered	5,760,000	metered
4-Jun-19	1,264,000	metered	5,760,000	metered
5-Jun-19	1,110,000	metered	5,760,000	metered
6-Jun-19	1,110,000	metered	5,760,000	metered
7-Jun-19	1,215,000	metered	5,540,000	metered
8-Jun-19	1,193,000	metered	5,760,000	metered
9-Jun-19	1,198,000	metered	5,760,000	metered
10-Jun-19	1,209,000	metered	5,760,000	metered
11-Jun-19	1,294,000	metered	5,500,000	metered
12-Jun-19	1,110,000	metered	5,760,000	metered
13-Jun-19	1,110,000	metered	5,760,000	metered
14-Jun-19	1,110,000	metered	5,760,000	metered
15-Jun-19	1,110,000	metered	5,760,000	metered
16-Jun-19	1,110,000	metered	5,760,000	metered
17-Jun-19	1,110,000	metered	5,760,000	metered
18-Jun-19	1,089,000	metered	5,760,000	metered
19-Jun-19	1,058,000	metered	5,760,000	metered
20-Jun-19	1,029,000	metered	5,760,000	metered
21-Jun-19	1,038,000	metered	5,760,000	metered
22-Jun-19	1,097,000	metered	5,760,000	metered
23-Jun-19	1,071,000	metered	5,760,000	metered
24-Jun-19	1,016,000	metered	5,760,000	metered
25-Jun-19	874,000	metered	5,760,000	metered
26-Jun-19	959,000	metered	5,760,000	metered
27-Jun-19	1,008,000	metered	5,760,000	metered
28-Jun-19	1,161,000	metered	5,760,000	metered
29-Jun-19	1,202,000	metered	5,760,000	metered
30-Jun-19	1,212,000	metered	5,760,000	metered
1-Jul-19	1,208,000	metered	5,760,000	metered
2-Jul-19	1,165,000	metered	5,760,000	metered
3-Jul-19	1,138,000	metered	5,760,000	metered
4-Jul-19	1,134,000	metered	5,760,000	metered
5-Jul-19	1,053,000	metered	5,760,000	metered
6-Jul-19	1,122,000	metered	5,540,000	metered
7-Jul-19	1,217,000	metered	5,760,000	metered
8-Jul-19	1,202,000	metered	5,760,000	metered
9-Jul-19	1,295,000	metered	5,760,000	metered
10-Jul-19	1,202,000	calculated	5,760,000	metered
11-Jul-19	1,202,000	calculated	5,760,000	metered
12-Jul-19	1,202,000	calculated	5,760,000	metered
13-Jul-19	889,000	calculated	5,760,000	metered
14-Jul-19	1,296,000	calculated	5,760,000	metered
15-Jul-19	1,296,000	calculated	5,760,000	metered
16-Jul-19	1,296,000	calculated	5,760,000	metered
17-Jul-19	1,296,000	calculated	5,520,000	metered
18-Jul-19	1,296,000	calculated	5,760,000	metered
19-Jul-19	1,296,000	calculated	5,760,000	metered
20-Jul-19	1,296,000	metered	5,760,000	metered
21-Jul-19	1,296,000	metered	5,760,000	metered
22-Jul-19	1,296,000	metered	5,760,000	metered
23-Jul-19	1,296,000	metered	5,760,000	metered
24-Jul-19	1,296,000	metered	5,760,000	metered
25-Jul-19	1,296,000	metered	5,760,000	metered
26-Jul-19	1,296,000	metered	5,760,000	metered
27-Jul-19	1,296,000	metered	5,760,000	metered
28-Jul-19	1,296,000	metered	5,760,000	metered
29-Jul-19	1,296,000	metered	5,760,000	metered
30-Jul-19	1,296,000	metered	5,520,000	metered
31-Jul-19	1,296,000	metered	5,760,000	metered
1-Aug-19	1,296,000	metered	5,760,000	metered
2-Aug-19	1,296,000	metered	5,760,000	metered
3-Aug-19	1,296,000	metered	5,760,000	metered
4-Aug-19	1,296,000	metered	5,760,000	metered
5-Aug-19	1,296,000	metered	5,760,000	metered
6-Aug-19	1,296,000	metered	5,760,000	metered
7-Aug-19	1,296,000	metered	5,760,000	metered
8-Aug-19	1,296,000	metered	5,760,000	metered
9-Aug-19	1,296,000	metered	5,760,000	metered
10-Aug-19	1,296,000	metered	5,760,000	metered
11-Aug-19	1,296,000	metered	5,760,000	metered
12-Aug-19	1,296,000	metered	5,760,000	metered
13-Aug-19	1,296,000	metered	5,740,000	metered

96-P-3009				
Quarry Sump 0200 SC			Quarry Sump 0100 NW	
Date	Taking Amount	Method	Taking Amount	Method
14-Aug-19	1,296,000	metered	5,760,000	metered
15-Aug-19	1,296,000	metered	5,760,000	metered
16-Aug-19	1,296,000	metered	5,760,000	metered
17-Aug-19	1,296,000	metered	5,760,000	metered
18-Aug-19	1,296,000	metered	5,760,000	metered
19-Aug-19	1,296,000	metered	5,760,000	metered
20-Aug-19	1,296,000	metered	5,760,000	metered
21-Aug-19	1,296,000	metered	5,760,000	metered
22-Aug-19	1,296,000	metered	5,760,000	metered
23-Aug-19	1,296,000	metered	5,760,000	metered
24-Aug-19	1,296,000	metered	5,760,000	metered
25-Aug-19	1,296,000	metered	5,760,000	metered
26-Aug-19	1,296,000	metered	5,760,000	metered
27-Aug-19	1,296,000	metered	5,760,000	metered
28-Aug-19	1,296,000	metered	5,540,000	metered
29-Aug-19	1,296,000	metered	5,760,000	metered
30-Aug-19	1,296,000	metered	5,760,000	metered
31-Aug-19	1,296,000	metered	5,760,000	metered
1-Sep-19	1,296,000	metered	5,760,000	metered
2-Sep-19	1,296,000	metered	5,760,000	metered
3-Sep-19	1,296,000	metered	5,760,000	metered
4-Sep-19	1,296,000	metered	5,760,000	metered
5-Sep-19	1,296,000	metered	5,760,000	metered
6-Sep-19	1,296,000	metered	5,760,000	metered
7-Sep-19	1,296,000	metered	5,520,000	metered
8-Sep-19	1,296,000	metered	5,760,000	metered
9-Sep-19	1,296,000	metered	5,120,000	metered
10-Sep-19	1,296,000	metered	5,760,000	metered
11-Sep-19	1,296,000	metered	5,760,000	metered
12-Sep-19	1,296,000	metered	5,760,000	metered
13-Sep-19	1,296,000	metered	5,760,000	metered
14-Sep-19	1,296,000	metered	5,760,000	metered
15-Sep-19	1,296,000	metered	5,760,000	metered
16-Sep-19	1,296,000	metered	5,760,000	metered
17-Sep-19	1,296,000	metered	5,760,000	metered
18-Sep-19	1,296,000	metered	5,760,000	metered
19-Sep-19	1,296,000	metered	5,760,000	metered
20-Sep-19	1,296,000	metered	5,540,000	metered
21-Sep-19	1,296,000	metered	5,760,000	metered
22-Sep-19	1,296,000	metered	5,760,000	metered
23-Sep-19	1,296,000	metered	5,760,000	metered
24-Sep-19	1,296,000	metered	5,760,000	metered
25-Sep-19	1,296,000	metered	5,760,000	metered
26-Sep-19	1,296,000	metered	5,760,000	metered
27-Sep-19	1,296,000	metered	5,760,000	metered
28-Sep-19	1,296,000	metered	5,760,000	metered
29-Sep-19	1,296,000	metered	5,760,000	metered
30-Sep-19	1,296,000	metered	5,760,000	metered
1-Oct-19	1,296,000	metered	5,760,000	metered
2-Oct-19	1,296,000	metered	5,760,000	metered
3-Oct-19	1,296,000	metered	5,760,000	metered
4-Oct-19	1,296,000	metered	5,760,000	metered
5-Oct-19	1,296,000	metered	5,760,000	metered
6-Oct-19	1,296,000	metered	5,760,000	metered
7-Oct-19	1,296,000	metered	5,760,000	metered
8-Oct-19	1,296,000	metered	5,760,000	metered
9-Oct-19	1,296,000	metered	5,760,000	metered
10-Oct-19	1,296,000	metered	5,760,000	metered
11-Oct-19	1,296,000	metered	5,760,000	metered
12-Oct-19	1,296,000	metered	5,760,000	metered
13-Oct-19	1,296,000	metered	5,760,000	metered
14-Oct-19	1,296,000	metered	5,760,000	metered
15-Oct-19	1,296,000	metered	5,760,000	metered
16-Oct-19	1,296,000	metered	5,760,000	metered
17-Oct-19	1,296,000	metered	5,760,000	metered
18-Oct-19	1,296,000	metered	5,760,000	metered
19-Oct-19	1,296,000	metered	5,760,000	metered
20-Oct-19	1,296,000	metered	5,760,000	metered
21-Oct-19	1,296,000	metered	5,760,000	metered
22-Oct-19	1,296,000	metered	5,760,000	metered
23-Oct-19	1,296,000	metered	5,760,000	metered
24-Oct-19	1,296,000	metered	5,760,000	metered
25-Oct-19	1,296,000	metered	5,760,000	metered
26-Oct-19	1,296,000	metered	5,760,000	metered
27-Oct-19	1,296,000	metered	5,520,000	metered

96-P-3009				
Quarry Sump 0200 SC			Quarry Sump 0100 NW	
Date	Taking Amount	Method	Taking Amount	Method
28-Oct-19	1,296,000	metered	5,760,000	metered
29-Oct-19	1,296,000	metered	5,760,000	metered
30-Oct-19	1,296,000	metered	5,760,000	metered
31-Oct-19	1,296,000	metered	5,760,000	metered
1-Nov-19	1,296,000	metered	5,760,000	metered
2-Nov-19	1,296,000	metered	5,760,000	metered
3-Nov-19	1,296,000	metered	5,760,000	metered
4-Nov-19	1,296,000	metered	5,760,000	metered
5-Nov-19	1,296,000	metered	5,760,000	metered
6-Nov-19	1,296,000	metered	5,760,000	metered
7-Nov-19	1,296,000	metered	5,760,000	metered
8-Nov-19	1,296,000	metered	5,760,000	metered
9-Nov-19	1,296,000	metered	5,760,000	metered
10-Nov-19	1,296,000	metered	5,760,000	metered
11-Nov-19	1,296,000	metered	5,760,000	metered
12-Nov-19	1,296,000	metered	5,760,000	metered
13-Nov-19	1,296,000	metered	5,760,000	metered
14-Nov-19	1,296,000	metered	5,760,000	metered
15-Nov-19	1,296,000	metered	5,760,000	metered
16-Nov-19	1,296,000	metered	5,760,000	metered
17-Nov-19	1,296,000	metered	5,760,000	metered
18-Nov-19	1,296,000	metered	5,760,000	metered
19-Nov-19	1,296,000	metered	5,760,000	metered
20-Nov-19	1,296,000	metered	5,760,000	metered
21-Nov-19	1,296,000	metered	5,760,000	metered
22-Nov-19	1,296,000	metered	5,760,000	metered
23-Nov-19	1,296,000	metered	5,760,000	metered
24-Nov-19	1,296,000	metered	5,760,000	metered
25-Nov-19	1,296,000	metered	5,760,000	metered
26-Nov-19	1,296,000	metered	5,760,000	metered
27-Nov-19	1,296,000	metered	5,760,000	metered
28-Nov-19	1,296,000	metered	5,760,000	metered
29-Nov-19	1,296,000	metered	5,760,000	metered
30-Nov-19	1,296,000	metered	5,760,000	metered
1-Dec-19	1,296,000	metered	5,760,000	metered
2-Dec-19	1,296,000	metered	5,760,000	metered
3-Dec-19	1,296,000	metered	5,540,000	metered
4-Dec-19	1,296,000	metered	5,760,000	metered
5-Dec-19	1,296,000	metered	5,760,000	metered
6-Dec-19	1,296,000	metered	5,760,000	metered
7-Dec-19	1,296,000	metered	5,760,000	metered
8-Dec-19	1,296,000	metered	4,100,000	metered
9-Dec-19	1,296,000	metered	3,100,000	metered
10-Dec-19	1,296,000	metered	5,760,000	metered
11-Dec-19	1,296,000	metered	5,760,000	metered
12-Dec-19	1,296,000	metered	5,760,000	metered
13-Dec-19	1,296,000	metered	5,760,000	metered
14-Dec-19	1,296,000	metered	5,760,000	metered
15-Dec-19	1,296,000	metered	5,760,000	metered
16-Dec-19	1,296,000	metered	5,760,000	metered
17-Dec-19	1,296,000	metered	5,760,000	metered
18-Dec-19	1,296,000	metered	5,760,000	metered
19-Dec-19	1,296,000	metered	5,760,000	metered
20-Dec-19	1,296,000	metered	5,760,000	metered
21-Dec-19	0	metered	5,760,000	metered
22-Dec-19	0	metered	5,760,000	metered
23-Dec-19	0	metered	5,760,000	metered
24-Dec-19	0	metered	5,760,000	metered
25-Dec-19	0	metered	5,760,000	metered
26-Dec-19	0	metered	5,760,000	metered
27-Dec-19	0	metered	5,760,000	metered
28-Dec-19	0	metered	5,760,000	metered
29-Dec-19	0	metered	5,760,000	metered
30-Dec-19	0	metered	5,760,000	metered
31-Dec-19	0	metered	500,000	metered

Whitewater
Hydrogeology Ltd.



BURLINGTON QUARRY

2020 Compliance Groundwater and Surface Water Monitoring Report

Completed in Compliance with:

Environmental Compliance Approval No.: 5203-AN6NGV

Prepared for:

NELSON AGGREGATE CO.

Whitewater Hydrogeology Ltd
Phone: 705.888.7064
Email: tecia@white-water.ca

Date: February 2021

Whitewater
Hydrogeology Ltd.

80 Chamberlain Cres
Collingwood, ON L9Y 0C8
Phone: 705-888-7064
Email: tecia@white-water.ca

February 23, 2020

Ministry of the Environment, Conservation and Parks
Halton-Peel District Office
4145 North Service Rd,
Burlington, ON
L7L 6A3

Attention: Steve Allingham, District Manager

Re: 2020 Compliance Monitoring Results
Environmental Compliance Approval for Industrial Sewage Works (No.: 5203-AN6NGV)

Whitewater Hydrogeology Ltd. (Whitewater) is pleased to present the results of the 2020 compliance monitoring program, which was carried out under the Environmental Compliance Approval (ECA) for Industrial Sewage Works (No.: 5203-AN6NGV) for the Burlington Quarry.

A copy of the ECA is provided in Appendix A.

If you have any questions, please do not hesitate to contact the undersigned.

Yours truly,

PROFESSIONAL GEOSCIENTIST
TECIA WHITE
PRACTISING MEMBER
0701
ONTARIO

Tecia White, M.Sc., P.Geo. (License 0701)
Senior Hydrogeologist
Whitewater Hydrogeology Ltd.

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Appendix A Copy of Environmental Compliance Approval
Appendix B Water Quality Results
Appendix C Meter Calibration Reports
Appendix D Water Takings (Flow Measurements)

1.0 INTRODUCTION

The Nelson Aggregate Company (Nelson) owns and operates the Burlington Quarry, located at 2433 No. 2 Side Rd, City of Burlington, Regional Municipality of Halton (Figure 1). On June 29, 2017, the Ministry of the Environment, Conservation and Parks (MECP) issued Nelson an Ontario Water Resources Act Section 53 Environmental Compliance Approval for Industrial Sewage Works (ECA No.: 5203-AN6NGV) for the site. The ECA allows for the site to operate a water management program to control the incidental water that enters the quarry footprint.

As a condition of the ECA, Nelson is required to complete an annual compliance report that contains the following information:

a) a summary and interpretation of all monitoring data and a comparison to the effluent limits outlined in Condition 4, including an overview of the success and adequacy of the Works;
b) a description of any operating problems encountered, and corrective actions taken;
c) a summary of all inspection, maintenance, and clean-out carried out on any major structure, equipment, apparatus, mechanism, or thing forming part of the Works;
d) a summary of any effluent quality assurance or control measures undertaken;
e) a summary of the calibration and maintenance carried out on all effluent monitoring equipment;
f) a summary of any complaints received during the reporting period and any steps taken to address the complaints;
g) a summary of all spill or abnormal discharge events; and,
h) a summary of any Notifications and Contingency Plan undertook during the reporting period and a discussion regarding their adequacy.

Whitewater Hydrogeology Ltd (Whitewater) has been retained to undertake the 2020 ECA reporting requirements. A copy of the ECA is provided in Appendix A.

1.1 Description of Sewage Works

Nelson has established sewage works at the Uhthoff Quarry for the collection, transmission, treatment, and disposal of groundwater and stormwater runoff collecting within the confines of the quarry. The sewage works consist of:

- one (1) settling pond (North Pond), collecting groundwater and surface water runoff from the active area of the quarry, with an estimated storage volume of 230,000 m at an average depth of 2.4 m, equipped with a discharge sump within the pond and submersible pump (North Discharge), discharging at a maximum release rate of 4,090 L/min to the roadside ditch of Colling Road and a tributary watercourse of Bronte Creek;
- one (1) settling pond (South Pond), collecting groundwater and surface water runoff from the active area of the quarry, with an estimated storage volume of 204,800 m at an average depth of 1.8 m, equipped with a discharge sump within the pond and submersible pump (South Discharge), discharging at a maximum release rate of 945 L/min to the West Mount Nemo Tributary; and
- all other controls, electrical equipment, instrumentation, piping, pumps, valves and associated appurtenances for the proper operations of the aforementioned sewage works.

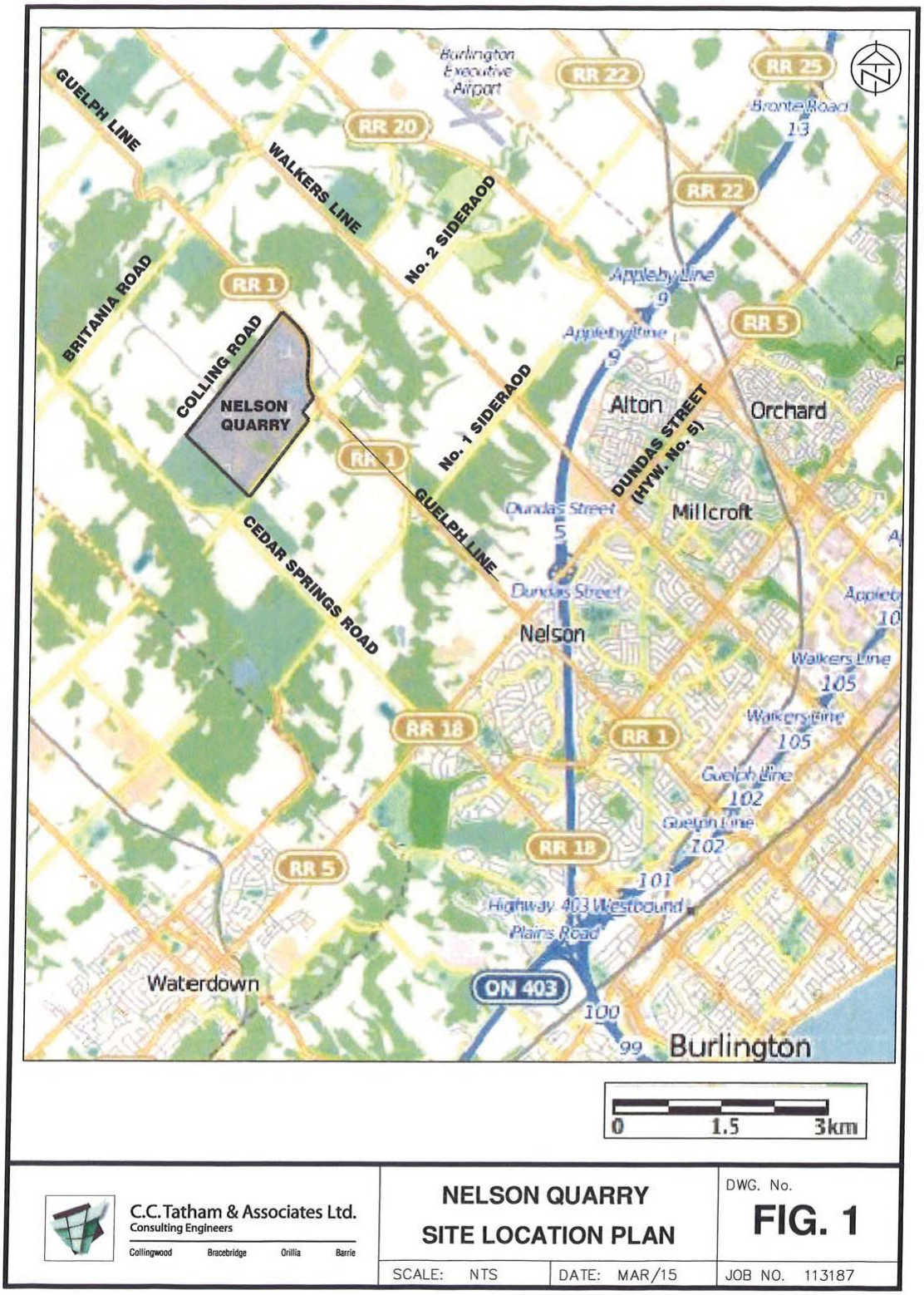

FIGURE 1: SITE LOCATION MAP

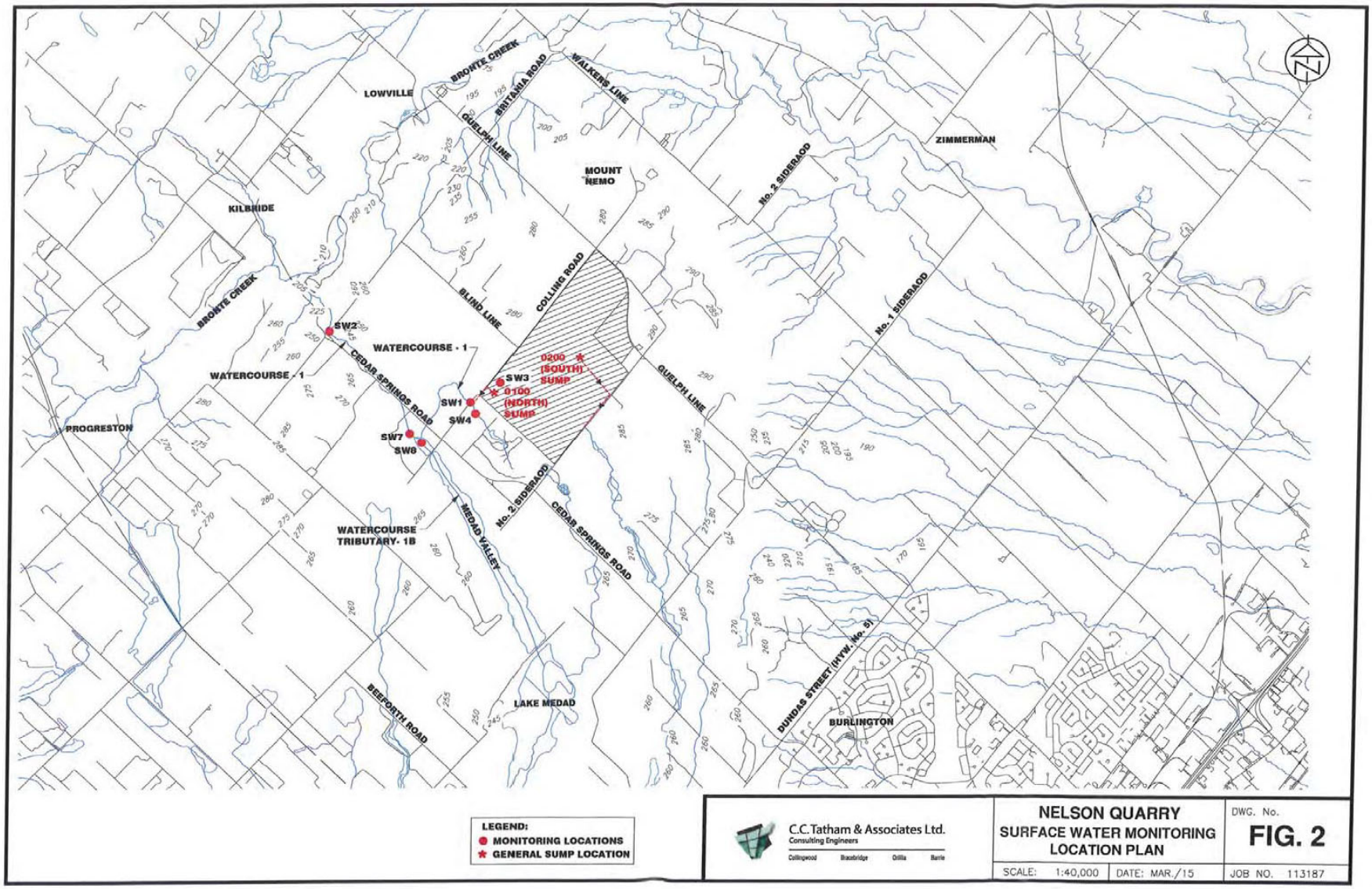

FIGURE 2: MONITORING LOCATIONS

1.2 Compliance Monitoring Program

The effluent monitoring is completed at two sampling locations. The North Discharge pipe, which is located along Collins Road and South Discharge pipe, which is located along the 2nd line (Figure 1 and Figure 2). Sampling is to be completed monthly and quarterly during operations. The sampling details are provided in Table 1.

TABLE 1: WATER QUALITY PARAMETERS

Frequency	Parameters
Monthly	pH (field), Temperature (field), Dissolved Oxygen (field), Conductivity (field), Total Suspended Solids, Total Dissolved Solids, Alkalinity, Hardness, Total Ammonia, calculated Unionized Ammonia, Oil, and Grease
Quarterly	Chloride, Sulphate, Total Kjeldahl Nitrogen, Dissolved Organic Carbon, Total Phosphorus, Nitrate, Nitrite, Phenols, PAHs, Metals (Total Aluminum, Antimony, Arsenic, Barium, Boron, Cadmium, Chromium, Copper, Iron, Lead, Manganese, Mercury, Selenium, Silver, and Zinc)

Note: the effluent from the works shall be essentially free of floating and settleable solids and does not contain oil or any other substance in amounts enough to create a visible film, sheen or foam on the receiving waters.

Also, quarterly field temperature monitoring (four times per year representing seasonal changes) is to be completed at the following locations:

- SW1: Outlet of the North Discharge;
- SW14: second tributary upstream of the quarry discharge;
- SW7: downstream of the SW1 tributary's confluence with a second tributary;
- SW2: a tributary of Bronte Creek downstream of the Britannia Rd crossing;

2.0 2020 MONITORING RESULTS AND REPORTING

2.1 Effluent Monitoring Results

For the purposes of determining compliance with and enforcing the effluent limits, non-compliance is deemed to have occurred when the concentration limit of any single (grab) sample analyzed for a parameter named in Column 1 is greater than the corresponding maximum concentration set out in Column 2, and/or the pH is deemed to have occurred when any single measurement is outside of the indicated range. The 2020 results are presented in the following tables.

Parameter	Limit (mg/L)	WATER QUALITY RESULTS 2020											
Column 1	Column 2	Jan 27	Feb 13	Mar 23	Apr 2	May 19	Jun 10	Jul 9	Aug 10	Sept 3	Oct 6	Nov 5	Dec 8
North-West Water Quality Results													
TSS	25	2.3	2.3	3.7	1.5	<	<	2	<	<	1.3	<	1.3
Oil & Grease	15	<	2	<	<	2	<	<	2	1	2	<	<
pH (field)	6.5 to 8.5	8.05	7.95	7.95	8.06	8.28	8.37	8.45	8.46	8.32	7.99	8.14	8.08
South-Central Water Quality Results													
TSS	25	4.5	12.5	3.5	1.3	2	16.7	1.5	6	3.7	22.5	18	10
Oil & Grease	15	<	1	<1	<	12	<	<	3	2	3	<	<
pH (field)	6.5 to 8.5	7.95	8.07	7.94	8.09	8.24	8.42	8.4	8.24	8.42	8	8.08	8.12

The results indicate that the water quality is representative of historical conditions. The quarterly sampling occurred on March 25, June 10, September 3, and December 8, 2020. The complete laboratory reports are provided in Appendix B.

2.2 Field Parameters – General Water Quality

The sampling protocol for the collection of effluent samples includes the measurements for field parameters (pH, conductivity, temperature, and dissolved oxygen). The concentration of un-ionized ammonia has been calculated using the total ammonia concentration, pH and temperature. The results of field measurements for 2020 are provided in tables below.

Parameter	North-West Sump Field Parameters											
	Jan 27	Feb 13	Mar 10	Apr 2	May 19	Jun 10	Jul 9	Aug 10	Sept 3	Oct 6	Nov 5	Dec 8
Temperature (°C)	4.8	4.5	6.8	9.3	11.8	24.7	31.4	28.8	24.2	16.3	15	2.7
Conductivity (µS/cm)	886	769	836	800	784	733	691	698	757	884	854	888
Dissolved Oxygen (mg/L)	8.9	11.1	9.9	9.1	10	8.9	8.3	9.7	8.2	9.8	10.9	11.1
pH	8.03	7.27	7.89	8.16	8.12	8.24	8.26	8.52	7.97	7.95	8.07	8.03
Total Ammonia (mg/L)	0.05	0.06	0.07	<	<	<	<	<	0.03	<	<	<
Un-ionized Ammonia (mg/L)	<	<	<	<	<	<	<	<	0.003	<	<	<

Parameter	South-Central Field Parameters											
	Jan 27	Feb 13	Mar 10	Apr 2	May 19	Jun 10	Jul 9	Aug 10	Sept 3	Oct 6	Nov 5	Dec 8
Temperature (°C)	2.9	4.6	6.4	9.2	12.5	25.8	23.7	28.9	26	16.9	15	3.6
Conductivity (µS/cm)	886	922	882	1000	985	836	870	1030	1020	1100	1130	1110
Dissolved Oxygen (mg/L)	9.4	12.3	10	9.1	10.1	9.2	8.2	10	8.1	9.7	10.6	11.1
pH	8.07	7.21	7.97	8.08	8.14	8.23	8.05	8.05	7.94	7.9	8.13	7.99
Total Ammonia (mg/L)	0.13	0.07	0.07	<	0.03	<	<	0.02	0.06	0.03	<	<
Un-ionized Ammonia (mg/L)	<	<	<	<	<	<	<	<	0.008	<	<	<

2.3 Surface Water Temperature Monitoring

Quarterly field temperature monitoring (four times per year representing seasonal changes) is required at SW1, SW2, SW7, and SW14. Water temperature was collected continuously at these locations, except for SW7 where in June access to the property was no longer permitted by the homeowner. The results are presented on Figure 3.

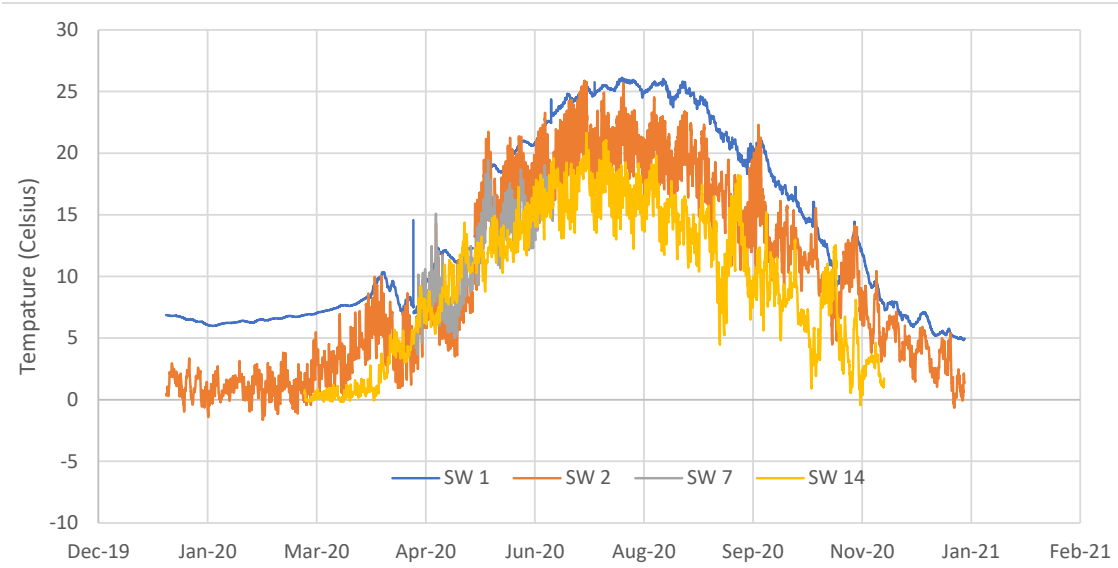

FIGURE 3: SURFACE WATER TEMPERATURE

2.4 Inspection Results and Operational Issues

There were no operational issues in 2020.

2.5 Effluent Quality Assurance or Control Measures

No effluent quality assurance or control measures were required in 2020.

2.6 Calibration and Maintenance

Wajax was retained in 2020 to complete the certification/calibration of the metering equipment at the Burlington Quarry. Seametrics FT430M-126 Mag Meters are used to measure the discharge rates at the north and south discharge locations. The results indicate that the flows are 880 L/min and 3,850 L/min, for the south and north locations, respectively. These rates were slightly over the maximum permitted instantaneous rate listed on the Permit to Take Water. Therefore, the pumps are throttled back to ensure compliance with the water taking limits.

Copies of the calibration reports are provided in Appendix C.

Nelson inspected the depth of sediment in the settling ponds in August 2020 to comply with Condition 6 of the ECA. The size of the ponds provides a large settling area. It is anticipated that the ponds will not require to be cleaned out for several years. Nelson will continue to inspect the Works at least once a year and periodically measure the amount of sediment accumulating in the settling ponds and remove the sediment, if necessary, to ensure continued suspended solids removal performance of the ponds.

2.7 Flow Monitoring to the North and South Discharge Locations

As per Condition 7(7) of the ECA, Nelson conducts continuous flow monitoring for the North Discharge and South Discharge during operation. This flow equals the discharge rate from the quarry sumps (North-West and South-Central). The total daily flows reported in 2020 are provided in Appendix D. This information has been submitted to the Water Taking Reporting System.

2.8 Complaints

There were no complaints in 2020.

2.9 Spill Occurrence

There was a spill on April 17,2020, a truck's fuel tank hit a rock or piece of shale as it was driving down in the quarry to dump its load. The truck was removed immediately from the site. Ipro Haulage (owner of the truck with the leaking fuel tank) retained Multi construction services, a subsidiary of GFL, to remove and process thescreenings pad. We also found out the volume of fuel spilt was 130 L max. The MECP was notified and the casewas closed, for reference MECP Incident Report# 1256-BNRLCW.

2.10 Notifications and Contingency Plan

There was no need to undertaken notifications or the contingency plan in 2020.

3.0 CONCLUSION

In 2020, the Burlington Quarry complied with the requirements stipulated in ECA No.: 5203-AN6NGV.

APPENDIX A

ENVIRONMENTAL COMPLIANCE APPROVAL

Ontario

Ministry of the Environment and Climate Change
Ministère de l'Environnement et de l'Action en matière de changement climatique

ENVIRONMENTAL COMPLIANCE APPROVAL

NUMBER 5203-AN6NGV
Issue Date: June 29, 2017

Lafarge Canada Inc. and Steed & Evans Holdings Inc.
operating as Nelson Aggregate Co.
Post Office Box, No. 1070
Burlington, Ontario
L7R 4L8

Site Location: Burlington Quarry - Nelson Aggregates
2433 No. 2 Side Rd
City of Burlington, Regional Municipality of Halton
L7P 0G8

You have applied under section 20.2 of Part II.1 of the Environmental Protection Act, R.S.O. 1990, c. E. 19 (Environmental Protection Act) for approval of:

Existing sewage works for the collection, transmission, treatment and disposal of surface water and quarry water from Burlington Quarry - Nelson Aggregates located in City of Burlington, Ontario, Consisting of the following:

- one (1) settling pond (North Pond), collecting groundwater and surface water runoff from the active area of the quarry, with an estimated storage volume of 230,000 m^3 at an average depth of 2.4 m, equipped with a discharge sump within the pond and submersible pump (North Discharge), discharging at a maximum release rate of 4,090 L/min to the roadside ditch of Colling Road and a tributary watercourse of Bronte Creek;

- one (1) settling pond (South Pond), collecting groundwater and surface water runoff from the active area of the quarry, with an estimated storage volume of 204,800 m^3 at an average depth of 1.8 m, equipped with a discharge sump within the pond and submersible pump (South Discharge), discharging at a maximum release rate of 945 L/min to the West Mount Nemo Tributary;

including all other controls, electrical equipment, instrumentation, piping, pumps, valves and associated appurtenances for the proper operations of the aforementioned sewage works;

all in accordance with the submitted supporting documents listed in Schedule "A" forming part of this Approval.

For the purpose of this environmental compliance approval, the following definitions apply:

"Approval" means this entire document including the application and any supporting documents listed in any schedules in this Approval;

"Director" means a person appointed by the Minister pursuant to section 5 of the EPA for the purposes of Part II.1 of the EPA;

"District Manager" means the District Manager of the Halton-Peel District Office of the Ministry*;*

"EPA" means the *Environmental Protection Act* , R.S.O. 1990, c.E.19, as amended;

"Ministry" means the ministry of the government of Ontario responsible for the EPA and OWRA and includes all officials, employees or other persons acting on its behalf;

"Owner" means Lafarge Canada Inc. and Steed & Evans Holdings Inc. operating as Nelson Aggregate Co. and its successors and assignees;

"OWRA" means the *Ontario Water Resources Act* , R.S.O. 1990, c. O.40, as amended;

"Works" means the sewage works described in the Owner's application, and this Approval.

You are hereby notified that this environmental compliance approval is issued to you subject to the terms and conditions outlined below:

TERMS AND CONDITIONS

1. GENERAL PROVISIONS

(1) The Owner shall ensure that any person authorized to carry out work on or operate any aspect of the Works is notified of this Approval and the terms and conditions herein and shall take all reasonable measures to ensure any such person complies with the same.

(2) Except as otherwise provided by these terms and conditions, the Owner shall design, build, install, operate and maintain the Works in accordance with this Approval.

(3) Where there is a conflict between a provision of this environmental compliance approval and any document submitted by the Owner, the conditions in this environmental compliance approval shall take precedence. Where there is a conflict between one or more of the documents submitted by the Owner, the Application shall take precedence unless it is clear that the purpose of the document was to amend the application.

(4) Where there is a conflict between the documents listed in the Schedule A, and the application, the application shall take precedence unless it is clear that the purpose of the document was to amend the application.

(5) The terms and conditions of this Approval are severable. If any term and condition of this environmental compliance approval, or the application of any requirement of this environmental compliance approval to any circumstance, is held invalid or unenforceable, the application of such condition to other circumstances and the remainder of this Approval shall not be affected thereby.

(6) The issuance of, and compliance with the Conditions of this Approval does not:

(a) relieve any person of any obligation to comply with any provision of any applicable statute, regulation or other legal requirement, including, but not limited to, the obligation to obtain approval from the local conservation authority necessary to construct or operate the sewage Works; or

(b) limit in any way the authority of the Ministry to require certain steps be taken to require the Owner to furnish any further information related to compliance with this Approval.

2. CHANGE OF OWNER

(1) The Owner shall notify the District Manager and the Director, in writing, of any of the following changes within **thirty (30) days** of the change occurring:

(a) change of Owner;

(b) change of address of the Owner;

(c) change of partners where the Owner is or at any time becomes a partnership, and a copy of the most recent declaration filed under the Business Names Act, R.S.O. 1990, c. B17 shall be included in the notification to the District Manager;

(d) change of name of the corporation where the Owner is or at any time becomes a corporation, and a copy of the most current information filed under the Corporations Information Act, R.S.O. 1990, c. C39 shall be included in the notification to the District Manager.

(2) In the event of any change in ownership of the Works, other than a change in ownership to the municipal, i.e. assumption of the Works, the Owner shall notify the succeeding owner in writing of the existence of this Approval, and a cop

3. OPERATIONS MANUAL

(1) The Owner shall prepare an operations manual for the sewage works described in this Approval within three months of the date of its issuance including, but not necessarily limited to, the following information:

(a) operating procedures for routine operation of the works;

(b) inspection programs, including frequency of inspection, for the works and the methods or tests employed to detect when maintenance is necessary;

(c) repair and maintenance programs, including the frequency of repair and maintenance for the works;

(d) contingency plans and procedures for dealing with potential spill, bypasses and any other abnormal situations and for notifying the District Manager; and

(e) complaint procedures for receiving and responding to public complaints.

(2) The Owner shall maintain the operations manual up to date through revisions undertaken from time to time and retain a copy at the location of the sewage works. Upon request, the Owner shall make the manual available for inspection and copying by Ministry personnel.

4. EFFLUENT LIMITS

(1) The Owner shall operate and maintain the Works such that the compliance limits of the materials named below as effluent parameters are not exceeded in the effluent from the works.

Table 1 - Effluent Limits	
Effluent Parameter	**Concentration Limit** (milligrams per litre unless otherwise indicated)
Column 1	Column 2
Total Suspended Solids	25.0
Oil and Grease	15.0
pH of the effluent maintained between 6.5 to 8.5, inclusive, at all times	

(2) For the purposes of determining compliance with and enforcing subsection (1):

(a) non-compliance with respect to a Concentration Limit is deemed to have occurred when any single (grab) sample analyzed for a parameter named in Column 1 of subsection (1) is greater than the corresponding maximum concentration set out in Column 2 of subsection (1);

(b) non-compliance with respect to pH is deemed to have occurred when any single measurement is outside of the indicated range.

5. EFFLUENT - VISUAL OBSERVATIONS

Notwithstanding any other condition in this certificate, the Owner shall ensure that the effluent from the works is essentially free of floating and settleable solids and does not contain oil or any other substance in amounts sufficient to create a visible film, sheen or foam on the receiving waters.

6. OPERATION AND MAINTENANCE

(1) The Owner shall inspect the Works at least once a year and periodically measure the amount of sediment accumulating in the settling ponds and remove the sediment, if necessary, to ensure continued suspended solids removal performance of the ponds.

(2) The Owner shall record, in a log book, the day measurement of sediment was undertaken, the amount of sediment measured, if sediment removal was undertaken and where any removed sediment

was disposed.

(3) The log book shall be retained at the site and be made available for Ministry inspection upon request.

7. MONITORING AND RECORDING

The Owner shall, upon the issuance of the Approval, carry out the following monitoring program:

(1) All samples and measurements taken for the purposes of this Approval are to be taken at a time and in a location characteristic of the quality and quantity of the effluent stream over the time period being monitored.

(2) For the purposes of this condition, the following definitions apply:

a. Monthly means once every month;
b. Quarterly means once every three months.

(3) Samples shall be collected at the following sampling points, at the frequency specified, by means of the specified sample type and analyzed for each parameter listed and all results recorded.

Table 2 - Effluent Monitoring	
Sampling Locations	1. at the end of the North Discharge pipe 2. at the end of the South Discharge pipe
Sampling Frequency	Monthly and Quarterly during Operation (see below)
Sample Type	Grab
Parameters	Monthly Monitoring Parameters pH (field), Temperature (field), Dissolved Oxygen (field), Conductivity (field), Total Suspended Solids, Total Dissolved Solids, Alkalinity, Hardness, Total Ammonia, calculated Unionized Ammonia, Oil and Grease Quarterly Monitoring Parameters Chloride, Sulphate, Total Kjeldahl Nitrogen, Dissolved Organic Carbon, Total Phosphorus, Nitrate, Nitrite, Phenols, PAHs, Metals (Total Aluminum, Antimony, Arsenic, Barium, Boron, Cadmium, Chromium, Copper, Iron, Lead, Manganese, Mercury, Selenium, Silver and Zinc)

(4) The Owner shall conduct **quarterly field temperature monitoring** (four times per year representing seasonal changes) at the following locations identified in the submitted documents of this application:

a. SW1: Outlet of the North Discharge;

b. SW14: second tributary upstream of the quarry discharge;

c. SW7: downstream of the SW1 tributary's confluence with a second tributary;

d. SW2: tributary of Bronte Creek downstream of the Britannia Rd crossing;

(5) The methods and protocols for sampling, analysis, and recording shall conform, in order of precedence, to the methods and protocols specified in the following:

(a) the Ministry's publication "Protocol for the Sampling and Analysis of Industrial/Municipal Wastewater" (August 1994), ISBN 0-7778-1880-9, as amended from time to time by more recently published editions;

(b) the publication "Standard Methods for the Examination of Water and Wastewater" (21st edition) as amended from time to time by more recently published editions; and,

(c) in respect of any parameters not mentioned in (a) or (b), the written approval of the District Manager, which approval shall be obtained prior to sampling.

(6) The temperature and pH of the effluent from the works shall be determined in the field at the time of sampling for total ammonia. The concentration of un-ionized ammonia shall be calculated using the total ammonia concentration, pH and temperature using the methodology stipulated in "Ontario's Provincial Water Quality Objectives" dated July 1994, as amended, for ammonia (un-ionized).

(7) The Owner shall conduct flow monitoring for the North Discharge and South Discharge during operation.

(8) The measurement frequencies and parameters specified in subsection (3) are minimum requirements which may, after two (2) years of monitoring in accordance with this Condition, be modified by the Director in writing from time to time.

(9) The Owner shall retain for a minimum of five (5) years from the date of their creation, all records and information related to or resulting from the monitoring activities required by this Approval.

8. SPILL CONTINGENCY AND POLLUTION PREVENTION PLAN

(1) Before the commencement of operation of the Works, the Owner shall prepare a Spill Contingency and Pollution Prevention Plan that outlines procedures as to how to mitigate the impacts of a spill within the drainage areas serviced by the Works and prevent pollution incidents, and provide a copy to the District Manager. The said plan shall include as a minimum, but not limited to:

(a) the name, job title and 24-hour telephone number of the person(s) responsible for activating the Spill Contingency and Pollution Prevention Plan;

(b) a site plan drawn to scale showing the types of business, streets, catch basins and/or manholes

and/or ditches and/or drainage channels , drainage patterns (including direction(s) of flow in storm sewers) and any features which need to be taken into account in terms of potential impacts on access and response (including physical obstructions and location of response and clean-up equipment);

(c) steps to be taken to report, contain, clean up and dispose of contaminants following a spill;

(d) a listing of telephone numbers for: local clean-up companies who may be called upon to assist in responding to spills; local emergency responders including health institution(s); and Ministry of the Environment and Climate Change (MOECC) Spills Action Centre 1-800-268-6060;

(e) Materials Safety Data Sheets (MSDS) for each and every hazardous material which may be transported or stored within the area serviced by the Works;

(f) a description of the spill response and pollution prevention training provided to employees assigned to work in the area serviced by the Works, the date(s) on which the training was provided and to whom;

(g) an inventory of response and clean-up equipment available to implement the Spill Contingency and Pollution Prevention Plan, location and date of maintenance/replacement if warranted, including testing and calibration of the equipment; and

(h) the date on which the Spill Contingency and Pollution Prevention Plan was prepared and subsequently, amended.

(2) The Spill Contingency and Pollution Prevention Plan shall be kept in a conspicuous place near the reception area on site.

(3) The Spill Contingency and Pollution Prevention Plan will be amended from time to time as needed by changes in the operation of the facility or to reflect updates in the Municipal By-Laws, or improved Best Management Practices by the Owner.

9. REPORTING

(1) The Owner shall report to the District Manager or designate, any exceedance of any parameter specified in Condition 4 orally, as soon as reasonably possible, and in writing within seven (7) days of the exceedance.

(2) The Owner shall, upon request, make all manuals, plans, records, data, procedures and supporting documentation available to Ministry staff.

(3) In addition to the obligations under Part X of the *Environmental Protection Act* , the Owner shall, within ten (10) working days of the occurrence of any reportable spill as defined in Ontario Regulation 675/98, bypass or loss of any product, by-product, intermediate product, oil, solvent, waste material or any other polluting substance into the environment, submit a full written report of the occurrence to the District Manager describing the cause and discovery of the spill or loss, clean-up and recovery measures

taken, preventative measures to be taken and schedule of implementation.

(4) The Owner shall prepare and submit a performance report to the District Manager on an annual basis within 60 days following the end of the period being reported upon. The first such report shall cover the first annual period following the commencement of operation of the works and subsequent reports shall be submitted to cover successive annual periods following thereafter. The reports shall contain, but shall not be limited to, the following information:

(a) a summary and interpretation of all monitoring data and a comparison to the effluent limits outlined in Condition 4, including an overview of the success and adequacy of the Works;

(b) a description of any operating problems encountered and corrective actions taken;

(c) a summary of all inspection, maintenance and clean-out carried out on any major structure, equipment, apparatus, mechanism or thing forming part of the Works;

(d) a summary of any effluent quality assurance or control measures undertaken in the reporting period;

(e) a summary of the calibration and maintenance carried out on all effluent monitoring equipment;

(f) a summary of any complaints received during the reporting period and any steps taken to address the complaints;

(g) a summary of all spill or abnormal discharge events; and,

(h) a summary of any Notifications and Contingency Plan undertaken during the reporting period and a discussion regarding their adequacy.

Schedule "A"

1. Application for Approval of Industrial Sewage Works, dated March 10, 2016, submitted by Daniel Twigger, C.C. Tatham & Associates Ltd.;

2. Environmental Compliance Application Report dated March 10, 2016, prepared by C.C. Tatham & Associates Ltd.;

3. Supplemental Information memo dated April 21, 2017, prepared by Dan Hurley from C.C. Tatham & Associates Ltd.;

4. All additional supporting information submitted by Daniel Twigger and Dan Hurley from C.C. Tatham & Associates Ltd. from July 2016 to June, 2017.

The reasons for the imposition of these terms and conditions are as follows:

1. Condition 1 is imposed to ensure that the Works are constructed and operated in the manner in which they were described and upon which approval was granted. This condition is also included to emphasize the precedence of Conditions in the Approval and the practice that the Approval is based on the most current document, if several conflicting documents are submitted for review.

2. Condition 2 is included to ensure that the Ministry records are kept accurate and current with respect to approved Works and to ensure that subsequent owners of the Works are made aware of the Approval and continue to operate the Works in compliance with it.

3. Condition 3 is included to ensure that a comprehensive operations manual governing all significant areas of operation, maintenance and repair is prepared, implemented and kept up-to-date by the owner and made available to the Ministry. Such a manual is an integral part of the operation of the works. Its compilation and use should assist the owner in staff training, in proper plant operation and in identifying and planning for contingencies during possible abnormal conditions. The manual will also act as a benchmark for Ministry staff when reviewing the owner's operation of the work.

4. Conditions 4 and 5 are imposed to ensure that the effluent discharged from the Works to the environment meets the Ministry's effluent quality requirements thus minimizing environmental impact on the receiver and to protect water quality, fish and other aquatic life in the receiving water body.

5. Condition 6 is included to require that the Works be properly operated and maintained such that the environment is protected.

6. Condition 7 is included to enable the Owner to evaluate and demonstrate the performance of the Works, on a continual basis, so that the Works are properly operated and maintained at a level which is consistent with the design objectives specified in the Approval and that the Works do not cause any impairment to the receiving watercourse.

7. Condition 8 is included to ensure that the Ministry is immediately informed of the occurrence of an emergency or otherwise abnormal situation so that appropriate steps are taken to address the immediate concerns regarding the protection of public health and minimizing environmental damage and to be able to devise an overall abatement strategy to prevent long term degradation and the re-occurrence of the situation.

8. Condition 9 is included to provide a performance record for future references, to ensure that the Ministry is made aware of problems as they arise, and to provide a compliance record for all the terms and conditions outlined in this Approval,so that the Ministry can work with the Owner in resolving any problems in a timely manner.

In accordance with Section 139 of the Environmental Protection Act, you may by written Notice served upon me, the Environmental Review Tribunal and in accordance with Section 47 of the Environmental Bill of Rights, 1993, S.O. 1993, c. 28 (Environmental Bill of Rights), the Environmental Commissioner, within 15

days after receipt of this Notice, require a hearing by the Tribunal. The Environmental Commissioner will place notice of your appeal on the Environmental Registry. Section 142 of the Environmental Protection Act provides that the Notice requiring the hearing shall state:

a. The portions of the environmental compliance approval or each term or condition in the environmental compliance approval in respect of which the hearing is required, and;
b. The grounds on which you intend to rely at the hearing in relation to each portion appealed.

The Notice should also include:

1. The name of the appellant;
2. The address of the appellant;
3. The environmental compliance approval number;
4. The date of the environmental compliance approval;
5. The name of the Director, and;
6. The municipality or municipalities within which the project is to be engaged in.

And the Notice should be signed and dated by the appellant.

This Notice must be served upon:

The Secretary*
Environmental Review Tribunal
655 Bay Street, Suite 1500
Toronto, Ontario
M5G 1E5

AND

The Environmental Commissioner
1075 Bay Street, Suite 605
Toronto, Ontario
M5S 2B1

AND

The Director appointed for the purposes of
Part II.1 of the Environmental Protection Act
Ministry of the Environment and
Climate Change
135 St. Clair Avenue West, 1st Floor
Toronto, Ontario
M4V 1P5

*** Further information on the Environmental Review Tribunal's requirements for an appeal can be obtained directly from the Tribunal at: Tel: (416) 212-6349, Fax: (416) 326-5370 or www.ert.gov.on.ca**

This instrument is subject to Section 38 of the Environmental Bill of Rights, 1993, that allows residents of Ontario to seek leave to appeal the decision on this instrument. Residents of Ontario may seek leave to appeal within 15 days from the date this decision is placed on the Environmental Registry. By accessing the Environmental Registry at www.ebr.gov.on.ca , you can determine when the leave to appeal period ends.

The above noted activity is approved under s.20.3 of Part II.1 of the Environmental Protection Act.

DATED AT TORONTO this 29th day of June, 2017



Fariha Pannu, P.Eng.
Director
appointed for the purposes of Part II.1 of the
Environmental Protection Act

YZ/
c: District Manager, MOECC Halton-Peel District Office
Daniel Twigger, C.C. Tatham & Associates Ltd.

APPENDIX B

WATER QUALITY RESULTS

TESTMARK Laboratories Ltd.
Committed to Quality and Service

CERTIFICATE OF ANALYSIS

Client:	Tecia White	Work Order Number:	392951
Company:	Whitewater Hydrogeology Ltd.	PO #:	
Address:	80 Chamberlain Cres Collingwood, ON, L9Y 0C8	Regulation: Project #:	Information not provided Nelson Aggregates - Burlington Quarry Monthly ECA
Phone:	(705) 888-7064	DWS #:	
Email:	tecia@white-water.ca	Sampled By:	
Date Order Received:	1/30/2020	Analysis Started:	1/30/2020
Arrival Temperature:	21.2 °C	Analysis Completed:	2/4/2020

WORK ORDER SUMMARY

ANALYSES WERE PERFORMED ON THE FOLLOWING SAMPLES. THE RESULTS RELATE ONLY TO THE ITEMS TESTED.

Sample Description	Lab ID	Matrix	Type	Comments	Date Collected	Time Collected
SC Sump	1513217	Water	None		1/27/2020	12:00 PM
NW Sump	1513218	Water	None		1/27/2020	1:00 PM

METHODS AND INSTRUMENTATION

THE FOLLOWING METHODS WERE USED FOR YOUR SAMPLE(S):

Method	Lab	Description	Reference
Alkalinity (A1.0)	Mississauga	Determination of Alkalinity by Titration	Modified from APHA-2320B
Ammonia Water (A42)	Mississauga	Determination of Ammonia/Ammonium in Water	Modified from EPA 350.1
Conductivity of Water (A12)	Mississauga	Determination of Conductivity in Water at 25°C	Modified from SM 2510 B
Dissolved Oxygen (A3)	Mississauga	Determination of Dissolved Oxygen in Water	Modified from APHA-5210
Field pH (R112)	Mississauga	Client Supplied Field Determination of pH of Water	Field Test
Field Temp (R113)	Mississauga	Client Supplied Field Determination of Temperature of Water	Field Test
Oil and Grease (A54)	Mississauga	Determination of Oil and Grease in Water	Modified from EPA 1664
pH of Water (A2.0)	Mississauga	Determination of Water pH by Ion Selective Electrode	Modified from APHA-4500H+ B
Reg. Hardness (A13)	Mississauga	Determination of Total Hardness	Modified from APHA-2340B
TDS (A27)	Mississauga	Determination of Total Dissolved Solids in water by gravimetry	Modified from SM-2540

6820 Kitimat Road Unit 4, Mississauga, ON, L5N 5M3
Phone: (905) 821-1112 Fax: (905) 821-2095 Web: www.testmark.ca

CERTIFICATE OF ANALYSIS

Whitewater Hydrogeology Ltd.

Work Order Number: 392951

Method	Lab	Description	Reference
TSS (A27)	Mississauga	Determination of Total Suspended Solids in water by gravimetry	Modified from SM-2540
Un-Ionized NH3 (A42.4)	Mississauga	Calculation of Un-Ionized Ammonia	Modified from APHA-4500

This report has been approved by:

Marc Creighton
Laboratory Director

6820 Kitimat Road Unit 4, Mississauga, ON, L5N 5M3
Phone: (905) 821-1112 Fax: (905) 821-2095 Web: www.testmark.ca

CERTIFICATE OF ANALYSIS

Whitewater Hydrogeology Ltd.

Work Order Number: 392951

WORK ORDER RESULTS

Sample Description	SC Sump		NW Sump		
Sample Date	1/27/2020 12:00 PM		1/27/2020 1:00 PM		
Lab ID	1513217		1513218		
Field Parameters	Result	MDL	Result	MDL	Units
Field pH	7.95	N/A	8.05	N/A	pH
Field Temp	2.9	N/A	4.8	N/A	°C

Sample Description	SC Sump		NW Sump		
Sample Date	1/27/2020 12:00 PM		1/27/2020 1:00 PM		
Lab ID	1513217		1513218		
General Chemistry	Result	MDL	Result	MDL	Units
Ammonia (as N)	0.13 [0.13]	0.01	0.05	0.01	mg/L
Conductivity	886	1	886	1	µS/cm
Dissolved Oxygen	9.4	0.2	8.9	0.2	mg/L
M-Alkalinity (pH 4.5)	159	2	165	2	mg/L as CaCO3
Oil and Grease, Animal (Calc.)	<1	1	<1	1	mg/L
Oil and Grease, Mineral	<1	1	<1	1	mg/L
Oil and Grease, Total	<1	1	<1	1	mg/L
pH	8.07	N/A	8.03	N/A	pH
Total Hardness (as CaCO3) (Calc.)	448.0	0.1	364.0	0.1	mg/L
Un-Ionized Ammonia (Calc.)	<0.002 [<0.002]	0.002	<0.002	0.002	mg/L

6820 Kitimat Road Unit 4, Mississauga, ON, L5N 5M3
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CERTIFICATE OF ANALYSIS

Whitewater Hydrogeology Ltd.

Work Order Number: 392951

Sample Description	SC Sump		NW Sump		
Sample Date	1/27/2020 12:00 PM		1/27/2020 1:00 PM		
Lab ID	1513217		1513218		
Solids	Result	MDL	Result	MDL	Units
Total Dissolved Solids	706 [712]	2	583	2	mg/L
Total Suspended Solids	4.5 [5]	1	2.30	0.67	mg/L

LEGEND

Dates: Dates are formatted as mm/dd/year throughout this report.

[rr]: After a parameter name indicates a re-run of that parameter. If multiple re-runs exist they are suffixed by a number. Sample may not have been handled according to the recommended temperature, hold time and head space requirements of the method after the initial analysis.

MDL: Method detection limit or minimum reporting limit.

[ ]: Results for laboratory replicates are shown in square brackets immediately below the associated sample result for ease of comparison.

Quality Control: All associated Quality Control data is available on request.

Exceedences: HIGHLIGHTED CELLS INDICATE THAT THE RESULT EXCEEDS A REGULATORY LIMIT. CALCULATED UNCERTAINTY ESTIMATIONS ARE NOT APPLIED FOR DETERMINING SAMPLE EXCEEDANCES.

Benzo(b)fluoranthene: Results for benzo(b)fluoranthene may include contributions from benzo(j)fluoranthene.

Field Data: Reports containing Field Parameters represent data that has been collected and provided by the client. Testmark is not responsible for the validity of this data which may be used in subsequent calculations.

Sample Condition Deviations: A noted sample condition deviation may affect the validity of the result. Results apply to the sample(s) as received.

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CERTIFICATE OF ANALYSIS

Client:	Tecia White	Work Order Number:	393862
Company:	Whitewater Hydrogeology Ltd.	PO #:	
Address:	80 Chamberlain Cres Collingwood, ON, L9Y 0C8	Regulation:	None
		Project #:	Nelson Aggregates - Burlington Quarry Monthly ECA
Phone:	(705) 888-7064	DWS #:	
Email:	tecia@white-water.ca	Sampled By:	Hudson Selles
Date Order Received:	2/13/2020	Analysis Started:	2/13/2020
Arrival Temperature:	6.3 °C	Analysis Completed:	2/20/2020

WORK ORDER SUMMARY

ANALYSES WERE PERFORMED ON THE FOLLOWING SAMPLES. THE RESULTS RELATE ONLY TO THE ITEMS TESTED.

Sample Description	Lab ID	Matrix	Type	Comments	Date Collected	Time Collected
NW Sump	1516071	Water	None		2/13/2020	9:00 AM
SC Sump	1516072	Water	None		2/13/2020	9:00 AM

METHODS AND INSTRUMENTATION

THE FOLLOWING METHODS WERE USED FOR YOUR SAMPLE(S):

Method	Lab	Description	Reference
Alkalinity (A1.0)	Mississauga	Determination of Alkalinity by Titration	Modified from APHA-2320B
Ammonia Water (A42)	Mississauga	Determination of Ammonia/Ammonium in Water	Modified from EPA 350.1
Conductivity of Water (A12)	Mississauga	Determination of Conductivity in Water at 25°C	Modified from SM 2510 B
Dissolved Oxygen (A3)	Mississauga	Determination of Dissolved Oxygen in Water	Modified from APHA-5210
Field pH (R112)	Mississauga	Client Supplied Field Determination of pH of Water	Field Test
Field Temp (R113)	Mississauga	Client Supplied Field Determination of Temperature of Water	Field Test
Oil and Grease (A54)	Mississauga	Determination of Oil and Grease in Water	Modified from EPA 1664
pH of Water (A2.0)	Mississauga	Determination of Water pH by Ion Selective Electrode	Modified from APHA-4500H+ B
Reg. Hardness (A13)	Mississauga	Determination of Total Hardness	Modified from APHA-2340B
TDS (A27)	Mississauga	Determination of Total Dissolved Solids in water by gravimetry	Modified from SM-2540

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Method	Lab	Description	Reference
TSS (A27)	Mississauga	Determination of Total Suspended Solids in water by gravimetry	Modified from SM-2540
Un-Ionized NH3 (A42.4)	Mississauga	Calculation of Un-Ionized Ammonia	Modified from APHA-4500

This report has been approved by:

Marc Creighton
Laboratory Director

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CERTIFICATE OF ANALYSIS

Whitewater Hydrogeology Ltd.

Work Order Number: 393862

WORK ORDER RESULTS

Sample Description	NW Sump		SC Sump		
Sample Date	2/13/2020 9:00 AM		2/13/2020 9:00 AM		
Lab ID	1516071		1516072		
Field Parameters	Result	MDL	Result	MDL	Units
Field pH	7.95	N/A	8.07	N/A	pH
Field Temp	4.5	N/A	4.6	N/A	°C

Sample Description	NW Sump		SC Sump		
Sample Date	2/13/2020 9:00 AM		2/13/2020 9:00 AM		
Lab ID	1516071		1516072		
General Chemistry	Result	MDL	Result	MDL	Units
Ammonia (as N)	0.06 [0.06]	0.01	0.07	0.01	mg/L
Conductivity	769	1	922	1	µS/cm
Dissolved Oxygen	11.1	0.2	12.3	0.2	mg/L
M-Alkalinity (pH 4.5)	159	2	157	2	mg/L as CaCO3
Oil and Grease, Animal (Calc.)	2	1	1	1	mg/L
Oil and Grease, Mineral	<1	1	<1	1	mg/L
Oil and Grease, Total	2	1	1	1	mg/L
pH	7.27	N/A	7.21	N/A	pH
Total Hardness (as CaCO3) (Calc.)	331.0	0.1	403.0	0.1	mg/L
Un-Ionized Ammonia (Calc.)	<0.002	0.002	<0.002	0.002	mg/L

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Whitewater Hydrogeology Ltd.

Work Order Number: 393862

Sample Description	NW Sump		SC Sump		
Sample Date	2/13/2020 9:00 AM		2/13/2020 9:00 AM		
Lab ID	1516071		1516072		
Solids	Result	MDL	Result	MDL	Units
Total Dissolved Solids	582	2	704 [712]	2	mg/L
Total Suspended Solids	2.30	0.67	12.5 [13.5]	1	mg/L

LEGEND

Dates: Dates are formatted as mm/dd/year throughout this report.

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MDL: Method detection limit or minimum reporting limit.

[ ]: Results for laboratory replicates are shown in square brackets immediately below the associated sample result for ease of comparison.

Quality Control: All associated Quality Control data is available on request.

Exceedences: HIGHLIGHTED CELLS INDICATE THAT THE RESULT EXCEEDS A REGULATORY LIMIT. CALCULATED UNCERTAINTY ESTIMATIONS ARE NOT APPLIED FOR DETERMINING SAMPLE EXCEEDANCES.

Benzo(b)fluoranthene: Results for benzo(b)fluoranthene may include contributions from benzo(j)fluoranthene.

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Sample Condition Deviations: A noted sample condition deviation may affect the validity of the result. Results apply to the sample(s) as received.

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CERTIFICATE OF ANALYSIS

Client:	Tecia White	Work Order Number:	395681
Company:	Whitewater Hydrogeology Ltd.	PO #:	
Address:	80 Chamberlain Cres Collingwood, ON, L9Y 0C8	Regulation: Project #:	None Nelson Aggregates - Burlington Quarry Monthly ECA
Phone:	(705) 888-7064	DWS #:	
Email:	tecia@white-water.ca	Sampled By:	Hudson Selles
Date Order Received:	3/12/2020	Analysis Started:	3/12/2020
Arrival Temperature:	8.2 °C	Analysis Completed:	3/18/2020

WORK ORDER SUMMARY

ANALYSES WERE PERFORMED ON THE FOLLOWING SAMPLES. THE RESULTS RELATE ONLY TO THE ITEMS TESTED.

Sample Description	Lab ID	Matrix	Type	Comments	Date Collected	Time Collected
NW Sump	1522003	Water	None		3/10/2020	9:00 AM
SC Sump	1522004	Water	None		3/10/2020	9:00 AM

METHODS AND INSTRUMENTATION

THE FOLLOWING METHODS WERE USED FOR YOUR SAMPLE(S):

Method	Lab	Description	Reference
Alkalinity (A1.0)	Mississauga	Determination of Alkalinity by Titration	Modified from APHA-2320B
Ammonia Water (A42)	Mississauga	Determination of Ammonia/Ammonium in Water	Modified from EPA 350.1
Conductivity of Water (A12)	Mississauga	Determination of Conductivity in Water at 25°C	Modified from SM 2510 B
Dissolved Oxygen (A3)	Mississauga	Determination of Dissolved Oxygen in Water	Modified from APHA-5210
Field pH (R112)	Mississauga	Client Supplied Field Determination of pH of Water	Field Test
Field Temp (R113)	Mississauga	Client Supplied Field Determination of Temperature of Water	Field Test
Oil and Grease (A54)	Mississauga	Determination of Oil and Grease in Water	Modified from EPA 1664
pH of Water (A2.0)	Mississauga	Determination of Water pH by Ion Selective Electrode	Modified from APHA-4500H+ B
Reg. Hardness (A13)	Mississauga	Determination of Total Hardness	Modified from APHA-2340B
TDS (A27)	Mississauga	Determination of Total Dissolved Solids in water by gravimetry	Modified from SM-2540

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Work Order Number: 395681

Method	Lab	Description	Reference
TSS (A27)	Mississauga	Determination of Total Suspended Solids in water by gravimetry	Modified from SM-2540
Un-Ionized NH3 (A42.4)	Mississauga	Calculation of Un-Ionized Ammonia	Modified from APHA-4500

This report has been approved by:

Marc Creighton
Laboratory Director

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CERTIFICATE OF ANALYSIS

Whitewater Hydrogeology Ltd.

Work Order Number: 395681

WORK ORDER RESULTS

Sample Description	NW Sump		SC Sump		
Sample Date	3/10/2020 9:00 AM		3/10/2020 9:00 AM		
Lab ID	1522003		1522004		
Field Parameters	Result	MDL	Result	MDL	Units
Field pH	7.83	N/A	7.95	N/A	pH
Field Temp	6.8	N/A	6.4	N/A	°C

Sample Description	NW Sump		SC Sump		
Sample Date	3/10/2020 9:00 AM		3/10/2020 9:00 AM		
Lab ID	1522003		1522004		
General Chemistry	Result	MDL	Result	MDL	Units
Ammonia (as N)	0.07 [0.07]	0.01	0.07	0.01	mg/L
Conductivity	836	1	882	1	µS/cm
Dissolved Oxygen	9.9	0.2	10.0	0.2	mg/L
M-Alkalinity (pH 4.5)	185	2	177	2	mg/L as CaCO3
Oil and Grease, Animal (Calc.)	<1	1	<1	1	mg/L
Oil and Grease, Mineral	<1	1	<1	1	mg/L
Oil and Grease, Total	<1	1	<1	1	mg/L
pH	7.89	N/A	7.97	N/A	pH
Total Hardness (as CaCO3) (Calc.)	356.0	0.1	426.0	0.1	mg/L
Un-Ionized Ammonia (Calc.)	<0.002 [<0.002]	0.002	<0.002	0.002	mg/L

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Whitewater Hydrogeology Ltd.

Work Order Number: 395681

Sample Description	NW Sump		SC Sump		
Sample Date	3/10/2020 9:00 AM		3/10/2020 9:00 AM		
Lab ID	1522003		1522004		
Solids	Result	MDL	Result	MDL	Units
Total Dissolved Solids	565	2	664 [649]	2	mg/L
Total Suspended Solids	2.00	0.67	6.5 [6.5]	1	mg/L

LEGEND

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MDL: Method detection limit or minimum reporting limit.

[ ]: Results for laboratory replicates are shown in square brackets immediately below the associated sample result for ease of comparison.

Quality Control: All associated Quality Control data is available on request.

Exceedences: HIGHLIGHTED CELLS INDICATE THAT THE RESULT EXCEEDS A REGULATORY LIMIT. CALCULATED UNCERTAINTY ESTIMATIONS ARE NOT APPLIED FOR DETERMINING SAMPLE EXCEEDANCES.

Benzo(b)fluoranthene: Results for benzo(b)fluoranthene may include contributions from benzo(j)fluoranthene.

Field Data: Reports containing Field Parameters represent data that has been collected and provided by the client. Testmark is not responsible for the validity of this data which may be used in subsequent calculations.

Sample Condition Deviations: A noted sample condition deviation may affect the validity of the result. Results apply to the sample(s) as received.

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CERTIFICATE OF ANALYSIS

Client:	Tecia White	Work Order Number:	396374
Company:	Whitewater Hydrogeology Ltd.	PO #:	
Address:	80 Chamberlain Cres Collingwood, ON, L9Y 0C8	Regulation: Project #:	Nelson Water Criteria Nelson Aggregates - Burlington Quarry Quaterly ECA
Phone:	(705) 888-7064	DWS #:	
Email:	tecia@white-water.ca	Sampled By:	Hudson Selles
Date Order Received:	3/25/2020	Analysis Started:	3/25/2020
Arrival Temperature:	8.3 °C	Analysis Completed:	4/3/2020

WORK ORDER SUMMARY

ANALYSES WERE PERFORMED ON THE FOLLOWING SAMPLES. THE RESULTS RELATE ONLY TO THE ITEMS TESTED.

Sample Description	Lab ID	Matrix	Type	Comments	Date Collected	Time Collected
NW Sump	1524492	Water	None		3/23/2020	9:00 AM
SC Sump	1524493	Water	None		3/23/2020	9:00 AM

METHODS AND INSTRUMENTATION

THE FOLLOWING METHODS WERE USED FOR YOUR SAMPLE(S):

Method	Lab	Description	Reference
Alkalinity (A1.0)	Mississauga	Determination of Alkalinity by Titration	Modified from APHA-2320B
Ammonia Water (A42)	Mississauga	Determination of Ammonia/Ammonium in Water	Modified from EPA 350.1
Anions Water (mg/L by IC) (A5)	Mississauga	Determination of Anions in Water by Ion Chromatography	Modified from SW846-9056A
Conductivity of Water (A12)	Mississauga	Determination of Conductivity in Water at 25°C	Modified from SM 2510 B
Dissolved Oxygen (A3)	Mississauga	Determination of Dissolved Oxygen in Water	Modified from APHA-5210
DOC Water (A55.1)	Garson	Determination of Dissolved Organic Carbon in Water	Modified from SM-5310 C
Field pH (R112)	Mississauga	Client Supplied Field Determination of pH of Water	Field Test
Field Temp (R113)	Mississauga	Client Supplied Field Determination of Temperature of Water	Field Test
ICPMS Tot. Water (A13)	Mississauga	Determination of Total Metals in Water by ICP/MS with Digestion	Modified from SW846-6020
Oil and Grease (A54)	Mississauga	Determination of Oil and Grease in Water	Modified from EPA 1664

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CERTIFICATE OF ANALYSIS

Whitewater Hydrogeology Ltd.

Work Order Number: 396374

Method	Lab	Description	Reference
PAH TO SU Water SIM (A41)	Garson	Determination of PAH in Water by GC/MS	Modified from SW846-8270D
pH of Water (A2.0)	Mississauga	Determination of Water pH by Ion Selective Electrode	Modified from APHA-4500H+ B
Phenols 4AAP (T38)	Mississauga	Determination of Total Phenols by 4AAP	Modified from APHA-5530
Reg. Hardness (A13)	Mississauga	Determination of Total Hardness	Modified from APHA-2340B
TDS (A27)	Mississauga	Determination of Total Dissolved Solids in water by gravimetry	Modified from SM-2540
TKN Water Dig. (A58)	Kirkland Lake	Determination of Total Kjeldahl Nitrogen in Waters with Block Digestion.	Modified from SM-4500 NORG-D
TP Water (A23.2)	Kirkland Lake	Determination of Total Phosphorus in Water.	Modified from EPA 365.3 and ESS 310.2,
TSS (A27)	Mississauga	Determination of Total Suspended Solids in water by gravimetry	Modified from SM-2540
Un-Ionized NH3 (A42.4)	Mississauga	Calculation of Un-Ionized Ammonia	Modified from APHA-4500

This report has been approved by:



Marc Creighton
Laboratory Director

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CERTIFICATE OF ANALYSIS

Whitewater Hydrogeology Ltd.

Work Order Number: 396374

WORK ORDER RESULTS

Sample Description	NW Sump		SC Sump			
Sample Date	3/23/2020 9:00 AM		3/23/2020 9:00 AM			
Lab ID	1524492		1524493			
Anions	Result	MDL	Result	MDL	Units	Criteria: Nelson Water Criteria
Bromide	<0.1 [<0.1]	0.1	<0.1	0.1	mg/L	~
Chloride	71.7 [72.2]	0.2	88.4	0.2	mg/L	~
Fluoride	0.16 [0.16]	0.06	0.18	0.06	mg/L	~
Nitrate (as N)	0.09 [0.09]	0.05	0.22	0.05	mg/L	~
Nitrite (as N)	<0.05 [<0.05]	0.05	<0.05	0.05	mg/L	~
Sulphate	130.0 [131.0]	0.3	247.0	0.3	mg/L	~

Sample Description	NW Sump		SC Sump			
Sample Date	3/23/2020 9:00 AM		3/23/2020 9:00 AM			
Lab ID	1524492		1524493			
Field Parameters	Result	MDL	Result	MDL	Units	Criteria: Nelson Water Criteria
Field pH	7.95	N/A	7.94	N/A	pH	~
Field Temp	5.39	N/A	4.29	N/A	°C	~

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Whitewater Hydrogeology Ltd.

Work Order Number: 396374

Sample Description	NW Sump		SC Sump			
Sample Date	3/23/2020 9:00 AM		3/23/2020 9:00 AM			
Lab ID	1524492		1524493			
General Chemistry	Result	MDL	Result	MDL	Units	Criteria: Nelson Water Criteria
Ammonia (as N)	0.03 [0.04]	0.01	0.09	0.01	mg/L	~
Conductivity	750	1	1010	1	µS/cm	~
Dissolved Organic Carbon	4.0 [3.8]	0.4	2.5	0.4	mg/L	~
Dissolved Oxygen	10.1	0.2	10.8	0.2	mg/L	~
M-Alkalinity (pH 4.5)	180	2	197	2	mg/L as CaCO3	~
Oil and Grease, Animal (Calc.)	<1	1	<1	1	mg/L	~
Oil and Grease, Mineral	<1	1	<1	1	mg/L	~
Oil and Grease, Total	<1	1	<1	1	mg/L	15
pH	7.88	N/A	7.96	N/A	pH	8.5
Total Hardness (as CaCO3) (Calc.)	272.0	0.1	410.0	0.1	mg/L	~
Total Kjeldahl Nitrogen	1.9	0.4	3.6	0.4	mg/L	~
Total Phenols	0.0014	0.0004	0.0016	0.0004	mg/L	~
Total Phosphorus (as P)	0.017	0.002	0.014	0.002	mg/L	~
Un-Ionized Ammonia (Calc.)	<0.002 [<0.002]	0.002	<0.002	0.002	mg/L	~

Sample Description	NW Sump		SC Sump			
Sample Date	3/23/2020 9:00 AM		3/23/2020 9:00 AM			
Lab ID	1524492		1524493			
Metals (Total)	Result	MDL	Result	MDL	Units	Criteria: Nelson Water Criteria
Total Aluminum	112 [116]	1	41	1	ug/L	~
Total Antimony	<0.5 [<0.5]	0.5	0.7	0.5	ug/L	~

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CERTIFICATE OF ANALYSIS

Whitewater Hydrogeology Ltd.

Work Order Number: 396374

Sample Description	NW Sump		SC Sump			
Sample Date	3/23/2020 9:00 AM		3/23/2020 9:00 AM			
Lab ID	1524492		1524493			
Metals (Total)	Result	MDL	Result	MDL	Units	Criteria: Nelson Water Criteria
Total Arsenic	2 [2]	1	2	1	ug/L	~
Total Barium	35 [36]	1	32	1	ug/L	~
Total Beryllium	<0.5 [<0.5]	0.5	<0.5	0.5	ug/L	~
Total Bismuth	<1 [<1]	1	<1	1	ug/L	~
Total Boron	58 [61]	2	120	2	ug/L	~
Total Cadmium	0.04 [0.04]	0.02	0.04	0.02	ug/L	~
Total Calcium	72900 [73200]	500	107000	500	ug/L	~
Total Cerium	<1 [<1]	1	<1	1	ug/L	~
Total Cesium	<1 [<1]	1	<1	1	ug/L	~
Total Chromium	<1 [<1]	1	<1	1	ug/L	~
Total Cobalt	0.3 [0.3]	0.1	0.8	0.1	ug/L	~
Total Copper	2 [2]	1	2	1	ug/L	~
Total Europium	<1 [<1]	1	<1	1	ug/L	~
Total Gallium	<1 [<1]	1	<1	1	ug/L	~
Total Iron	268 [280]	20	305	20	ug/L	~
Total Lanthanum	<1 [<1]	1	<1	1	ug/L	~
Total Lead	0.2 [0.2]	0.1	0.2	0.1	ug/L	~

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CERTIFICATE OF ANALYSIS

Whitewater Hydrogeology Ltd.

Work Order Number: 396374

Sample Description	NW Sump		SC Sump			
Sample Date	3/23/2020 9:00 AM		3/23/2020 9:00 AM			
Lab ID	1524492		1524493			
Metals (Total)	Result	MDL	Result	MDL	Units	Criteria: Nelson Water Criteria
Total Lithium	7 [7]	5	13	5	ug/L	~
Total Magnesium	28900 [29900]	4	39600	4	ug/L	~
Total Manganese	43 [49]	1	40	1	ug/L	~
Total Mercury	<0.1 [<0.1]	0.1	<0.1	0.1	ug/L	~
Total Molybdenum	2 [2]	1	5	1	ug/L	~
Total Nickel	3 [3]	1	6	1	ug/L	~
Total Niobium	<1 [<1]	1	<1	1	ug/L	~
Total Phosphorus	<50 [<50]	50	<50	50	ug/L	~
Total Potassium	4490 [4620]	100	5140	100	ug/L	~
Total Rubidium	2 [2]	1	2	1	ug/L	~
Total Scandium	<1 [<1]	1	<1	1	ug/L	~
Total Selenium	<0.5 [0.9]	0.5	0.9	0.5	ug/L	~
Total Silicon	1590 [1670]	2	1360	2	ug/L	~
Total Silver	<0.1 [<0.1]	0.1	<0.1	0.1	ug/L	~
Total Sodium	38500 [38900]	1000	45000	1000	ug/L	~
Total Strontium	769 [799]	1	1440	10	ug/L	~
Total Sulphur	42100 [43400]	800	75900	800	ug/L	~

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CERTIFICATE OF ANALYSIS

Whitewater Hydrogeology Ltd.

Work Order Number: 396374

Sample Description	NW Sump		SC Sump			
Sample Date	3/23/2020 9:00 AM		3/23/2020 9:00 AM			
Lab ID	1524492		1524493			
Metals (Total)	Result	MDL	Result	MDL	Units	Criteria: Nelson Water Criteria
Total Tellurium	<1 [<1]	1	<1	1	ug/L	~
Total Thallium	<0.1 [<0.1]	0.1	<0.1	0.1	ug/L	~
Total Thorium	<1 [<1]	1	<1	1	ug/L	~
Total Tin	<1 [<1]	1	<1	1	ug/L	~
Total Titanium	3 [4]	1	1	1	ug/L	~
Total Tungsten	<1 [<1]	1	<1	1	ug/L	~
Total Uranium	<1 [<1]	1	1	1	ug/L	~
Total Vanadium	<1 [<1]	1	<1	1	ug/L	~
Total Yttrium	<1 [<1]	1	<1	1	ug/L	~
Total Zinc	12 [12]	1	10	1	ug/L	~
Total Zirconium	<1 [<1]	1	<1	1	ug/L	~

Sample Description	NW Sump		SC Sump			
Sample Date	3/23/2020 9:00 AM		3/23/2020 9:00 AM			
Lab ID	1524492		1524493			
PAH	Result	MDL	Result	MDL	Units	Criteria: Nelson Water Criteria
1,6-dinitropyrene	<1	1	<1	1	ug/L	~
1,8-dinitropyrene	<1	1	<1	1	ug/L	~
13dinitropyrene	<1	1	<1	1	ug/L	~

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CERTIFICATE OF ANALYSIS

Whitewater Hydrogeology Ltd.

Work Order Number: 396374

Sample Description	NW Sump		SC Sump			
Sample Date	3/23/2020 9:00 AM		3/23/2020 9:00 AM			
Lab ID	1524492		1524493			
PAH	Result	MDL	Result	MDL	Units	Criteria: Nelson Water Criteria
7H-Dibenzo(c,g)carbazole	<0.1	0.1	<0.1	0.1	ug/L	~
Anthracene	<0.1	0.1	<0.1	0.1	ug/L	~
Benzo(a)anthracene	<0.1	0.1	<0.1	0.1	ug/L	~
Benzo(a)pyrene	<0.1	0.1	<0.1	0.1	ug/L	~
Benzo(b)fluoranthene	<0.1	0.1	<0.1	0.1	ug/L	~
Benzo(b+j)fluoranthene	<0.1	0.1	<0.1	0.1	ug/L	~
Benzo(e)pyrene	<0.1	0.1	<0.1	0.1	ug/L	~
Benzo(ghi)perylene	<0.1	0.1	<0.1	0.1	ug/L	~
Benzo(j)fluoranthene	<0.1	0.1	<0.1	0.1	ug/L	~
Benzo(k)fluoranthene	<0.1	0.1	<0.1	0.1	ug/L	~
Chrysene	<0.1	0.1	<0.1	0.1	ug/L	~
Dibenz(a,h)anthracene	<0.1	0.1	<0.1	0.1	ug/L	~
Dibenzo(a,i)pyrene	<0.1	0.1	<0.1	0.1	ug/L	~
Dibenzo(a,j)acridine	<0.1	0.1	<0.1	0.1	ug/L	~
Fluoranthene	<0.1	0.1	<0.1	0.1	ug/L	~
Indeno(1,2,3-c,d)pyrene	<0.1	0.1	<0.1	0.1	ug/L	~
Perylene	<0.1	0.1	<0.1	0.1	ug/L	~
Phenanthrene	<0.1	0.1	<0.1	0.1	ug/L	~
Pyrene	<0.1	0.1	<0.1	0.1	ug/L	~
Total PAH	<2	2	<2	2	ug/L	~

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CERTIFICATE OF ANALYSIS

Whitewater Hydrogeology Ltd.

Work Order Number: 396374

Sample Description	NW Sump		SC Sump			
Sample Date	3/23/2020 9:00 AM		3/23/2020 9:00 AM			
Lab ID	1524492		1524493			
Solids	Result	MDL	Result	MDL	Units	Criteria: Nelson Water Criteria
Total Dissolved Solids	504	2	711 [710]	2	mg/L	~
Total Suspended Solids	3.70	0.67	3.5 [4]	1	mg/L	25

LEGEND

Dates: Dates are formatted as mm/dd/year throughout this report.

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MDL: Method detection limit or minimum reporting limit.

[ ]: Results for laboratory replicates are shown in square brackets immediately below the associated sample result for ease of comparison.

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Quality Control: All associated Quality Control data is available on request.

Exceedences: HIGHLIGHTED CELLS INDICATE THAT THE RESULT EXCEEDS A REGULATORY LIMIT. CALCULATED UNCERTAINTY ESTIMATIONS ARE NOT APPLIED FOR DETERMINING SAMPLE EXCEEDANCES.

Benzo(b)fluoranthene: Results for benzo(b)fluoranthene may include contributions from benzo(j)fluoranthene.

Field Data: Reports containing Field Parameters represent data that has been collected and provided by the client. Testmark is not responsible for the validity of this data which may be used in subsequent calculations.

Sample Condition Deviations: A noted sample condition deviation may affect the validity of the result. Results apply to the sample(s) as received.

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CERTIFICATE OF ANALYSIS

Client:	Tecia White	Work Order Number:	397231
Company:	Whitewater Hydrogeology Ltd.	PO #:	
Address:	80 Chamberlain Cres Collingwood, ON, L9Y 0C8	Regulation: Project #:	Nelson Water Criteria Nelson Aggregates - Burlington Quarry Monthly ECA
Phone:	(705) 888-7064	DWS #:	
Email:	tecia@white-water.ca	Sampled By:	Hudson Selles
Date Order Received:	4/8/2020	Analysis Started:	4/8/2020
Arrival Temperature:	9.3 °C	Analysis Completed:	4/16/2020

WORK ORDER SUMMARY

ANALYSES WERE PERFORMED ON THE FOLLOWING SAMPLES. THE RESULTS RELATE ONLY TO THE ITEMS TESTED.

Sample Description	Lab ID	Matrix	Type	Comments	Date Collected	Time Collected
NW Sump	1527302	Water	None		4/2/2020	9:30 AM
SC Sump	1527303	Water	None		4/2/2020	9:30 AM

METHODS AND INSTRUMENTATION

THE FOLLOWING METHODS WERE USED FOR YOUR SAMPLE(S):

Method	Lab	Description	Reference
Alkalinity (A1.0)	Mississauga	Determination of Alkalinity by Titration	Modified from APHA-2320B
Ammonia Water (A42)	Mississauga	Determination of Ammonia/Ammonium in Water	Modified from EPA 350.1
Conductivity of Water (A12)	Mississauga	Determination of Conductivity in Water at 25°C	Modified from SM 2510 B
Dissolved Oxygen (A3)	Mississauga	Determination of Dissolved Oxygen in Water	Modified from APHA-5210
Field pH (R112)	Mississauga	Client Supplied Field Determination of pH of Water	Field Test
Field Temp (R113)	Mississauga	Client Supplied Field Determination of Temperature of Water	Field Test
Oil and Grease (A54)	Mississauga	Determination of Oil and Grease in Water	Modified from EPA 1664
pH of Water (A2.0)	Mississauga	Determination of Water pH by Ion Selective Electrode	Modified from APHA-4500H+ B
Reg. Hardness (A13)	Mississauga	Determination of Total Hardness	Modified from APHA-2340B
TDS (A27)	Mississauga	Determination of Total Dissolved Solids in water by gravimetry	Modified from SM-2540

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CERTIFICATE OF ANALYSIS

Whitewater Hydrogeology Ltd.

Work Order Number: 397231

Method	Lab	Description	Reference
TSS (A27)	Mississauga	Determination of Total Suspended Solids in water by gravimetry	Modified from SM-2540
Un-Ionized NH3 (A42.4)	Mississauga	Calculation of Un-Ionized Ammonia	Modified from APHA-4500

This report has been approved by:

Marc Creighton
Laboratory Director

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CERTIFICATE OF ANALYSIS

Whitewater Hydrogeology Ltd.

Work Order Number: 397231

WORK ORDER RESULTS

Sample Description	NW Sump		SC Sump			
Sample Date	4/2/2020 9:30 AM		4/2/2020 9:30 AM			
Lab ID	1527302		1527303			
Field Parameters	Result	MDL	Result	MDL	Units	Criteria: Nelson Water Criteria
Field pH	8.06	N/A	8.09	N/A	pH	~
Field Temp	9.3	N/A	9.2	N/A	°C	~

Sample Description	NW Sump		SC Sump			
Sample Date	4/2/2020 9:30 AM		4/2/2020 9:30 AM			
Lab ID	1527302		1527303			
General Chemistry	Result	MDL	Result	MDL	Units	Criteria: Nelson Water Criteria
Ammonia (as N)	<0.01	0.01	<0.01	0.01	mg/L	~
Conductivity	800	1	1000	1	µS/cm	~
Dissolved Oxygen	9.1	0.2	9.1	0.2	mg/L	~
M-Alkalinity (pH 4.5)	169	2	199	2	mg/L as CaCO3	~
Oil and Grease, Animal (Calc.)	<1	1	<1	1	mg/L	~
Oil and Grease, Mineral	<1	1	<1	1	mg/L	~
Oil and Grease, Total	<1	1	<1	1	mg/L	15
pH	8.16	N/A	8.08	N/A	pH	8.5
Total Hardness (as CaCO3) (Calc.)	304.0	0.1	417.0	0.1	mg/L	~
Un-Ionized Ammonia (Calc.)	<0.002	0.002	<0.002	0.002	mg/L	~

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Whitewater Hydrogeology Ltd.

Work Order Number: 397231

Sample Description	NW Sump		SC Sump			
Sample Date	4/2/2020 9:30 AM		4/2/2020 9:30 AM			
Lab ID	1527302		1527303			
Solids	Result	MDL	Result	MDL	Units	Criteria: Nelson Water Criteria
Total Dissolved Solids	490 [502]	2	679	2	mg/L	~
Total Suspended Solids	1.5 [1.5]	1	1.30	0.67	mg/L	25

LEGEND

Dates: Dates are formatted as mm/dd/year throughout this report.

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MDL: Method detection limit or minimum reporting limit.

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Quality Control: All associated Quality Control data is available on request.

Exceedences: HIGHLIGHTED CELLS INDICATE THAT THE RESULT EXCEEDS A REGULATORY LIMIT. CALCULATED UNCERTAINTY ESTIMATIONS ARE NOT APPLIED FOR DETERMINING SAMPLE EXCEEDANCES.

Benzo(b)fluoranthene: Results for benzo(b)fluoranthene may include contributions from benzo(j)fluoranthene.

Field Data: Reports containing Field Parameters represent data that has been collected and provided by the client. Testmark is not responsible for the validity of this data which may be used in subsequent calculations.

Sample Condition Deviations: A noted sample condition deviation may affect the validity of the result. Results apply to the sample(s) as received.

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CERTIFICATE OF ANALYSIS

Client:	Tecia White	Work Order Number:	400706
Company:	Whitewater Hydrogeology Ltd.	PO #:	
Address:	80 Chamberlain Cres Collingwood, ON, L9Y 0C8	Regulation: Project #:	Nelson Water Criteria Nelson Aggregates - Burlington Quarry Monthly ECA
Phone:	(705) 888-7064	DWS #:	
Email:	tecia@white-water.ca	Sampled By:	Hudson Selles
Date Order Received:	5/21/2020	Analysis Started:	5/21/2020
Arrival Temperature:	11.6 °C	Analysis Completed:	5/28/2020

WORK ORDER SUMMARY

ANALYSES WERE PERFORMED ON THE FOLLOWING SAMPLES. THE RESULTS RELATE ONLY TO THE ITEMS TESTED.

Sample Description	Lab ID	Matrix	Type	Comments	Date Collected	Time Collected
NW Sump	1538748	Water	None		5/19/2020	10:30 AM
SC Sump	1538749	Water	None		5/19/2020	10:30 AM

METHODS AND INSTRUMENTATION

THE FOLLOWING METHODS WERE USED FOR YOUR SAMPLE(S):

Method	Lab	Description	Reference
Alkalinity (A1.0)	Mississauga	Determination of Alkalinity by Titration	Modified from APHA-2320B
Ammonia Water (A42)	Mississauga	Determination of Ammonia/Ammonium in Water	Modified from EPA 350.1
Conductivity of Water (A12)	Mississauga	Determination of Conductivity in Water at 25°C	Modified from SM 2510 B
Dissolved Oxygen (A3)	Mississauga	Determination of Dissolved Oxygen in Water	Modified from APHA-5210
Field pH (R112)	Mississauga	Client Supplied Field Determination of pH of Water	Field Test
Field Temp (R113)	Mississauga	Client Supplied Field Determination of Temperature of Water	Field Test
Oil and Grease (A54)	Mississauga	Determination of Oil and Grease in Water	Modified from EPA 1664
pH of Water (A2.0)	Mississauga	Determination of Water pH by Ion Selective Electrode	Modified from APHA-4500H+ B
Reg. Hardness (A13)	Mississauga	Determination of Total Hardness	Modified from APHA-2340B
TDS (A27)	Mississauga	Determination of Total Dissolved Solids in water by gravimetry	Modified from SM-2540

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CERTIFICATE OF ANALYSIS

Whitewater Hydrogeology Ltd.

Work Order Number: 400706

Method	Lab	Description	Reference
TSS (A27)	Mississauga	Determination of Total Suspended Solids in water by gravimetry	Modified from SM-2540
Un-Ionized NH3 (A42.4)	Mississauga	Calculation of Un-Ionized Ammonia	Modified from APHA-4500

This report has been approved by:

Marc Creighton
Laboratory Director

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CERTIFICATE OF ANALYSIS

Whitewater Hydrogeology Ltd.

Work Order Number: 400706

WORK ORDER RESULTS

Sample Description	NW Sump		SC Sump			
Sample Date	5/19/2020 10:30 AM		5/19/2020 10:30 AM			
Lab ID	1538748		1538749			
Field Parameters	Result	MDL	Result	MDL	Units	Criteria: Nelson Water Criteria
Field pH	8.28	N/A	8.24	N/A	pH	~
Field Temp	11.8	N/A	12.5	N/A	°C	~

Sample Description	NW Sump		SC Sump			
Sample Date	5/19/2020 10:30 AM		5/19/2020 10:30 AM			
Lab ID	1538748		1538749			
General Chemistry	Result	MDL	Result	MDL	Units	Criteria: Nelson Water Criteria
Ammonia (as N)	<0.01 [<0.01]	0.01	0.03	0.01	mg/L	~
Conductivity	784	1	985	1	µS/cm	~
Dissolved Oxygen	10.0	0.2	10.1	0.2	mg/L	~
M-Alkalinity (pH 4.5)	165	2	174	2	mg/L as CaCO3	~
Oil and Grease, Animal (Calc.)	1	1	8	1	mg/L	~
Oil and Grease, Mineral	1	1	4	1	mg/L	~
Oil and Grease, Total	2	1	12	1	mg/L	15
pH	8.12	N/A	8.14	N/A	pH	8.5
Total Hardness (as CaCO3) (Calc.)	283.0	0.1	376.0	0.1	mg/L	~
Un-Ionized Ammonia (Calc.)	<0.002	0.002	<0.002	0.002	mg/L	~

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CERTIFICATE OF ANALYSIS

Whitewater Hydrogeology Ltd.

Work Order Number: 400706

Sample Description	NW Sump		SC Sump			
Sample Date	5/19/2020 10:30 AM		5/19/2020 10:30 AM			
Lab ID	1538748		1538749			
Solids	Result	MDL	Result	MDL	Units	Criteria: Nelson Water Criteria
Total Dissolved Solids	592 [514]	2	737	2	mg/L	~
Total Suspended Solids	<2	2	2	2	mg/L	25

LEGEND

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Quality Control: All associated Quality Control data is available on request.

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Benzo(b)fluoranthene: Results for benzo(b)fluoranthene may include contributions from benzo(j)fluoranthene.

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Sample Condition Deviations: A noted sample condition deviation may affect the validity of the result. Results apply to the sample(s) as received.

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CERTIFICATE OF ANALYSIS

Client:	Tecia White	Work Order Number:	402770
Company:	Whitewater Hydrogeology Ltd.	PO #:	
Address:	80 Chamberlain Cres Collingwood, ON, L9Y 0C8	Regulation: Project #:	Nelson Water Criteria Nelson Aggregates Burlington Quarry - Quarterly ECA
Phone:	(705) 888-7064	DWS #:	
Email:	tecia@white-water.ca	Sampled By:	Hudson Selles
Date Order Received:	6/11/2020	Analysis Started:	6/11/2020
Arrival Temperature:	24.1 °C	Analysis Completed:	6/22/2020

WORK ORDER SUMMARY

ANALYSES WERE PERFORMED ON THE FOLLOWING SAMPLES. THE RESULTS RELATE ONLY TO THE ITEMS TESTED.

Sample Description	Lab ID	Matrix	Type	Comments	Date Collected	Time Collected
NE Sump	1545868	Water	None		6/10/2020	1:00 PM
SC Sump	1545869	Water	None		6/10/2020	1:00 PM

METHODS AND INSTRUMENTATION

THE FOLLOWING METHODS WERE USED FOR YOUR SAMPLE(S):

Method	Lab	Description	Reference
Alkalinity (A1.0)	Mississauga	Determination of Alkalinity by Titration	Modified from APHA-2320B
Ammonia Water (A42)	Mississauga	Determination of Ammonia/Ammonium in Water	Modified from EPA 350.1
Anions Water (mg/L by IC) (A5)	Mississauga	Determination of Anions in Water by Ion Chromatography	Modified from SW846-9056A
Conductivity of Water (A12)	Mississauga	Determination of Conductivity in Water at 25°C	Modified from SM 2510 B
Dissolved Oxygen (A3)	Mississauga	Determination of Dissolved Oxygen in Water	Modified from APHA-5210
DOC Water (A55.1)	Mississauga	Determination of Dissolved Organic Carbon in Water	Modified from SM-5310 C
Field pH (R112)	Mississauga	Client Supplied Field Determination of pH of Water	Field Test
Field Temp (R113)	Mississauga	Client Supplied Field Determination of Temperature of Water	Field Test
ICPMS Tot. Water (A13)	Mississauga	Determination of Total Metals in Water by ICP/MS with Digestion	Modified from SW846-6020
Oil and Grease (A54)	Mississauga	Determination of Oil and Grease in Water	Modified from EPA 1664

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CERTIFICATE OF ANALYSIS

Whitewater Hydrogeology Ltd.

Work Order Number: 402770

Method	Lab	Description	Reference
PAH Water SIM (A41)	Garson	Determination of PAH in Water by GC/MS	Modified from SW846-8270D
pH of Water (A2.0)	Mississauga	Determination of Water pH by Ion Selective Electrode	Modified from APHA-4500H+ B
Phenols 4AAP (T38)	Mississauga	Determination of Total Phenols by 4AAP	Modified from APHA-5530
Reg. Hardness (A13)	Mississauga	Determination of Total Hardness	Modified from APHA-2340B
TDS (A27)	Mississauga	Determination of Total Dissolved Solids in water by gravimetry	Modified from SM-2540
TKN Water Dig. (A58)	Kirkland Lake	Determination of Total Kjeldahl Nitrogen in Waters with Block Digestion.	Modified from SM-4500 NORG-D
TP Water (A23.2)	Kirkland Lake	Determination of Total Phosphorus in Water.	Modified from EPA 365.3 and ESS 310.2,
TSS (A27)	Mississauga	Determination of Total Suspended Solids in water by gravimetry	Modified from SM-2540
Un-Ionized NH3 (A42.4)	Mississauga	Calculation of Un-Ionized Ammonia	Modified from APHA-4500

This report has been approved by:



Marc Creighton
Laboratory Director

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CERTIFICATE OF ANALYSIS

Whitewater Hydrogeology Ltd.

Work Order Number: 402770

WORK ORDER RESULTS

Sample Description	NE Sump		SC Sump			
Sample Date	6/10/2020 1:00 PM		6/10/2020 1:00 PM			
Lab ID	1545868		1545869			
Anions	Result	MDL	Result	MDL	Units	Criteria: Nelson Water Criteria
Bromide	<0.1	0.1	<0.1	0.1	mg/L	~
Chloride	78.7	0.2	89.1	0.2	mg/L	~
Fluoride	0.18	0.06	0.20	0.06	mg/L	~
Nitrate (as N)	<0.05	0.05	<0.05	0.05	mg/L	~
Nitrite (as N)	<0.05	0.05	<0.05	0.05	mg/L	~
Sulphate	142.0	0.3	241.0	0.3	mg/L	~

Sample Description	NE Sump		SC Sump			
Sample Date	6/10/2020 1:00 PM		6/10/2020 1:00 PM			
Lab ID	1545868		1545869			
Field Parameters	Result	MDL	Result	MDL	Units	Criteria: Nelson Water Criteria
Field pH	8.37	N/A	8.42	N/A	pH	~
Field Temp	24.7	N/A	25.8	N/A	°C	~

Sample Description	NE Sump		SC Sump			
Sample Date	6/10/2020 1:00 PM		6/10/2020 1:00 PM			
Lab ID	1545868		1545869			
General Chemistry	Result	MDL	Result	MDL	Units	Criteria: Nelson Water Criteria
Ammonia (as N)	<0.01	0.01	<0.01	0.01	mg/L	~
Conductivity	743	1	912	1	µS/cm	~
Dissolved Organic Carbon	4.7 [4.4]	0.4	3.2	0.4	mg/L	~

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CERTIFICATE OF ANALYSIS

Whitewater Hydrogeology Ltd.

Work Order Number: 402770

Sample Description	NE Sump		SC Sump			
Sample Date	6/10/2020 1:00 PM		6/10/2020 1:00 PM			
Lab ID	1545868		1545869			
General Chemistry	Result	MDL	Result	MDL	Units	Criteria: Nelson Water Criteria
Dissolved Oxygen	8.9	0.2	9.9	0.2	mg/L	~
M-Alkalinity (pH 4.5)	143	2	126	2	mg/L as CaCO3	~
Oil and Grease, Animal (Calc.)	<1	1	<1	1	mg/L	~
Oil and Grease, Mineral	<1	1	<1	1	mg/L	~
Oil and Grease, Total	<1	1	<1	1	mg/L	15
pH	8.27	N/A	8.25	N/A	pH	8.5
Total Hardness (as CaCO3) (Calc.)	280.0	0.1	371.0	0.1	mg/L	~
Total Kjeldahl Nitrogen	1.3 [1.2]	0.4	0.8	0.4	mg/L	~
Total Phenols	<0.0004	0.0004	0.0011	0.0004	mg/L	~
Total Phosphorus (as P)	0.014	0.002	0.025	0.002	mg/L	~
Un-Ionized Ammonia (Calc.)	<0.002	0.002	<0.002	0.002	mg/L	~

Sample Description	NE Sump		SC Sump			
Sample Date	6/10/2020 1:00 PM		6/10/2020 1:00 PM			
Lab ID	1545868		1545869			
Metals (Total)	Result	MDL	Result	MDL	Units	Criteria: Nelson Water Criteria
Total Aluminum	26 [22]	1	361	1	ug/L	~
Total Antimony	<0.5 [<0.5]	0.5	<0.5	0.5	ug/L	~
Total Arsenic	2 [2]	1	4	1	ug/L	~
Total Barium	31 [31]	1	31	1	ug/L	~

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CERTIFICATE OF ANALYSIS

Whitewater Hydrogeology Ltd.

Work Order Number: 402770

Sample Description	NE Sump		SC Sump			
Sample Date	6/10/2020 1:00 PM		6/10/2020 1:00 PM			
Lab ID	1545868		1545869			
Metals (Total)	Result	MDL	Result	MDL	Units	Criteria: Nelson Water Criteria
Total Beryllium	<0.5 [<0.5]	0.5	<0.5	0.5	ug/L	~
Total Bismuth	<1 [<1]	1	<1	1	ug/L	~
Total Boron	67 [67]	2	126	2	ug/L	~
Total Cadmium	0.07 [0.08]	0.02	0.06	0.02	ug/L	~
Total Calcium	55900 [56800]	500	74800	500	ug/L	~
Total Cerium	<1 [<1]	1	<1	1	ug/L	~
Total Cesium	<1 [<1]	1	<1	1	ug/L	~
Total Chromium	<1 [<1]	1	<1	1	ug/L	~
Total Cobalt	0.2 [0.2]	0.1	0.5	0.1	ug/L	~
Total Copper	3 [2]	1	3	1	ug/L	~
Total Europium	<1 [<1]	1	<1	1	ug/L	~
Total Gallium	<1 [<1]	1	<1	1	ug/L	~
Total Iron	232 [228]	20	740	200	ug/L	~
Total Lanthanum	<1 [<1]	1	<1	1	ug/L	~
Total Lead	0.2 [0.2]	0.1	1.2	0.1	ug/L	~
Total Lithium	8 [8]	5	14	5	ug/L	~
Total Magnesium	31900 [31400]	4	40500	4	ug/L	~

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CERTIFICATE OF ANALYSIS

Whitewater Hydrogeology Ltd.

Work Order Number: 402770

Sample Description	NE Sump		SC Sump			
Sample Date	6/10/2020 1:00 PM		6/10/2020 1:00 PM			
Lab ID	1545868		1545869			
Metals (Total)	Result	MDL	Result	MDL	Units	Criteria: Nelson Water Criteria
Total Manganese	8 [8]	1	39	1	ug/L	~
Total Mercury	<0.1 [<0.1]	0.1	<0.1	0.1	ug/L	~
Total Molybdenum	2 [2]	1	4	1	ug/L	~
Total Nickel	4 [4]	1	5	1	ug/L	~
Total Niobium	<1 [<1]	1	<1	1	ug/L	~
Total Phosphorus	<50 [<50]	50	<50	50	ug/L	~
Total Potassium	4590 [4530]	100	5020	100	ug/L	~
Total Rubidium	2 [2]	1	3	1	ug/L	~
Total Scandium	<1 [<1]	1	<1	1	ug/L	~
Total Selenium	0.7 [0.9]	0.5	1.3	0.5	ug/L	~
Total Silicon	318 [312]	2	979	2	ug/L	~
Total Silver	0.1 [<0.1]	0.1	<0.1	0.1	ug/L	~
Total Sodium	43400 [43900]	1000	46300	1000	ug/L	~
Total Strontium	834 [817]	1	1360	10	ug/L	~
Total Sulphur	49100 [48600]	800	78100	800	ug/L	~
Total Tellurium	<1 [<1]	1	<1	1	ug/L	~
Total Thallium	<0.1 [<0.1]	0.1	<0.1	0.1	ug/L	~

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CERTIFICATE OF ANALYSIS

Whitewater Hydrogeology Ltd.

Work Order Number: 402770

Sample Description	NE Sump		SC Sump			
Sample Date	6/10/2020 1:00 PM		6/10/2020 1:00 PM			
Lab ID	1545868		1545869			
Metals (Total)	Result	MDL	Result	MDL	Units	Criteria: Nelson Water Criteria
Total Thorium	<1 [<1]	1	<1	1	ug/L	~
Total Tin	<1 [<1]	1	<1	1	ug/L	~
Total Titanium	<1 [<1]	1	7	1	ug/L	~
Total Tungsten	<1 [<1]	1	<1	1	ug/L	~
Total Uranium	<1 [<1]	1	1	1	ug/L	~
Total Vanadium	<1 [<1]	1	<1	1	ug/L	~
Total Yttrium	<1 [<1]	1	<1	1	ug/L	~
Total Zinc	2 [2]	1	4	1	ug/L	~
Total Zirconium	3 [4]	1	3	1	ug/L	~

Sample Description	NE Sump		SC Sump			
Sample Date	6/10/2020 1:00 PM		6/10/2020 1:00 PM			
Lab ID	1545868		1545869			
PAH	Result	MDL	Result	MDL	Units	Criteria: Nelson Water Criteria
1+2-Methylnaphthalene (Calc.)	<0.05	0.05	<0.05	0.05	ug/L	~
1-Methylnaphthalene	<0.03	0.03	<0.04	0.04	ug/L	~
2-Methylnaphthalene	<0.02	0.02	<0.02	0.02	ug/L	~
3,3'-Dichlorobenzidine	<0.06	0.06	<0.06	0.06	ug/L	~
Acenaphthene	<0.05	0.05	<0.05	0.05	ug/L	~

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Whitewater Hydrogeology Ltd.

Work Order Number: 402770

Sample Description	NE Sump		SC Sump			
Sample Date	6/10/2020 1:00 PM		6/10/2020 1:00 PM			
Lab ID	1545868		1545869			
PAH	Result	MDL	Result	MDL	Units	Criteria: Nelson Water Criteria
Acenaphthylene	<0.05	0.05	<0.05	0.05	ug/L	~
Anthracene	<0.02	0.02	<0.02	0.02	ug/L	~
Benzo(a)anthracene	<0.02	0.02	<0.02	0.02	ug/L	~
Benzo(a)pyrene	<0.01	0.01	<0.01	0.01	ug/L	~
Benzo(b)fluoranthene	<0.07	0.07	<0.07	0.07	ug/L	~
Benzo(ghi)perylene	<0.05	0.05	<0.05	0.05	ug/L	~
Benzo(k)fluoranthene	<0.05	0.05	<0.05	0.05	ug/L	~
Biphenyl	<0.1	0.1	<0.1	0.1	ug/L	~
Chrysene	<0.06	0.06	<0.06	0.06	ug/L	~
Dibenz(a,h)anthracene	<0.05	0.05	<0.05	0.05	ug/L	~
Fluoranthene	<0.03	0.03	<0.04	0.04	ug/L	~
Fluorene	<0.05	0.05	<0.05	0.05	ug/L	~
Fluorobiphenyl (Surr.)	104	N/A	104	N/A	% Rec	~
Indeno(1,2,3-c,d)pyrene	<0.03	0.03	<0.04	0.04	ug/L	~
Naphthalene	<0.06	0.06	<0.06	0.06	ug/L	~
Phenanthrene	<0.03	0.03	<0.04	0.04	ug/L	~
p-Terphenyl-d14 (Surr.)	100	N/A	98	N/A	% Rec	~
Pyrene	<0.05	0.05	<0.05	0.05	ug/L	~

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Whitewater Hydrogeology Ltd.

Work Order Number: 402770

Sample Description	NE Sump		SC Sump			
Sample Date	6/10/2020 1:00 PM		6/10/2020 1:00 PM			
Lab ID	1545868		1545869			
Solids	Result	MDL	Result	MDL	Units	Criteria: Nelson Water Criteria
Total Dissolved Solids	494	2	633	2	mg/L	~
Total Suspended Solids	<0.67	0.67	16.70	0.67	mg/L	25

LEGEND

Dates: Dates are formatted as mm/dd/year throughout this report.

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MDL: Method detection limit or minimum reporting limit.

[ ]: Results for laboratory replicates are shown in square brackets immediately below the associated sample result for ease of comparison.

~: In a criteria column indicates the criteria is not applicable for the parameter row.

Quality Control: All associated Quality Control data is available on request.

Exceedences: HIGHLIGHTED CELLS INDICATE THAT THE RESULT EXCEEDS A REGULATORY LIMIT. CALCULATED UNCERTAINTY ESTIMATIONS ARE NOT APPLIED FOR DETERMINING SAMPLE EXCEEDANCES.

Benzo(b)fluoranthene: Results for benzo(b)fluoranthene may include contributions from benzo(j)fluoranthene.

Field Data: Reports containing Field Parameters represent data that has been collected and provided by the client. Testmark is not responsible for the validity of this data which may be used in subsequent calculations.

Sample Condition Deviations: A noted sample condition deviation may affect the validity of the result. Results apply to the sample(s) as received.

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CERTIFICATE OF ANALYSIS

Client:	Tecia White	Work Order Number:	406409
Company:	Whitewater Hydrogeology Ltd.	PO #:	
Address:	80 Chamberlain Cres Collingwood, ON, L9Y 0C8	Regulation: Project #:	Nelson Water Criteria Nelson Aggregates Burlington Quarry Monthly ECA
Phone:	(705) 888-7064	DWS #:	
Email:	tecia@white-water.ca	Sampled By:	Hudson Selles
Date Order Received:	7/22/2020	Analysis Started:	7/22/2020
Arrival Temperature:	24.6 °C	Analysis Completed:	7/29/2020

WORK ORDER SUMMARY

ANALYSES WERE PERFORMED ON THE FOLLOWING SAMPLES. THE RESULTS RELATE ONLY TO THE ITEMS TESTED.

Sample Description	Lab ID	Matrix	Type	Comments	Date Collected	Time Collected
SC Sump	1558533	Water	None		7/22/2020	9:00 AM

METHODS AND INSTRUMENTATION

THE FOLLOWING METHODS WERE USED FOR YOUR SAMPLE(S):

Method	Lab	Description	Reference
Alkalinity (A1.0)	Mississauga	Determination of Alkalinity by Titration	Modified from APHA-2320B
Ammonia Water (A42)	Mississauga	Determination of Ammonia/Ammonium in Water	Modified from EPA 350.1
Conductivity of Water (A12)	Mississauga	Determination of Conductivity in Water at 25°C	Modified from SM 2510 B
Dissolved Oxygen (A3)	Mississauga	Determination of Dissolved Oxygen in Water	Modified from APHA-5210
Field pH (R112)	Mississauga	Client Supplied Field Determination of pH of Water	Field Test
Field Temp (R113)	Mississauga	Client Supplied Field Determination of Temperature of Water	Field Test
Oil and Grease (A54)	Mississauga	Determination of Oil and Grease in Water	Modified from EPA 1664
pH of Water (A2.0)	Mississauga	Determination of Water pH by Ion Selective Electrode	Modified from APHA-4500H+ B
Reg. Hardness (A13)	Mississauga	Determination of Total Hardness	Modified from APHA-2340B
TDS (A27)	Mississauga	Determination of Total Dissolved Solids in water by gravimetry	Modified from SM-2540
TSS (A27)	Mississauga	Determination of Total Suspended Solids in water by gravimetry	Modified from SM-2540

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Whitewater Hydrogeology Ltd.

Work Order Number: 406409

Method	Lab	Description	Reference
Un-Ionized NH3 (A42.4)	Mississauga	Calculation of Un-Ionized Ammonia	Modified from APHA-4500

This report has been approved by:



Marc Creighton
Laboratory Director

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CERTIFICATE OF ANALYSIS

Whitewater Hydrogeology Ltd.

Work Order Number: 406409

WORK ORDER RESULTS

Sample Description	SC Sump
Sample Date	7/22/2020 9:00 AM
Lab ID	1558533

Field Parameters	Result	MDL	Units	Criteria: Nelson Water Criteria
Field pH	8.4	N/A	pH	~
Field Temp	23.7	N/A	°C	~

Sample Description	SC Sump
Sample Date	7/22/2020 9:00 AM
Lab ID	1558533

General Chemistry	Result	MDL	Units	Criteria: Nelson Water Criteria
Ammonia (as N)	<0.01 [<0.01]	0.01	mg/L	~
Conductivity	870	1	µS/cm	~
Dissolved Oxygen	8.2	0.2	mg/L	~
M-Alkalinity (pH 4.5)	78	2	mg/L as CaCO3	~
Oil and Grease, Animal (Calc.)	<1	1	mg/L	~
Oil and Grease, Mineral	<1	1	mg/L	~
Oil and Grease, Total	<1	1	mg/L	15
pH	8.05	N/A	pH	8.5
Total Hardness (as CaCO3) (Calc.)	343.0	0.1	mg/L	~
Un-Ionized Ammonia (Calc.)	<0.002	0.002	mg/L	~

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CERTIFICATE OF ANALYSIS

Whitewater Hydrogeology Ltd.

Work Order Number: 406409

Sample Description	SC Sump
Sample Date	7/22/2020 9:00 AM
Lab ID	1558533

Solids	Result	MDL	Units	Criteria: Nelson Water Criteria
Total Dissolved Solids	663 [723]	2	mg/L	~
Total Suspended Solids	1.5 [1.5]	1	mg/L	25

LEGEND

Dates: Dates are formatted as mm/dd/year throughout this report.

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MDL: Method detection limit or minimum reporting limit.

[ ]: Results for laboratory replicates are shown in square brackets immediately below the associated sample result for ease of comparison.

~: In a criteria column indicates the criteria is not applicable for the parameter row.

Quality Control: All associated Quality Control data is available on request.

Exceedences: HIGHLIGHTED CELLS INDICATE THAT THE RESULT EXCEEDS A REGULATORY LIMIT. CALCULATED UNCERTAINTY ESTIMATIONS ARE NOT APPLIED FOR DETERMINING SAMPLE EXCEEDANCES.

Benzo(b)fluoranthene: Results for benzo(b)fluoranthene may include contributions from benzo(j)fluoranthene.

Field Data: Reports containing Field Parameters represent data that has been collected and provided by the client. Testmark is not responsible for the validity of this data which may be used in subsequent calculations.

Sample Condition Deviations: A noted sample condition deviation may affect the validity of the result. Results apply to the sample(s) as received.

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CERTIFICATE OF ANALYSIS

Client:	Tecia White	Work Order Number:	410808
Company:	Whitewater Hydrogeology Ltd.	PO #:	
Address:	80 Chamberlain Cres Collingwood, ON, L9Y 0C8	Regulation: Project #:	Nelson Water Criteria Nelson Aggregates Burlington Quarry Monthly ECA
Phone:	(705) 888-7064	DWS #:	
Email:	tecia@white-water.ca	Sampled By:	Hudson Selles
Date Order Received:	9/10/2020	Analysis Started:	9/10/2020
Arrival Temperature:	18 °C	Analysis Completed:	9/17/2020

WORK ORDER SUMMARY

ANALYSES WERE PERFORMED ON THE FOLLOWING SAMPLES. THE RESULTS RELATE ONLY TO THE ITEMS TESTED.

Sample Description	Lab ID	Matrix	Type	Comments	Date Collected	Time Collected
NW Sump	1574257	Water	None		9/3/2020	1:00 PM
SC Sump	1574258	Water	None		9/3/2020	1:00 PM

METHODS AND INSTRUMENTATION

THE FOLLOWING METHODS WERE USED FOR YOUR SAMPLE(S):

Method	Lab	Description	Reference
Alkalinity (A1.0)	Mississauga	Determination of Alkalinity by Titration	Modified from APHA-2320B
Ammonia Water (A42)	Mississauga	Determination of Ammonia/Ammonium in Water	Modified from EPA 350.1
Conductivity of Water (A12)	Mississauga	Determination of Conductivity in Water at 25°C	Modified from SM 2510 B
Dissolved Oxygen (A3)	Mississauga	Determination of Dissolved Oxygen in Water	Modified from APHA-5210
Field pH (R112)	Mississauga	Client Supplied Field Determination of pH of Water	Field Test
Field Temp (R113)	Mississauga	Client Supplied Field Determination of Temperature of Water	Field Test
ICPMS Reg. Water (A13)	Mississauga	Determination of Metals in Water by ICP/MS	Modified from SW846-6020
Oil and Grease (A54)	Mississauga	Determination of Oil and Grease in Water	Modified from EPA 1664
pH of Water (A2.0)	Mississauga	Determination of Water pH by Ion Selective Electrode	Modified from APHA-4500H+ B
Reg. Hardness (A13)	Mississauga	Determination of Total Hardness	Modified from APHA-2340B

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Whitewater Hydrogeology Ltd.

Work Order Number: 410808

Method	Lab	Description	Reference
TDS (A27)	Mississauga	Determination of Total Dissolved Solids in water by gravimetry	Modified from SM-2540
TSS (A27)	Mississauga	Determination of Total Suspended Solids in water by gravimetry	Modified from SM-2540
Un-Ionized NH3 (A42.4)	Mississauga	Calculation of Un-Ionized Ammonia	Modified from APHA-4500

REPORT COMMENTS

Samples past hold time, proceed with analysis as per the client notes.09/10/20 A.P

This report has been approved by:



Marc Creighton
Laboratory Director

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CERTIFICATE OF ANALYSIS

Whitewater Hydrogeology Ltd.

Work Order Number: 410808

WORK ORDER RESULTS

Sample Description	NW Sump		SC Sump			
Sample Date	9/3/2020 1:00 PM		9/3/2020 1:00 PM			
Lab ID	1574257		1574258			
Field Parameters	Result	MDL	Result	MDL	Units	Criteria: Nelson Water Criteria
Field pH	8.32	N/A	8.42	N/A	pH	~
Field Temp	24.2	N/A	26	N/A	°C	~

Sample Description	NW Sump		SC Sump			
Sample Date	9/3/2020 1:00 PM		9/3/2020 1:00 PM			
Lab ID	1574257		1574258			
General Chemistry	Result	MDL	Result	MDL	Units	Criteria: Nelson Water Criteria
Ammonia (as N)	0.03	0.01	0.06	0.01	mg/L	~
Conductivity	757	1	1020	1	µS/cm	~
Dissolved Oxygen	8.2	0.2	8.1	0.2	mg/L	~
M-Alkalinity (pH 4.5)	93	2	87	2	mg/L as CaCO3	~
Oil and Grease, Animal (Calc.)	1	1	<1	1	mg/L	~
Oil and Grease, Mineral	<1	1	1	1	mg/L	~
Oil and Grease, Total	1	1	2	1	mg/L	15
pH	7.97	N/A	7.94	N/A	pH	8.5
Total Hardness (as CaCO3) (Calc.)	257.0	0.1	383.0	0.1	mg/L	~
Un-Ionized Ammonia (Calc.)	0.003	0.002	0.008	0.002	mg/L	~

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CERTIFICATE OF ANALYSIS

Whitewater Hydrogeology Ltd.

Work Order Number: 410808

Sample Description	NW Sump		SC Sump			
Sample Date	9/3/2020 1:00 PM		9/3/2020 1:00 PM			
Lab ID	1574257		1574258			
Solids	Result	MDL	Result	MDL	Units	Criteria: Nelson Water Criteria
Total Dissolved Solids	517	2	764	2	mg/L	~
Total Suspended Solids	<0.67	0.67	3.70	0.67	mg/L	25

LEGEND

Dates: Dates are formatted as mm/dd/year throughout this report.

[rr]: After a parameter name indicates a re-run of that parameter. If multiple re-runs exist they are suffixed by a number. Sample may not have been handled according to the recommended temperature, hold time and head space requirements of the method after the initial analysis.

MDL: Method detection limit or minimum reporting limit.

~: In a criteria column indicates the criteria is not applicable for the parameter row.

Quality Control: All associated Quality Control data is available on request.

Field Data: Reports containing Field Parameters represent data that has been collected and provided by the client. Testmark is not responsible for the validity of this data which may be used in subsequent calculations.

Sample Condition Deviations: A noted sample condition deviation may affect the validity of the result. Results apply to the sample(s) as received.

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CERTIFICATE OF ANALYSIS

Client:	Tecia White	Work Order Number:	410794
Company:	Whitewater Hydrogeology Ltd.	PO #:	
Address:	80 Chamberlain Cres Collingwood, ON, L9Y 0C8	Regulation: Project #:	Nelson Water Criteria Nelson Aggregates Burlington Quarry Quarterly ECA
Phone:	(705) 888-7064	DWS #:	
Email:	tecia@white-water.ca	Sampled By:	Hudson Selles
Date Order Received:	9/10/2020	Analysis Started:	9/10/2020
Arrival Temperature:	18 °C	Analysis Completed:	9/17/2020

WORK ORDER SUMMARY

ANALYSES WERE PERFORMED ON THE FOLLOWING SAMPLES. THE RESULTS RELATE ONLY TO THE ITEMS TESTED.

Sample Description	Lab ID	Matrix	Type	Comments	Date Collected	Time Collected
NW Sump	1574225	Water	None		9/3/2020	1:00 PM
SC Sump	1574226	Water	None		9/3/2020	1:00 PM

METHODS AND INSTRUMENTATION

THE FOLLOWING METHODS WERE USED FOR YOUR SAMPLE(S):

Method	Lab	Description	Reference
Alkalinity (A1.0)	Mississauga	Determination of Alkalinity by Titration	Modified from APHA-2320B
Ammonia Water (A42)	Mississauga	Determination of Ammonia/Ammonium in Water	Modified from EPA 350.1
Anions Water (mg/L by IC) (A5)	Mississauga	Determination of Anions in Water by Ion Chromatography	Modified from SW846-9056A
Conductivity of Water (A12)	Mississauga	Determination of Conductivity in Water at 25°C	Modified from SM 2510 B
Dissolved Oxygen (A3)	Mississauga	Determination of Dissolved Oxygen in Water	Modified from APHA-5210
DOC Water (A55.1)	Mississauga	Determination of Dissolved Organic Carbon in Water	Modified from SM-5310 C
Field pH (R112)	Mississauga	Client Supplied Field Determination of pH of Water	Field Test
Field Temp (R113)	Mississauga	Client Supplied Field Determination of Temperature of Water	Field Test
ICPMS Reg. Water (A13)	Mississauga	Determination of Metals in Water by ICP/MS	Modified from SW846-6020
ICPMS Tot. Water (A13)	Mississauga	Determination of Total Metals in Water by ICP/MS with Digestion	Modified from SW846-6020

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CERTIFICATE OF ANALYSIS

Whitewater Hydrogeology Ltd.

Work Order Number: 410794

Method	Lab	Description	Reference
Oil and Grease (A54)	Mississauga	Determination of Oil and Grease in Water	Modified from EPA 1664
PAH TO SU Water SIM (A41)	Garson	Determination of PAH in Water by GC/MS	Modified from SW846-8270D
pH of Water (A2.0)	Mississauga	Determination of Water pH by Ion Selective Electrode	Modified from APHA-4500H+ B
Phenols 4AAP (T38)	Mississauga	Determination of Total Phenols by 4AAP	Modified from APHA-5530
Reg. Hardness (A13)	Mississauga	Determination of Total Hardness	Modified from APHA-2340B
TDS (A27)	Mississauga	Determination of Total Dissolved Solids in water by gravimetry	Modified from SM-2540
TKN Water Dig. (A58)	Kirkland Lake	Determination of Total Kjeldahl Nitrogen in Waters with Block Digestion.	Modified from SM-4500 NORG-D
TP Water (A23.2)	Kirkland Lake	Determination of Total Phosphorus in Water.	Modified from EPA 365.3 and ESS 310.2,
TSS (A27)	Mississauga	Determination of Total Suspended Solids in water by gravimetry	Modified from SM-2540
Un-Ionized NH3 (A42.4)	Mississauga	Calculation of Un-Ionized Ammonia	Modified from APHA-4500

REPORT COMMENTS

Samples past hold time, proceed with analysis as per the client notes.09/10/20 A.P

This report has been approved by:



Marc Creighton
Laboratory Director

6820 Kitimat Road Unit 4, Mississauga, ON, L5N 5M3
Phone: (905) 821-1112 Fax: (905) 821-2095 Web: www.testmark.ca

CERTIFICATE OF ANALYSIS

Whitewater Hydrogeology Ltd.

Work Order Number: 410794

WORK ORDER RESULTS

Sample Description	NW Sump		SC Sump			
Sample Date	9/3/2020 1:00 PM		9/3/2020 1:00 PM			
Lab ID	1574225		1574226			
Anions	Result	MDL	Result	MDL	Units	Criteria: Nelson Water Criteria
Bromide	<0.1	0.1	<0.1	0.1	mg/L	~
Chloride	90.1	0.2	105.0	0.2	mg/L	~
Fluoride	0.17	0.06	0.24	0.06	mg/L	~
Nitrate (as N)	<0.05	0.05	<0.05	0.05	mg/L	~
Nitrite (as N)	<0.05	0.05	<0.05	0.05	mg/L	~
Sulphate	156.0	0.3	286.0	0.3	mg/L	~

Sample Description	NW Sump		SC Sump			
Sample Date	9/3/2020 1:00 PM		9/3/2020 1:00 PM			
Lab ID	1574225		1574226			
Field Parameters	Result	MDL	Result	MDL	Units	Criteria: Nelson Water Criteria
Field pH	8.32	N/A	8.4	N/A	pH	~
Field Temp	24.2	N/A	26	N/A	°C	~

Sample Description	NW Sump		SC Sump			
Sample Date	9/3/2020 1:00 PM		9/3/2020 1:00 PM			
Lab ID	1574225		1574226			
General Chemistry	Result	MDL	Result	MDL	Units	Criteria: Nelson Water Criteria
Ammonia (as N)	0.09	0.01	0.08	0.01	mg/L	~
Conductivity	764	1	1020	1	µS/cm	~
Dissolved Organic Carbon	3.6	0.4	3.4	0.4	mg/L	~

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CERTIFICATE OF ANALYSIS

Whitewater Hydrogeology Ltd.

Work Order Number: 410794

Sample Description	NW Sump		SC Sump			
Sample Date	9/3/2020 1:00 PM		9/3/2020 1:00 PM			
Lab ID	1574225		1574226			
General Chemistry	Result	MDL	Result	MDL	Units	Criteria: Nelson Water Criteria
Dissolved Oxygen	8.1	0.2	8.6	0.2	mg/L	~
M-Alkalinity (pH 4.5)	93	2	88	2	mg/L as CaCO3	~
Oil and Grease, Animal (Calc.)	<1	1	2	1	mg/L	~
Oil and Grease, Mineral	<1	1	2	1	mg/L	~
Oil and Grease, Total	<1	1	4	1	mg/L	15
pH	8.04	N/A	7.88	N/A	pH	8.5
Total Hardness (as CaCO3) (Calc.)	255.0	0.1	386.0	0.1	mg/L	~
Total Kjeldahl Nitrogen	2.4 [2.5]	0.4	1.8	0.4	mg/L	~
Total Phenols	0.0007	0.0004	0.0014	0.0004	mg/L	~
Total Phosphorus (as P)	0.011	0.002	0.027	0.002	mg/L	~
Un-Ionized Ammonia (Calc.)	0.009	0.002	0.011	0.002	mg/L	~

Sample Description	NW Sump		SC Sump			
Sample Date	9/3/2020 1:00 PM		9/3/2020 1:00 PM			
Lab ID	1574225		1574226			
Metals (Total)	Result	MDL	Result	MDL	Units	Criteria: Nelson Water Criteria
Total Aluminum	4	1	132	1	ug/L	~
Total Antimony	<0.5	0.5	<0.5	0.5	ug/L	~
Total Arsenic	5	1	7	1	ug/L	~
Total Barium	28	1	35	1	ug/L	~
Total Beryllium	<0.5	0.5	<0.5	0.5	ug/L	~
Total Bismuth	<1	1	<1	1	ug/L	~

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CERTIFICATE OF ANALYSIS

Whitewater Hydrogeology Ltd.

Work Order Number: 410794

Sample Description	NW Sump		SC Sump			
Sample Date	9/3/2020 1:00 PM		9/3/2020 1:00 PM			
Lab ID	1574225		1574226			
Metals (Total)	Result	MDL	Result	MDL	Units	Criteria: Nelson Water Criteria
Total Boron	89	2	207	2	ug/L	~
Total Cadmium	<0.02	0.02	<0.02	0.02	ug/L	~
Total Calcium	50400	500	87200	500	ug/L	~
Total Cerium	<1	1	<1	1	ug/L	~
Total Cesium	<1	1	<1	1	ug/L	~
Total Chromium	<1	1	<1	1	ug/L	~
Total Cobalt	0.1	0.1	0.4	0.1	ug/L	~
Total Copper	1	1	2	1	ug/L	~
Total Europium	<1	1	<1	1	ug/L	~
Total Gallium	<1	1	1	1	ug/L	~
Total Iron	110	20	375	20	ug/L	~
Total Lanthanum	<1	1	<1	1	ug/L	~
Total Lead	<0.1	0.1	0.2	0.1	ug/L	~
Total Lithium	9	5	20	5	ug/L	~
Total Magnesium	38200	4	51000	4	ug/L	~
Total Manganese	14	1	43	1	ug/L	~
Total Mercury	<0.1	0.1	<0.1	0.1	ug/L	~
Total Molybdenum	2	1	7	1	ug/L	~
Total Nickel	1	1	3	1	ug/L	~
Total Niobium	<1	1	<1	1	ug/L	~
Total Phosphorus	<50	50	<50	50	ug/L	~
Total Potassium	5970	100	7920	100	ug/L	~
Total Rubidium	3	1	4	1	ug/L	~
Total Scandium	<1	1	<1	1	ug/L	~

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CERTIFICATE OF ANALYSIS

Whitewater Hydrogeology Ltd.

Work Order Number: 410794

Sample Description	NW Sump		SC Sump			
Sample Date	9/3/2020 1:00 PM		9/3/2020 1:00 PM			
Lab ID	1574225		1574226			
Metals (Total)	Result	MDL	Result	MDL	Units	Criteria: Nelson Water Criteria
Total Selenium	1.5	0.5	1.6	0.5	ug/L	~
Total Silicon	934	2	851	2	ug/L	~
Total Silver	<0.1	0.1	<0.1	0.1	ug/L	~
Total Sodium	53400	1000	55200	1000	ug/L	~
Total Strontium	687	1	1610	10	ug/L	~
Total Sulphur	61700	800	106000	800	ug/L	~
Total Tellurium	<1	1	<1	1	ug/L	~
Total Thallium	<0.1	0.1	<0.1	0.1	ug/L	~
Total Thorium	<1	1	<1	1	ug/L	~
Total Tin	<1	1	<1	1	ug/L	~
Total Titanium	<1	1	3	1	ug/L	~
Total Tungsten	<1	1	<1	1	ug/L	~
Total Uranium	<1	1	<1	1	ug/L	~
Total Vanadium	<1	1	<1	1	ug/L	~
Total Yttrium	<1	1	<1	1	ug/L	~
Total Zinc	3	1	4	1	ug/L	~
Total Zirconium	<1	1	<1	1	ug/L	~

Sample Description	NW Sump		SC Sump			
Sample Date	9/3/2020 1:00 PM		9/3/2020 1:00 PM			
Lab ID	1574225		1574226			
PAH	Result	MDL	Result	MDL	Units	Criteria: Nelson Water Criteria
1,6-dinitropyrene	<2	2	<2	2	ug/L	~

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CERTIFICATE OF ANALYSIS

Whitewater Hydrogeology Ltd.

Work Order Number: 410794

Sample Description	NW Sump		SC Sump			
Sample Date	9/3/2020 1:00 PM		9/3/2020 1:00 PM			
Lab ID	1574225		1574226			
PAH	Result	MDL	Result	MDL	Units	Criteria: Nelson Water Criteria
1,8-dinitropyrene	<2	2	<2	2	ug/L	~
13dinitropyrene	<2	2	<2	2	ug/L	~
7H-Dibenzo(c,g)carbazole	<0.2	0.2	<0.2	0.2	ug/L	~
Anthracene	<0.2	0.2	<0.2	0.2	ug/L	~
Benzo(a)anthracene	<0.2	0.2	<0.2	0.2	ug/L	~
Benzo(a)pyrene	<0.2	0.2	<0.2	0.2	ug/L	~
Benzo(b)fluoranthene	<0.2	0.2	<0.2	0.2	ug/L	~
Benzo(b+j)fluoranthene	<0.2	0.2	<0.2	0.2	ug/L	~
Benzo(e)pyrene	<0.2	0.2	<0.2	0.2	ug/L	~
Benzo(ghi)perylene	<0.2	0.2	<0.2	0.2	ug/L	~
Benzo(j)fluoranthene	<0.2	0.2	<0.2	0.2	ug/L	~
Benzo(k)fluoranthene	<0.2	0.2	<0.2	0.2	ug/L	~
Chrysene	<0.2	0.2	<0.2	0.2	ug/L	~
Dibenz(a,h)anthracene	<0.2	0.2	<0.2	0.2	ug/L	~
Dibenzo(a,i)pyrene	<0.2	0.2	<0.2	0.2	ug/L	~
Dibenzo(a,j)acridine	<0.2	0.2	<0.2	0.2	ug/L	~
Fluoranthene	<0.2	0.2	<0.2	0.2	ug/L	~
Indeno(1,2,3-c,d)pyrene	<0.2	0.2	<0.2	0.2	ug/L	~
Perylene	<0.2	0.2	<0.2	0.2	ug/L	~
Phenanthrene	<0.2	0.2	<0.2	0.2	ug/L	~
Pyrene	<0.2	0.2	<0.2	0.2	ug/L	~
Total PAH	<4	4	<4	4	ug/L	~

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CERTIFICATE OF ANALYSIS

Whitewater Hydrogeology Ltd.

Work Order Number: 410794

Sample Description	NW Sump		SC Sump			
Sample Date	9/3/2020 1:00 PM		9/3/2020 1:00 PM			
Lab ID	1574225		1574226			
Solids	Result	MDL	Result	MDL	Units	Criteria: Nelson Water Criteria
Total Dissolved Solids	489	2	741	2	mg/L	~
Total Suspended Solids	<0.67	0.67	4.00	0.67	mg/L	25

LEGEND

Dates: Dates are formatted as mm/dd/year throughout this report.

[rr]: After a parameter name indicates a re-run of that parameter. If multiple re-runs exist they are suffixed by a number. Sample may not have been handled according to the recommended temperature, hold time and head space requirements of the method after the initial analysis.

MDL: Method detection limit or minimum reporting limit.

[ ]: Results for laboratory replicates are shown in square brackets immediately below the associated sample result for ease of comparison.

~: In a criteria column indicates the criteria is not applicable for the parameter row.

Quality Control: All associated Quality Control data is available on request.

Benzo(b)fluoranthene: Results for benzo(b)fluoranthene may include contributions from benzo(j)fluoranthene.

Field Data: Reports containing Field Parameters represent data that has been collected and provided by the client. Testmark is not responsible for the validity of this data which may be used in subsequent calculations.

Sample Condition Deviations: A noted sample condition deviation may affect the validity of the result. Results apply to the sample(s) as received.

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TESTMARK Laboratories Ltd.
Committed to Quality and Service

CERTIFICATE OF ANALYSIS

Client:	Tecia White	Work Order Number:	413604
Company:	Whitewater Hydrogeology Ltd.	PO #:	
Address:	80 Chamberlain Cres Collingwood, ON, L9Y 0C8	Regulation: Project #:	Nelson Water Criteria Nelson Aggregates Burlington Quarry Monthly ECA
Phone:	(705) 888-7064	DWS #:	
Email:	tecia@white-water.ca	Sampled By:	Hudson Selles
Date Order Received:	10/8/2020	Analysis Started:	10/8/2020
Arrival Temperature:	12.7 °C	Analysis Completed:	10/14/2020

WORK ORDER SUMMARY

ANALYSES WERE PERFORMED ON THE FOLLOWING SAMPLES. THE RESULTS RELATE ONLY TO THE ITEMS TESTED.

Sample Description	Lab ID	Matrix	Type	Comments	Date Collected	Time Collected
NW Sump	1584664	Water	None		10/6/2020	2:00 PM
SC Sump	1584665	Water	None		10/6/2020	2:00 PM

METHODS AND INSTRUMENTATION

THE FOLLOWING METHODS WERE USED FOR YOUR SAMPLE(S):

Method	Lab	Description	Reference
Alkalinity (A1.0)	Mississauga	Determination of Alkalinity by Titration	Modified from APHA-2320B
Ammonia Water (A42)	Mississauga	Determination of Ammonia/Ammonium in Water	Modified from EPA 350.1
Conductivity of Water (A12)	Mississauga	Determination of Conductivity in Water at 25°C	Modified from SM 2510 B
Dissolved Oxygen (A3)	Mississauga	Determination of Dissolved Oxygen in Water	Modified from APHA-5210
Field pH (R112)	Mississauga	Client Supplied Field Determination of pH of Water	Field Test
Field Temp (R113)	Mississauga	Client Supplied Field Determination of Temperature of Water	Field Test
ICPMS Reg. Water (A13)	Mississauga	Determination of Metals in Water by ICP/MS	Modified from SW846-6020
Oil and Grease (A54)	Mississauga	Determination of Oil and Grease in Water	Modified from EPA 1664
pH of Water (A2.0)	Mississauga	Determination of Water pH by Ion Selective Electrode	Modified from APHA-4500H+ B
Reg. Hardness (A13)	Mississauga	Determination of Total Hardness	Modified from APHA-2340B

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CERTIFICATE OF ANALYSIS

Whitewater Hydrogeology Ltd.

Work Order Number: 413604

Method	Lab	Description	Reference
TDS (A27)	Mississauga	Determination of Total Dissolved Solids in water by gravimetry	Modified from SM-2540
TSS (A27)	Mississauga	Determination of Total Suspended Solids in water by gravimetry	Modified from SM-2540
Un-Ionized NH3 (A42.4)	Mississauga	Calculation of Un-Ionized Ammonia	Modified from APHA-4500

REPORT COMMENTS

Samples past hold times for DO, proceed with the analysis as per client notes.10/08/20 A.P

This report has been approved by:



Marc Creighton
Laboratory Director

6820 Kitimat Road Unit 4, Mississauga, ON, L5N 5M3
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CERTIFICATE OF ANALYSIS

Whitewater Hydrogeology Ltd.

Work Order Number: 413604

WORK ORDER RESULTS

Sample Description	NW Sump		SC Sump			
Sample Date	10/6/2020 2:00 PM		10/6/2020 2:00 PM			
Lab ID	1584664		1584665			
Field Parameters	Result	MDL	Result	MDL	Units	Criteria: Nelson Water Criteria
Field pH	7.99	N/A	8	N/A	pH	~
Field Temp	16.3	N/A	16.9	N/A	°C	~

Sample Description	NW Sump		SC Sump			
Sample Date	10/6/2020 2:00 PM		10/6/2020 2:00 PM			
Lab ID	1584664		1584665			
General Chemistry	Result	MDL	Result	MDL	Units	Criteria: Nelson Water Criteria
Ammonia (as N)	<0.01 [<0.01]	0.01	0.03	0.01	mg/L	~
Conductivity	884	1	1100	1	µS/cm	~
Dissolved Oxygen	9.8	0.2	9.7	0.2	mg/L	~
M-Alkalinity (pH 4.5)	114	2	96	2	mg/L as CaCO3	~
Oil and Grease, Animal (Calc.)	<1	1	<1	1	mg/L	~
Oil and Grease, Mineral	1	1	2	1	mg/L	~
Oil and Grease, Total	2	1	3	1	mg/L	15
pH	7.95	N/A	7.9	N/A	pH	8.5
Total Hardness (as CaCO3) (Calc.)	289.0	0.1	415.0	0.1	mg/L	~
Un-Ionized Ammonia (Calc.)	<0.002	0.002	<0.002	0.002	mg/L	~

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CERTIFICATE OF ANALYSIS

Whitewater Hydrogeology Ltd.

Work Order Number: 413604

Sample Description	NW Sump		SC Sump			
Sample Date	10/6/2020 2:00 PM		10/6/2020 2:00 PM			
Lab ID	1584664		1584665			
Solids	Result	MDL	Result	MDL	Units	Criteria: Nelson Water Criteria
Total Dissolved Solids	572	2	757 [782]	2	mg/L	~
Total Suspended Solids	1.30	0.67	22.5 [23]	1	mg/L	25

LEGEND

Dates: Dates are formatted as mm/dd/year throughout this report.

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MDL: Method detection limit or minimum reporting limit.

[ ]: Results for laboratory replicates are shown in square brackets immediately below the associated sample result for ease of comparison.

~: In a criteria column indicates the criteria is not applicable for the parameter row.

Quality Control: All associated Quality Control data is available on request.

Field Data: Reports containing Field Parameters represent data that has been collected and provided by the client. Testmark is not responsible for the validity of this data which may be used in subsequent calculations.

Sample Condition Deviations: A noted sample condition deviation may affect the validity of the result. Results apply to the sample(s) as received.

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TESTMARK Laboratories Ltd.
Committed to Quality and Service

CERTIFICATE OF ANALYSIS

Client:	Tecia White	Work Order Number:	416381
Company:	Whitewater Hydrogeology Ltd.	PO #:	
Address:	80 Chamberlain Cres Collingwood, ON, L9Y 0C8	Regulation: Project #:	Nelson Water Criteria Nelson Aggregates Burlington Quarry - Monthly ECA
Phone:	(705) 888-7064	DWS #:	
Email:	tecia@white-water.ca	Sampled By:	Hudson Selles
Date Order Received:	11/6/2020	Analysis Started:	11/6/2020
Arrival Temperature:	12.7 °C	Analysis Completed:	11/12/2020

WORK ORDER SUMMARY

ANALYSES WERE PERFORMED ON THE FOLLOWING SAMPLES. THE RESULTS RELATE ONLY TO THE ITEMS TESTED.

Sample Description	Lab ID	Matrix	Type	Comments	Date Collected	Time Collected
NW Sump	1596057	Water	None		11/5/2020	1:00 PM
SC Sump	1596058	Water	None		11/5/2020	1:00 PM

METHODS AND INSTRUMENTATION

THE FOLLOWING METHODS WERE USED FOR YOUR SAMPLE(S):

Method	Lab	Description	Reference
Alkalinity (A1.0)	Mississauga	Determination of Alkalinity by Titration	Modified from APHA-2320B
Ammonia Water (A42)	Mississauga	Determination of Ammonia/Ammonium in Water	Modified from EPA 350.1
Conductivity of Water (A12)	Mississauga	Determination of Conductivity in Water at 25°C	Modified from SM 2510 B
Dissolved Oxygen (A3)	Mississauga	Determination of Dissolved Oxygen in Water	Modified from APHA-5210
Field pH (R112)	Mississauga	Client Supplied Field Determination of pH of Water	Field Test
Field Temp (R113)	Mississauga	Client Supplied Field Determination of Temperature of Water	Field Test
ICPMS Reg. Water (A13)	Mississauga	Determination of Metals in Water by ICP/MS	Modified from SW846-6020
Oil and Grease (A54)	Mississauga	Determination of Oil and Grease in Water	Modified from EPA 1664
pH of Water (A2.0)	Mississauga	Determination of Water pH by Ion Selective Electrode	Modified from APHA-4500H+ B
Reg. Hardness (A13)	Mississauga	Determination of Total Hardness	Modified from APHA-2340B

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CERTIFICATE OF ANALYSIS

Whitewater Hydrogeology Ltd.

Work Order Number: 416381

Method	Lab	Description	Reference
TDS (A27)	Mississauga	Determination of Total Dissolved Solids in water by gravimetry	Modified from SM-2540
TSS (A27)	Mississauga	Determination of Total Suspended Solids in water by gravimetry	Modified from SM-2540
Un-Ionized NH3 (A42.4)	Mississauga	Calculation of Un-Ionized Ammonia	Modified from APHA-4500

REPORT COMMENTS

Samples received past hold time for DO, proceed with analysis as per client notes 11/06/2020 YH

This report has been approved by:



Marc Creighton
Laboratory Director

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CERTIFICATE OF ANALYSIS

Whitewater Hydrogeology Ltd.

Work Order Number: 416381

WORK ORDER RESULTS

Sample Description	NW Sump		SC Sump			
Sample Date	11/5/2020 1:00 PM		11/5/2020 1:00 PM			
Lab ID	1596057		1596058			
Field Parameters	Result	MDL	Result	MDL	Units	Criteria: Nelson Water Criteria
Field pH	8.14	N/A	8.08	N/A	pH	~
Field Temp	15	N/A	15	N/A	°C	~

Sample Description	NW Sump		SC Sump			
Sample Date	11/5/2020 1:00 PM		11/5/2020 1:00 PM			
Lab ID	1596057		1596058			
General Chemistry	Result	MDL	Result	MDL	Units	Criteria: Nelson Water Criteria
Ammonia (as N)	<0.01	0.01	<0.01	0.01	mg/L	~
Conductivity	854	1	1130	1	µS/cm	~
Dissolved Oxygen	10.9	0.2	10.6	0.2	mg/L	~
M-Alkalinity (pH 4.5)	122	2	113	2	mg/L as CaCO3	~
Oil and Grease, Animal (Calc.)	<1	1	<1	1	mg/L	~
Oil and Grease, Mineral	<1	1	<1	1	mg/L	~
Oil and Grease, Total	<1	1	<1	1	mg/L	15
pH	8.07	N/A	8.13	N/A	pH	8.5
Total Hardness (as CaCO3) (Calc.)	322.0	0.1	453.0	0.1	mg/L	~
Un-Ionized Ammonia (Calc.)	<0.002	0.002	<0.002	0.002	mg/L	~

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CERTIFICATE OF ANALYSIS

Whitewater Hydrogeology Ltd.

Work Order Number: 416381

Sample Description	NW Sump		SC Sump			
Sample Date	11/5/2020 1:00 PM		11/5/2020 1:00 PM			
Lab ID	1596057		1596058			
Solids	Result	MDL	Result	MDL	Units	Criteria: Nelson Water Criteria
Total Dissolved Solids	564	2	777 [773]	2	mg/L	~
Total Suspended Solids	<0.67	0.67	18 [18]	1	mg/L	25

LEGEND

Dates: Dates are formatted as mm/dd/year throughout this report.

[rr]: After a parameter name indicates a re-run of that parameter. If multiple re-runs exist they are suffixed by a number. Sample may not have been handled according to the recommended temperature, hold time and head space requirements of the method after the initial analysis.

MDL: Method detection limit or minimum reporting limit.

[ ]: Results for laboratory replicates are shown in square brackets immediately below the associated sample result for ease of comparison.

~: In a criteria column indicates the criteria is not applicable for the parameter row.

Quality Control: All associated Quality Control data is available on request.

Field Data: Reports containing Field Parameters represent data that has been collected and provided by the client. Testmark is not responsible for the validity of this data which may be used in subsequent calculations.

Sample Condition Deviations: A noted sample condition deviation may affect the validity of the result. Results apply to the sample(s) as received.

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CERTIFICATE OF ANALYSIS

Client:	Tecia White	Work Order Number:	419224
Company:	Whitewater Hydrogeology Ltd.	PO #:	
Address:	80 Chamberlain Cres Collingwood, ON, L9Y 0C8	Regulation: Project #:	Nelson Water Criteria Nelson Aggregates Burlington Quarry - Monthly ECA
Phone:	(705) 888-7064	DWS #:	
Email:	tecia@white-water.ca	Sampled By:	Hudson Selles
Date Order Received:	12/10/2020	Analysis Started:	12/10/2020
Arrival Temperature:	3.5 °C	Analysis Completed:	12/16/2020

WORK ORDER SUMMARY

ANALYSES WERE PERFORMED ON THE FOLLOWING SAMPLES. THE RESULTS RELATE ONLY TO THE ITEMS TESTED.

Sample Description	Lab ID	Matrix	Type	Comments	Date Collected	Time Collected
NW Sump	1605838	Water	None		12/8/2020	11:00 AM
SC Sump	1605839	Water	None		12/8/2020	11:00 AM

METHODS AND INSTRUMENTATION

THE FOLLOWING METHODS WERE USED FOR YOUR SAMPLE(S):

Method	Lab	Description	Reference
Alkalinity (A1.0)	Mississauga	Determination of Alkalinity by Titration	Modified from APHA-2320B
Ammonia Water (A42)	Mississauga	Determination of Ammonia/Ammonium in Water	Modified from EPA 350.1
Conductivity of Water (A12)	Mississauga	Determination of Conductivity in Water at 25°C	Modified from SM 2510 B
Dissolved Oxygen (A3)	Mississauga	Determination of Dissolved Oxygen in Water	Modified from APHA-5210
Field pH (R112)	Mississauga	Client Supplied Field Determination of pH of Water	Field Test
Field Temp (R113)	Mississauga	Client Supplied Field Determination of Temperature of Water	Field Test
ICPMS Reg. Water (A13)	Mississauga	Determination of Metals in Water by ICP/MS	Modified from SW846-6020
Oil and Grease (A54)	Mississauga	Determination of Oil and Grease in Water	Modified from EPA 1664
pH of Water (A2.0)	Mississauga	Determination of Water pH by Ion Selective Electrode	Modified from APHA-4500H+ B
Reg. Hardness (A13)	Mississauga	Determination of Total Hardness	Modified from APHA-2340B

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Whitewater Hydrogeology Ltd.

Work Order Number: 419224

Method	Lab	Description	Reference
TDS (A27)	Mississauga	Determination of Total Dissolved Solids in water by gravimetry	Modified from SM-2540
TSS (A27)	Mississauga	Determination of Total Suspended Solids in water by gravimetry	Modified from SM-2540
Un-Ionized NH3 (A42.4)	Mississauga	Calculation of Un-Ionized Ammonia	Modified from APHA-4500

REPORT COMMENTS

Samples received past hold time for DO, proceed with analysis as per client notes 12/10/2020 YH

This report has been approved by:



Marc Creighton
Laboratory Director

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CERTIFICATE OF ANALYSIS

Whitewater Hydrogeology Ltd.

Work Order Number: 419224

WORK ORDER RESULTS

Sample Description	NW Sump		SC Sump			
Sample Date	12/8/2020 11:00 AM		12/8/2020 11:00 AM			
Lab ID	1605838		1605839			
Field Parameters	Result	MDL	Result	MDL	Units	Criteria: Nelson Water Criteria
Field pH	8.08	N/A	8.12	N/A	pH	~
Field Temp	2.7	N/A	3.6	N/A	°C	~

Sample Description	NW Sump		SC Sump			
Sample Date	12/8/2020 11:00 AM		12/8/2020 11:00 AM			
Lab ID	1605838		1605839			
General Chemistry	Result	MDL	Result	MDL	Units	Criteria: Nelson Water Criteria
Ammonia (as N)	<0.01	0.01	<0.01	0.01	mg/L	~
Conductivity	888	1	1110	1	µS/cm	~
Dissolved Oxygen	11.1	0.2	11.1	0.2	mg/L	~
M-Alkalinity (pH 4.5)	137	2	120	2	mg/L as CaCO3	~
Oil and Grease, Animal (Calc.)	<1	1	<1	1	mg/L	~
Oil and Grease, Mineral	<1	1	<1	1	mg/L	~
Oil and Grease, Total	<1	1	<1	1	mg/L	15
pH	8.03	N/A	7.99	N/A	pH	8.5
Total Hardness (as CaCO3) (Calc.)	349.0	0.1	456.0	0.1	mg/L	~
Un-Ionized Ammonia (Calc.)	<0.002	0.002	<0.002	0.002	mg/L	~

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Whitewater Hydrogeology Ltd.

Work Order Number: 419224

Sample Description	NW Sump		SC Sump			
Sample Date	12/8/2020 11:00 AM		12/8/2020 11:00 AM			
Lab ID	1605838		1605839			
Solids	Result	MDL	Result	MDL	Units	Criteria: Nelson Water Criteria
Total Dissolved Solids	629	2	772	2	mg/L	~
Total Suspended Solids	1.30	0.67	10.00	0.67	mg/L	25

LEGEND

Dates: Dates are formatted as mm/dd/year throughout this report.

[rr]: After a parameter name indicates a re-run of that parameter. If multiple re-runs exist they are suffixed by a number. Sample may not have been handled according to the recommended temperature, hold time and head space requirements of the method after the initial analysis.

MDL: Method detection limit or minimum reporting limit.

~: In a criteria column indicates the criteria is not applicable for the parameter row.

Quality Control: All associated Quality Control data is available on request.

Field Data: Reports containing Field Parameters represent data that has been collected and provided by the client. Testmark is not responsible for the validity of this data which may be used in subsequent calculations.

Sample Condition Deviations: A noted sample condition deviation may affect the validity of the result. Results apply to the sample(s) as received.

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CERTIFICATE OF ANALYSIS

Client:	Tecia White	Work Order Number:	419227
Company:	Whitewater Hydrogeology Ltd.	PO #:	
Address:	80 Chamberlain Cres Collingwood, ON, L9Y 0C8	Regulation: Project #:	Nelson Water Criteria Nelson Aggregates Burlington Quarry - Quarterly ECA
Phone:	(705) 888-7064	DWS #:	
Email:	tecia@white-water.ca	Sampled By:	Hudson Selles
Date Order Received:	12/10/2020	Analysis Started:	12/10/2020
Arrival Temperature:	3.5 °C	Analysis Completed:	12/16/2020

WORK ORDER SUMMARY

ANALYSES WERE PERFORMED ON THE FOLLOWING SAMPLES. THE RESULTS RELATE ONLY TO THE ITEMS TESTED.

Sample Description	Lab ID	Matrix	Type	Comments	Date Collected	Time Collected
NW Sump	1605843	Water	None		12/8/2020	11:00 AM
SC Sump	1605844	Water	None		12/8/2020	11:00 AM

METHODS AND INSTRUMENTATION

THE FOLLOWING METHODS WERE USED FOR YOUR SAMPLE(S):

Method	Lab	Description	Reference
Alkalinity (A1.0)	Mississauga	Determination of Alkalinity by Titration	Modified from APHA-2320B
Ammonia Water (A42)	Mississauga	Determination of Ammonia/Ammonium in Water	Modified from EPA 350.1
Anions Water (mg/L by IC) (A5)	Mississauga	Determination of Anions in Water by Ion Chromatography	Modified from SW846-9056A
Conductivity of Water (A12)	Mississauga	Determination of Conductivity in Water at 25°C	Modified from SM 2510 B
Dissolved Oxygen (A3)	Mississauga	Determination of Dissolved Oxygen in Water	Modified from APHA-5210
DOC Water (A55.1)	Mississauga	Determination of Dissolved Organic Carbon in Water	Modified from SM-5310 C
Field pH (R112)	Mississauga	Client Supplied Field Determination of pH of Water	Field Test
Field Temp (R113)	Mississauga	Client Supplied Field Determination of Temperature of Water	Field Test
ICPMS Reg. Water (A13)	Mississauga	Determination of Metals in Water by ICP/MS	Modified from SW846-6020
ICPMS Tot. Water (A13)	Mississauga	Determination of Total Metals in Water by ICP/MS with Digestion	Modified from SW846-6020

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Whitewater Hydrogeology Ltd.

Work Order Number: 419227

Method	Lab	Description	Reference
Oil and Grease (A54)	Mississauga	Determination of Oil and Grease in Water	Modified from EPA 1664
PAH Water SIM (A41)	Garson	Determination of PAH in Water by GC/MS	Modified from SW846-8270D
pH of Water (A2.0)	Mississauga	Determination of Water pH by Ion Selective Electrode	Modified from APHA-4500H+ B
Phenols 4AAP (T38)	Mississauga	Determination of Total Phenols by 4AAP	Modified from APHA-5530
Reg. Hardness (A13)	Mississauga	Determination of Total Hardness	Modified from APHA-2340B
TDS (A27)	Mississauga	Determination of Total Dissolved Solids in water by gravimetry	Modified from SM-2540
TKN Water Dig. (A58)	Kirkland Lake	Determination of Total Kjeldahl Nitrogen in Waters with Block Digestion.	Modified from SM-4500 NORG-D
TP Water (A23.2)	Kirkland Lake	Determination of Total Phosphorus in Water.	Modified from EPA 365.3 and ESS 310.2,
TSS (A27)	Mississauga	Determination of Total Suspended Solids in water by gravimetry	Modified from SM-2540
Un-Ionized NH3 (A42.4)	Mississauga	Calculation of Un-Ionized Ammonia	Modified from APHA-4500

This report has been approved by:



Marc Creighton
Laboratory Director

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CERTIFICATE OF ANALYSIS

Whitewater Hydrogeology Ltd.

Work Order Number: 419227

WORK ORDER RESULTS

Sample Description	NW Sump		SC Sump			
Sample Date	12/8/2020 11:00 AM		12/8/2020 11:00 AM			
Lab ID	1605843		1605844			
Anions	Result	MDL	Result	MDL	Units	Criteria: Nelson Water Criteria
Bromide	0.2	0.1	0.3	0.1	mg/L	~
Chloride	93.0	0.2	99.6	0.2	mg/L	~
Fluoride	0.18	0.06	0.23	0.06	mg/L	~
Nitrate (as N)	<0.05	0.05	0.35	0.05	mg/L	~
Nitrite (as N)	<0.05	0.05	<0.05	0.05	mg/L	~
Sulphate	228.0	0.3	339.0	0.3	mg/L	~

Sample Description	NW Sump		SC Sump			
Sample Date	12/8/2020 11:00 AM		12/8/2020 11:00 AM			
Lab ID	1605843		1605844			
Field Parameters	Result	MDL	Result	MDL	Units	Criteria: Nelson Water Criteria
Field pH	8.08	N/A	8.12	N/A	pH	~
Field Temp	2.7	N/A	3.6	N/A	°C	~

Sample Description	NW Sump		SC Sump			
Sample Date	12/8/2020 11:00 AM		12/8/2020 11:00 AM			
Lab ID	1605843		1605844			
General Chemistry	Result	MDL	Result	MDL	Units	Criteria: Nelson Water Criteria
Ammonia (as N)	<0.01	0.01	0.01	0.01	mg/L	~
Conductivity	919	1	1110	1	µS/cm	~
Dissolved Organic Carbon	3.2	0.4	2.9	0.4	mg/L	~

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CERTIFICATE OF ANALYSIS

Whitewater Hydrogeology Ltd.

Work Order Number: 419227

Sample Description	NW Sump		SC Sump			
Sample Date	12/8/2020 11:00 AM		12/8/2020 11:00 AM			
Lab ID	1605843		1605844			
General Chemistry	Result	MDL	Result	MDL	Units	Criteria: Nelson Water Criteria
Dissolved Oxygen	11.4	0.2	11.5	0.2	mg/L	~
M-Alkalinity (pH 4.5)	138	2	121	2	mg/L as CaCO3	~
Oil and Grease, Animal (Calc.)	1	1	1	1	mg/L	~
Oil and Grease, Mineral	<1	1	<1	1	mg/L	~
Oil and Grease, Total	1	1	1	1	mg/L	15
pH	8.05	N/A	7.98	N/A	pH	8.5
Total Hardness (as CaCO3) (Calc.)	351.0	0.1	429.0	0.1	mg/L	~
Total Kjeldahl Nitrogen	1.5	0.4	1.4	0.4	mg/L	~
Total Phenols	<0.0004	0.0004	<0.0004	0.0004	mg/L	~
Total Phosphorus (as P)	0.018	0.002	0.055	0.002	mg/L	~
Un-Ionized Ammonia (Calc.)	<0.002	0.002	<0.002	0.002	mg/L	~

Sample Description	NW Sump		SC Sump			
Sample Date	12/8/2020 11:00 AM		12/8/2020 11:00 AM			
Lab ID	1605843		1605844			
Metals (Total)	Result	MDL	Result	MDL	Units	Criteria: Nelson Water Criteria
Total Aluminum	50	1	552	1	ug/L	~
Total Antimony	<0.5	0.5	<0.5	0.5	ug/L	~
Total Arsenic	2	1	3	1	ug/L	~
Total Barium	41	1	39	1	ug/L	~
Total Beryllium	<0.5	0.5	<0.5	0.5	ug/L	~
Total Bismuth	<1	1	<1	1	ug/L	~
Total Boron	202	2	269	2	ug/L	~

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CERTIFICATE OF ANALYSIS

Whitewater Hydrogeology Ltd.

Work Order Number: 419227

Sample Description	NW Sump		SC Sump			
Sample Date	12/8/2020 11:00 AM		12/8/2020 11:00 AM			
Lab ID	1605843		1605844			
Metals (Total)	Result	MDL	Result	MDL	Units	Criteria: Nelson Water Criteria
Total Cadmium	0.02	0.02	0.04	0.02	ug/L	~
Total Calcium	62400	500	88600	500	ug/L	~
Total Cerium	<1	1	1	1	ug/L	~
Total Cesium	<1	1	<1	1	ug/L	~
Total Chromium	<1	1	2	1	ug/L	~
Total Cobalt	0.3	0.1	0.9	0.1	ug/L	~
Total Copper	2	1	5	1	ug/L	~
Total Europium	<1	1	<1	1	ug/L	~
Total Gallium	2	1	2	1	ug/L	~
Total Iron	526	20	1300	200	ug/L	~
Total Lanthanum	<1	1	<1	1	ug/L	~
Total Lead	0.2	0.1	1.1	0.1	ug/L	~
Total Lithium	11	5	21	5	ug/L	~
Total Magnesium	40700	4	49600	4	ug/L	~
Total Manganese	49	1	74	1	ug/L	~
Total Mercury	<0.1	0.1	<0.1	0.1	ug/L	~
Total Molybdenum	3	1	6	1	ug/L	~
Total Nickel	3	1	6	1	ug/L	~
Total Niobium	<1	1	<1	1	ug/L	~
Total Phosphorus	<50	50	62	50	ug/L	~
Total Potassium	5930	100	7280	100	ug/L	~
Total Rubidium	2	1	4	1	ug/L	~
Total Scandium	<1	1	1	1	ug/L	~
Total Selenium	1.4	0.5	2.5	0.5	ug/L	~

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CERTIFICATE OF ANALYSIS

Whitewater Hydrogeology Ltd.

Work Order Number: 419227

Sample Description	NW Sump		SC Sump			
Sample Date	12/8/2020 11:00 AM		12/8/2020 11:00 AM			
Lab ID	1605843		1605844			
Metals (Total)	Result	MDL	Result	MDL	Units	Criteria: Nelson Water Criteria
Total Silicon	684	2	1390	2	ug/L	~
Total Silver	<0.1	0.1	<0.1	0.1	ug/L	~
Total Sodium	40900	1000	44300	1000	ug/L	~
Total Strontium	1170	10	1990	10	ug/L	~
Total Sulphur	72600	800	109000	800	ug/L	~
Total Tellurium	<1	1	<1	1	ug/L	~
Total Thallium	<0.1	0.1	<0.1	0.1	ug/L	~
Total Thorium	<1	1	<1	1	ug/L	~
Total Tin	<1	1	<1	1	ug/L	~
Total Titanium	<1	1	8	1	ug/L	~
Total Tungsten	<1	1	<1	1	ug/L	~
Total Uranium	<1	1	1	1	ug/L	~
Total Vanadium	<1	1	2	1	ug/L	~
Total Yttrium	<1	1	<1	1	ug/L	~
Total Zinc	24	1	15	1	ug/L	~
Total Zirconium	<1	1	<1	1	ug/L	~

Sample Description	NW Sump		SC Sump			
Sample Date	12/8/2020 11:00 AM		12/8/2020 11:00 AM			
Lab ID	1605843		1605844			
PAH	Result	MDL	Result	MDL	Units	Criteria: Nelson Water Criteria
1+2-Methylnaphthalene (Calc.)	<0.05	0.05	<0.05	0.05	ug/L	~
1-Methylnaphthalene	<0.03	0.03	<0.04	0.04	ug/L	~

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CERTIFICATE OF ANALYSIS

Whitewater Hydrogeology Ltd.

Work Order Number: 419227

Sample Description	NW Sump		SC Sump			
Sample Date	12/8/2020 11:00 AM		12/8/2020 11:00 AM			
Lab ID	1605843		1605844			
PAH	Result	MDL	Result	MDL	Units	Criteria: Nelson Water Criteria
2-Methylnaphthalene	<0.02	0.02	<0.02	0.02	ug/L	~
3,3'-Dichlorobenzidine	<0.06	0.06	<0.06	0.06	ug/L	~
Acenaphthene	<0.05	0.05	<0.05	0.05	ug/L	~
Acenaphthylene	<0.05	0.05	<0.05	0.05	ug/L	~
Anthracene	<0.02	0.02	<0.02	0.02	ug/L	~
Benzo(a)anthracene	<0.02	0.02	<0.02	0.02	ug/L	~
Benzo(a)pyrene	<0.009	0.009	<0.01	0.01	ug/L	~
Benzo(b)fluoranthene	<0.07	0.07	<0.07	0.07	ug/L	~
Benzo(ghi)perylene	<0.05	0.05	<0.05	0.05	ug/L	~
Benzo(k)fluoranthene	<0.05	0.05	<0.05	0.05	ug/L	~
Biphenyl	<0.1	0.1	<0.1	0.1	ug/L	~
Chrysene	<0.06	0.06	<0.06	0.06	ug/L	~
Dibenz(a,h)anthracene	<0.05	0.05	<0.05	0.05	ug/L	~
Fluoranthene	<0.03	0.03	<0.04	0.04	ug/L	~
Fluorene	<0.05	0.05	<0.05	0.05	ug/L	~
Fluorobiphenyl (Surr.)	57	N/A	67	N/A	% Rec	~
Indeno(1,2,3-c,d)pyrene	<0.03	0.03	<0.04	0.04	ug/L	~
Naphthalene	<0.06	0.06	<0.06	0.06	ug/L	~
Phenanthrene	<0.03	0.03	<0.04	0.04	ug/L	~
p-Terphenyl-d14 (Surr.)	92.6	N/A	104	N/A	% Rec	~
Pyrene	<0.06	0.06	<0.06	0.06	ug/L	~

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CERTIFICATE OF ANALYSIS

Whitewater Hydrogeology Ltd.

Work Order Number: 419227

Sample Description	NW Sump		SC Sump			
Sample Date	12/8/2020 11:00 AM		12/8/2020 11:00 AM			
Lab ID	1605843		1605844			
Solids	Result	MDL	Result	MDL	Units	Criteria: Nelson Water Criteria
Total Dissolved Solids	640	2	780	2	mg/L	~
Total Suspended Solids	3.30	0.67	12.00	0.67	mg/L	25

LEGEND

Dates: Dates are formatted as mm/dd/year throughout this report.

[rr]: After a parameter name indicates a re-run of that parameter. If multiple re-runs exist they are suffixed by a number. Sample may not have been handled according to the recommended temperature, hold time and head space requirements of the method after the initial analysis.

MDL: Method detection limit or minimum reporting limit.

% Rec: Surrogate compounds are added to the sample in some cases and the recovery is reported as a % recovered.

~: In a criteria column indicates the criteria is not applicable for the parameter row.

Quality Control: All associated Quality Control data is available on request.

Benzo(b)fluoranthene: Results for benzo(b)fluoranthene may include contributions from benzo(j)fluoranthene.

Field Data: Reports containing Field Parameters represent data that has been collected and provided by the client. Testmark is not responsible for the validity of this data which may be used in subsequent calculations.

Sample Condition Deviations: A noted sample condition deviation may affect the validity of the result. Results apply to the sample(s) as received.

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APPENDIX C

METER CALIBRATION REPORTS

WAJAX

Mississauga Ontario L5N 6A5
Telephone (905) 813-8310
Fax (905)812-1397

ISO 9001 Quality

Certified Test Report

Report #: 23280
Description: Seametrics FT430M-126 Mag Meter
Pulse Output: 1000 L/P
Serial #: 072016000966
Customer: Nelson Aggregate Burlington
Location: 2433 #2 Side Road South Central

Cert Date: July 21, 2020
Recert Date: July 22, 2021
Tolerance: See Manual
P.O.# 4177

Calibration Test Equipment Used

Standard used: Flexim Ultra Sonic Flow Meter
Type: CDK1NZ7
Serial No: 13018
Traceability to: N.I.S.T
Position: Vertical

Our Order No.: CSW10070660
Accuracy: 0.5% of Rdg
Report #: F14-368
Temperature: 23°C ± 2°

Master	Indication
870 L/M	880 L/M

Frequency Output = 1 pules /1000 Liters

Wajax Industrial Components certifies that the above item has been inspected and tested to comply in every way with the relevant specifications in accordance with the requirements of the above purchase order.

Signed: Chene Middleton

Approved:

Mississauga Ontario L5N 6A5
Telephone (905) 813-8310
Fax (905)812-1397

ISO 9001 Quality

Certified Test Report

Report #: 23281
Description: Seametrics FT430M-126 Mag Meter
Pulse Output: 1000 L/P
Serial #: 072010000854
Customer: Nelson Aggregate Burlington
Location: 2433 #2 Side Road North East Sump
Cert Date: July 21, 2020
Recert Date: July 22, 2021
Tolerance: See Manual
P.O.# 4177

Calibration Test Equipment Used

Standard used: Flexim Ultra Sonic Flow Meter
Type: CDK1NZ7
Serial No: 13018
Traceability to: N.I.S.T
Position: Vertical
Our Order No.: CSW10070660
Accuracy: 0.5% of Rdg
Report #: F14-368
Temperature: 23°C ± 2°

Master	Indication
3800 L/M	3850 L/M

Frequency Output = 1 pules /1000 Liters

Wajax Industrial Components certifies that the above item has been inspected and tested to comply in every way with the relevant specifications in accordance with the requirements of the above purchase order.

Signed: _____
Chene Middleton

Approved: _____

APPENDIX D

WATER TAKINGS

96-P-3009				
Quarry Sump 0200 SC			Quarry Sump 0100 NW	
Date	Taking Amount	Method	Taking Amount	Method
01-Jan-20	0	metered	0	metered
02-Jan-20	0	metered	0	metered
03-Jan-20	0	metered	0	metered
04-Jan-20	0	metered	0	metered
05-Jan-20	0	metered	0	metered
06-Jan-20	0	metered	0	metered
07-Jan-20	0	metered	0	metered
08-Jan-20	0	metered	0	metered
09-Jan-20	0	metered	0	metered
10-Jan-20	0	metered	0	metered
11-Jan-20	0	metered	0	metered
12-Jan-20	0	metered	0	metered
13-Jan-20	0	metered	0	metered
14-Jan-20	0	metered	0	metered
15-Jan-20	0	metered	0	metered
16-Jan-20	0	metered	0	metered
17-Jan-20	0	metered	0	metered
18-Jan-20	1,350,000	metered	5,760,000	metered
19-Jan-20	1,350,000	metered	5,760,000	metered
20-Jan-20	1,350,000	metered	5,760,000	metered
21-Jan-20	1,350,000	metered	5,760,000	metered
22-Jan-20	1,350,000	metered	5,760,000	metered
23-Jan-20	1,350,000	metered	5,760,000	metered
24-Jan-20	1,350,000	metered	5,760,000	metered
25-Jan-20	1,350,000	metered	5,760,000	metered
26-Jan-20	1,350,000	metered	5,760,000	metered
27-Jan-20	1,350,000	metered	5,760,000	metered
28-Jan-20	1,350,000	metered	5,760,000	metered
29-Jan-20	1,350,000	metered	5,760,000	metered
30-Jan-20	1,350,000	metered	5,760,000	metered
31-Jan-20	1,350,000	metered	5,760,000	metered
01-Feb-20	1,350,000	metered	5,760,000	metered
02-Feb-20	1,350,000	metered	5,760,000	metered
03-Feb-20	1,350,000	metered	5,760,000	metered
04-Feb-20	1,350,000	metered	5,760,000	metered
05-Feb-20	1,350,000	metered	5,760,000	metered
06-Feb-20	1,350,000	metered	5,760,000	metered
07-Feb-20	1,350,000	metered	5,760,000	metered
08-Feb-20	1,350,000	metered	5,760,000	metered
09-Feb-20	1,350,000	metered	5,760,000	metered
10-Feb-20	1,350,000	metered	5,760,000	metered
11-Feb-20	1,350,000	metered	5,760,000	metered
12-Feb-20	1,350,000	metered	5,760,000	metered
13-Feb-20	1,350,000	metered	5,760,000	metered
14-Feb-20	1,350,000	metered	5,760,000	metered
15-Feb-20	1,350,000	metered	5,760,000	metered
16-Feb-20	1,350,000	metered	5,760,000	metered
17-Feb-20	1,350,000	metered	5,760,000	metered
18-Feb-20	1,350,000	metered	5,760,000	metered
19-Feb-20	1,350,000	metered	5,760,000	metered
20-Feb-20	1,350,000	metered	5,760,000	metered
21-Feb-20	1,350,000	metered	5,760,000	metered
22-Feb-20	1,350,000	metered	5,760,000	metered
23-Feb-20	1,350,000	metered	5,760,000	metered
24-Feb-20	1,350,000	metered	5,760,000	metered
25-Feb-20	1,350,000	metered	5,760,000	metered
26-Feb-20	1,350,000	metered	5,760,000	metered
27-Feb-20	1,350,000	metered	5,760,000	metered
28-Feb-20	1,350,000	metered	5,760,000	metered
29-Feb-20	1,350,000	metered	5,760,000	metered
01-Mar-20	1,350,000	metered	5,760,000	metered
02-Mar-20	1,350,000	metered	5,760,000	metered
03-Mar-20	1,350,000	metered	5,760,000	metered
04-Mar-20	1,350,000	metered	5,760,000	metered
05-Mar-20	1,350,000	metered	5,760,000	metered
06-Mar-20	1,350,000	metered	5,760,000	metered
07-Mar-20	1,350,000	metered	5,760,000	metered
08-Mar-20	1,350,000	metered	5,760,000	metered
09-Mar-20	1,350,000	metered	5,760,000	metered
10-Mar-20	1,350,000	metered	5,760,000	metered
11-Mar-20	1,350,000	metered	5,760,000	metered
12-Mar-20	1,350,000	metered	5,760,000	metered
13-Mar-20	1,350,000	metered	5,760,000	metered
14-Mar-20	1,350,000	metered	5,760,000	metered

96-P-3009				
Quarry Sump 0200 SC			Quarry Sump 0100 NW	
Date	Taking Amount	Method	Taking Amount	Method
15-Mar-20	1,350,000	metered	5,760,000	metered
16-Mar-20	1,350,000	metered	5,760,000	metered
17-Mar-20	1,350,000	metered	5,760,000	metered
18-Mar-20	1,350,000	metered	5,760,000	metered
19-Mar-20	1,350,000	metered	5,760,000	metered
20-Mar-20	1,350,000	metered	5,760,000	metered
21-Mar-20	1,350,000	metered	5,760,000	metered
22-Mar-20	1,350,000	metered	5,760,000	metered
23-Mar-20	1,350,000	metered	5,760,000	metered
24-Mar-20	1,350,000	metered	5,760,000	metered
25-Mar-20	1,350,000	metered	5,760,000	metered
26-Mar-20	1,350,000	metered	5,760,000	metered
27-Mar-20	1,350,000	metered	5,760,000	metered
28-Mar-20	1,350,000	metered	5,760,000	metered
29-Mar-20	1,350,000	metered	5,760,000	metered
30-Mar-20	1,350,000	metered	5,760,000	metered
31-Mar-20	1,350,000	metered	5,760,000	metered
01-Apr-20	1,350,000	metered	5,760,000	metered
02-Apr-20	1,350,000	metered	5,760,000	metered
03-Apr-20	1,350,000	metered	5,760,000	metered
04-Apr-20	1,350,000	metered	5,760,000	metered
05-Apr-20	1,350,000	metered	5,760,000	metered
06-Apr-20	1,350,000	metered	5,760,000	metered
07-Apr-20	1,350,000	metered	5,760,000	metered
08-Apr-20	1,350,000	metered	5,760,000	metered
09-Apr-20	1,350,000	metered	5,760,000	metered
10-Apr-20	1,350,000	metered	5,760,000	metered
11-Apr-20	1,350,000	metered	5,760,000	metered
12-Apr-20	1,350,000	metered	5,760,000	metered
13-Apr-20	1,350,000	metered	5,760,000	metered
14-Apr-20	1,350,000	metered	5,760,000	metered
15-Apr-20	1,350,000	metered	5,760,000	metered
16-Apr-20	1,350,000	metered	5,760,000	metered
17-Apr-20	1,350,000	metered	5,760,000	metered
18-Apr-20	1,350,000	metered	5,760,000	metered
19-Apr-20	1,350,000	metered	5,760,000	metered
20-Apr-20	1,350,000	metered	5,760,000	metered
21-Apr-20	1,350,000	metered	5,760,000	metered
22-Apr-20	1,350,000	metered	5,760,000	metered
23-Apr-20	1,350,000	metered	5,760,000	metered
24-Apr-20	1,350,000	metered	5,760,000	metered
25-Apr-20	1,350,000	metered	5,760,000	metered
26-Apr-20	1,350,000	metered	5,760,000	metered
27-Apr-20	1,350,000	metered	5,760,000	metered
28-Apr-20	1,350,000	metered	5,760,000	metered
29-Apr-20	1,350,000	metered	5,760,000	metered
30-Apr-20	1,350,000	metered	5,760,000	metered
01-May-20	1,350,000	metered	5,760,000	metered
02-May-20	1,350,000	metered	5,760,000	metered
03-May-20	1,350,000	metered	5,760,000	metered
04-May-20	1,350,000	metered	5,760,000	metered
05-May-20	1,350,000	metered	5,760,000	metered
06-May-20	1,350,000	metered	5,760,000	metered
07-May-20	1,350,000	metered	5,760,000	metered
08-May-20	1,350,000	metered	5,760,000	metered
09-May-20	1,350,000	metered	5,760,000	metered
10-May-20	1,350,000	metered	5,760,000	metered
11-May-20	1,350,000	metered	5,760,000	metered
12-May-20	1,350,000	metered	5,760,000	metered
13-May-20	1,350,000	metered	5,760,000	metered
14-May-20	1,350,000	metered	5,760,000	metered
15-May-20	1,350,000	metered	5,760,000	metered
16-May-20	1,350,000	metered	5,760,000	metered
17-May-20	1,350,000	metered	5,760,000	metered
18-May-20	1,350,000	metered	5,760,000	metered
19-May-20	1,350,000	metered	5,760,000	metered
20-May-20	1,350,000	metered	5,760,000	metered
21-May-20	1,350,000	metered	5,760,000	metered
22-May-20	1,350,000	metered	5,760,000	metered
23-May-20	1,350,000	metered	5,760,000	metered
24-May-20	1,350,000	metered	5,760,000	metered
25-May-20	1,350,000	metered	5,760,000	metered
26-May-20	1,350,000	metered	5,760,000	metered
27-May-20	1,350,000	metered	5,760,000	metered

96-P-3009				
Quarry Sump 0200 SC			Quarry Sump 0100 NW	
Date	Taking Amount	Method	Taking Amount	Method
28-May-20	1,350,000	metered	5,760,000	metered
29-May-20	1,350,000	metered	5,760,000	metered
30-May-20	1,350,000	metered	5,760,000	metered
31-May-20	1,350,000	metered	5,760,000	metered
01-Jun-20	1,350,000	metered	5,760,000	metered
02-Jun-20	1,350,000	metered	5,760,000	metered
03-Jun-20	1,350,000	metered	5,760,000	metered
04-Jun-20	1,350,000	metered	5,760,000	metered
05-Jun-20	1,350,000	metered	5,760,000	metered
06-Jun-20	1,350,000	metered	5,760,000	metered
07-Jun-20	1,350,000	metered	5,760,000	metered
08-Jun-20	1,350,000	metered	5,760,000	metered
09-Jun-20	1,350,000	metered	5,760,000	metered
10-Jun-20	1,350,000	metered	5,760,000	metered
11-Jun-20	1,350,000	metered	5,760,000	metered
12-Jun-20	1,350,000	metered	5,760,000	metered
13-Jun-20	1,350,000	metered	5,760,000	metered
14-Jun-20	1,350,000	metered	5,760,000	metered
15-Jun-20	1,350,000	metered	5,760,000	metered
16-Jun-20	1,350,000	metered	5,760,000	metered
17-Jun-20	1,350,000	metered	5,760,000	metered
18-Jun-20	1,350,000	metered	5,760,000	metered
19-Jun-20	1,350,000	metered	5,760,000	metered
20-Jun-20	1,350,000	metered	5,760,000	metered
21-Jun-20	1,350,000	metered	5,760,000	metered
22-Jun-20	1,350,000	metered	5,760,000	metered
23-Jun-20	1,350,000	metered	5,760,000	metered
24-Jun-20	1,350,000	metered	5,760,000	metered
25-Jun-20	1,350,000	metered	5,760,000	metered
26-Jun-20	1,350,000	metered	5,760,000	metered
27-Jun-20	1,350,000	metered	5,760,000	metered
28-Jun-20	1,350,000	metered	5,760,000	metered
29-Jun-20	1,350,000	metered	5,760,000	metered
30-Jun-20	1,350,000	metered	5,760,000	metered
01-Jul-20	1,350,000	metered	5,760,000	metered
02-Jul-20	1,350,000	metered	5,760,000	metered
03-Jul-20	1,350,000	metered	5,760,000	metered
04-Jul-20	1,350,000	metered	5,760,000	metered
05-Jul-20	1,350,000	metered	5,760,000	metered
06-Jul-20	1,350,000	metered	5,760,000	metered
07-Jul-20	1,350,000	metered	5,760,000	metered
08-Jul-20	1,350,000	metered	5,760,000	metered
09-Jul-20	1,350,000	metered	5,760,000	metered
10-Jul-20	1,350,000	metered	5,760,000	metered
11-Jul-20	1,350,000	metered	5,760,000	metered
12-Jul-20	1,350,000	metered	5,760,000	metered
13-Jul-20	1,350,000	metered	5,760,000	metered
14-Jul-20	1,350,000	metered	5,760,000	metered
15-Jul-20	1,350,000	metered	5,760,000	metered
16-Jul-20	1,350,000	metered	5,760,000	metered
17-Jul-20	1,350,000	metered	5,760,000	metered
18-Jul-20	1,350,000	metered	5,760,000	metered
19-Jul-20	1,350,000	metered	5,760,000	metered
20-Jul-20	1,350,000	metered	5,760,000	metered
21-Jul-20	1,350,000	metered	5,760,000	metered
22-Jul-20	1,350,000	metered	5,760,000	metered
23-Jul-20	1,350,000	metered	5,760,000	metered
24-Jul-20	1,350,000	metered	5,760,000	metered
25-Jul-20	1,350,000	metered	5,760,000	metered
26-Jul-20	1,350,000	metered	5,760,000	metered
27-Jul-20	1,350,000	metered	5,760,000	metered
28-Jul-20	1,350,000	metered	5,760,000	metered
29-Jul-20	1,350,000	metered	5,760,000	metered
30-Jul-20	1,350,000	metered	5,760,000	metered
31-Jul-20	1,350,000	metered	5,760,000	metered
01-Aug-20	1,350,000	metered	5,760,000	metered
02-Aug-20	1,350,000	metered	5,760,000	metered
03-Aug-20	1,350,000	metered	5,760,000	metered
04-Aug-20	1,350,000	metered	5,760,000	metered
05-Aug-20	1,350,000	metered	5,760,000	metered
06-Aug-20	1,350,000	metered	5,760,000	metered
07-Aug-20	1,350,000	metered	5,760,000	metered
08-Aug-20	1,350,000	metered	5,760,000	metered
09-Aug-20	1,350,000	metered	5,760,000	metered

96-P-3009				
Quarry Sump 0200 SC			Quarry Sump 0100 NW	
Date	Taking Amount	Method	Taking Amount	Method
10-Aug-20	1,350,000	metered	5,760,000	metered
11-Aug-20	1,350,000	metered	5,760,000	metered
12-Aug-20	1,350,000	metered	5,760,000	metered
13-Aug-20	1,350,000	metered	5,760,000	metered
14-Aug-20	1,350,000	metered	5,760,000	metered
15-Aug-20	1,350,000	metered	5,760,000	metered
16-Aug-20	1,350,000	metered	5,760,000	metered
17-Aug-20	1,350,000	metered	5,760,000	metered
18-Aug-20	1,350,000	metered	5,760,000	metered
19-Aug-20	1,350,000	metered	5,760,000	metered
20-Aug-20	1,350,000	metered	5,760,000	metered
21-Aug-20	1,350,000	metered	5,760,000	metered
22-Aug-20	1,350,000	metered	5,760,000	metered
23-Aug-20	1,350,000	metered	5,760,000	metered
24-Aug-20	1,350,000	metered	5,760,000	metered
25-Aug-20	1,350,000	metered	5,760,000	metered
26-Aug-20	1,350,000	metered	5,760,000	metered
27-Aug-20	1,350,000	metered	5,760,000	metered
28-Aug-20	1,350,000	metered	5,760,000	metered
29-Aug-20	1,350,000	metered	5,760,000	metered
30-Aug-20	1,350,000	metered	5,760,000	metered
31-Aug-20	1,350,000	metered	5,760,000	metered
01-Sep-20	1,350,000	metered	5,760,000	metered
02-Sep-20	1,350,000	metered	5,760,000	metered
03-Sep-20	1,350,000	metered	5,760,000	metered
04-Sep-20	1,350,000	metered	5,760,000	metered
05-Sep-20	1,350,000	metered	5,760,000	metered
06-Sep-20	1,350,000	metered	5,760,000	metered
07-Sep-20	1,350,000	metered	5,760,000	metered
08-Sep-20	1,350,000	metered	5,760,000	metered
09-Sep-20	1,350,000	metered	5,760,000	metered
10-Sep-20	1,350,000	metered	5,760,000	metered
11-Sep-20	1,350,000	metered	5,760,000	metered
12-Sep-20	1,350,000	metered	5,760,000	metered
13-Sep-20	1,350,000	metered	5,760,000	metered
14-Sep-20	1,350,000	metered	5,760,000	metered
15-Sep-20	1,350,000	metered	5,760,000	metered
16-Sep-20	1,350,000	metered	5,760,000	metered
17-Sep-20	1,350,000	metered	5,760,000	metered
18-Sep-20	1,350,000	metered	5,760,000	metered
19-Sep-20	1,350,000	metered	5,760,000	metered
20-Sep-20	1,350,000	metered	5,760,000	metered
21-Sep-20	1,350,000	metered	5,760,000	metered
22-Sep-20	1,350,000	metered	5,760,000	metered
23-Sep-20	1,350,000	metered	5,760,000	metered
24-Sep-20	1,350,000	metered	5,760,000	metered
25-Sep-20	1,350,000	metered	5,760,000	metered
26-Sep-20	1,350,000	metered	5,760,000	metered
27-Sep-20	1,350,000	metered	5,760,000	metered
28-Sep-20	1,350,000	metered	5,760,000	metered
29-Sep-20	1,350,000	metered	5,760,000	metered
30-Sep-20	1,350,000	metered	5,760,000	metered
01-Oct-20	1,350,000	metered	5,760,000	metered
02-Oct-20	1,350,000	metered	5,760,000	metered
03-Oct-20	1,350,000	metered	5,760,000	metered
04-Oct-20	1,350,000	metered	5,760,000	metered
05-Oct-20	1,350,000	metered	5,760,000	metered
06-Oct-20	1,350,000	metered	5,760,000	metered
07-Oct-20	1,350,000	metered	5,760,000	metered
08-Oct-20	1,350,000	metered	5,760,000	metered
09-Oct-20	1,350,000	metered	5,760,000	metered
10-Oct-20	1,350,000	metered	5,760,000	metered
11-Oct-20	1,350,000	metered	5,760,000	metered
12-Oct-20	1,350,000	metered	5,760,000	metered
13-Oct-20	1,350,000	metered	5,760,000	metered
14-Oct-20	1,350,000	metered	5,760,000	metered
15-Oct-20	1,350,000	metered	5,760,000	metered
16-Oct-20	1,350,000	metered	5,760,000	metered
17-Oct-20	1,350,000	metered	5,760,000	metered
18-Oct-20	1,350,000	metered	5,760,000	metered
19-Oct-20	1,350,000	metered	5,760,000	metered
20-Oct-20	1,350,000	metered	5,760,000	metered
21-Oct-20	1,350,000	metered	5,760,000	metered
22-Oct-20	1,350,000	metered	5,760,000	metered

96-P-3009				
Quarry Sump 0200 SC			Quarry Sump 0100 NW	
Date	Taking Amount	Method	Taking Amount	Method
23-Oct-20	1,350,000	metered	5,760,000	metered
24-Oct-20	1,350,000	metered	5,760,000	metered
25-Oct-20	1,350,000	metered	5,760,000	metered
26-Oct-20	1,350,000	metered	5,760,000	metered
27-Oct-20	1,350,000	metered	5,760,000	metered
28-Oct-20	1,350,000	metered	5,760,000	metered
29-Oct-20	1,350,000	metered	5,760,000	metered
30-Oct-20	1,350,000	metered	5,760,000	metered
31-Oct-20	1,350,000	metered	5,760,000	metered
01-Nov-20	1,350,000	metered	5,760,000	metered
02-Nov-20	1,350,000	metered	5,760,000	metered
03-Nov-20	1,350,000	metered	5,760,000	metered
04-Nov-20	1,350,000	metered	5,760,000	metered
05-Nov-20	1,350,000	metered	5,760,000	metered
06-Nov-20	1,350,000	metered	5,760,000	metered
07-Nov-20	1,350,000	metered	5,760,000	metered
08-Nov-20	1,350,000	metered	5,760,000	metered
09-Nov-20	1,350,000	metered	5,760,000	metered
10-Nov-20	1,350,000	metered	5,760,000	metered
11-Nov-20	1,350,000	metered	5,760,000	metered
12-Nov-20	1,350,000	metered	5,760,000	metered
13-Nov-20	1,350,000	metered	5,760,000	metered
14-Nov-20	1,350,000	metered	5,760,000	metered
15-Nov-20	1,350,000	metered	5,760,000	metered
16-Nov-20	1,350,000	metered	5,760,000	metered
17-Nov-20	1,350,000	metered	5,760,000	metered
18-Nov-20	1,350,000	metered	5,760,000	metered
19-Nov-20	1,350,000	metered	5,760,000	metered
20-Nov-20	1,350,000	metered	5,760,000	metered
21-Nov-20	1,350,000	metered	5,760,000	metered
22-Nov-20	1,350,000	metered	5,760,000	metered
23-Nov-20	1,350,000	metered	5,760,000	metered
24-Nov-20	1,350,000	metered	5,760,000	metered
25-Nov-20	1,350,000	metered	5,760,000	metered
26-Nov-20	1,350,000	metered	5,760,000	metered
27-Nov-20	1,350,000	metered	5,760,000	metered
28-Nov-20	1,350,000	metered	5,760,000	metered
29-Nov-20	1,350,000	metered	5,760,000	metered
30-Nov-20	1,350,000	metered	5,760,000	metered
01-Dec-20	1,350,000	metered	5,760,000	metered
02-Dec-20	1,350,000	metered	5,760,000	metered
03-Dec-20	1,350,000	metered	5,760,000	metered
04-Dec-20	1,350,000	metered	5,760,000	metered
05-Dec-20	1,350,000	metered	5,760,000	metered
06-Dec-20	1,350,000	metered	5,760,000	metered
07-Dec-20	1,350,000	metered	5,760,000	metered
08-Dec-20	1,350,000	metered	5,760,000	metered
09-Dec-20	1,350,000	metered	5,760,000	metered
10-Dec-20	1,350,000	metered	5,760,000	metered
11-Dec-20	1,350,000	metered	5,760,000	metered
12-Dec-20	1,350,000	metered	5,760,000	metered
13-Dec-20	1,350,000	metered	5,760,000	metered
14-Dec-20	1,350,000	metered	5,760,000	metered
15-Dec-20	1,350,000	metered	5,760,000	metered
16-Dec-20	1,350,000	metered	5,760,000	metered
17-Dec-20	1,350,000	metered	0	metered
18-Dec-20	1,350,000	metered	0	metered
19-Dec-20	1,350,000	metered	0	metered
20-Dec-20	1,350,000	metered	0	metered
21-Dec-20	1,350,000	metered	0	metered
22-Dec-20	1,350,000	metered	0	metered
23-Dec-20	1,350,000	metered	0	metered
24-Dec-20	0	metered	0	metered
25-Dec-20	0	metered	0	metered
26-Dec-20	0	metered	0	metered
27-Dec-20	0	metered	0	metered
28-Dec-20	0	metered	0	metered
29-Dec-20		metered		metered
30-Dec-20	0	metered	0	metered
31-Dec-20	0	metered	0	metered

Wetland Characterization Summaries Proposed Burlington Quarry Extension, Nelson Aggregates Co.

Prepared for:

March 2021
Version 1.0

March 2021

Nelson Aggregate Co.
2433 No. 2 Sideroad
Burlington, Ontario
L7P 0G8

Attention: Mr. Quinn Moyer, President

RE: Burlington Quarry Wetland Characterization Summaries

Dear Mr. Moyer,

Earthfx Incorporated, Savanta Inc. and Tatham Engineering Limited are pleased to provide Nelson Aggregates Co. with the enclosed wetland characterization summaries in support of the Proposed Burlington Quarry Extension. The wetland characterization summaries have been prepared in response to comments received by the Ministry of Natural Resources and Forestry.

The wetland characterization summaries have been prepared to summarize the wetland information provided in the Level 1 and Level 2 Hydrogeological Impact Assessment, Level 1 and Level 2 Natural Environment Technical Report, and Surface Water Assessment. The hope is the wetland characterization summaries will aid in the review of the reports and expedite the review process.

Regards,

Dirk Kassenaar, M.Sc., P.Eng.
President, Eartfx Incorporated

Shannon Catton, MSc.
Branch Manager & Senior Ecologist, Savanta Inc.

Daniel Twigger, B.Sc.Eng., P.Eng.
Senior Engineer, Group Leader, Tatham Engineering Limited

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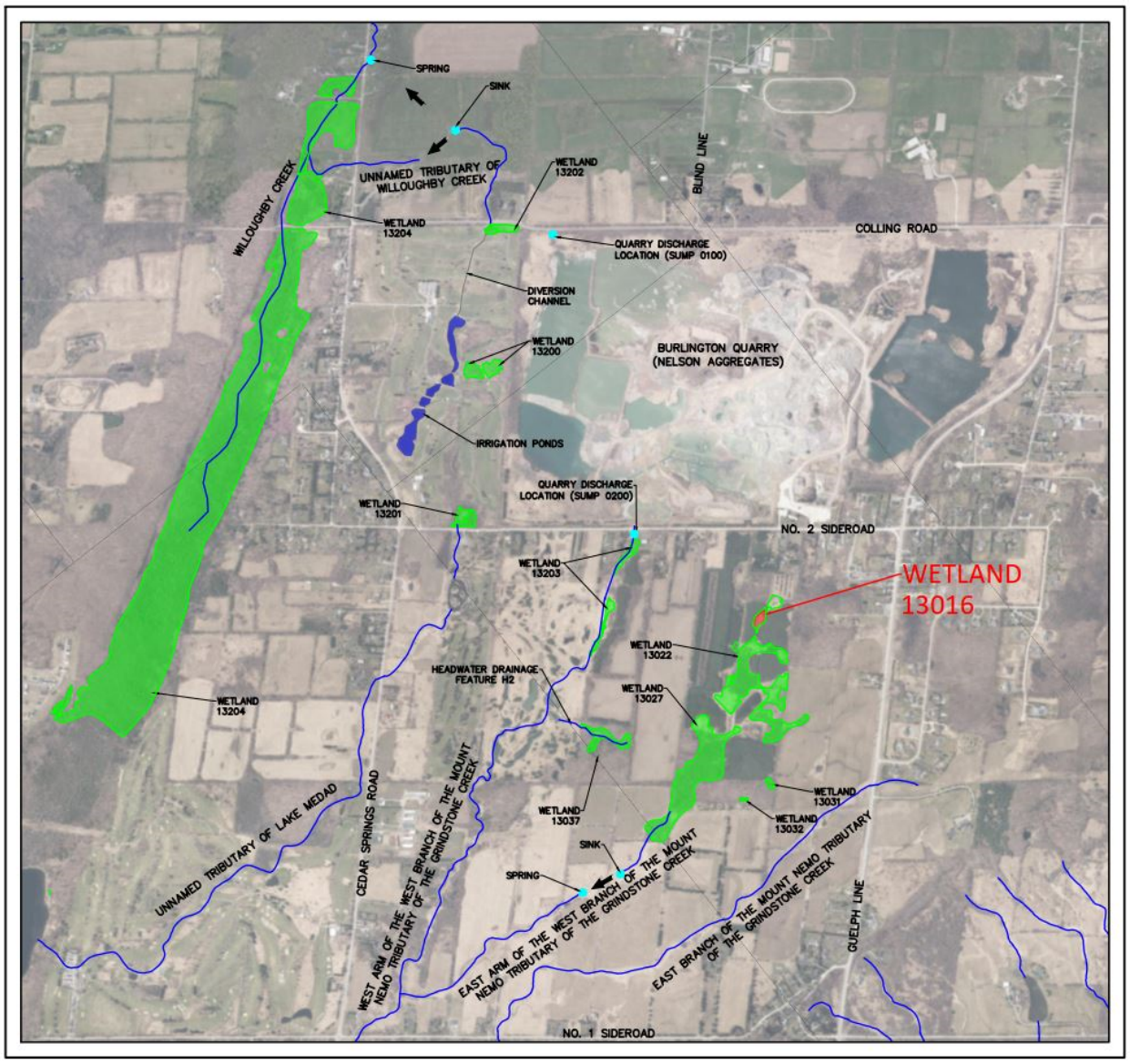
WETLAND 13016





Legend

- 120 m Adjacent Lands
- Subject Lands
- Existing Subcatchment Boundary (Tatham Engineering, 2020)
- Proposed Subcatchment Boundary - Operations and Post-Rehabilitation (Tatham Engineering, 2020
- Wetland (Savanta, 2020)
- Ecological Land Classification (Savanta, 2019 & 2020)
- Provincially Significant Wetland (LIO/MNRF, 2020)
- MECP Jefferson Salamander Regulated Habitat

Current Instrumentation

- Groundwater Monitoring Station (EarthFx)
- Mini Piezometer (Tatham Engineering)
- Staff Gauge & Surface Water Monitoring Station (Tatham Engineering)

Previous Instrumentation

- Mini Piezometer (Golder)

ELC Legend

CUM1, Mineral Cultural Meadow
CUP3-2, White Pine Coniferous Plantation
CUP3-13*, White Spruce Coniferous Plantation
CUT1-1, Sumac Cultural Thicket
CUW1, Mineral Cultural Woodland
HR, Hedgerow
MAM2-2, Reed-canary Grass Mineral Meadow Marsh
RES, Residential
SWD2-2, Green Ash Mineral Deciduous Swamp

NOTES:

1. Coordinate System: NAD 1983 UTM Zone 17N.
2. Base features produced under license with the Ontario Ministry of Natural Resources and Forestry © Queen's Printer for Ontario, 2021.
3. Orthoimagery © First Base Solutions, 2021. Imagery taken in 2019.

Project 8133

Burlington Quarry Extension
Nelson Aggregates Co.

Figure 1
Wetland Characterization
Wetland 13016 - South Extension

0 10 m
1:1,000

N

GEI Consultants
Savanta Division

Path: C:\Savanta\8133 - Burlington Quarry\figures\report_figures\2021 01 21 natural feature tech summary\8133_rpt_wetland_char_mapbook.mxd Date Saved: January 11, 2021

Wetland 13016

Wetland Characteristics	Description	Figure / Graph	Reference	
			Report	Section / Page
Wetland IDs:	MNRF - 67567121 (OGF ID 67657140) Earthfx - 11 Tatham - 13016 Savanta - 13016 Golder (Background) - 13016			
Wetland Area (ha):	LIO/MNRF - 0.28 Savanta - 0.22			
Watershed:	Grindstone Creek Watershed			
Sub-Watershed:	East Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek			
Located in Proposed Limit of Extraction:	No			
Located in Proposed License Boundary:	No			
Catchment Area (ha):	1.48		SWA (Tatham, April 2020)	Drawing DP-1
Catchment ID:	S118		SWA (Tatham, April 2020)	Drawing DP-1
Closed or Connected System:	On-line (connected to downstream wetland; cascading)			
Condition:	Natural			
Bathymetry:	A bathymetry survey of Wetland 13016 was completed by Tatham Engineering Limited and incorporated into the integrated model (see Earthfx Section 18.3, p.381). Wetland lakes were assigned to Layer 1 of the integrated model by adjusting the base of Layer 1 to correspond with the interpolated bottom elevation. Care was taken to ensure that the lowest elevation observed in the wetland was honored in the assigned elevations.	Figure 1	HHIAR (Earthfx, April 2020)	18.3 (page 381)
Outlet:	Downstream wetland (MNRF - OGF ID 67567143; Earthfx - 12; Tatham - 13018; Savanta - 13022; Golder {Background} - 13018)			
Hydroperiod:	Spring hydroperiod (date wetland dries out) - May 16th - July 22nd Fall hydroperiod (start of hydroperiod) - November 15th - February 18th	Graph 1	SWA (Tatham, April 2020)	2.2.4, 3 and Appendix F
Surface Water Monitoring:	ID: SW13A (Tatham) Installation Date: October 2, 2014 Data Collection: Continuous water level and temperature and manual monthly water level measurements Coordinates of Monitoring Station: Easting 591177.323, Northing 4805244.509	Graph 1	SWA (Tatham, April 2020)	2.2.4, 3 and Appendix F

Natural Heritage and Habitat Features	Description	Figure / Graph	Reference	
			Report	Section / Page
Wetland Name & Provincial Significance Evaluation:	Grindstone Creek Headwaters Wetland Complex – Provincially Significant		NETR (Savanta, April 2020)	6.1.2
ELC Unit(s):	Reed-canary Grass Mineral Meadow Marsh: MAM2-2			
Regulated Habitat (MECP):	Yes – Jefferson Salamander (not field verified during 2019 field program; regulated based on historical data) Hydroperiod sensitive species; water presence necessary until end of June		NETR (Savanta, April 2020)	6.1.2
Significant Wildlife Habitat:	Unknown – outside of 120 m adjacent lands			
Fish Habitat:	None			
Habitat of Endangered and Threatened Species:	Unknown – outside of 120 m adjacent lands			

Groundwater Interaction	Description	Figure / Graph	Reference	
			Report	Section / Page
Lithology:	Halton Till			
Hydraulic Conductivity:	Integrated Model (Earthfx) – The hydraulic conductivity for Golder MP19 was $1x10^{-9}$ m/s. The harmonic mean hydraulic conductivity, based on testing by Golder (2007) of 10 mini-piezometers, was $1.2x10^{-8}$ m/s. Model value for the vertical hydraulic conductivity was $1.6x10^{-7}$ m/s, about an order of magnitude higher, to account for limited flow through fractures in the till. Wetland Water Balance (Tatham) – $8.2x10^{-9}$ m/s.			
Surface Water/Groundwater Interaction:	The low permeability of the Halton Till underlying the wetland is the dominant control on 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. This wetland does not receive significant groundwater inflow and is isolated from any changes in the water table due to quarry development.			
Shallow Groundwater (Mini-piezometer) Monitoring:	ID: SW13B (Tatham) Installation Date: October 23, 2018 Data Collection: Continuous water level and temperature and manual monthly water level measurements Coordinates of Monitoring Station: Easting 591177.323, Northing 4805244.509	Graph 2	SWA (Tatham, April 2020)	2.3 and Appendix G

Background Shallow Groundwater (Mini-piezometer) Monitoring: — Graph 3

Mini-piezometer ID	Ground Elevation	Bottom Elevation	Average WL	Logger	Manual Meas.
Golder MP19	278.56	277.36	276.90	-	2007 - 2013
Golder MP20	278.36	277.16	276.86	-	2007 - 2013

Groundwater Monitoring (Monitoring Wells): — Graph 3

Monitoring Well ID	Distance (Dir.)	Geologic Unit	Ground Elevation	Monitoring Elev	Average WL
OW03-31A	122 (NE)	Bedrock	278.5	268.6 - 263.2	275.3
OW03-31B	122 (NE)	Bedrock	279.7	276.2 - 270.8	274.1

Water Budget Results: — Figure 2a

A detailed average water budget, as simulated by the integrated model, was not presented in the Main report but is provided in Figure 2a. The wetland is a net provider of groundwater. Simulated groundwater levels, groundwater discharge to riparian areas, and streamflow in the vicinity of Wetland 13016 (Earthfx Wetland 11) for baseline conditions is discussed in Section 7 of the main report.

Wetland 13016	GW Outflow (%)	GW Inflow (%)
Baseline (Existing)	3.97	0.00

Groundwater Interaction	Description	Figure / Graph	Reference	
			Report	Section / Page
Integrated Model Calibration:	Two mini-piezometers provide multiple years of monitoring in the soil zone and weathered Halton Till materials. These monitors correspond to the PRMS soil zone and upper-most part of Layer 1 of the GSFLOW model. A comparison of the mini-piezometer data to the simulated soil moisture conditions demonstrates that the model is closely matching both the soil moisture and hydroperiod of the shallow subsurface at this wetland.	Graphs 4 & 5		
	Earthfx Figure 19.41 (p.442) in the Main Report shows a hydrograph for SW13A along with simulated shallow water levels. The figure is reproduced in Graph 6. The total range in observed water level fluctuation is about 70 cm. A brief discussion of the Wetland 13016 (Earthfx Wetland 11) is contained in Appendix E, Section 19.6 (p. 441).	Graph 6	HHIAR (Earthfx, April 2020)	441 - 442

Impact Assessment (Operations Phases 1 & 2)	Description	Figure / Graph	Reference	
			Report	Section / Page
Change in Wetland Area (ha):	No change. Wetland located greater than 120 m from licensed boundary.		SWA (Tatham, April 2020)	4.2.1
Change in Wetland Catchment Area (ha):	No change. Subcatchment area protected.		SWA (Tatham, April 2020)	4.2.1 & Drawing DP-2
Change in Hydroperiod:	No Change. Wetland is perched and isolated from the groundwater system. Subcatchment area being protected.		SWA (Tatham, April 2020)	4.2.1
Change in Water Budget:	A detailed average water budget as simulated by the integrated model is not provided in the Main report. The water budget results for Scenario P12 are reproduced in Figure 2b. Results for nearby wetlands are provided in the Main Report. Simulated change in groundwater levels (drawdowns), groundwater discharge to riparian areas, and change in streamflow in the vicinity of Wetland 13016 (Earthfx Wetland 11) for each scenario are discussed in Section 8 of the main report.	Figure 2b	HHIAR (Earthfx, April 2020)	191 - 303
Change on Soil Moisture Conditions:	The Water Budget figures indicate that there is no groundwater seepage entering the wetland under baseline conditions, so there will be no change under P12 conditions.			
Potential Impact to Form and Function of Feature:	No wetlands will be removed and the wetlands subcatchment will be protected. There will be no encroachment from the project into the wetland. The proposed limit of extraction is >120 m from the wetland boundary. Licensed boundary will be demarcated and fenced to ensure site construction and operations do not extend beyond the proposed limits of the project .			

Wetland 13016	GW Outflow (%)	GW Inflow (%)	Δ in Outflow (%)	Δ in Inflow (%)
Baseline (Existing)	3.97	0.00	-	-
Operations Ph 1 & 2	3.90	0.00	-0.07	0.00

Mitigation (Operational Phases 1 & 2)	Description	Figure / Graph	Reference	
			Report	Section / Page
Proposed Mitigation Measures:	None required.			

Impact Assessment (Operations Phases 3 - 6)	Description	Figure / Graph	Reference	
			Report	Section / Page
Change in Wetland Area (ha):	No change. Wetland located greater than 120 m from licensed boundary.		SWA (Tatham, April 2020)	4.2.1
Change in Wetland Catchment Area (ha):	No change. Subcatchment area protected.		SWA (Tatham, April 2020)	4.2.1 & Drawing DP-2
Change in Hydroperiod:	No Change. Wetland is perched and isolated from the groundwater system. Subcatchment area being protected.		SWA (Tatham, April 2020)	4.2.1
Change in Water Budget:	A detailed average water budget as simulated by the integrated model is not provided in the Main report. The water budget results for Scenario P3456 are reproduced in Figure 2c. Results for nearby wetlands are provided in the Main Report. Simulated change in groundwater levels (drawdowns), groundwater discharge to riparian areas, and change in streamflow in the vicinity of Wetland 13016 (Earthfx Wetland 11) for each scenario are discussed in Section 8 of the main report.	Figure 2c	HHIAR (Earthfx, April 2020)	191 - 303
Change on Soil Moisture Conditions:	The Water Budget figures indicate that there is no groundwater seepage entering the wetland under baseline conditions, so there will be no change under P3456 conditions.			
Potential Impact to Form and Function of Feature:	No wetlands will be removed and the wetlands subcatchment will be protected. There will be no encroachment from the project into the wetland. The proposed limit of extraction is >120 m from the wetland boundary. Licensed boundary will be demarcated and fenced to ensure site construction and operations do not extend beyond the proposed limits of the project .			

Wetland 13016	GW Outflow (%)	GW Inflow (%)	Δ in Outflow (%)	Δ in Inflow (%)
Baseline (Existing)	3.97	0.00	-	-
Operations Ph 3 - 6	4.00	0.00	0.03	0.00

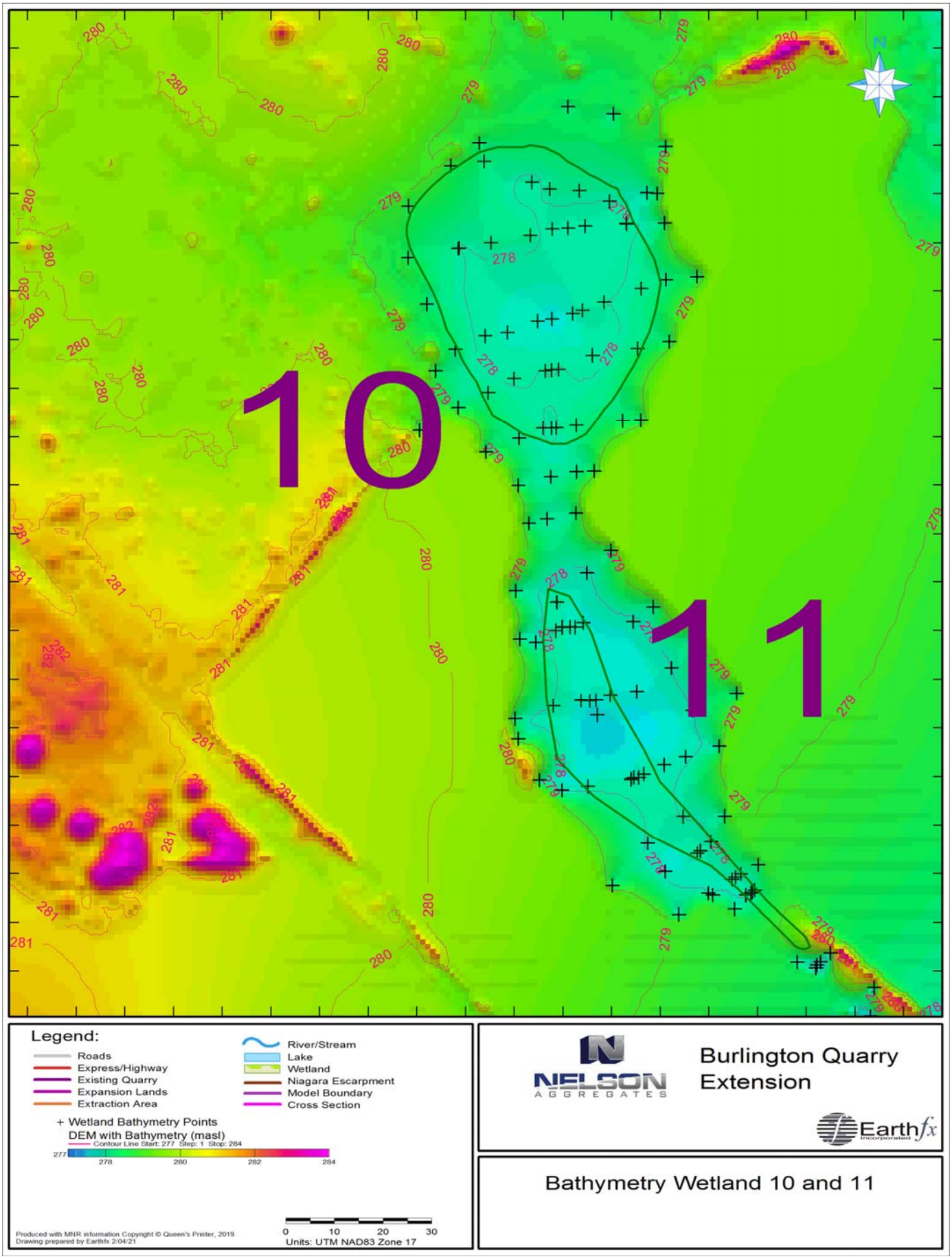
Mitigation (Operational Phases 3 - 6)	Description	Figure / Graph	Reference	
			Report	Section / Page
Proposed Mitigation Measures:	None required.			

Impact Assessment (Rehabilitation)	Description	Figure / Graph	Reference	
			Report	Section / Page
Change in Wetland Area (ha):	No change. Wetland located greater than 120 m from licensed boundary.		SWA (Tatham, April 2020)	5.4.1
Change in Wetland Catchment Area (ha):	No change. Subcatchment area protected.		SWA (Tatham, April 2020)	5.4.1 & Drawing DP-3
Change in Hydroperiod:	No Change. Wetland is perched and isolated from the groundwater system. Subcatchment area being protected.		SWA (Tatham, April 2020)	5.4.1
Change in Water Budget:	A detailed average water budget as simulated by the integrated model is not provided in the Main report. The water budget results for Scenarios RHB1 and RHB2 are reproduced in Figures 2d and 2e. Results for nearby wetlands are provided in the Main Report. Simulated change in groundwater levels (drawdowns), groundwater discharge to riparian areas, and change in streamflow in the vicinity of Wetland 13016 (Earthfx Wetland 11) for each scenario are discussed in Section 8 of the main report.	Figure 2d and 2e	HHIAR (Earthfx, April 2020)	191 - 303
Change on Soil Moisture Conditions:	The Water Budget figures indicate that there is no groundwater seepage entering the wetland under baseline conditions, so there will be no change under Rehab Scenario 1 and 2 conditions.			
Potential Impact to Form and Function of Feature:	No wetlands will be removed and the wetlands subcatchment will be protected. There will be no encroachment from the project into the wetland. The proposed limit of extraction is >120 m from the wetland boundary. Licensed boundary will be demarcated and fenced to ensure site construction and operations do not extend beyond the proposed limits of the project .			

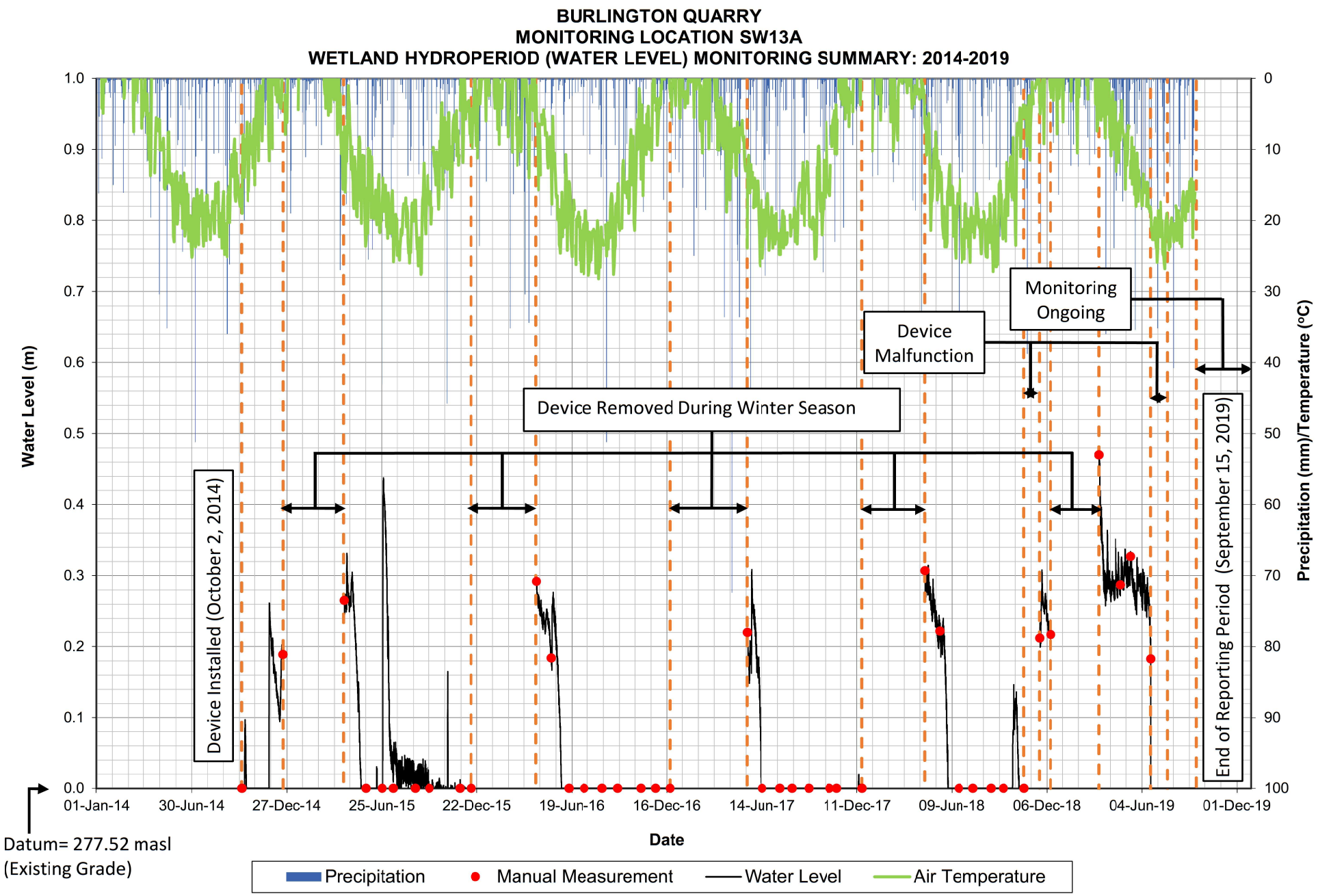
Wetland 13016	GW Outflow (%)	GW Inflow (%)	Δ in Outflow (%)	Δ in Inflow (%)
Baseline (Existing)	3.97	0.00	-	-
Rehab Scenario 1	4.15	0.00	0.18	0.00
Rehab Scenario 2	3.47	0.00	-0.05	0.00

Mitigation (Rehabilitation)	Description	Figure / Graph	Reference	
			Report	Section / Page
Proposed Mitigation Measures:	None required.			

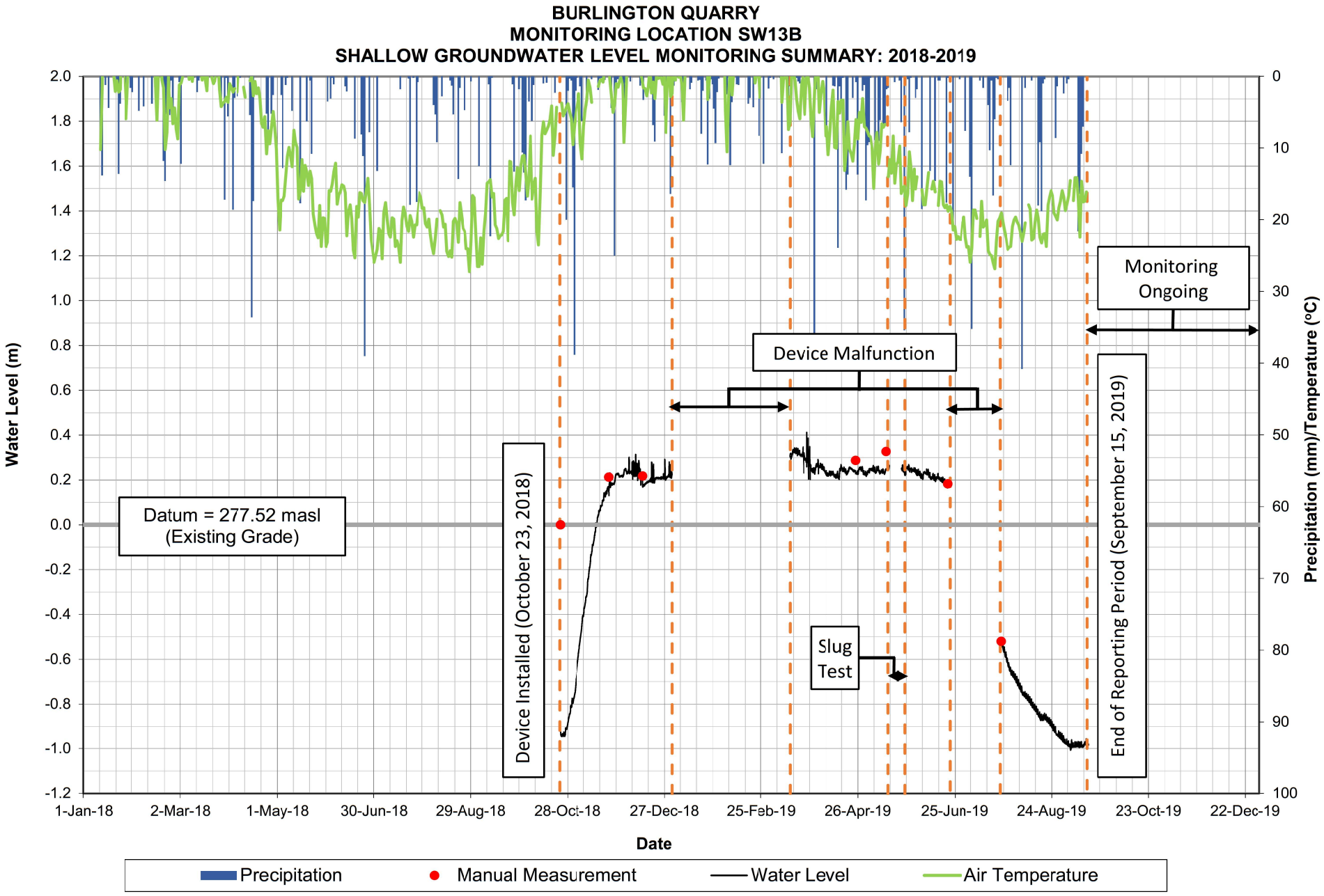
WETLAND 13016 - FIGURE 1



WETLAND 13016 - GRAPH 1

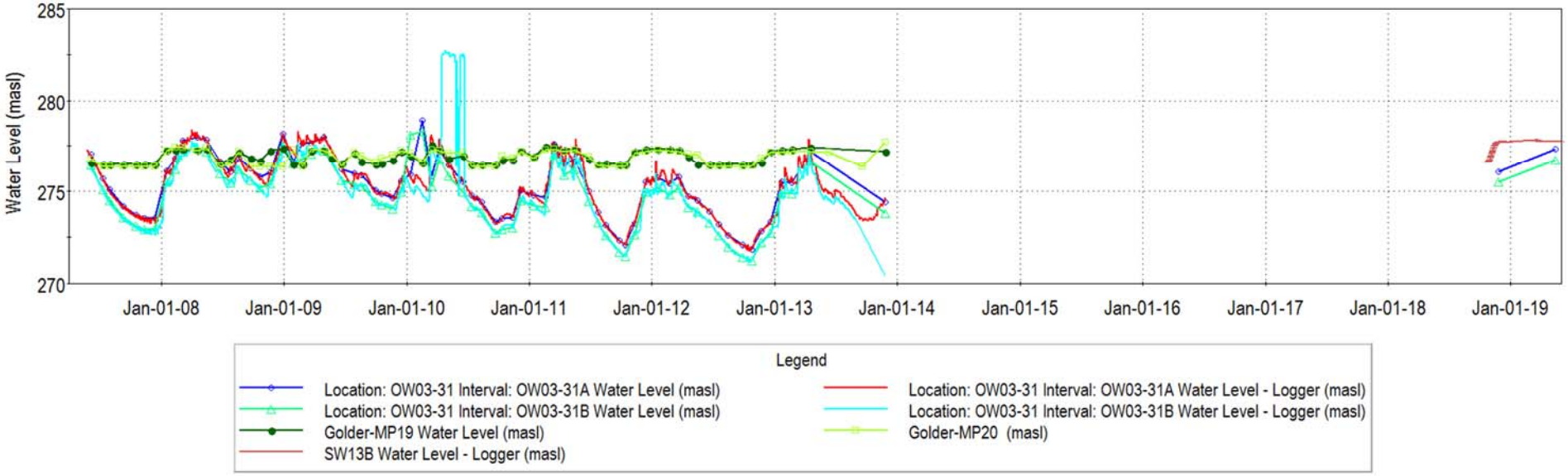


WETLAND 13016 - GRAPH 2



WETLAND 13016 - GRAPH 3

Shallow and Deep Groundwater Hydrographs
Wetland 13016



WETLAND 13016

FIGURE 2A

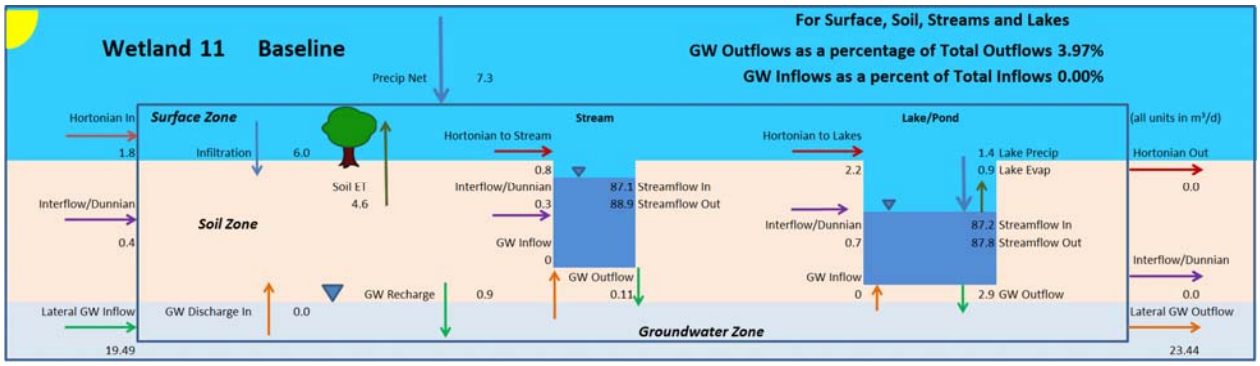


FIGURE 2B

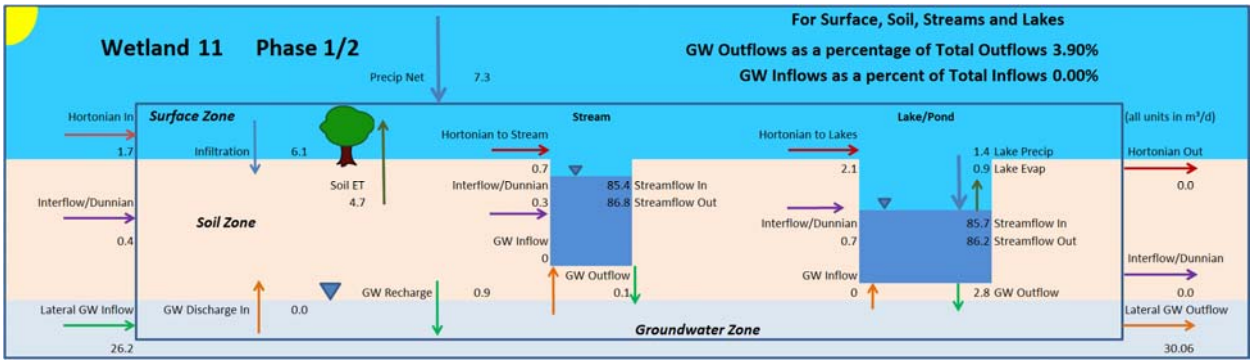


FIGURE 2C

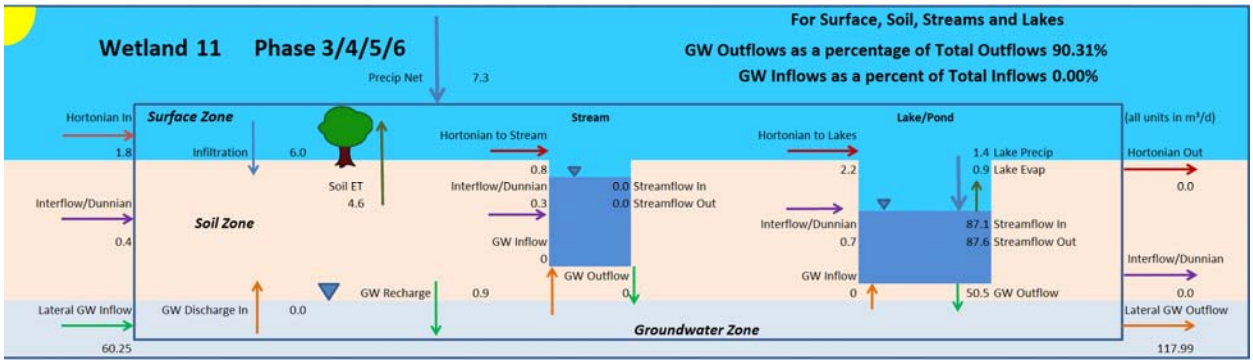


FIGURE 2D

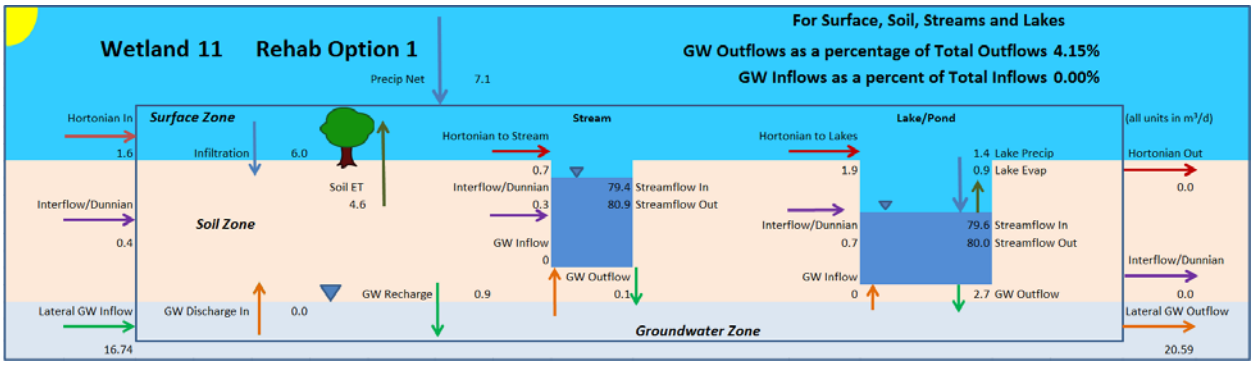
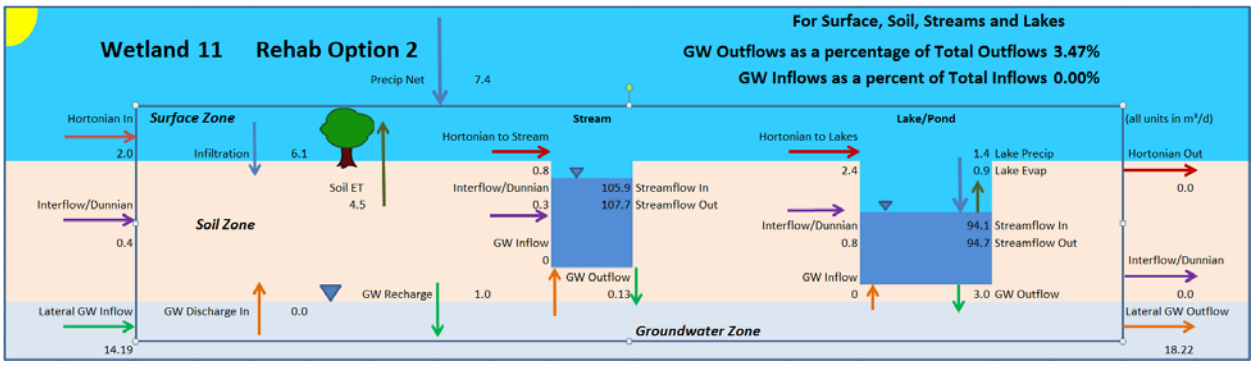
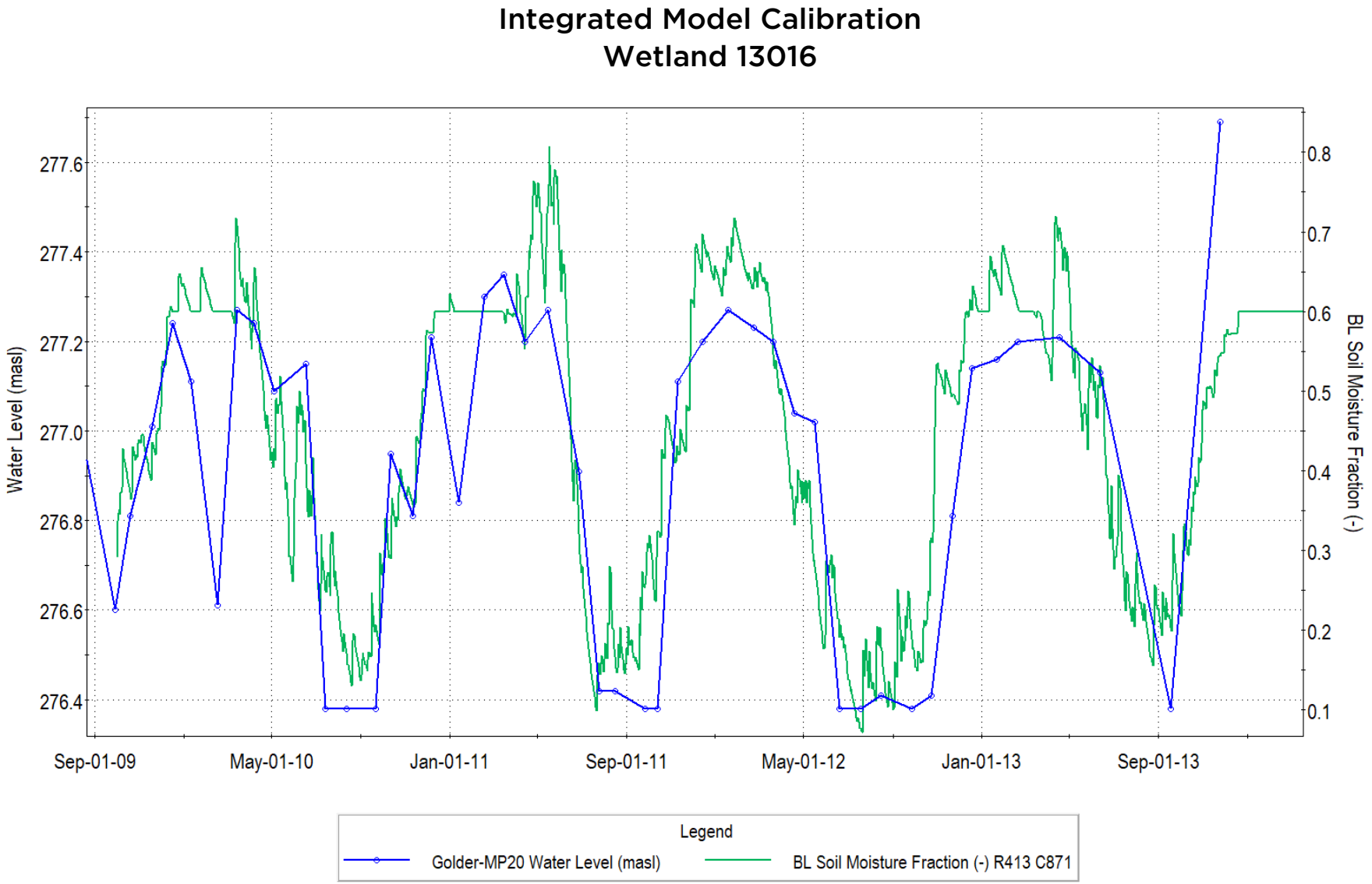


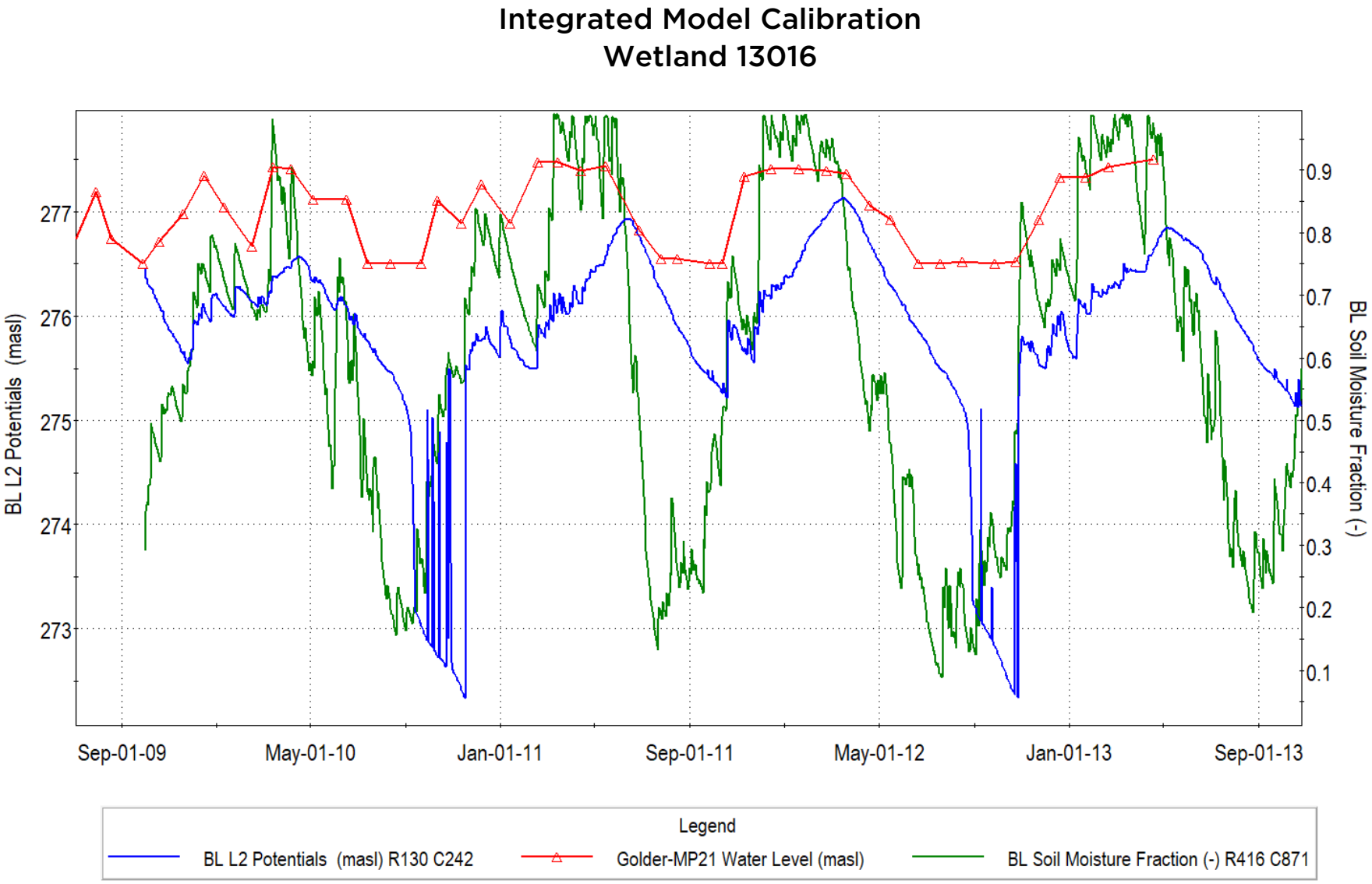
FIGURE 2E



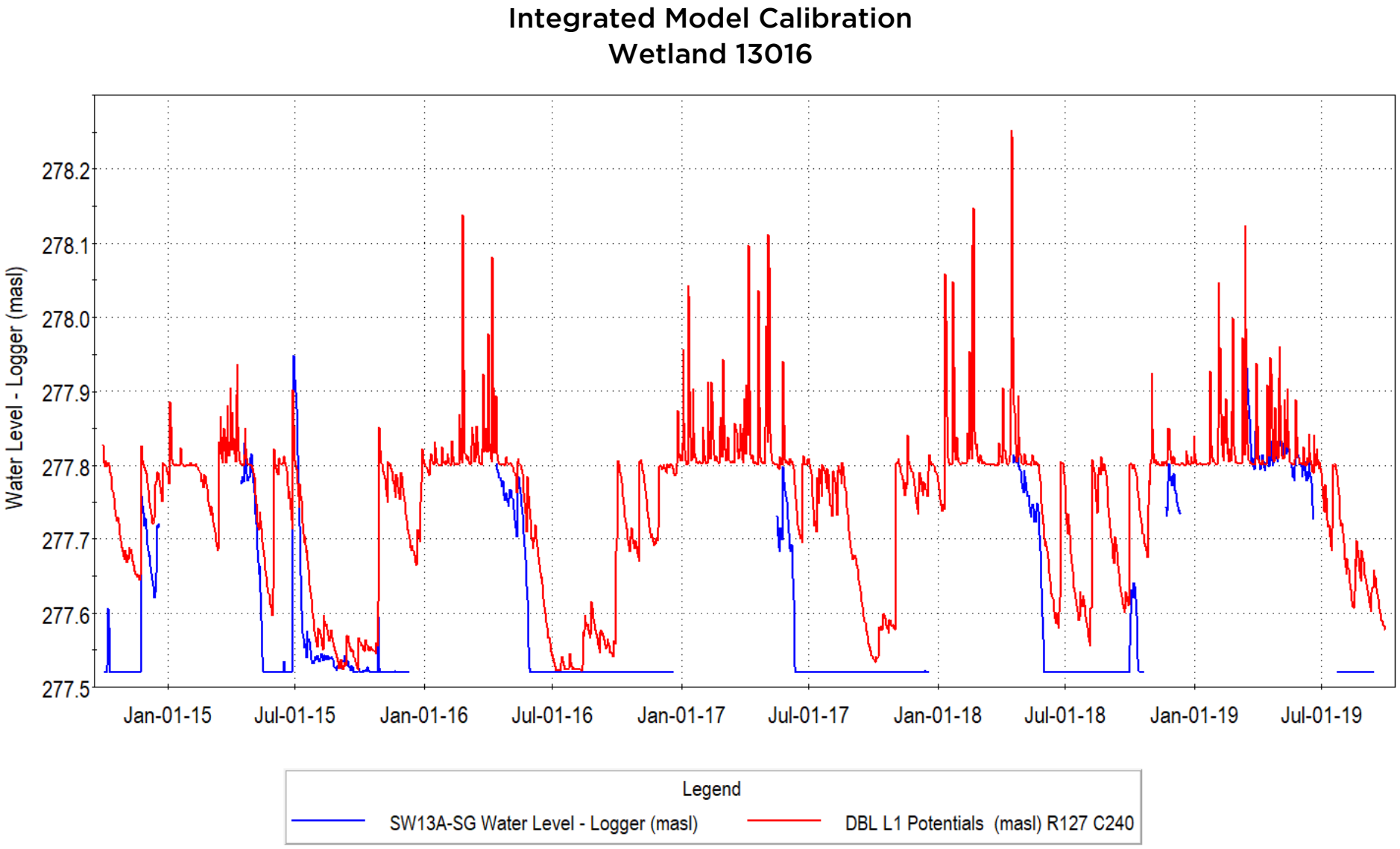
WETLAND 13016 - GRAPH 4



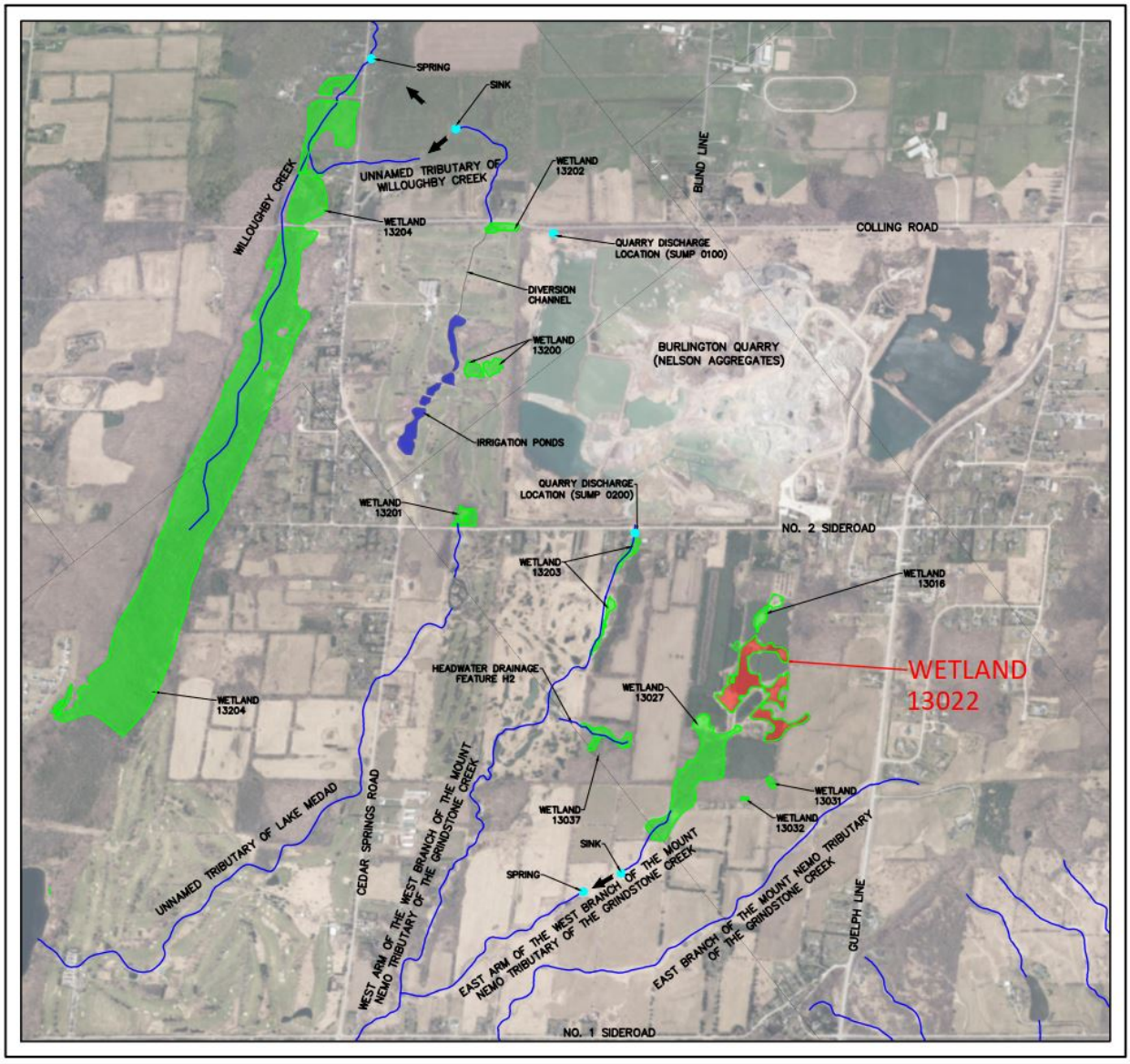
WETLAND 13016 - GRAPH 5

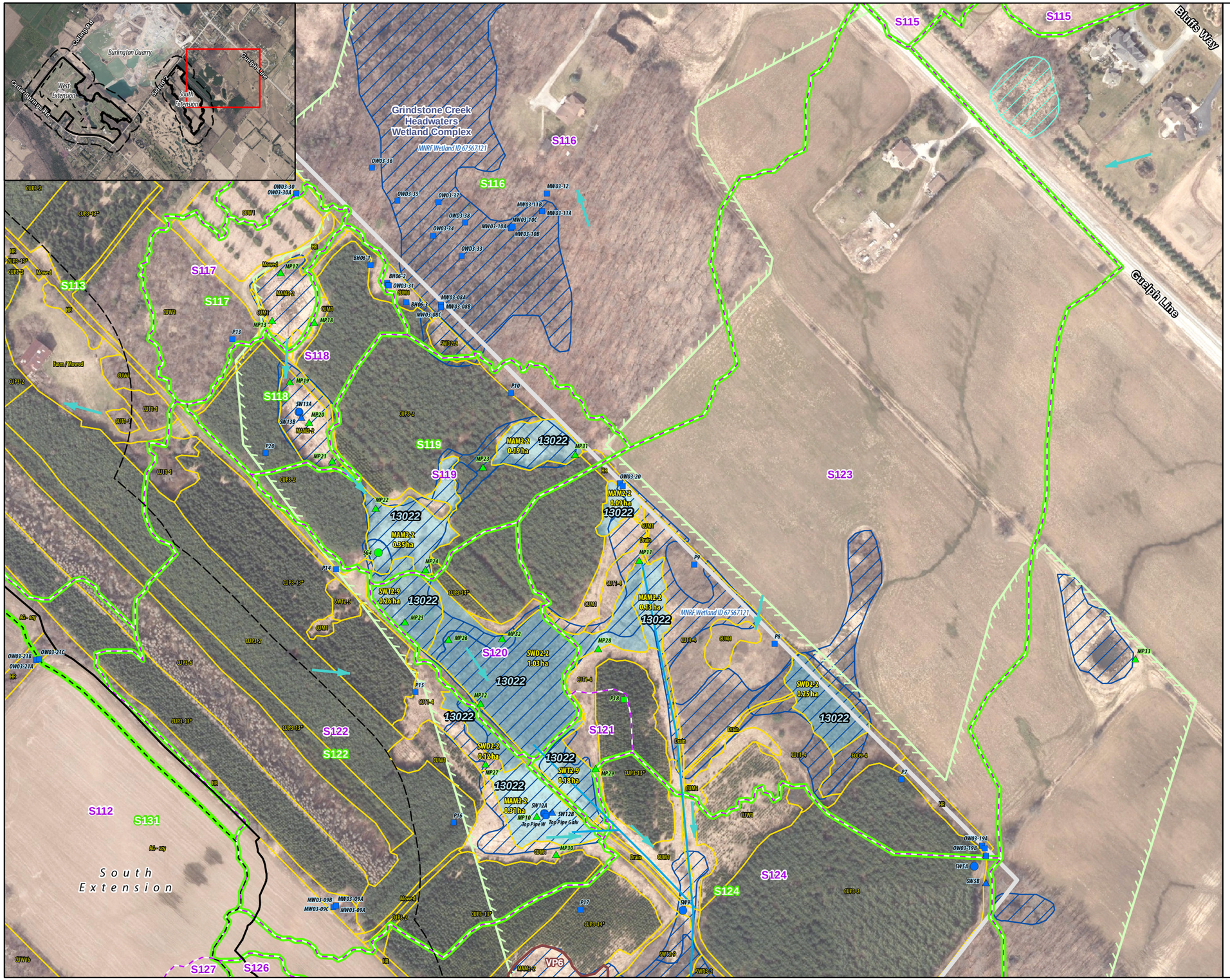


WETLAND 13016 - GRAPH 6



WETLAND 13022





Legend

- Licensed Boundary
- Limit of Extraction
- 120 m Adjacent Lands
- Subject Lands
- Salamander Habitat Assessment (2019)
- Indirect Fish Habitat
- Existing Subcatchment Boundary (Tatham Engineering, 2020)
- Proposed Subcatchment Boundary - Operations and Post-Rehabilitation (Tatham Engineering, 2020
- Wetland (Savanta, 2020)
- Ecological Land Classification (Savanta, 2019 & 2020)
- Provincially Significant Wetland (LIO/MNRF, 2020)
- Wetland - Not Evaluated per OWES (MNRF/LIO, 2020)
- MECP Jefferson Salamander Regulated Habitat

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- Mini Piezometer (Tatham Engineering)
- Staff Gauge & Surface Water Monitoring Station (Tatham Engineering)
- Manual Stream Flow Measurement (Tatham Engineering)

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- Groundwater Monitoring Station (Golder)
- Mini Piezometer (Golder)
- Staff Gauge & Surface Water Monitoring Station (Golder)

ELC Legend

AG, Agriculture
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CUP3-2, White Pine Coniferous Plantation
CUP3-6, European Larch Coniferous Plantation
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HR, Hedgerow
MAM2-2, Reed-canary Grass Mineral Meadow Marsh
RES, Residential
SWD2-2, Green Ash Mineral Deciduous Swamp
SWD3-2, Silver Maple Mineral Deciduous Swamp
SWT2-5, Red-osier Dogwood Mineral Thicket Swamp
SWT2-9, Gray Dogwood Mineral Thicket Swamp

NOTES:

1. Coordinate System: NAD 1983 UTM Zone 17N.
2. Base features produced under license with the Ontario Ministry of Natural Resources and Forestry © Queen's Printer for Ontario, 2021.
3. Orthoimagery © First Base Solutions, 2021. Imagery taken in 2019.

Project 8133

Burlington Quarry Extension
Nelson Aggregates Co.

Figure 2
Wetland Characterization
Wetland 13022 - South Extension

0 50 m
1:3,000

N

GEI Consultants
Savanta Division

Wetland 13022

Wetland Characteristics	Description	Figure / Graph	Reference	
			Report	Section / Page
Wetland IDs:	MNRF – 67567121 (OGF ID 67567134, 67567144, 67567123, 67567137, 67567136, 67567146, 67567133, 67567146, 67567151) Earthfx – 12, 13, 14, 15, 16 Tatham – 13017, 13018, 13019, 13020, 13021, 13022, 13023, 13029, 13030, 13051 Savanta – 13022 Golder (Background) - 13017, 13018, 13019, 13020, 13021, 13022, 13023, 13029, 13030, 13051			
Wetland Area (ha):	LIO/MNRF - 4.45 Savanta - 2.91			
Watershed:	Grindstone Creek Watershed			
Sub-Watershed:	East Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek			
Located in Proposed Limit of Extraction:	No			
Located in Proposed License Boundary:	No			
Catchment Area (ha):	30.45		SWA (Tatham, April 2020)	Drawing DP-1
Catchment ID:	S119, S120, S121, S122, S123		SWA (Tatham, April 2020)	Drawing DP-1
Closed or Connected System:	On-line (connected to downstream wetland; cascading)			
Condition:	Natural			
Bathymetry:	A bathymetry survey of Wetland 13022 was completed by Tatham Engineering Limited and incorporated into the integrated model (see Earthfx Section 18.3, p.381). Wetland lakes were assigned to Layer 1 of the integrated model by adjusting the base of Layer 1 to correspond with the interpolated bottom elevation. Care was taken to ensure that the lowest elevation observed in the wetland was honored in the assigned elevations.	Figure 1	HHIAR (Earthfx, April 2020)	18.3 (page 381)
Outlet:	Downstream wetland (MNRF – OGF ID 67567149; Earthfx – 17, Tatham – 13049; Savanta – 13027; Golder {Background} – 13049)			
Hydroperiod:	Spring Hydroperiod (date wetland dries out) – March 20th – July 5th Fall Hydroperiod (start of hydroperiod) – October 8th – January 25th	Graph 1	SWA (Tatham, April 2020)	2.2.3, 3 and Appendix F
Surface Water Monitoring:	ID: SW12A (Tatham) Installation Date: October 2, 2014 Data Collection: Continuous water level and temperature and manual monthly water level measurements Coordinates of Monitoring Station: Easting 591126.758, Northing 4805392.503	Graph 1	SWA (Tatham, April 2020)	2.2.3, 3 and Appendix F

Natural Heritage and Habitat Features	Description	Figure / Graph	Reference	
			Report	Section / Page
Wetland Name & Provincial Significance Evaluation:	Grindstone Creek Headwaters Wetland Complex – Provincially Significant		NETR (Savanta, April 2020)	6.1.2
ELC Unit(s):	Reed-canary Grass Mineral Meadow Marsh: MAM2-2 Gray Dogwood Mineral Thicket Swamp: SWT2-9 Green Ash Mineral Deciduous Swamp: SWD2-2		NETR (Savanta, April 2020)	Table 2
Regulated Habitat (MECP):	Yes – Jefferson Salamander (not field verified during 2019 field program; regulated based on historical data) Hydroperiod sensitive species; water presence necessary until end of June		NETR (Savanta, April 2020)	6.7
Significant Wildlife Habitat:	Unknown – outside of 120 m adjacent lands			
Fish Habitat:	Indirect		NETR (Savanta, April 2020)	6.6
Habitat of Endangered and Threatened Species:	Unknown – outside of 120 m adjacent lands			

Groundwater Interaction	Description	Figure / Graph	Reference	
			Report	Section / Page
Lithology:	Halton Till			
Hydraulic Conductivity:	Integrated Model (Earthfx) - The hydraulic conductivity for Golder MP10 was $9x10^{-10}$ m/s. The harmonic mean hydraulic conductivity, based on testing by Golder (2007) of 10 mini-piezometers, was $1.2x10^{-8}$ m/s. Model value for the vertical hydraulic conductivity was $1.6x10^{-7}$ m/s, about an order of magnitude higher, to account for limited flow through fractures in the till. Wetland Water Balance (Tatham) – $3.8x10^{-9}$ m/s.			
Surface Water/Groundwater Interaction:	The low permeability of the Halton Till underlying the wetland is the dominant control on 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.			
Shallow Groundwater (Mini-piezometer) Monitoring:	ID: SW12B (Tatham) Installation Date: October 23, 2018 Data Collection: Continuous water level and temperature and manual monthly water level measurements Coordinates of Monitoring Station: Easting 591126.758, Northing 4805392.503	Graph 2	SWA (Tatham, April 2020)	2.3 and Appendix G

Background Shallow Groundwater (Mini-piezometer) Monitoring: — Graph 3 & 4

Mini-piezometer ID	Ground Elevation	Bottom Elevation	Average WL	Logger	Manual Meas.
Golder MP10	278.17	276.97	275.13	2006-2013	2006-2013
Golder MP11	279.5	278.3	276.53	2007-2013	2007-2013
Golder MP12	278.07	276.87	275.29	2006-2013	2006-2013
Golder MP15	278.76	277.9	-	-	-
Golder MP22	278.41	277.21	276.08	-	2012-2013
Golder MP23	280.17	278.97	277.26	-	2007-2013
Golder MP24	279.69	278.49	275.78	-	2007-2013
Golder MP25	278.35	277.15	275.6	-	2007-2013
Golder MP26	278.22	277.02	275.57	-	2007-2013
Golder MP27	278.61	277.41	275.23	-	2007-2013
Golder MP28	279.32	278.12	276.57	-	2007-2013
Golder MP29	277.66	276.46	276.23	-	2007-2013
Golder MP 30	279.12	277.92	275.31	-	2007-2013
Golder MP 31	280.63	279.43	277.26	-	2007-2013
Golder MP 32	276.6	275.53	275.99	-	2007-2013

Groundwater Monitoring (Monitoring Wells): — Graphs 5 & 6

Monitoring Well ID	Distance (Dir.)	Geologic Unit	Ground Elevation	Monitoring Elev	Average WL
MW03-09A	180 (WSW)	Bedrock	278.5	268.6 - 263.2	276.29
MW03-09B	180 (WSW)	Bedrock	279.7	276.2 - 270.8	276.68
MW03-09C	180 (WSW)	Overburden	279.7	276.2 - 270.8	277.60
OW03-20A	266 (NNW)	Overburden	277.68	259.0 - 252.2	277.03
OW03-20B	266 (NNW)	Overburden	277.69	275.2 - 268.2	276.90
OW03-20C	266 (NNW)	Overburden	277.66	275.5 - 273.9	276.74

Water Budget Results: — Figure 2a — HHIAR (Earthfx, April 2020) — 186

A detailed average water budget for Wetland 13022 (Earthfx Wetland 16), as simulated by the integrated model, is provided in the main report for Baseline Conditions (Earthfx Figure 7.24, p. 186). The baseline water budget is reproduced in Figure 1a. The wetland is a net provider of groundwater. Simulated groundwater levels, groundwater discharge to riparian areas, and streamflow in the vicinity of Wetland 13022 (Earthfx Wetland 16) for baseline conditions are discussed in Section 7 of the main report. Wetland budgets for Wetlands 12 to 15 are also provided.

Wetland 13022	GW Outflow (%)	GW Inflow (%)
Baseline (Existing)	1.25	0.34

Groundwater Interaction	Description	Figure / Graph	Reference	
			Report	Section / Page
Integrated Model Calibration:	Six mini-piezometers in the vicinity of this wetland provide multiple years of monitoring in the soil zone and weathered Halton Till materials. These monitors correspond to the PRMS soil zone and upper-most part of Layer 1 of the GSFLOW model. A comparison of the mini-piezometer data to the simulated soil moisture conditions demonstrates that the model is closely matching both the soil moisture and hydroperiod of the shallow subsurface at this wetland. Wetland 16 is not discussed in the Main Report. Other nearby wetlands are discussed in Appendix E, Section 19.6.	Graphs 7, 8, 9, 10, 11 & 12		

Impact Assessment (Operations Phases 1 & 2)	Description	Figure / Graph	Reference	
			Report	Section / Page
Change in Wetland Area (ha):	No change. Wetland located greater than 120 m from licensed boundary.		SWA (Tatham, April 2020)	4.2.1
Change in Wetland Catchment Area (ha):	No change. Subcatchment area protected.		SWA (Tatham, April 2020)	4.2.1 & Drawing DP-2
Change in Hydroperiod:	No Change. Wetland is perched and isolated from the groundwater system. Subcatchment area being protected.		SWA (Tatham, April 2020)	4.2.1
Change in Water Budget:	A detailed average water budget for Wetland 13022 (Earthfx Wetland 16), as simulated by the integrated model, is provided in the Earthfx report for Baseline Conditions (Figure 7.24, p. 186); Scenario P12 (Figure 8.31, p. 221); P3456 (Figure 8.63, p. 248); RHB1 (Figure 8.99, p. 277), and RHB2 (Figure 8.126, p. 299). The water budget results for Scenario P12 are reproduced in Figure 2b. Simulated change in groundwater levels (drawdowns), groundwater discharge to riparian areas, and change in streamflow in the vicinity of Wetland 13022 (Earthfx Wetland 16) for each scenario are discussed in Section 8 of the main report.	Figure 2b	HHIAR (Earthfx, April 2020)	191 - 303
Change on Soil Moisture Conditions:	The soil moisture and surface discharge patterns in Wetland 13 are shown in Graph 13, and pond leakage is shown in Graph 14 (Note the scale range is very small). The effects of development can be illustrated by comparing the average soil moisture in Wetland 13 under Baseline and P12 development conditions. Graph 13 shows average daily soil moisture for Baseline conditions as a blue line. The soil moisture under P12 development is shown in red, and it overlies (covers) the Baseline for much of the time period. Under P12 development, soil moisture is essentially identical in the winter and spring, but slightly dryer in the summer and fall during a wet year. Wetland 13 lake seepage (Graph 14) under Baseline (Blue) and P12 conditions (Red) are shown in Graph 13. Under Baseline conditions, the ponds leak water to the groundwater system for most of the year, and only receive upwelling (negative leakage or seepage) for short periods of the wetter years when the water table is higher (generally in late spring). Under P12 conditions (red line), the ponds leak water to the groundwater system at varying rates throughout the year; generally higher in the spring and declining through the summer.	Graphs 13 & 14		
Potential Impact to Form and Function of Feature:	No wetlands will be removed and the wetlands subcatchment will be protected. There will be no encroachment from the project into the wetland. The proposed limit of extraction is >120 m from the wetland boundary. Licensed boundary will be demarcated and fenced to ensure site construction and operations do not extend beyond the proposed limits of the project .			

Wetland 13022	GW Outflow (%)	GW Inflow (%)	Δ in Outflow (%)	Δ in Inflow (%)
Baseline (Existing)	1.25	0.34	-	-
Operations Ph 1 & 2	1.31	0.00	0.06	-0.34

Mitigation (Operational Phases 1 & 2)	Description	Figure / Graph	Reference	
			Report	Section / Page
Proposed Mitigation Measures:	None required.			

<table>
<tr><th>Impact Assessment (Operations Phases 3 - 6)</th><th>Description</th><th>Figure / Graph</th><th colspan="2">Reference</th></tr>
<tr><th></th><th></th><th></th><th>Report</th><th>Section / Page</th></tr>
<tr><td>Change in Wetland Area (ha):</td><td>No change. Wetland located greater than 120 m from licensed boundary.</td><td></td><td>SWA (Tatham, April 2020)</td><td>4.2.1</td></tr>
<tr><td>Change in Wetland Catchment Area (ha):</td><td>No change. Subcatchment area protected.</td><td></td><td>SWA (Tatham, April 2020)</td><td>4.2.1 & Drawing DP-2</td></tr>
<tr><td>Change in Hydroperiod:</td><td>No Change. Wetland is perched and isolated from the groundwater system. Subcatchment area being protected.</td><td></td><td>SWA (Tatham, April 2020)</td><td>4.2.1</td></tr>
<tr><td>Change in Water Budget:</td><td>A detailed average water budget for Wetland 13022 (Earthfx Wetland 16), as simulated by the integrated model, is provided in the Earthfx report for Baseline Conditions (Figure 7.24, p. 186); Scenario P12 (Figure 8.31, p. 221); P3456 (Figure 8.63, p. 248); RHB1 (Figure 8.99, p. 277), and RHB2 (Figure 8.126, p. 299). The water budget results for Scenario P3456 are reproduced in Figure 2c. Simulated change in groundwater levels (drawdowns), groundwater discharge to riparian areas, and change in streamflow in the vicinity of Wetland 13022 (Earthfx Wetland 16) for each scenario are discussed in Section 8 of the main report.
<table>
<tr><td>Wetland 13022</td><td>GW Outflow (%)</td><td>GW Inflow (%)</td><td>Δ in Outflow (%)</td><td>Δ in Inflow (%)</td></tr>
<tr><td>Baseline (Existing)</td><td>1.25</td><td>0.34</td><td>-</td><td>-</td></tr>
<tr><td>Operations Ph 3 - 6</td><td>1.34</td><td>0.00</td><td>0.09</td><td>-0.34</td></tr>
</table></td><td>Figure 2c</td><td>HHIAR (Earthfx, April 2020)</td><td>191 - 303</td></tr>
<tr><td>Potential Impact to Form and Function of Feature:</td><td>No wetlands will be removed and the wetlands subcatchment will be protected. There will be no encroachment from the project into the wetland. The proposed limit of extraction is >120 m from the wetland boundary. Licensed boundary will be demarcated and fenced to ensure site construction and operations do not extend beyond the proposed limits of the project .</td><td></td><td></td><td></td></tr>
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Mitigation (Operational Phases 3 - 6)	Description	Figure / Graph	Reference	
			Report	Section / Page
Proposed Mitigation Measures:	None required.			

<table>
<tr><th>Impact Assessment (Rehabilitation)</th><th>Description</th><th>Figure / Graph</th><th colspan="2">Reference</th></tr>
<tr><th></th><th></th><th></th><th>Report</th><th>Section / Page</th></tr>
<tr><td>Change in Wetland Area (ha):</td><td>No change. Wetland located greater than 120 m from licensed boundary.</td><td></td><td>SWA (Tatham, April 2020)</td><td>5.4.1</td></tr>
<tr><td>Change in Wetland Catchment Area (ha):</td><td>No change. Subcatchment area protected.</td><td></td><td>SWA (Tatham, April 2020)</td><td>5.4.1 & Drawing DP-3</td></tr>
<tr><td>Change in Hydroperiod:</td><td>No Change. Wetland is perched and isolated from the groundwater system. Subcatchment area being protected.</td><td></td><td>SWA (Tatham, April 2020)</td><td>5.4.1</td></tr>
<tr><td>Change in Water Budget:</td><td>A detailed average water budget for Wetland 13022 (Earthfx Wetland 16), as simulated by the integrated model, is provided in the Earthfx report for Baseline Conditions (Figure 7.24, p. 186); Scenario P12 (Figure 8.31, p. 221); P3456 (Figure 8.63, p. 248); RHB1 (Figure 8.99, p. 277), and RHB2 (Figure 8.126, p. 299). The water budget results for Scenarios RHB1 and RHB2 are reproduced in Figures 2d and 2e. Simulated change in groundwater levels (drawdowns), groundwater discharge to riparian areas, and change in streamflow in the vicinity of Wetland 13022 (Earthfx Wetland 16) for each scenario are discussed in Section 8 of the main report.
<table>
<tr><td>Wetland 13022</td><td>GW Outflow (%)</td><td>GW Inflow (%)</td><td>Δ in Outflow (%)</td><td>Δ in Inflow (%)</td></tr>
<tr><td>Baseline (Existing)</td><td>1.25</td><td>0.34</td><td>-</td><td>-</td></tr>
<tr><td>Rehab Scenario 1</td><td>1.37</td><td>0.02</td><td>0.12</td><td>-0.32</td></tr>
<tr><td>Rehab Scenario 2</td><td>1.17</td><td>0.04</td><td>-0.08</td><td>-0.30</td></tr>
</table></td><td>Figure 2d and 2e</td><td>HHIAR (Earthfx, April 2020)</td><td>191 - 303</td></tr>
<tr><td>Potential Impact to Form and Function of Feature:</td><td>No wetlands will be removed and the wetlands subcatchment will be protected. There will be no encroachment from the project into the wetland. The proposed limit of extraction is >120 m from the wetland boundary. Licensed boundary will be demarcated and fenced to ensure site construction and operations do not extend beyond the proposed limits of the project .</td><td></td><td></td><td></td></tr>
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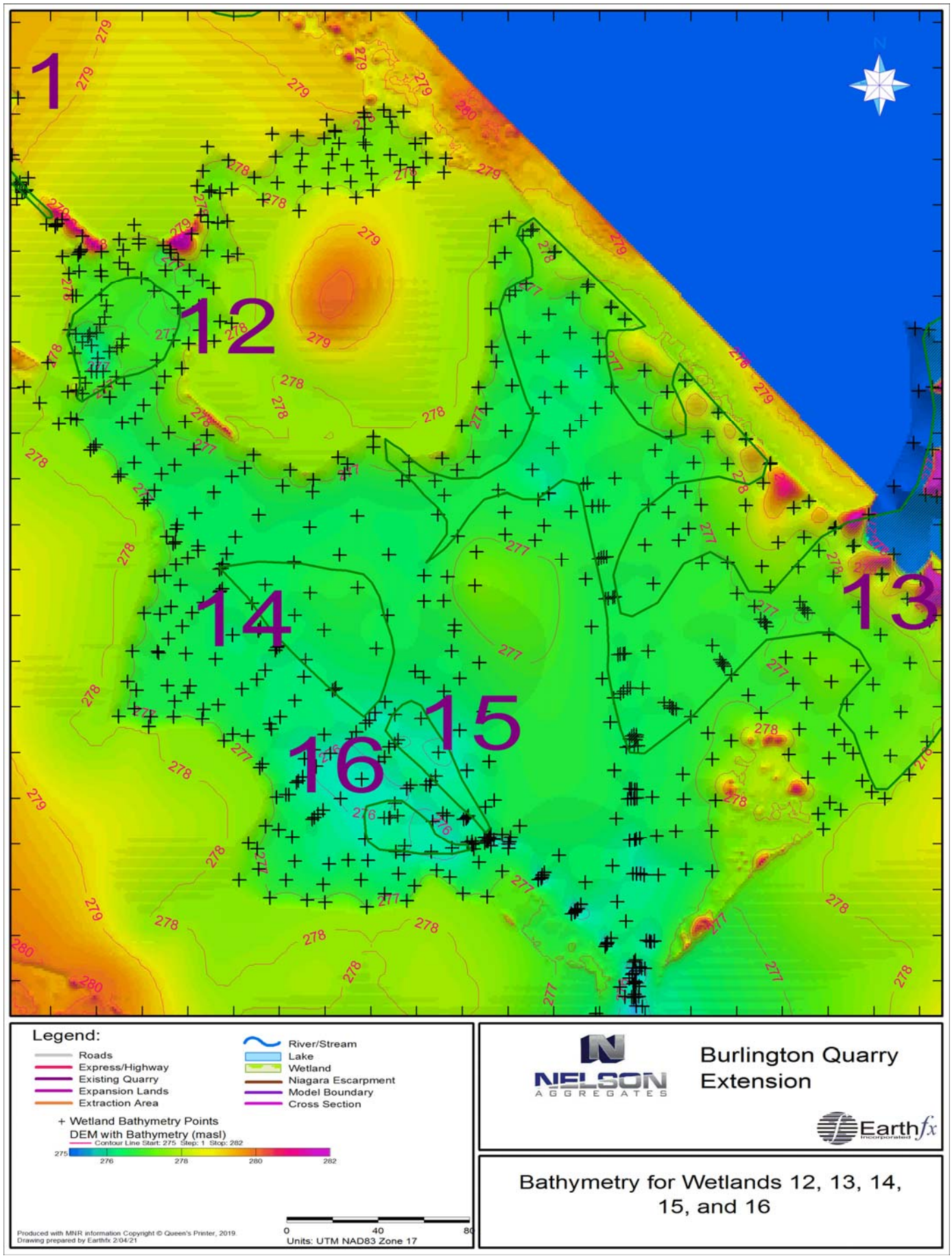
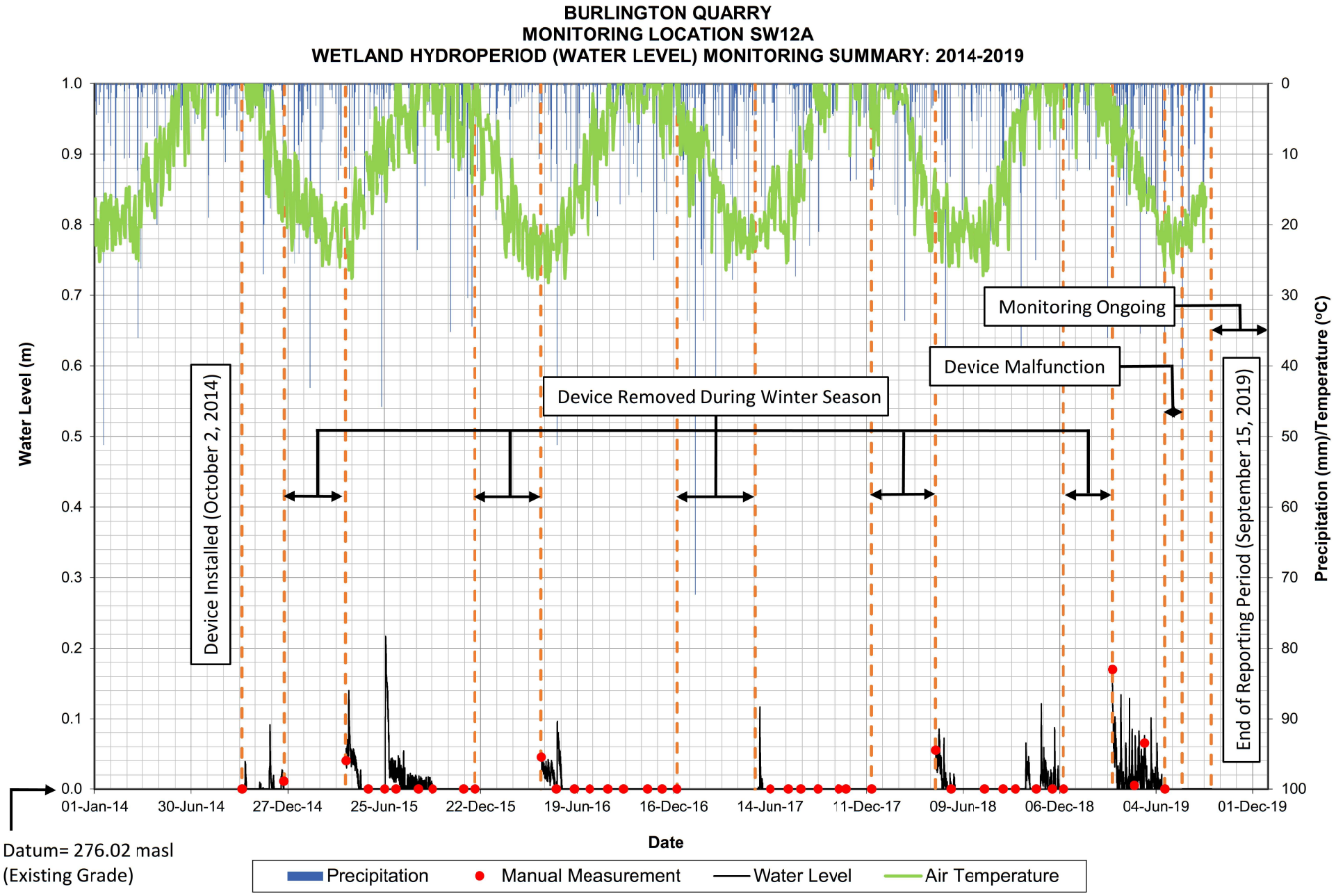
Mitigation (Rehabilitation)	Description	Figure / Graph	Reference	
			Report	Section / Page
Proposed Mitigation Measures:	None required.			

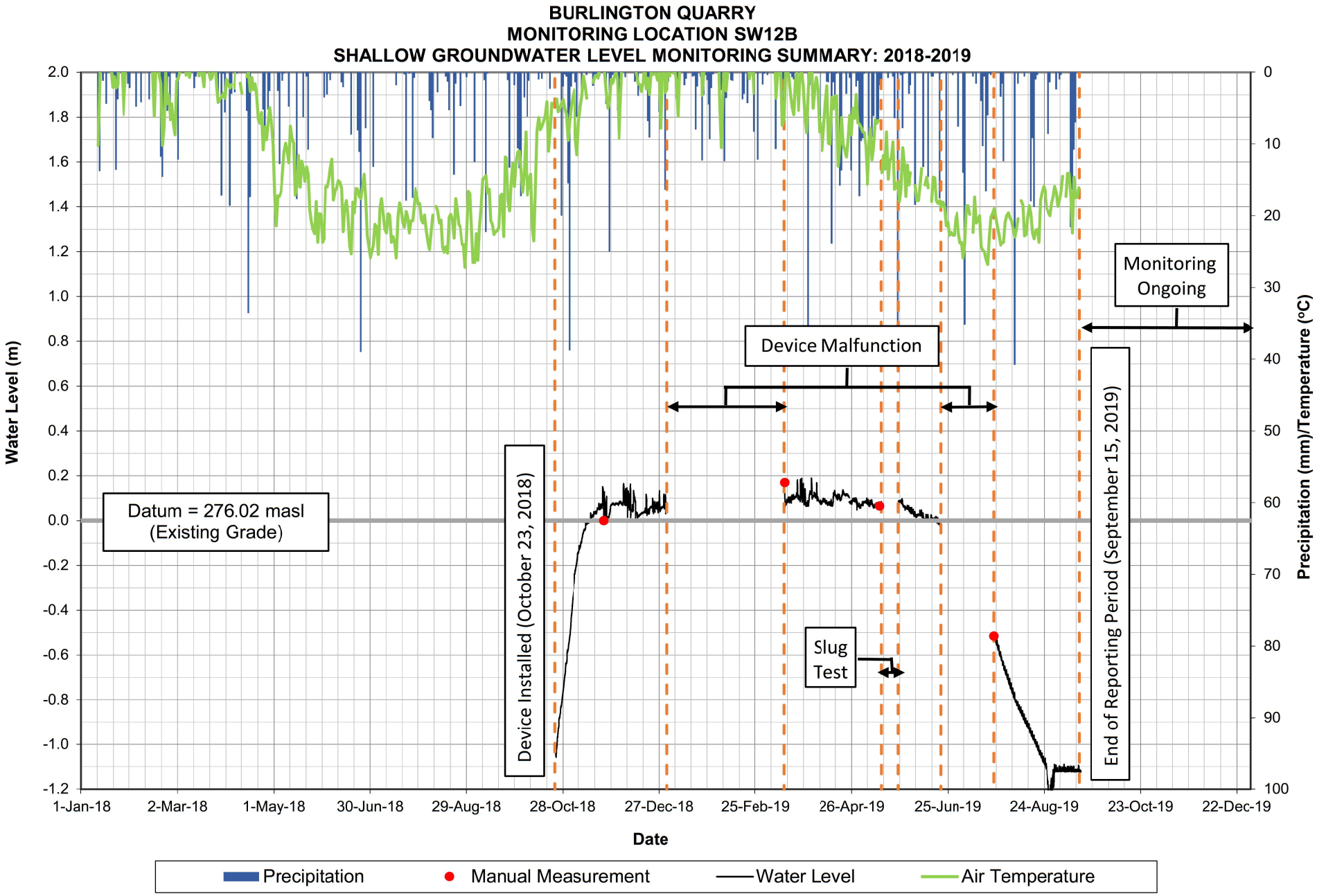
WETLAND 13022 - FIGURE 1



WETLAND 13022 - GRAPH 1

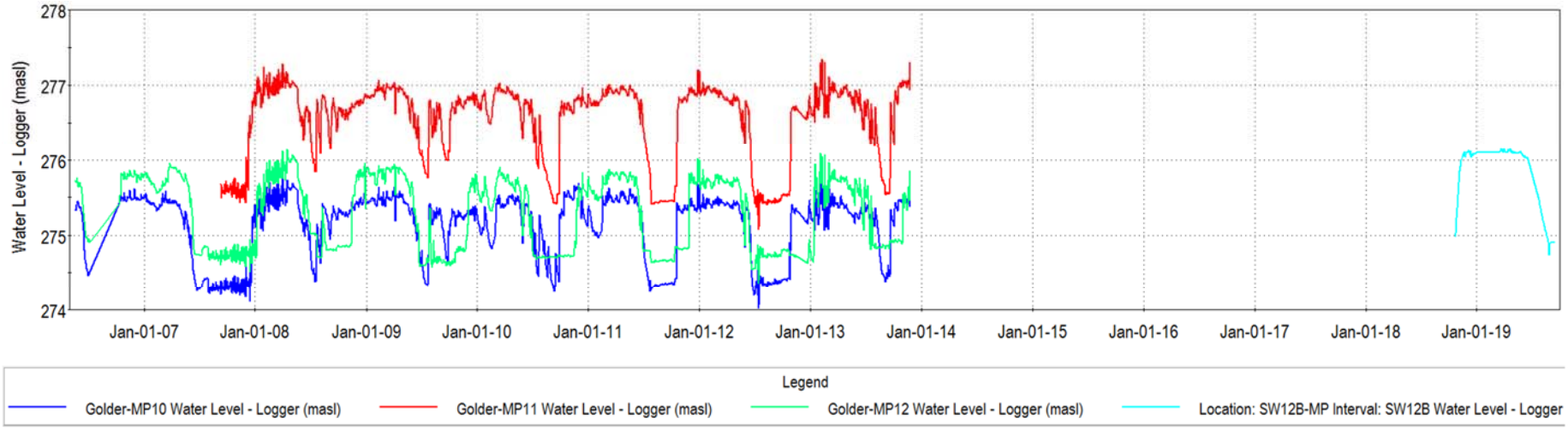


WETLAND 13022 - GRAPH 2



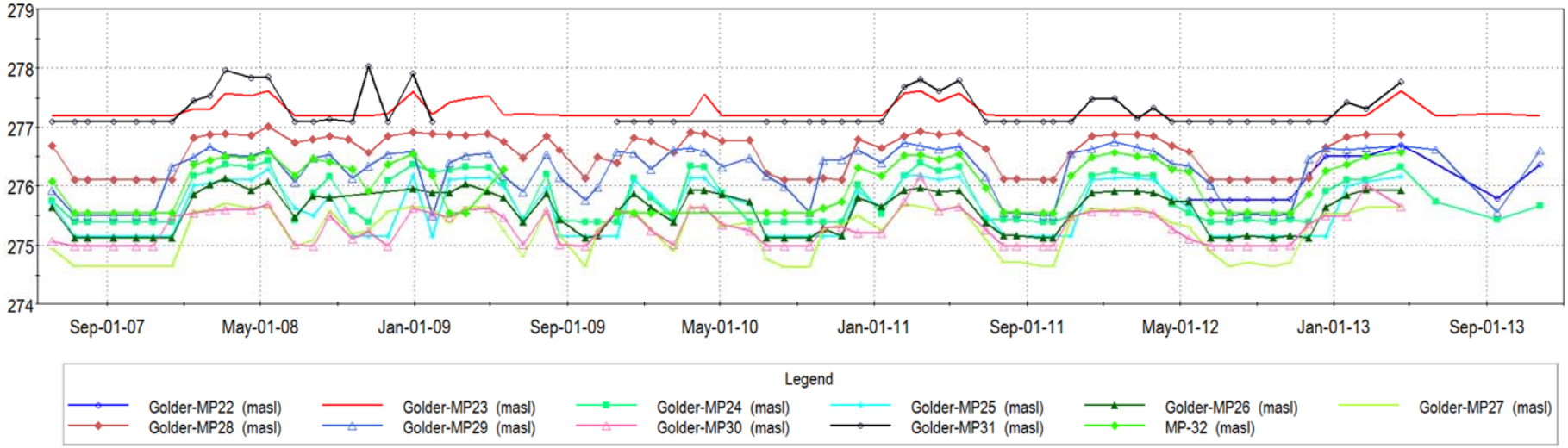
WETLAND 13022 - GRAPH 3

Shallow Groundwater Hydrographs
Wetland 13022



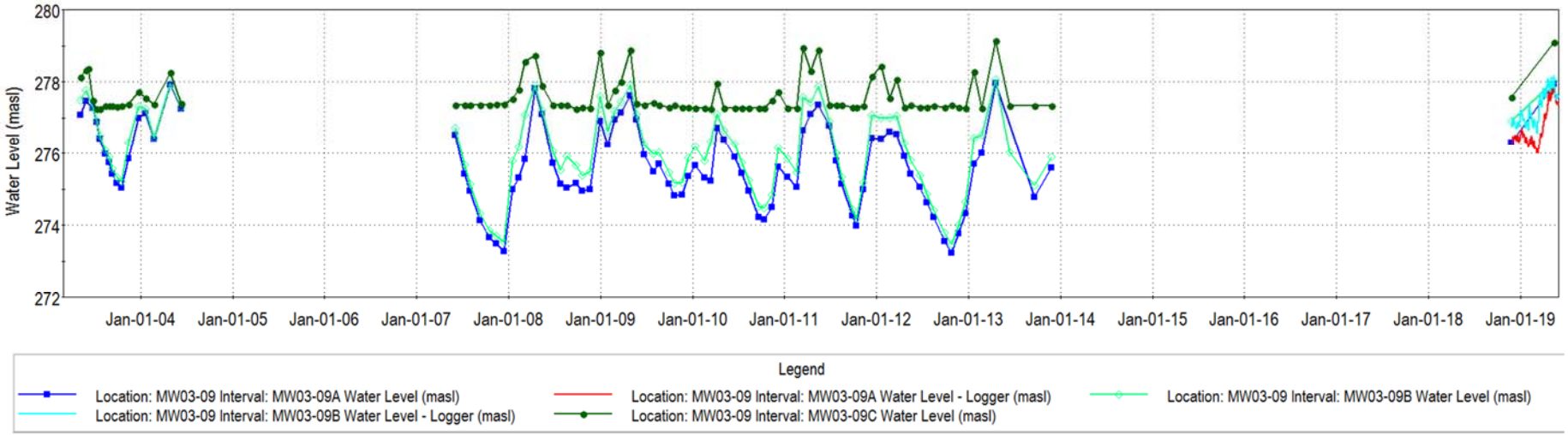
WETLAND 13022 - GRAPH 4

Shallow Groundwater Hydrographs
Wetland 13022

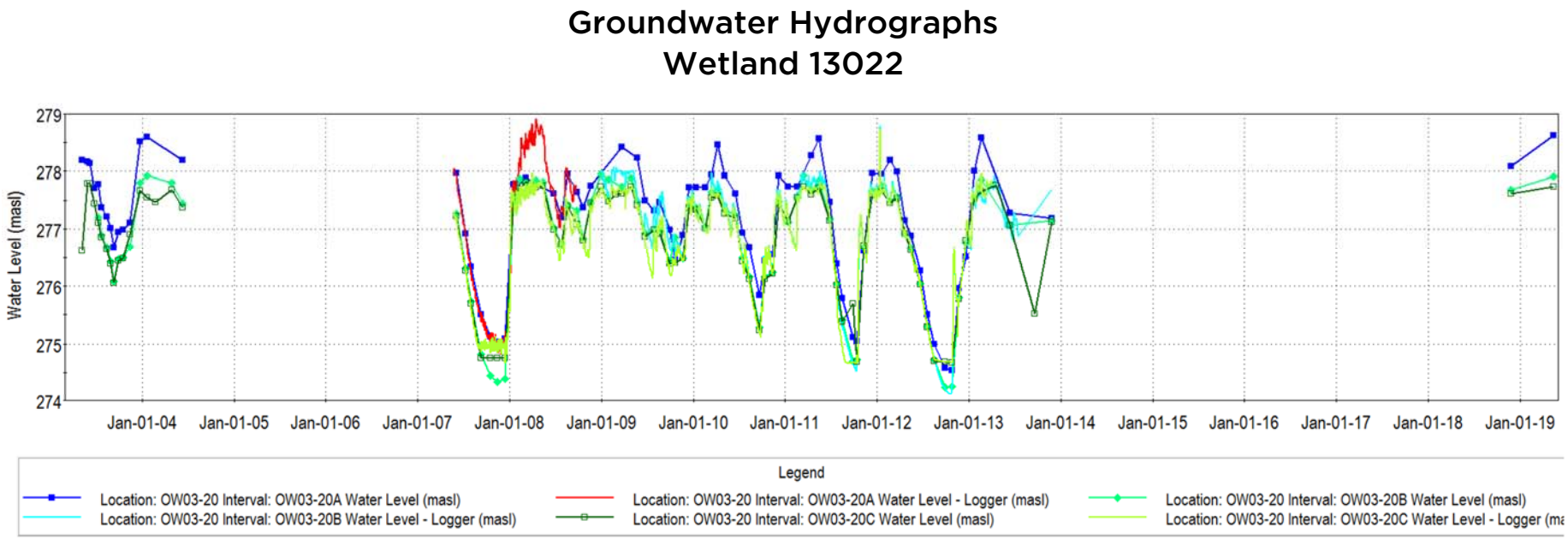


WETLAND 13022 - GRAPH 5

Groundwater Hydrographs
Wetland 13022



WETLAND 13022 - GRAPH 6



WETLAND 13022

FIGURE 2A

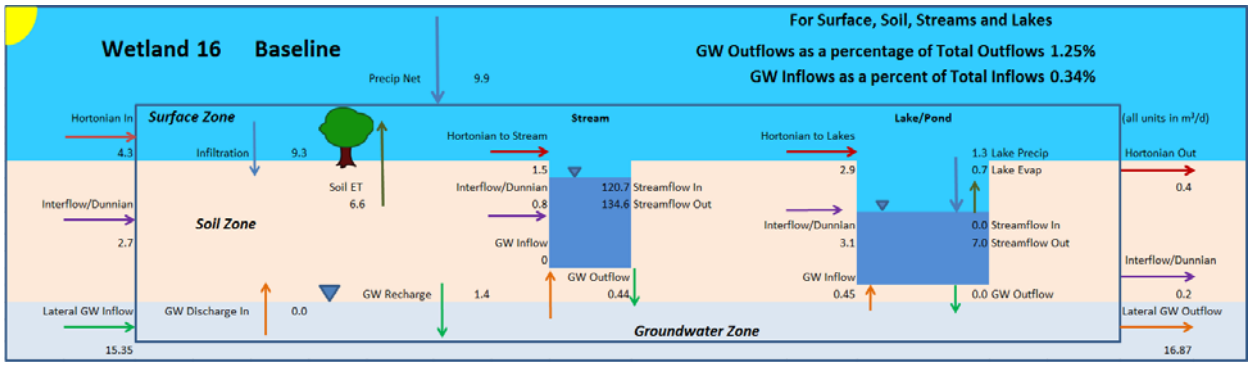


FIGURE 2B

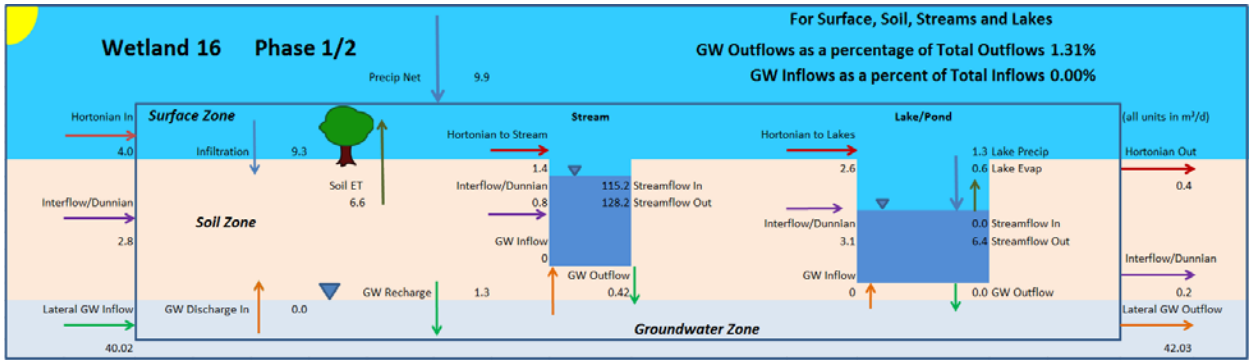


FIGURE 2C

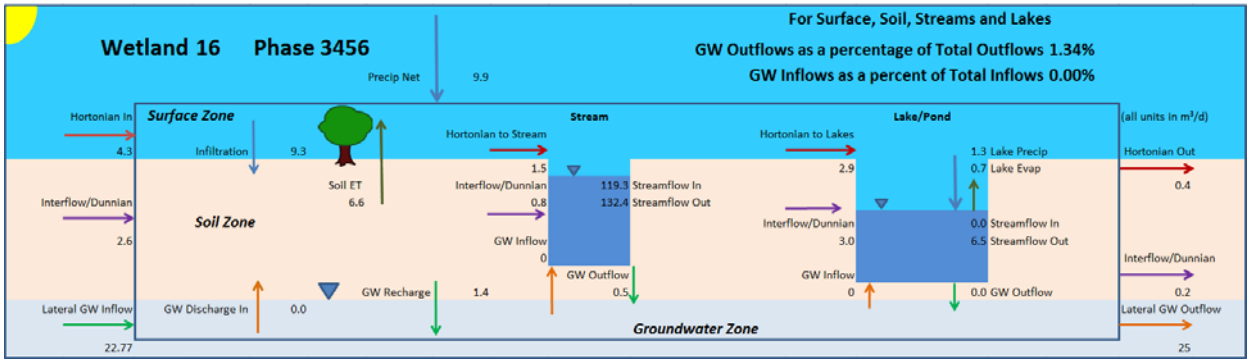


FIGURE 2D

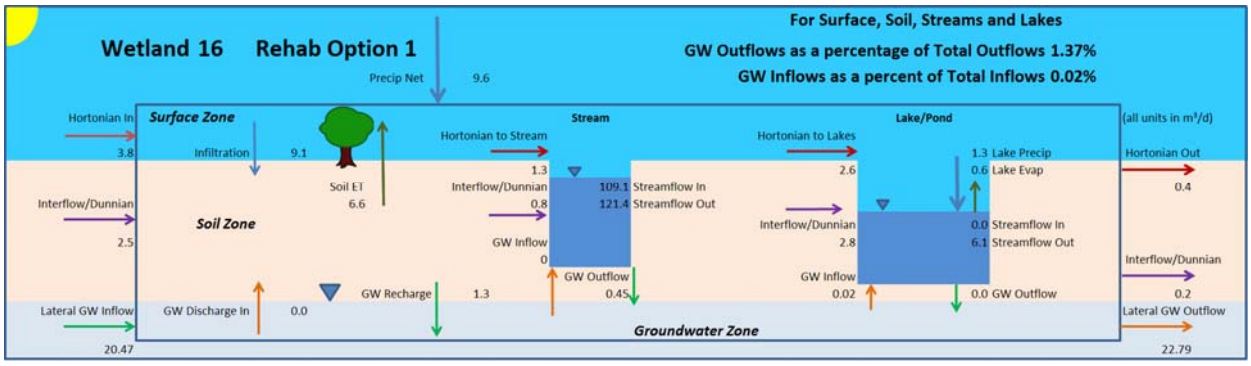
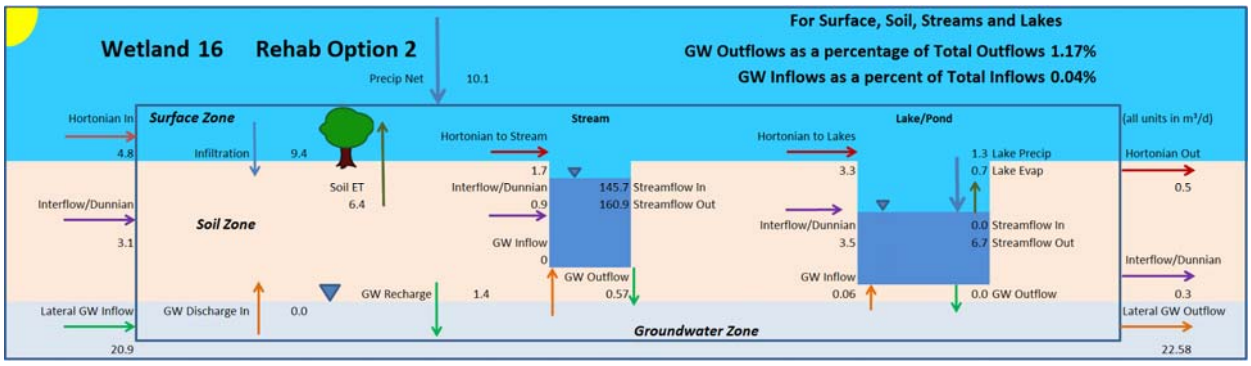
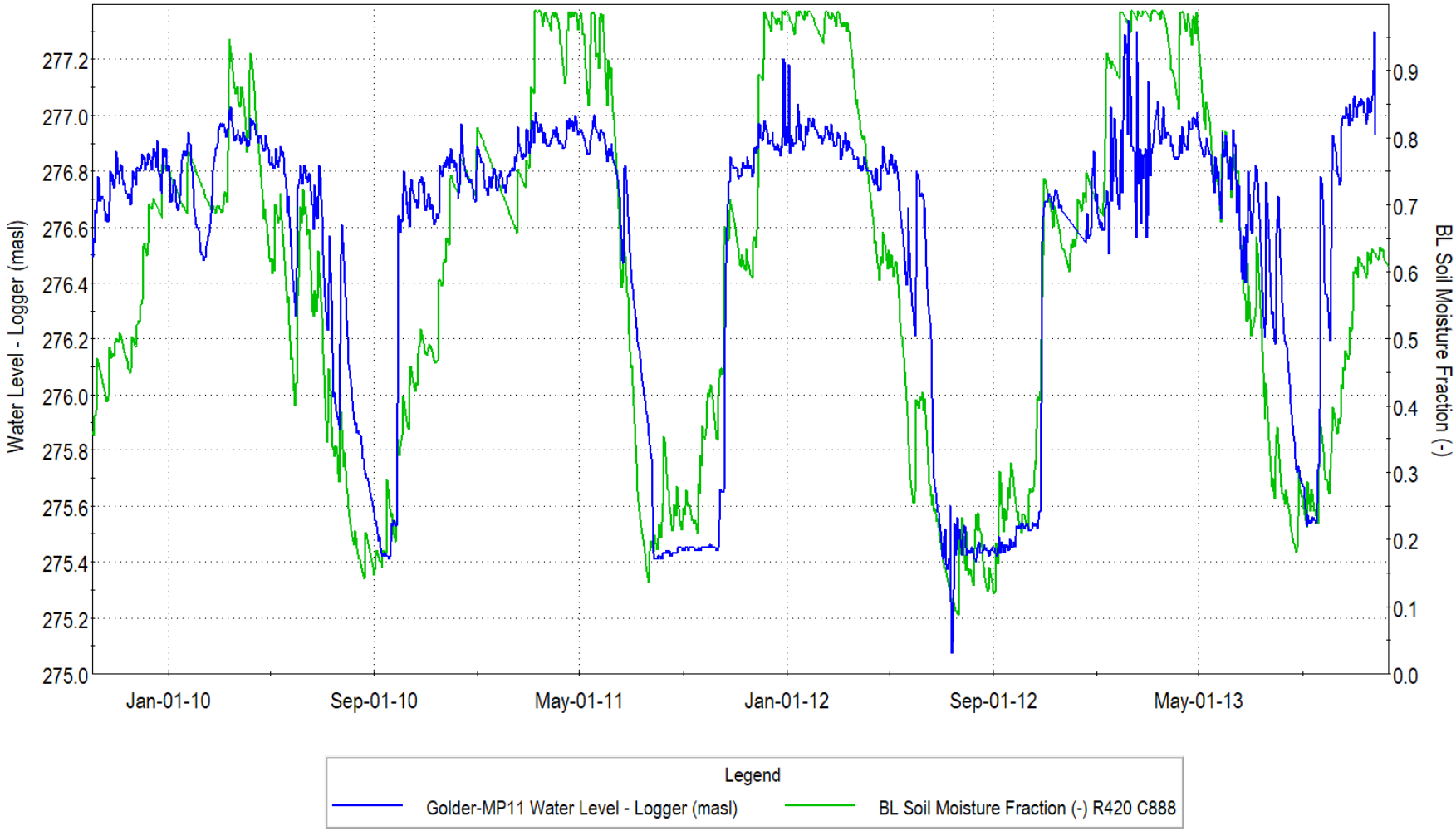


FIGURE 2E



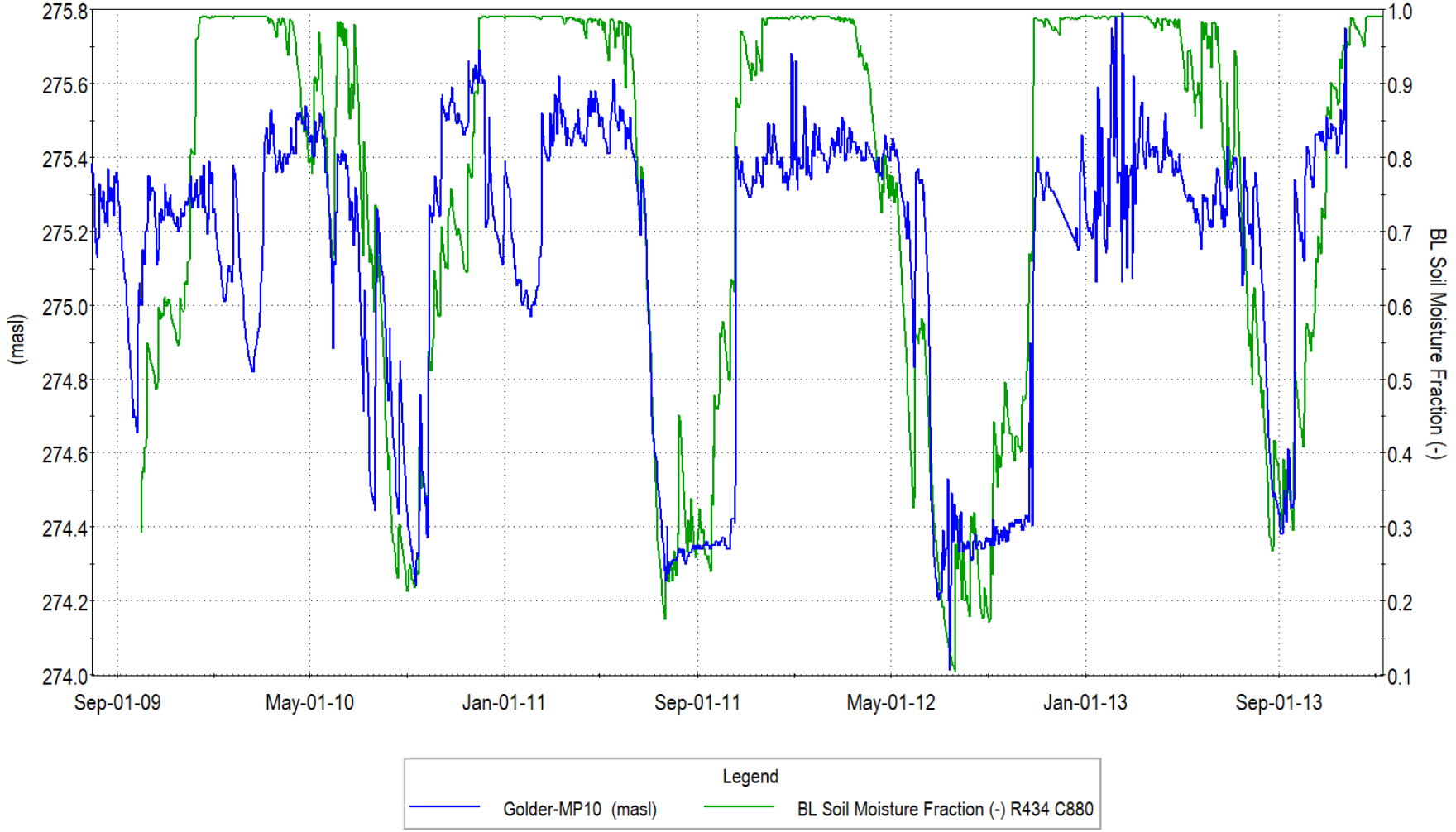
WETLAND 13022 - GRAPH 7

Integrated Model Calibration
Wetland 13022



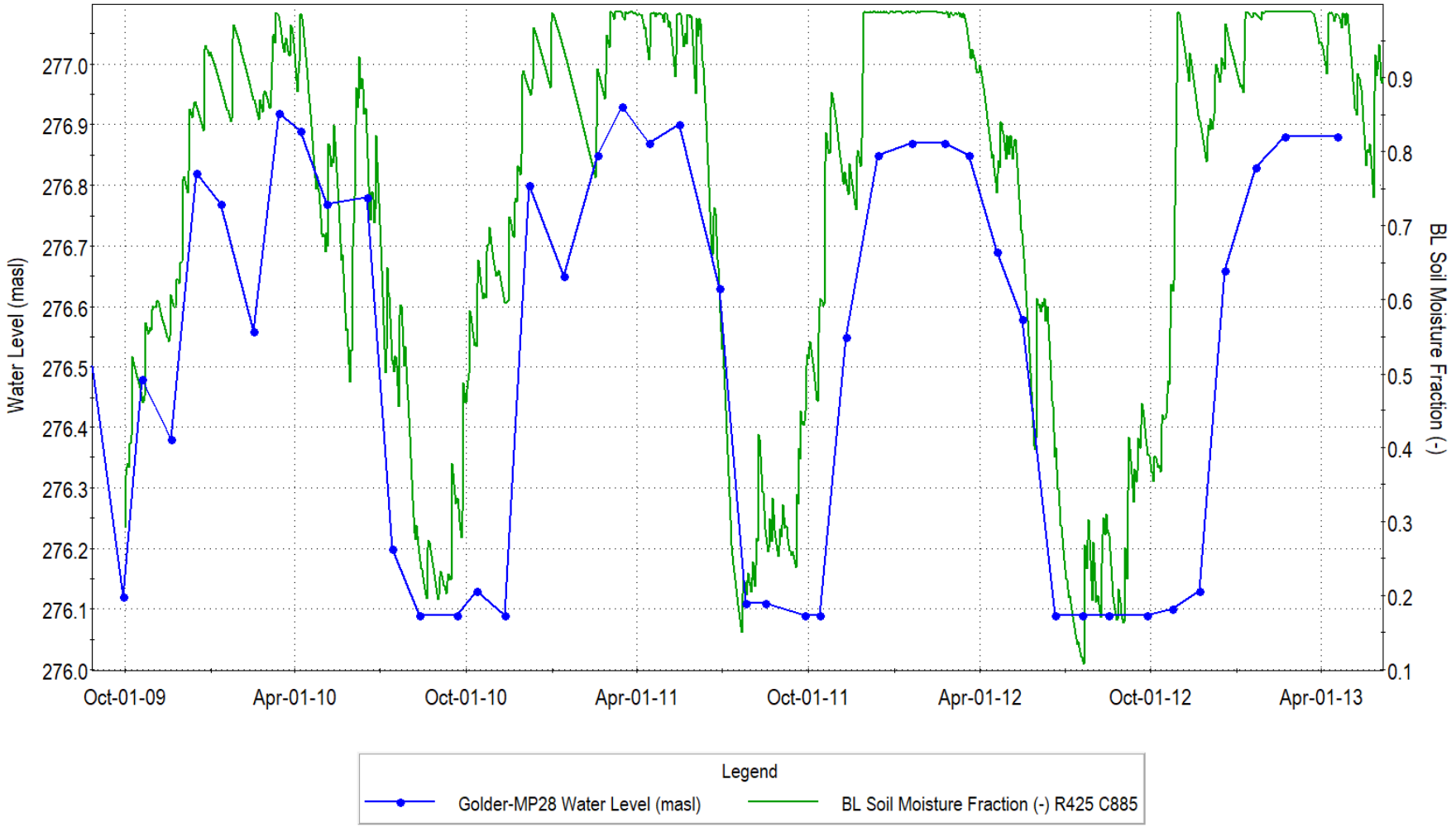
WETLAND 13022 - GRAPH 8

Integrated Model Calibration
Wetland 13022



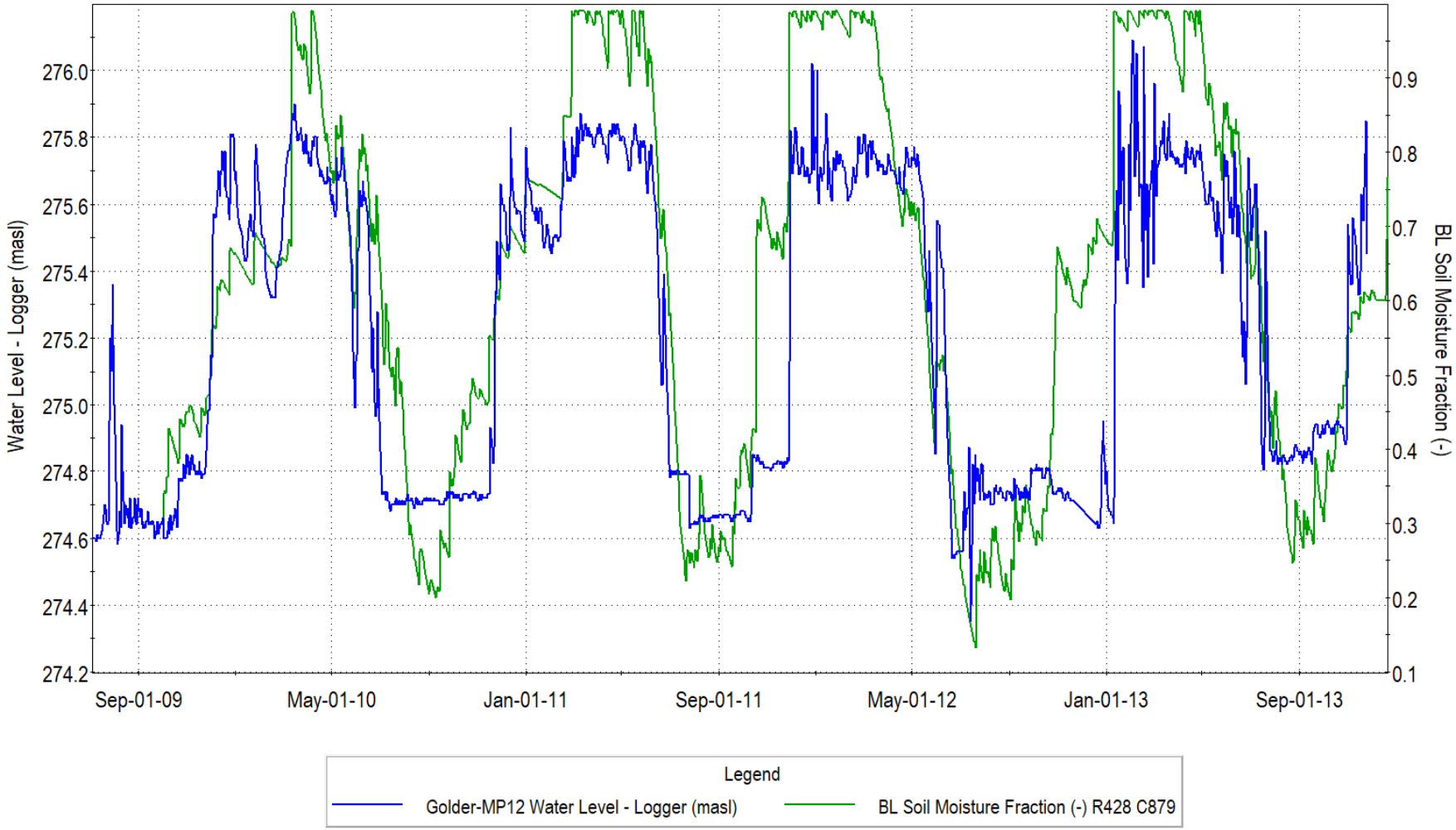
WETLAND 13022 - GRAPH 9

Integrated Model Calibration
Wetland 13022

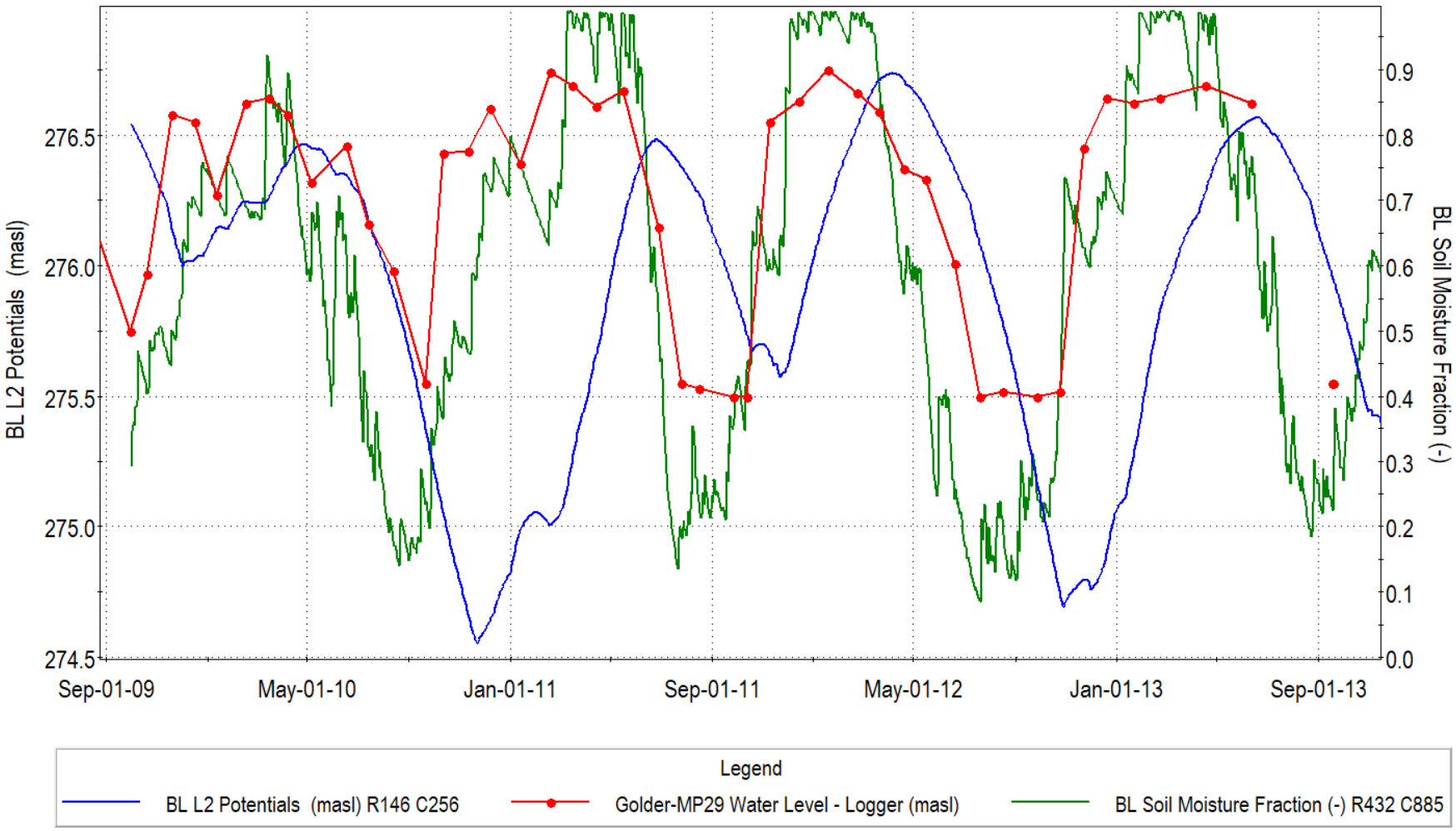


WETLAND 13022 - GRAPH 10

Integrated Model Calibration
Wetland 13022

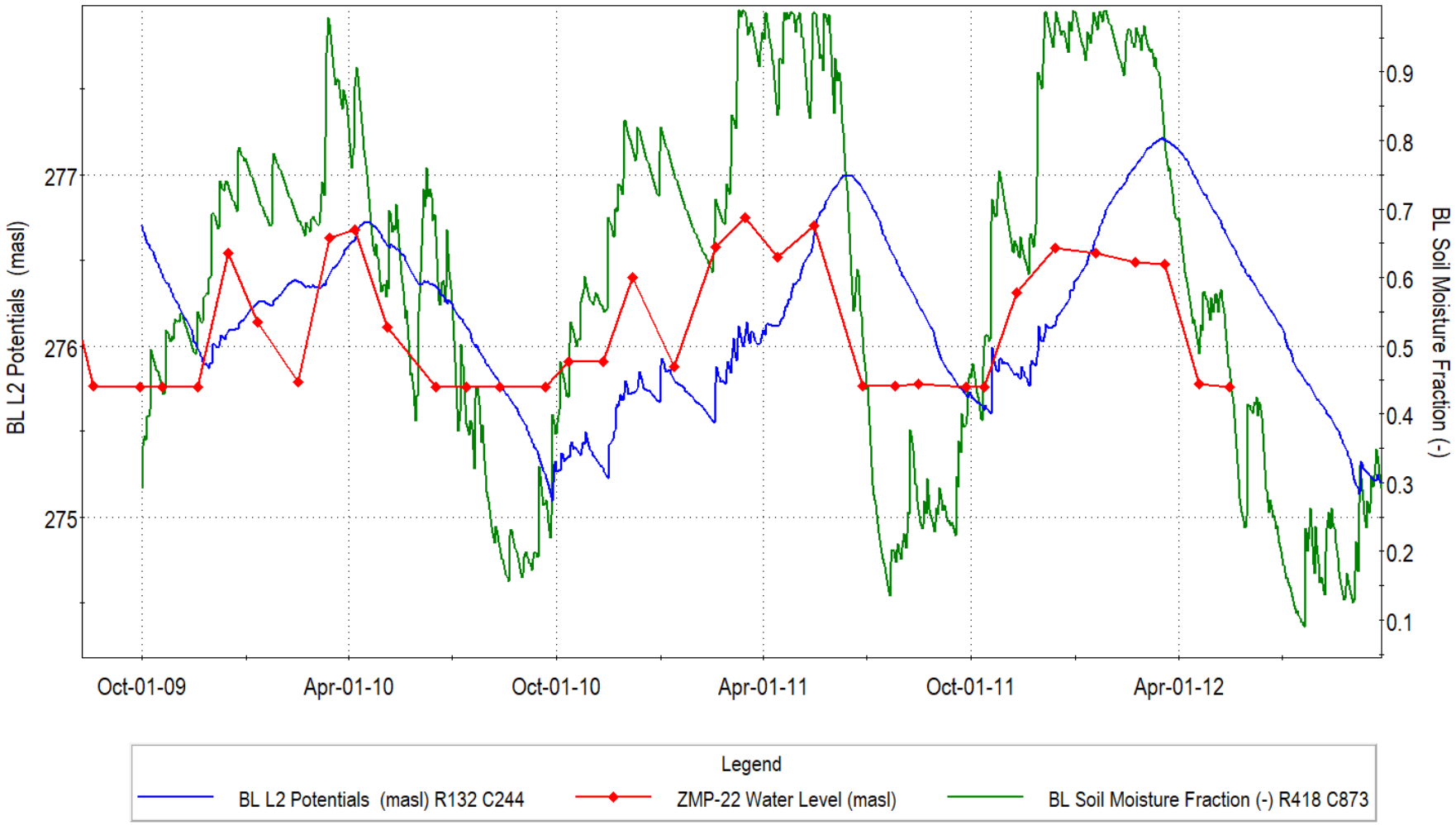


Integrated Model Calibration
Wetland 13022



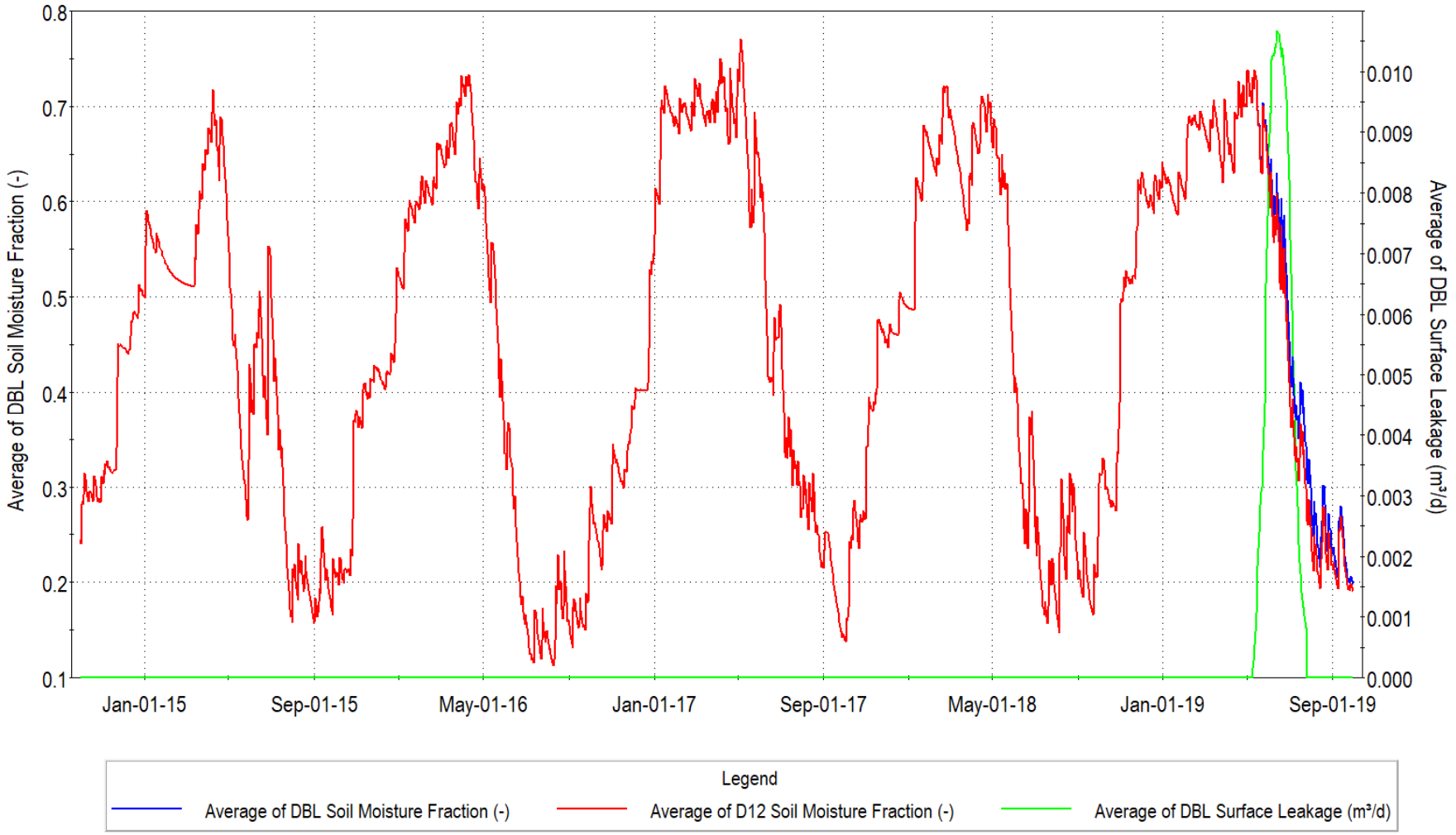
WETLAND 13022 - GRAPH 12

Integrated Model Calibration
Wetland 13022



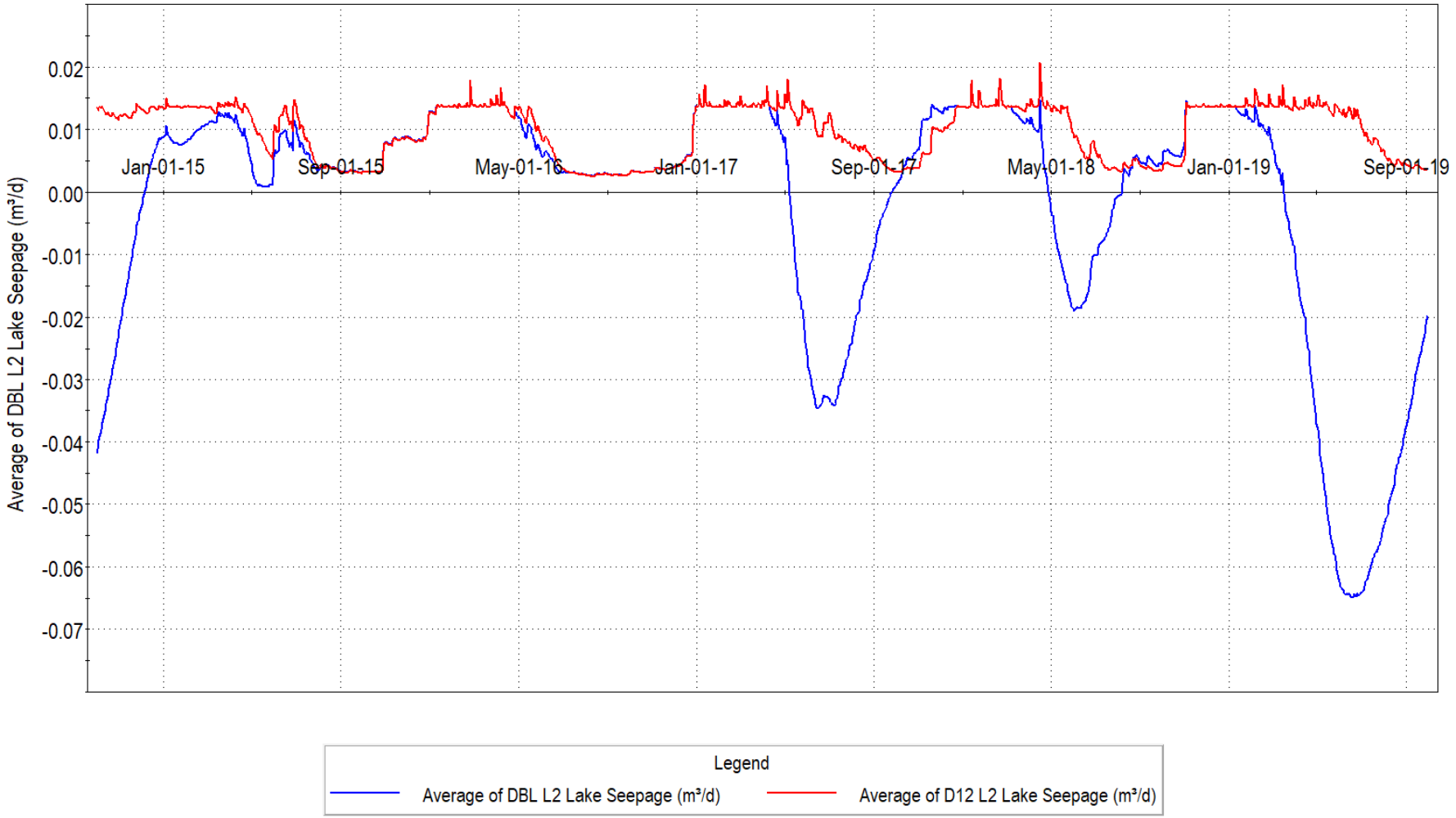
WETLAND 13022 - GRAPH 13

Change in Soil Moisture Conditions
Wetland 13022

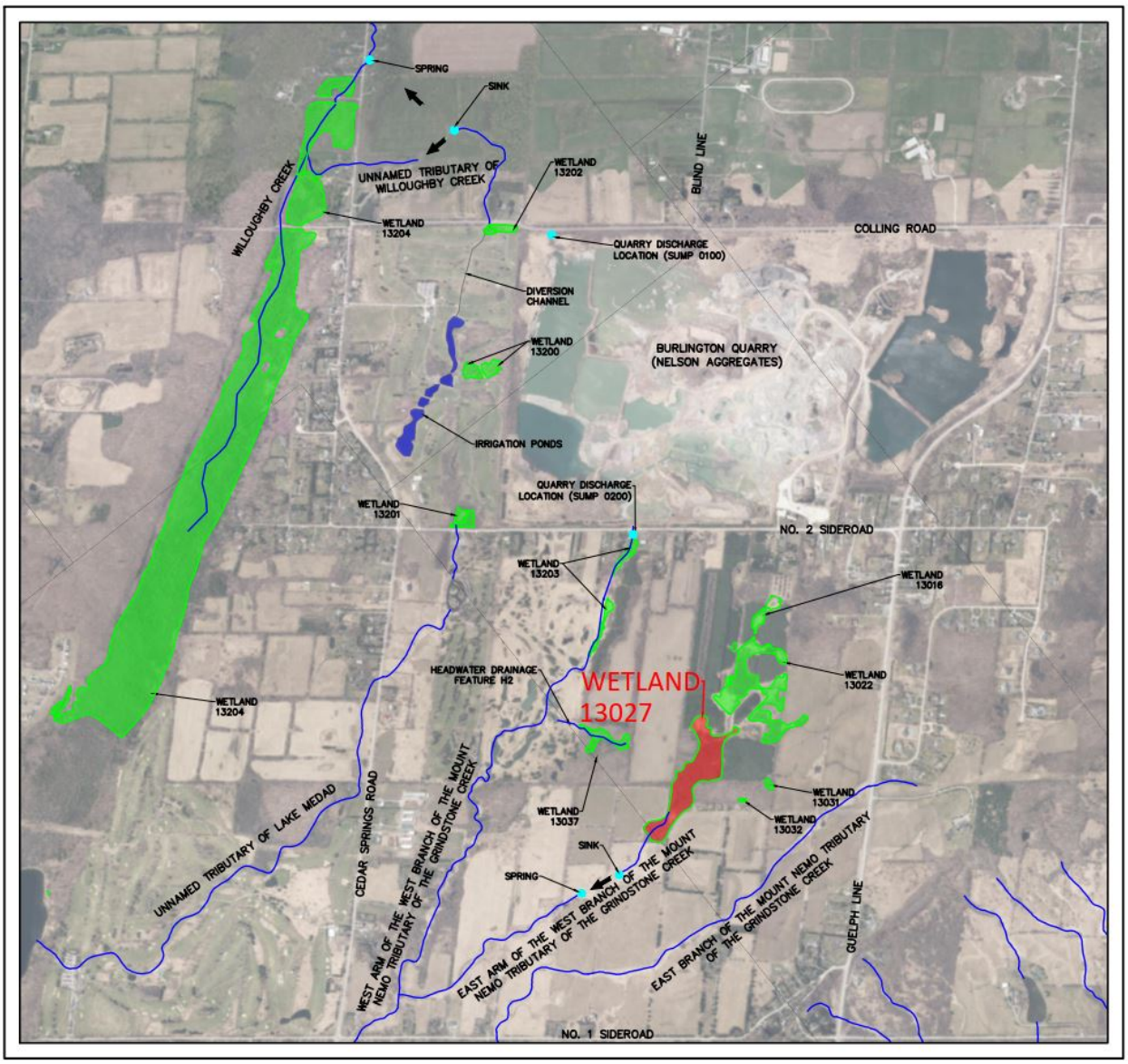


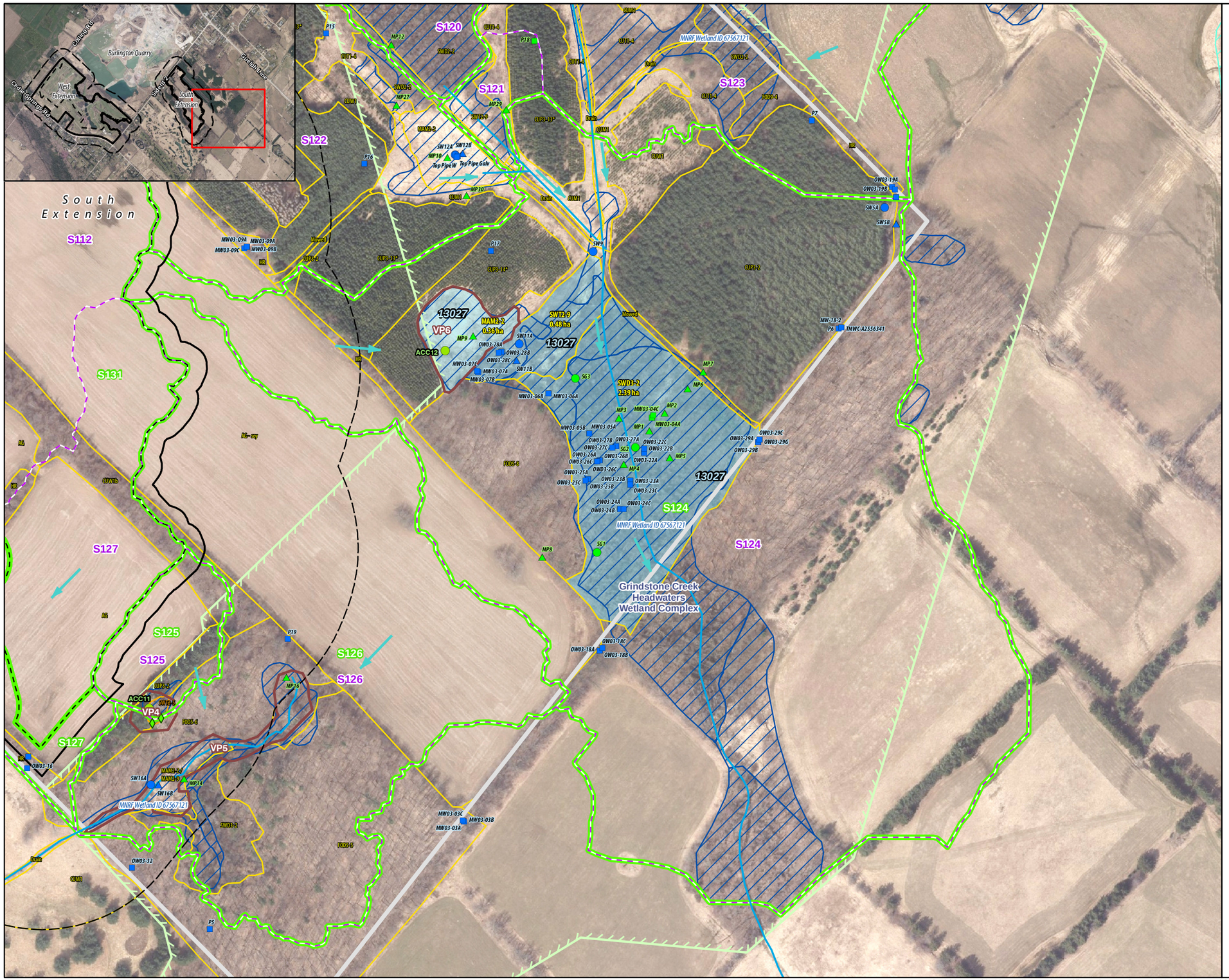
WETLAND 13022 - GRAPH 14

Change in Soil Moisture Conditions
Wetland 13022



WETLAND 13027





Legend

- Licensed Boundary
- Limit of Extraction
- 120 m Adjacent Lands
- Subject Lands
- Amphibian Call Count Station (2019)
- Salamander Trap (2019)
- Salamander Habitat Assessment (2019)
- Indirect Fish Habitat
- Existing Subcatchment Boundary (Tatham Engineering, 2020)
- Proposed Subcatchment Boundary - Operations and Post-Rehabilitation (Tatham Engineering, 2020
- Wetland (Savanta, 2020)
- Ecological Land Classification (Savanta, 2019 & 2020)
- Ecological Land Classification (Savanta, 2020)
- Provincially Significant Wetland (LIO/MNRF, 2020)
- Wetland - Not Evaluated per OWES (MNRF/LIO, 2020)
- MECP Jefferson Salamander Regulated Habitat

Current Instrumentation

- Groundwater Monitoring Station (EarthFx)
- Mini Piezometer (Tatham Engineering)
- Staff Gauge & Surface Water Monitoring Station (Tatham Engineering)

Previous Instrumentation

- Groundwater Monitoring Station (Golder)
- Mini Piezometer (Golder)
- Staff Gauge & Surface Water Monitoring Station (Golder)

ELC Legend

AG, Agriculture
CUM1, Mineral Cultural Meadow
CUP3-2, White Pine Coniferous Plantation
CUP3-6, European Larch Coniferous Plantation
CUP3-13*, White Spruce Coniferous Plantation
CUP3-14*, White Cedar Coniferous Plantation
CUT1-4, Gray Dogwood Cultural Thicket
CUW1, Mineral Cultural Woodland
FOD5-5, Dry – Fresh Sugar Maple – Hickory Deciduous Forest
FOD5-6, Dry- Fresh Sugar Maple-Basswood Deciduous Forest
FOD5-8, Dry – Fresh Sugar Maple – White Ash Deciduous Forest
FOD9-4, Fresh – Moist Shagbark Hickory Deciduous Forest
HR, Hedgerow
MAM2-2, Reed-canary Grass Mineral Meadow Marsh
MAM2-9, Jewelweed Mineral Meadow Marsh
SWD2-2, Green Ash Mineral Deciduous Swamp
SWD3-2, Silver Maple Mineral Deciduous Swamp
SWT2-5, Red-osier Dogwood Mineral Thicket Swamp
SWT2-9, Gray Dogwood Mineral Thicket Swamp

NOTES:

1. Coordinate System: NAD 1983 UTM Zone 17N.
2. Base features produced under license with the Ontario Ministry of Natural Resources and Forestry © Queen's Printer for Ontario, 2021.
3. Orthoimagery © First Base Solutions, 2021. Imagery taken in 2019.

Project 8133

Burlington Quarry Extension
Nelson Aggregates Co.

Figure 3
Wetland Characterization
Wetland 13027 - South Extension

0 50 m
1:3,000

N

GEI Consultants
Savanta Division

Path: C:\Savanta\8133 - Burlington Quarry\figures\report_figures\2021 01 21 natural feature tech summary\8133_rpt_wetland_char_mapbook.mxd Date S...uary 11, 2021

Wetland 13027

Wetland Characteristics	Description	Figure / Graph	Reference	
			Report	Section / Page
Wetland IDs:	MNRF – 67567121(OGF ID 67567149, 67567122, 67567135, 67567124, 67567123, 67567127) Earthfx – 17 Tatham – 13049, 13027, 13048, 13038, 13035, 13034 Savanta – 13027 Golder (Background) - 13049, 13027, 13048, 13038, 13035, 13034			
Wetland Area (ha):	LIO/MNRF - 6.53 (excludes wetland area on neighbouring property) Savanta - 3.23 (excludes wetland area on neighbouring property)			
Watershed:	Grindstone Creek Watershed			
Sub-Watershed:	East Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek			
Located in Proposed Limit of Extraction:	No			
Located in Proposed License Boundary:	No			
Catchment Area (ha):	22.04		SWA (Tatham, April 2020)	Drawing DP-1
Catchment ID:	S124		SWA (Tatham, April 2020)	Drawing DP-1
Closed or Connected System:	On-line (connected to downstream watercourse)			
Condition:	Natural			
Bathymetry:	A bathymetry survey of Wetland 13027 was completed by Tatham Engineering Limited and incorporated into the integrated model (see Earthfx Section 18.3, p.381). Wetland lakes were assigned to Layer 1 of the integrated model by adjusting the base of Layer 1 to correspond with the interpolated bottom elevation. Care was taken to ensure that the lowest elevation observed in the wetland was honored in the assigned elevations.	Figure 1	HHIAR (Earthfx, April 2020)	18.3 (page 381)
Outlet:	East Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek			
Hydroperiod:	Spring Hydroperiod (date wetland dries out) – April 7th – July 17th Fall Hydroperiod (start of hydroperiod) – September 4th –December 27th	Graph 1	SWA (Tatham, April 2020)	2.2.2, 3 and Appendix F
Surface Water Monitoring:	ID: SW11A (Tatham) Installation Date: October 2, 2014 Data Collection: Continuous water level and temperature and manual monthly water level measurements Coordinates of Monitoring Station: Easting 591177.323, Northing 4805244.509	Graph 1	SWA (Tatham, April 2020)	2.2.2, 3 and Appendix F

Natural Heritage and Habitat Features	Description	Figure / Graph	Reference	
			Report	Section / Page
Wetland Name & Provincial Significance Evaluation:	Grindstone Creek Headwaters Wetland Complex – Provincially Significant		NETR (Savanta, April 2020)	6.1.2
ELC Unit(s):	Reed-canary Grass Mineral Meadow Marsh: MAM2-2 Gray Dogwood Mineral Thicket Swamp: SWT2-9 Green Ash Mineral Deciduous Swamp: SWD2-2		NETR (Savanta, April 2020)	Table 2
Regulated Habitat (MECP):	Yes – Jefferson Salamander (not field verified during 2019 field program; regulated based on historical data) Hydroperiod sensitive species; water presence necessary until end of June		NETR (Savanta, April 2020)	6.7
Significant Wildlife Habitat:	Unknown – outside of 120 m adjacent lands			
Fish Habitat:	Indirect		NETR (Savanta, April 2020)	6.6
Habitat of Endangered and Threatened Species:	Unknown – outside of 120 m adjacent lands			

Groundwater Interaction	Description	Figure / Graph	Reference	
			Report	Section / Page
Lithology:	Halton Till			
Hydraulic Conductivity:	Integrated Model (Earthfx) - The harmonic mean hydraulic conductivity, based on testing by Golder (2007) of 10 mini-piezometers, was $1.2x10^{-8}$ m/s. Model value for the vertical hydraulic conductivity was $1.6x10^{-7}$ m/s, about an order of magnitude higher, to account for limited flow through fractures in the till. Wetland Water Balance (Tatham) – $8.2x10^{-9}$ m/s.			
Surface Water/Groundwater Interaction:	The low permeability of the Halton Till underlying the wetland is the dominant control on 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. This wetland receives some groundwater inflow but is relatively isolated from any changes in the water table due to quarry development.			
Shallow Groundwater (Mini-piezometer) Monitoring:	ID: SW11B (Tatham) Installation Date: October 25, 2018 Data Collection: Continuous water level and temperature and manual monthly water level measurements Coordinates of Monitoring Station: Easting 591177.323, Northing 4805244.509	Graph 2	SWA (Tatham, April 2020)	2.3 and Appendix G

Background Shallow Groundwater (Mini-piezometer) Monitoring: — Graph 3

Mini-piezometer ID	Ground Elevation	Bottom Elevation	Average WL	Logger	Manual Meas.
Golder-MP1	275.05	273.55	274.65	-	2007-2013
Golder-MP2	275.28	273.78	274.95	-	2007-2013
Golder-MP3	275.15	273.65	274.85	-	2007-2013
Golder-MP4	275.15	273.65	274.8	-	2007-2013
Golder-MP5	275.04	273.54	274.75	-	2007-2013
Golder-MP6	276.48	274.98	275.18	-	2007-2013
Golder-MP7	276.32	274.82	274.74	-	2007-2013
Golder-MP9	278.71	277.51	275.12	2006-2013	2006-2013

<table>
<tr><th>Groundwater Interaction</th><th colspan="6">Description</th><th>Figure / Graph</th><th colspan="2">Reference</th></tr>
<tr><th></th><th colspan="6"></th><th></th><th>Report</th><th>Section / Page</th></tr>
<tr><td rowspan="32">Groundwater Monitoring (Monitoring Wells):</td><td>Monitoring Well ID</td><td>Distance (Dir.)</td><td>Geologic Unit</td><td>Ground Elevation</td><td>Monitoring Elev</td><td>Average WL</td><td rowspan="32">Graphs 4, 5, 6 & 7</td><td rowspan="32"></td><td rowspan="32"></td></tr>
<tr><td>MW03-04A</td><td>16 (E)</td><td>Bedrock</td><td>274.92</td><td>257.24 - 253.28</td><td>274.79</td></tr>
<tr><td>MW03-04B</td><td>16 (E)</td><td>Bedrock</td><td>274.92</td><td>266.69 - 262.42</td><td>274.71</td></tr>
<tr><td>MW03-04C</td><td>17 (E)</td><td>Bedrock</td><td>274.86</td><td>273.46 - 271.66</td><td>274.66</td></tr>
<tr><td>MW03-05A</td><td>33 (ESE)</td><td>Bedrock</td><td>275.01</td><td>272.42 - 271.66</td><td>274.70</td></tr>
<tr><td>MW03-05B</td><td>33 (ESE)</td><td>Overburden</td><td>275.01</td><td>273.94 - 272.88</td><td>274.54</td></tr>
<tr><td>MW03-06A</td><td>65 (ENE)</td><td>Bedrock</td><td>275.01</td><td>273.03 - 272.6</td><td>274.83</td></tr>
<tr><td>MW03-06B</td><td>65 (ENE)</td><td>Overburden</td><td>275.01</td><td>273.79 - 273.33</td><td>274.82</td></tr>
<tr><td>MW03-07A</td><td>120 (ENE)</td><td>Bedrock</td><td>275.37</td><td>260.89 - 256.6</td><td>274.83</td></tr>
<tr><td>MW03-07B</td><td>120 (ENE)</td><td>Bedrock</td><td>275.38</td><td>269.74 - 267.46</td><td>275.03</td></tr>
<tr><td>MW03-07C</td><td>121 (ENE)</td><td>Bedrock</td><td>275.37</td><td>273.54 - 271.56</td><td>275.11</td></tr>
<tr><td>OW03-22A</td><td>10 (SSE)</td><td>Bedrock</td><td>275.01</td><td>255.41 - 247.31</td><td>274.15</td></tr>
<tr><td>OW03-22B</td><td>10 (SSE)</td><td>Bedrock</td><td>275.02</td><td>271.19 - 263.82</td><td>274.44</td></tr>
<tr><td>OW03-22C</td><td>10 (SSE)</td><td>Bedrock</td><td>274.92</td><td>273.22 - 271.62</td><td>274.58</td></tr>
<tr><td>OW03-23A</td><td>1 (S)</td><td>Bedrock</td><td>274.96</td><td>256.31 - 249.66</td><td>274.18</td></tr>
<tr><td>OW03-23B</td><td>1 (S)</td><td>Bedrock</td><td>274.91</td><td>270.88 - 264.21</td><td>274.44</td></tr>
<tr><td>OW03-23C</td><td>1 (S)</td><td>Bedrock</td><td>274.78</td><td>273.28 - 271.68</td><td>274.46</td></tr>
<tr><td>OW03-24A</td><td>9 (S)</td><td>Bedrock</td><td>274.88</td><td>256.75 - 250.13</td><td>274.16</td></tr>
<tr><td>OW03-24B</td><td>9 (S)</td><td>Bedrock</td><td>274.88</td><td>270.88 - 264.24</td><td>274.26</td></tr>
<tr><td>OW03-24C</td><td>6 (S)</td><td>Bedrock</td><td>274.74</td><td>272.97 - 271.39</td><td>274.35</td></tr>
<tr><td>OW03-25A</td><td>34 (SE)</td><td>Bedrock</td><td>275</td><td>255.9 - 247.48</td><td>274.14</td></tr>
<tr><td>OW03-25B</td><td>34 (SE)</td><td>Bedrock</td><td>274.99</td><td>270.69 - 264.22</td><td>274.43</td></tr>
<tr><td>OW03-25C</td><td>36 (SE)</td><td>Bedrock</td><td>274.99</td><td>273.19 - 271.59</td><td>274.50</td></tr>
<tr><td>OW03-26A</td><td>25 (SE)</td><td>Bedrock</td><td>275.02</td><td>255.82 - 248.42</td><td>274.16</td></tr>
<tr><td>OW03-26B</td><td>25 (SE)</td><td>Bedrock</td><td>275.03</td><td>272.04 - 263.7</td><td>274.46</td></tr>
<tr><td>OW03-26C</td><td>27 (SE)</td><td>Bedrock</td><td>275.005</td><td>272.71 - 271.11</td><td>274.22</td></tr>
<tr><td>OW03-27A</td><td>12 (SE)</td><td>Bedrock</td><td>275.05</td><td>256.05 - 247.28</td><td>274.19</td></tr>
<tr><td>OW03-27B</td><td>12 (SE)</td><td>Bedrock</td><td>275.06</td><td>270.91 - 263.88</td><td>274.50</td></tr>
<tr><td>OW03-27C</td><td>15 (SE)</td><td>Bedrock</td><td>275.04</td><td>272.74 - 271.14</td><td>274.48</td></tr>
<tr><td>OW03-28A</td><td>102 (ENE)</td><td>Bedrock</td><td>275.46</td><td>256.76 - 248.96</td><td>275.33</td></tr>
<tr><td>OW03-28B</td><td>102 (ENE)</td><td>Bedrock</td><td>275.46</td><td>272.36 - 265.66</td><td>275.07</td></tr>
<tr><td>OW03-28C</td><td>104 (ENE)</td><td>Bedrock</td><td>275.4</td><td>273.9 - 272.3</td><td>275.11</td></tr>
<tr><td>OW03-29A</td><td>99 (ENE)</td><td>Bedrock</td><td>277.06</td><td>256.46 - 248.92</td><td>274.84</td></tr>
<tr><td>OW03-29B</td><td>99 (ESE)</td><td>Bedrock</td><td>277.05</td><td>273.93 - 266.83</td><td>275.47</td></tr>
<tr><td>OW03-29C</td><td>100 (ESE)</td><td>Overburden</td><td>277.02</td><td>276.72 - 275.12</td><td>275.79</td></tr>
<tr><td>OW03-29G</td><td>100 (ESE)</td><td>Overburden</td><td>277.02</td><td></td><td></td></tr>
<tr><td>Water Budget Results:</td><td colspan="6">A detailed average water budget, as simulated by the integrated model, is provided in the main report for Baseline Conditions (Earthfx Figure 7.25, p. 187). The baseline water budget is reproduced in Figure 2a. The wetland is a net provider of groundwater. Simulated groundwater levels, groundwater discharge to riparian areas, and streamflow in the vicinity of Wetland 17 for baseline conditions are discussed in Section 7 of the main report.

Wetland 13027 | GW Outflow (%) | GW Inflow (%)
Baseline (Existing) | 2.51 | 1.31</td><td>Figure 2a</td><td>HHIAR (Earthfx, April 2020)</td><td>187</td></tr>
</table>

Groundwater Interaction	Description	Figure / Graph	Reference	
			Report	Section / Page
Integrated Model Calibration:	Four mini-piezometers in Wetland 17 provide multiple years of monitoring in the soil zone and upper weathered Halton Till. These monitors correspond to the PRMS soil zone and upper-most part of Layer 1 of the GSFLOW model. A comparison of the mini-piezometer data to the simulated soil moisture conditions demonstrates that the model is closely matching both the soil moisture and hydroperiod in the shallow subsurface at this wetland (see Graphs 8 through 12).	Graphs 8, 9, 10, 11 & 12		
	Earthfx Figure 19.42 (p.442) in the Main Report shows a hydrograph for Golder SG-3 along with simulated shallow water levels. Earthfx Figure 6.31 (p.155) and Figure 19.43 (p.443) in the Main Report shows a hydrograph for Golder SG-2 and MP5 along with simulated shallow water levels. The results are reproduced in Graphs 13 and 14. A brief discussion of the Wetland 13027 (Earthfx Wetland 17) is contained in Earthfx Section 6.11.4 (p. 155). A more detailed discussion is provided in Appendix E, Section 19.6 (p. 441).	Graphs 13 & 14	HHIAR (Earthfx, April 2020)	155 and 441 - 443

<table>
<tr><th>Impact Assessment (Operations Phases 1 & 2)</th><th>Description</th><th>Figure / Graph</th><th colspan="2">Reference</th></tr>
<tr><th></th><th></th><th></th><th>Report</th><th>Section / Page</th></tr>
<tr><td>Change in Wetland Area (ha):</td><td>No change. Wetland located greater than 120 m from licensed boundary.</td><td></td><td>SWA (Tatham, April 2020)</td><td>4.2.1</td></tr>
<tr><td>Change in Wetland Catchment Area (ha):</td><td>No change. Subcatchment area protected.</td><td></td><td>SWA (Tatham, April 2020)</td><td>4.2.1 & Drawing DP-2</td></tr>
<tr><td>Change in Hydroperiod:</td><td>No Change. Wetland is perched and isolated from the groundwater system. Subcatchment area being protected.</td><td></td><td>SWA (Tatham, April 2020)</td><td>4.2.1</td></tr>
<tr><td>Change in Water Budget:</td><td>A detailed average water budget for Wetland 13027 (Earthfx Wetland 17), as simulated by the integrated model, is provided in the Earthfx report for Baseline Conditions (Figure 7.25, p. 187); Scenario P12 (Figure 8.32, p. 222); P3456 (Figure 8.64, p. 249); RHB1 (Figure 8.100, p. 278), and RHB2 (Figure 8.127, p. 300). The water budget results for Scenario P12 are reproduced in Figure 2b. Simulated change in groundwater levels (drawdowns), groundwater discharge to riparian areas, and change in streamflow in the vicinity of Wetland 13027 (Earthfx Wetland 17) for each scenario are discussed in Section 8 of the main report.
<table>
<tr><td>Wetland 13027</td><td>GW Outflow (%)</td><td>GW Inflow (%)</td><td>Δ in Outflow (%)</td><td>Δ in Inflow (%)</td></tr>
<tr><td>Baseline (Existing)</td><td>2.51</td><td>1.31</td><td>-</td><td>-</td></tr>
<tr><td>Operations Ph 1 & 2</td><td>5.71</td><td>0.00</td><td>3.20</td><td>-1.31</td></tr>
</table></td><td>Figure 2b</td><td>HHIAR (Earthfx, April 2020)</td><td>191 - 303</td></tr>
<tr><td>Change on Soil Moisture Conditions:</td><td>The effects of development can be illustrated by comparing the average soil moisture in Wetland 17 under Baseline and P12 development conditions. Graph 15 shows average daily soil moisture for Baseline conditions as a blue line. The soil moisture under P12 development is shown in red, and it overlies (covers) the Baseline for much of the time period. Under P12 development, soil moisture is essentially identical in the winter and spring, but slightly dryer in the summer and fall. The Baseline groundwater discharge into Wetland 17 (seepage or “surface leakage” in GSFLOW) is shown as a green line on the graph (right hand scale). The decline in soil moisture under P12 is due to the loss of this groundwater discharge (due to the drawdown in groundwater levels near the excavation). Under baseline conditions, groundwater seepage occurs as water levels rise in the late spring in response to snowmelt. Seepage fluctuates significantly, however, due to natural inter-annual climate variability. During a dry year (2015-2016) groundwater levels are naturally low, there is no groundwater seepage, and so there is no difference in soil moisture between Baseline and P12. During an average year (2017-2018) there is small change in the late summer soil moisture conditions due to the loss of groundwater discharge during P12 development. During a wet year there is a modest loss of soil moisture in the May-September time frame. The water budget summary for Wetland 17 indicates that groundwater inflows account for only 1.31% of all inflows, and that this will be lost with development. Graph 16 illustrates how and when that loss of groundwater inflow will occur. The loss will primarily occur during the late summer of a wet year. There will be no impact during dry years when the wetland already experiences limited groundwater inflow. Additional surface water and groundwater interaction occurs through the bottom of the ponded water portions of Wetland 17 (Graph 15). The ponded water areas within the wetland are represented in the model as MODFLOW “Lakes”. Pond seepage is positive when the lake or pond is leaking water to the deeper groundwater system. Negative seepage indicates groundwater is upwelling into the pond. The pond seepage under Baseline (Blue) and P12 conditions (Red) are shown in Graph 15. Under Baseline conditions, the ponds leak water to the groundwater system for most of the year, and only receive upwelling (negative leakage or seepage) for short periods of the wetter years when the water table is higher (generally in late spring). Under P12 conditions (red line), the ponds leak water to the groundwater system at varying rates throughout the year; generally higher in the spring and declining through the summer. Overall, the pond leakage patterns under Baseline and P12 conditions are similar to that of soil moisture response.</td><td>Graphs 15 & 16</td><td></td><td></td></tr>
<tr><td>Potential Impact to Form and Function of Feature:</td><td>No wetlands will be removed and the wetlands subcatchment will be protected. There will be no encroachment from the project into the wetland. The proposed limit of extraction is >120 m from the wetland boundary. Licensed boundary will be demarcated and fenced to ensure site construction and operations do not extend beyond the proposed limits of the project .</td><td></td><td></td><td></td></tr>
</table>

Mitigation (Operational Phases 1 & 2)	Description	Figure / Graph	Reference	
			Report	Section / Page
Proposed Mitigation Measures:	None required.			

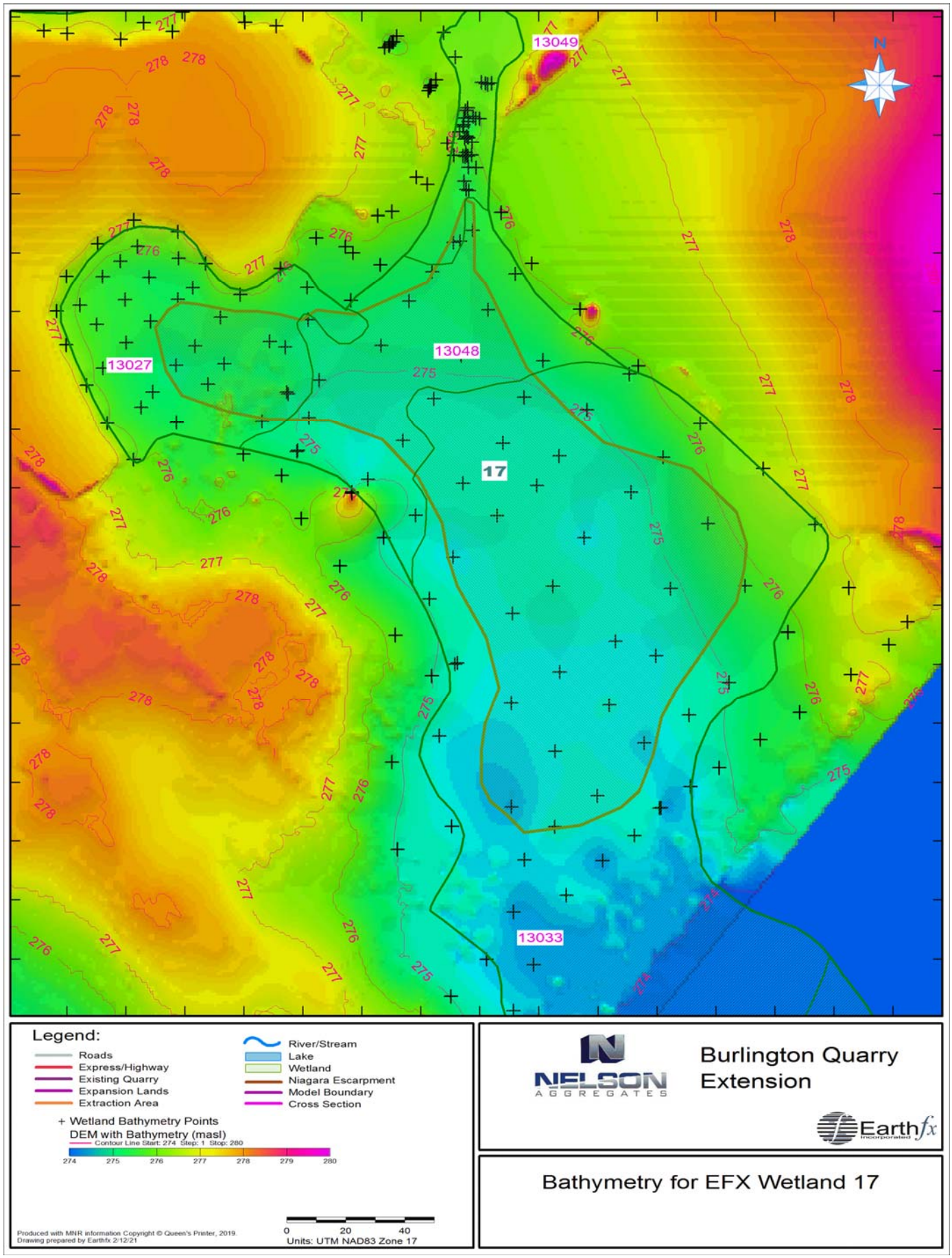
<table>
<tr><th>Impact Assessment (Operations Phases 3 - 6)</th><th>Description</th><th>Figure / Graph</th><th colspan="2">Reference</th></tr>
<tr><th></th><th></th><th></th><th>Report</th><th>Section / Page</th></tr>
<tr><td>Change in Wetland Area (ha):</td><td>No change. Wetland located greater than 120 m from licensed boundary.</td><td></td><td>SWA (Tatham, April 2020)</td><td>4.2.1</td></tr>
<tr><td>Change in Wetland Catchment Area (ha):</td><td>No change. Subcatchment area protected.</td><td></td><td>SWA (Tatham, April 2020)</td><td>4.2.1 & Drawing DP-2</td></tr>
<tr><td>Change in Hydroperiod:</td><td>No Change. Wetland is perched and isolated from the groundwater system. Subcatchment area being protected.</td><td></td><td>SWA (Tatham, April 2020)</td><td>4.2.1</td></tr>
<tr><td>Change in Water Budget:</td><td>A detailed average water budget for Wetland 13027 (Earthfx Wetland 17), as simulated by the integrated model, is provided in the Earthfx report for Baseline Conditions (Figure 7.25, p. 187); Scenario P12 (Figure 8.32, p. 222); P3456 (Figure 8.64, p. 249); RHB1 (Figure 8.100, p. 278), and RHB2 (Figure 8.127, p. 300). The water budget results for Scenario P3456 are reproduced in Figure 2c. Simulated change in groundwater levels (drawdowns), groundwater discharge to riparian areas, and change in streamflow in the vicinity of Wetland 13027 (Earthfx Wetland 17) for each scenario are discussed in Section 8 of the main report.
<table>
<tr><td>Wetland 13027</td><td>GW Outflow (%)</td><td>GW Inflow (%)</td><td>Δ in Outflow (%)</td><td>Δ in Inflow (%)</td></tr>
<tr><td>Baseline (Existing)</td><td>2.51</td><td>1.31</td><td>-</td><td>-</td></tr>
<tr><td>Operations Ph 3 - 6</td><td>4.18</td><td>0.34</td><td>1.67</td><td>-0.97</td></tr>
</table></td><td>Figure 2c</td><td>HHIAR (Earthfx, April 2020)</td><td>191 - 303</td></tr>
<tr><td>Potential Impact to Form and Function of Feature:</td><td>No wetlands will be removed and the wetlands subcatchment will be protected. There will be no encroachment from the project into the wetland. The proposed limit of extraction is >120 m from the wetland boundary. Licensed boundary will be demarcated and fenced to ensure site construction and operations do not extend beyond the proposed limits of the project .</td><td></td><td></td><td></td></tr>
</table>

Mitigation (Operational Phases 3 - 6)	Description	Figure / Graph	Reference	
			Report	Section / Page
Proposed Mitigation Measures:	None required.			

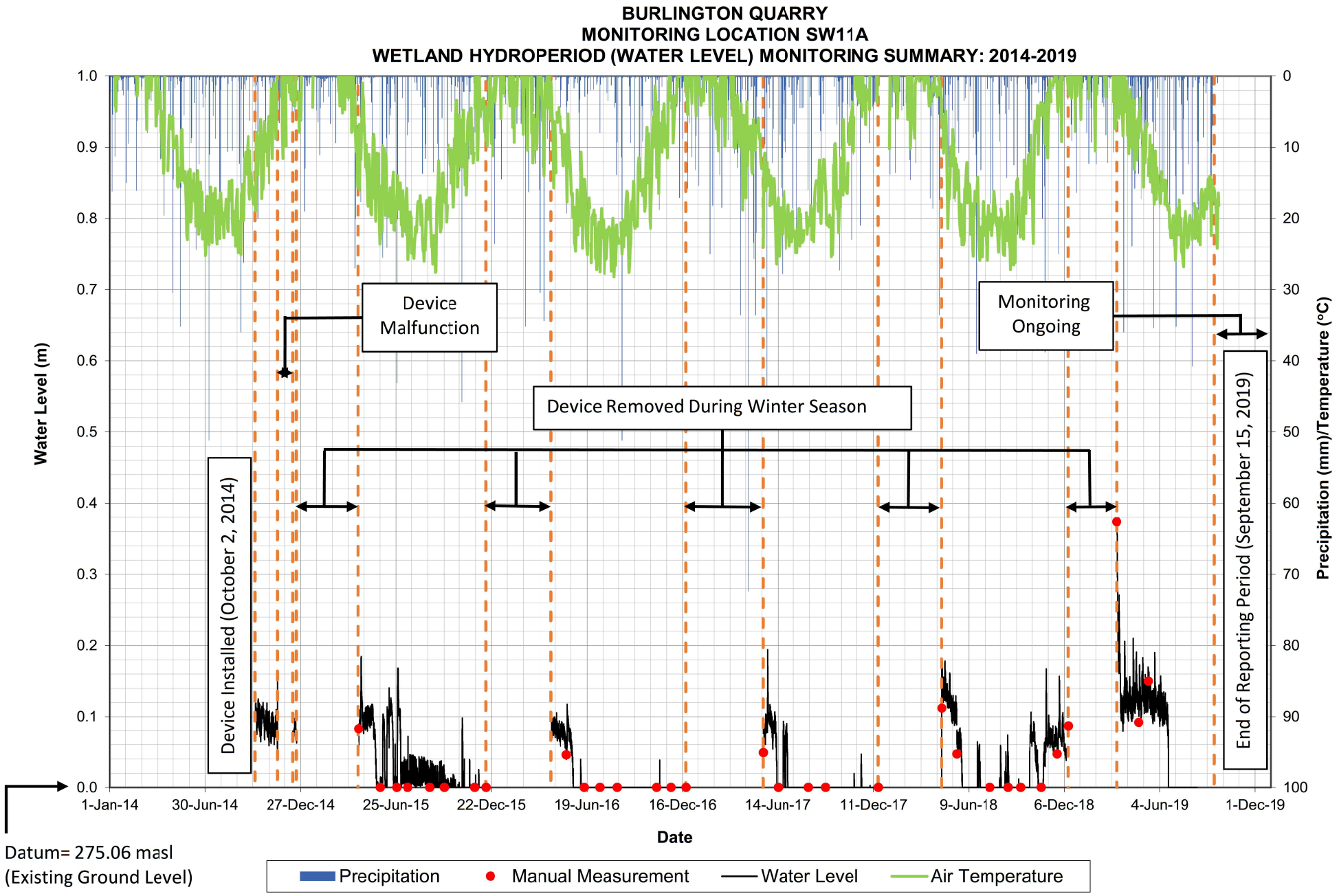
<table>
<tr><th>Impact Assessment (Rehabilitation)</th><th>Description</th><th>Figure / Graph</th><th colspan="2">Reference</th></tr>
<tr><th></th><th></th><th></th><th>Report</th><th>Section / Page</th></tr>
<tr><td>Change in Wetland Area (ha):</td><td>No change. Wetland located greater than 120 m from licensed boundary.</td><td></td><td>SWA (Tatham, April 2020)</td><td>5.4.1</td></tr>
<tr><td>Change in Wetland Catchment Area (ha):</td><td>No change. Subcatchment area protected.</td><td></td><td>SWA (Tatham, April 2020)</td><td>5.4.1 & Drawing DP-3</td></tr>
<tr><td>Change in Hydroperiod:</td><td>No Change. Wetland is perched and isolated from the groundwater system. Subcatchment area being protected.</td><td></td><td>SWA (Tatham, April 2020)</td><td>5.4.1</td></tr>
<tr><td>Change in Water Budget:</td><td>A detailed average water budget for Wetland 13027 (Earthfx Wetland 17), as simulated by the integrated model, is provided in the Earthfx report for Baseline Conditions (Figure 7.25, p. 187); Scenario P12 (Figure 8.32, p. 222); P3456 (Figure 8.64, p. 249); RHB1 (Figure 8.100, p. 278), and RHB2 (Figure 8.127, p. 300). The water budget results for Scenario RHB1 and RHB2 are reproduced in Figure 2d and 2e. Simulated change in groundwater levels (drawdowns), groundwater discharge to riparian areas, and change in streamflow in the vicinity of Wetland 13027 (Earthfx Wetland 17) for each scenario are discussed in Section 8 of the main report.
<table>
<tr><td>Wetland 13027</td><td>GW Outflow (%)</td><td>GW Inflow (%)</td><td>Δ in Outflow (%)</td><td>Δ in Inflow (%)</td></tr>
<tr><td>Baseline (Existing)</td><td>2.51</td><td>1.31</td><td>-</td><td>-</td></tr>
<tr><td>Rehab Scenario 1</td><td>3.65</td><td>0.55</td><td>1.14</td><td>-0.76</td></tr>
<tr><td>Rehab Scenario 2</td><td>3.38</td><td>0.45</td><td>0.87</td><td>-0.86</td></tr>
</table></td><td>Figure 2d and 2e</td><td>HHIAR (Earthfx, April 2020)</td><td>191 - 303</td></tr>
<tr><td>Potential Impact to Form and Function of Feature:</td><td>No wetlands will be removed and the wetlands subcatchment will be protected. There will be no encroachment from the project into the wetland. The proposed limit of extraction is >120 m from the wetland boundary. Licensed boundary will be demarcated and fenced to ensure site construction and operations do not extend beyond the proposed limits of the project.</td><td></td><td></td><td></td></tr>
</table>

Mitigation (Rehabilitation)	Description	Figure / Graph	Reference	
			Report	Section / Page
Proposed Mitigation Measures:	None required.			

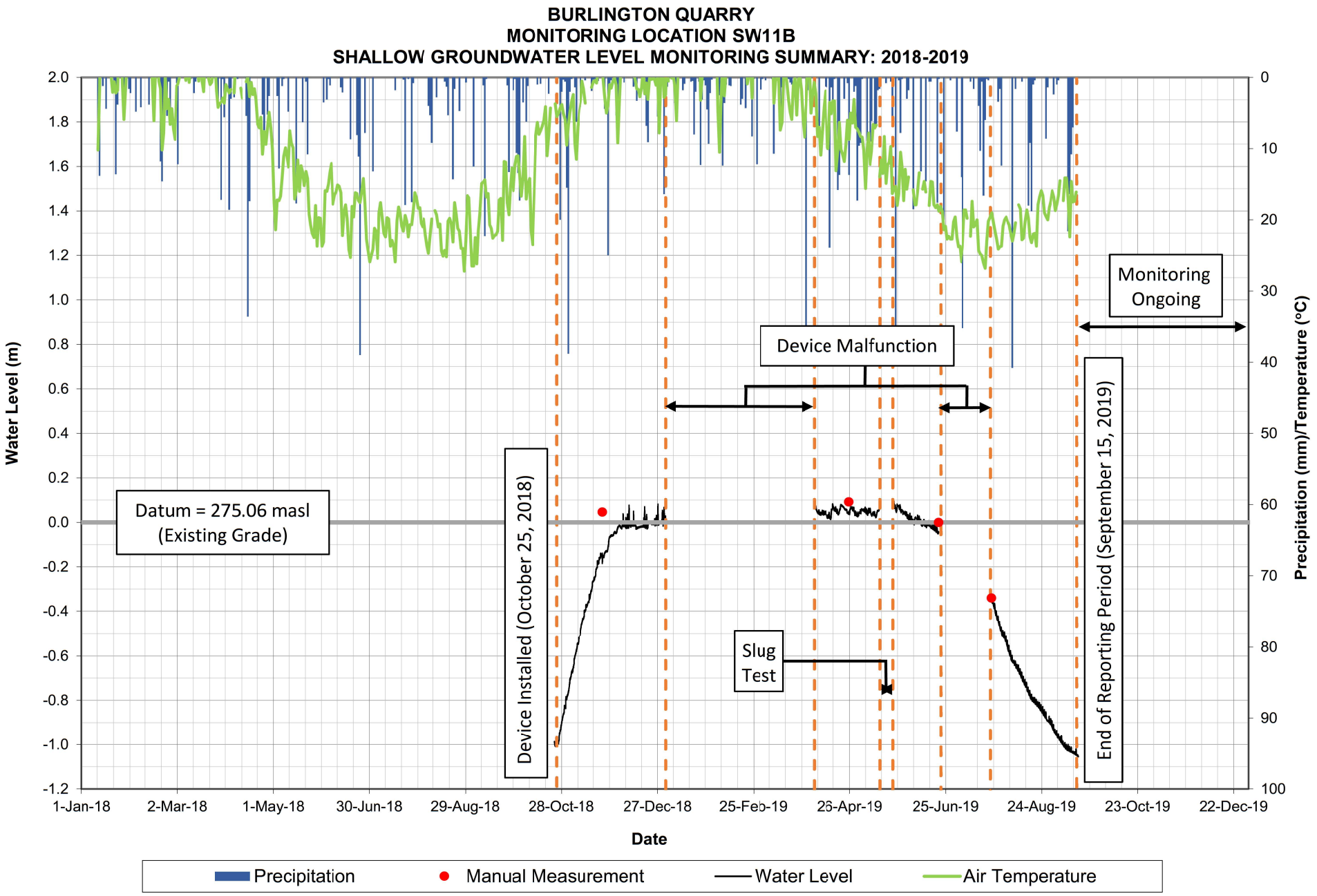
WETLAND 13027 - FIGURE 1



WETLAND 13027 - GRAPH 1

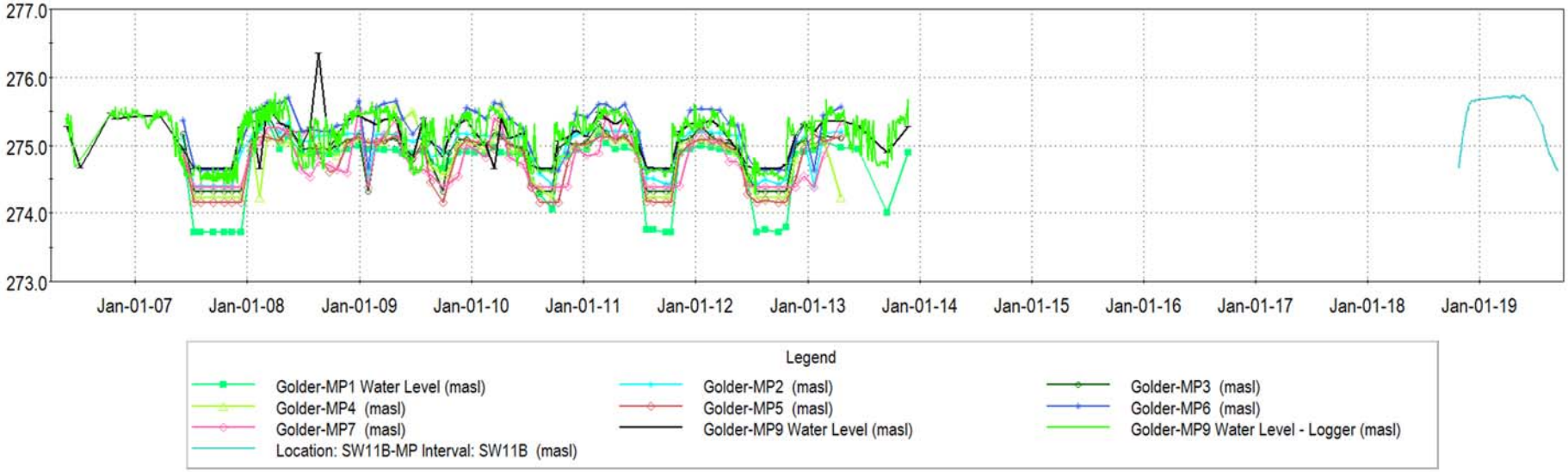


WETLAND 13027 - GRAPH 2



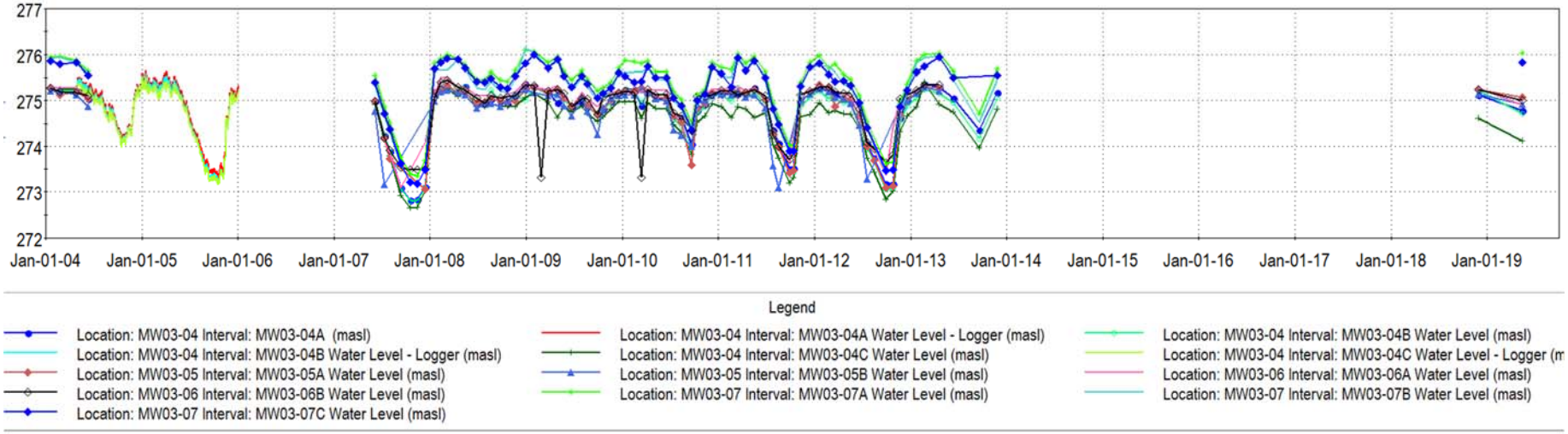
WETLAND 13027 - GRAPH 3

Shallow Groundwater Hydrographs
Wetland 13027



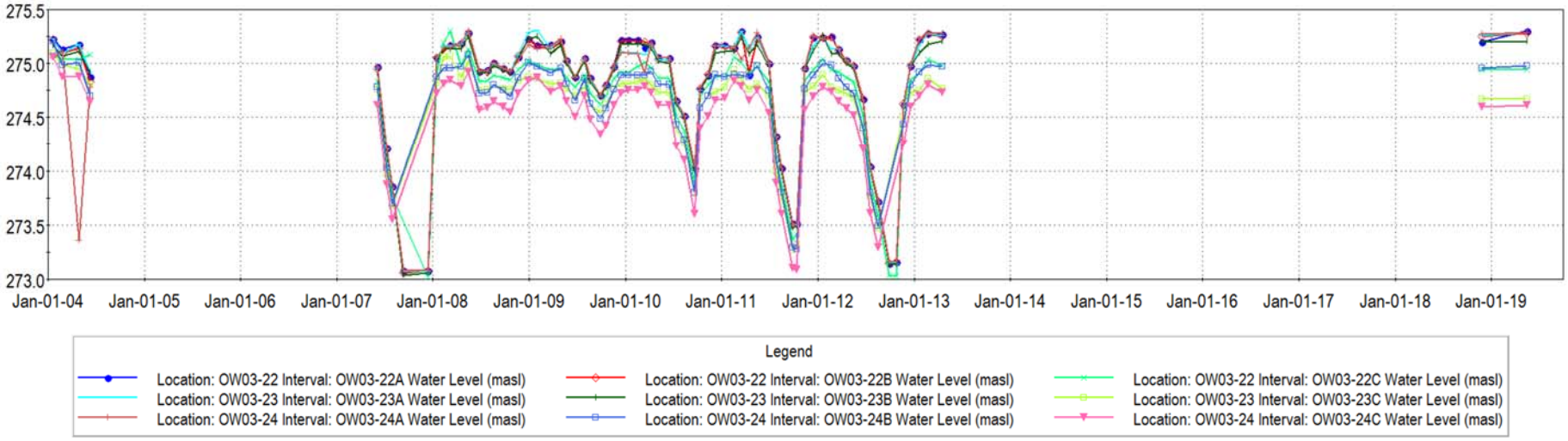
WETLAND 13027 - GRAPH 4

Groundwater Hydrographs
Wetland 13027



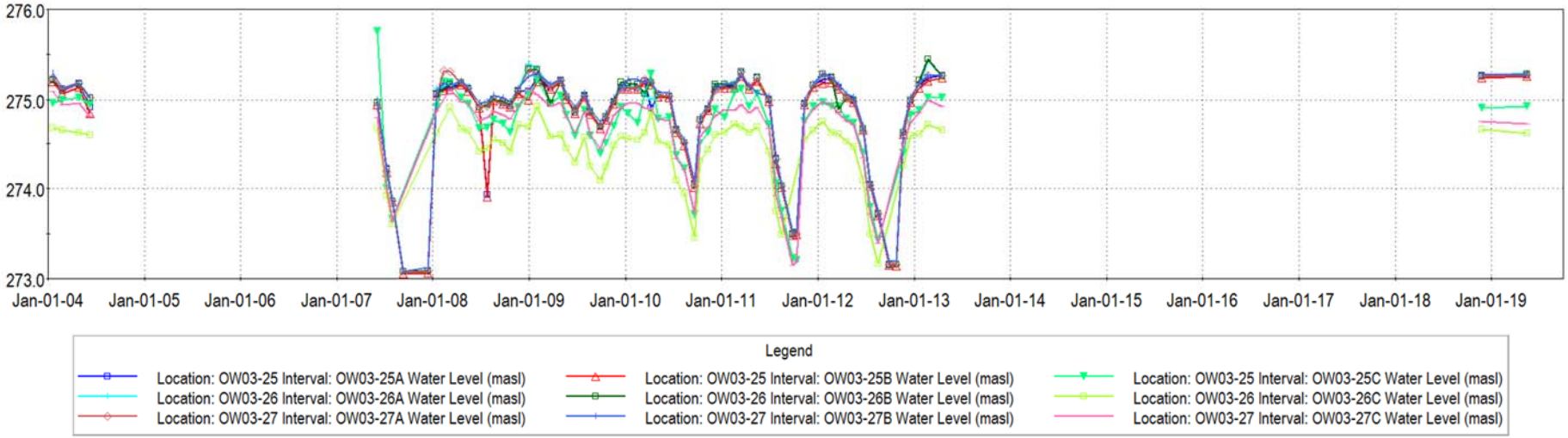
WETLAND 13027 - GRAPH 5

Groundwater Hydrographs
Wetland 13027



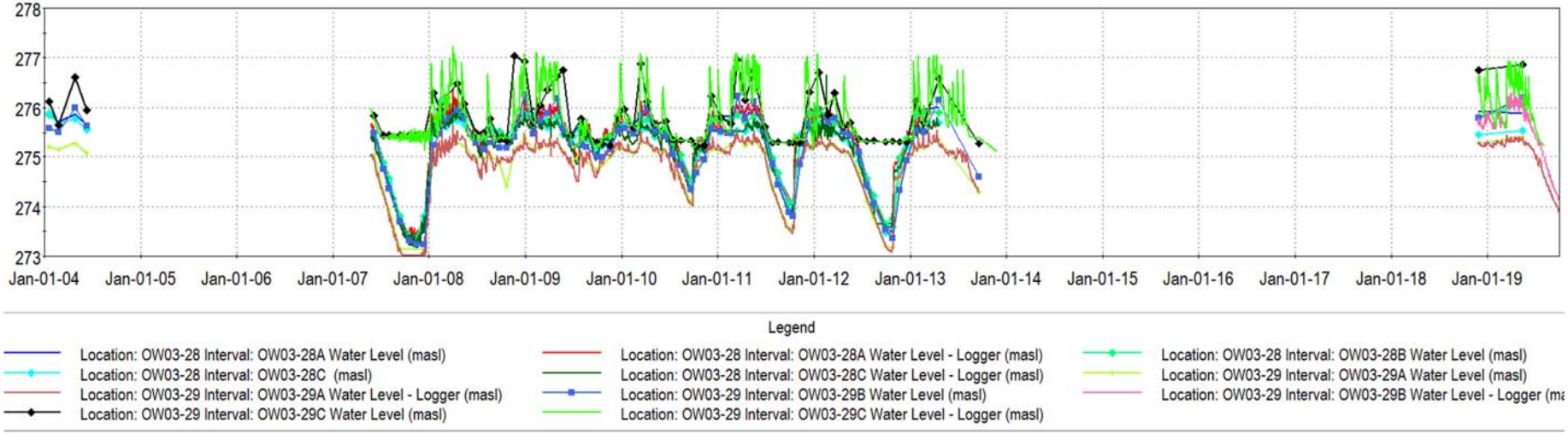
WETLAND 13027 - GRAPH 6

Groundwater Hydrographs
Wetland 13027



WETLAND 13027 - GRAPH 7

Groundwater Hydrographs
Wetland 13027



WETLAND 13027

FIGURE 2A

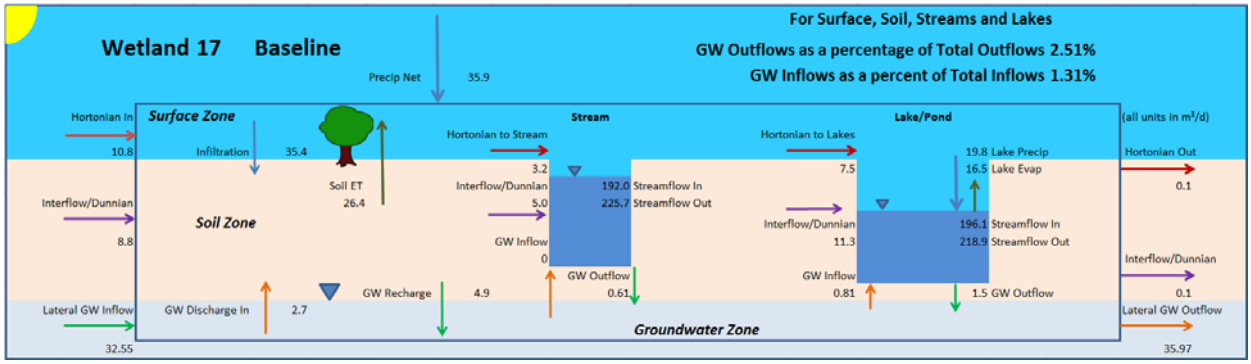


FIGURE 2B

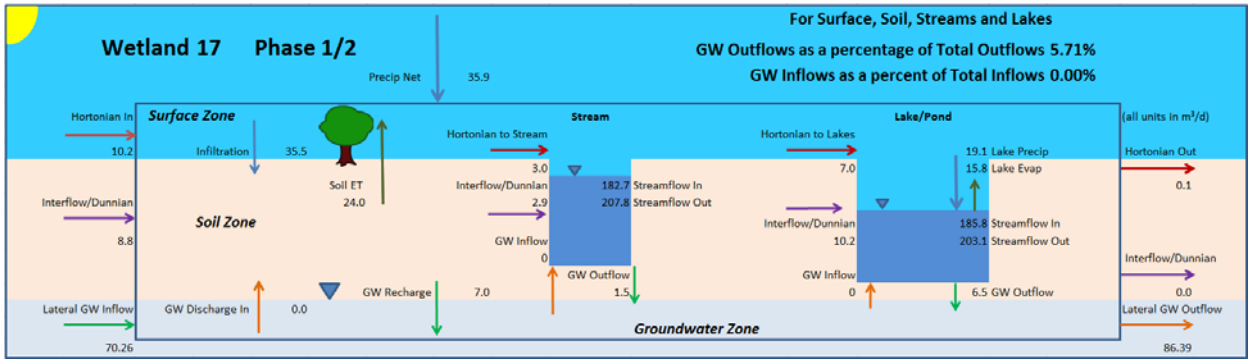


FIGURE 2C

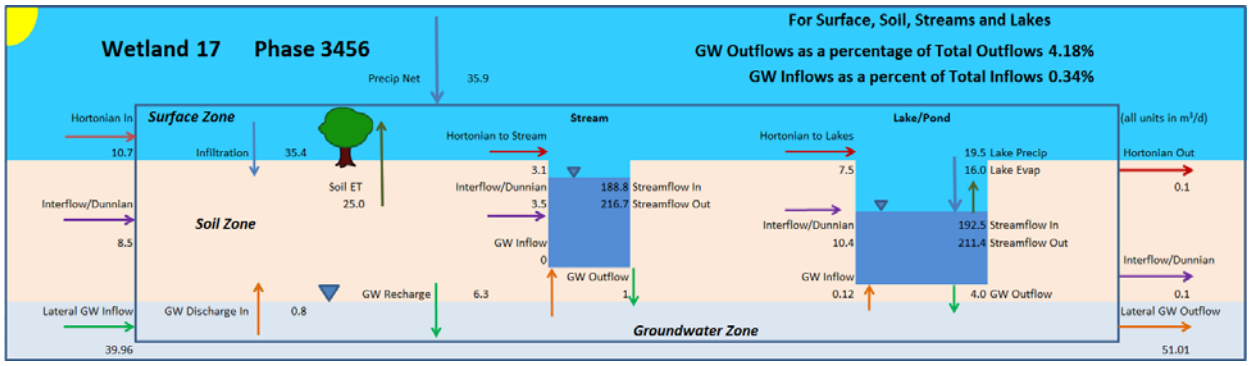


FIGURE 2D

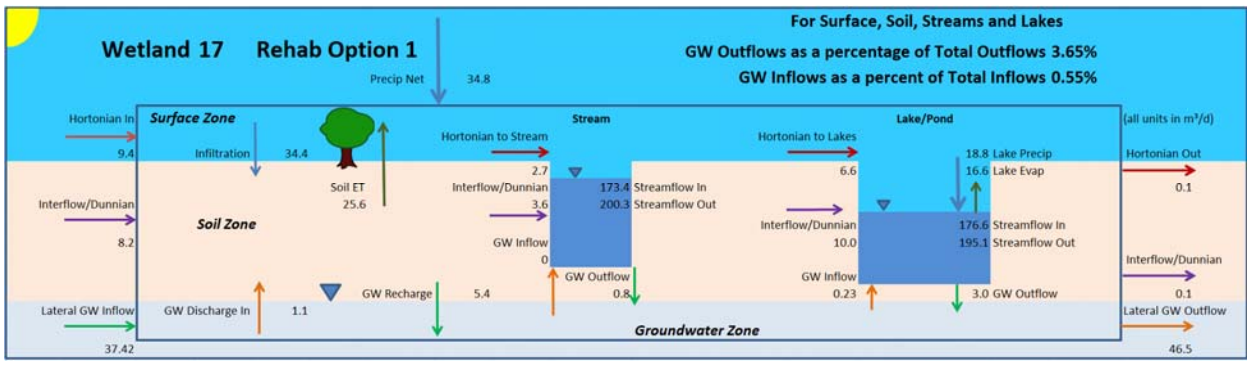
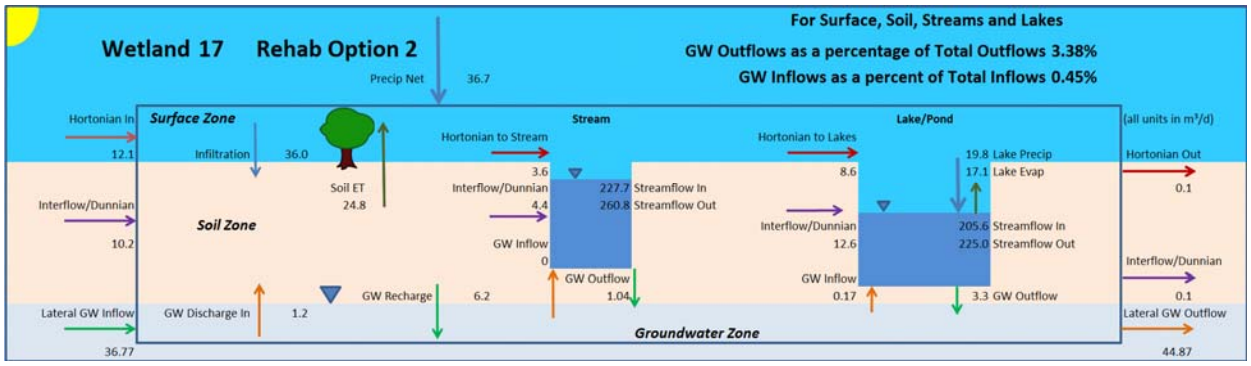
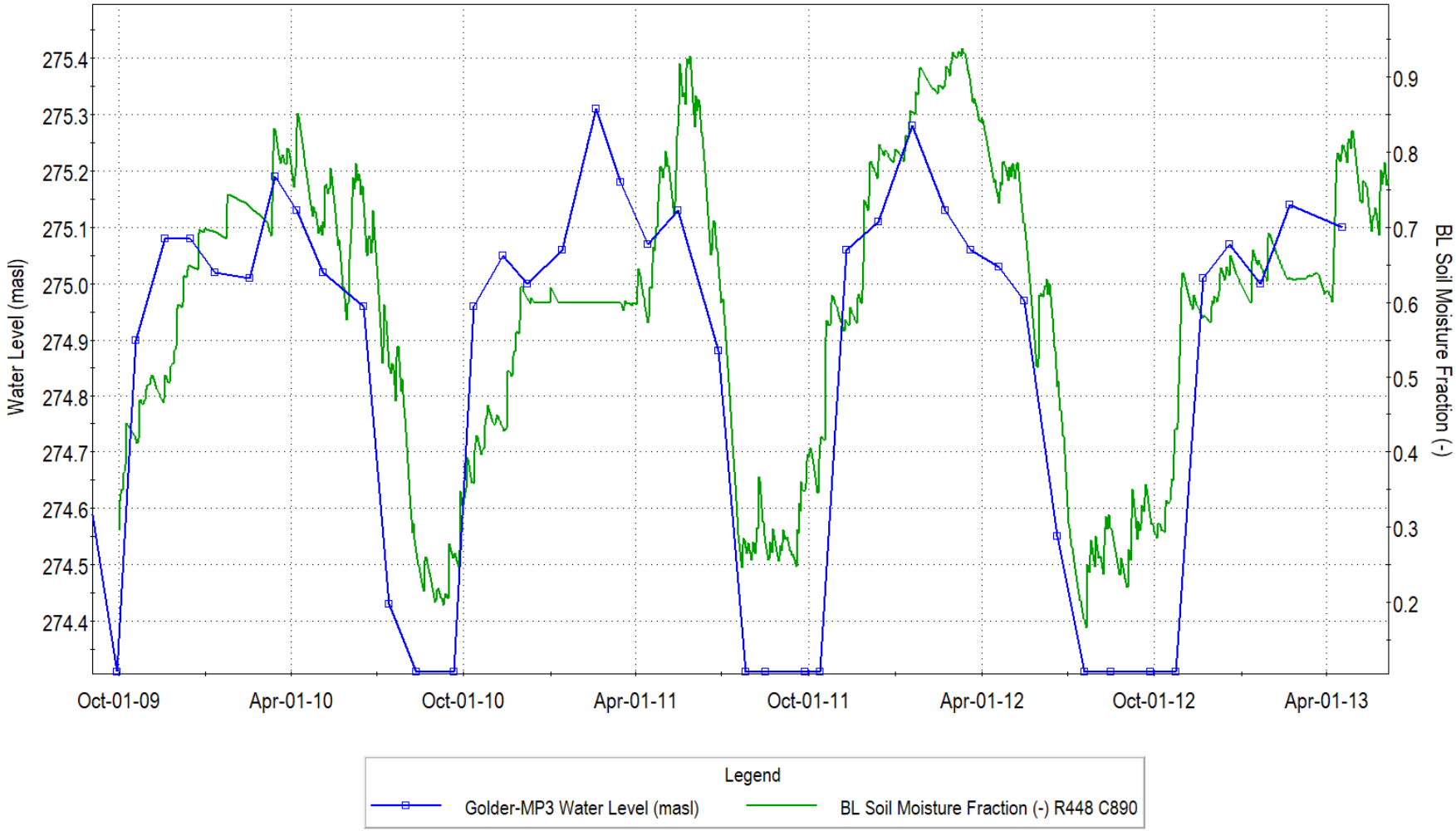


FIGURE 2E



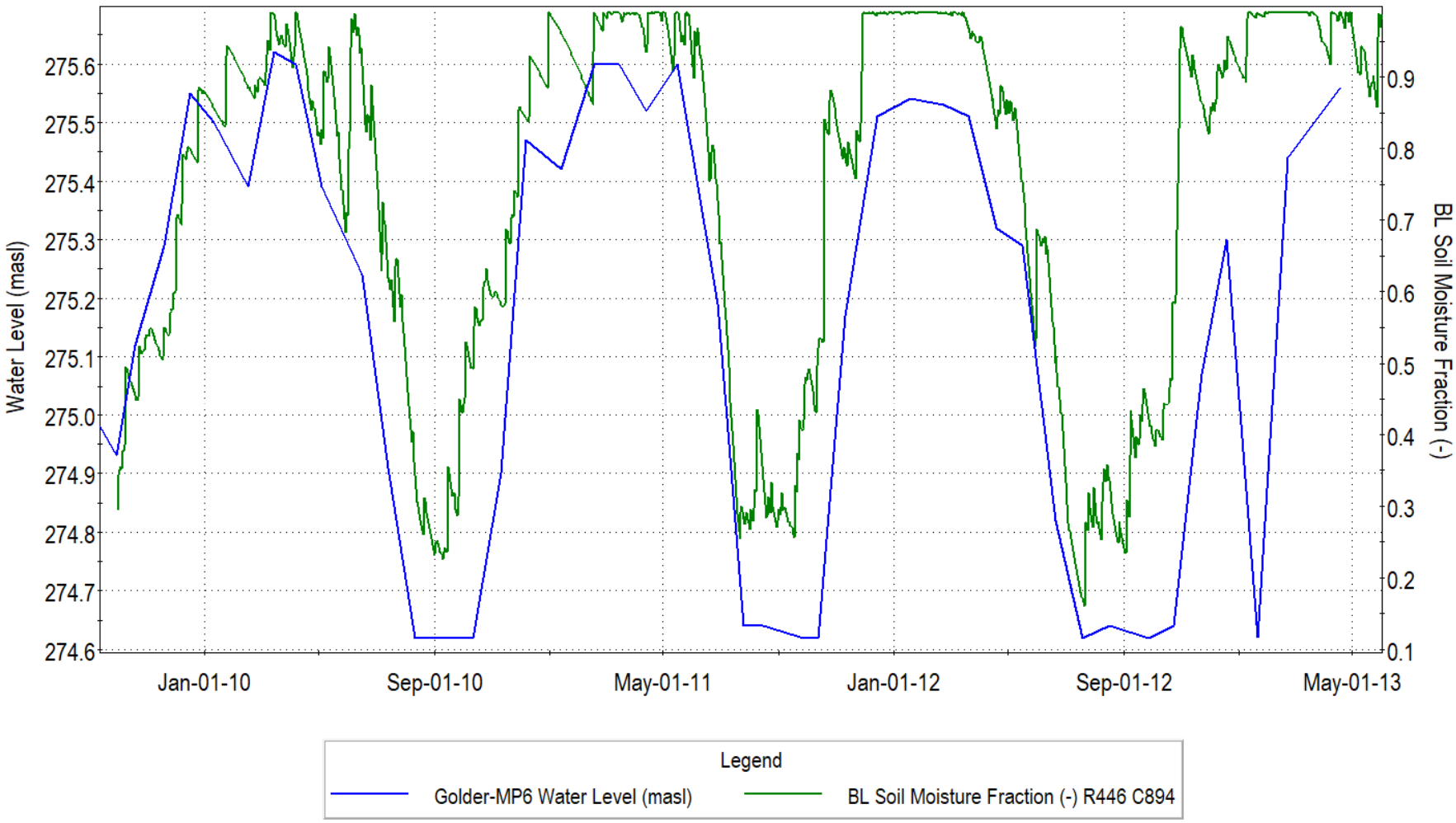
WETLAND 13027 - GRAPH 8

Integrated Model Calibration
Wetland 13027

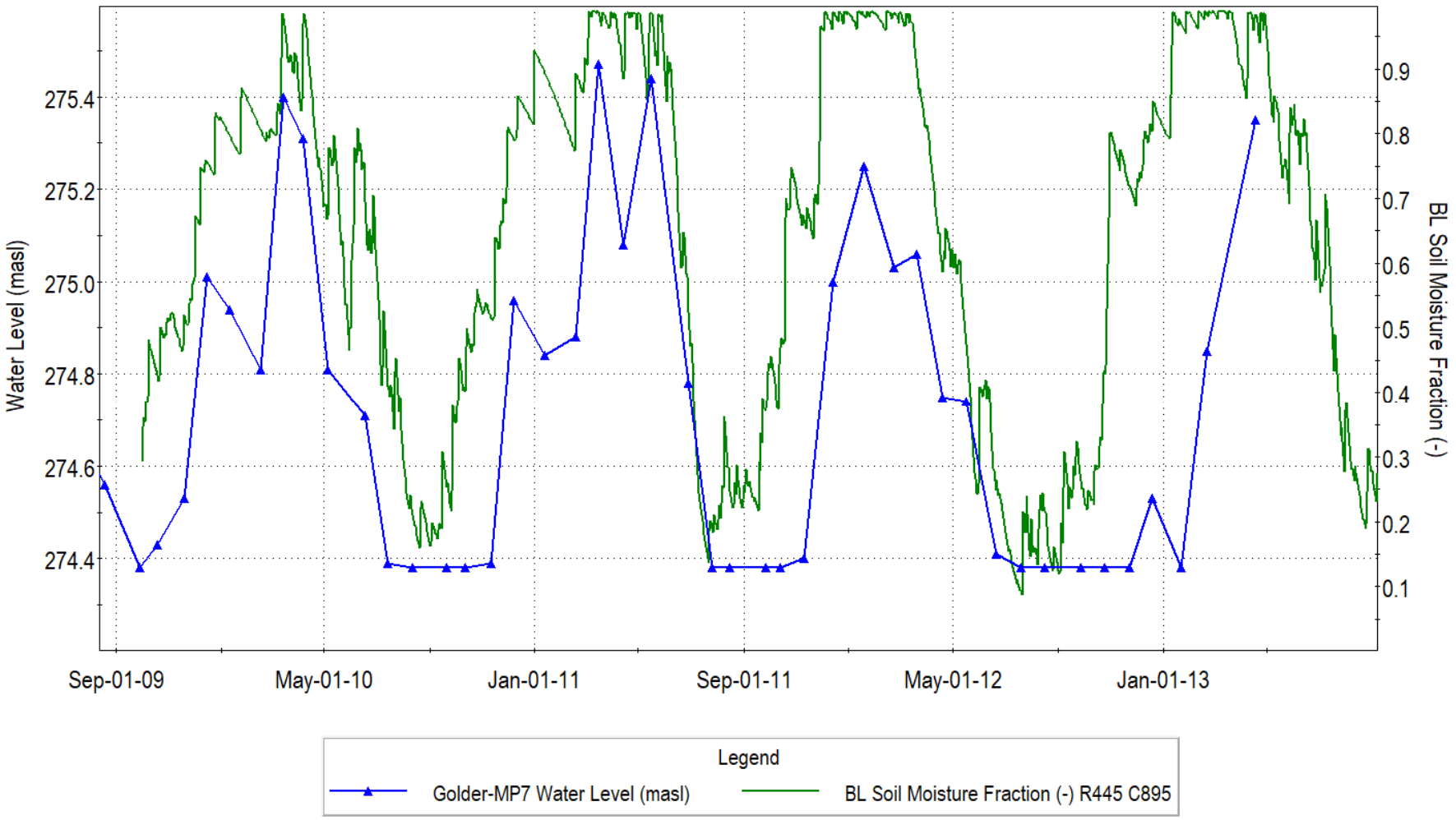


WETLAND 13027 - GRAPH 9

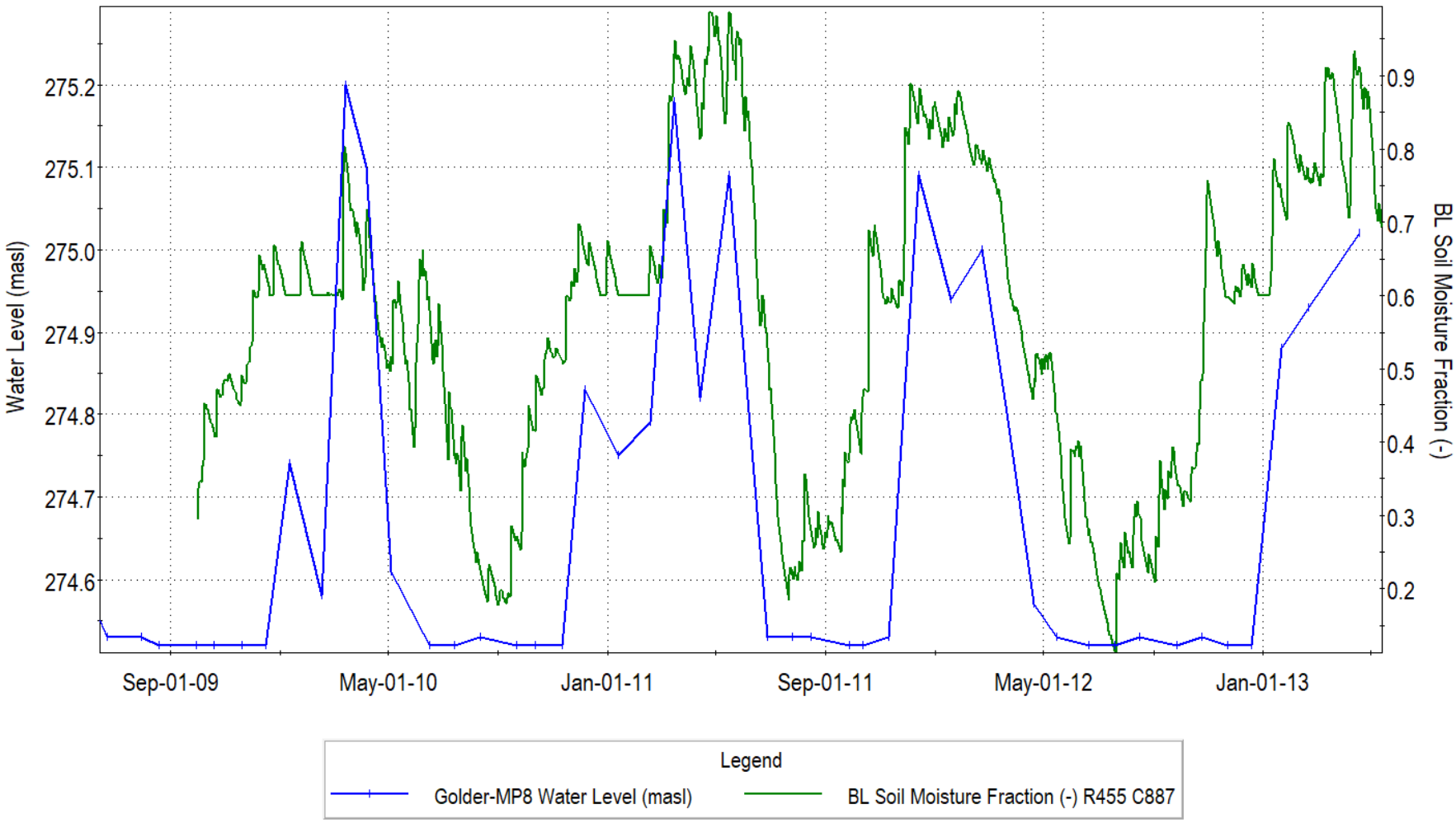
Integrated Model Calibration
Wetland 13027



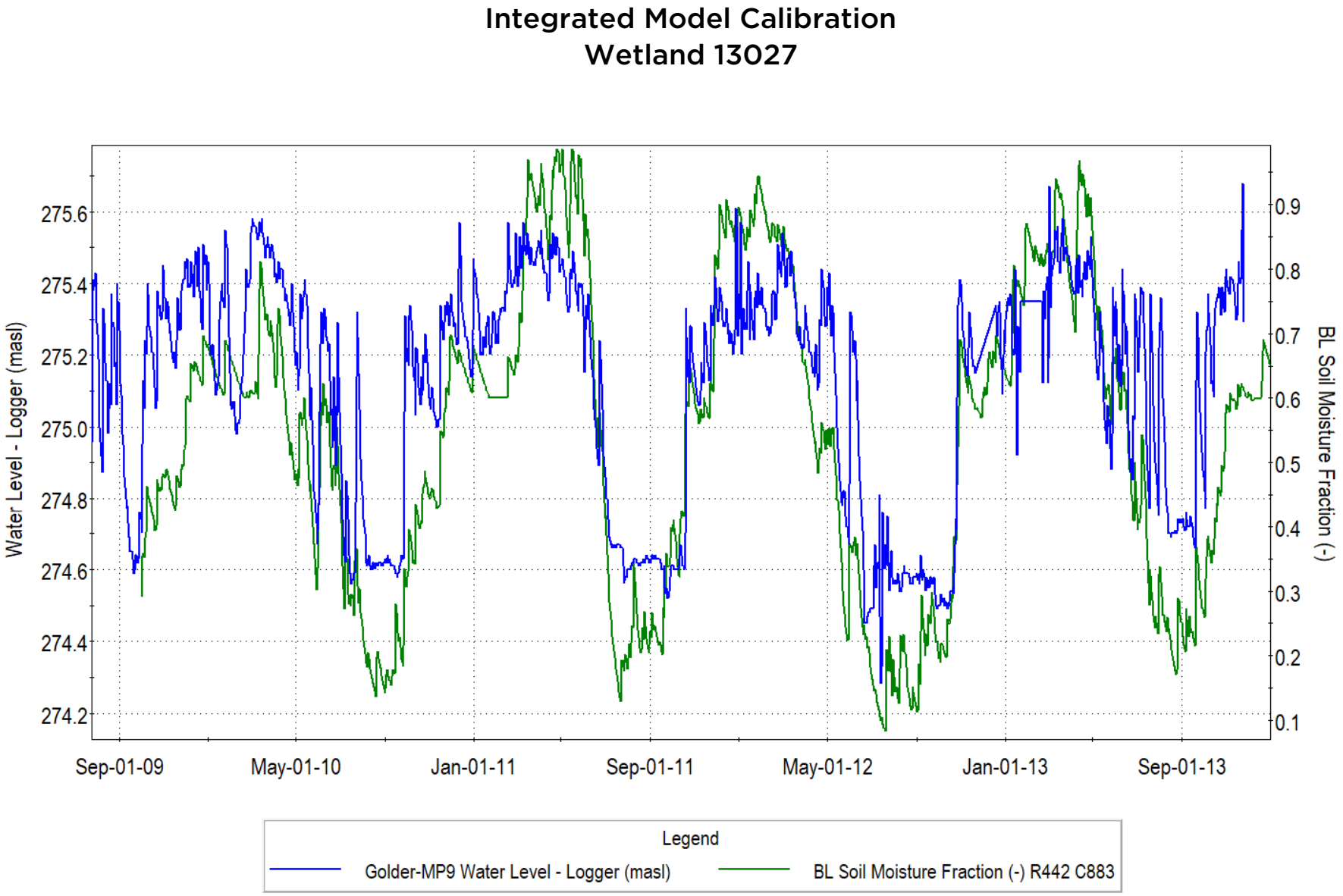
Integrated Model Calibration
Wetland 13027



Integrated Model Calibration
Wetland 13027



WETLAND 13027 - GRAPH 12



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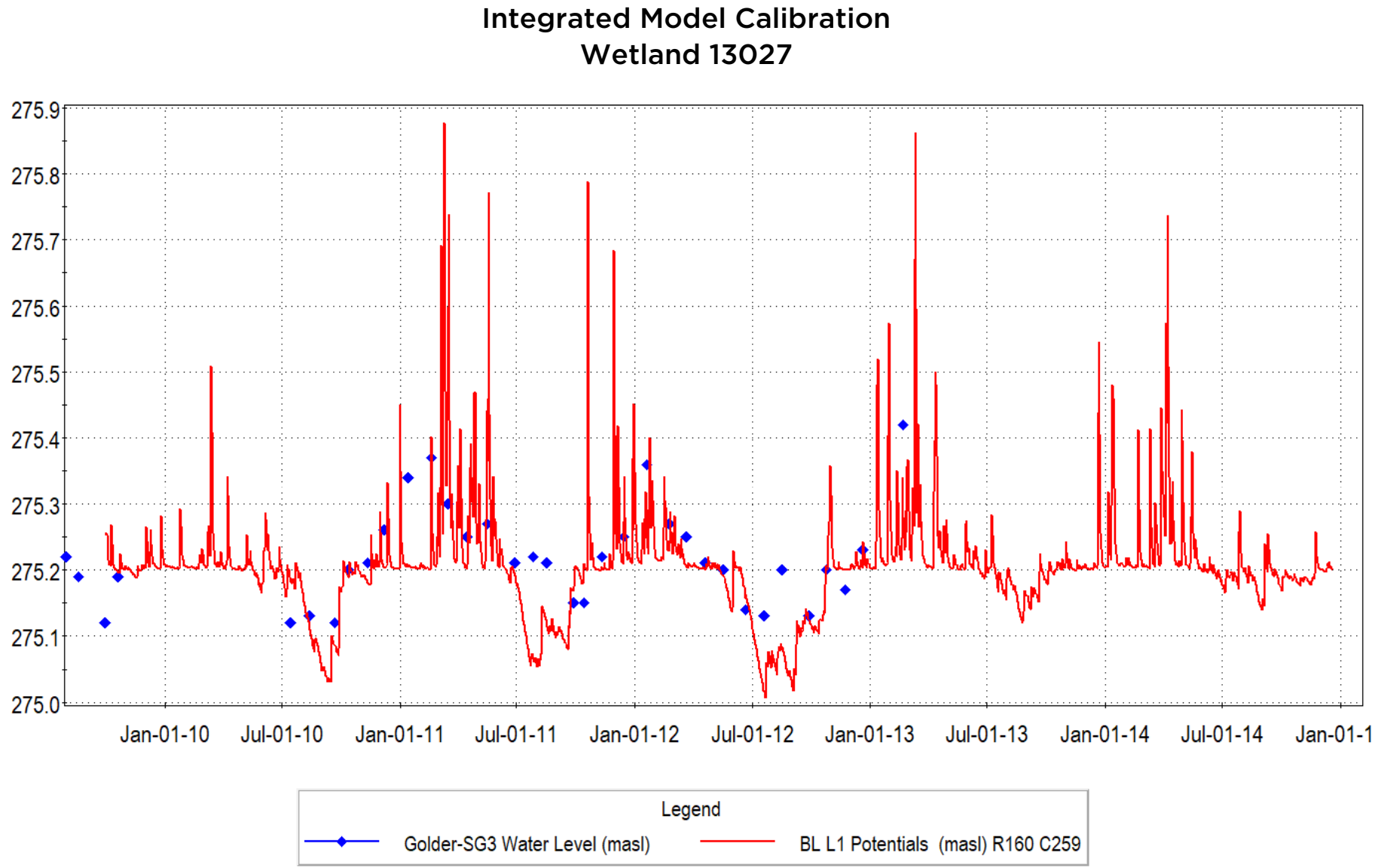
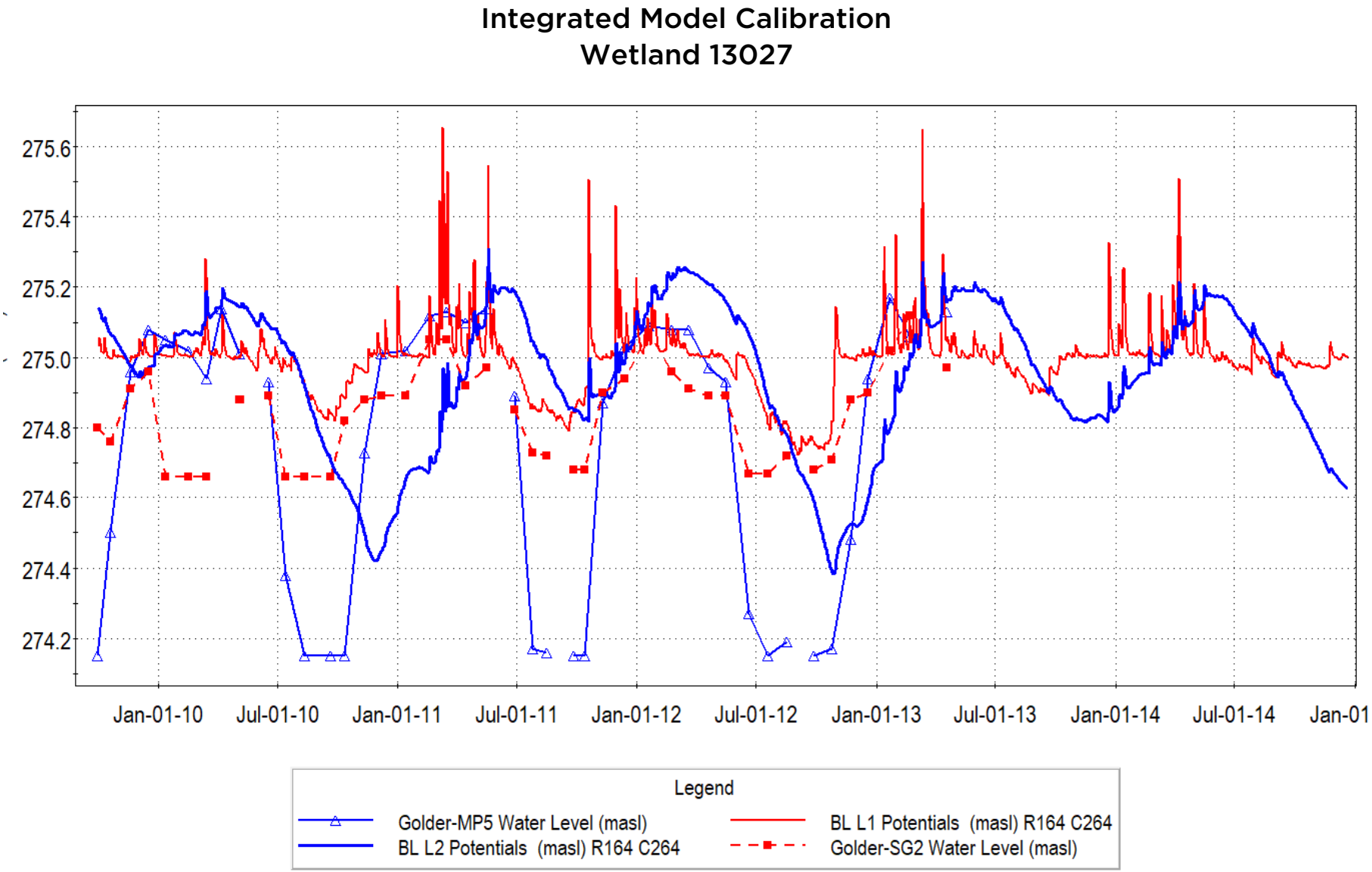
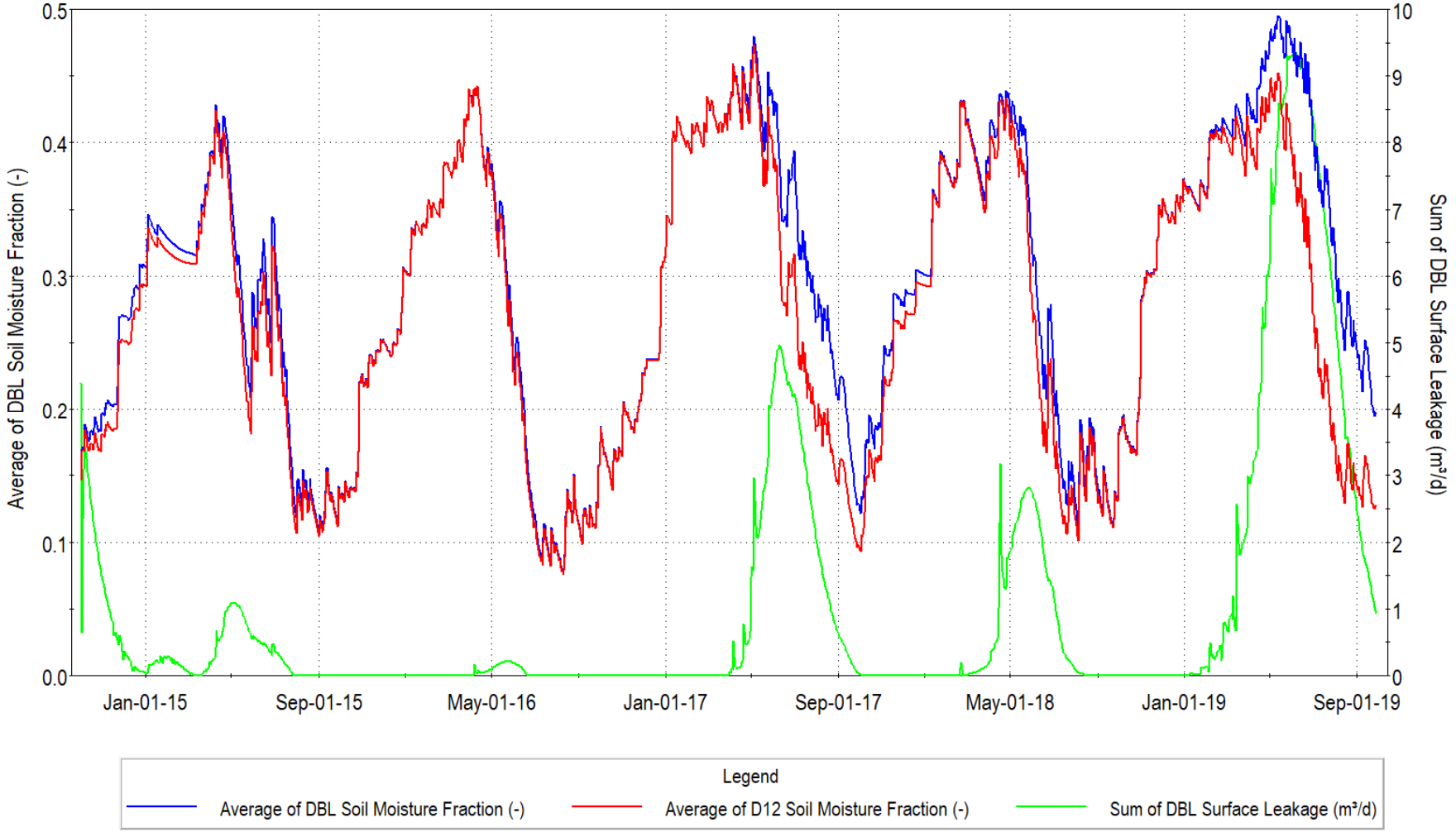


WETLAND 13027 - GRAPH 14



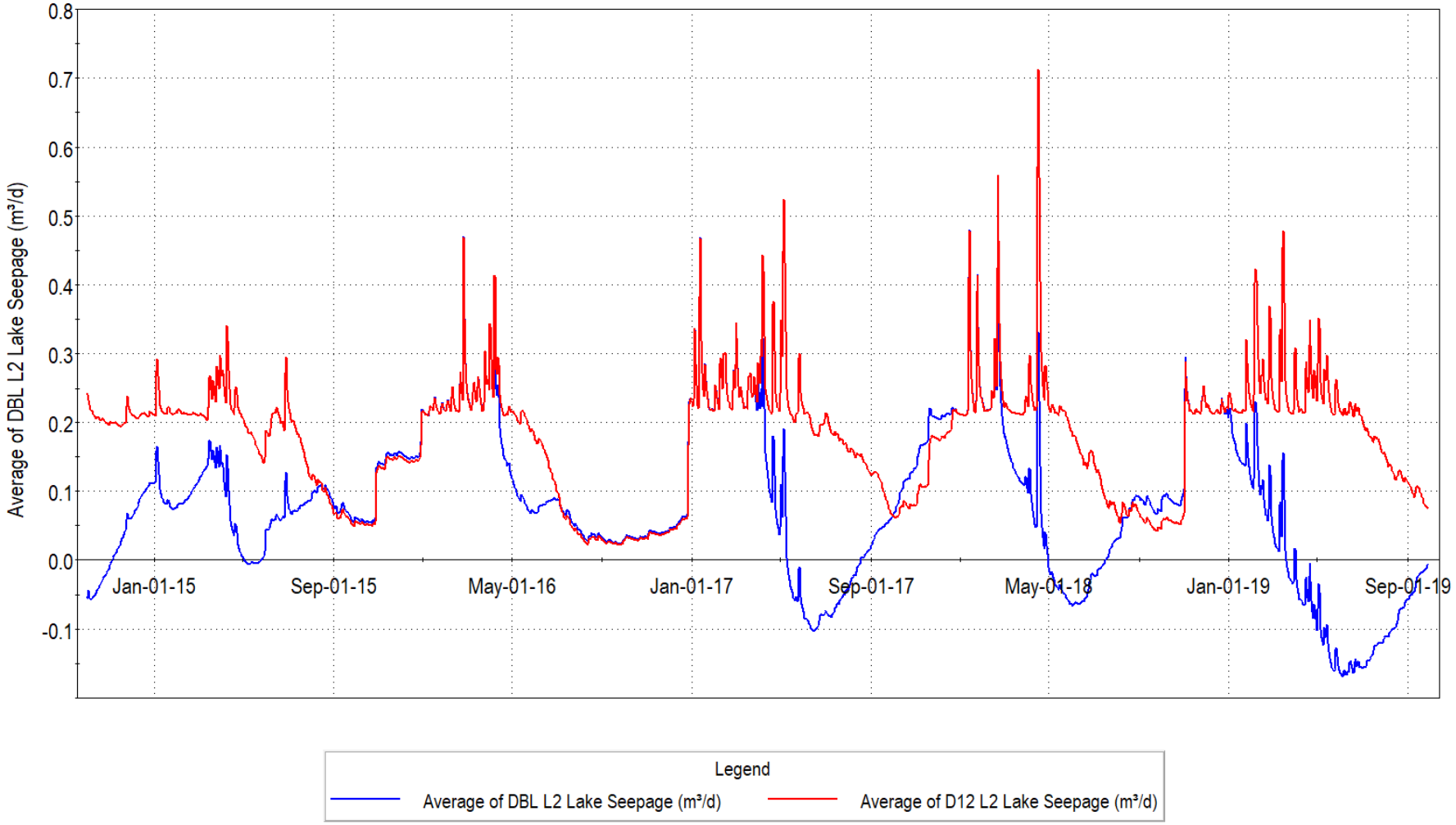
WETLAND 13027 - GRAPH 15

Change in Soil Moisture Conditions
Wetland 13027

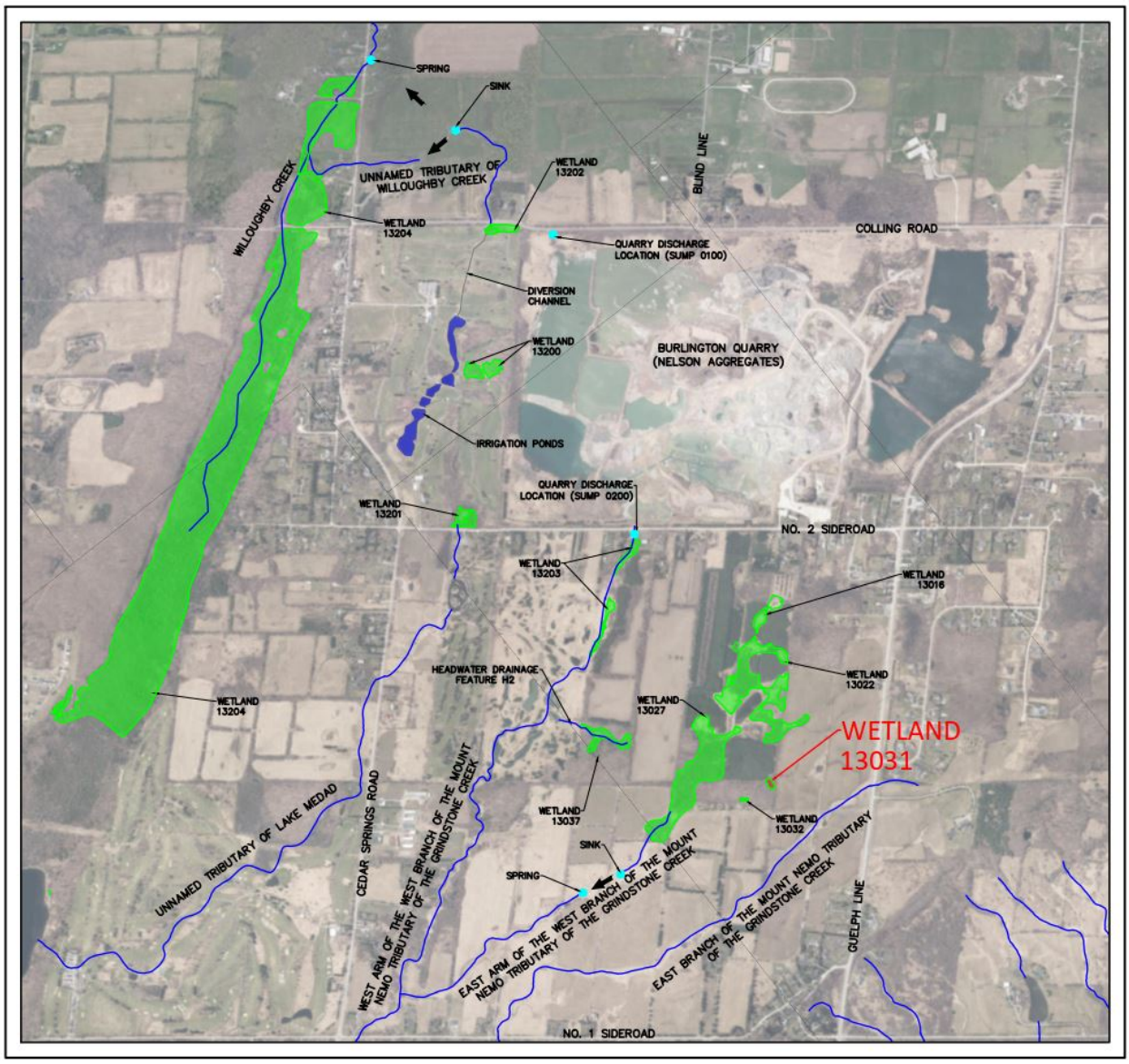


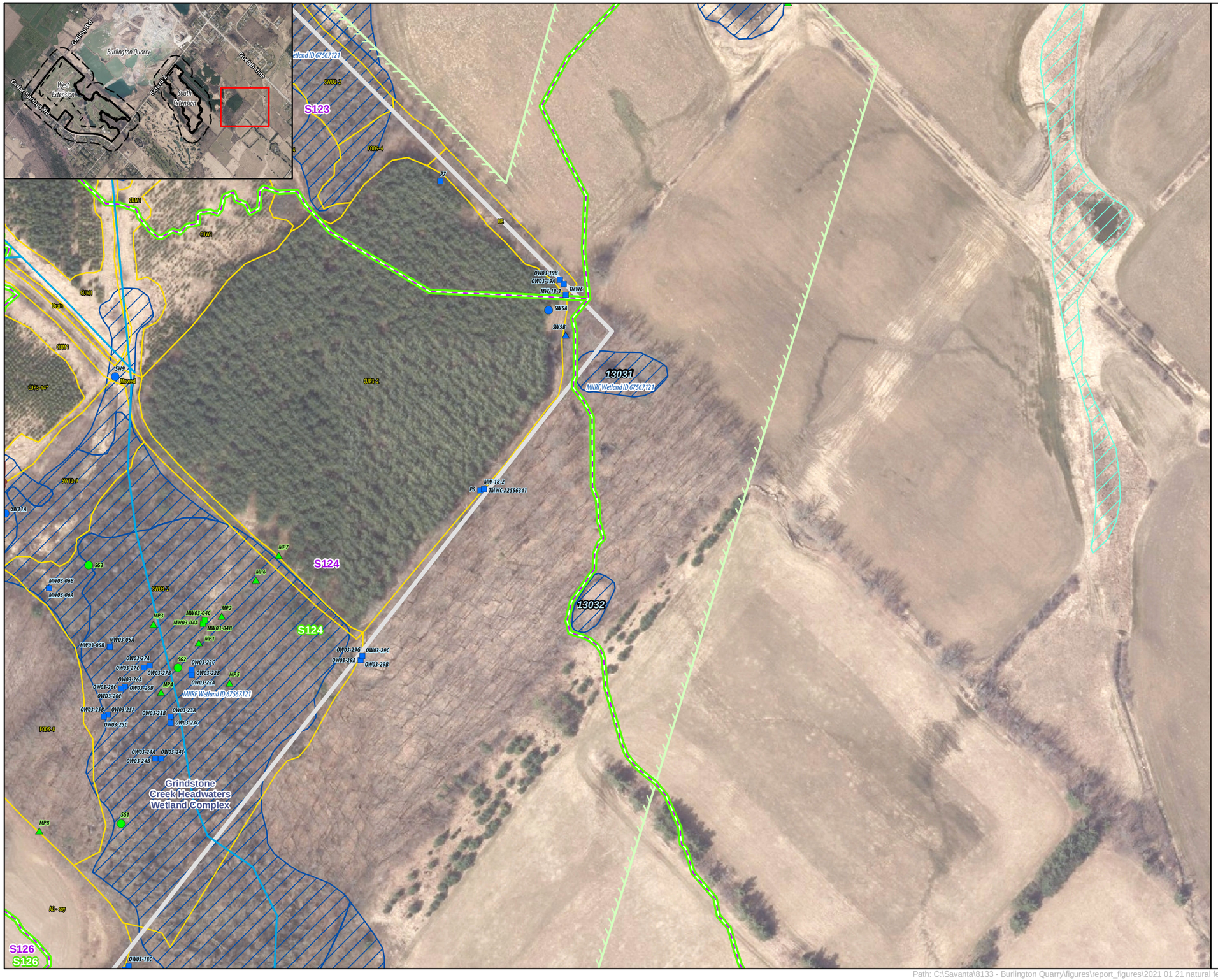
WETLAND 13027 - GRAPH 16

Change in Soil Moisture Conditions
Wetland 13027



WETLAND 13031





Legend

- Subject Lands
- Salamander Habitat Assessment (2019)
- Indirect Fish Habitat
- Existing Subcatchment Boundary (Tatham Engineering, 2020)
- Proposed Subcatchment Boundary - Operations and Post-Rehabilitation (Tatham Engineering, 2020
- Ecological Land Classification (Savanta, 2019 & 2020)
- Provincially Significant Wetland (LIO/MNRF, 2020)
- Wetland - Not Evaluated per OWES (MNRF/LIO, 2020)
- MECP Jefferson Salamander Regulated Habitat

Current Instrumentation

- Groundwater Monitoring Station (EarthFx)
- Mini Piezometer (Tatham Engineering)
- Staff Gauge & Surface Water Monitoring Station (Tatham Engineering)

Previous Instrumentation

- Groundwater Monitoring Station (Golder)
- Mini Piezometer (Golder)
- Staff Gauge & Surface Water Monitoring Station (Golder)

ELC Legend

AG, Agriculture
CUM1, Mineral Cultural Meadow
CUP3-2, White Pine Coniferous Plantation
CUP3-13*, White Spruce Coniferous Plantation
CUP3-14*, White Cedar Coniferous Plantation
CUT1-4, Gray Dogwood Cultural Thicket
CUW1, Mineral Cultural Woodland
FOD5-8, Dry – Fresh Sugar Maple – White Ash Deciduous Forest
FOD9-4, Fresh – Moist Shagbark Hickory Deciduous Forest
HR, Hedgerow
MAM2-2, Reed-canary Grass Mineral Meadow Marsh
SWD2-2, Green Ash Mineral Deciduous Swamp
SWD3-2, Silver Maple Mineral Deciduous Swamp
SWT2-9, Gray Dogwood Mineral Thicket Swamp

NOTES:

1. Coordinate System: NAD 1983 UTM Zone 17N.
2. Base features produced under license with the Ontario Ministry of Natural Resources and Forestry © Queen's Printer for Ontario, 2021.
3. Orthoimagery © First Base Solutions, 2021. Imagery taken in 2019.

Project 8133

Burlington Quarry Extension
Nelson Aggregates Co.

Figure 4
Wetland Characterization

Wetland 13031 and 13032 - South Extension

0 30 m
1:2,000

N

GEI Consultants
Savanta Division

Path: C:\Savanta\8133 - Burlington Quarry\figures\report_figures\2021 01 21 natural feature tech summary\8133_rpt_wetland_char_mapbook.mxd Date S...ary 11, 2021

Wetland 13031

Wetland Characteristics	Description	Figure / Graph	Reference	
			Report	Section / Page
Wetland IDs:	MNRF – 67567121 (OGF ID 67567125) Earthfx – N/A Tatham – 13031 Savanta – 13031 Golder (Background) - 13031			
Wetland Area (ha):	LIO/MNRF - 0.09			
Watershed:	Grindstone Creek Watershed			
Sub-Watershed:	East Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek			
Located in Proposed Limit of Extraction:	No			
Located in Proposed License Boundary:	No			
Catchment Area (ha):	N/A			
Catchment ID:	N/A			
Closed or Connected System:	Isolated Feature			
Condition:	Natural			
Bathymetry:	Bathymetry unavailable; off-site wetland without permission to survey.			
Outlet:	Isolated Feature			
Hydroperiod:	Spring Hydroperiod (date wetland dries out) – June 13th – July 24th Fall Hydroperiod (start of hydroperiod) – November 1st – N/A	Graph 1	SWA (Tatham, April 2020)	2.2.1, 3 and Appendix F
Surface Water Monitoring:	ID: SW5A (Tatham) Installation Date: October 2, 2014 Data Collection: Continuous water level and temperature and manual monthly water level measurements Coordinates of Monitoring Station: Easting 591476.534, Northing 4805331.03	Graph 1	SWA (Tatham, April 2020)	2.2.1, 3 and Appendix F

Natural Heritage and Habitat Features	Description	Figure / Graph	Reference	
			Report	Section / Page
Wetland Name & Provincial Significance Evaluation:	Grindstone Creek Headwaters Wetland Complex – Provincially Significant		NETR (Savanta, April 2020)	6.1.2
ELC Unit(s):	Unknown – outside of 120 m adjacent lands			
Regulated Habitat (MECP):	Yes – Jefferson Salamander (not field verified during 2019 field program; regulated based on historical data) Hydroperiod sensitive species; water presence necessary until end of June		NETR (Savanta, April 2020)	6.7
Significant Wildlife Habitat:	Unknown – outside of 120 m adjacent lands			
Fish Habitat:	None			
Habitat of Endangered and Threatened Species:	Unknown – outside of 120 m adjacent lands			

<table>
<tr><th>Groundwater Interaction</th><th>Description</th><th>Figure / Graph</th><th colspan="2">Reference</th></tr>
<tr><th></th><th></th><th></th><th>Report</th><th>Section / Page</th></tr>
<tr><td>Lithology:</td><td>Halton Till</td><td></td><td></td><td></td></tr>
<tr><td>Hydraulic Conductivity:</td><td>Integrated Model (Earthfx) - The harmonic mean hydraulic conductivity, based on testing by Golder (2007) of 10 mini-piezometers, was 1.2x10^{-8} m/s. Model value for the vertical hydraulic conductivity was 1.6x10^{-7} m/s, about an order of magnitude higher, to account for limited flow through fractures in the till.</td><td></td><td></td><td></td></tr>
<tr><td>Surface Water/Groundwater Interaction:</td><td>The low permeability of the Halton Till underlying the wetland is the dominant control on 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.</td><td></td><td></td><td></td></tr>
<tr><td>Shallow Groundwater (Mini-piezometer) Monitoring:</td><td>ID: SW5B (Tatham)
Installation Date: October 23, 2018
Data Collection: Continuous water level and temperature and manual monthly water level measurements
Coordinates of Monitoring Station: Easting 591476.534, Northing 4805331.03</td><td>Graph 2</td><td>SWA (Tatham, April 2020)</td><td>2.3 and Appendix G</td></tr>
<tr><td>Groundwater Monitoring (Monitoring Wells):</td><td>
<table>
<tr><th>Monitoring Well ID</th><th>Distance (Dir.)</th><th>Geologic Unit</th><th>Ground Elevation</th><th>Monitoring Elev</th><th>Average WL</th></tr>
<tr><td>OW03-19A</td><td>50(NW)</td><td>Bedrock</td><td>284.87</td><td>262.1 - 255.4</td><td>268.62</td></tr>
<tr><td>OW03-19B</td><td>50(NW)</td><td>Bedrock</td><td>284.87</td><td>273.9 – 267.3</td><td>268.64</td></tr>
<tr><td>OW03-19C</td><td>50(NW)</td><td>Overburden</td><td>284.98</td><td>276.7 – 275.1</td><td>276.91</td></tr>
</table>
</td><td>Graph 3</td><td></td><td></td></tr>
<tr><td>Water Budget Results:</td><td>A detailed water budget was not produced for this wetland. The wetland is close to Wetland 13032 (Earthfx Wetland 19) and similar in size. The water budget for this wetland should be similar. Simulated groundwater levels, groundwater discharge to riparian areas, and streamflow in the vicinity of Wetland 13032 (Earthfx Wetland 19) for baseline conditions is discussed in Section 7 of the main report.</td><td></td><td>HHIAR (Earthfx, April 2020)</td><td>165 - 190</td></tr>
<tr><td>Integrated Model Calibration:</td><td>The calibration of this wetland is not discussed in the Earthfx Main Report. Section 6.11.6.3 discusses the calibration to nearby Wetland 13032 (Earthfx Wetland 19) in great detail. The calibration to nearby well OW03-19 is shown in Graph 4. The groundwater monitors are completed in the shallow and intermediate depth bedrock and exhibit similar water level elevations and fluctuations. The model simulations match the observations closely (the ground surface and model layer tops are shown as horizontal reference lines to illustrate the thickness of the till at this location).</td><td>Graph 4</td><td></td><td></td></tr>
</table>

Impact Assessment (Operations Phases 1 & 2)	Description	Figure / Graph	Reference	
			Report	Section / Page
Change in Wetland Area (ha):	No change. Wetland located greater than 120 m from licensed boundary.		SWA (Tatham, April 2020)	4.2.1
Change in Wetland Catchment Area (ha):	No change. Subcatchment area protected.		SWA (Tatham, April 2020)	4.2.1 & Drawing DP-2
Change in Hydroperiod:	No Change. Wetland is perched and isolated from the groundwater system. Subcatchment area being protected.		SWA (Tatham, April 2020)	4.2.1
Change in Water Budget:	Detailed water budgets were not prepared for this feature. A detailed average water budget as simulated by the integrated model is provided for nearby Wetland 13032 (Earthfx Wetland 19) Simulated change in groundwater levels (drawdowns), groundwater discharge to riparian areas, and change in streamflow in the vicinity of Wetland 13032 (Earthfx Wetland 19) for each scenario are discussed in Section 8 of the main report.		HHIAR (Earthfx, April 2020)	191 - 303
Potential Impact to Form and Function of Feature:	No wetlands will be removed and the wetlands subcatchment will be protected. There will be no encroachment from the project into the wetland. The proposed limit of extraction is >120 m from the wetland boundary. Licensed boundary will be demarcated and fenced to ensure site construction and operations do not extend beyond the proposed limits of the project.			

Mitigation (Operational Phases 1 & 2)	Description	Figure / Graph	Reference	
			Report	Section / Page
Proposed Mitigation Measures:	None required.			

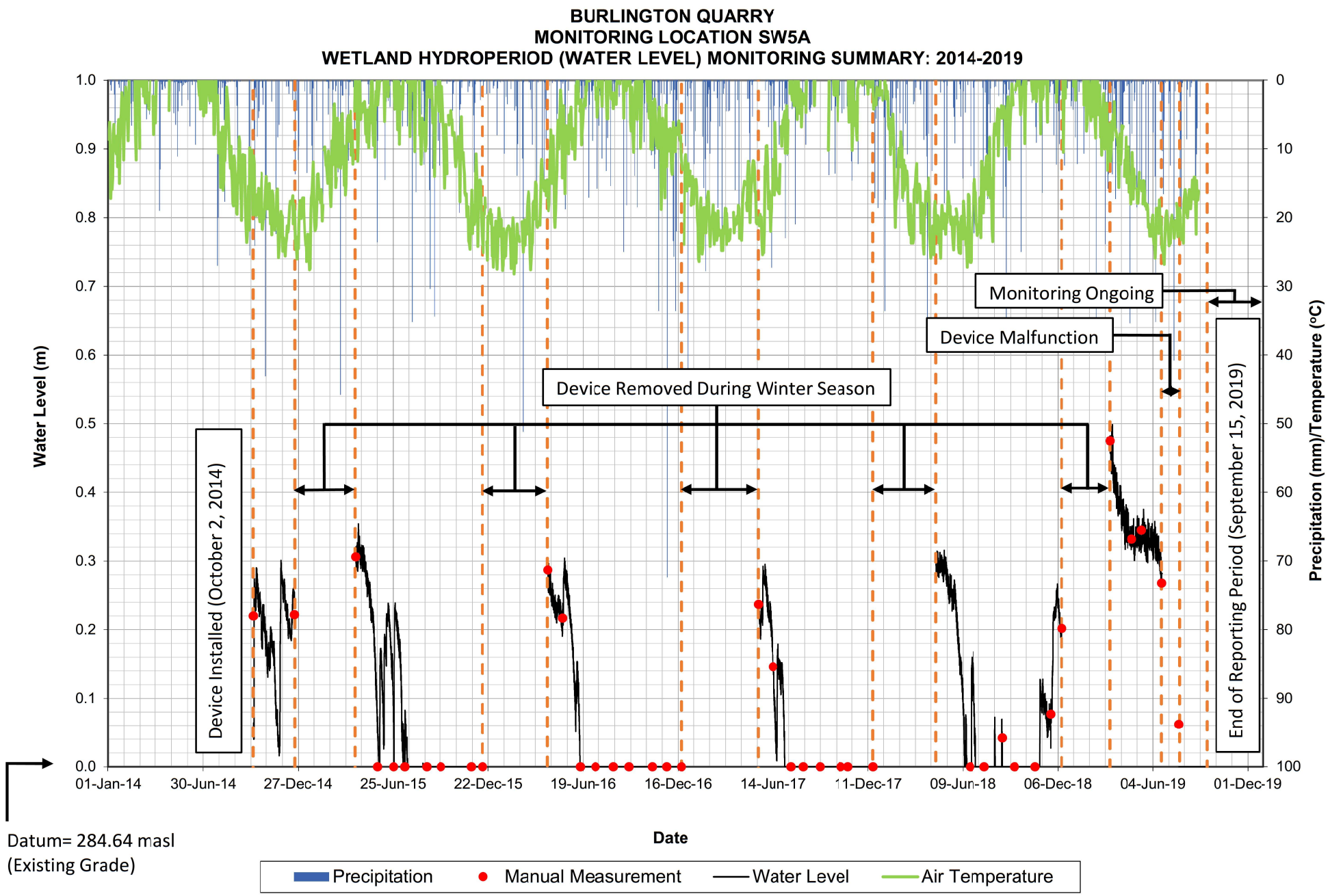
Impact Assessment (Operations Phases 3 - 6)	Description	Figure / Graph	Reference	
			Report	Section / Page
Change in Wetland Area (ha):	No change. Wetland located greater than 120 m from licensed boundary.		SWA (Tatham, April 2020)	4.2.1
Change in Wetland Catchment Area (ha):	No change. Subcatchment area protected.		SWA (Tatham, April 2020)	4.2.1 & Drawing DP-2
Change in Hydroperiod:	No Change. Wetland is perched and isolated from the groundwater system. Subcatchment area being protected.		SWA (Tatham, April 2020)	4.2.1
Change in Water Budget:	Detailed water budgets were not prepared for this feature. A detailed average water budget as simulated by the integrated model is provided for nearby Wetland 13032 (Earthfx Wetland 19) Simulated change in groundwater levels (drawdowns), groundwater discharge to riparian areas, and change in streamflow in the vicinity of Wetland 13032 (Earthfx Wetland 19) for each scenario are discussed in Section 8 of the main report.		HHIAR (Earthfx, April 2020)	191 - 303
Potential Impact to Form and Function of Feature:	No wetlands will be removed and the wetlands subcatchment will be protected. There will be no encroachment from the project into the wetland. The proposed limit of extraction is >120 m from the wetland boundary. Licensed boundary will be demarcated and fenced to ensure site construction and operations do not extend beyond the proposed limits of the project .			

Mitigation (Operational Phases 3 - 6)	Description	Figure / Graph	Reference	
			Report	Section / Page
Proposed Mitigation Measures:	None required.			

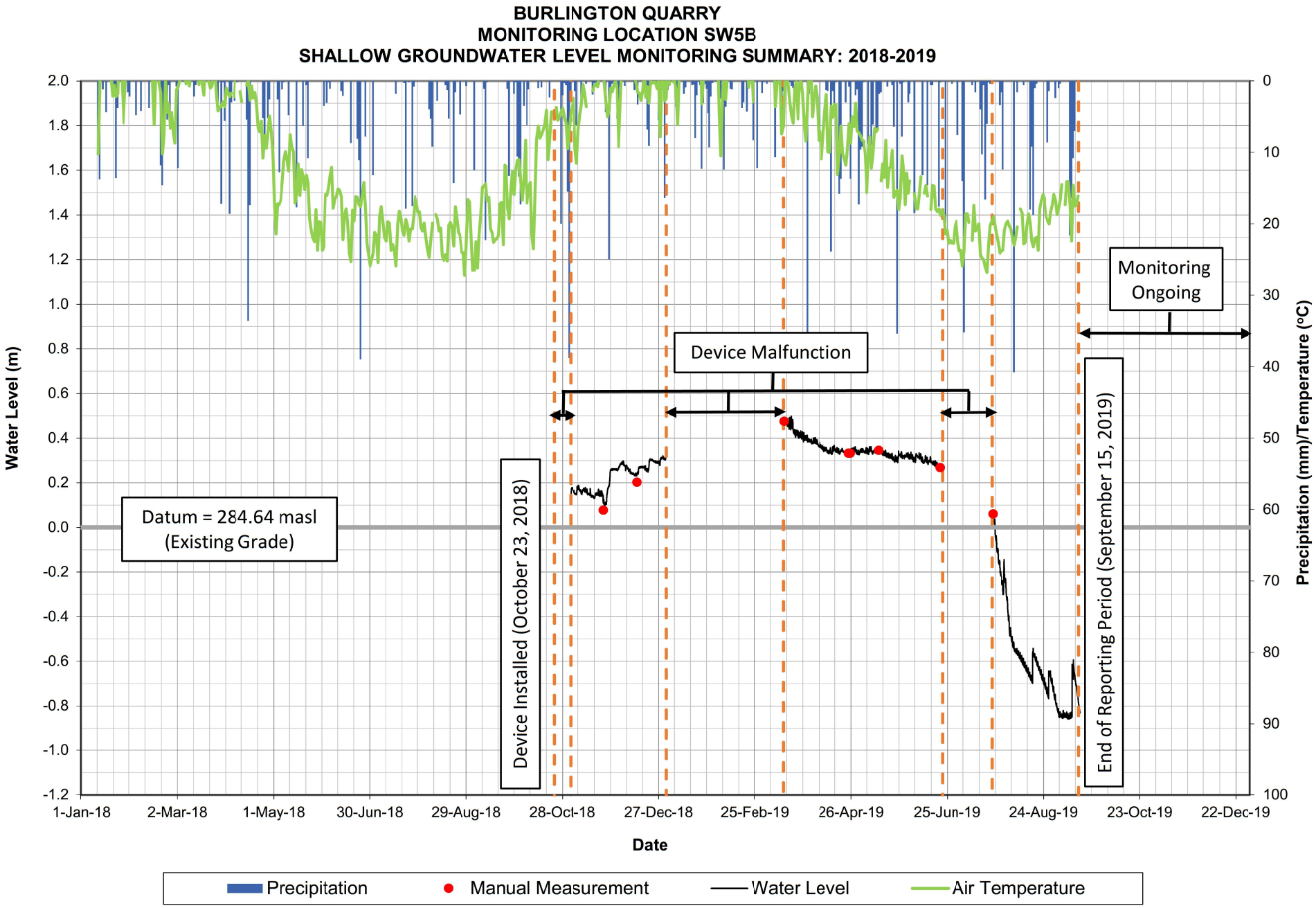
Impact Assessment (Rehabilitation)	Description	Figure / Graph	Reference	
			Report	Section / Page
Change in Wetland Area (ha):	No change. Wetland located greater than 120 m from licensed boundary.		SWA (Tatham, April 2020)	5.4.1
Change in Wetland Catchment Area (ha):	No change. Subcatchment area protected.		SWA (Tatham, April 2020)	5.4.1 & Drawing DP-3
Change in Hydroperiod:	No Change. Wetland is perched and isolated from the groundwater system. Subcatchment area being protected.		SWA (Tatham, April 2020)	5.4.1
Change in Water Budget:	Detailed water budgets were not prepared for this feature. A detailed average water budget as simulated by the integrated model is provided for nearby Wetland 13032 (Earthfx Wetland 19) Simulated change in groundwater levels (drawdowns), groundwater discharge to riparian areas, and change in streamflow in the vicinity of Wetland 13032 (Earthfx Wetland 19) for each scenario are discussed in Section 8 of the main report.		HHIAR (Earthfx, April 2020)	191 - 303
Potential Impact to Form and Function of Feature:	No wetlands will be removed and the wetlands subcatchment will be protected. There will be no encroachment from the project into the wetland. The proposed limit of extraction is >120 m from the wetland boundary. Licensed boundary will be demarcated and fenced to ensure site construction and operations do not extend beyond the proposed limits of the project .			

Mitigation (Rehabilitation)	Description	Figure / Graph	Reference	
			Report	Section / Page
Proposed Mitigation Measures:	None required.			

WETLAND 13031 - GRAPH 1

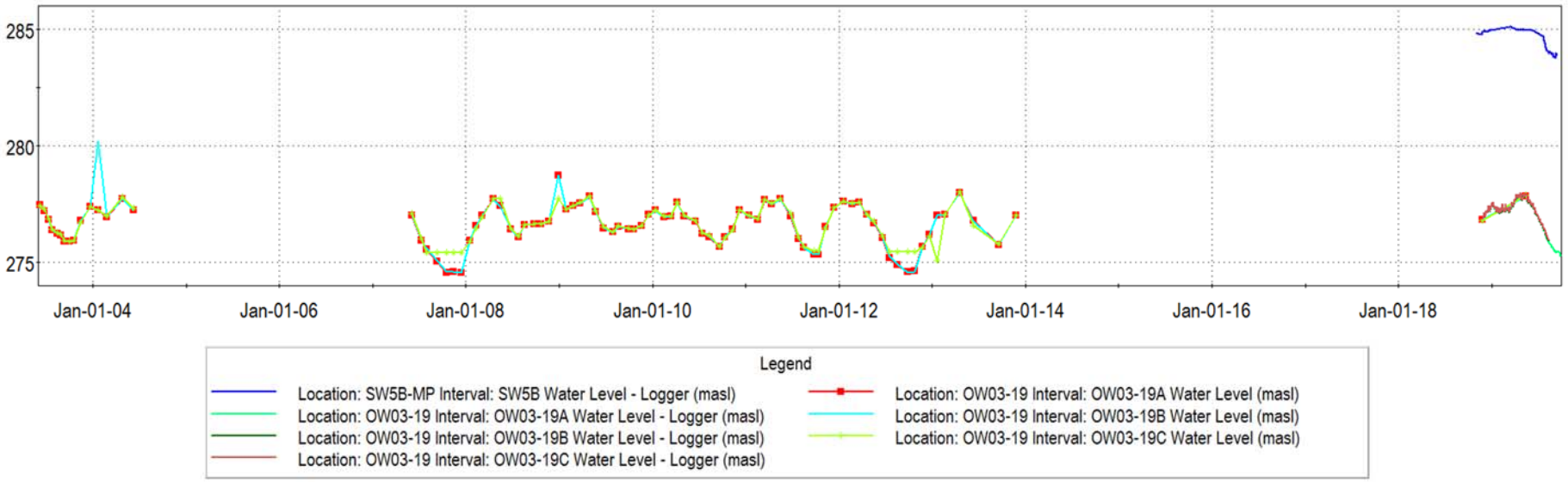


WETLAND 13031 - GRAPH 2

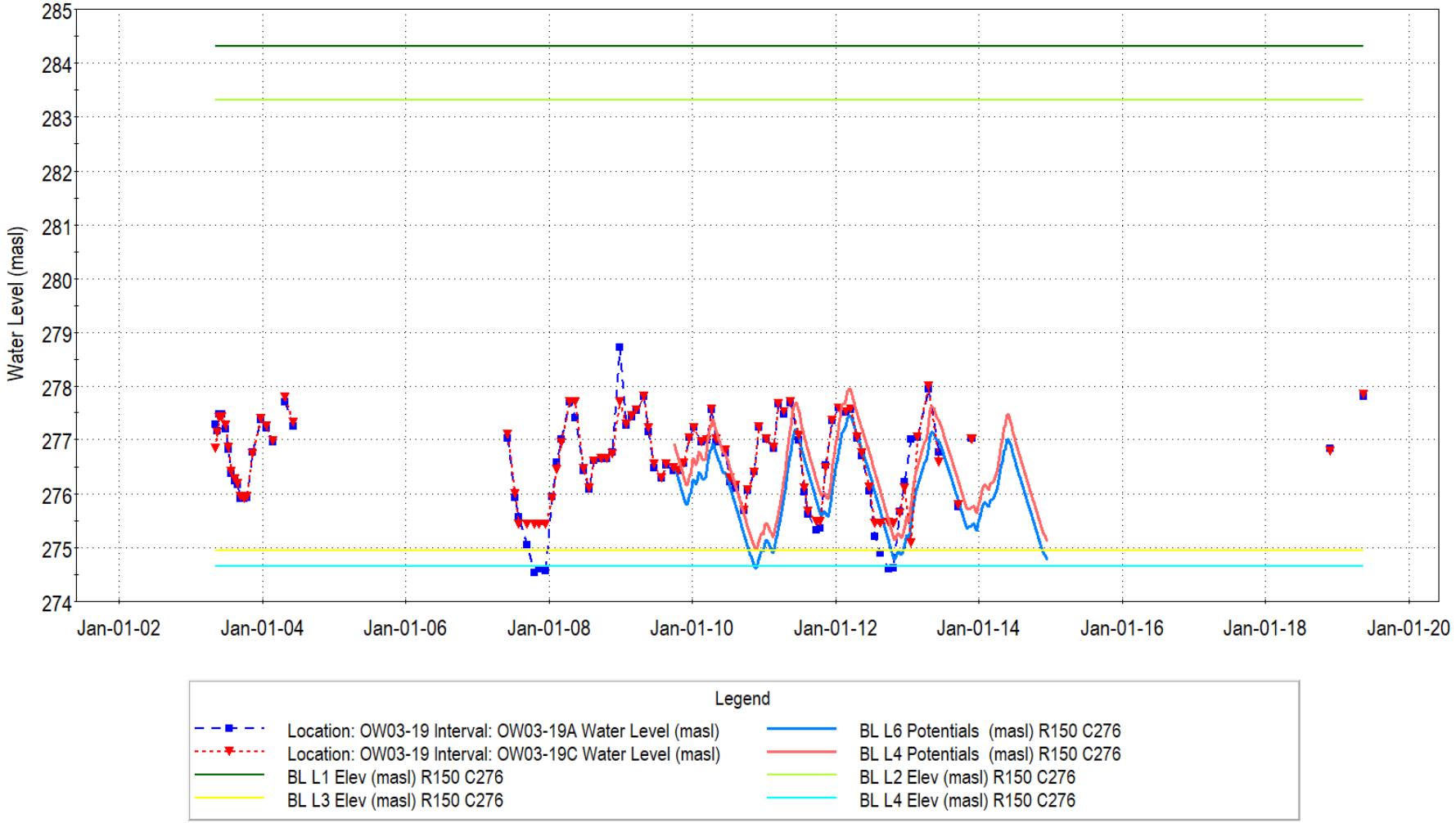


WETLAND 13031 - GRAPH 3

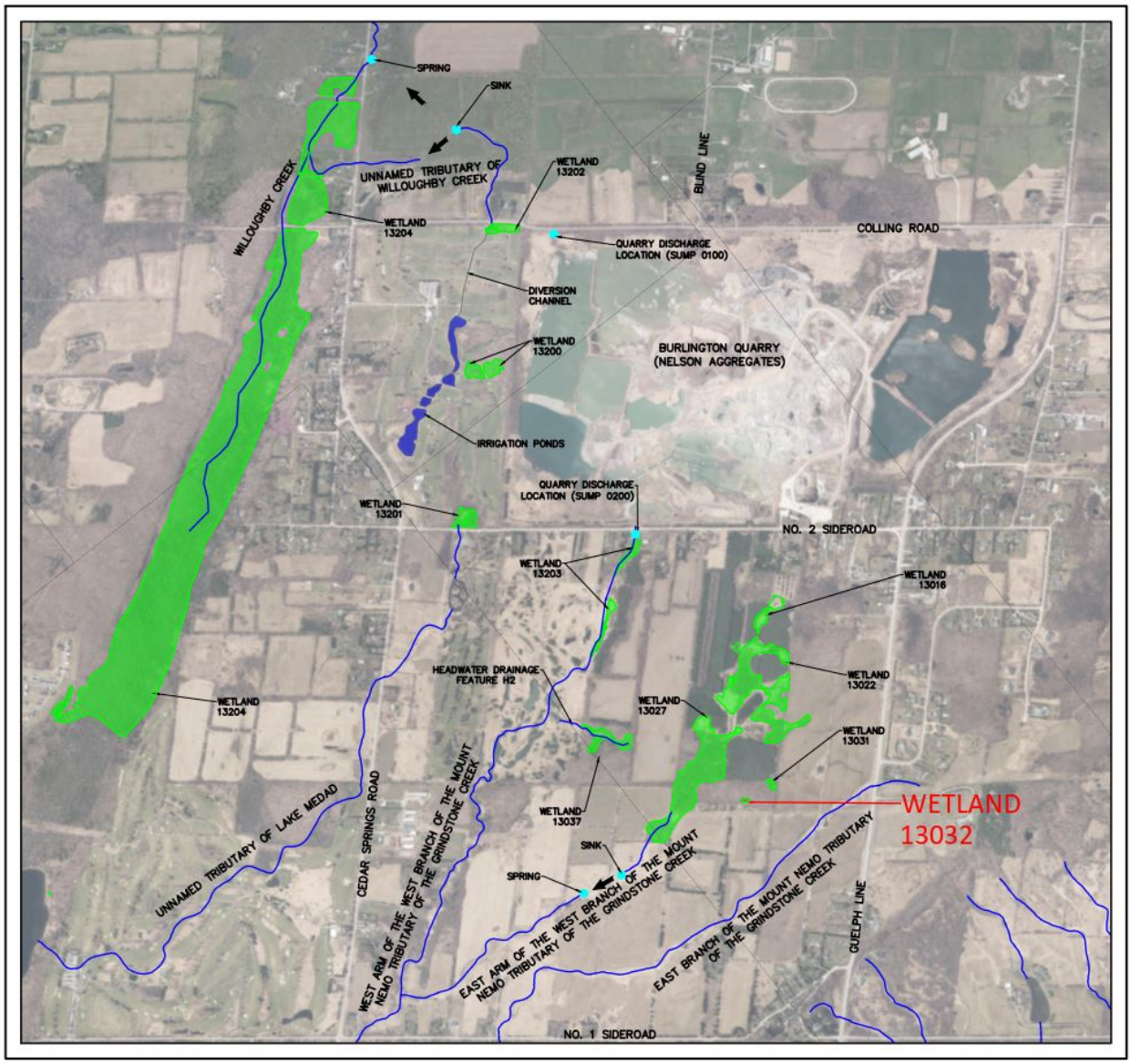
Groundwater Hydrograph
Wetland 13031

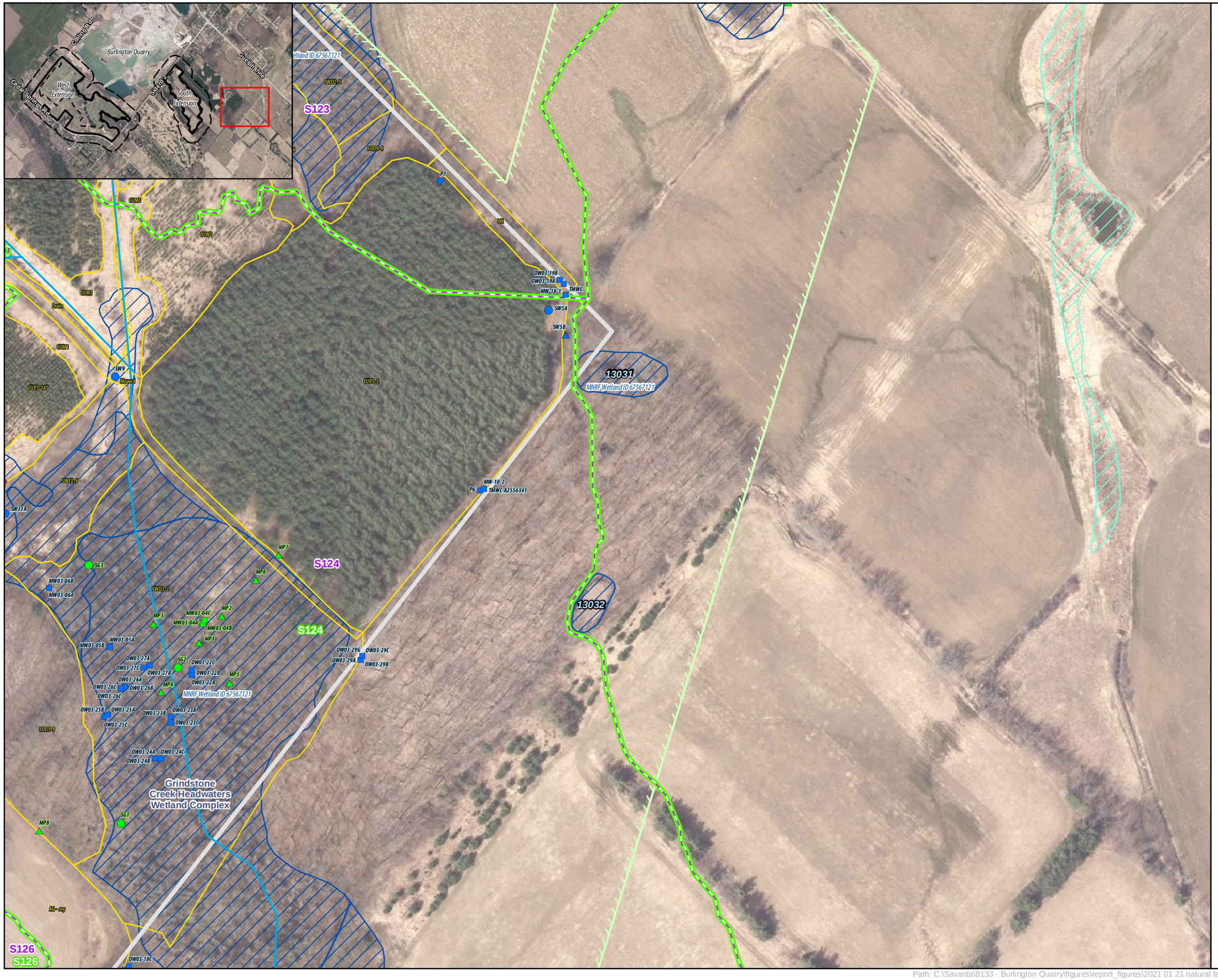


Integrated Model Calibration
Wetland 13031



WETLAND 13032





Legend

- Subject Lands
- Salamander Habitat Assessment (2019)
- Indirect Fish Habitat
- Existing Subcatchment Boundary (Tatham Engineering, 2020)
- Proposed Subcatchment Boundary - Operations and Post-Rehabilitation (Tatham Engineering, 2020
- Ecological Land Classification (Savanta, 2019 & 2020)
- Provincially Significant Wetland (LIO/MNRF, 2020)
- Wetland - Not Evaluated per OWES (MNRF/LIO, 2020)
- MECP Jefferson Salamander Regulated Habitat

Current Instrumentation

- Groundwater Monitoring Station (EarthFx)
- Mini Piezometer (Tatham Engineering)
- Staff Gauge & Surface Water Monitoring Station (Tatham Engineering)

Previous Instrumentation

- Groundwater Monitoring Station (Golder)
- Mini Piezometer (Golder)
- Staff Gauge & Surface Water Monitoring Station (Golder)

ELC Legend

AG, Agriculture
CUM1, Mineral Cultural Meadow
CUP3-2, White Pine Coniferous Plantation
CUP3-13*, White Spruce Coniferous Plantation
CUP3-14*, White Cedar Coniferous Plantation
CUT1-4, Gray Dogwood Cultural Thicket
CUW1, Mineral Cultural Woodland
FOD5-8, Dry – Fresh Sugar Maple – White Ash Deciduous Forest
FOD9-4, Fresh – Moist Shagbark Hickory Deciduous Forest
HR, Hedgerow
MAM2-2, Reed-canary Grass Mineral Meadow Marsh
SWD2-2, Green Ash Mineral Deciduous Swamp
SWD3-2, Silver Maple Mineral Deciduous Swamp
SWT2-9, Gray Dogwood Mineral Thicket Swamp

NOTES:

1. Coordinate System: NAD 1983 UTM Zone 17N.
2. Base features produced under license with the Ontario Ministry of Natural Resources and Forestry © Queen's Printer for Ontario, 2021.
3. Orthoimagery © First Base Solutions, 2021. Imagery taken in 2019.

Project 8133

Burlington Quarry Extension
Nelson Aggregates Co.

Figure 4
Wetland Characterization

Wetland 13031 and 13032 - South Extension

0 30 m
1:2,000

N

GEI Consultants
Savanta Division

Wetland 13032

Wetland Characteristics	Description	Figure / Graph	Reference	
			Report	Section / Page
Wetland IDs:	MNRF – 67567121 (OGF ID 67567150) Earthfx – 19 Tatham – 13032 Savanta – 13032 Golder (Background) - 13032			
Wetland Area (ha):	LIO/MNRF - 0.04			
Watershed:	Grindstone Creek Watershed			
Sub-Watershed:	East Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek			
Located in Proposed Limit of Extraction:	No			
Located in Proposed License Boundary:	No			
Catchment Area (ha):	N/A			
Catchment ID:	N/A			
Closed or Connected System:	Isolated Feature			
Condition:	Natural			
Bathymetry:	Bathymetry unavailable; off-site wetland without permission to survey.			
Outlet:	Isolated Feature			
Hydroperiod:	It is understood a permanent pool of water is maintained in Wetland 13032 year-round.			
Surface Water Monitoring:	MNRF Wetland 13032 was monitored in 2007 by the H Pond Staff Gauge (HPond SG). In addition to the staff gauge in the pond, two drive point mini-piezometers were installed near this pond in 2007. These drive points were always dry, indicating that the pond is perched above the water table.		HHIAR (Earthfx, April 2020)	158

Water Level Measurement Summary			
	Pond	DP1	DP2
Ref:	283.09	284.09	283.31
GS:	-	283.29	282.63
Date	Water Level Elevations		
17-May-07	283.40	N/A	N/A
11-Jul-07	283.21	282.25	281.83

Notes:
Ref: = reference point elevation
GS = ground surface elevation
DP1 is adjacent to the pond (north)
DP2 is about 20 m north (downslope) of the pond

Natural Heritage and Habitat Features	Description	Figure / Graph	Reference	
			Report	Section / Page
Wetland Name & Provincial Significance Evaluation:	Grindstone Creek Headwaters Wetland Complex – Provincially Significant		NETR (Savanta, April 2020)	6.1.2
ELC Unit(s):	Unknown – outside of 120 m adjacent lands			
Regulated Habitat (MECP):	Yes – Jefferson Salamander (not field verified during 2019 field program; regulated based on historical data) Hydroperiod sensitive species; water presence necessary until end of June		NETR (Savanta, April 2020)	6.7
Significant Wildlife Habitat:	Unknown – outside of 120 m adjacent lands			
Fish Habitat:	None			
Habitat of Endangered and Threatened Species:	Unknown – outside of 120 m adjacent lands			

<table>
<tr><th>Groundwater Interaction</th><th>Description</th><th>Figure / Graph</th><th colspan="2">Reference</th></tr>
<tr><th></th><th></th><th></th><th>Report</th><th>Section / Page</th></tr>
<tr><td>Lithology:</td><td>Halton Till</td><td></td><td></td><td></td></tr>
<tr><td>Hydraulic Conductivity:</td><td>Integrated Model (Earthfx) - The harmonic mean hydraulic conductivity, based on testing by Golder (2007) of 10 mini-piezometers, was 1.2x10^{-8} m/s. Model value for the vertical hydraulic conductivity was 1.6x10^{-7} m/s, about an order of magnitude higher, to account for limited flow through fractures in the till.</td><td></td><td></td><td></td></tr>
<tr><td>Surface Water/Groundwater Interaction:</td><td>The low permeability of the Halton Till underlying the wetland is the dominant control on 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. This wetland receives no significant groundwater inflow, and is isolated from any changes in the water table due to quarry development.</td><td></td><td></td><td></td></tr>
<tr><td>Background Shallow Groundwater (Mini-piezometer) Monitoring:</td><td>
<table>
<tr><td>Mini-piezometer ID</td><td>Ground Elevation</td><td>Bottom Elevation</td><td>Average WL</td><td>Logger</td><td>Manual Meas.</td></tr>
<tr><td>DP1</td><td>283.29</td><td>282.25</td><td>Dry</td><td>-</td><td>2007.00</td></tr>
<tr><td>DP2</td><td>282.63</td><td>281.83</td><td>Dry</td><td>-</td><td>2007.00</td></tr>
</table>
</td><td></td><td></td><td></td></tr>
<tr><td>Groundwater Monitoring (Monitoring Wells):</td><td>
<table>
<tr><td>Monitoring Well ID</td><td>Distance (Dir.)</td><td>Geologic Unit</td><td>Ground Elevation</td><td>Monitoring Elev</td><td>Average WL</td></tr>
<tr><td>OW03-29A</td><td>126 (W)</td><td>Bedrock</td><td>277.06</td><td>256.46 - 248.92</td><td>274.84</td></tr>
<tr><td>OW03-29B</td><td>126 (W)</td><td>Bedrock</td><td>277.05</td><td>273.93 - 266.83</td><td>275.47</td></tr>
<tr><td>OW03-29C</td><td>126 (W)</td><td>Overburden</td><td>277.02</td><td>276.72 - 275.12</td><td>275.79</td></tr>
<tr><td>OW03-29G</td><td>126 (W)</td><td>Overburden</td><td>277.02</td><td>-</td><td>-</td></tr>
</table>
</td><td>Graph 1</td><td></td><td></td></tr>
<tr><td>Water Budget Results:</td><td>A detailed average water budget, as simulated by the integrated model, is provided in the main report for Baseline Conditions (Earthfx Figure 7.27, p. 188). The baseline water budget is reproduced in Figure 1a. The wetland is a net provider of groundwater and never receives groundwater inflow. Simulated groundwater levels, groundwater discharge to riparian areas, and streamflow in the vicinity of Wetland 13032 (Earthfx Wetland 19) are discussed in Section 7 of the main report.
<table>
<tr><td>Wetland 13032</td><td>GW Outflow (%)</td><td>GW Inflow (%)</td></tr>
<tr><td>Baseline (Existing)</td><td>19.82</td><td>0.00</td></tr>
</table>
</td><td>Figure 1a</td><td>HHIAR (Earthfx, April 2020)</td><td>165 - 190</td></tr>
<tr><td>Integrated Model Calibration:</td><td>Earthfx Figures 6.35 and 6.36 (p.159) in the Main Report shows data for the H Pond staff gauge along with hydrographs of simulated shallow water levels. The results are reproduced in Graph 2. A discussion of Wetland 19 is contained in Earthfx Section 6.11.6.3 (p. 158).</td><td>Graph 2</td><td></td><td></td></tr>
</table>

Impact Assessment (Operations Phases 1 & 2)	Description	Figure / Graph	Reference	
			Report	Section / Page
Change in Wetland Area (ha):	No change. Wetland located greater than 120 m from licensed boundary.		SWA (Tatham, April 2020)	4.2.1
Change in Wetland Catchment Area (ha):	No change. Subcatchment area protected.		SWA (Tatham, April 2020)	4.2.1 & Drawing DP-2
Change in Hydroperiod:	No Change. Wetland is perched and isolated from the groundwater system. Subcatchment area being protected.		SWA (Tatham, April 2020)	4.2.1
Change in Water Budget:	A detailed average water budget as simulated by the integrated model is provided in the Earthfx report for Baseline Conditions (Figure 7.28, p. 188); Scenario P12 (Figure 8.34, p. 223); and P3456 (Figure 8.66, p. 250). The water budget results for Scenario P12 are reproduced in Figure 1b. Simulated change in groundwater levels (drawdowns), groundwater discharge to riparian areas, and change in streamflow in the vicinity of Wetland 13032 (Earthfx Wetland 19) for each scenario are discussed in Section 8 of the main report.	Figure 1b	HHIAR (Earthfx, April 2020)	191 - 303
Change on Soil Moisture Conditions:	The Water Budget figures indicate that there is no groundwater seepage entering the wetland under baseline conditions, so there will be no change under P12 conditions.			
Potential Impact to Form and Function of Feature:	No wetlands will be removed and the wetlands subcatchment will be protected. There will be no encroachment from the project into the wetland. The proposed limit of extraction is >120 m from the wetland boundary. Licensed boundary will be demarcated and fenced to ensure site construction and operations do not extend beyond the proposed limits of the project .			

Wetland 13032	GW Outflow (%)	GW Inflow (%)	Change in GW	Change in GW
Baseline (Existing)	19.82	0.00	-	-
Operations Ph 1 & 2	19.35	0.00	-0.47	0.00

Mitigation (Operational Phases 1 & 2)	Description	Figure / Graph	Reference	
			Report	Section / Page
Proposed Mitigation Measures:	None required.			

Impact Assessment (Operations Phases 3 - 6)	Description	Figure / Graph	Reference	
			Report	Section / Page
Change in Wetland Area (ha):	No change. Wetland located greater than 120 m from licensed boundary.		SWA (Tatham, April 2020)	4.2.1
Change in Wetland Catchment Area (ha):	No change. Subcatchment area protected.		SWA (Tatham, April 2020)	4.2.1 & Drawing DP-2
Change in Hydroperiod:	No Change. Wetland is perched and isolated from the groundwater system. Subcatchment area being protected.		SWA (Tatham, April 2020)	4.2.1
Change in Water Budget:	A detailed average water budget as simulated by the integrated model is provided in the Earthfx report for Baseline Conditions (Figure 7.28, p. 188); Scenario P12 (Figure 8.34, p. 223); and P3456 (Figure 8.66, p. 250). The water budget results for Scenario P3456 are reproduced in Figure 1c. Simulated change in groundwater levels (drawdowns), groundwater discharge to riparian areas, and change in streamflow in the vicinity of Wetland 13032 (Earthfx Wetland 19) for each scenario are discussed in Section 8 of the main report.	Figure 1c	HHIAR (Earthfx, April 2020)	191 - 303
Potential Impact to Form and Function of Feature:	No wetlands will be removed and the wetlands subcatchment will be protected. There will be no encroachment from the project into the wetland. The proposed limit of extraction is >120 m from the wetland boundary. Licensed boundary will be demarcated and fenced to ensure site construction and operations do not extend beyond the proposed limits of the project .			

Wetland 13032	GW Outflow (%)	GW Inflow (%)	Change in GW	Change in GW
Baseline (Existing)	19.82	0.00	-	-
Operations Ph 3 - 6	19.79	0.00	-0.03	0.00

Mitigation (Operational Phases 3 - 6)	Description	Figure / Graph	Reference	
			Report	Section / Page
Proposed Mitigation Measures:	None required.			

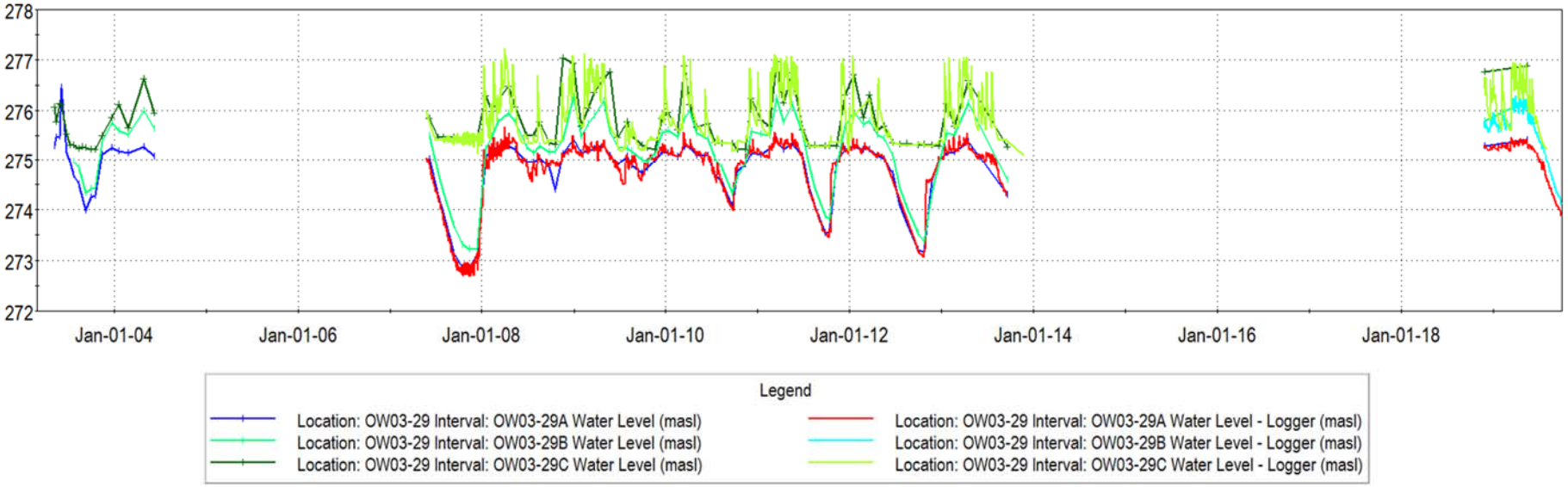
Impact Assessment (Rehabilitation)	Description	Figure / Graph	Reference	
			Report	Section / Page
Change in Wetland Area (ha):	No change. Wetland located greater than 120 m from licensed boundary.		SWA (Tatham, April 2020)	5.4.1
Change in Wetland Catchment Area (ha):	No change. Subcatchment area protected.		SWA (Tatham, April 2020)	5.4.1 & Drawing DP-3
Change in Hydroperiod:	No Change. Wetland is perched and isolated from the groundwater system. Subcatchment area being protected.		SWA (Tatham, April 2020)	5.4.1
Change in Water Budget:	A detailed average water budget as simulated by the integrated model is provided in the Earthfx report for Baseline Conditions (Figure 7.28, p. 188); Scenario P12 (Figure 8.34, p. 223); and P3456 (Figure 8.66, p. 250). The water budget results for Scenario RHB1 and RHB2 are reproduced in Figures 1d and 1e. Simulated change in groundwater levels (drawdowns), groundwater discharge to riparian areas, and change in streamflow in the vicinity of Wetland 13032 (Earthfx Wetland 19) for each scenario are discussed in Section 8 of the main report.	Figure 1d and 1e	HHIAR (Earthfx, April 2020)	191 - 303
Potential Impact to Form and Function of Feature:	No wetlands will be removed and the wetlands subcatchment will be protected. There will be no encroachment from the project into the wetland. The proposed limit of extraction is >120 m from the wetland boundary. Licensed boundary will be demarcated and fenced to ensure site construction and operations do not extend beyond the proposed limits of the project .			

Wetland 13027	GW Outflow (%)	GW Inflow (%)	Δ in Outflow (%)	Δ in Inflow (%)
Baseline (Existing)	19.82	0.00	-	-
Rehab Scenario 1	20.94	0.00	1.12	0.00
Rehab Scenario 2	20.30	0.00	0.48	0.00

Mitigation (Rehabilitation)	Description	Figure / Graph	Reference	
			Report	Section / Page
Proposed Mitigation Measures:	None required.			

WETLAND 13032 - GRAPH 1

Groundwater Hydrograph
Wetland 13032



WETLAND 13032

FIGURE 1A

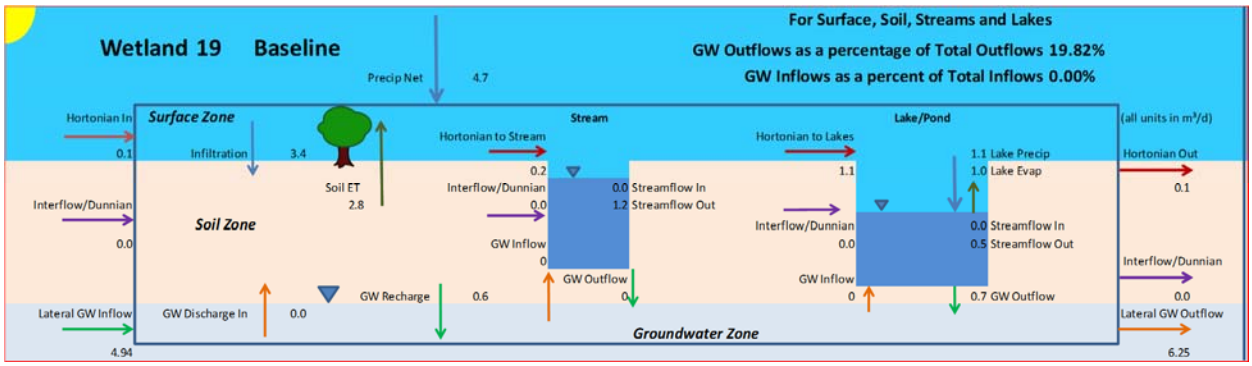


FIGURE 1B

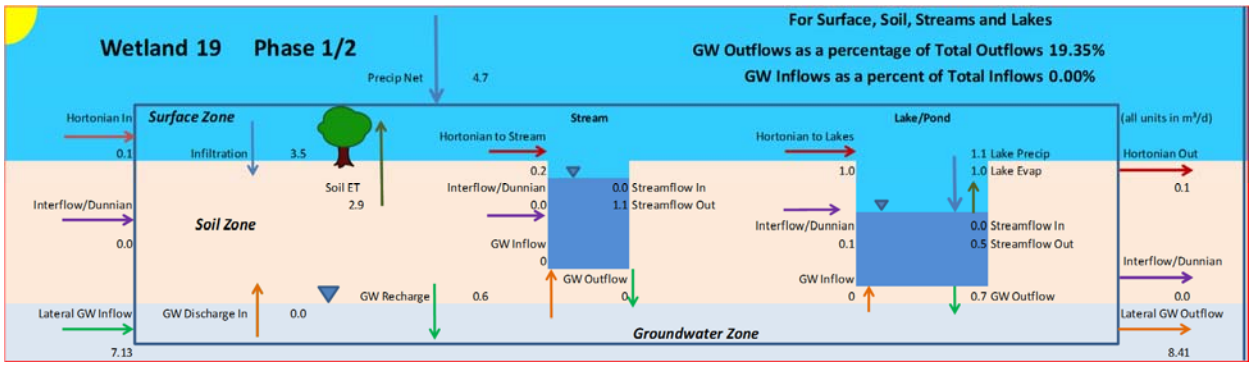


FIGURE 1C

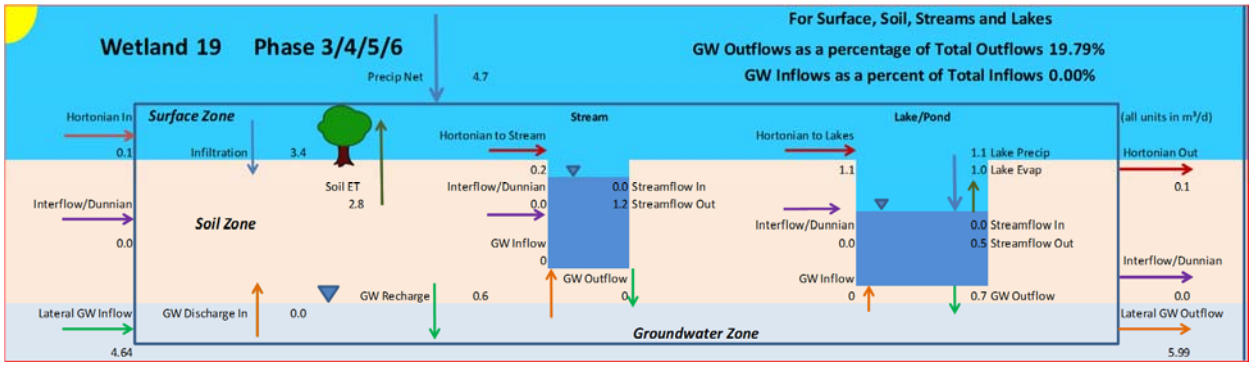


FIGURE 1D

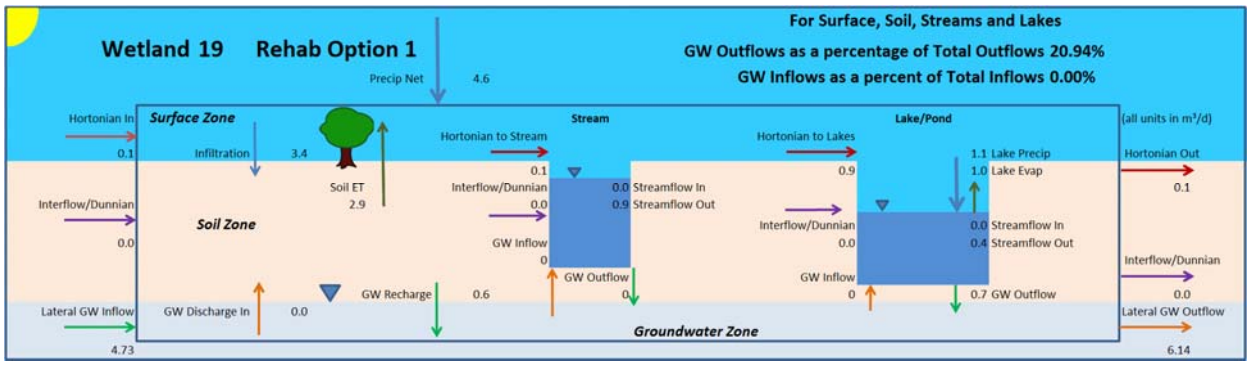
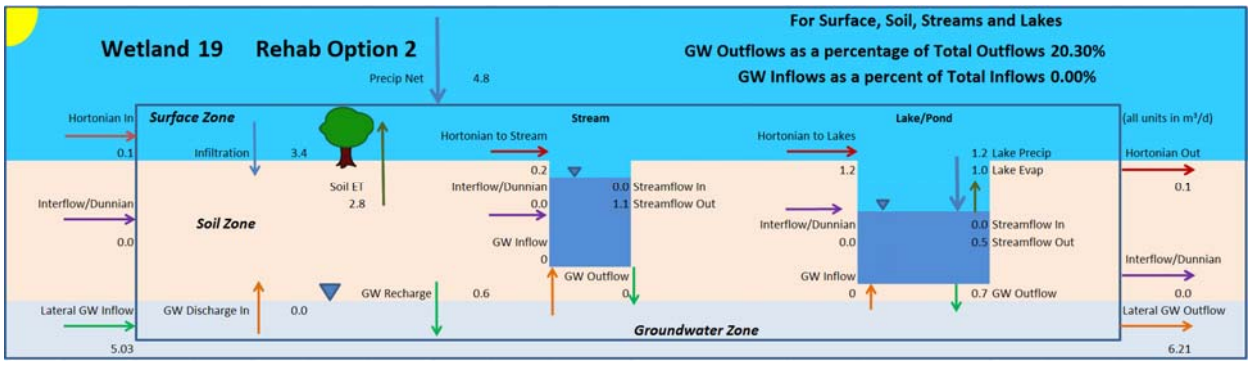
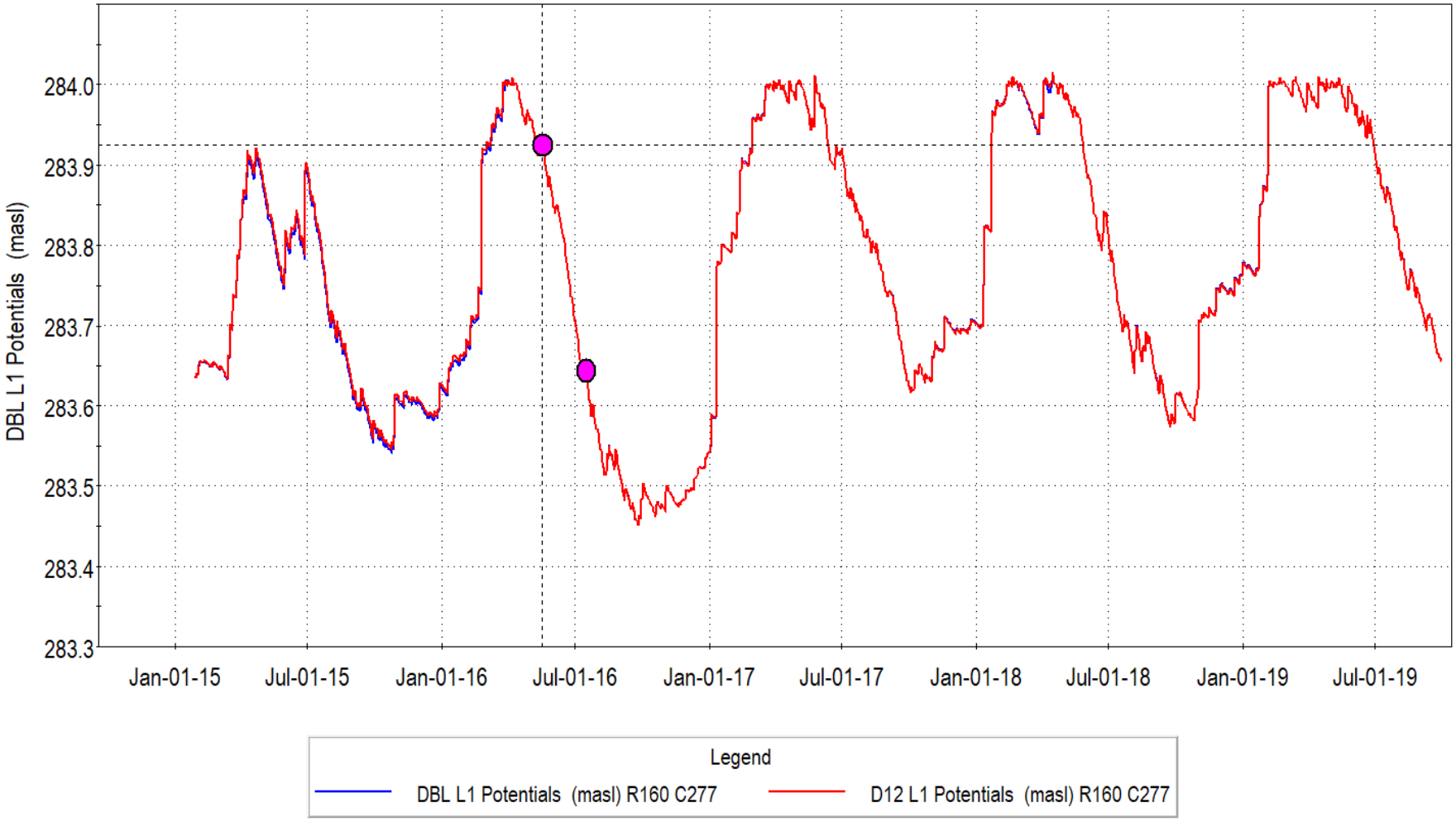


FIGURE 1E

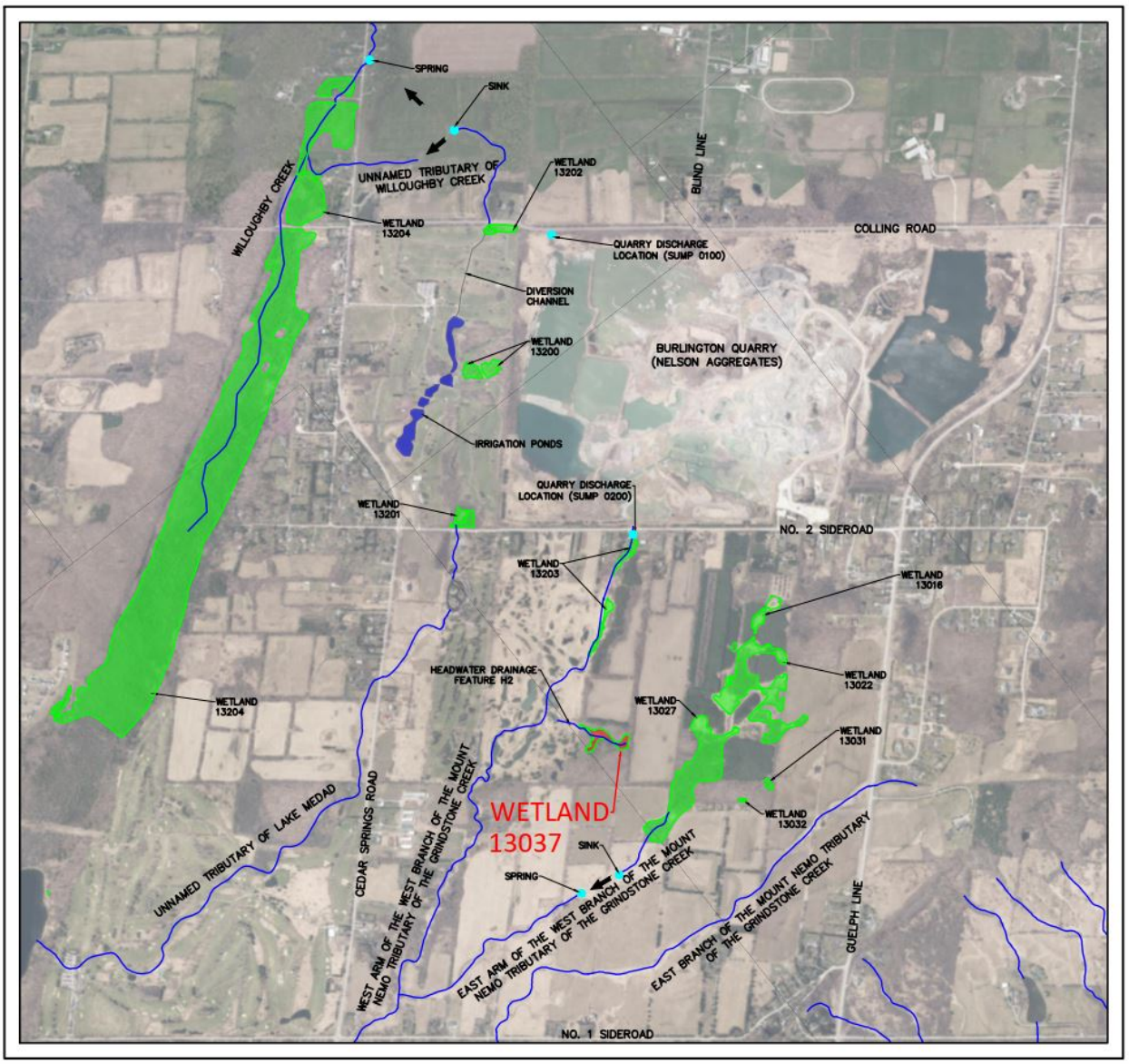


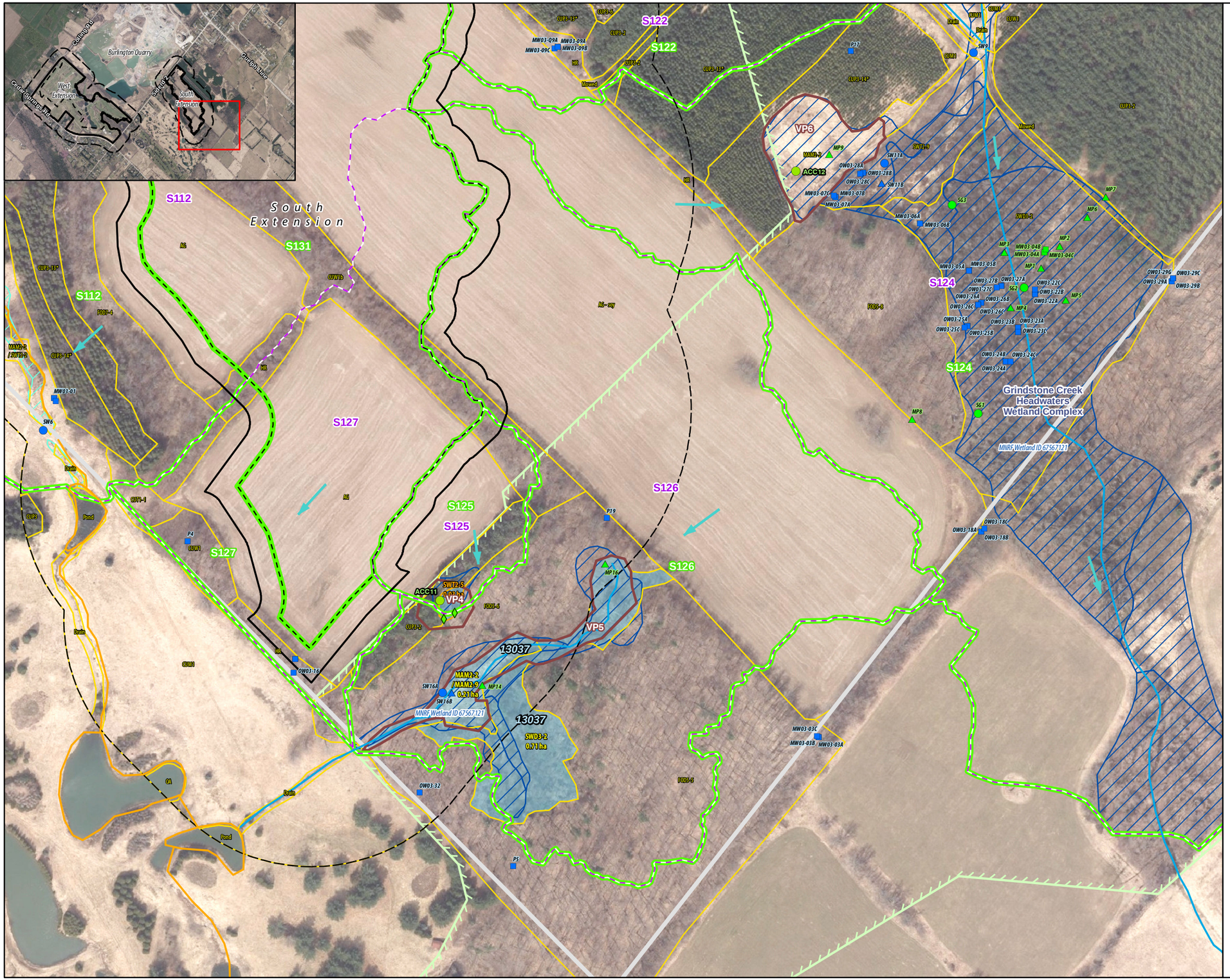
WETLAND 13032 - GRAPH 2

Integrated Model Calibration
Wetland 13032



WETLAND 13037





Legend

- Licensed Boundary
- Limit of Extraction
- 120 m Adjacent Lands
- Subject Lands
- Amphibian Call Count Station (2019)
- Salamander Trap (2019)
- Salamander Habitat Assessment (2019)
- Indirect Fish Habitat
- Direct Fish Habitat
- Existing Subcatchment Boundary (Tatham Engineering, 2020)
- Proposed Subcatchment Boundary - Operations and Post-Rehabilitation (Tatham Engineering, 2020
- Wetland (Savanta, 2020)
- Ecological Land Classification (Savanta, 2019 & 2020)
- Provincially Significant Wetland (LIO/MNRF, 2020)
- Wetland - Not Evaluated per OWES (MNRF/LIO, 2020)
- MECP Jefferson Salamander Regulated Habitat

Current Instrumentation

- Groundwater Monitoring Station (EarthFx)
- Mini Piezometer (Tatham Engineering)
- Staff Gauge & Surface Water Monitoring Station (Tatham Engineering)

Previous Instrumentation

- Groundwater Monitoring Station (Golder)
- Mini Piezometer (Golder)
- Staff Gauge & Surface Water Monitoring Station (Golder)

ELC Legend

AG, Agriculture
CUM1, Mineral Cultural Meadow
CUP3, Coniferous Plantation
CUP3-2, White Pine Coniferous Plantation
CUP3-6, European Larch Coniferous Plantation
CUP3-13*, White Spruce Coniferous Plantation
CUP3-14*, White Cedar Coniferous Plantation
CUT1-1, Sumac Cultural Thicket
CUW1, Mineral Cultural Woodland
FOD5-5, Dry – Fresh Sugar Maple – Hickory Deciduous Forest
FOD5-6, Dry- Fresh Sugar Maple-Basswood Deciduous Forest
FOD5-8, Dry – Fresh Sugar Maple – White Ash Deciduous Forest
FOD7-4, Fresh – Moist Black Walnut Lowland Deciduous Forest
HR, Hedgerow
MAM2-2, Reed-canary Grass Mineral Meadow Marsh
MAM2-9, Jewelweed Mineral Meadow Marsh
OA, Open Aquatic
SWD3-2, Silver Maple Mineral Deciduous Swamp
SWT2-2, Willow Mineral Thicket Swamp
SWT2-5, Red-osier Dogwood Mineral Thicket Swamp
SWT2-9, Gray Dogwood Mineral Thicket Swamp

NOTES:

1. Coordinate System: NAD 1983 UTM Zone 17N.
2. Base features produced under license with the Ontario Ministry of Natural Resources and Forestry © Queen's Printer for Ontario, 2021.
3. Orthoimagery © First Base Solutions, 2021. Imagery taken in 2019.

Project 8133

Burlington Quarry Extension
Nelson Aggregates Co.

Figure 5
Wetland Characterization
Wetland 13037 - South Extension

0 40 m
1:2,500

N

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Savanta Division

Path: C:\Savanta\8133 - Burlington Quarry\figures\report_figures\2021 01 21 natural feature tech summary\8133_rpt_wetland_char_mapbook.mxd Date S...uary 11, 2021

Wetland 13037

Wetland Characteristics	Description	Figure / Graph	Reference	
			Report	Section / Page
Wetland IDs:	MNRF – 67567121 (OGF ID 67567139, 67567128, 67567138, 67567132) Earthfx - 20 Tatham – 13036, 13037 Savanta - 13037 Golder (Background) – 13036, 13037, 13038, 13039			
Wetland Area (ha):	LIO/MNRF - 1.05 Savanta - 0.95			
Watershed:	Grindstone Creek Watershed			
Sub-Watershed:	West Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek			
Located in Proposed Limit of Extraction:	No			
Located in Proposed License Boundary:	No			
Catchment Area (ha):	10.05		SWA (Tatham, April 2020)	Drawing DP-1
Catchment ID:	S125, S126		SWA (Tatham, April 2020)	Drawing DP-1
Closed or Connected System:	On-line (connected to downstream watercourse)			
Condition:	Natural			
Bathymetry:	A bathymetry survey of Wetland 13037 was completed by Tatham Engineering Limited and incorporated into the integrated model (see Earthfx Section 18.3, p.381). Wetland lakes were assigned to Layer 1 of the integrated model by adjusting the base of Layer 1 to correspond with the interpolated bottom elevation. Care was taken to ensure that the lowest elevation observed in the wetland was honored in the assigned elevations.	Figure 1	HHIAR (Earthfx, April 2020)	18.3 (page 381)
Outlet:	Headwater Drainage Feature H2			
Hydroperiod:	Spring Hydroperiod (date wetland dries out) – May 25th – August 26th Fall Hydroperiod (start of hydroperiod) – September 6th – December 25th	Graph 1	SWA (Tatham, April 2020)	2.2.5, 3 and Appendix F
Surface Water Monitoring:	ID: SW16A (Tatham) Installation Date: October 23, 2018 Data Collection: Continuous water level and temperature and manual monthly water level measurements Coordinates of Monitoring Station: Easting 590888.61, Northing 4804899.887	Graph 1	SWA (Tatham, April 2020)	2.2.5, 3 and Appendix F

Natural Heritage and Habitat Features	Description	Figure / Graph	Reference	
			Report	Section / Page
Wetland Name & Provincial Significance Evaluation:	Grindstone Creek Headwaters Wetland Complex – Provincially Significant		NETR (Savanta, April 2020)	6.1.2
ELC Unit(s):	Dogwood Mineral Swamp Thicket: SWT2-5 Reed-canary grass / Jewelweed Mineral Meadow Marsh: MAM2-2/MAM2-9 Silver Maple Mineral Deciduous Swamp: SWD3-2		NETR (Savanta, April 2020)	Table 2
Regulated Habitat (MECP):	Yes – Jefferson Salamander (none observed despite survey effort) Hydroperiod sensitive species; water presence necessary until end of June		NETR (Savanta, April 2020)	6.1.2
Significant Wildlife Habitat:	None confirmed for amphibian breeding, despite survey effort through salamander habitat assessments, salamander trapping and call count surveys.		NETR (Savanta, April 2020)	4.2.2; 4.2.3; 4.2.5; 5.2.2; 5.2.3; 5.2.5; 6.4; Table 19
Fish Habitat:	Indirect		NETR (Savanta, April 2020)	6.6
Habitat of Endangered and Threatened Species:	No species at risk salamanders observed, despite survey effort including salamander habitat assessment, salamander trapping and egg mass surveys.		NETR (Savanta, April 2020)	4.2.2; 4.2.3; 5.2.2; 5.2.3; 6.7

Groundwater Interaction	Description	Figure / Graph	Reference	
			Report	Section / Page
Lithology:	Halton Till			
Hydraulic Conductivity:	Integrated Model (Earthfx) - The harmonic mean hydraulic conductivity, based on testing by Golder (2007) of 10 mini-piezometers, was $1.2x10^{-8}$ m/s. Model value for the vertical hydraulic conductivity was $1.6x10^{-7}$ m/s, about an order of magnitude higher, to account for limited flow through fractures in the till. Wetland Water Balance (Tatham) – $1.2x10^{-10}$ m/s.			
Surface Water/Groundwater Interaction:	The low permeability of the Halton Till underlying the wetland is the dominant control on 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. This wetland receives some groundwater inflow but is relatively isolated from changes in the water table due to quarry development.			
Shallow Groundwater (Mini-piezometer) Monitoring:	ID: SW16B (Tatham) Installation Date: October 23, 2018 Data Collection: Continuous water level and temperature and manual monthly water level measurements Coordinates of Monitoring Station: Easting 590888.61, Northing 4804899.887	Graph 2	SWA (Tatham, April 2020)	2.3 and Appendix G

Background Shallow Groundwater (Mini-piezometer) Monitoring: — Graph 3

Mini-piezometer ID	Ground Elevation	Bottom Elevation	Average WL	Logger	Manual Meas.
Golder MP14	274.57	273.37	270.93	-	2007-2013
Golder MP16	276.37	275.17	273.45	2007-2013	2007-2013

Groundwater Monitoring (Monitoring Wells): — Graph 3

Monitoring Well ID	Distance (Dir.)	Geologic Unit	Ground Elevation	Monitoring Elev	Average WL
OW03-32A	78 (SSW)	Bedrock	278.00	265.0 - 254.4	268.62
OW03-32B	78 (SSW)	Bedrock	271.00	269.1 – 261.3	268.64
OW03-16A	114 (W)	Bedrock	272.20	254.4 – 246.6	268.28
OW03-16B	114 (W)	Bedrock	272.20	269.3 – 262.2	270.22
OW03-16C	112 (W)	Bedrock	272.30	270.0 – 268.4	270.55
MW03-03A	212 (E)	Bedrock	274.80	255.6 – 251.6	273.33
MW03-03B	212 (E)	Bedrock	274.80	264.7 – 260.8	273.69
MW03-03C	212 (E)	Overburden	274.70	274.1 – 272.1	272.93

Water Budget Results: — Figure 2a — HHIAR (Earthfx, April 2020) — 165 - 190

A detailed average water budget, as simulated by the integrated model, was not presented in the Main report but is provided in Figure 2a. The wetland is a net provider of groundwater. Simulated groundwater levels, groundwater discharge to riparian areas, and streamflow in the vicinity of Wetland 13016 (Earthfx Wetland 11) for baseline conditions is discussed in Section 7 of the main report.

Wetland 13037	GW Outflow (%)	GW Inflow (%)
Baseline (Existing)	12.84	1.76

Integrated Model Calibration: — Graphs 4 & 5

Two mini-piezometers in Wetland 20 provide multiple years of monitoring in the soil zone and upper weathered Halton Till. These monitors correspond to the PRMS soil zone and upper-most part of Layer 1 of the GSFLOW model. A comparison of the mini-piezometer data to the simulated soil moisture conditions (see Graphs 4 and 5) demonstrates that the model is closely matching both the soil moisture and hydroperiod of the shallow subsurface at this wetland. Based on recent measurements at SW16B, it appears that the historic data at MP14 may have an elevation offset. The timing of the simulated response does, however, match the recorded data.

Earthfx Figure 6.29 (p.154) and Figure 19.44 (p.444) in the Main Report shows a hydrograph for Golder MP16 along with simulated shallow water levels. The figure is reproduced in Graphs 4 and 5. Note that the total range in observed water level fluctuation is less than 40 cm. A brief discussion of the Wetland 20 is contained in Earthfx Section 6.11.4 (p. 152). A more detailed discussion is provided in Appendix E, Section 19.6 (p. 443).

Graph 6 — HHIAR (Earthfx, April 2020) — 154, 443 - 444

<table>
<tr><th>Impact Assessment (Operations Phases 1 & 2)</th><th>Description</th><th>Figure / Graph</th><th colspan="2">Reference</th></tr>
<tr><th></th><th></th><th></th><th>Report</th><th>Section / Page</th></tr>
<tr><td>Change in Wetland Area (ha):</td><td>No change. Wetland located greater than 120 m from licensed boundary.</td><td></td><td>SWA (Tatham, April 2020)</td><td>4.2.1</td></tr>
<tr><td>Change in Wetland Catchment Area (ha):</td><td>No change. Subcatchment area protected.</td><td></td><td>SWA (Tatham, April 2020)</td><td>4.2.1 & Drawing DP-2</td></tr>
<tr><td>Change in Hydroperiod:</td><td>No Change. Wetland is perched and isolated from the groundwater system. Subcatchment area being protected.</td><td></td><td>SWA (Tatham, April 2020)</td><td>4.2.1</td></tr>
<tr><td>Change in Water Budget:</td><td>A detailed average water budget as simulated by the integrated model is provided in the Earthfx report for Baseline Conditions (Figure 7.28, p. 188); Scenario P12 (Figure 8.35, p. 223); P3456 (Figure 8.67, p. 250); RHB1 (Figure 8.102, p. 279), and RHB2 (Figure 8.129, p. 300). The water budget results for Scenario P12 are reproduced in Figure 2b. Simulated change in groundwater levels (drawdowns), groundwater discharge to riparian areas, and change in streamflow in the vicinity of Wetland 13037 (Earthfx Wetland 20) for each scenario are discussed in Section 8 of the main report.
<table>
<tr><td>Wetland 13037</td><td>GW Outflow (%)</td><td>GW Inflow (%)</td><td>Δ in Outflow (%)</td><td>Δ in Inflow (%)</td></tr>
<tr><td>Baseline (Existing)</td><td>12.84</td><td>1.76</td><td>-</td><td>-</td></tr>
<tr><td>Operations Ph 1 & 2</td><td>15.90</td><td>0.00</td><td>3.45</td><td>-1.76</td></tr>
</table></td><td>Figure 2b</td><td>HHIAR (Earthfx, April 2020)</td><td>191 - 303</td></tr>
<tr><td>Change on Soil Moisture Conditions:</td><td>The soil moisture under Baseline and P12 conditions, as well as Baseline surface discharge (seepage), are shown in Graph 7. The small reduction in soil moisture under P12 conditions is due to the loss of groundwater seepage (due to the drawdown in groundwater levels near the excavation). Under baseline conditions, groundwater seepage occurs as water levels rise in the late spring in response to snowmelt. Seepage fluctuates significantly, however, due to natural inter-annual climate variability. During a dry year (2015-2016) groundwater levels are naturally low, there is limited groundwater seepage, and a very minor difference in soil moisture between Baseline and P12. During an average year (2017-2018) there is small change in the late summer soil moisture conditions due to the loss of groundwater discharge during P12 development. During a wet year there is a modest loss of soil moisture in the May-September time frame. Additional surface water and ground water interaction occurs through the bottom of the ponded water portions of Wetland 20. Pond leakage to the groundwater system is shown in Graph 8. Negative seepage indicates groundwater is upwelling into the pond. Under Baseline conditions, the ponds leak water to the groundwater system for most of the year, and only receive upwelling (negative leakage or seepage) for short periods during the wetter years when the water table is higher. Under P12 conditions (red line), the ponds leak water to the groundwater system at varying rates throughout the year; generally higher in the spring and declining through the summer.</td><td>Graphs 7 & 8</td><td></td><td></td></tr>
<tr><td>Potential Impact to Form and Function of Feature:</td><td>No wetlands will be removed and the wetlands subcatchment will be protected. There will be no encroachment from the project into the wetland. The proposed limit of extraction is >120 m from the wetland boundary. Licensed boundary will be demarcated and fenced to ensure site construction and operations do not extend beyond the proposed limits of the project .</td><td></td><td></td><td></td></tr>
</table>

Mitigation (Operational Phases 1 & 2)	Description	Figure / Graph	Reference	
			Report	Section / Page
Proposed Mitigation Measures:	None required.			

Impact Assessment (Operations Phases 3 - 6)	Description	Figure / Graph	Reference	
			Report	Section / Page
Change in Wetland Area (ha):	No change. Wetland located greater than 120 m from licensed boundary.		SWA (Tatham, April 2020)	4.2.1
Change in Wetland Catchment Area (ha):	No change. Subcatchment area protected.		SWA (Tatham, April 2020)	4.2.1 & Drawing DP-2
Change in Hydroperiod:	No Change. Wetland is perched and isolated from the groundwater system. Subcatchment area being protected.		SWA (Tatham, April 2020)	4.2.1
Change in Water Budget:	A detailed average water budget as simulated by the integrated model is provided in the Earthfx report for Baseline Conditions (Figure 7.28, p. 188); Scenario P12 (Figure 8.35, p. 223); P3456 (Figure 8.67, p. 250); RHB1 (Figure 8.102, p. 279), and RHB2 (Figure 8.129, p. 300). The water budget results for Scenario P3456 are reproduced in Figure 2c. Simulated change in groundwater levels (drawdowns), groundwater discharge to riparian areas, and change in streamflow in the vicinity of Wetland 13037 (Earthfx Wetland 20) for each scenario are discussed in Section 8 of the main report.	Figure 2c	HHIAR (Earthfx, April 2020)	191 - 303
Potential Impact to Form and Function of Feature:	No wetlands will be removed and the wetlands subcatchment will be protected. There will be no encroachment from the project into the wetland. The proposed limit of extraction is >120 m from the wetland boundary. Licensed boundary will be demarcated and fenced to ensure site construction and operations do not extend beyond the proposed limits of the project .			

Wetland 13037	GW Outflow (%)	GW Inflow (%)	Δ in Outflow (%)	Δ in Inflow (%)
Baseline (Existing)	12.84	1.76	-	-
Operations Ph 3 - 6	16.29	0.00	3.45	-1.76

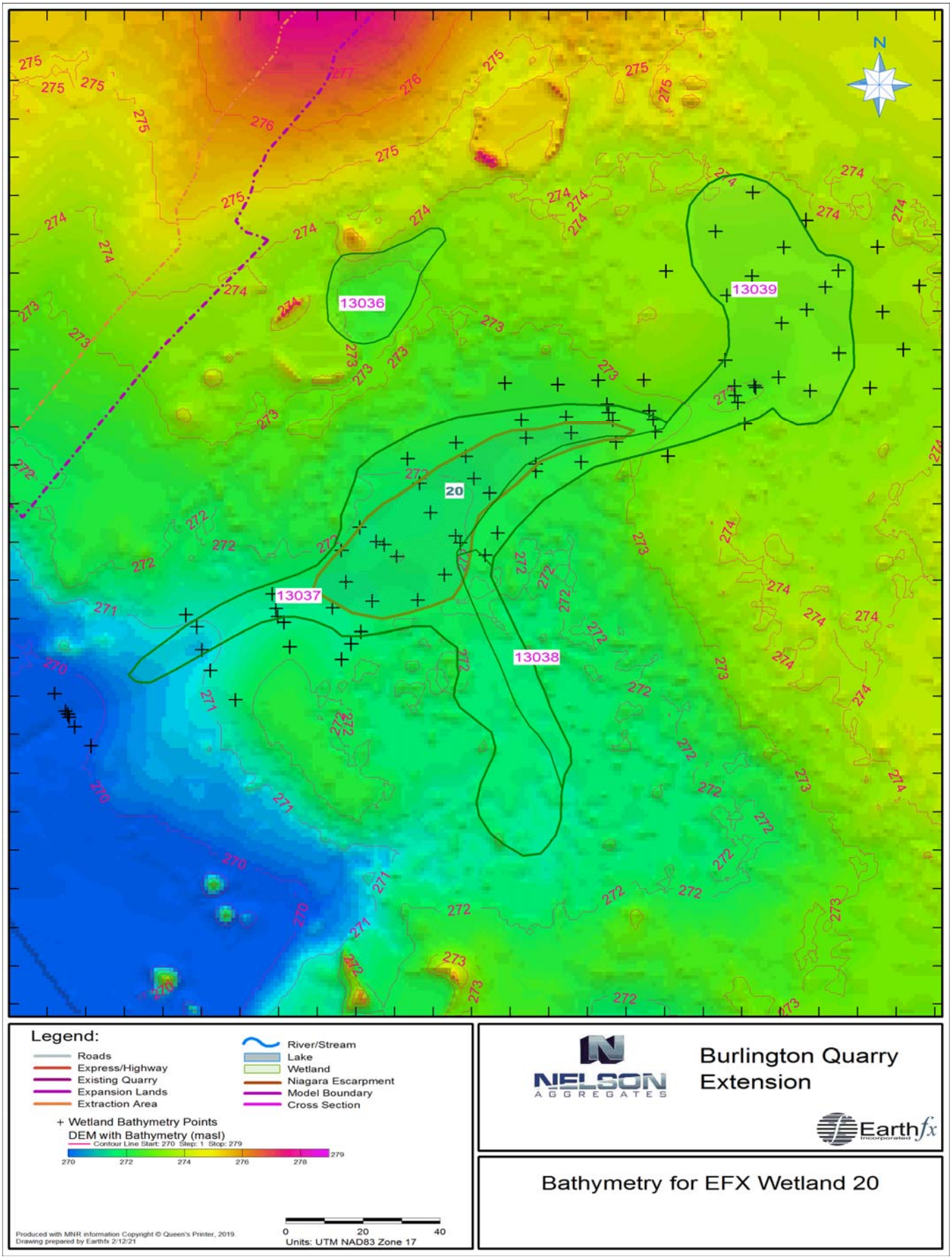
Mitigation (Operational Phases 3 - 6)	Description	Figure / Graph	Reference	
			Report	Section / Page
Proposed Mitigation Measures:	None required.			

Impact Assessment (Rehabilitation)	Description	Figure / Graph	Reference	
			Report	Section / Page
Change in Wetland Area (ha):	No change. Wetland located greater than 120 m from licensed boundary.		SWA (Tatham, April 2020)	5.4.1
Change in Wetland Catchment Area (ha):	No change. Subcatchment area protected.		SWA (Tatham, April 2020)	5.4.1 & Drawing DP-3
Change in Hydroperiod:	No Change. Wetland is perched and isolated from the groundwater system. Subcatchment area being protected.		SWA (Tatham, April 2020)	5.4.1
Change in Water Budget:	A detailed average water budget as simulated by the integrated model is provided in the Earthfx report for Baseline Conditions (Figure 7.28, p. 188); Scenario P12 (Figure 8.35, p. 223); P3456 (Figure 8.67, p. 250); RHB1 (Figure 8.102, p. 279), and RHB2 (Figure 8.129, p. 300). The water budget results for Scenarios RHB1 and RHB2 are reproduced in Figures 2d and 2e. Simulated change in groundwater levels (drawdowns), groundwater discharge to riparian areas, and change in streamflow in the vicinity of Wetland 13037 (Earthfx Wetland 20) for each scenario are discussed in Section 8 of the main report.	Figure 2d and 2e	HHIAR (Earthfx, April 2020)	191 - 303
Potential Impact to Form and Function of Feature:	No wetlands will be removed and the wetlands subcatchment will be protected. There will be no encroachment from the project into the wetland. The proposed limit of extraction is >120 m from the wetland boundary. Licensed boundary will be demarcated and fenced to ensure site construction and operations do not extend beyond the proposed limits of the project .			

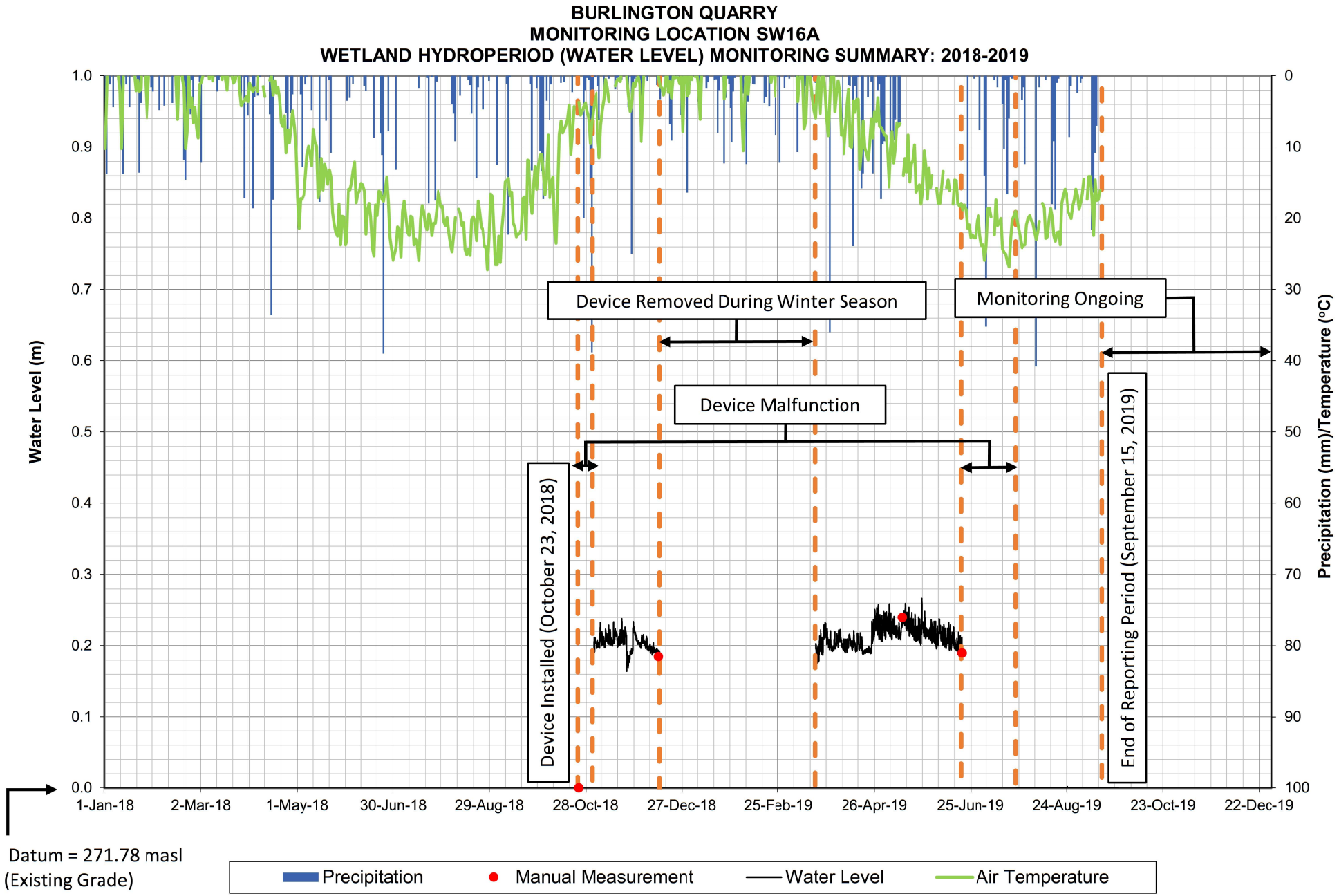
Wetland 13037	GW Outflow (%)	GW Inflow (%)	Δ in Outflow (%)	Δ in Inflow (%)
Baseline (Existing)	12.84	1.76	-	-
Rehab Scenario 1	15.85	0.17	3.01	-1.59
Rehab Scenario 2	14.91	0.22	2.07	-1.54

Mitigation (Rehabilitation)	Description	Figure / Graph	Reference	
			Report	Section / Page
Proposed Mitigation Measures:	None required.			

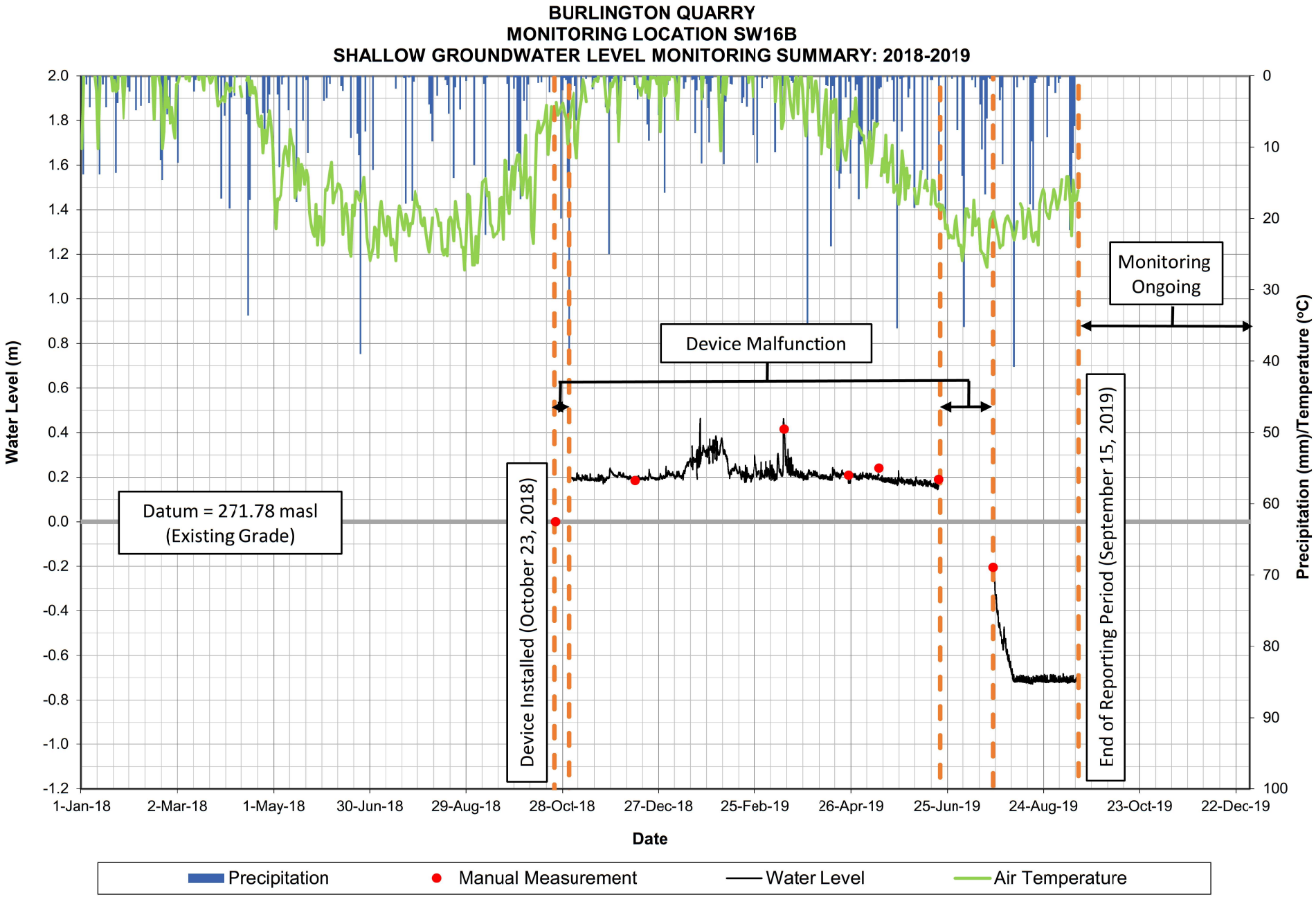
WETLAND 13037 - FIGURE 1



WETLAND 13037 - GRAPH 1

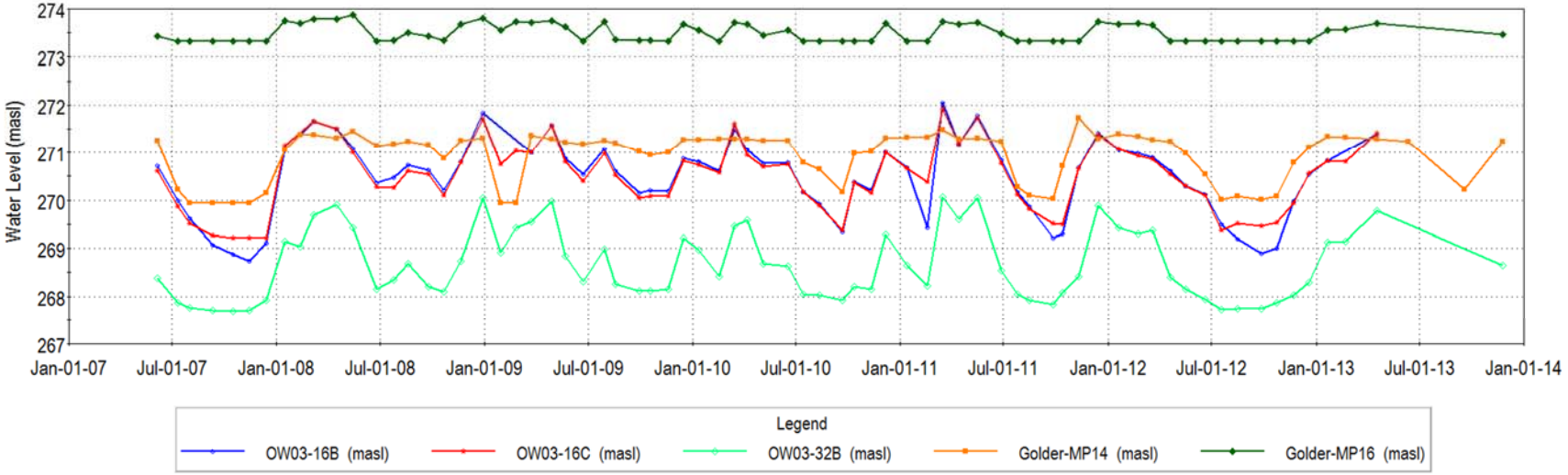


WETLAND 13037 - GRAPH 2



WETLAND 13037 - GRAPH 3

Shallow and Deep Groundwater Hydrographs
Wetland 13037



WETLAND 13037

FIGURE 2A

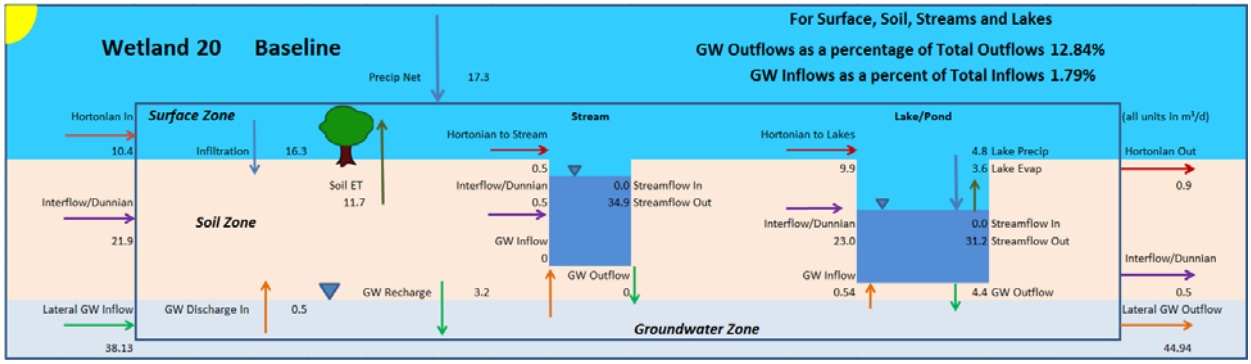


FIGURE 2B

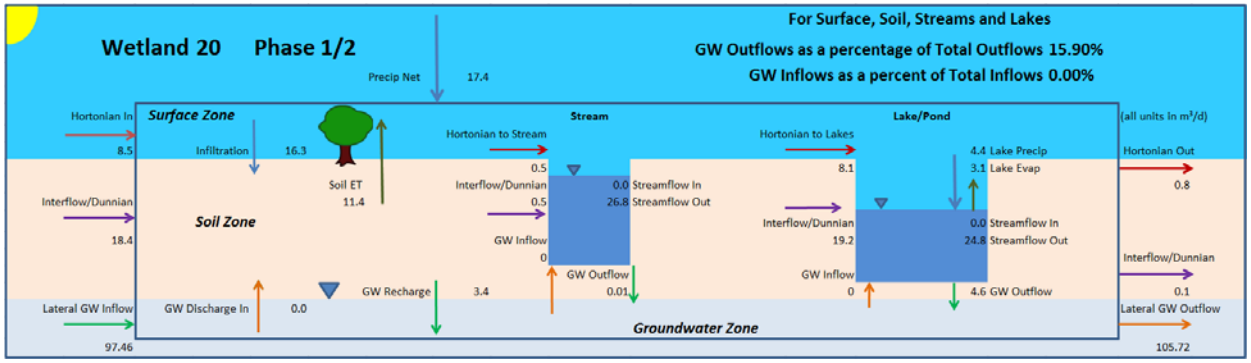


FIGURE 2C

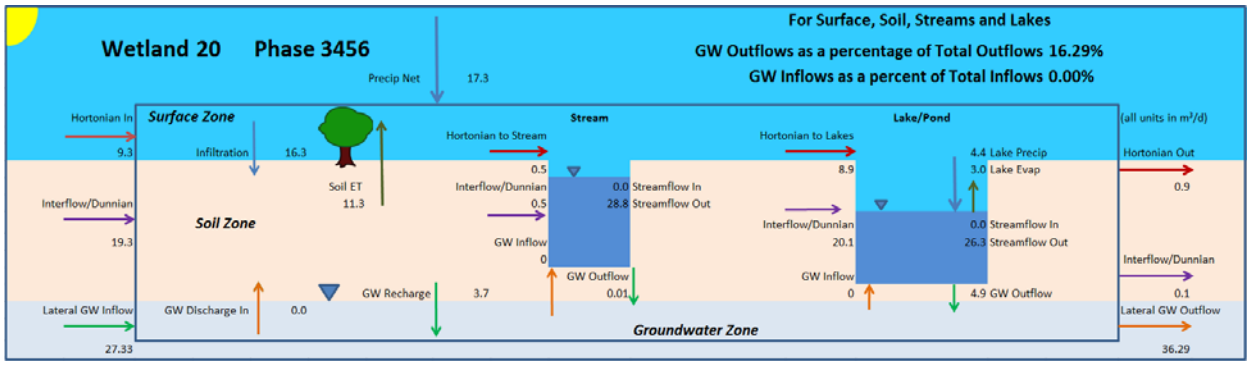


FIGURE 2D

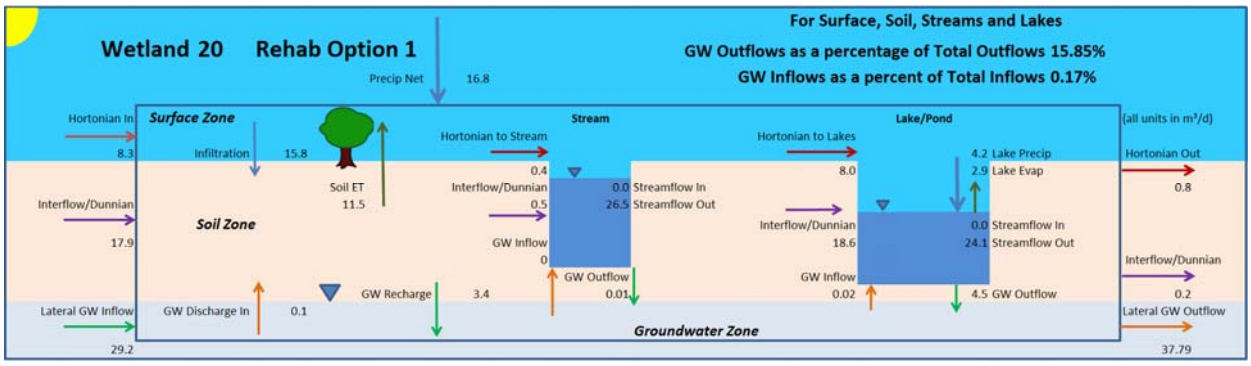
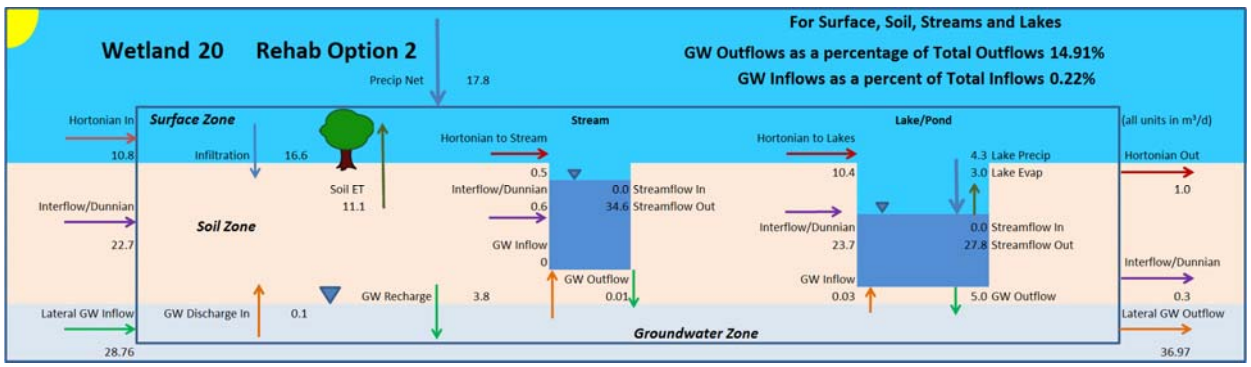
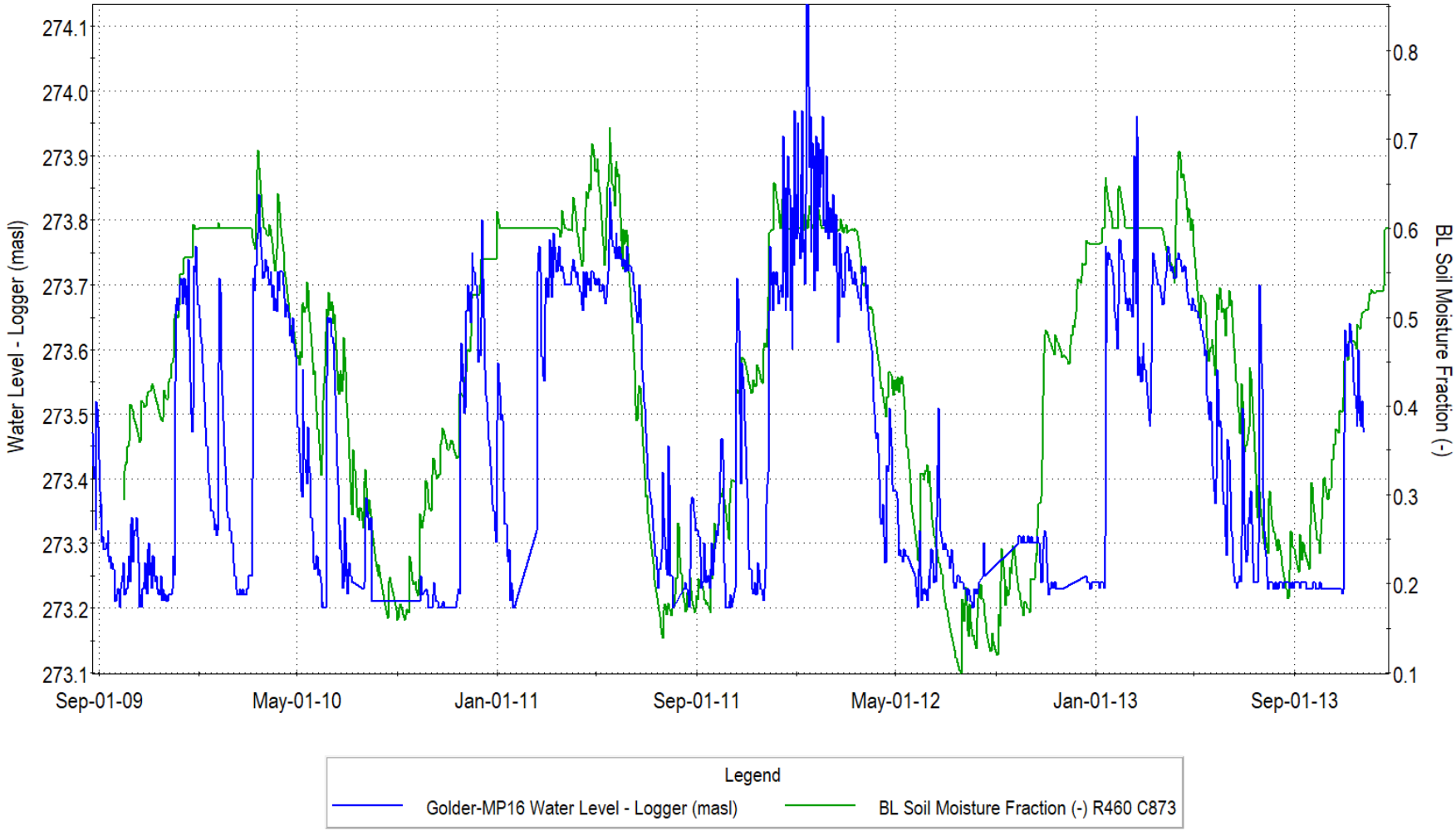


FIGURE 2E



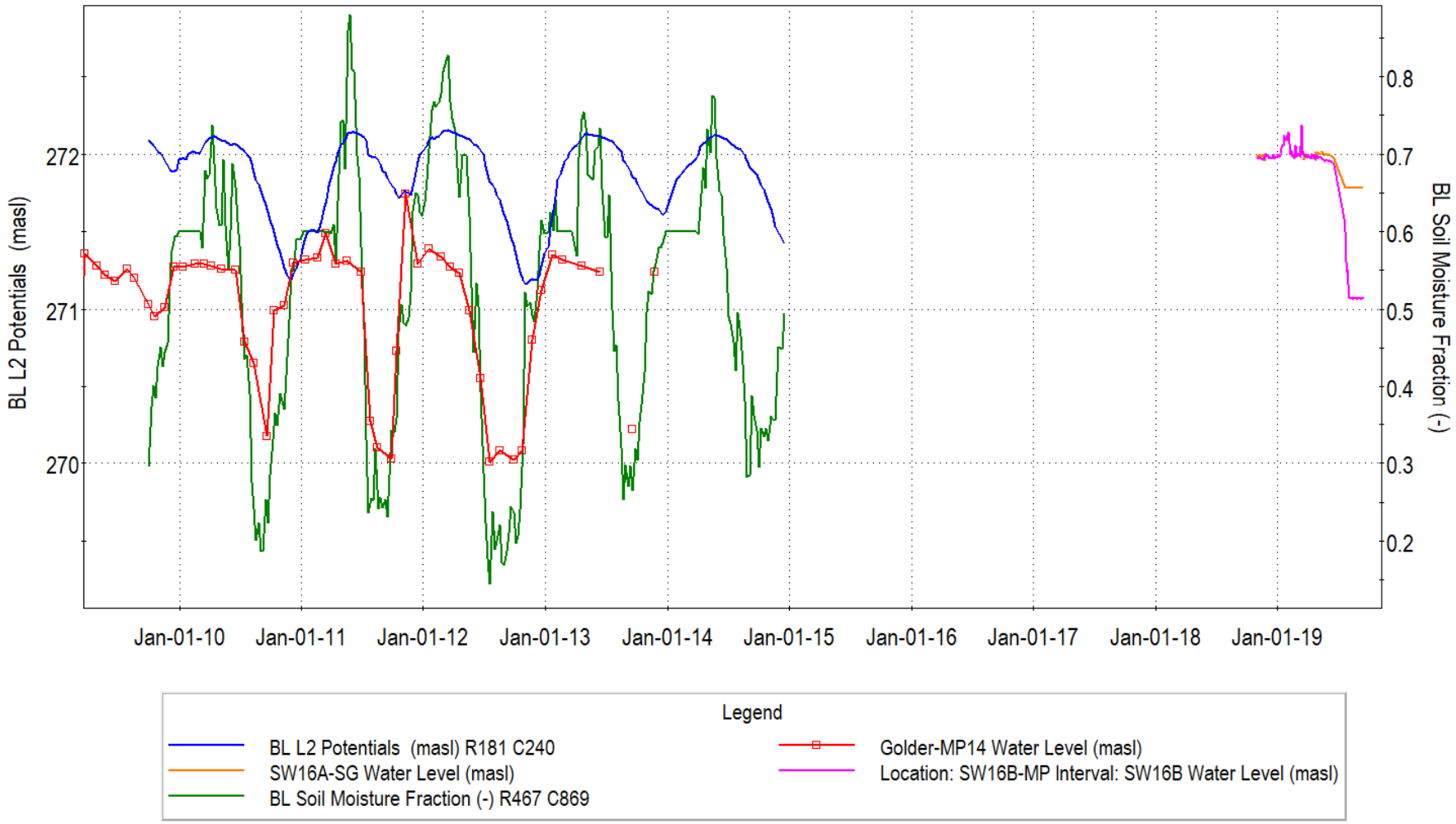
WETLAND 13037 - GRAPH 4

Integrated Model Calibration
Wetland 13037



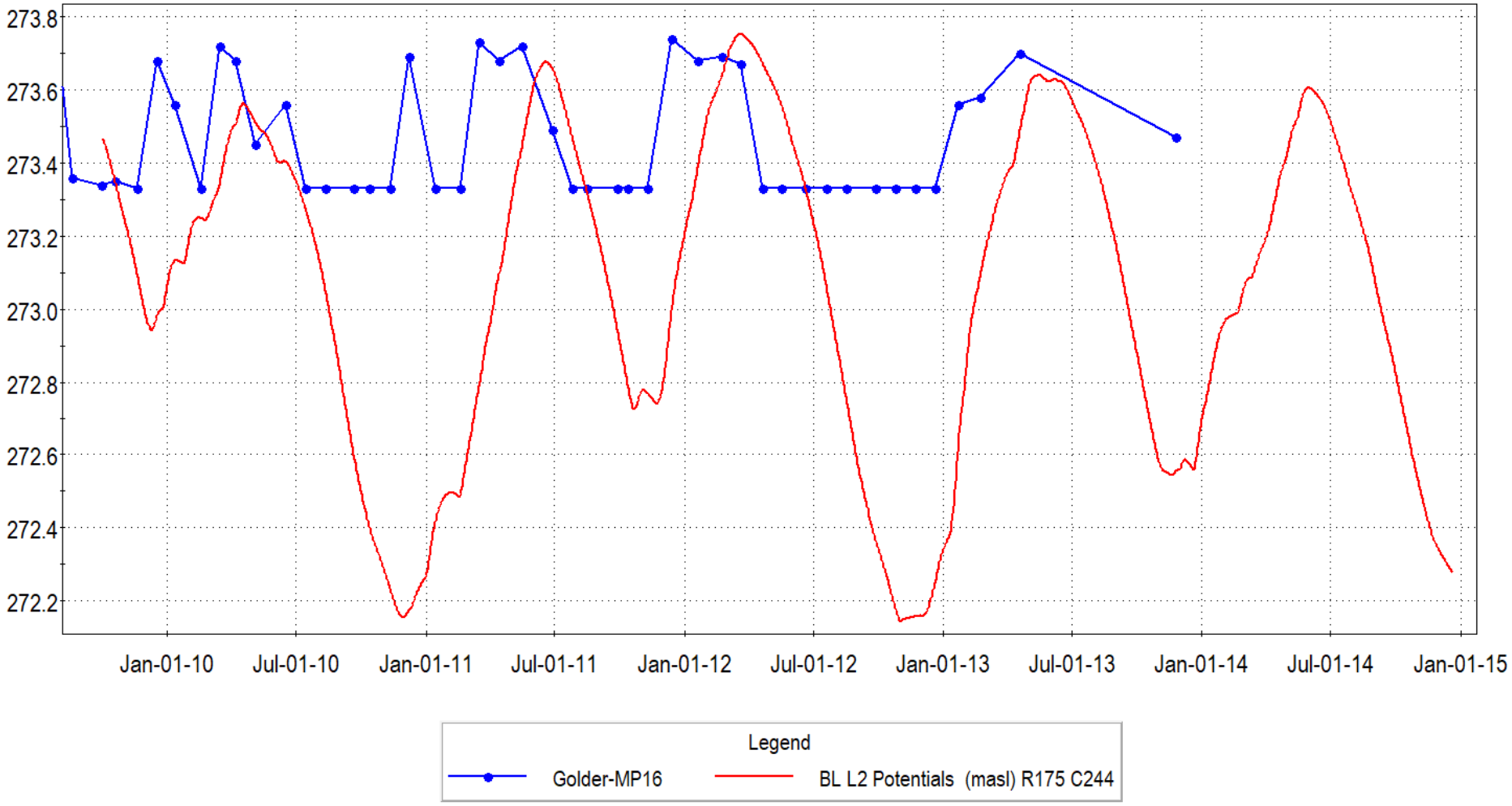
WETLAND 13037 - GRAPH 5

Integrated Model Calibration
Wetland 13037



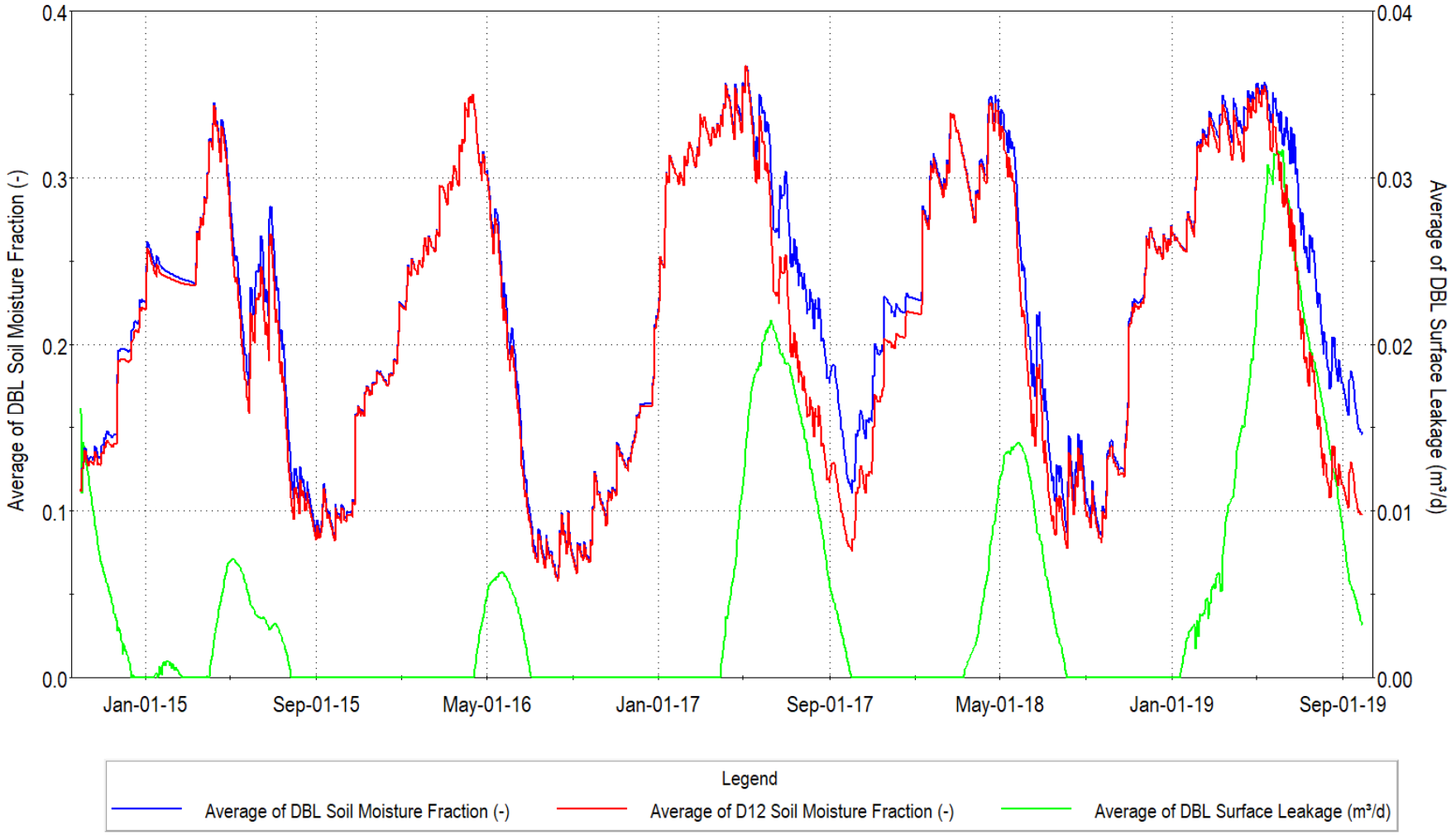
WETLAND 13037 - GRAPH 6

Integrated Model Calibration
Wetland 13037



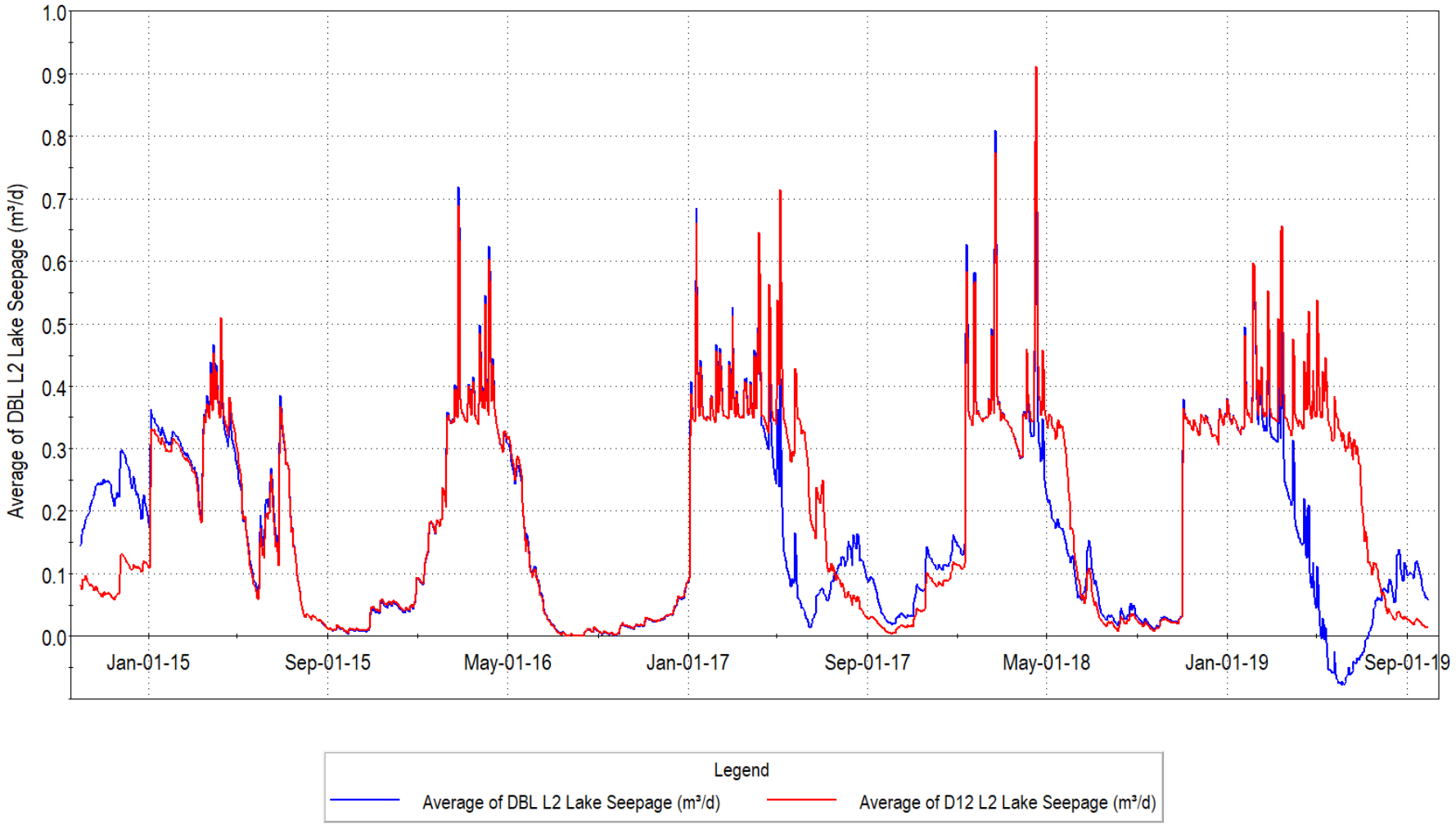
WETLAND 13037 - GRAPH 7

Change in Soil Moisture Conditions
Wetland 13037

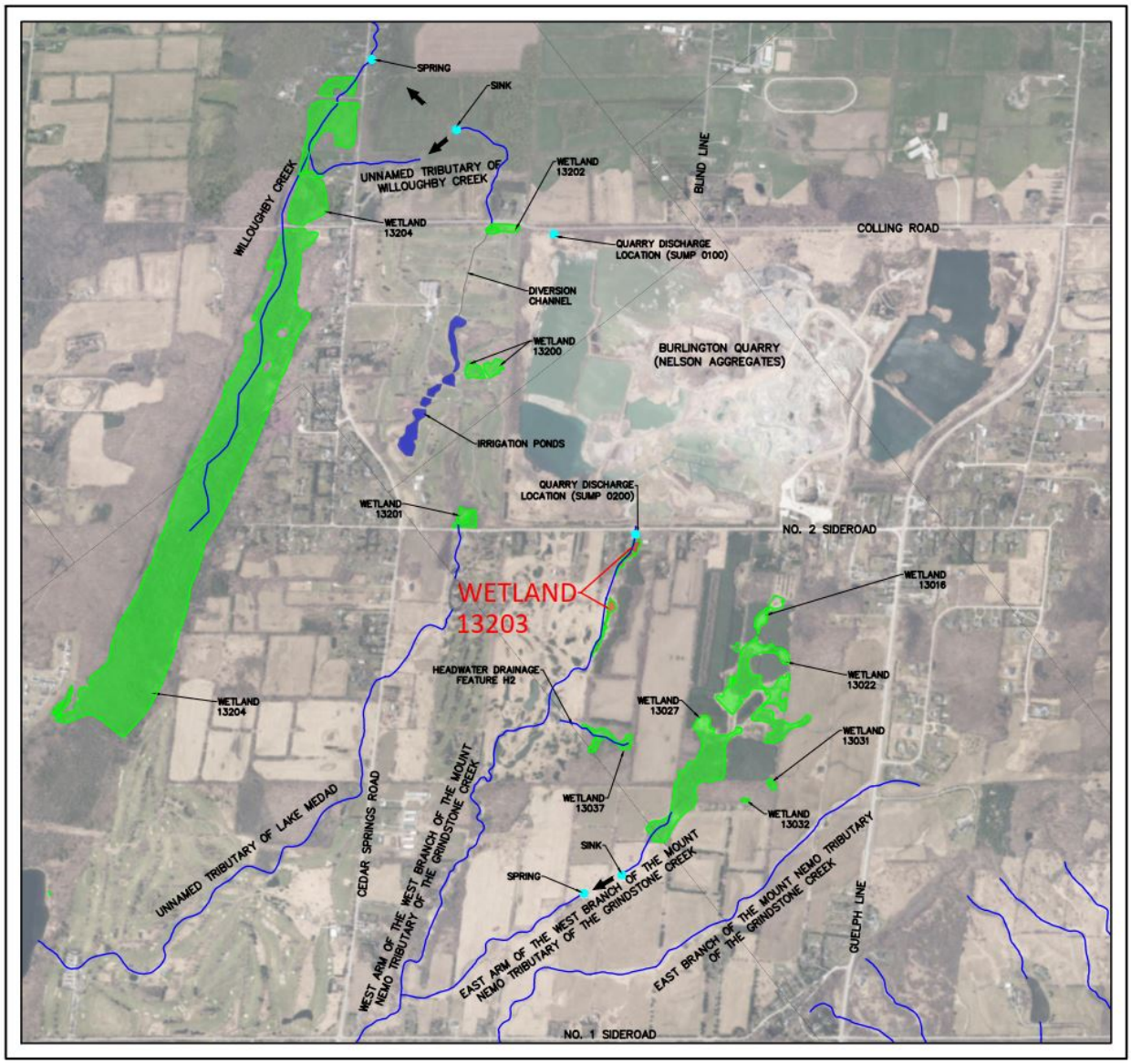


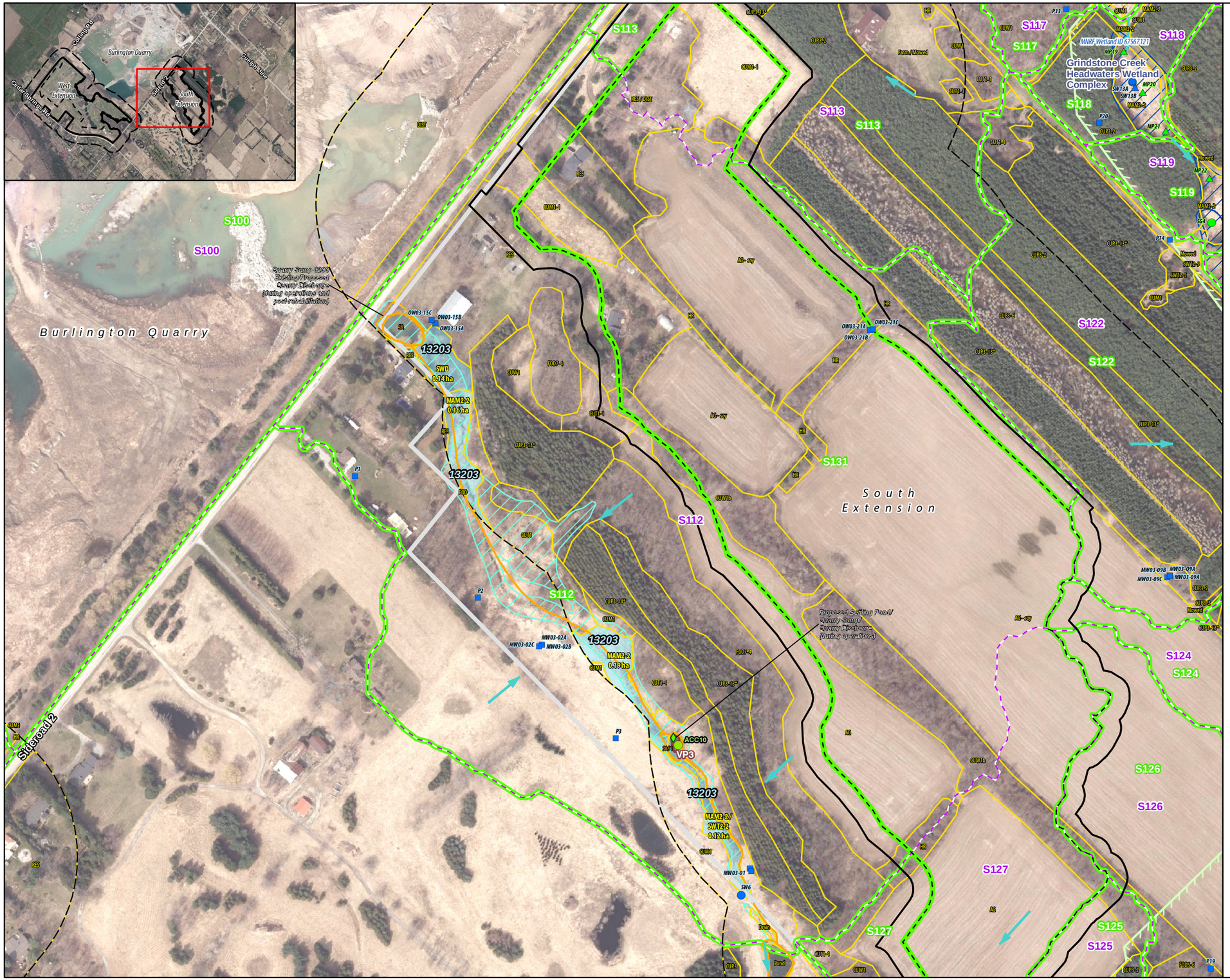
WETLAND 13037 - GRAPH 8

Change in Soil Moisture Conditions
Wetland 13037



WETLAND 13203





Legend

- Licensed Boundary
- Limit of Extraction
- 120 m Adjacent Lands
- Subject Lands
- Amphibian Call Count Station (2019)
- Salamander Trap (2019)
- Salamander Habitat Assessment (2019)
- Direct Fish Habitat
- Existing Subcatchment Boundary (Tatham Engineering, 2020)
- Proposed Subcatchment Boundary - Operations and Post-Rehabilitation (Tatham Engineering, 2020
- Wetland (Savanta, 2020)
- Ecological Land Classification (Savanta, 2019 & 2020)
- Ecological Land Classification (Savanta, 2020)
- Provincially Significant Wetland (LIO/MNRF, 2020)
- Wetland - Not Evaluated per OWES (MNRF/LIO, 2020)
- MECP Jefferson Salamander Regulated Habitat

Current Instrumentation

- Groundwater Monitoring Station (EarthFx)
- Mini Piezometer (Tatham Engineering)
- Staff Gauge & Surface Water Monitoring Station (Tatham Engineering)

Previous Instrumentation

- Mini Piezometer (Golder)
- Staff Gauge & Surface Water Monitoring Station (Golder)

ELC Legend

AG, Agriculture
CUM1, Mineral Cultural Meadow
CUM1-1, Dry Moist Old Field Meadow
CUP3, Coniferous Plantation
CUP3-2, White Pine Coniferous Plantation
CUP3-6, European Larch Coniferous Plantation
CUP3-13*, White Spruce Coniferous Plantation
CUP3-14*, White Cedar Coniferous Plantation
CUT1, Mineral Cultural Thicket
CUT1-1, Sumac Cultural Thicket
CUW1, Mineral Cultural Woodland
DIST, Disturbed
FOD, Deciduous Forest
FOD5-6, Dry- Fresh Sugar Maple-Basswood Deciduous Forest
FOD7-4, Fresh – Moist Black Walnut Lowland Deciduous Forest
HR, Hedgerow
MAM2-2, Reed-canary Grass Mineral Meadow Marsh
RES, Residential
SA, Shallow Aquatic
SAS1, Submerged Shallow Aquatic
SWD, Deciduous Swamp
SWT2-2, Willow Mineral Thicket Swamp
SWT2-5, Red-osier Dogwood Mineral Thicket Swamp
SWT2-9, Gray Dogwood Mineral Thicket Swamp

NOTES:

1. Coordinate System: NAD 1983 UTM Zone 17N.
2. Base features produced under license with the Ontario Ministry of Natural Resources and Forestry © Queen's Printer for Ontario, 2021.
3. Orthoimagery © First Base Solutions, 2021. Imagery taken in 2019.

Project 8133

Burlington Quarry Extension
Nelson Aggregates Co.

Figure 6
Wetland Characterization

Wetland 13203 - South Extension

0 50 m
1:3,000

N

GEI Consultants
Savanta Division

Wetland 13203

Wetland Characteristics	Description	Figure / Graph	Reference	
			Report	Section / Page
Wetland IDs:	MNRF – N/A (OGF ID 67196365, 67196392, 67196289) Earthfx - 18 Tatham - 13203 Savanta - 13203 Golder (Background) - N/A			
Wetland Area (ha):	LIO/MNRF – 1.84 (includes wetland area outside 120 m adjacent lands) Savanta – 0.61 (excludes wetland area outside 120 m adjacent lands)			
Watershed:	Grindstone Creek Watershed			
Sub-Watershed:	West Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek			
Located in Proposed Limit of Extraction:	No			
Located in Proposed License Boundary:	No			
Catchment Area (ha):	26.2 + quarry discharge (Sump 0200)		SWA (Tatham, April 2020)	Drawing DP-1
Catchment ID:	S112		SWA (Tatham, April 2020)	Drawing DP-1
Closed or Connected System:	On-line (connected to downstream watercourse)			
Condition:	Modified			
Bathymetry:	A bathymetric survey of Wetland 13202 has not been completed.			
Outlet:	West Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek			
Hydroperiod:	Water level in Wetland 13203 maintained by quarry discharge. When quarry discharge ceases, flow through West Arm ceases.		SWA (Tatham, April 2020)	2.1.2, 3 and Appendix C
Surface Water Monitoring:	ID: SW6 (Tatham) Installation Date: September 19, 2014 Data Collection: Continuous water level and temperature, manual monthly in-situ streamflow measurements and calibration data (water level converted to flow using rating curve) Coordinates of Monitoring Station: Easting 590629.123, Northing 4805071.124	Graph 1	SWA (Tatham, April 2020)	2.1.2 and Appendix C

Natural Heritage and Habitat Features	Description	Figure / Graph	Reference	
			Report	Section / Page
Wetland Name & Provincial Significance Evaluation:	Wetland 13203 – Other (as determined by MNRF and it is completely dependent on pumping from the existing quarry; however it has been designed to demonstrate no negative impacts.)		NETR (Savanta, April 2020)	6.1.2
ELC Unit(s):	Shallow Aquatic: SA Submerged Shallow Aquatic: SAS1 Deciduous Swamp: SWD Reed-canary Grass Mineral Meadow Marsh: MAM2-2 Reed-canary Grass Mineral Meadow Marsh / Willow Mineral Thicket Swamp: MAM2-2 / SWT2-2		NETR (Savanta, April 2020)	Table 2
Regulated Habitat (MECP):	No		NETR (Savanta, April 2020)	6.7
Significant Wildlife Habitat:	Confirmed for amphibian breeding (woodland) – SAS1. Salamander species absent, despite survey effort including salamander habitat assessment, salamander trapping and egg mass surveys.		NETR (Savanta, April 2020)	4.2.2; 4.2.3; 4.2.5; 5.2.2; 5.2.3; 5.2.5; 6.4; Table 19
Fish Habitat:	Indirect		NETR (Savanta, April 2020)	6.6
Habitat of Endangered and Threatened Species:	No species at risk salamanders observed, despite survey effort including salamander habitat assessment, salamander trapping and egg mass surveys.		NETR (Savanta, April 2020)	4.2.2; 4.2.3; 5.2.2; 5.2.3; 6.7

<table>
<tr><th>Groundwater Interaction</th><th>Description</th><th>Figure / Graph</th><th colspan="2">Reference</th></tr>
<tr><th></th><th></th><th></th><th>Report</th><th>Section / Page</th></tr>
<tr><td>Lithology:</td><td>Halton Till</td><td></td><td></td><td></td></tr>
<tr><td>Hydraulic Conductivity:</td><td>Integrated Model (Earthfx) - The harmonic mean hydraulic conductivity, based on testing by Golder (2007) of 10 mini-piezometers, was 1.2x10^{-8} m/s. Model value for the vertical hydraulic conductivity was 1.6x10^{-7} m/s, about an order of magnitude higher, to account for limited flow through fractures in the till.</td><td></td><td></td><td></td></tr>
<tr><td>Surface Water/Groundwater Interaction:</td><td>The low permeability of the Halton Till underlying the wetland is the dominant control on 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. This wetland receives some groundwater inflow but is generally isolated from any changes in the water table due to quarry development.</td><td></td><td></td><td></td></tr>
<tr><td>Groundwater Monitoring (Monitoring Wells):</td><td>
<table>
<tr><th>Monitoring Well ID</th><th>Distance (Dir.)</th><th>Geologic Unit</th><th>Ground Elevation</th><th>Monitoring Elev</th><th>Average WL</th></tr>
<tr><td>MW03-01A</td><td>227 (SW)</td><td>Bedrock</td><td>270.94</td><td>251.9 – 247.7</td><td>269.33</td></tr>
<tr><td>MW03-01B</td><td>227 (SW)</td><td>Bedrock</td><td>270.94</td><td>261.8 – 256.8</td><td>269.37</td></tr>
<tr><td>MW03-01C</td><td>227 (SW)</td><td>Bedrock</td><td>270.97</td><td>270.4 - 269.5</td><td>270.13</td></tr>
<tr><td>MW03-02A</td><td>36 (E)</td><td>Bedrock</td><td>272.48</td><td>251.8 – 247.8</td><td>259.76</td></tr>
<tr><td>MW03-02B</td><td>36 (E)</td><td>Bedrock</td><td>272.48</td><td>260.9 – 256.6</td><td>262.02</td></tr>
<tr><td>MW03-02C</td><td>36 (E)</td><td>Bedrock</td><td>272.54</td><td>270.0 – 268.4</td><td>269.89</td></tr>
<tr><td>OW03-15A</td><td>226 (NNE)</td><td>Bedrock</td><td>275.12</td><td>256.8 – 250.0</td><td>259.11</td></tr>
<tr><td>OW03-15B</td><td>226 (NNE)</td><td>Bedrock</td><td>275.12</td><td>269.2 – 264.9</td><td>268.97</td></tr>
<tr><td>OW03-15B</td><td>226 (NNE)</td><td>Bedrock</td><td>275.13</td><td>273.2 – 271.6</td><td>272.93</td></tr>
</table>
</td><td>Graphs 2, 3 & 4</td><td></td><td></td></tr>
<tr><td>Water Budget Results:</td><td>A detailed average water budget, as simulated by the integrated model, is provided in the main report for Baseline Conditions (Earthfx Figure 7.26, p. 187). The baseline water budget is reproduced in Figure 1a. The wetland is a net provider of groundwater. Simulated groundwater levels, groundwater discharge to riparian areas, and streamflow in the vicinity of Wetland 18 for baseline conditions are discussed in Section 7 of the main report.
<table>
<tr><th>Wetland 13203</th><th>GW Outflow (%)</th><th>GW Inflow (%)</th></tr>
<tr><td>Baseline (Existing)</td><td>5.98</td><td>2.42</td></tr>
</table>
</td><td>Figure 1a</td><td>HHIAR (Earthfx, April 2020)</td><td>165 - 190</td></tr>
<tr><td>Integrated Model Calibration:</td><td>No mini-piezometers for calibration. The model is replicating the dewatering effects of the existing quarry at the north end of the wetland (see Graph 5). Water level calibration at the south end of wetland is reasonable (see Graph 6). There is some uncertainty in the calibration because records and operations of south quarry discharge are intermittent. Wetland 13203 is not discussed in the Main Report. Other nearby wetlands are discussed in Appendix E, Section 19.6.</td><td>Graphs 5 & 6</td><td></td><td></td></tr>
</table>

<table>
<tr><th>Impact Assessment (Operations Phases 1 & 2)</th><th>Description</th><th>Figure / Graph</th><th colspan="2">Reference</th></tr>
<tr><th></th><th></th><th></th><th>Report</th><th>Section / Page</th></tr>
<tr><td>Change in Wetland Area (ha):</td><td>No change.</td><td></td><td></td><td></td></tr>
<tr><td>Change in Wetland Catchment Area (ha):</td><td>Reduction in catchment area. During operations in Phases 1 and 2 the catchment area will be reduced to 14.5 ha (reduction of 11.7 ha)</td><td></td><td>SWA (Tatham, April 2020)</td><td>Drawing DP-2</td></tr>
<tr><td>Change in Hydroperiod:</td><td>No change in hydroperiod expected as quarry discharge maintains wetland water levels.</td><td></td><td></td><td></td></tr>
<tr><td>Change in Water Budget:</td><td>A detailed average water budget as simulated by the integrated model is provided in the Earthfx report for Baseline Conditions (Figure 7.26, p. 187); Scenario P12 (Figure 8.33, p. 222); P3456 (Figure 8.65, p. 249); RHB1 (Figure 8.101, p. 278), and RHB2 (Figure 8.126, p. 300). The water budget results for Scenario P12 are reproduced in Figure 1b. Simulated change in groundwater levels (drawdowns), groundwater discharge to riparian areas, and change in streamflow in the vicinity of Wetland 13203 (Earthfx Wetland 18) for each scenario are discussed in Section 8 of the main report.
<table>
<tr><td>Wetland 13203</td><td>GW Outflow (%)</td><td>GW Inflow (%)</td><td>Δ in Outflow (%)</td><td>Δ in Inflow (%)</td></tr>
<tr><td>Baseline (Existing)</td><td>5.98</td><td>2.42</td><td>-</td><td>-</td></tr>
<tr><td>Operations Ph 1 & 2</td><td>9.95</td><td>0.00</td><td>3.97</td><td>-2.42</td></tr>
</table></td><td>Figure 1b</td><td>HHIAR (Earthfx, April 2020)</td><td>191 - 303</td></tr>
<tr><td>Change on Soil Moisture Conditions:</td><td>The soil moisture and surface discharge patterns in Wetland 18 are shown in Graph 7. There will only be a minimal change in soil moisture conditions under P12 conditions. Note that the Baseline groundwater inflow as a percentage of total inflows is only 2.42% (the right-hand scale range is very small).</td><td>Graph 7</td><td></td><td></td></tr>
<tr><td>Potential Impact to Form and Function of Feature:</td><td>Both the pond and the wetland will remain in place. There will be no encroachment from the project into the wetlands. Proposed limit of extraction is >30 m from the wetland boundary. The extraction limit will be demarcated and fenced to ensure site construction and operations do not extend beyond the proposed limits of the project .</td><td></td><td>NETR (Savanta, April 2020)</td><td>7.2.1; 7.1.1; 7.1.2</td></tr>
</table>

Mitigation (Operational Phases 1 & 2)	Description	Figure / Graph	Reference	
			Report	Section / Page
Proposed Mitigation Measures:	The wetland is supplied with water by pumping from the existing adjacent quarry. The proposed quarry Extension is not anticipated to have any impact on pumping or water quality related to discharge from the existing quarry. Pumping and discharge are recommended to occur at the same location at the upstream end of the tributary and in the same manner as existing pumping.		NETR (Savanta, April 2020)	7.2.1; 7.1.1; 7.1.2

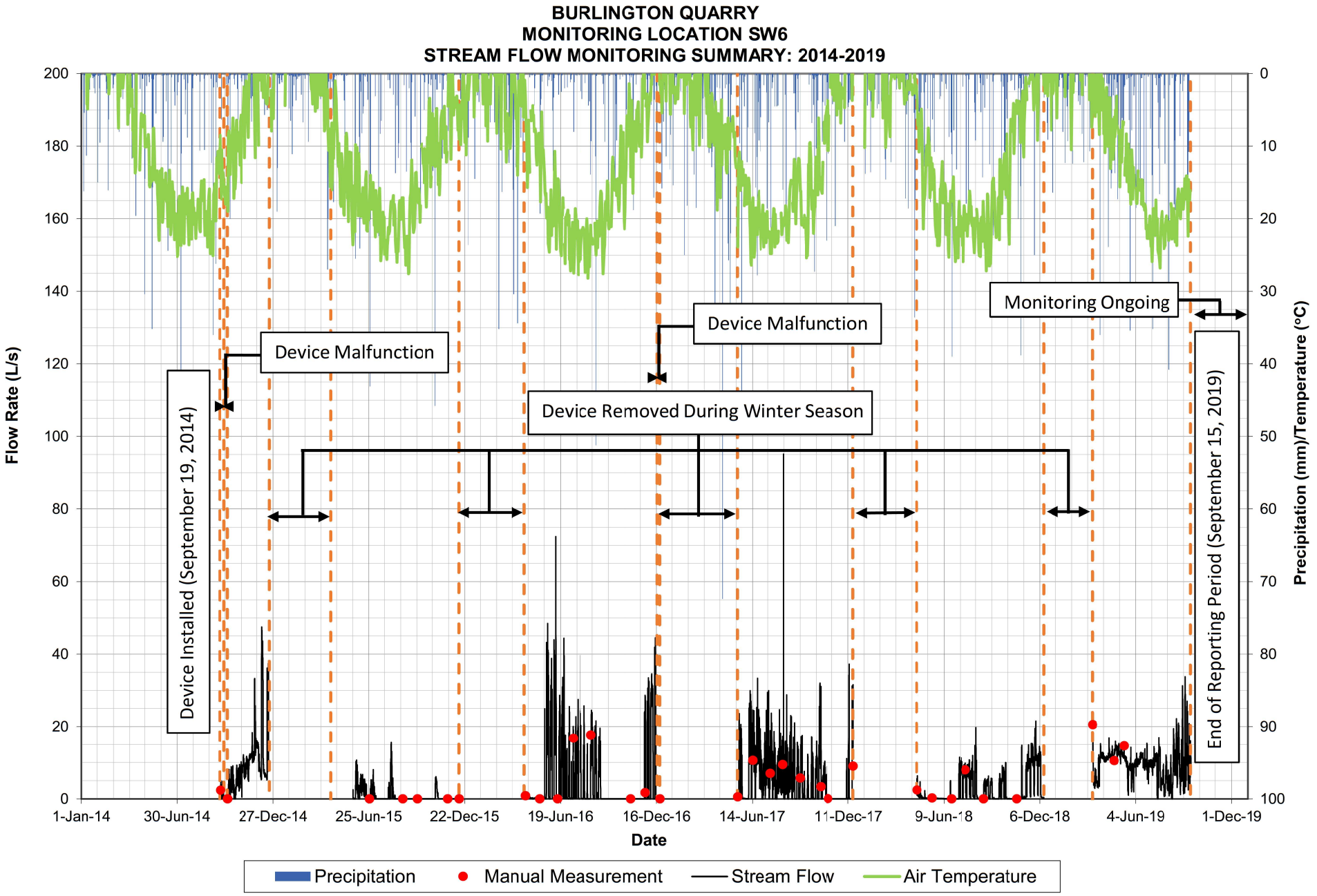
<table>
<tr><th>Impact Assessment (Operations Phases 3 - 6)</th><th>Description</th><th>Figure / Graph</th><th colspan="2">Reference</th></tr>
<tr><th></th><th></th><th></th><th>Report</th><th>Section / Page</th></tr>
<tr><td>Change in Wetland Area (ha):</td><td>No change.</td><td></td><td></td><td></td></tr>
<tr><td>Change in Wetland Catchment Area (ha):</td><td>Reduction in catchment area. During operations in Phases 1 and 2 the catchment area will be reduced to 14.5 ha (reduction of 11.7 ha). This reduction in drainage area will remain long-term.</td><td></td><td>SWA (Tatham, April 2020)</td><td>Drawing DP-2</td></tr>
<tr><td>Change in Hydroperiod:</td><td>No change in hydroperiod expected as quarry discharge maintains wetland water levels.</td><td></td><td></td><td></td></tr>
<tr><td>Change in Water Budget:</td><td>A detailed average water budget as simulated by the integrated model is provided in the Earthfx report for Baseline Conditions (Figure 7.26, p. 187); Scenario P12 (Figure 8.33, p. 222); P3456 (Figure 8.65, p. 249); RHB1 (Figure 8.101, p. 278), and RHB2 (Figure 8.126, p. 300). The water budget results for Scenario P3456 are reproduced in Figure 1c. Simulated change in groundwater levels (drawdowns), groundwater discharge to riparian areas, and change in streamflow in the vicinity of Wetland 13203 (Earthfx Wetland 18) for each scenario are discussed in Section 8 of the main report.
<table>
<tr><td>Wetland 13203</td><td>GW Outflow (%)</td><td>GW Inflow (%)</td><td>Δ in Outflow (%)</td><td>Δ in Inflow (%)</td></tr>
<tr><td>Baseline (Existing)</td><td>5.98</td><td>2.42</td><td>-</td><td>-</td></tr>
<tr><td>Operations Ph 3 - 6</td><td>7.11</td><td>0.04</td><td>1.13</td><td>-2.38</td></tr>
</table></td><td>Figure 1c</td><td>HHIAR (Earthfx, April 2020)</td><td>191 - 303</td></tr>
<tr><td>Potential Impact to Form and Function of Feature:</td><td>Both the pond and the wetland will remain in place. There will be no encroachment from the project into the wetlands. Proposed limit of extraction is >30 m from the wetland boundary. The extraction limit will be demarcated and fenced to ensure site construction and operations do not extend beyond the proposed limits of the project .</td><td></td><td>NETR (Savanta, April 2020)</td><td>7.2.1; 7.1.1; 7.1.2</td></tr>
</table>

<table>
<tr><th>Mitigation (Operational Phases 3 - 6)</th><th>Description</th><th>Figure / Graph</th><th colspan="2">Reference</th></tr>
<tr><th></th><th></th><th></th><th>Report</th><th>Section / Page</th></tr>
<tr><td>Proposed Mitigation Measures:</td><td>The wetland is supplied with water by pumping from the existing adjacent quarry. The proposed quarry Extension is not anticipated to have any impact on pumping or water quality related to discharge from the existing quarry. Pumping and discharge are recommended to occur at the same location at the upstream end of the tributary and in the same manner as existing pumping.</td><td></td><td>NETR (Savanta, April 2020)</td><td>7.2.1; 7.1.1; 7.1.2</td></tr>
</table>

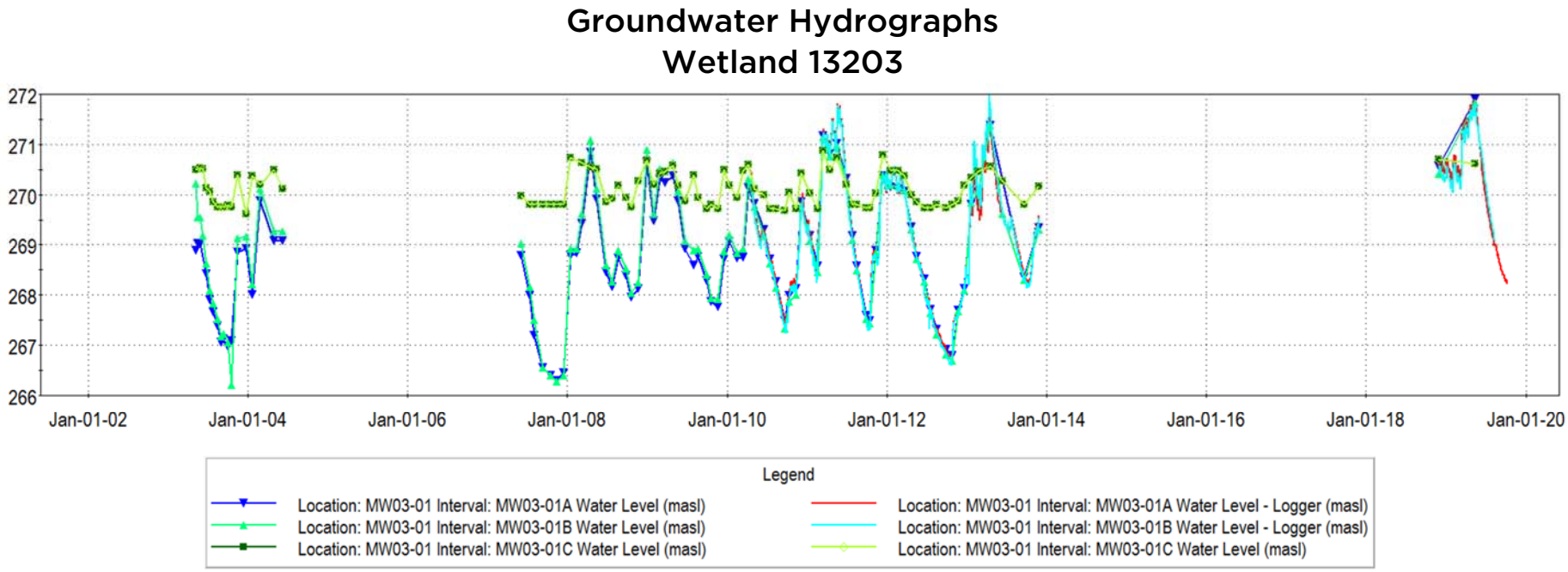
<table>
<tr><th>Impact Assessment (Rehabilitation)</th><th>Description</th><th>Figure / Graph</th><th colspan="2">Reference</th></tr>
<tr><th></th><th></th><th></th><th>Report</th><th>Section / Page</th></tr>
<tr><td>Change in Wetland Area (ha):</td><td>No change.</td><td></td><td></td><td></td></tr>
<tr><td>Change in Wetland Catchment Area (ha):</td><td>Reduction in catchment area. During operations in Phases 1 and 2 the catchment area will be reduced to 14.5 ha (reduction of 11.7 ha). This reduction in drainage area will remain long-term.</td><td></td><td>SWA (Tatham, April 2020)</td><td>Drawing DP-3</td></tr>
<tr><td>Change in Hydroperiod:</td><td>No change in hydroperiod expected as quarry discharge maintains wetland water levels.</td><td></td><td></td><td></td></tr>
<tr><td>Change in Water Budget:</td><td>A detailed average water budget as simulated by the integrated model is provided in the Earthfx report for Baseline Conditions (Figure 7.26, p. 187); Scenario P12 (Figure 8.33, p. 222); P3456 (Figure 8.65, p. 249); RHB1 (Figure 8.101, p. 278), and RHB2 (Figure 8.126, p. 300). The water budget results for Scenario RHB1 and RHB2 are reproduced below. Simulated change in groundwater levels (drawdowns), groundwater discharge to riparian areas, and change in streamflow in the vicinity of Wetland 13203 (Earthfx Wetland 18) for each scenario are discussed in Section 8 of the main report.
<table>
<tr><td>Wetland 13203</td><td>GW Outflow (%)</td><td>GW Inflow (%)</td><td>Δ in Outflow (%)</td><td>Δ in Inflow (%)</td></tr>
<tr><td>Baseline (Existing)</td><td>5.98</td><td>2.42</td><td>-</td><td>-</td></tr>
<tr><td>Rehab Scenario 1</td><td>5.19</td><td>1.36</td><td>-0.79</td><td>-1.06</td></tr>
<tr><td>Rehab Scenario 2</td><td>6.68</td><td>3.53</td><td>0.70</td><td>1.11</td></tr>
</table></td><td>Figure 1d and 1e</td><td>HHIAR (Earthfx, April 2020)</td><td>191 - 303</td></tr>
<tr><td>Potential Impact to Form and Function of Feature:</td><td>Both the pond and the wetland will remain in place. There will be no encroachment from the project into the wetlands. Proposed limit of extraction is >30 m from the wetland boundary. The extraction limit will be demarcated and fenced to ensure site construction and operations do not extend beyond the proposed limits of the project .</td><td></td><td>NETR (Savanta, April 2020)</td><td>7.2.1; 7.1.1; 7.1.2</td></tr>
</table>

Mitigation (Rehabilitation)	Description	Figure / Graph	Reference	
			Report	Section / Page
Proposed Mitigation Measures:	The wetland is supplied with water by pumping from the existing adjacent quarry. The proposed quarry Extension is not anticipated to have any impact on pumping or water quality related to discharge from the existing quarry. Pumping and discharge are recommended to occur at the same location at the upstream end of the tributary and in the same manner as existing pumping.		NETR (Savanta, April 2020)	7.2.1; 7.1.1; 7.1.2

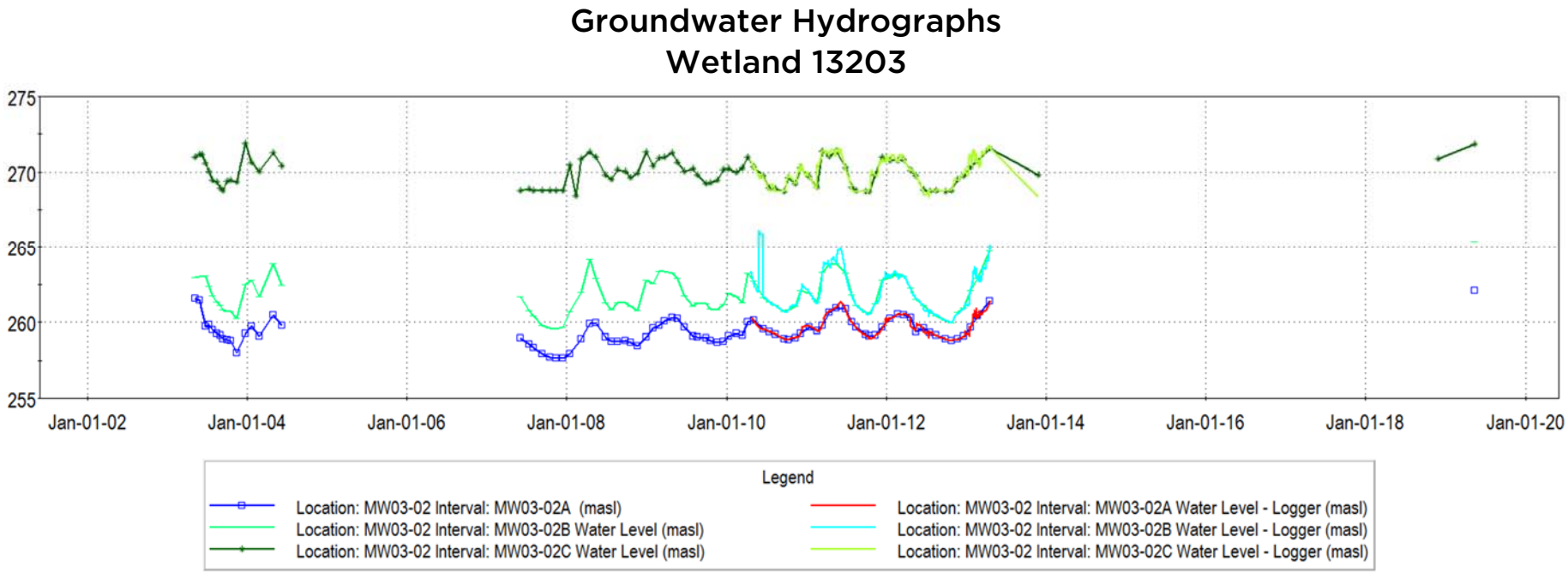
WETLAND 13203 - GRAPH 1



WETLAND 13203 - GRAPH 2

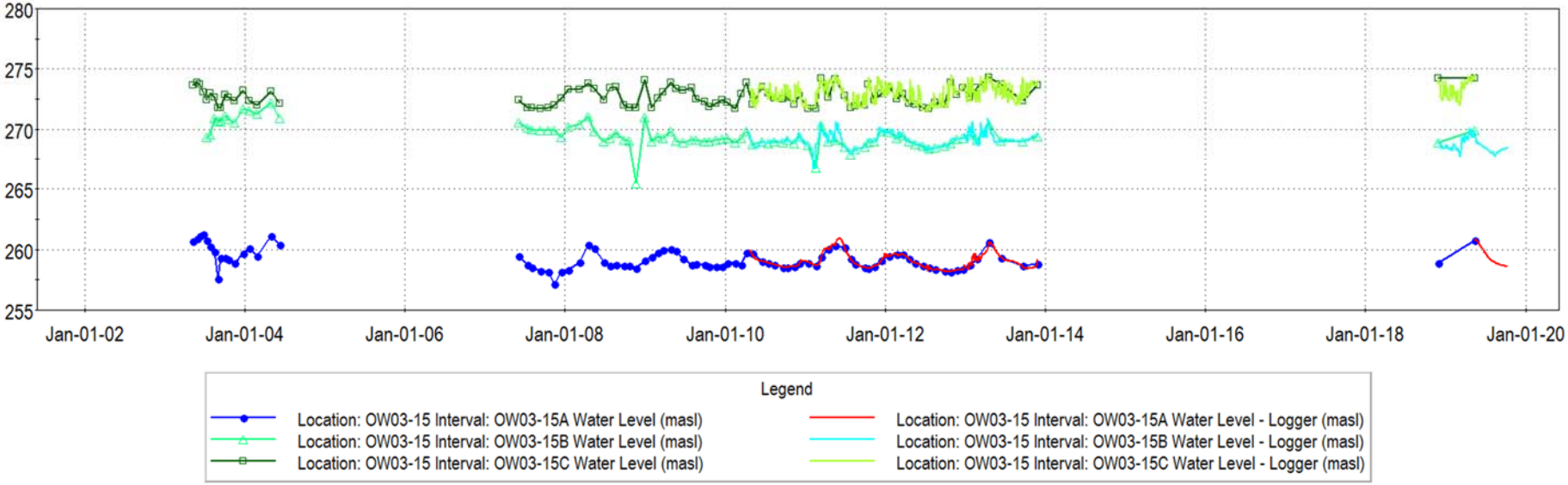


WETLAND 13203 - GRAPH 3



WETLAND 13203 - GRAPH 4

Groundwater Hydrographs
Wetland 13203



WETLAND 13203

FIGURE 1A

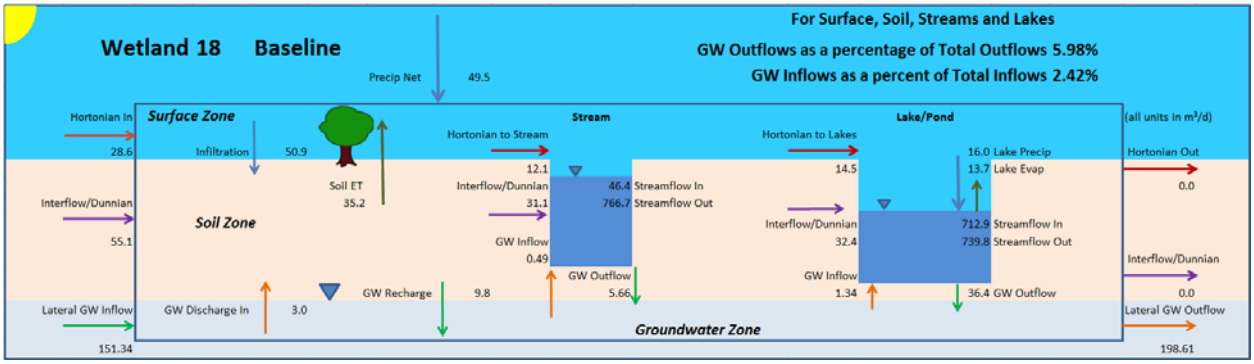


FIGURE 1B

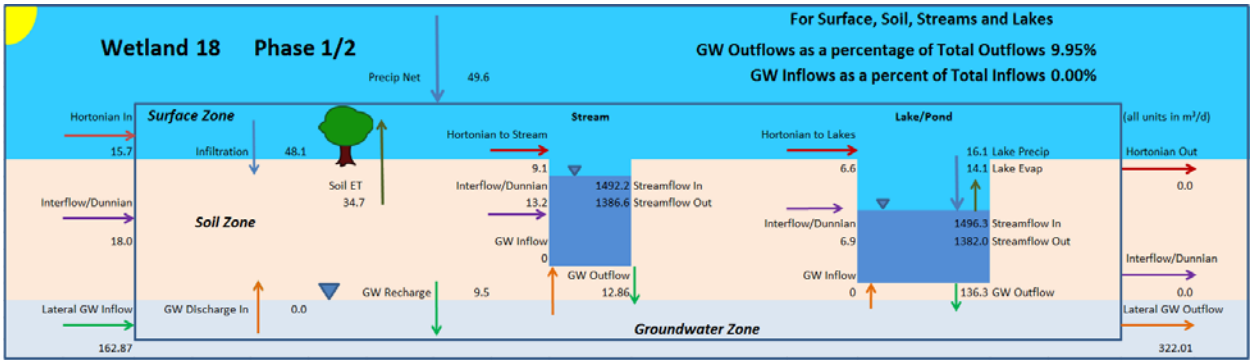


FIGURE 1C

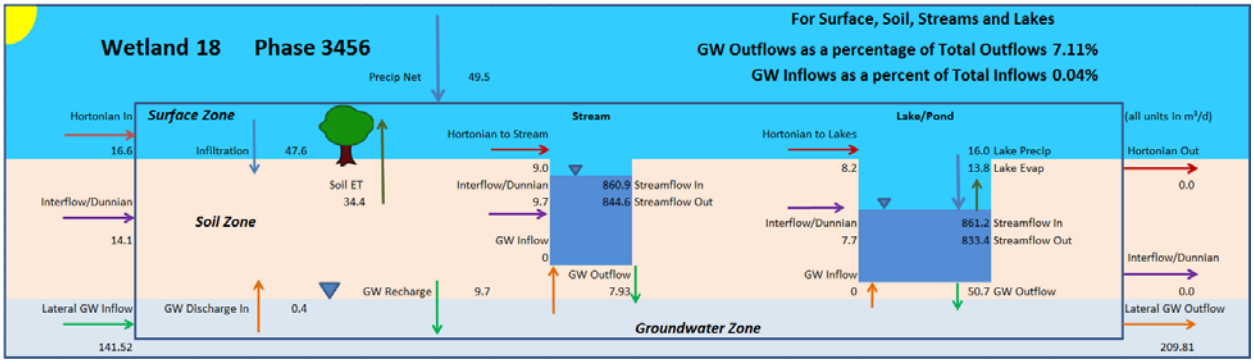


FIGURE 1D

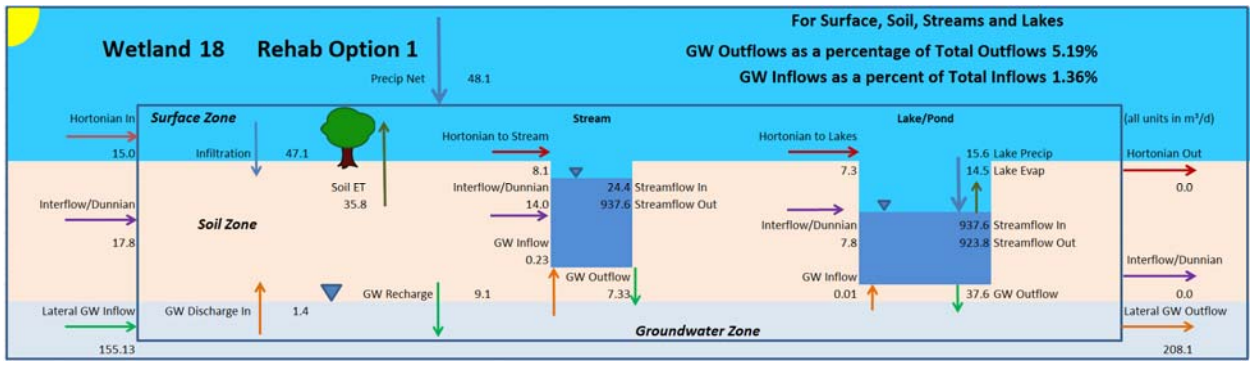
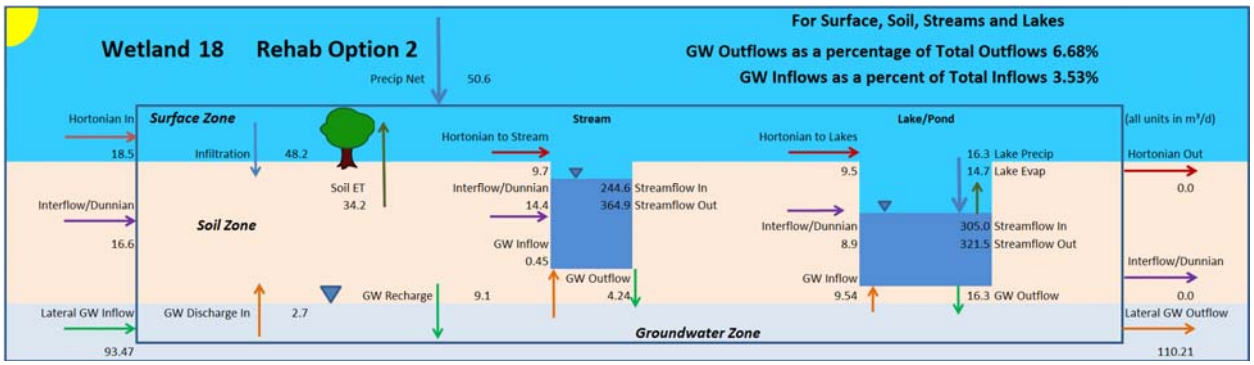
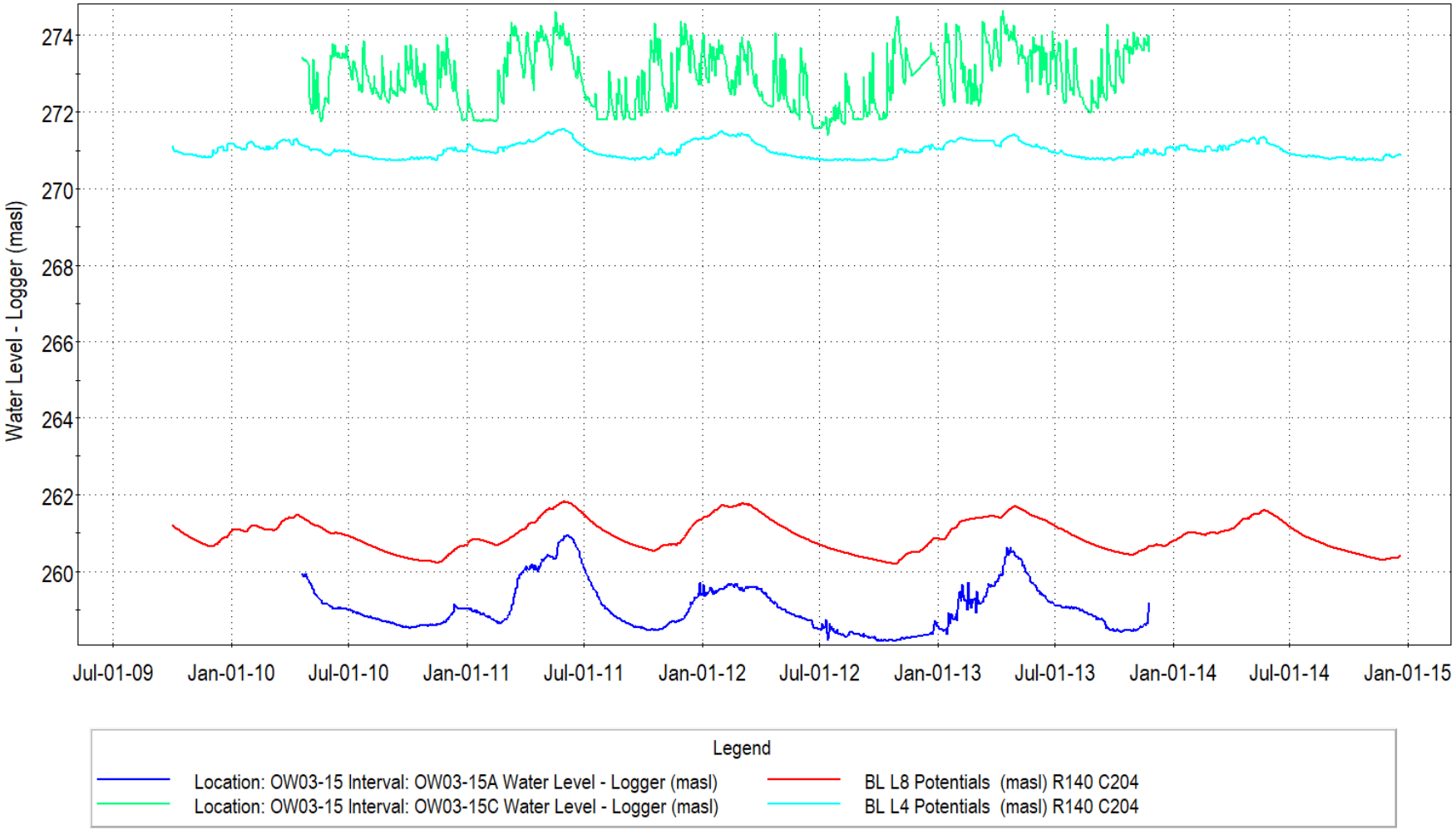


FIGURE 1E

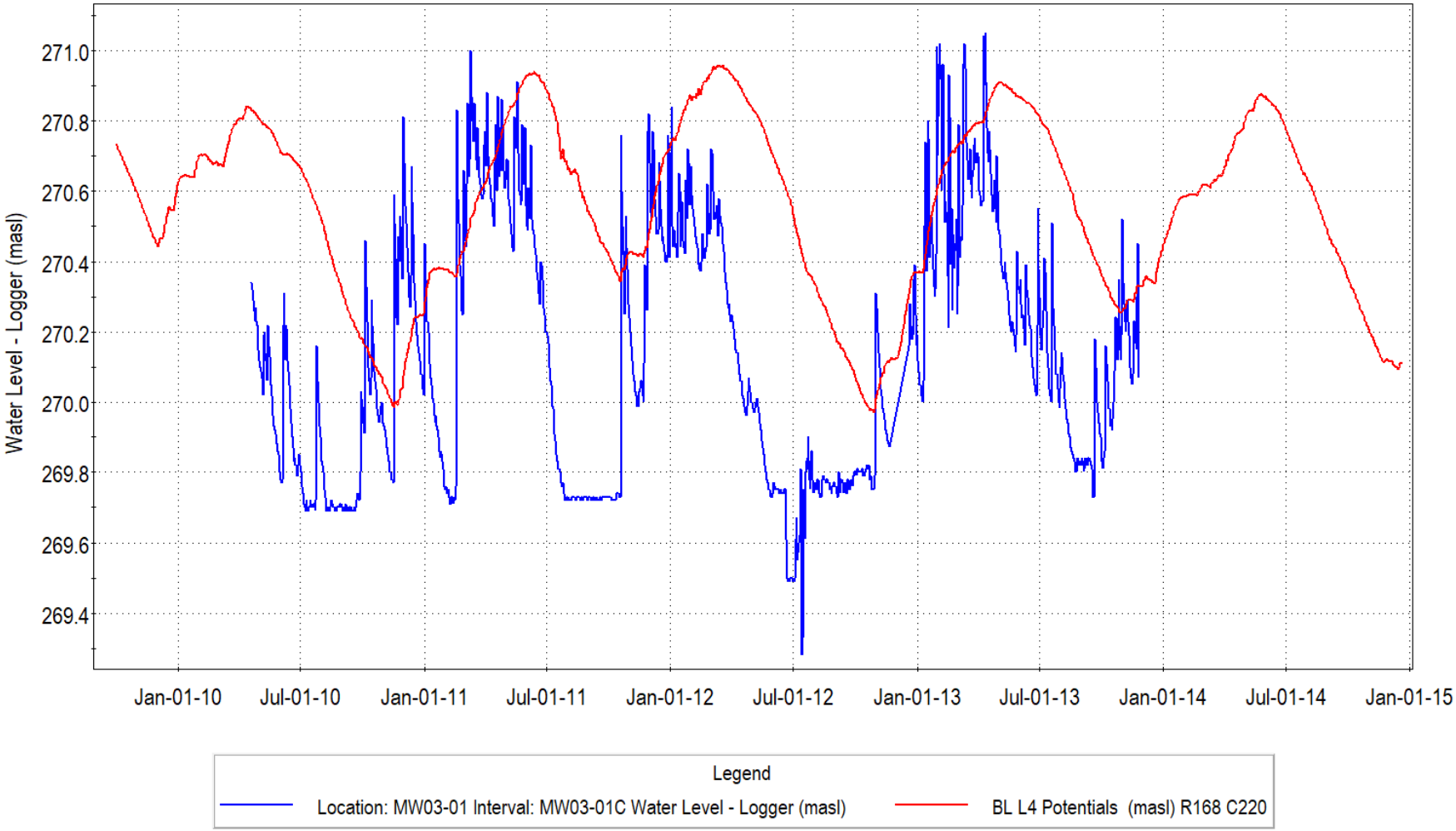


Integrated Model Calibration
Wetland 13203



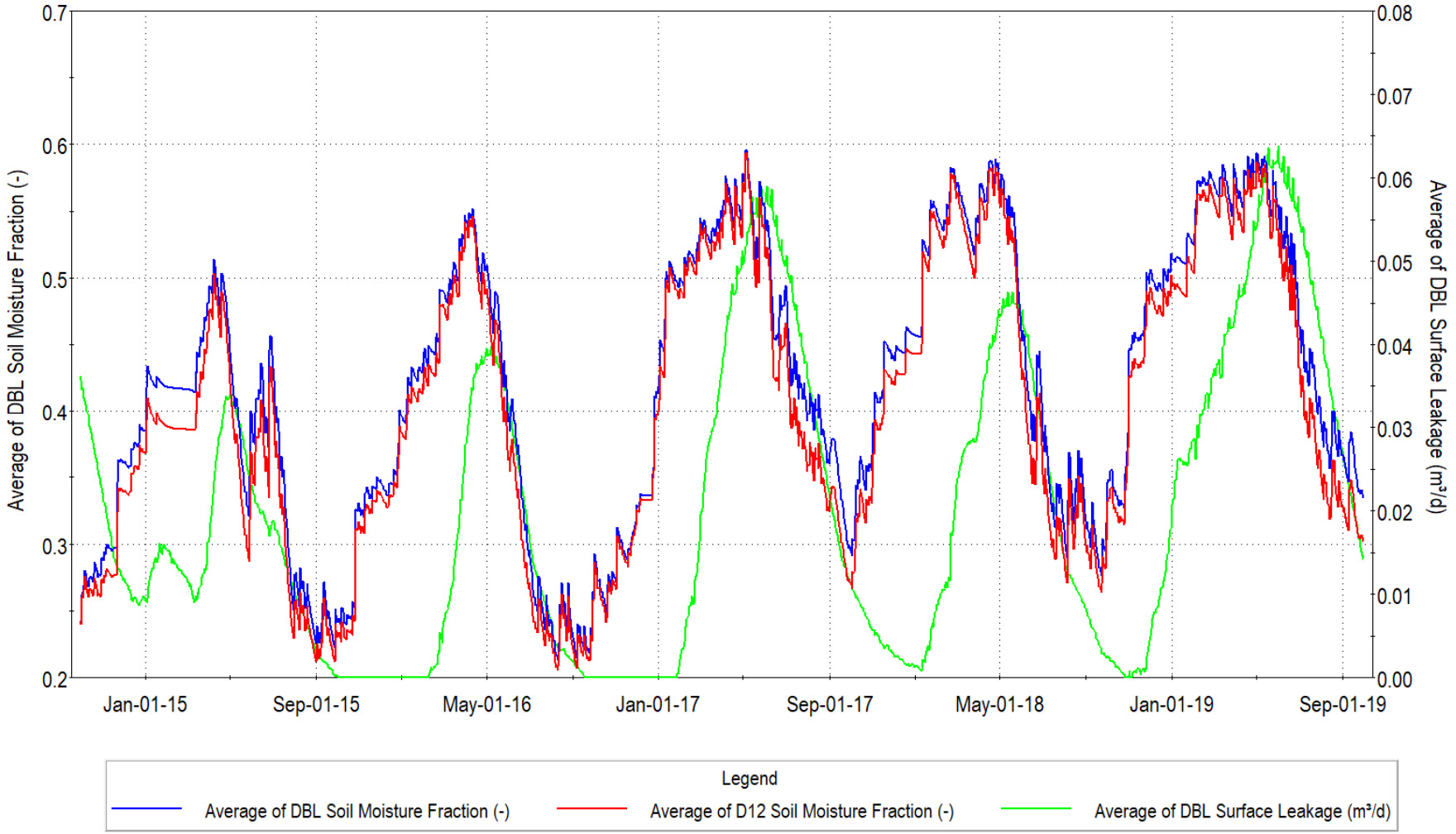
WETLAND 13203 - GRAPH 6

Integrated Model Calibration
Wetland 13203

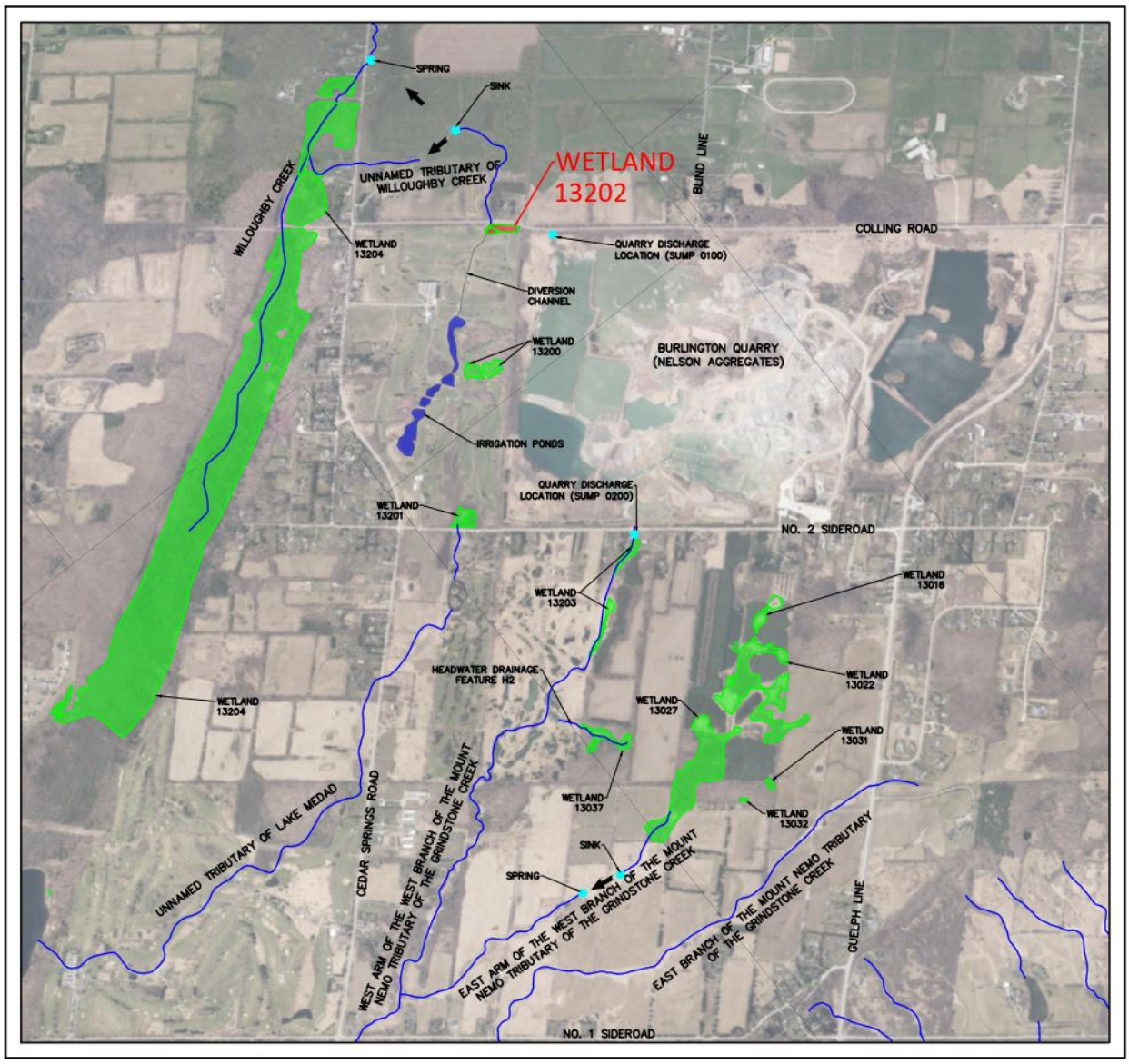


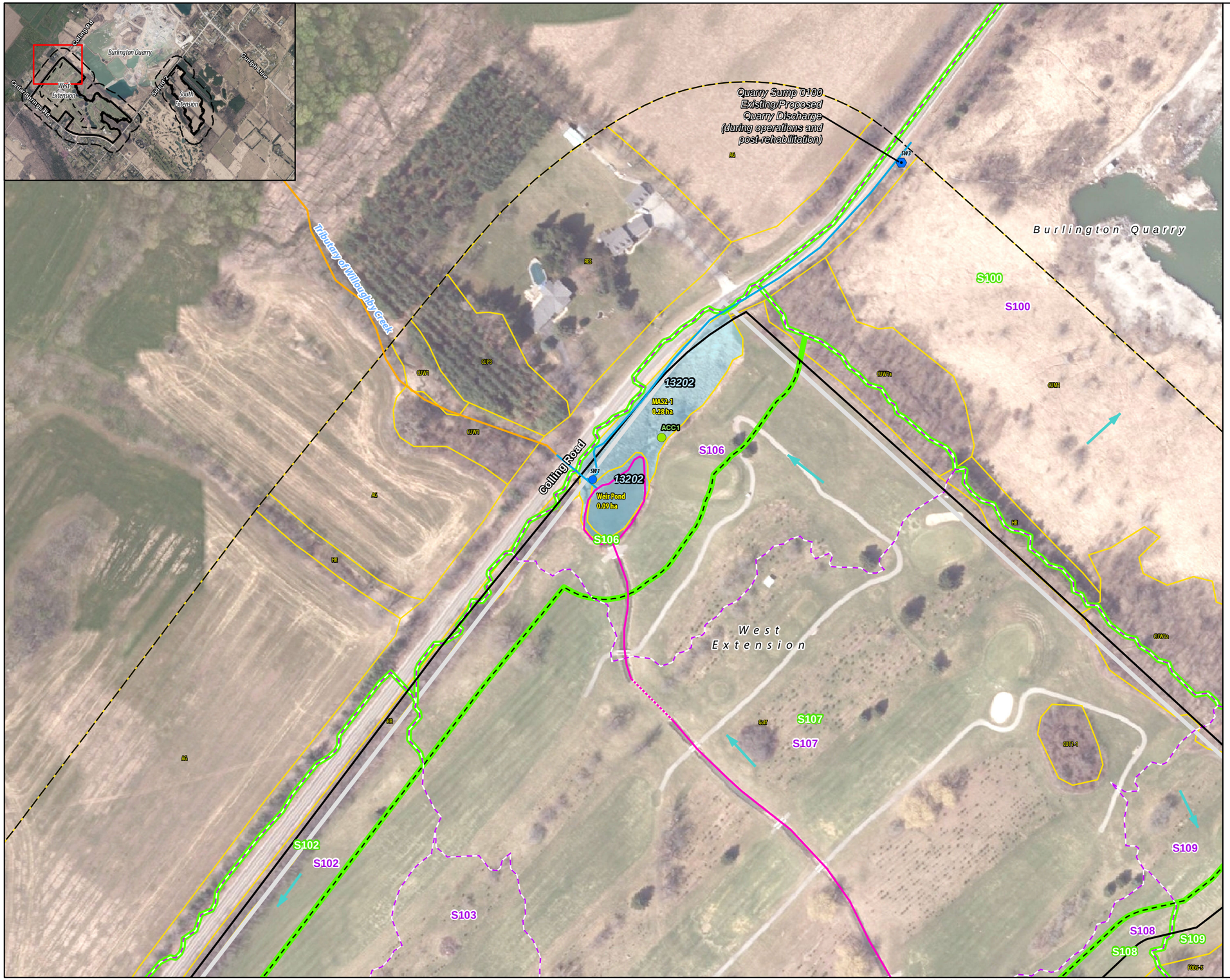
WETLAND 13203 - GRAPH 7

Change in Soil Moisture Conditions
Wetland 13203



WETLAND 13202





Legend

- Licensed Boundary
- Limit of Extraction
- 120 m Adjacent Lands
- Subject Lands
- Amphibian Call Count Station (2019)
- Golf Course Irrigation Ponds and Channel
- Indirect Fish Habitat
- Direct Fish Habitat
- Existing Subcatchment Boundary (Tatham Engineering, 2020)
- Proposed Subcatchment Boundary - Operations and Post-Rehabilitation (Tatham Engineering, 2020
- Wetland (Savanta, 2020)
- Ecological Land Classification (Savanta, 2019 & 2020)

Current Instrumentation

- Staff Gauge & Surface Water Monitoring Station (Tatham Engineering)
- Manual Stream Flow Measurement (Tatham Engineering)

ELC Legend

AG, Agriculture
CUM1, Mineral Cultural Meadow
CUP3, Coniferous Plantation
CUT1-1, Sumac Cultural Thicket
CUW1, Mineral Cultural Woodland
FOD5-5, Dry – Fresh Sugar Maple – Hickory Deciduous Forest
HR, Hedgerow
MAS2-1, Cattail Mineral Shallow Marsh
RES, Residential

NOTES:

1. Coordinate System: NAD 1983 UTM Zone 17N.
2. Base features produced under license with the Ontario Ministry of Natural Resources and Forestry © Queen's Printer for Ontario, 2021.
3. Orthoimagery © First Base Solutions, 2021. Imagery taken in 2019.

Project 8133

Burlington Quarry Extension
Nelson Aggregates Co.

Figure 7
Wetland Characterization

Wetland 13202 - West Extension

0 30 m
1:2,000

N

GEI Consultants
Savanta Division

Path: C:\Savanta\8133 - Burlington Quarry\figures\report_figures\2021 01 21 natural feature tech summary\8133_rpt_wetland_char_mapbook.mxd Date: January 11, 2021

Wetland 13202

Wetland Characteristics	Description	Figure / Graph	Reference	
			Report	Section / Page
Wetland IDs:	MNRF -N/A Earthfx - N/A Tatham - 13202 Savanta - 13202 Golder (Background) - N/A			
Wetland Area (ha):	Savanta - 0.37			
Watershed:	Bronte Creek Watershed			
Sub-Watershed:	Willoughby Creek Watershed			
Located in Proposed Limit of Extraction:	No			
Located in Proposed License Boundary:	Yes			
Catchment Area (ha):	2.32 + quarry discharge (Sump 0100)		SWA (Tatham, April 2020)	Drawing DP-1
Catchment ID:	S106		SWA (Tatham, April 2020)	Drawing DP-1
Closed or Connected System:	On-line (connected to downstream watercourse)			
Condition:	Modified			
Bathymetry:	A bathymetric survey of Wetland 13202 has not been completed.			
Outlet:	Tributary of Willoughby Creek			
Hydroperiod:	Water level in Wetland 13202 and the weir pond maintained by quarry discharge. Water levels in Wetland 13202 and the weir pond are also manipulated by a weir structure operated by the Burlington Springs Golf and Country Club for irrigation of the golf course and to maintain water levels in the on-site irrigation/hazard ponds.		SWA (Tatham, April 2020)	2.1.1, 3 and Appendix B
Surface Water Monitoring:	ID: SW1 (Tatham) Installation Date: July 17, 2015 Data Collection: Continuous water level and temperature, manual monthly in-situ streamflow measurements and calibration data (water level converted to flow using rating curve) Coordinates of Monitoring Station: Easting 589015.325, Northing 4805832.639	Graph 1	SWA (Tatham, April 2020)	2.1.1 and Appendix B

Natural Heritage and Habitat Features	Description	Figure / Graph	Reference	
			Report	Section / Page
Wetland Name & Provincial Significance Evaluation:	Wetland 13202 – Other (it is completely dependent on pumping from the existing quarry; however it has been designed to demonstrate no negative impacts.)		NETR (Savanta, April 2020)	6.1.2
ELC Unit(s):	Pond: Weir Pond Cattail Mineral Shallow Marsh: MAS2-1		NETR (Savanta, April 2020)	Table 2
Regulated Habitat (MECP):	No		NETR (Savanta, April 2020)	6.7
Significant Wildlife Habitat:	None confirmed for amphibian breeding, despite survey effort through habitat assessments and call count surveys. Confirmed for species of conservation concern – Unicorn Clubtail.		NETR (Savanta, April 2020)	4.2.2; 4.2.5; 5.2.2; 5.2.5; 6.4; Table 19
Fish Habitat:	Weir Pond – part of the golf course irrigation ponds and channel MAS2-1 – Indirect fish habitat		NETR (Savanta, April 2020)	6.6
Habitat of Endangered and Threatened Species:	No species at risk salamanders observed, despite survey effort including habitat assessment.		NETR (Savanta, April 2020)	5.2.2

Groundwater Interaction	Description	Figure / Graph	Reference	
			Report	Section / Page
Lithology:	Halton Till			
Hydraulic Conductivity:	Integrated Model (Earthfx) - The harmonic mean hydraulic conductivity, based on testing by Golder (2007) of 10 mini-piezometers, was $1.2x10^{-8}$ m/s. Model value for the vertical hydraulic conductivity was $1.6x10^{-7}$ m/s, about an order of magnitude higher, to account for limited flow through fractures in the till.			
Surface Water/Groundwater Interaction:	The low permeability of the Halton Till underlying the wetland is the dominant control on 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.			
Water Budget Results:	No detailed water budget was produced for this wetland. The wetland is close to Wetland 13032 (Earthfx Wetland 19) and similar in size. The water budget for this wetland should be similar. Simulated groundwater levels, groundwater discharge to riparian areas, and streamflow in the vicinity of Wetland 13032 (Earthfx Wetland 19) for baseline conditions is discussed in Section 7 of the main report			
Integrated Model Calibration:	The calibration of this wetland is not discussed in the Earthfx Report.			

Impact Assessment (Operations Phases 1 & 2)	Description	Figure / Graph	Reference	
			Report	Section / Page
Change in Wetland Area (ha):	No change.			
Change in Wetland Catchment Area (ha):	No change. No extraction proposed in West Extension as part of Phases 1 and 2 of extraction.		SWA (Tatham, April 2020)	Drawing DP-2
Change in Hydroperiod:	No Change.			
Change in Water Budget:	Detailed water budgets were not prepared for this feature. Changes in streamflow at SW1 were discussed in Section 8.7.6. Simulated change in groundwater levels (drawdowns), groundwater discharge to riparian areas, and change in streamflow in the vicinity of the wetland are discussed in Section 8 of the main report for each scenario a.		HHIAR (Earthfx, April 2020)	191 - 303
Potential Impact to Form and Function of Feature:	No potential impacts to Wetland 13202 and the weir pond under Phases 1 and 2 of operations.			

Mitigation (Operational Phases 1 & 2)	Description	Figure / Graph	Reference	
			Report	Section / Page
Proposed Mitigation Measures:	No mitigation required under Phase 1 and 2 of operations. Existing quarry discharge to be maintained.			

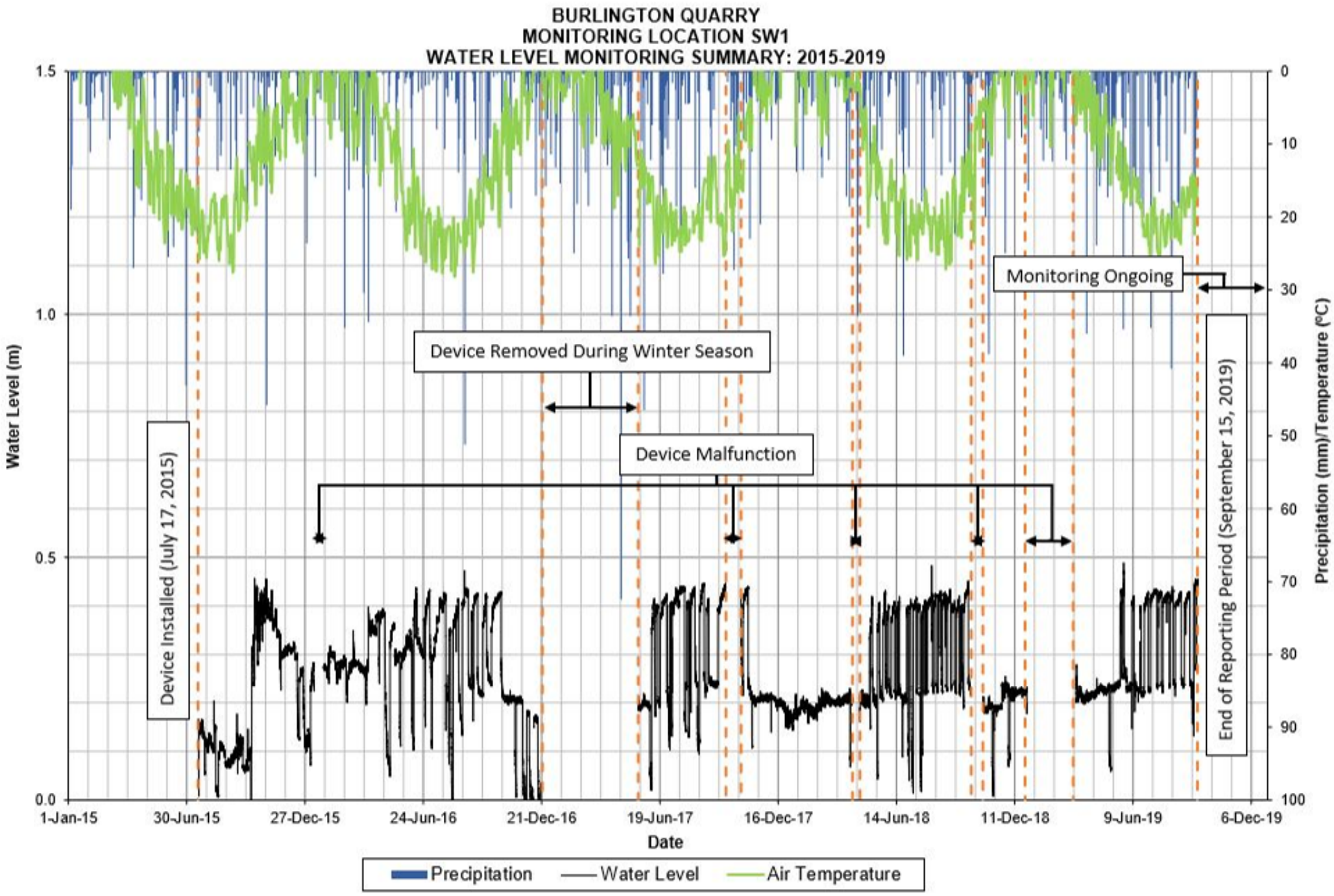
Impact Assessment (Operations Phases 3 - 6)	Description	Figure / Graph	Reference	
			Report	Section / Page
Change in Wetland Area (ha):	No change.			
Change in Wetland Catchment Area (ha):	Reduction in catchment area. During operations in Phases 3 through 6 the catchment area will be reduced to 1.6 ha (reduction of 0.72 ha)		SWA (Tatham, April 2020)	Drawing DP-2
Change in Hydroperiod:	No change in hydroperiod expected as quarry discharge maintains wetland and weir pond water levels.			
Change in Water Budget:	Detailed water budgets were not prepared for this feature. Changes in streamflow at SW1 were discussed in Section 8.7.6. Simulated change in groundwater levels (drawdowns), groundwater discharge to riparian areas, and change in streamflow in the vicinity of the wetland are discussed in Section 8 of the main report for each scenario.		HHIAR (Earthfx, April 2020)	191 - 303
Potential Impact to Form and Function of Feature:	Both the pond and the wetland will remain in place. There will be no encroachment from the project into the wetlands. Proposed limit of extraction is ≥30 m from the wetland boundary. A proposed berm will be constructed within the 30 m setback. The closest point of the berm will be 14 m from the wetland boundary. The extraction limit will be demarcated and fenced to ensure site construction and operations do not extend beyond the proposed limits of the project . The berm will be vegetated with common, native species (as approved by Conservation Halton) to ensure soil stability and prevention of erosion. The Weir Pond and the MAS2-1 are supplied with water by pumping from the existing adjacent quarry. The proposed quarry Extension is not anticipated to have any impact on pumping or water quality related to discharge from the existing quarry. Pumping and discharge are recommended to occur at the same location at the upstream end of the tributary and in the same manner as existing pumping.		NETR (Savanta, April 2020)	7.2.1; 7.1.1; 7.1.2

Mitigation (Operational Phases 3 - 6)	Description	Figure / Graph	Reference	
			Report	Section / Page
Proposed Mitigation Measures:	The Weir Pond and the MAS2-1 are supplied with water by pumping from the existing adjacent quarry. The proposed quarry Extension is not anticipated to have any impact on pumping or water quality related to discharge from the existing quarry. Pumping and discharge are recommended to occur at the same location at the upstream end of the tributary and in the same manner as existing pumping.		NETR (Savanta, April 2020)	7.2.1; 7.1.1; 7.1.2

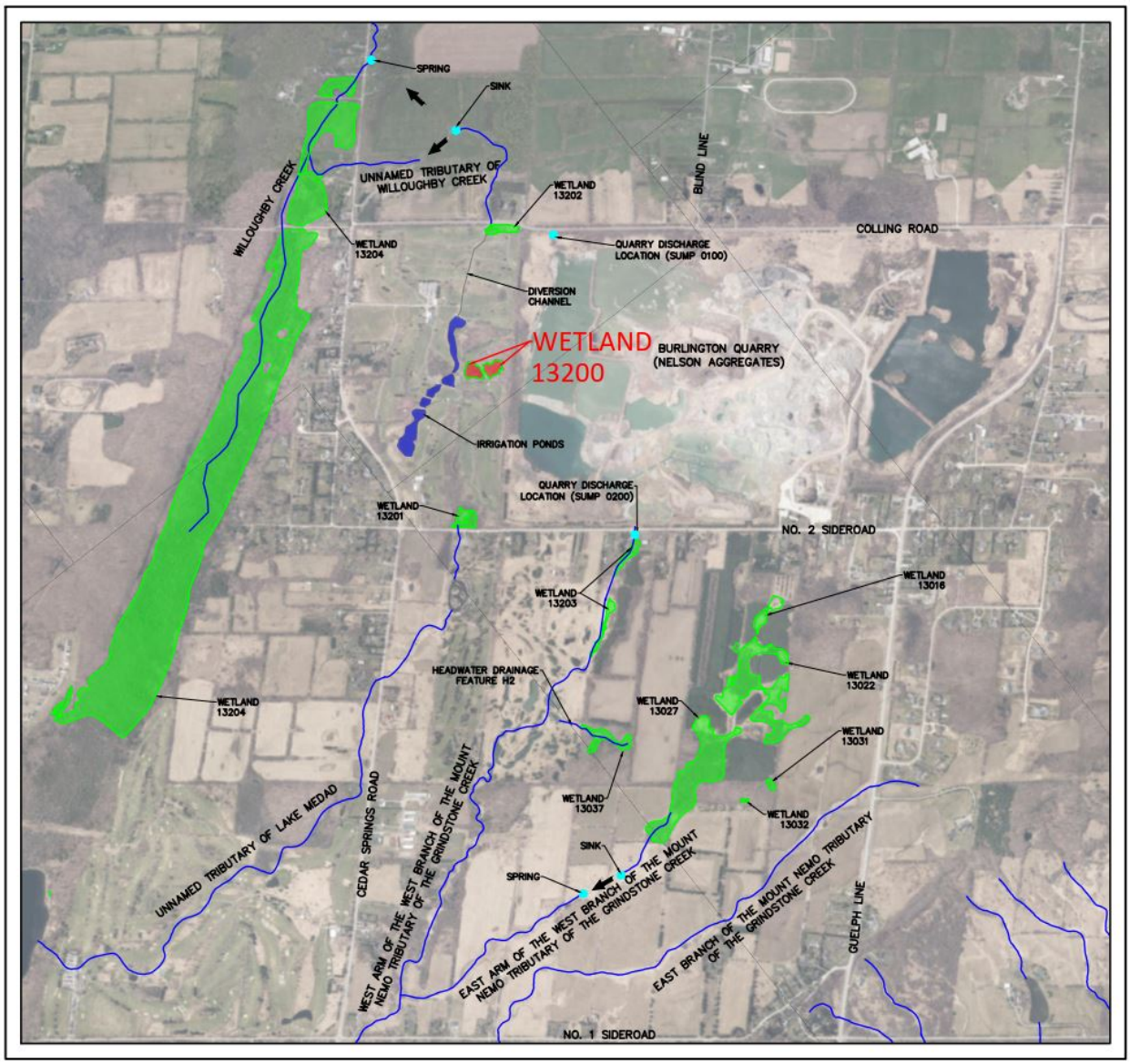
Impact Assessment (Rehabilitation)	Description	Figure / Graph	Reference	
			Report	Section / Page
Change in Wetland Area (ha):	No change.			
Change in Wetland Catchment Area (ha):	Reduction in catchment area. During operations in Phases 3 through 6 the catchment area will be reduced to 1.6 ha (reduction of 0.72 ha). Drainage area to remain 1.6 ha post rehabilitation.		SWA (Tatham, April 2020)	Drawing DP-3
Change in Hydroperiod:	Currently approved plan for Burlington Quarry is to cease discharge following operations creating a pit lake. Ceasing discharge from the quarry will adversely impact Wetland 13202 and the Tributary of Willoughby Creek. No change in hydroperiod expected if quarry discharge is maintained.			
Change in Water Budget:	Detailed water budgets were not prepared for this feature. Changes in streamflow at SW1 were discussed in Section 8.7.6. Simulated change in groundwater levels (drawdowns), groundwater discharge to riparian areas, and change in streamflow in the vicinity of the wetland are discussed in Section 8 of the main report for each scenario.		HHIAR (Earthfx, April 2020)	191 - 303
Potential Impact to Form and Function of Feature:	Both the pond and the wetland will remain in place. There will be no encroachment from the project into the wetlands. Proposed limit of extraction is ≥30 m from the wetland boundary. A proposed berm will be constructed within the 30 m setback. The closest point of the berm will be 14 m from the wetland boundary. The extraction limit will be demarcated and fenced to ensure site construction and operations do not extend beyond the proposed limits of the project . The berm will be vegetated with common, native species (as approved by Conservation Halton) to ensure soil stability and prevention of erosion. The Weir Pond and the MAS2-1 are supplied with water by pumping from the existing adjacent quarry. The proposed quarry Extension is not anticipated to have any impact on pumping or water quality related to discharge from the existing quarry. Pumping and discharge are recommended to occur long-term at the same location at the upstream end of the tributary and in the same manner as existing pumping.		NETR (Savanta, April 2020)	7.2.1; 7.1.1; 7.1.2

Mitigation (Rehabilitation)	Description	Figure / Graph	Reference	
			Report	Section / Page
Proposed Mitigation Measures:	The Weir Pond and the MAS2-1 are supplied with water by pumping from the existing adjacent quarry. The proposed quarry Extension is not anticipated to have any impact on pumping or water quality related to discharge from the existing quarry. Pumping and discharge are recommended to occur long-term at the same location at the upstream end of the tributary and in the same manner as existing pumping. The cessation of quarry discharge will adversely impact Wetland 13202 and the Unnamed Tributary of Willoughby Creek.		NETR (Savanta, April 2020)	7.2.1; 7.1.1; 7.1.2

WETLAND 13202 - GRAPH 1



WETLAND 13200





Legend

- Licensed Boundary
- Limit of Extraction
- 120 m Adjacent Lands
- Subject Lands
- Amphibian Call Count Station (2019)
- Golf Course Irrigation Ponds and Channel
- Existing Subcatchment Boundary (Tatham Engineering, 2020)
- Proposed Subcatchment Boundary - Operations and Post-Rehabilitation (Tatham Engineering, 2020
- Proposed Subcatchment Boundary - Operations (Tatham Engineering, 2020)
- Proposed Subcatchment Boundary - Post-Rehabilitation (Tatham Engineering, 2020)
- Wetland (Savanta, 2020)
- Ecological Land Classification (Savanta, 2019 & 2020)
- Ecological Land Classification (Savanta, 2020)

Current Instrumentation

- Mini Piezometer (Tatham Engineering)

Previous Instrumentation

- Groundwater Monitoring Station (Golder)

ELC Legend

CUM1, Mineral Cultural Meadow
CUT1, Mineral Cultural Thicket
CUT1-1, Sumac Cultural Thicket
CUW1, Mineral Cultural Woodland
DIST, Disturbed
FOD5-1, Dry- Fresh Sugar Maple Deciduous Forest
FOD5-2, Dry- Fresh Sugar Maple-Beech Deciduous Forest
FOD5-5, Dry – Fresh Sugar Maple – Hickory Deciduous Forest
FOD7-2, Fresh-Moist Ash Lowland Deciduous Forest
HR, Hedgerow
OA, Open Aquatic
RES, Residential
SWD3-2, Silver Maple Mineral Deciduous Swamp

NOTES:

1. Coordinate System: NAD 1983 UTM Zone 17N.
2. Base features produced under license with the Ontario Ministry of Natural Resources and Forestry © Queen's Printer for Ontario, 2021.
3. Orthoimagery © First Base Solutions, 2021. Imagery taken in 2019.

Project 8133

Burlington Quarry Extension
Nelson Aggregates Co.

Figure 8
Wetland Characterization

Wetland 13200 - West Extension

0 30 m
1:2,000

N

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Wetland 13200

Wetland Characteristics	Description	Figure / Graph	Reference	
			Report	Section / Page
Wetland IDs:	MNRF -N/A Earthfx - 22 Tatham - 13200 Savanta - 13200 Golder (Background) - N/A			
Wetland Area (ha):	Savanta - 0.73			
Watershed:	Bronte Creek Watershed			
Sub-Watershed:	Willoughby Creek Watershed			
Located in Proposed Limit of Extraction:	No			
Located in Proposed License Boundary:	No			
Catchment Area (ha):	7.38		SWA (Tatham, April 2020)	Drawing DP-1
Catchment ID:	S109		SWA (Tatham, April 2020)	Drawing DP-1
Closed or Connected System:	Isolated Feature			
Condition:	Natural			
Bathymetry:	A bathymetric survey of Wetland 13200 has not been completed.			
Outlet:	None			
Hydroperiod:	Monitoring station established April 22, 2020. Hydroperiod to be determined.			
Surface Water Monitoring:	ID: SW37 (Tatham) Installation Date: April 22, 2020 Data Collection: Continuous water level and temperature and manual monthly water level measurements Coordinates of Monitoring Station: Easting 589429.71, Northing 4805390.25			

Natural Heritage and Habitat Features	Description	Figure / Graph	Reference	
			Report	Section / Page
Wetland Name & Provincial Significance Evaluation:	Wetland 13200 – Other (considered not significant due to lack of amphibian breeding habitat, isolated and not connected to a PSW; however it has been designed to demonstrate no negative impacts.)		NETR (Savanta, April 2020)	6.1.2
ELC Unit(s):	Silver Maple Mineral Deciduous Swamp: SWD3-2a		NETR (Savanta, April 2020)	Table 2
Regulated Habitat (MECP):	No		NETR (Savanta, April 2020)	6.7
Significant Wildlife Habitat:	None confirmed for amphibian breeding, despite survey effort through habitat assessments. Salamander trapping and call count surveys were not completed due to absence of water.		NETR (Savanta, April 2020)	4.2.2; 5.2.2; Table 19
Fish Habitat:	None		NETR (Savanta, April 2020)	6.6
Habitat of Endangered and Threatened Species:	No species at risk salamanders observed, despite survey effort including habitat assessment.		NETR (Savanta, April 2020)	5.2.2

<table>
<tr><th>Groundwater Interaction</th><th>Description</th><th>Figure / Graph</th><th colspan="2">Reference</th></tr>
<tr><th></th><th></th><th></th><th>Report</th><th>Section / Page</th></tr>
<tr><td>Lithology:</td><td>Halton Till</td><td></td><td></td><td></td></tr>
<tr><td>Hydraulic Conductivity:</td><td>Integrated Model (Earthfx) - The harmonic mean hydraulic conductivity, based on testing by Golder (2007) of 10 mini-piezometers, was 1.2x10^{-8} m/s. Model value for the vertical hydraulic conductivity was 1.6x10^{-7} m/s, about an order of magnitude higher, to account for limited flow through fractures in the till.</td><td></td><td></td><td></td></tr>
<tr><td>Surface Water/Groundwater Interaction:</td><td>The low permeability of the Halton Till underlying the wetland is the dominant control on 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. This wetland does not receive significant groundwater inflow and is isolated from any changes in the water table due to quarry development.</td><td></td><td></td><td></td></tr>
<tr><td>Shallow Groundwater (Mini-piezometer) Monitoring:</td><td>ID: SW37 (Tatham)
Installation Date: April 22, 2020
Data Collection: Continuous water level and temperature and manual monthly water level measurements
Coordinates of Monitoring Station: Easting 589429.71, Northing 4805390.25</td><td></td><td></td><td></td></tr>
<tr><td>Groundwater Monitoring (Monitoring Wells):</td><td>
<table>
<tr><td>Monitoring Well ID</td><td>Distance (Dir.)</td><td>Geologic Unit</td><td>Ground Elevation</td><td>Monitoring Elev</td><td>Average WL</td></tr>
<tr><td>BS-03A</td><td>131 (SSW)</td><td>Bedrock</td><td>271.73</td><td>-</td><td>264.53</td></tr>
<tr><td>BS-03B</td><td>131 (SSW)</td><td>Bedrock</td><td>271.73</td><td>-</td><td>264.57</td></tr>
<tr><td>BS-03</td><td>131 (SSW)</td><td>Bedrock</td><td>271.73</td><td>-</td><td>266.05</td></tr>
</table>
</td><td>Graph 1</td><td></td><td></td></tr>
<tr><td>Water Budget Results:</td><td>A detailed average water budget, as simulated by the integrated model, is provided in the main report for Baseline Conditions (Earthfx Figure 7.30, p. 189). The baseline water budget is reproduced in Figure 1a. The wetland is a net provider of groundwater. Simulated groundwater levels, groundwater discharge to riparian areas, and streamflow in the vicinity of Wetland 13200 (Earthfx Wetland 22) for baseline conditions are discussed in Section 7 of the main report.
<table>
<tr><td>Wetland 13200</td><td>GW Outflow (%)</td><td>GW Inflow (%)</td></tr>
<tr><td>Baseline (Existing)</td><td>26.31</td><td>0.00</td></tr>
</table>
</td><td>Figure 1a</td><td>HHIAR (Earthfx, April 2020)</td><td>165 - 190</td></tr>
<tr><td>Integrated Model Calibration:</td><td>No mini-piezometers for calibration. The model calibration to the new groundwater monitoring well 100 m south west show a good calibration to the available monitoring record (see Graph 2). Wetland 22 is not discussed in the Main Report. Other nearby wetlands are discussed in Appendix E, Section 19.6.</td><td>Graph 2</td><td></td><td></td></tr>
</table>

<table>
<tr><th>Impact Assessment (Operations Phases 1 & 2)</th><th>Description</th><th>Figure / Graph</th><th colspan="2">Reference</th></tr>
<tr><th></th><th></th><th></th><th>Report</th><th>Section / Page</th></tr>
<tr><td>Change in Wetland Area (ha):</td><td>No change.</td><td></td><td></td><td></td></tr>
<tr><td>Change in Wetland Catchment Area (ha):</td><td>No change. No extraction proposed in West Extension as part of Phases 1 and 2 of extraction.</td><td></td><td>SWA (Tatham, April 2020)</td><td>Drawing DP-2</td></tr>
<tr><td>Change in Hydroperiod:</td><td>No Change</td><td></td><td></td><td></td></tr>
<tr><td>Change in Water Budget:</td><td>A detailed average water budget as simulated by the integrated model is provided in the Earthfx report for Baseline Conditions (Figure 7.30, p. 189); Scenario P12 (Figure 8.37, p. 224); P3456 (Figure 8.69, p. 251 Wetland 22); RHB1 (Figure 8.103, p. 279), and RHB2 (Figure 8.130, p. 301). The water budget results for Scenario P12 are reproduced in Figure 1b. Wetland 13200 (Earthfx 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 during Phase 1 and 2 operations because it is perched year-round and there was no change in the contributing area. Simulated change in groundwater levels (drawdowns), groundwater discharge to riparian areas, and change in streamflow in the vicinity of Wetland 13200 (Earthfx Wetland 22) for each scenario are discussed in Section 8 of the main report.
<table>
<tr><td>Wetland 13200</td><td>GW Outflow (%)</td><td>GW Inflow (%)</td><td>Δ in Outflow (%)</td><td>Δ in Inflow (%)</td></tr>
<tr><td>Baseline (Existing)</td><td>26.31</td><td>0.00</td><td>-</td><td>-</td></tr>
<tr><td>Operations Ph 1 & 2</td><td>25.24</td><td>0.00</td><td>-1.07</td><td>0.00</td></tr>
</table></td><td>Figure 1b</td><td>HHIAR (Earthfx, April 2020)</td><td>191 - 303</td></tr>
<tr><td>Potential Impact to Form and Function of Feature:</td><td>No wetlands will be removed and the wetlands subcatchment will be maintained. There will be no encroachment from the project into the wetland.</td><td></td><td></td><td></td></tr>
</table>

Mitigation (Operational Phases 1 & 2)	Description	Figure / Graph	Reference	
			Report	Section / Page
Proposed Mitigation Measures:	None required.			

Impact Assessment (Operations Phases 3 - 6)	Description	Figure / Graph	Reference	
			Report	Section / Page
Change in Wetland Area (ha):	No change.			
Change in Wetland Catchment Area (ha):	Reduction in catchment area. During operations in Phases 3 through 6 the catchment area will be reduced to 5.40 ha (reduction of 1.98 ha)		SWA (Tatham, April 2020)	Drawing DP-2
Change in Hydroperiod:	Reduction due to reduction in catchment area. Change in hydroperiod to be determined (to be mitigated).			
Change in Water Budget:	A detailed average water budget as simulated by the integrated model is provided in the Earthfx report for Baseline Conditions (Figure 7.30, p. 189); Scenario P12 (Figure 8.37, p. 224); P3456 (Figure 8.69, p. 251 Wetland 22); RHB1 (Figure 8.103, p. 279), and RHB2 (Figure 8.130, p. 301). The water budget results for Scenario P3456 are reproduced in Figure 1c. Wetland 13200 (Earthfx Wetland 22) is located between the P3456 extraction area and the existing quarry. This wetland had a minor change in the water budget compared to baseline conditions due to changes to the contributing drainage area. However the wetland remained perched. This wetland will be monitored and receive supplemental inflows as required to maintain its hydroperiod, as described in the Tatham, 2020 report. The planned supplementation has not been represented in the model, so the Wetland 13201 (Earthfx Wetland 21) water budget is not fully representative of future conditions. Simulated change in groundwater levels (drawdowns), groundwater discharge to riparian areas, and change in streamflow in the vicinity of Wetland 13200 (Earthfx Wetland 13200) for each scenario are discussed in Section 8 of the main report.	Figure 1c	HHIAR (Earthfx, April 2020)	191 - 303
Change on Soil Moisture Conditions:	The Water Budget figures indicate that there is no groundwater seepage entering the wetland under baseline conditions, so there will be no change under P3456 conditions.			
Potential Impact to Form and Function of Feature:	Both wetlands will remain in place. There will be no encroachment from the project into the wetlands. The proposed limit of extraction is >30 m from the wetland boundary. The licensed boundary/extraction limit will be demarcated and fenced to ensure site construction and operations do not extend beyond the proposed limits of the project . The drainage area to these wetland units will be reduced during operations, which has the potential to adversely impact the hydroperiods.		NETR (Savanta, April 2020)	7.2.1; 7.1.1; 7.1.2

Wetland 13200	GW Outflow (%)	GW Inflow (%)	Δ in Outflow (%)	Δ in Inflow (%)
Baseline (Existing)	26.31	0.00	-	-
Operations Ph 3 - 6	26.31	0.00	0.00	0.00

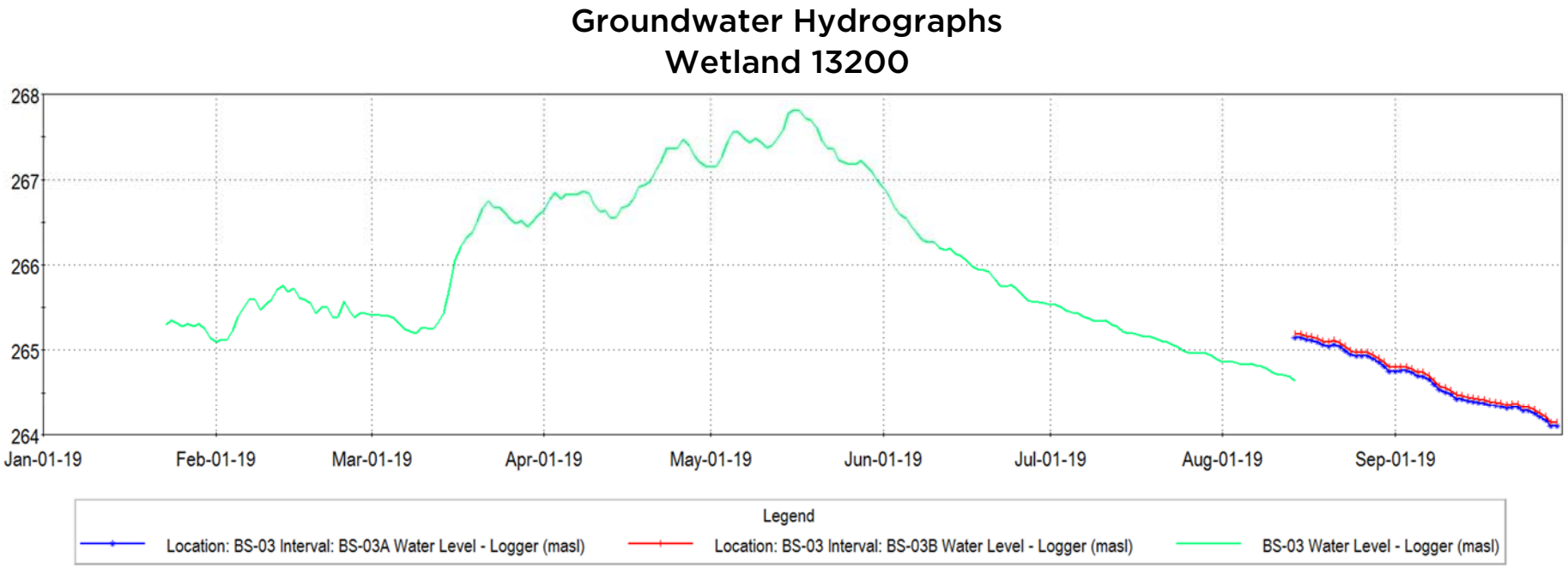
Mitigation (Operational Phases 3 - 6)	Description	Figure / Graph	Reference	
			Report	Section / Page
Proposed Mitigation Measures:	To mitigate this potential impact, flow to the wetlands will be supplemented by pumping from Quarry Sump 0100 directly into the wetland at specified rates and volumes to maintain the wetland hydroperiod. Wetland hydroperiod and shallow groundwater monitoring stations were installed in spring 2020. This data will be used to establish existing thresholds so existing conditions can be maintained throughout extraction operations.		NETR (Savanta, April 2020)	7.2.1; 7.1.1; 7.1.2

Impact Assessment (Rehabilitation)	Description	Figure / Graph	Reference	
			Report	Section / Page
Change in Wetland Area (ha):	No change.			
Change in Wetland Catchment Area (ha):	No change. Subcatchment area will be reinstated as part of rehabilitation.		SWA (Tatham, April 2020)	Drawing DP-3
Change in Hydroperiod:	No Change. Wetland is perched and isolated from the groundwater system. Subcatchment area will be reinstated as part of rehabilitation.			
Change in Water Budget:	A detailed average water budget as simulated by the integrated model is provided in the Earthfx report for Baseline Conditions (Figure 7.30, p. 189); Scenario P12 (Figure 8.37, p. 224); P3456 (Figure 8.69, p. 251 Wetland 22); RHB1 (Figure 8.103, p. 279), and RHB2 (Figure 8.130, p. 301). The water budget results for Scenarios RHB1 and RHB2 are presented in Figures 1d and 1e. Wetland 13200 (Earthfx Wetland 22) is located between the P3456 extraction area and the existing quarry. This wetland had no significant change in the water budget compared to baseline conditions because it is perched year-round and the catchment area will be reinstated as part of rehabilitation of the site. Simulated change in groundwater levels (drawdowns), groundwater discharge to riparian areas, and change in streamflow in the vicinity of Wetland 13200 (Earthfx Wetland 13200) for each scenario are discussed in Section 8 of the main report	Figure 1d and 1e	HHIAR (Earthfx, April 2020)	191 - 303
Potential Impact to Form and Function of Feature:	Both wetlands will remain in place. There will be no encroachment from the project into the wetlands. The proposed limit of extraction is >30 m from the wetland boundary. The licensed boundary/extraction limit will be demarcated and fenced to ensure site construction and operations do not extend beyond the proposed limits of the project . The drainage area to these wetland units will be reduced during operations, which has the potential to adversely impact the hydroperiods.		NETR (Savanta, April 2020)	7.2.1; 7.1.1; 7.1.2

Wetland 13200	GW Outflow (%)	GW Inflow (%)	Δ in Outflow (%)	Δ in Inflow (%)
Baseline (Existing)	26.31	0.00	-	-
Rehab Scenario 1	24.14	0.00	-2.17	0.00
Rehab Scenario 2	28.47	0.00	2.16	0.00

Mitigation (Rehabilitation)	Description	Figure / Graph	Reference	
			Report	Section / Page
Proposed Mitigation Measures:	Once operations are complete and the rehabilitation is implemented, the grade around the wetlands will be returned to existing conditions reinstating the catchment area to the wetland. Wetland hydroperiods and shallow groundwater monitoring stations were installed in spring 2020. This data will be used to establish existing thresholds so existing conditions can be maintained throughout extraction operations and replicated in post-operation / rehabilitated conditions.		NETR (Savanta, April 2020)	7.2.1; 7.1.1; 7.1.2

WETLAND 13200 - GRAPH 1



WETLAND 13200

FIGURE 1A

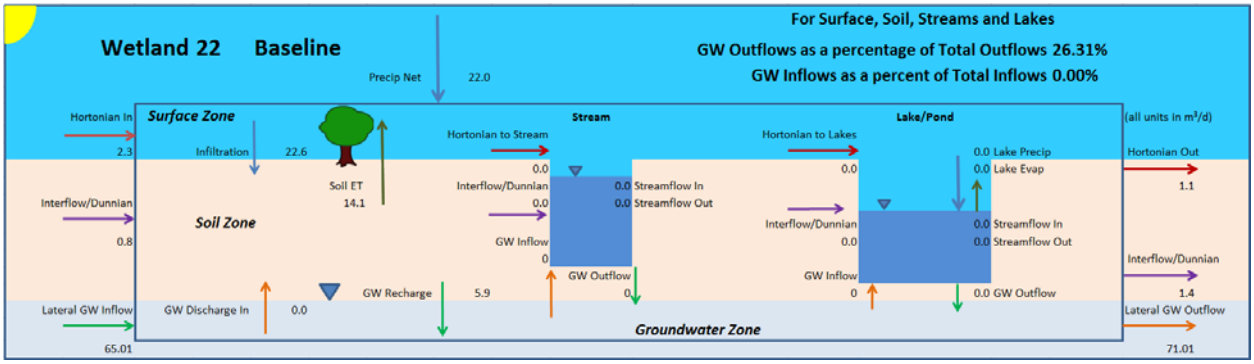


FIGURE 1B

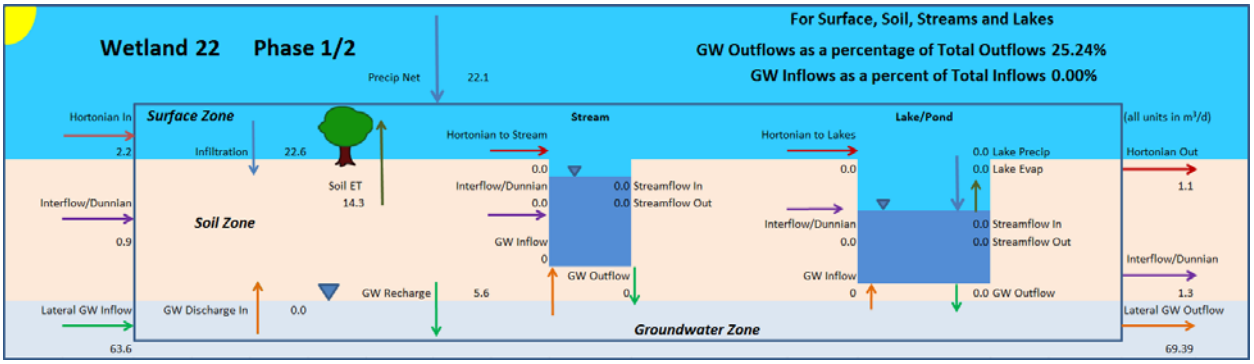


FIGURE 1C

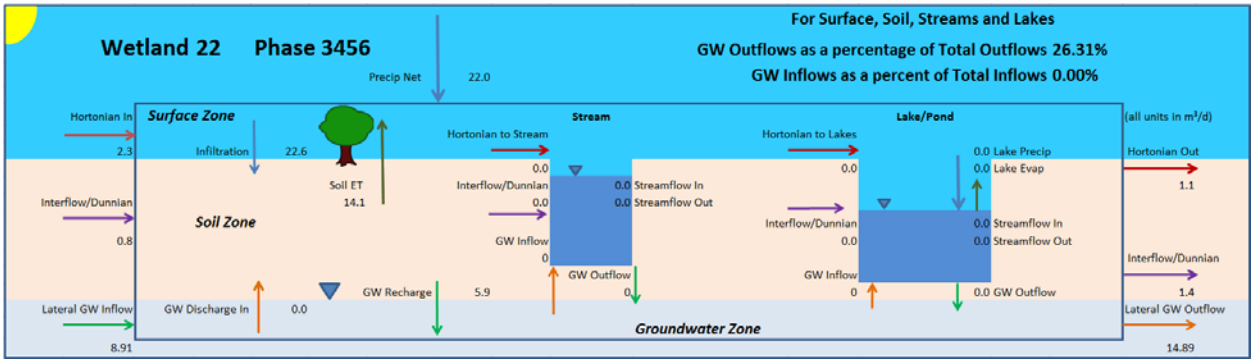


FIGURE 1D

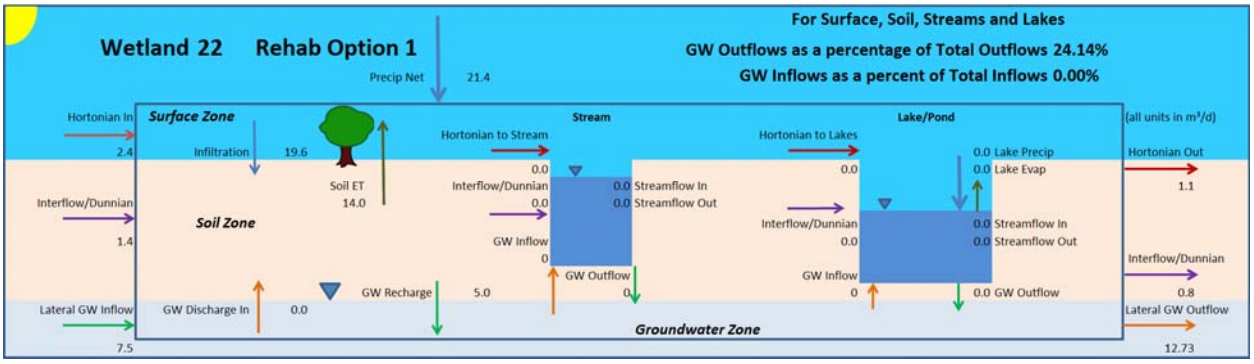
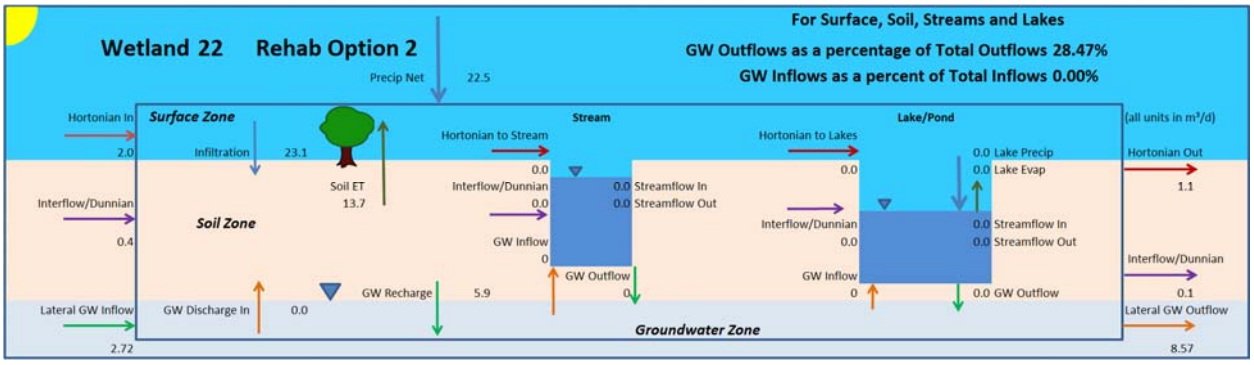
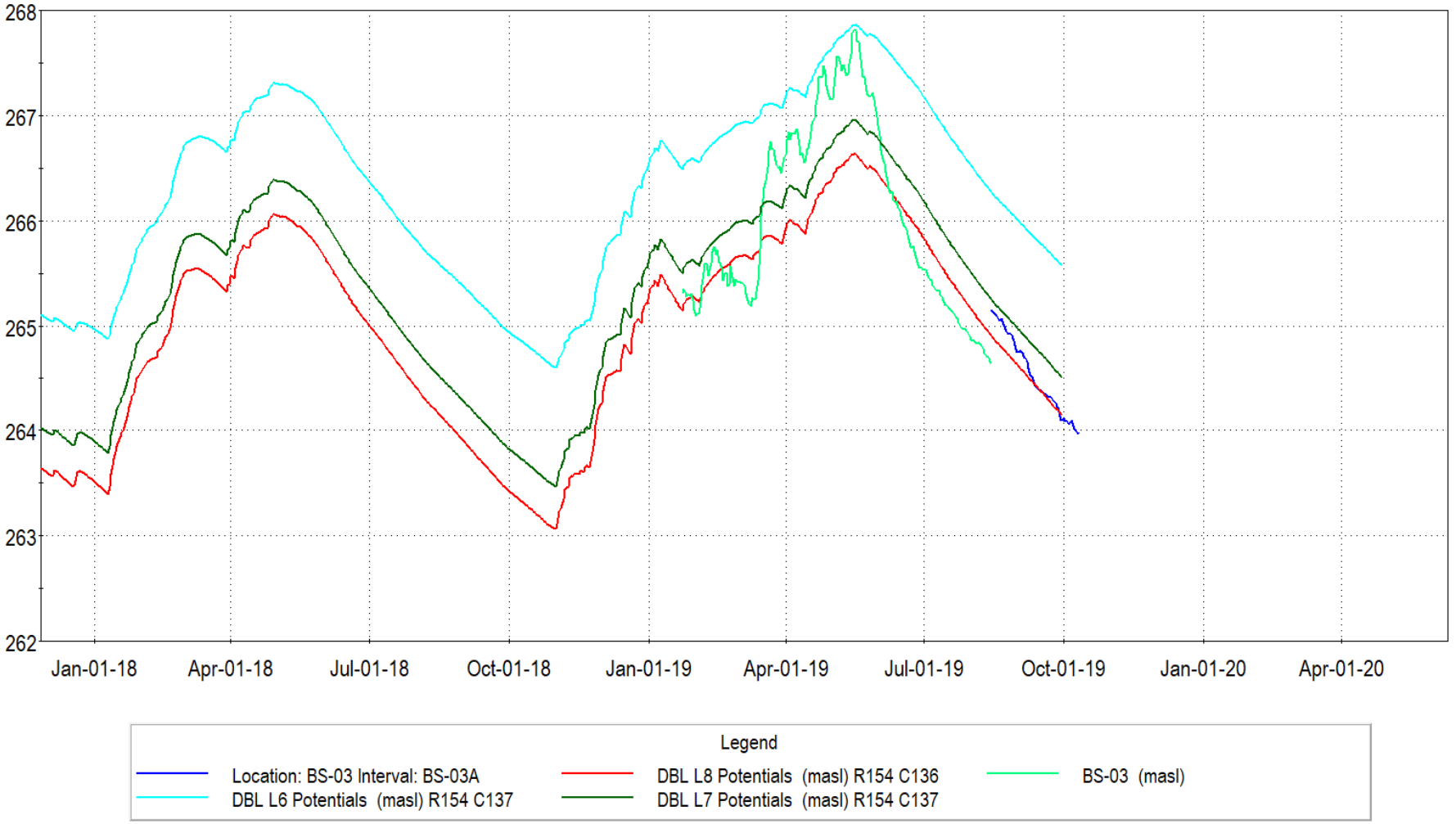


FIGURE 1E

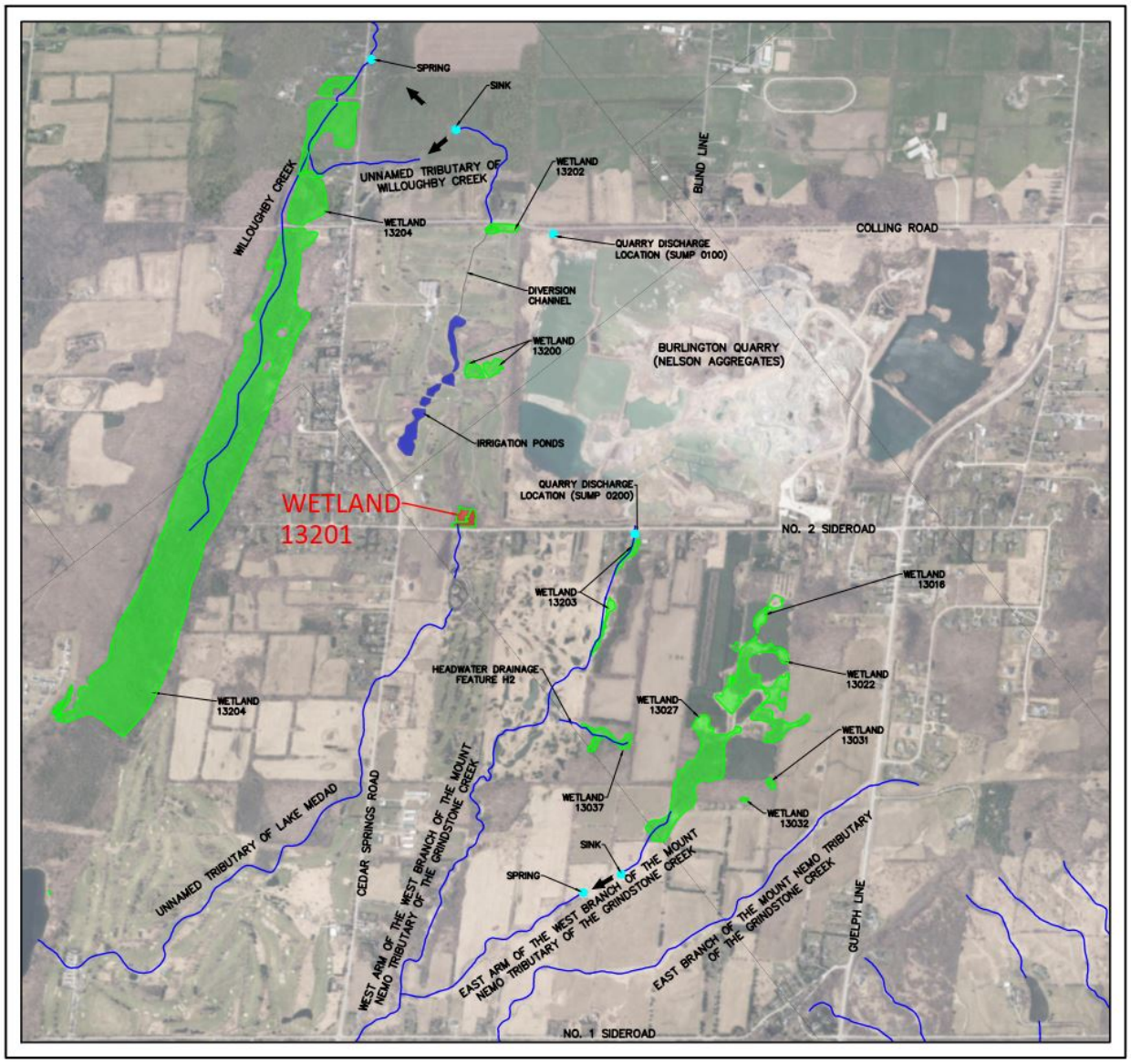


WETLAND 13200 - GRAPH 2

Integrated Model Calibration
Wetland 13200



WETLAND 13201





Legend

- Licensed Boundary
- Limit of Extraction
- 120 m Adjacent Lands
- Subject Lands
- Amphibian Call Count Station (2019)
- Salamander Trap (2019)
- Salamander Habitat Assessment (2019)
- Indirect Fish Habitat
- Direct Fish Habitat
- Existing Subcatchment Boundary (Tatham Engineering, 2020)
- Proposed Subcatchment Boundary - Operations and Post-Rehabilitation (Tatham Engineering, 2020
- Wetland (Savanta, 2020)
- Ecological Land Classification (Savanta, 2019 & 2020)

Current Instrumentation

- Groundwater Monitoring Station (EarthFx)
- Mini Piezometer (Tatham Engineering)
- Manual Stream Flow Measurement (Tatham Engineering)

ELC Legend

AG, Agriculture
CUM1, Mineral Cultural Meadow
CUT1, Mineral Cultural Thicket
CUW1, Mineral Cultural Woodland
FOD, Deciduous Forest
FOD7-2, Fresh-Moist Ash Lowland Deciduous Forest
FOD7-4, Fresh – Moist Black Walnut Lowland Deciduous Forest
HR, Hedgerow
MAM2-2, Reed-canary Grass Mineral Meadow Marsh
RES, Residential
SWD, Deciduous Swamp
SWD3-2, Silver Maple Mineral Deciduous Swamp

NOTES:

1. Coordinate System: NAD 1983 UTM Zone 17N.
2. Base features produced under license with the Ontario Ministry of Natural Resources and Forestry © Queen's Printer for Ontario, 2021.
3. Orthoimagery © First Base Solutions, 2021. Imagery taken in 2019.

Project 8133

Burlington Quarry Extension
Nelson Aggregates Co.

Figure 9
Wetland Characterization

Wetland 13201 - West Extension

0 30 m
1:2,000

N

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Savanta Division

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Wetland 13201

Wetland Characteristics	Description	Figure / Graph	Reference	
			Report	Section / Page
Wetland IDs:	MNRF -N/A Earthfx - 21 Tatham - 13201 Savanta - 13201 Golder (Background) - N/A			
Wetland Area (ha):	Savanta - 0.92			
Watershed:	Bronte Creek Watershed			
Sub-Watershed:	Willoughby Creek Watershed			
Located in Proposed Limit of Extraction:	No			
Located in Proposed License Boundary:	No			
Catchment Area (ha):	14.85		SWA (Tatham, April 2020)	Drawing DP-1
Catchment ID:	S111		SWA (Tatham, April 2020)	Drawing DP-1
Closed or Connected System:	Isolated Feature (culvert under No. 2 Sideroad plugged and there is no evidence of a culvert or channel connection to the Unnamed Tributary of Lake Medad).			
Condition:	Modified			
Bathymetry:	A bathymetric survey of Wetland 13201 has not been completed.			
Outlet:	None			
Hydroperiod:	Monitoring station established April 22, 2020. Hydroperiod to be determined.			
Surface Water Monitoring:	ID: SW36 (Tatham) Installation Date: April 22, 2020 Data Collection: Continuous water level and temperature and manual monthly water level measurements Coordinates of Monitoring Station: Easting 589880.52, Northing 4804990.81			

Natural Heritage and Habitat Features	Description	Figure / Graph	Reference	
			Report	Section / Page
Wetland Name & Provincial Significance Evaluation:	Wetland 13201 – Other (considered not significant due to lack of amphibian breeding habitat, isolated and not connected to a PSW; however it has been designed to demonstrate no negative impacts.)		NETR (Savanta, April 2020)	6.1.2
ELC Unit(s):	Reed-canary Grass Mineral Meadow Marsh: MAM2-2 Silver Maple Mineral Deciduous Swamp: SWD3-2b		NETR (Savanta, April 2020)	Table 2
Regulated Habitat (MECP):	No		NETR (Savanta, April 2020)	6.7
Significant Wildlife Habitat:	None confirmed for amphibian breeding, despite survey effort through salamander habitat assessments, salamander trapping and call count surveys.		NETR (Savanta, April 2020)	4.2.2; 5.2.2; Table 19
Fish Habitat:	None		NETR (Savanta, April 2020)	6.6
Habitat of Endangered and Threatened Species:	No species at risk salamanders observed, despite survey effort including salamander habitat assessment and salamander trapping.		NETR (Savanta, April 2020)	5.2.2

<table>
<tr><th>Groundwater Interaction</th><th>Description</th><th>Figure / Graph</th><th colspan="2">Reference</th></tr>
<tr><th></th><th></th><th></th><th>Report</th><th>Section / Page</th></tr>
<tr><td>Lithology:</td><td>Halton Till</td><td></td><td></td><td></td></tr>
<tr><td>Hydraulic Conductivity:</td><td>Integrated Model (Earthfx) - The harmonic mean hydraulic conductivity, based on testing by Golder (2007) of 10 mini-piezometers, was 1.2x10^{-8} m/s. Model value for the vertical hydraulic conductivity was 1.6x10^{-7} m/s, about an order of magnitude higher, to account for limited flow through fractures in the till.</td><td></td><td></td><td></td></tr>
<tr><td>Surface Water/Groundwater Interaction:</td><td>The low permeability of the Halton Till underlying the wetland is the dominant control on 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. This wetland receives some groundwater inflow but is relatively isolated from any changes in the water table due to quarry development.</td><td></td><td></td><td></td></tr>
<tr><td>Shallow Groundwater (Mini-piezometer) Monitoring:</td><td>ID: SW36 (Tatham)
Installation Date: April 22, 2020
Data Collection: Continuous water level and temperature and manual monthly water level measurements
Coordinates of Monitoring Station: Easting 589880.52, Northing 4804990.81</td><td></td><td></td><td></td></tr>
<tr><td>Background Shallow Groundwater (Mini-piezometer) Monitoring:</td><td>
<table>
<tr><td>Mini-piezometer ID</td><td>Ground Elevation</td><td>Bottom Elevation</td><td>Average WL</td><td>Logger</td><td>Manual Meas.</td></tr>
<tr><td>Golder MP34</td><td>273.66</td><td>273.15</td><td>173.26</td><td>2010 - 2013</td><td>2010 - 2013</td></tr>
</table>
</td><td></td><td></td><td></td></tr>
<tr><td>Groundwater Monitoring (Monitoring Wells):</td><td>
<table>
<tr><td>Monitoring Well ID</td><td>Distance (Dir.)</td><td>Geologic Unit</td><td>Ground Elevation</td><td>Monitoring Elev</td><td>Average WL</td></tr>
<tr><td>BS-04A</td><td>144 (SW)</td><td>Bedrock</td><td>284.87</td><td>-</td><td>264.34</td></tr>
<tr><td>BS-04B</td><td>144 (SW)</td><td>Bedrock</td><td>284.87</td><td>-</td><td>264.69</td></tr>
<tr><td>BS-04C</td><td>144 (SW)</td><td>Bedrock</td><td>284.98</td><td>-</td><td>264.70</td></tr>
</table>
</td><td>Graphs 1 & 2</td><td></td><td></td></tr>
<tr><td>Water Budget Results:</td><td>A detailed average water budget, as simulated by the integrated model, is provided in the main report for Baseline Conditions (Earthfx Figure 7.29, p. 189). The baseline water budget is reproduced in Figure 1a. The wetland is a net provider of groundwater. Simulated groundwater levels, groundwater discharge to riparian areas, and streamflow in the vicinity of Wetland 13201 (Earthfx Wetland 21) for baseline conditions are discussed in Section 7 of the main report.
<table>
<tr><td>Wetland 13201</td><td>GW Outflow (%)</td><td>GW Inflow (%)</td></tr>
<tr><td>Baseline (Existing)</td><td>29.78</td><td>2.98</td></tr>
</table>
</td><td>Figure 1a</td><td>HHIAR (Earthfx, April 2020)</td><td>165 - 190</td></tr>
<tr><td>Integrated Model Calibration:</td><td>The model calibration to Well BS02 shows a good calibration to the available monitoring record (see Graph 3). Wetland 22 is not discussed in the Main Report. Other nearby wetlands are discussed in Appendix E, Section 19.6.</td><td>Graph 3</td><td></td><td></td></tr>
</table>

<table>
<tr><th>Impact Assessment (Operations Phases 1 & 2)</th><th>Description</th><th>Figure / Graph</th><th colspan="2">Reference</th></tr>
<tr><th></th><th></th><th></th><th>Report</th><th>Section / Page</th></tr>
<tr><td>Change in Wetland Area (ha):</td><td>No change.</td><td></td><td></td><td></td></tr>
<tr><td>Change in Wetland Catchment Area (ha):</td><td>No change. No extraction proposed in West Extension as part of Phases 1 and 2 of extraction.</td><td></td><td>SWA (Tatham, April 2020)</td><td>Drawing DP-2</td></tr>
<tr><td>Change in Hydroperiod:</td><td>No Change</td><td></td><td></td><td></td></tr>
<tr><td>Change in Water Budget:</td><td>A detailed average water budget as simulated by the integrated model is provided in the Earthfx report for Baseline Conditions (Figure 7.29, p. 189); Scenario P12 (Figure 8.36, p. 224); P3456 (Figure 8.68, p. 251 Wetland 22). The water budget results for Scenario P12 are reproduced in Figure 1b. Wetland 13201 (Earthfx Wetland 21) is located at the south edge of the West Extension area. This wetland will be monitored and receive supplemental inflows as required to maintain its hydroperiod, as described in the Tatham, 2020 report. The planned supplementation has not been represented in the model, so the Wetland 13201 (Earthfx Wetland 21) water budget is not fully representative of future conditions. Simulated change in groundwater levels (drawdowns), groundwater discharge to riparian areas, and change in streamflow in the vicinity of Wetland 13201 (Earthfx Wetland 21) for each scenario are discussed in Section 8 of the main report.
<table>
<tr><td>Wetland 13201</td><td>GW Outflow (%)</td><td>GW Inflow (%)</td><td>Δ in Outflow (%)</td><td>Δ in Inflow (%)</td></tr>
<tr><td>Baseline (Existing)</td><td>29.78</td><td>2.98</td><td>-</td><td>-</td></tr>
<tr><td>Operations Ph 1 & 2</td><td>30.38</td><td>1.76</td><td>-0.60</td><td>-1.22</td></tr>
</table></td><td>Figure 1b</td><td>HHIAR (Earthfx, April 2020)</td><td>191 - 303</td></tr>
<tr><td>Potential Impact to Form and Function of Feature:</td><td>No wetlands will be removed and the wetlands subcatchment will be maintained. There will be no encroachment from the project into the wetland.</td><td></td><td></td><td></td></tr>
</table>

<table>
<tr><th>Mitigation (Operational Phases 1 & 2)</th><th>Description</th><th>Figure / Graph</th><th colspan="2">Reference</th></tr>
<tr><th></th><th></th><th></th><th>Report</th><th>Section / Page</th></tr>
<tr><td>Proposed Mitigation Measures:</td><td>None required.</td><td></td><td></td><td></td></tr>
</table>

<table>
<tr><th>Impact Assessment (Operations Phases 3 - 6)</th><th>Description</th><th>Figure / Graph</th><th colspan="2">Reference</th></tr>
<tr><th></th><th></th><th></th><th>Report</th><th>Section / Page</th></tr>
<tr><td>Change in Wetland Area (ha):</td><td>No change.</td><td></td><td></td><td></td></tr>
<tr><td>Change in Wetland Catchment Area (ha):</td><td>Reduction in catchment area. During operations in Phases 3 through 6 the catchment area will be reduced to 7.6 ha (reduction of 7.25 ha)</td><td></td><td>SWA (Tatham, April 2020)</td><td>Drawing DP-2</td></tr>
<tr><td>Change in Hydroperiod:</td><td>Reduction due to reduction in catchment area. Change in hydroperiod to be determined (to be mitigated).</td><td></td><td></td><td></td></tr>
<tr><td>Change in Water Budget:</td><td>A detailed average water budget as simulated by the integrated model is provided in the Earthfx report for Baseline Conditions (Figure 7.29, p. 189); Scenario P12 (Figure 8.36, p. 224); P3456 (Figure 8.68, p. 251 Wetland 22). The water budget results for Scenario P3456 are reproduced in Figure 1c. Wetland 13201 (Earthfx Wetland 21) is located at the south edge of the West Extension area. This wetland will be monitored and receive supplemental inflows as required to maintain its hydroperiod, as described in the Tatham, 2020 report. The planned supplementation has not been represented in the model, so the Wetland 13201 (Earthfx Wetland 21) water budget is not fully representative of future conditions. Simulated change in groundwater levels (drawdowns), groundwater discharge to riparian areas, and change in streamflow in the vicinity of Wetland 13201 (Earthfx Wetland 21) for each scenario are discussed in Section 8 of the main report.
<table>
<tr><td>Wetland 13201</td><td>GW Outflow (%)</td><td>GW Inflow (%)</td><td>Δ in Outflow (%)</td><td>Δ in Inflow (%)</td></tr>
<tr><td>Baseline (Existing)</td><td>29.78</td><td>2.98</td><td>-</td><td>-</td></tr>
<tr><td>Operations Ph 3 - 6</td><td>51.69</td><td>0.01</td><td>21.91</td><td>-2.97</td></tr>
</table></td><td>Figure 1c</td><td>HHIAR (Earthfx, April 2020)</td><td>191 - 303</td></tr>
<tr><td>Change on Soil Moisture Conditions:</td><td>The predicted soil moisture and surface discharge patterns in Wetland 21 are shown in Graph 4. The pond leakage for Wetland 21 is shown in Graph 5. The change in soil moisture and pond seepage is somewhat more complex in Wetland 21 than the other wetlands because the headwater catchment area will be reduced by the development of P3456. Under Baseline conditions, the wetland receives runoff and interflow from a larger catchment resulting in higher average soil moisture conditions. Under P3456 conditions the change in catchment area reduces the soil moisture and groundwater seepage. These changes (due to lower water availability and the drop in the water table) cause higher pond leakage in the spring, and lower leakage in the fall (Graph 5). It is important to note that groundwater inflow as a percentage of total inflows is only 2.98% under baseline conditions.</td><td>Graph 4 & 5</td><td></td><td></td></tr>
<tr><td>Potential Impact to Form and Function of Feature:</td><td>Both wetlands will remain in place. There will be no encroachment from the project into the wetlands. The proposed limit of extraction is >30 m from the wetland boundary. The licensed boundary/extraction limit will be demarcated and fenced to ensure site construction and operations do not extend beyond the proposed limits of the project . The drainage area to these wetland units will be reduced during operations, which has the potential to adversely impact the hydroperiods.</td><td></td><td>NETR (Savanta, April 2020)</td><td>7.2.1; 7.1.1; 7.1.2</td></tr>
</table>

<table>
<tr><th>Mitigation (Operational Phases 3 - 6)</th><th>Description</th><th>Figure / Graph</th><th colspan="2">Reference</th></tr>
<tr><th></th><th></th><th></th><th>Report</th><th>Section / Page</th></tr>
<tr><td>Proposed Mitigation Measures:</td><td>To mitigate this potential impact, flow to the wetlands will be supplemented by a bottom draw outlet constructed in the southeast corner of the proposed infiltration pond and an outlet pipe with a control valve will be installed to discharge water into the roadside ditch along No. 2 Sideroad, feeding the wetland. The bottom draw outlet, outlet pipe and control valve will remain post extraction as part of the rehabilitation of the site. Wetland hydroperiod and shallow groundwater monitoring stations were installed in spring 2020. This data will be used to establish existing thresholds so existing conditions can be maintained throughout extraction operations and replicated in post-operation / rehabilitated conditions.</td><td></td><td>NETR (Savanta, April 2020)</td><td>7.2.1; 7.1.1; 7.1.2</td></tr>
</table>

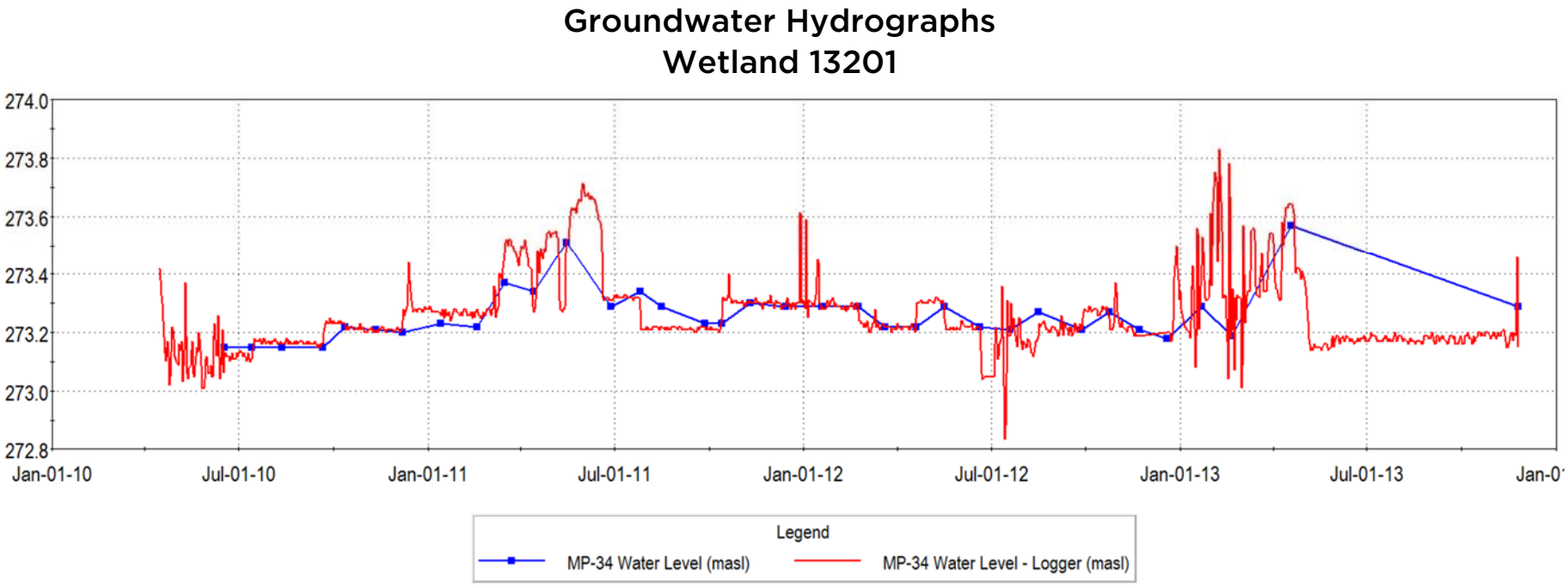
Impact Assessment (Rehabilitation)	Description	Figure / Graph	Reference	
			Report	Section / Page
Change in Wetland Area (ha):	No change.			
Change in Wetland Catchment Area (ha):	Reduction in catchment area. During operations in Phases 3 through 6 the catchment area will be reduced to 7.6 ha (reduction of 7.25 ha)		SWA (Tatham, April 2020)	Drawing DP-3
Change in Hydroperiod:	Reduction due to reduction in catchment area. Change in hydroperiod to be determined (to be mitigated).			
Change in Water Budget:	A detailed average water budget as simulated by the integrated model is provided in the Earthfx report for Baseline Conditions (Figure 7.29, p. 189); Scenario P12 (Figure 8.36, p. 224); P3456 (Figure 8.68, p. 251 Wetland 22). The water budget results for Scenario RHB1 and RHB2 are reproduced in Figures 1d and 1e. Wetland 13201 (Earthfx Wetland 21) is located at the south edge of the West Extension area. This wetland will be monitored and receive supplemental inflows as required to maintain its hydroperiod, as described in the Tatham, 2020 report. The planned supplementation has not been represented in the model, so the Wetland 13201 (Earthfx Wetland 21) water budget is not fully representative of future conditions. Simulated change in groundwater levels (drawdowns), groundwater discharge to riparian areas, and change in streamflow in the vicinity of Wetland 13201 (Earthfx Wetland 21) for each scenario are discussed in Section 8 of the main report.	Figure 1d and 1e	HHIAR (Earthfx, April 2020)	191 - 303

Wetland 13201	GW Outflow (%)	GW Inflow (%)	Δ in Outflow (%)	Δ in Inflow (%)
Baseline (Existing)	26.31	0.00	-	-
Rehab Scenario 1	49.00	0.23	19.22	-2.75
Rehab Scenario 2	2.21	15.67	-27.57	12.69

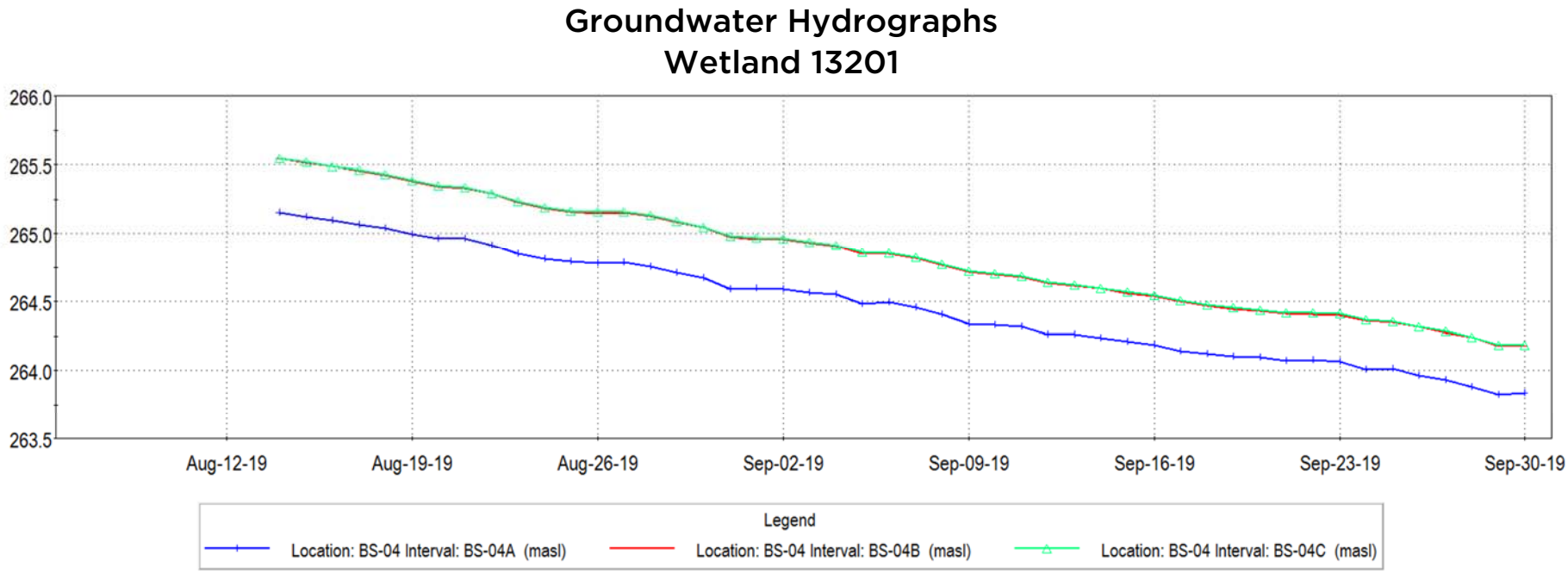
Impact Assessment (Rehabilitation)	Description	Figure / Graph	Reference	
			Report	Section / Page
Potential Impact to Form and Function of Feature:	Both wetlands will remain in place. There will be no encroachment from the project into the wetlands. The proposed limit of extraction is >30 m from the wetland boundary. The licensed boundary/extraction limit will be demarcated and fenced to ensure site construction and operations do not extend beyond the proposed limits of the project . The drainage area to these wetland units will be reduced during operations, which has the potential to adversely impact the hydroperiods.		NETR (Savanta, April 2020)	7.2.1; 7.1.1; 7.1.2

Mitigation (Rehabilitation)	Description	Figure / Graph	Reference	
			Report	Section / Page
Proposed Mitigation Measures:	To mitigate this potential impact, flow to the wetlands will be supplemented by a bottom draw outlet constructed in the southeast corner of the proposed infiltration pond and an outlet pipe with a control valve will be installed to discharge water into the roadside ditch along No. 2 Sideroad, feeding the wetland. The bottom draw outlet, outlet pipe and control valve will remain post extraction as part of the rehabilitation of the site. Wetland hydroperiods and shallow groundwater monitoring stations were installed in spring 2020. This data will be used to establish existing thresholds so existing conditions can be maintained throughout extraction operations and replicated in post-operation / rehabilitated conditions.		NETR (Savanta, April 2020)	7.2.1; 7.1.1; 7.1.2

WETLAND 13201 - GRAPH 1



WETLAND 13201 - GRAPH 2



WETLAND 13201

FIGURE 1A

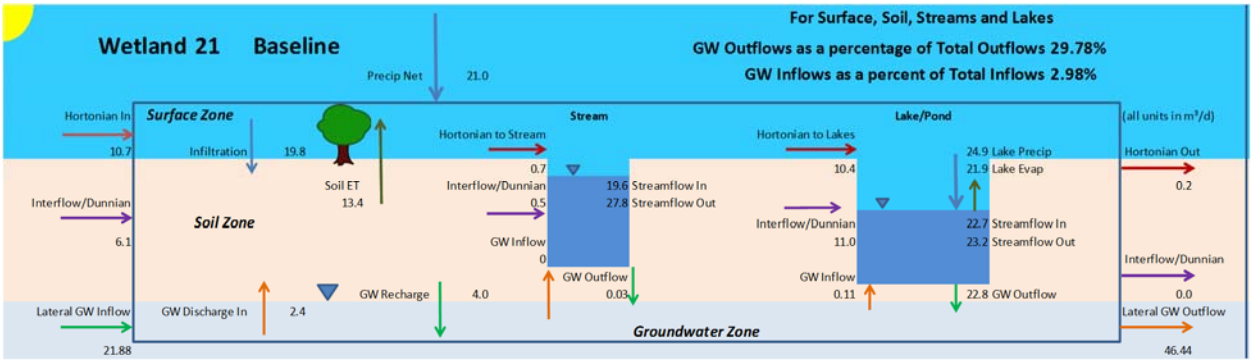


FIGURE 1B

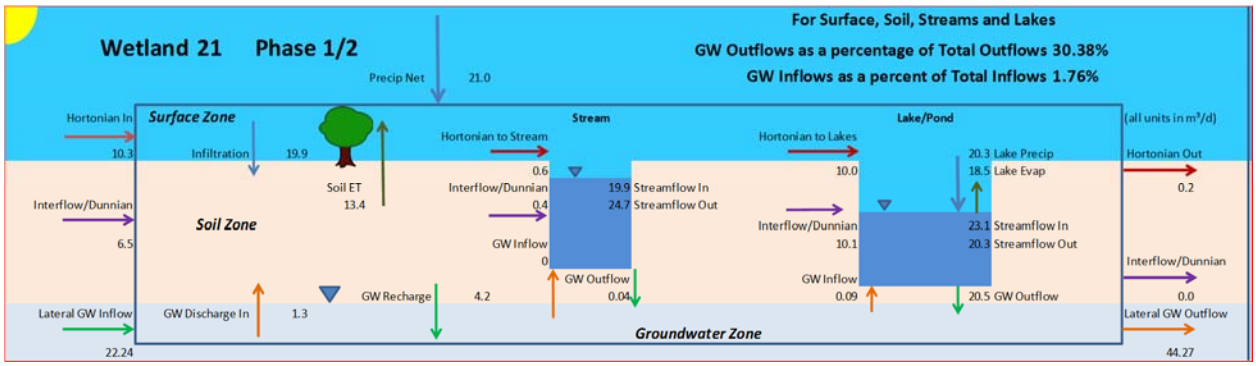


FIGURE 1C

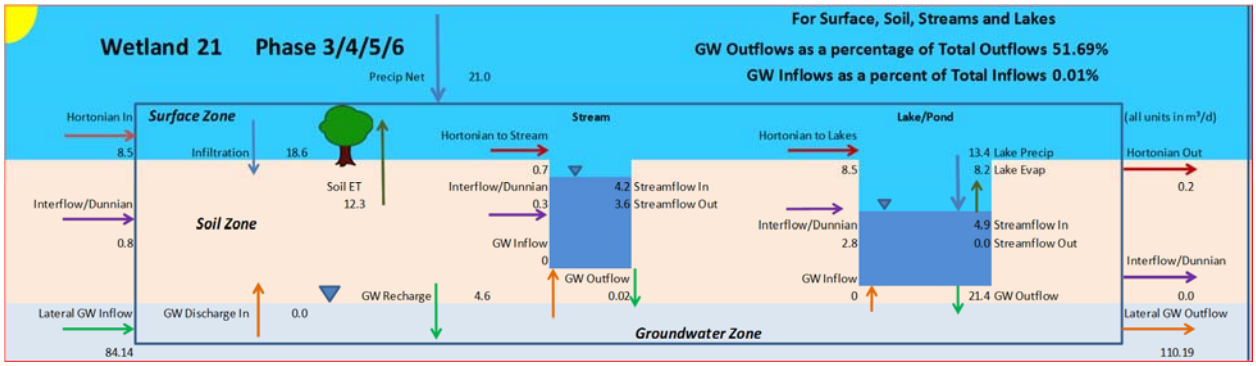


FIGURE 1D

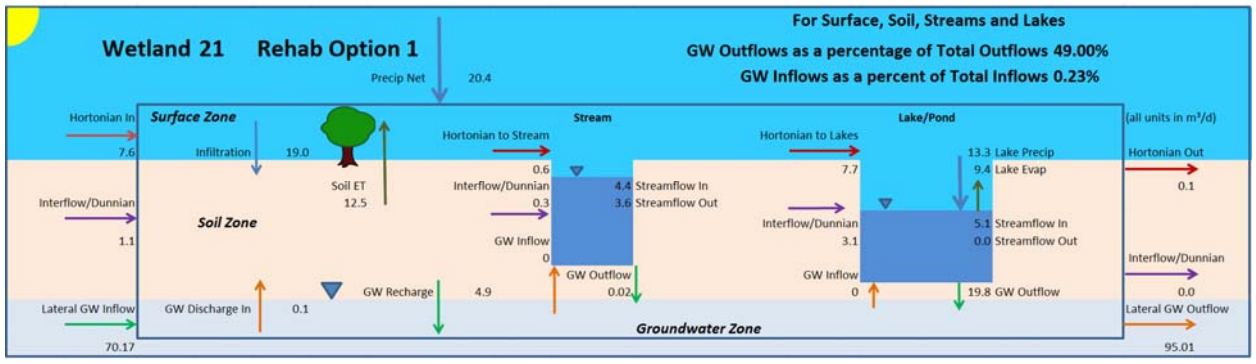
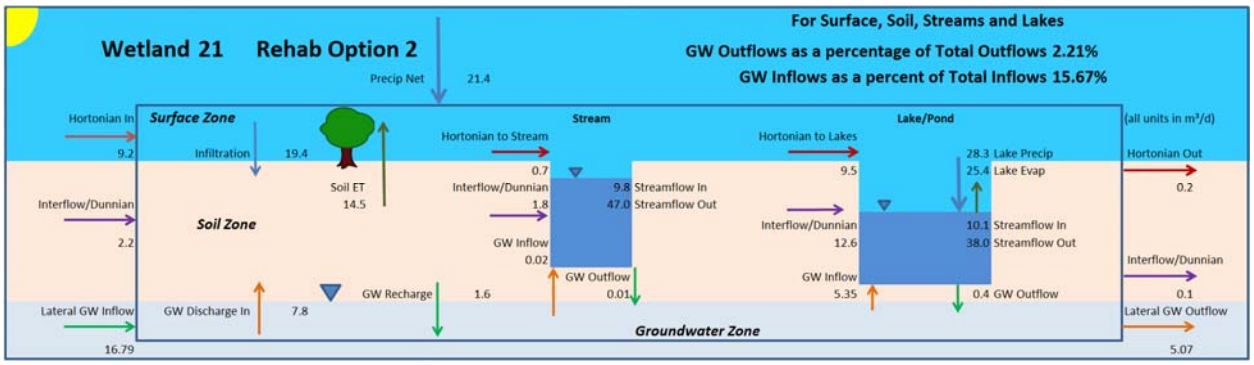
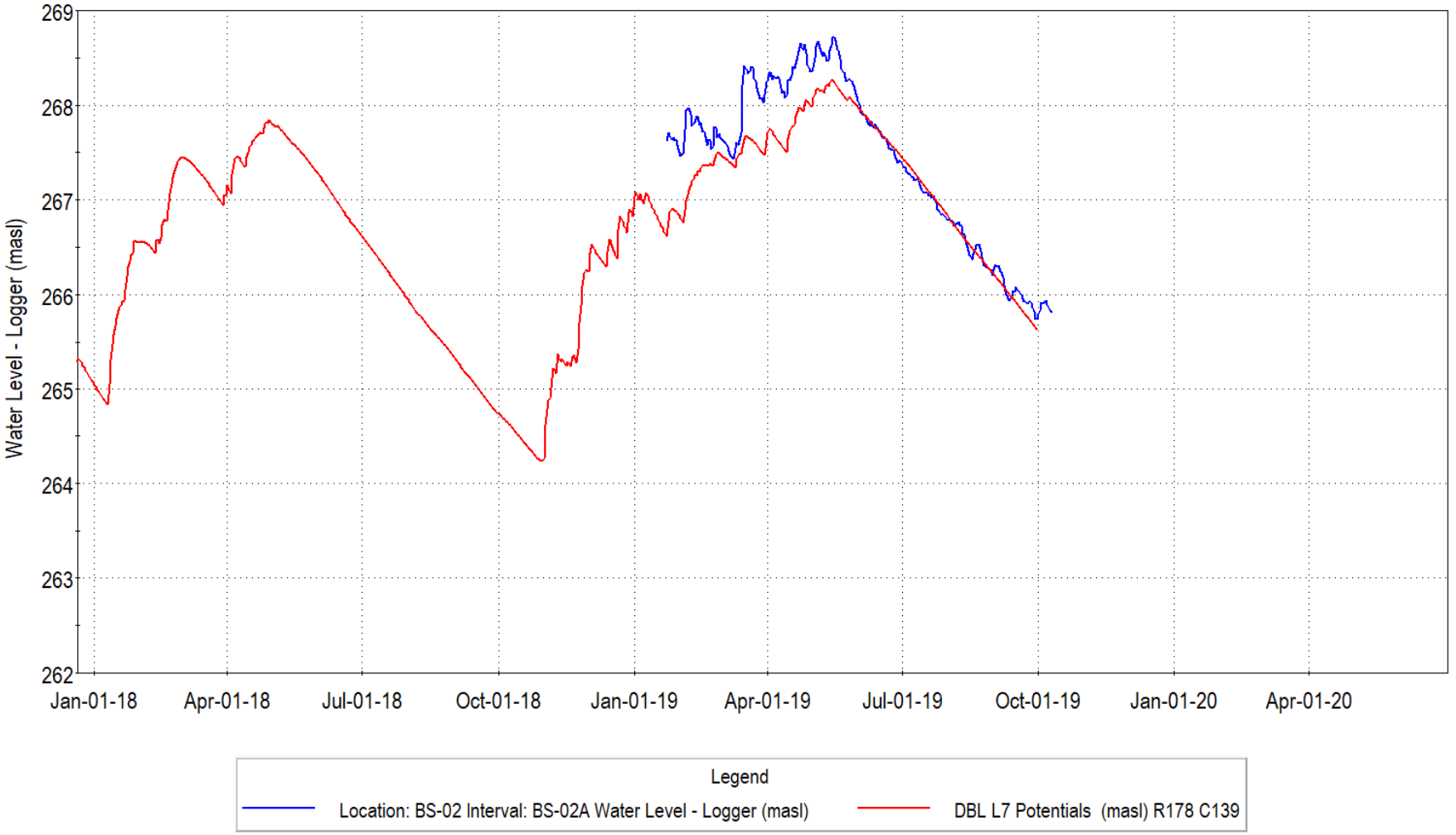


FIGURE 1E



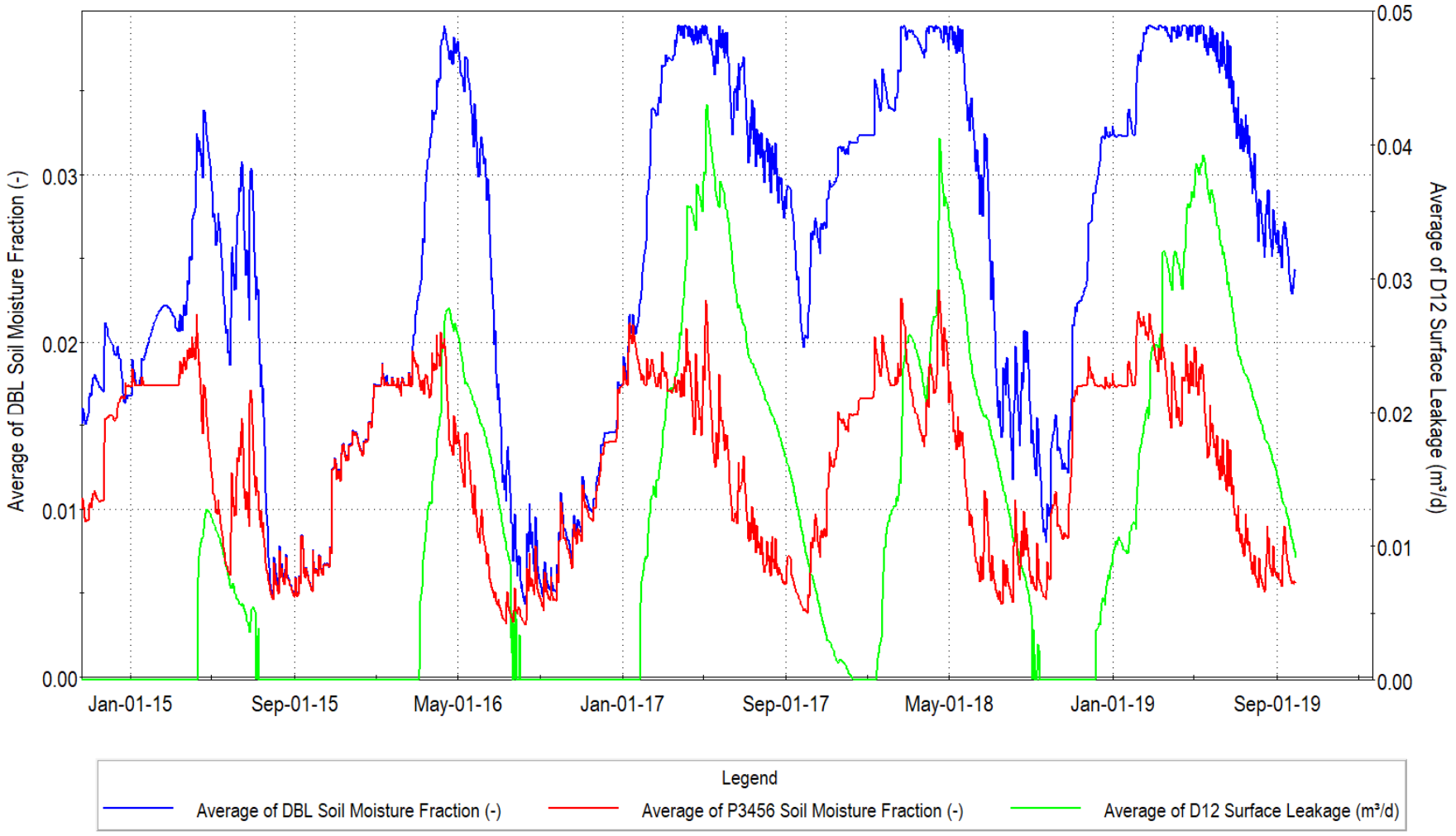
WETLAND 13201 - GRAPH 3

Integrated Model Calibration
Wetland 13201



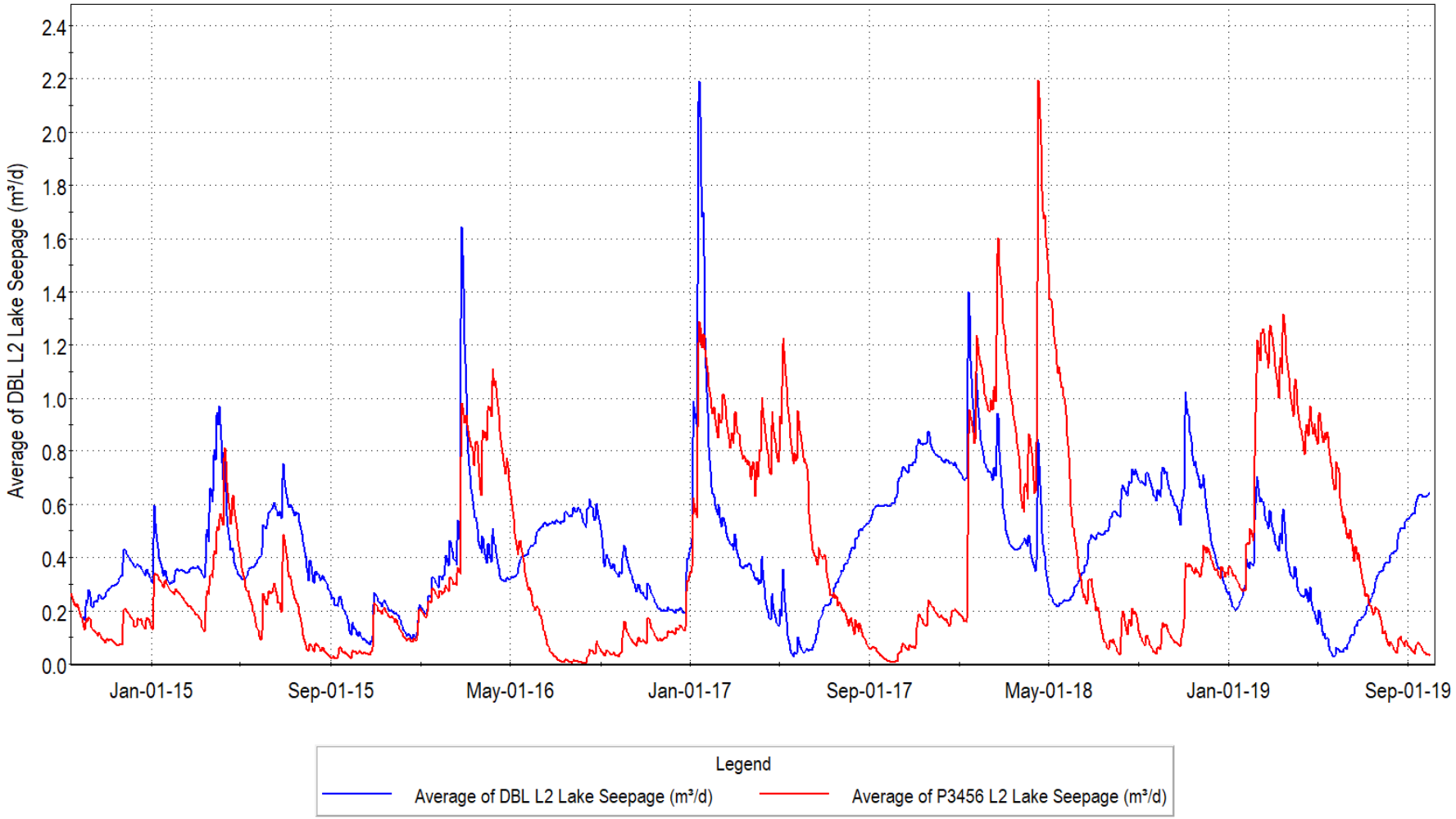
WETLAND 13201 - GRAPH 4

Change in Soil Moisture Conditions
Wetland 13201

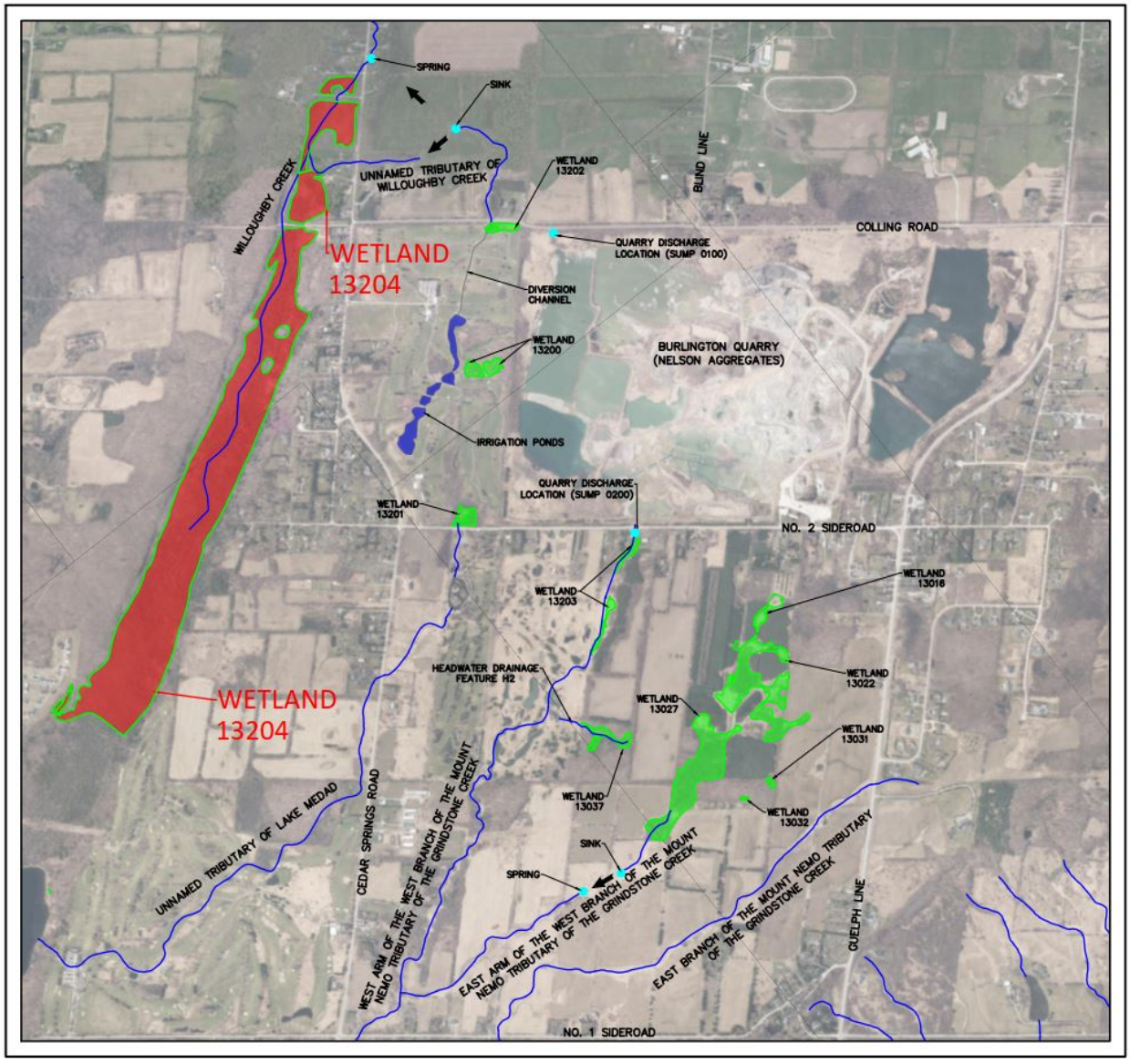


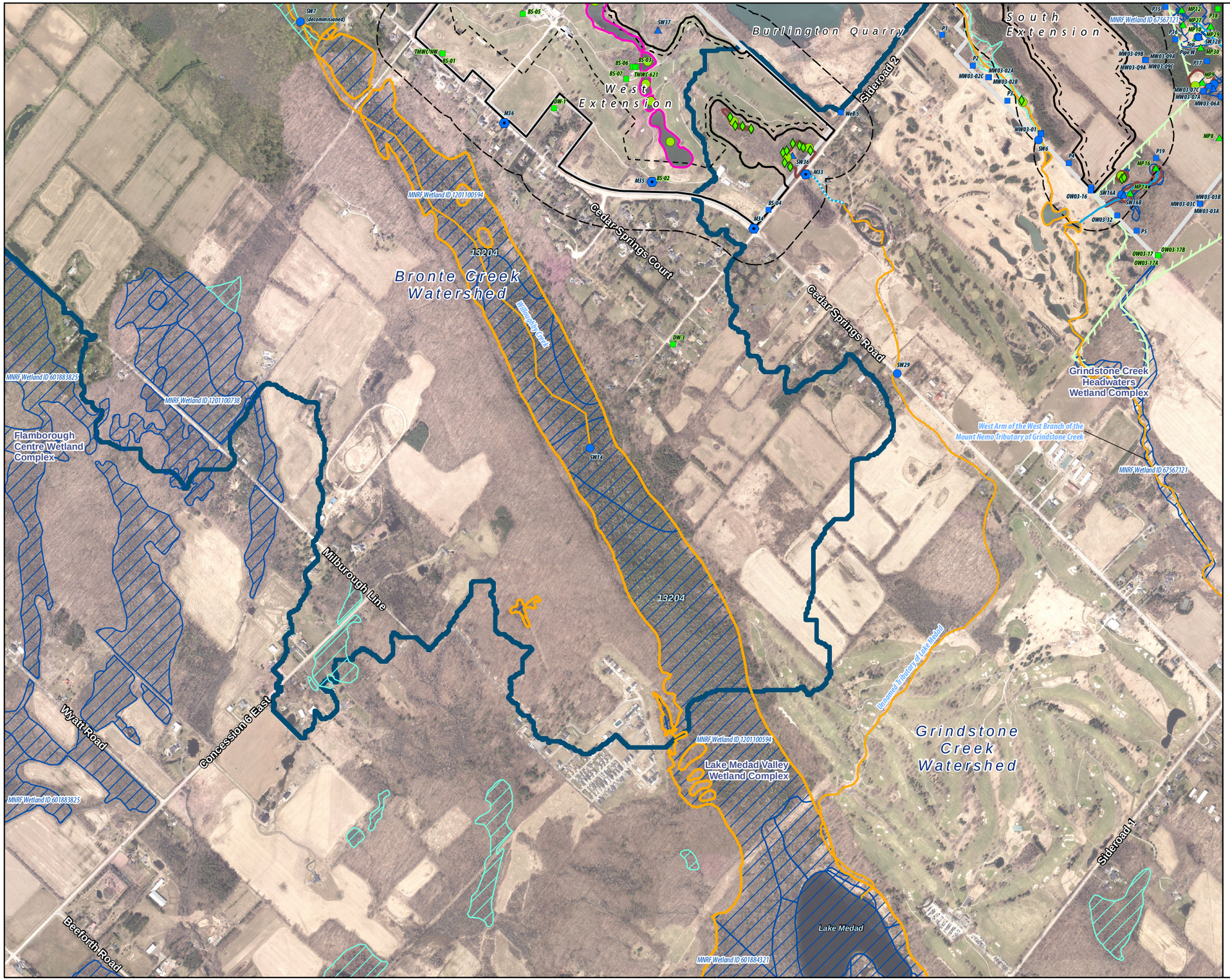
WETLAND 13201 - GRAPH 5

Change in Soil Moisture Conditions
Wetland 13201



WETLAND 13204





Legend

- Licensed Boundary
- Limit of Extraction
- 120 m Adjacent Lands
- Subject Lands
- Lake Medad Valley Wetland Complex
- Amphibian Call Count Station (2019)
- Salamander Trap (2019)
- Salamander Habitat Assessment (2019)
- Golf Course Irrigation Ponds and Channel
- Indirect Fish Habitat
- Direct Fish Habitat
- Provincially Significant Wetland (LIO/MNRF, 2020)
- Wetland - Not Evaluated per OWES (MNRF/LIO, 2020)
- MECP Jefferson Salamander Regulated Habitat
- Watershed Boundary (Conservation Halton)

Current Instrumentation

- Groundwater Monitoring Station (EarthFx)
- Mini Piezometer (Tatham Engineering)
- Staff Gauge & Surface Water Monitoring Station (Tatham Engineering)
- Manual Stream Flow Measurement (Tatham Engineering)

Previous Instrumentation

- Groundwater Monitoring Station (Golder)
- Mini Piezometer (Golder)

NOTES:

1. Coordinate System: NAD 1983 UTM Zone 17N.
2. Base features produced under license with the Ontario Ministry of Natural Resources and Forestry © Queen's Printer for Ontario, 2021; © Conservation Halton, 2021.
3. Orthoimagery © First Base Solutions, 2021. Imagery taken in 2019.

Project 8133

Burlington Quarry Extension
Nelson Aggregates Co.

Figure 10
Wetland Characterization

Wetland 13204 - Medad Valley PSW Complex

0 220 m

1:12,000

N

GEI Consultants
Savanta Division

Wetland 13204

Wetland Characteristics	Description	Figure / Graph	Reference	
			Report	Section / Page
Wetland IDs:	MNRF – 1201100594 (OGF 1200821993, 1200821992, 1200821982, 1200821988, 67340473, 1200821978, 67196301, Earthfx - Medad Valley Tatham - 13204 Savanta - Lake Medad Wetland Golder (Background) - N/A			
Wetland Area (ha):	LIO/MNRF - 48.5			
Watershed:	Bronte Creek Watershed			
Sub-Watershed:	Willoughby Creek Watershed			
Located in Proposed Limit of Extraction:	No			
Located in Proposed License Boundary:	No			
Catchment Area (ha):	844 + quarry discharge (Sump 0100)			
Catchment ID:	N/A			
Closed or Connected System:	On-line (connected to downstream watercourse)			
Condition:	Natural			
Bathymetry:	No bathymetric data available for the Lake Medad PSW.			
Outlet:	Willoughby Creek			
Hydroperiod:	Seasonal			
Surface Water Monitoring:	ID: SW14 (Tatham) Installation Date: October 2, 2014 Data Collection: Continuous water level and temperature and manual monthly water level measurements Coordinates of Monitoring Station: Easting 589226.754, Northing 4804106.857	Graph 1	SWA (Tatham, April 2020)	2.1.1, 3 and Appendix B

Natural Heritage and Habitat Features	Description	Figure / Graph	Reference	
			Report	Section / Page
Wetland Name & Provincial Significance Evaluation:	Lake Medad Valley Wetland Complex – Provincially Significant		NETR (Savanta, April 2020)	6.1.2
ELC Unit(s):	Unknown – outside of 120 m adjacent lands			
Regulated Habitat (MECP):	No			
Significant Wildlife Habitat:	Unknown – outside of 120 m adjacent lands			
Fish Habitat:	Unknown – outside of 120 m adjacent lands			
Habitat of Endangered and Threatened Species:	Unknown – outside of 120 m adjacent lands			

Groundwater Interaction	Description	Figure / Graph	Reference	
			Report	Section / Page
Lithology:	The Medad Valley is a partly-buried gorge that carried meltwater from the receding ice for a period of time (Karrow, 1987). The infill deposits are likely coarse-grained glaciofluvial deposits overlain by organic deposits. While there is limited borehole information in the Medad Valley, there is some evidence that the sand deposits are thicker in the valley to the north and south of the site.			
Hydraulic Conductivity:	Integrated Model (Earthfx) - Model values for the horizontal hydraulic conductivity of the MIS sands were $5.0x10^{-5}$ m/s and $2.5x10^{-5}$ m/s for vertical hydraulic conductivity.			
Surface Water/Groundwater Interaction:	The Medad Valley is a local groundwater discharge zone. Flow is supplemented by groundwater discharge to springs on the flanks of the valley. The GSFLOW model indicated that groundwater discharge exceeds groundwater recharge in this area. The model also indicated that lowering the water table in the quarry vicinity has limited effect on the major areas of groundwater discharge, such as the Medad Valley, which are already at a lower elevation than the quarry. The model also indicated that, while the Medad Valley is generally a groundwater discharge area, there are reaches of the main stream in the centerline of the valley that lose water to the groundwater system (see figure 7.21 in Earthfx report, reproduced below). This demonstrates that the incised Medad wetlands and streams are isolated from and behave differently than the streams and wetlands of the upland plateau (where the quarry is located). Despite these losing conditions, there is still a net gain of water in the stream between gauges SW14 and SW07.	Figure 1		
Water Budget Results:	A detailed Baseline water budget (to stream gauge SW7) was produced for this wetland and it is discussed in the Watercourse Characterization Table for Willoughby Creek.	Figure 2a		
Integrated Model Calibration:	Model calibration focused on matching observed streamflow. The calibration to streamflow is presented in Earthfx Section 19.4. The figure shows the calibration to SW2.	Graph 2	HHIAR (Earthfx, April 2020)	19.4

Impact Assessment (Operations Phases 1 & 2)	Description	Figure / Graph	Reference	
			Report	Section / Page
Change in Wetland Area (ha):	No change. Wetland located greater than 120 m from licensed boundary.			
Change in Wetland Catchment Area (ha):	No Change as a result of extraction in Phase 1. Catchment area remains unaltered.			
Change in Hydroperiod:	No Change. Subcatchment area remains unaltered.			
Change in Water Budget:	A detailed Baseline water budget (to stream gauge SW7) was produced for this wetland and it is discussed in the Watercourse Characterization Table for Willoughby Creek.	Figure 2b		
Potential Impact to Form and Function of Feature:	No wetlands will be removed and the wetlands subcatchment will be protected. There will be no encroachment from the project into the wetland. The proposed limit of extraction is >120 m from the wetland boundary. Licensed boundary will be demarcated and fenced to ensure site construction and operations do not extend beyond the proposed limits of the project.			

Mitigation (Operational Phases 1 & 2)	Description	Figure / Graph	Reference	
			Report	Section / Page
Proposed Mitigation Measures:	None required.			

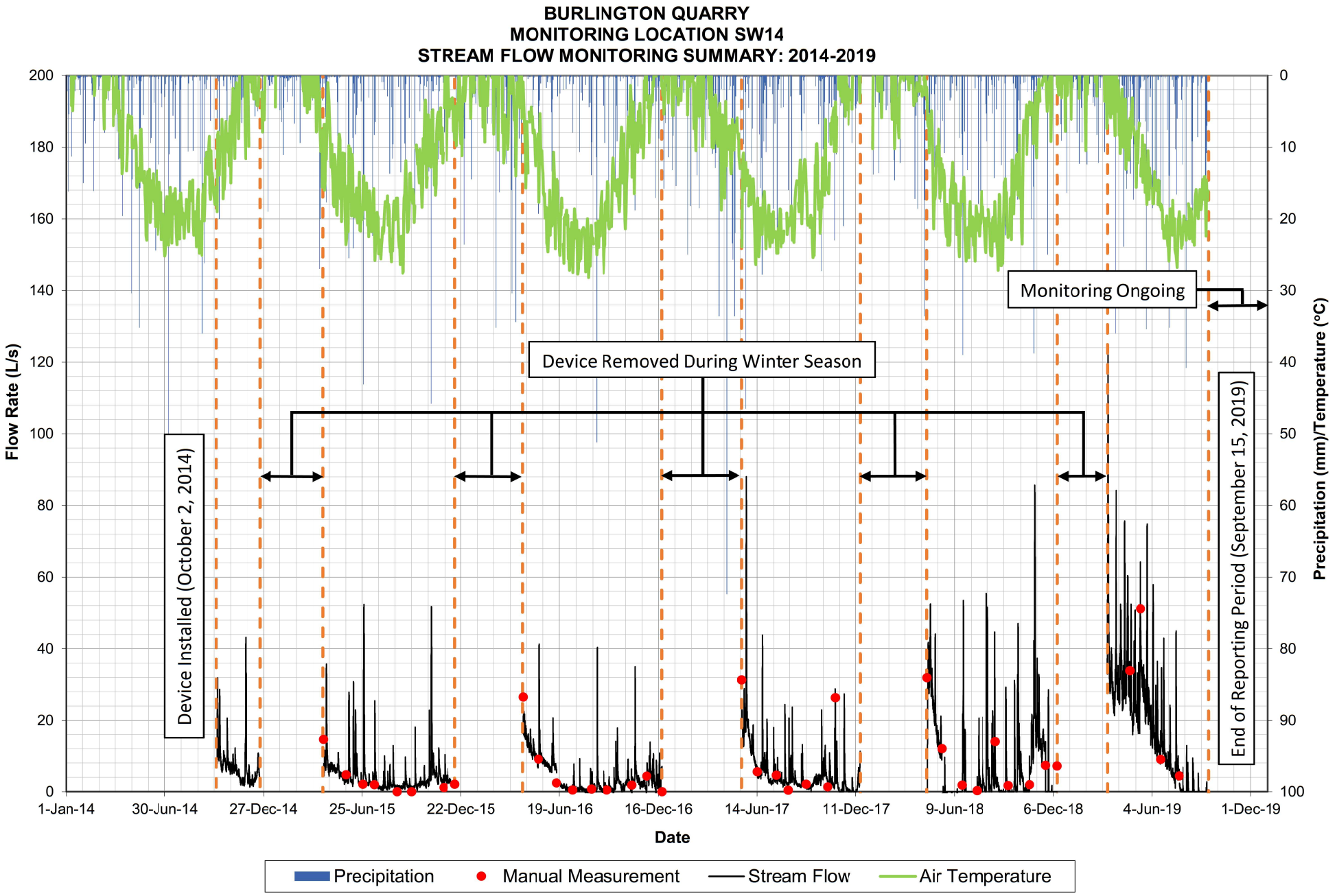
Impact Assessment (Operations Phases 3 - 6)	Description	Figure / Graph	Reference	
			Report	Section / Page
Change in Wetland Area (ha):	No change. Wetland located greater than 120 m from licensed boundary.			
Change in Wetland Catchment Area (ha):	Reduction in catchment area. During operations in Phases 3 through 6 the catchment area will be reduced by 18.6 ha (reduction of 2%).			
Change in Hydroperiod:	Insignificant reduction due to reduction in catchment area. Potential reduction due to groundwater drawdown to be mitigated through construction of infiltration pond.			
Change in Water Budget:	A detailed Baseline water budget (to stream gauge SW7) was produced for this wetland and it is discussed in the Watercourse Characterization Table for Willoughby Creek. Changes in streamflow at SW7 in the Medad Valley were generally small. Figures 8.11 (p. 203) and Figure 8.49 (p. 237) compare streamflow under Phase 12 and Phase 3456, respectively, to baseline flows. The figures are reproduced in Graphs 3 and 4. The small changes indicate that changes to the Medad wetland are also likely to be small.	Figure 2c and Graphs 3 & 4		
Change on Soil Moisture Conditions:	The total change in surface leakage between Baseline and P3456 in catchment SW7 is shown in Graph 5. A small amount of groundwater seepage will be intercepted by P3456 and discharged to the Medad Valley just downstream of SW7. This change in seepage is relatively uniform over time and will not be observable because it is highly diffuse.	Graph 5		
Potential Impact to Form and Function of Feature:	Potential adverse impacts to wetland hydroperiod due to reduction in catchment area and groundwater drawdown to be mitigated.			

Mitigation (Operational Phases 3 - 6)	Description	Figure / Graph	Reference	
			Report	Section / Page
Proposed Mitigation Measures:	Construction of infiltration pond is intended to maintain seepage to GW in the vicinity West Extension to maintain GW levels and GW discharge to the Medad Valley.			

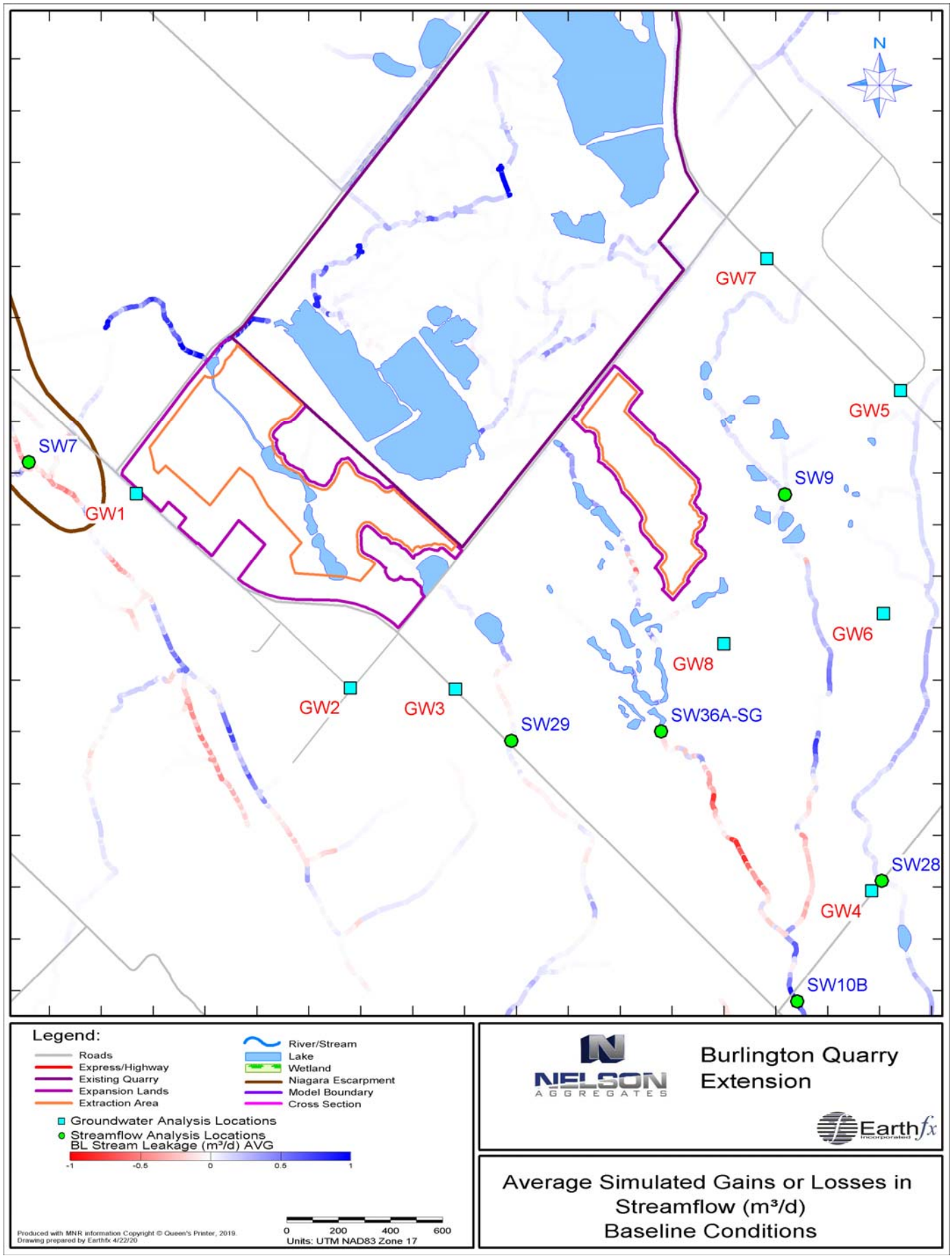
Impact Assessment (Rehabilitation)	Description	Figure / Graph	Reference	
			Report	Section / Page
Change in Wetland Area (ha):	No change. Wetland located greater than 120 m from licensed boundary.			
Change in Wetland Catchment Area (ha):	Reduction in catchment area. During operations in Phases 3 through 6 the catchment area will be reduced by 18.6 ha (reduction of 2%).			
Change in Hydroperiod:	Insignificant reduction due to reduction in catchment area. Potential reduction due to groundwater drawdown to be mitigated through construction of infiltration pond.			
Change in Water Budget:	See Change in Water Budget described under Impact Assessment (Phases 3 through 6).			
Potential Impact to Form and Function of Feature:	Potential adverse impacts to wetland hydroperiod due to reduction in catchment area and groundwater drawdown to be mitigated.			

Mitigation (Rehabilitation)	Description	Figure / Graph	Reference	
			Report	Section / Page
Proposed Mitigation Measures:	Construction of infiltration pond is intended to maintain seepage to GW in the vicinity West Extension to maintain GW levels and GW discharge to the Medad Valley.			

WETLAND 13204 - GRAPH 1



WETLAND 13204 - FIGURE 1



WETLAND 13204

FIGURE 2A

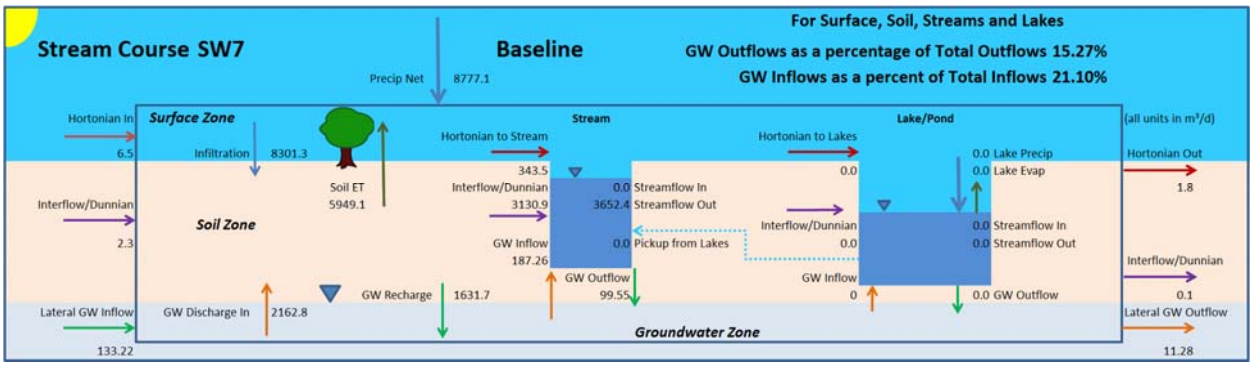


FIGURE 2B

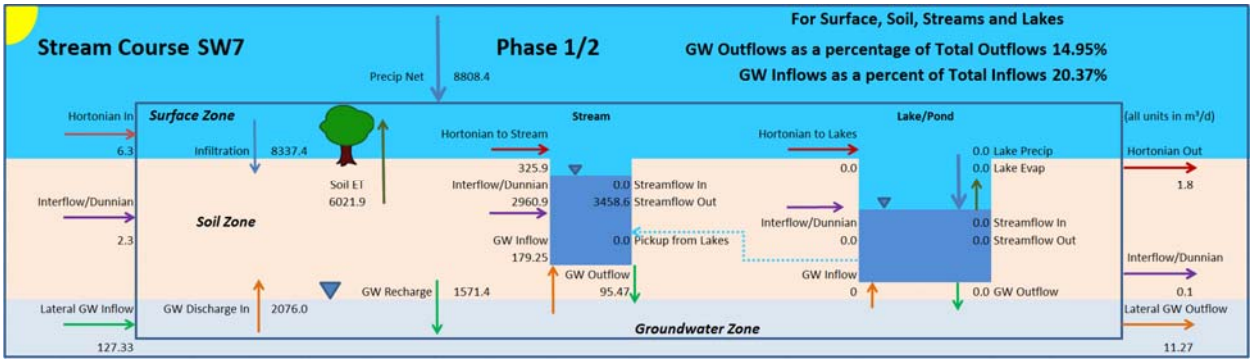


FIGURE 2C

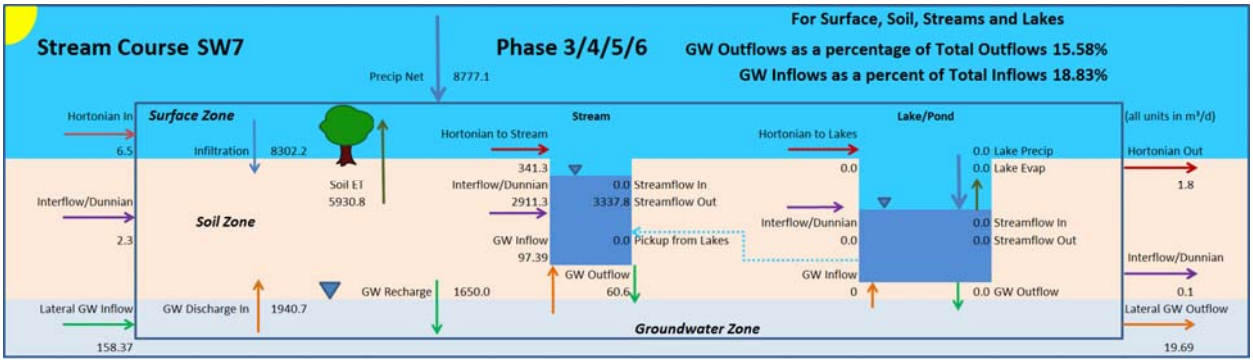


FIGURE 2D

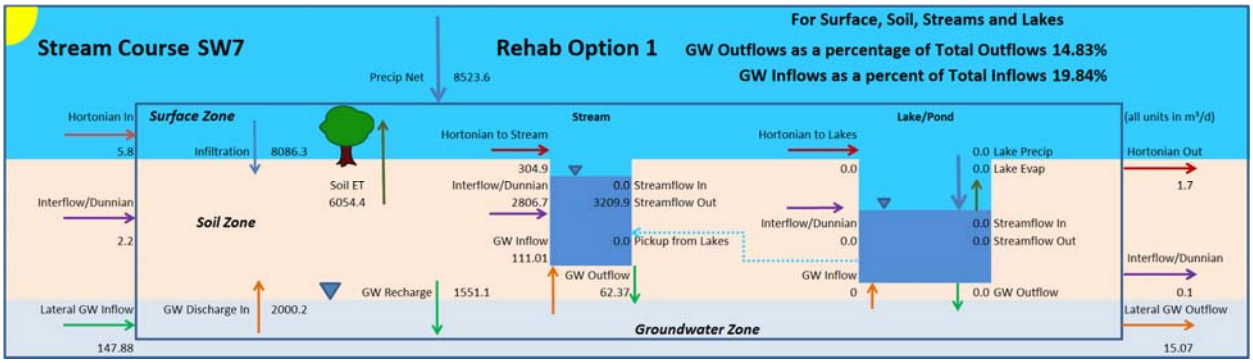
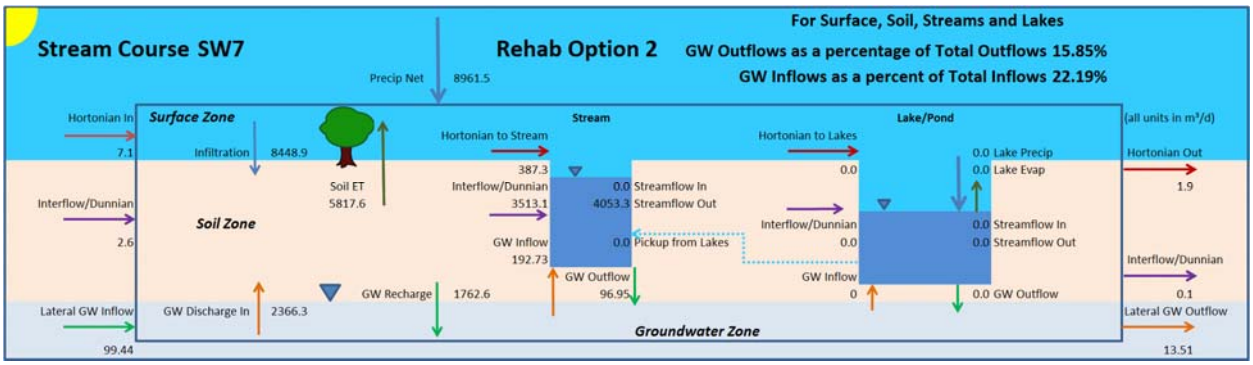
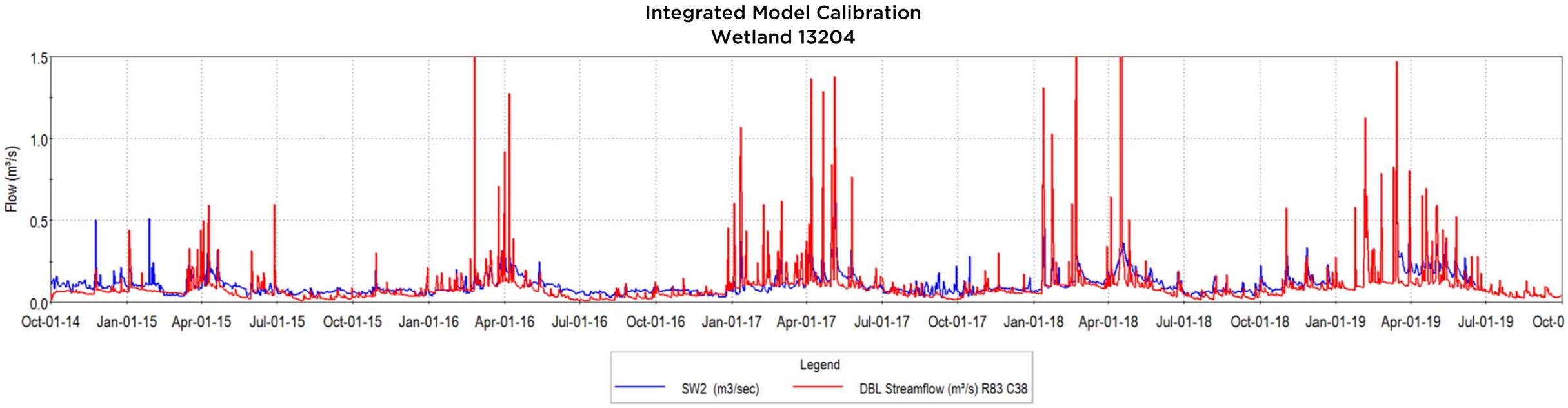


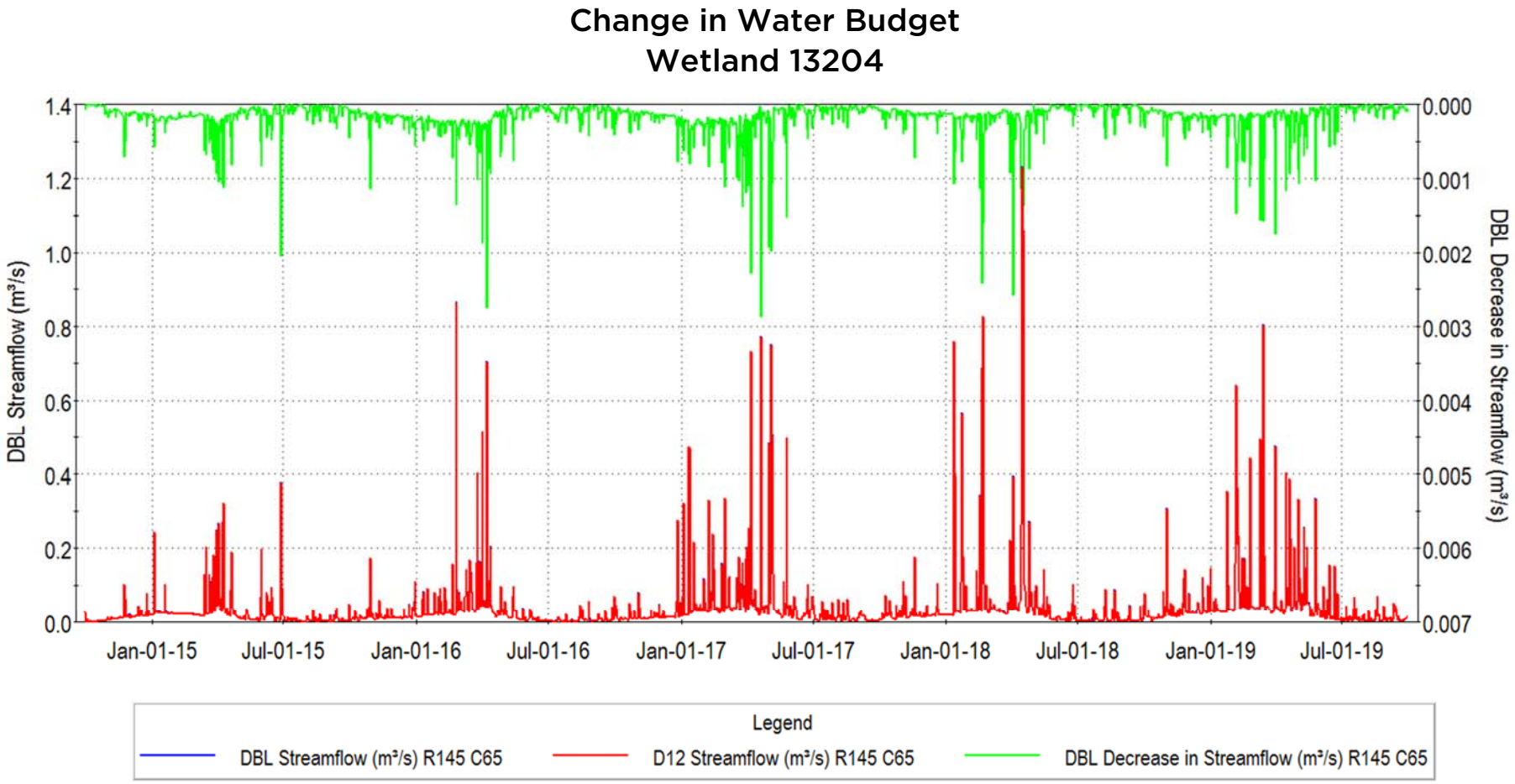
FIGURE 2E



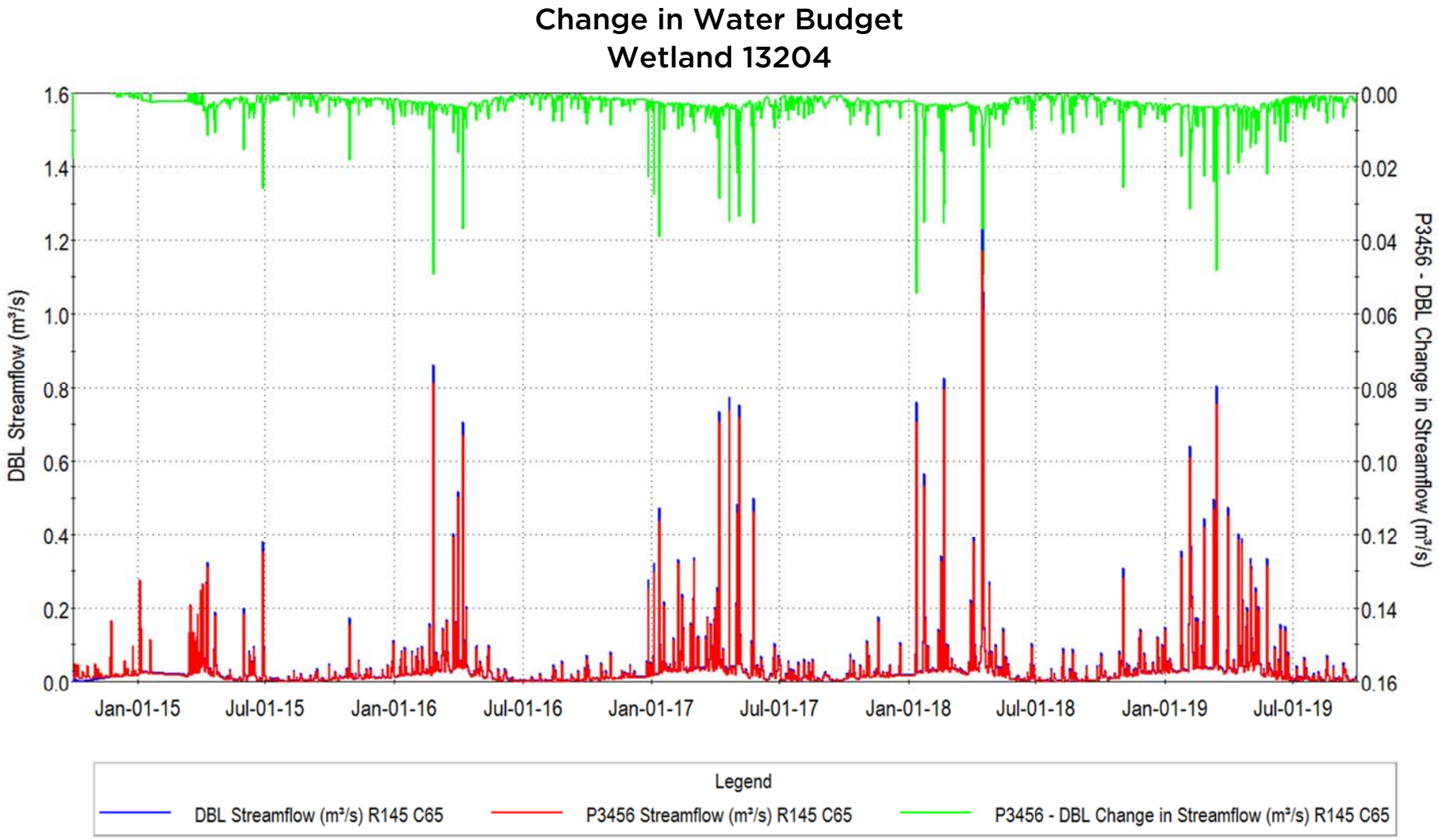
WETLAND 13204 - GRAPH 2



WETLAND 13204 - GRAPH 3

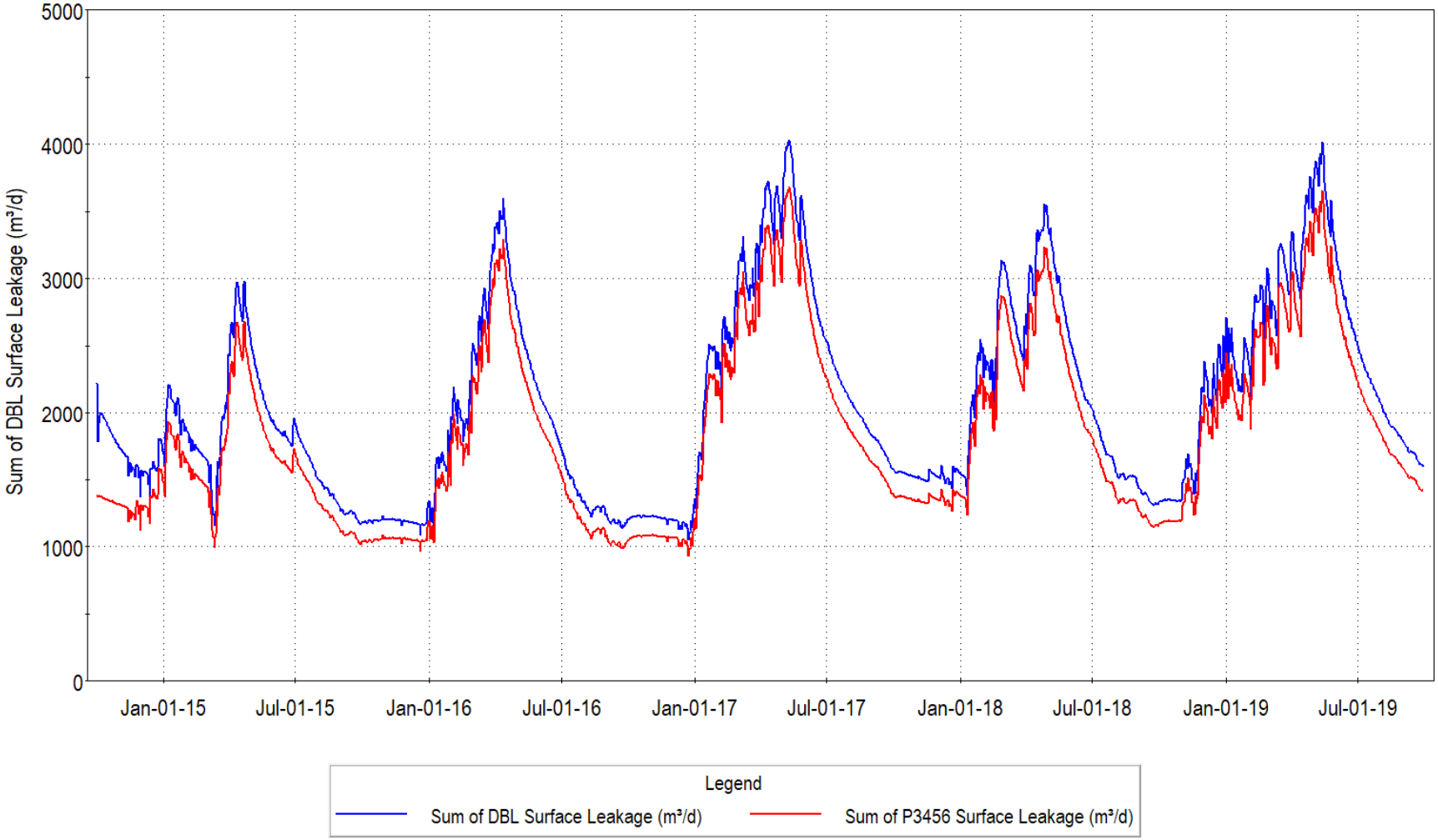


WETLAND 13204 - GRAPH 4



WETLAND 13204 - GRAPH 5

Change in Soil Moisture Conditions
Wetland 13204



Watercourse Characterization Summaries Proposed Burlington Quarry Extension, Nelson Aggregates Co.

Prepared for:



April 2021
Version 1.0

April 2021

Nelson Aggregate Co.
2433 No. 2 Sideroad
Burlington, Ontario
L7P 0G8

Attention: Mr. Quinn Moyer, President

RE: Burlington Quarry Watercourse Characterization Summaries

Dear Mr. Moyer,

Earthfx Incorporated, Savanta Inc. and Tatham Engineering Limited are pleased to provide Nelson Aggregates Co. with the enclosed watercourse characterization summaries in support of the Proposed Burlington Quarry Extension. The watercourse characterization summaries have been prepared in response to comments received by the Ministry of Natural Resources and Forestry.

The watercourse characterization summaries have been prepared to summarize the watercourse information provided in the Level 1 and Level 2 Hydrogeological Impact Assessment, Level 1 and Level 2 Natural Environment Technical Report, and Surface Water Assessment. The hope is the watercourse characterization summaries will aid in the review of the reports and expedite the review process.

Regards,

Dirk Kassenaar, M.Sc., P.Eng.
President, Eartfx Incorporated

Shannon Catton, MSc.
Branch Manager & Senior Ecologist, Savanta Inc.

Daniel Twigger, B.Sc.Eng., P.Eng.
Senior Engineer, Group Leader, Tatham Engineering Limited

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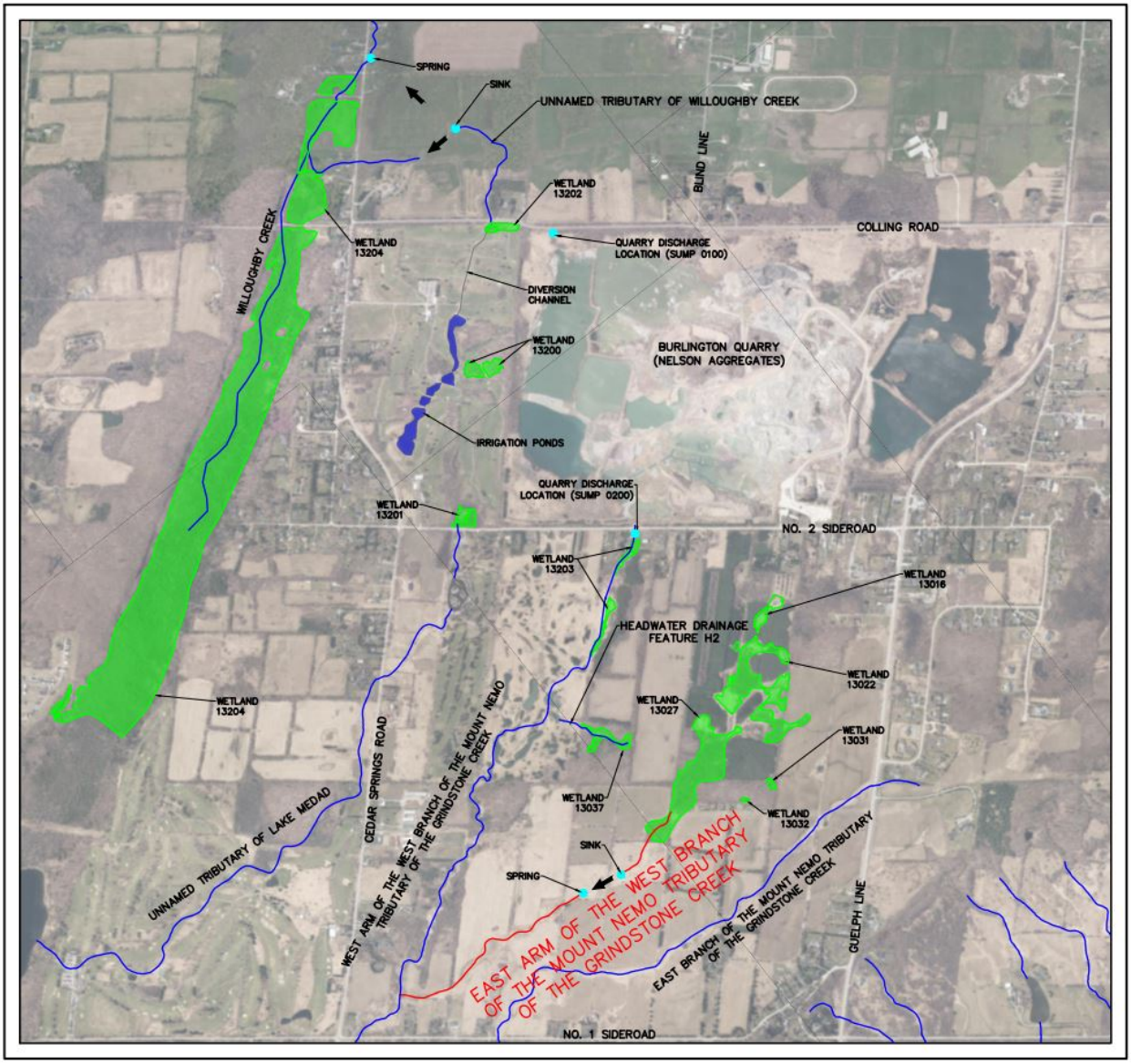
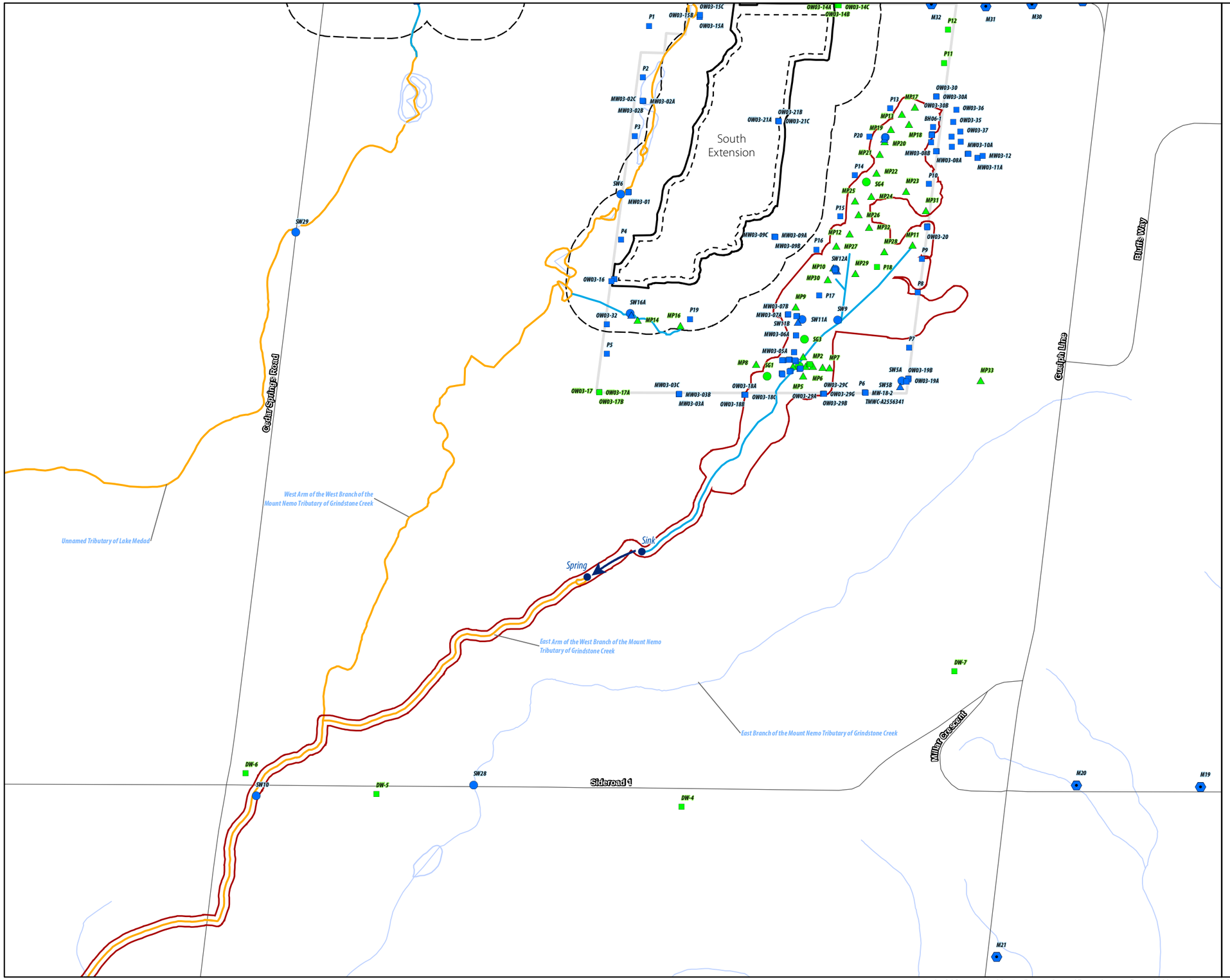
EAST ARM OF THE WEST BRANCH





Legend

- Licensed Boundary
- Limit of Extraction
- 120 m Adjacent Lands
- Subject Lands
- East Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek
- Road
- Indirect Fish Habitat
- Direct Fish Habitat
- Watercourse
- Waterbody
- Wetland (Savanta, 2020)

Current Instrumentation

- Groundwater Monitoring Station (EarthFx)
- Mini Piezometer (Tatham Engineering)
- Staff Gauge & Surface Water Monitoring Station (Tatham Engineering)
- Manual Stream Flow Measurement (Tatham Engineering)

Previous Instrumentation

- Groundwater Monitoring Station (Golder)
- Mini Piezometer (Golder)
- Staff Gauge & Surface Water Monitoring Station (Golder)

NOTES:

1. Coordinate System: NAD 1983 UTM Zone 17N.
2. Base features produced under license with the Ontario Ministry of Natural Resources and Forestry © Queen's Printer for Ontario, 2021.
3. Orthoimagery © First Base Solutions, 2021. Imagery taken in 2019.

Project 8133

Burlington Quarry Extension
Nelson Aggregates Co.

Figure 16
Watercourse Characterization

East Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek

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April 8, 2021

East Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek

Surface Water Characteristics	Description	Figure / Graph / Table	Reference	
			Report	Section / Page
Watercourse Name:	East Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek			
Watershed:	Grindstone Creek			
Sub-Watershed:	Mount Nemo Tributary of Grindstone Creek			
Located in Proposed Limit of Extraction:	No			
Located in Proposed License Boundary:	No			
Catchment Area (ha):	85 ha (at confluence with West Arm)			
Catchment ID:	N/A			
Primary Source(s) of Flow:	Surface runoff			
Discharge from Quarry / PTTW:	No			
Conditions of PTTW:	Not Applicable			
Surface Water Monitoring:	ID: SW9 (Tatham) Installation Date: October 2, 2014 Data Collection: Continuous water level and temperature, manual monthly in-situ streamflow measurements and calibration data (water level converted to flow using rating curve) Coordinates of Monitoring Station: Easting 591235.384, Northing 4805317.071	Graphs 1 & 2	SWA (Tatham, April 2020)	2.1.2 and Appendix C
Streamflow Conditions:	Intermittent	Graphs 1 & 2	SWA (Tatham, April 2020)	2.1.2 and Appendix C
Average Daily Flow (SW9):	Average Daily Streamflow (L/s)	Graph 1	SWA (Tatham, April 2020)	2.1.2 and Appendix C

Month	Minimum	Average	Maximum
January	N/A	N/A	N/A
February	N/A	N/A	N/A
March	1.2	9.1	62.1
April	0.0	2.6	27.1
May	0.0	1.2	13.2
June	0.0	0.3	5.1
July	0.0	0.0	1.2
August	0.0	0.0	0.0
September	0.0	0.0	0.0
October	0.0	0.0	0.0
November	0.0	0.5	36.3
December	0.0	0.2	9.7

Notes:

Minimum - lowest daily average streamflow recorded for period of record

Average - average daily streamflow recorded for period of record

Maximum - maximum daily average streamflow recorded for period of record

N/A - data not available as device removed from watercourse during winter months

East Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek

Surface Water Characteristics	Description					Figure / Graph / Table	Reference	
							Report	Section / Page
Watercourse Thermal Regime (SW9):	Average Daily Water Temperature (°C)				Notes:	Graph 2	SWA (Tatham, April 2020)	2.1.2 and Appendix C
	Month	Minimum	Average	Maximum	Minimum - lowest daily average streamflow recorded for period of record Average - average daily streamflow recorded for period of record Maximum - maximum daily average streamflow recorded for period of record N/A - data not available as device removed from watercourse during winter months			
	January	N/A	N/A	N/A				
	February	N/A	N/A	N/A				
	March	1.0	2.6	6.5				
	April	1.5	8.0	15.9				
	May	6.9	12.2	19.1				
	June	11.5	15.6	19.6				
	July	16.8	17.1	17.7				
	August	Dry	Dry	Dry				
	September	Dry	Dry	Dry				
	October	Dry	Dry	Dry				
	November	2.4	4.5	10.1				
	December	3.5	4.6	5.9				

Fish & Fish Habitat Features	Description	Figure / Graph / Table	Reference	
			Report	Section / Page
Fish Habitat (Direct/Indirect and Assumed/Confirmed):	1) The upstream reaches of the East Arm (from the headwaters to approximately 540 m downstream from the Subject Lands) are considered to be indirect fish habitat. These headwater areas are ephemeral to intermittent and have been observed to dry up completely in summer. Approximately 540 m downstream of the Subject Lands, the watercourse enters a karst sink, where it flows underground for approximately 162 m before discharging to a surface pond. No fish movement is expected to be possible through the 162 m long underground flow path, therefore, given that the upstream area is intermittent and dries out completely, and there is no upstream fish movement, fish are not present in the upper reaches. This upstream reach provides indirect contributing habitat functions to support the downstream fish community. 2) The remainder of the watercourse downstream from the karst outflow provides direct fish habitat. Fish have been previously captured by MNRF at the online pond at karst discharge and are assumed to be present through the watercourse downstream.		NETR (Savanta, April 2020)	44 - 45 and Figure 9b
Fish Species Present:	Stantec (2010) previously reported that in 2006, MNRF captured several different age classes of Fathead Minnow, Bluntnose Minnow, Brook Stickleback and Green Sunfish in the pond at the karst discharge point.		NETR (Savanta, April 2020)	44 - 45 and Figure 9b
Fish Community Thermal Regime:	Warm/Cool (based on fish species present)		NETR (Savanta, April 2020)	44 - 45 and Figure 9b
Fish Habitat Types Present:	1) The headwater wetlands, swales and drainage ditches on the Subject Lands provide indirect habitat that supports the downstream direct fish community. Habitat functions of these areas include flow conveyance and regulation, water quality maintenance and organic allochthonous inputs and potentially seasonal benthic drift. 2) No investigations were completed in the downstream (off-site reaches) providing direct fish habitat.		NETR (Savanta, April 2020)	44 - 45 and Figure 9b
Habitat Uses by Known Fish Community:	The local fish community likely uses the off-site habitat for the complete range of life history processes including spawning, nursery, foraging and overwintering.		NETR (Savanta, April 2020)	44 - 45 and Figure 9b
Known Barriers to Fish Movement:	The karst inlet and associated 162 m long underground reach are assumed to provide a barrier to upstream fish movement.		NETR (Savanta, April 2020)	44 - 45 and Figure 9b

East Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek

<table>
<tr><th rowspan="2">Groundwater Interaction</th><th rowspan="2">Description</th><th rowspan="2">Figure / Graph / Table</th><th colspan="2">Reference</th></tr>
<tr><th>Report</th><th>Section / Page</th></tr>
<tr><td>Underlying Deposits:</td><td>Halton Till. The harmonic mean hydraulic conductivity, based on testing by Golder (2007) of 10 mini-piezometers, was $1.2x10^{-8}$ m/s. Model value for the vertical hydraulic conductivity was $1.6x10^{-7}$ m/s, about an order of magnitude higher, to account for limited flow through fractures in the till.</td><td></td><td></td><td></td></tr>
<tr><td>Surface Water / Groundwater Interactions:</td><td>Seasonal groundwater contributions to watercourse. Groundwater seepage under baseline conditions during spring months equates to 0.1 L/s or less. Groundwater seepage is at its maximum during and immediately following the spring freshet.</td><td>Figures 1 & 2</td><td></td><td></td></tr>
<tr><td>Water Budget Results (SW9):</td><td>The baseline condition water budget results from the integrated model at monitoring location SW9 are presented in Figure 3a.
<table><tr><td>Condition</td><td>GW Out</td><td>GW In</td></tr><tr><td>Baseline (Existing)</td><td>23.13%</td><td>0.15%</td></tr></table></td><td>Figure 3a</td><td></td><td></td></tr>
<tr><td>Water Budget Results (600m Downstream of SW9):</td><td>The baseline condition water budget results from the integrated model 600 m downstream of monitoring location SW9 are presented in Figure 4a.
<table><tr><td>Condition</td><td>GW Out</td><td>GW In</td></tr><tr><td>Baseline (Existing)</td><td>22.18%</td><td>0.75%</td></tr></table></td><td>Figure 4a</td><td></td><td></td></tr>
<tr><td>Integrated Model Calibration:</td><td>SW9 monitors the flow through the wetland complex immediately to the east of the South extension. Simulated and observed streamflow at SW9 are presented in Earthfx (p. 414) for WY2017 to WY2019. Flow in the stream is intermittent and both the observed and simulated results are very flashy. The observed data also contain gaps. The match to the newly collected 2019 data is excellent (Earthfx, p.4141).</td><td>Graphs 3 & 4</td><td>HHIAR (Earthfx, April 2020)</td><td>411 - 414</td></tr>
</table>

East Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek

<table>
<tr><th rowspan="2">Impact Assessment</th><th rowspan="2">Description</th><th rowspan="2">Figure / Graph / Table</th><th colspan="2">Reference</th></tr>
<tr><th>Report</th><th>Section / Page</th></tr>
<tr><td>Direct Alterations to Watercourse:</td><td>No direct alterations to this watercourse are proposed.</td><td></td><td>NETR (Savanta, April 2020)</td><td>75</td></tr>
<tr><td>Change in Primary Source of Flow:</td><td>Modeling predicted less than a 1% reduction in groundwater discharge to the existing headwater wetlands on the Subject Lands. This was predicted to result in an approximate reduction in surface water runoff volume to the watercourse of less than 1%.</td><td></td><td></td><td></td></tr>
<tr><td>Change in Watercourse Catchment Area:</td><td>Catchment area to remain undisturbed, no change in catchment area.</td><td></td><td></td><td></td></tr>
<tr><td>Simulated Streamflow Change (Integrated Model Results):</td><td>The Earthfx report discusses changes in simulated streamflow under the different quarry expansion phases. The figure appended (GRaph 5) reproduces Figure 8.6 (p. 201) and presents simulated baseline(red) and Scenario P12 (blue) flows at location SW9. Decrease in flow (green) are plotted in reverse on the upper X axis with the scale shown on the right Y axis. Very small decreases in streamflow, primarily in winter and spring, are predicted Phase 12 area. A similar figure (Graph 6) is reproduced for Phase 3456 (Figure 8.44, p. 235) although the upper X axis shows the decrease in streamflow (with positive values indicating an decrease in flow relative to baseline). Spring flows are generally lower in the winter and spring but higher in the summer and fall periods.</td><td>Graphs 5, 6 & 7</td><td>HHIAR (Earthfx, April 2020)</td><td>198 - 203 and 230 - 237</td></tr>
<tr><td colspan="5">Water Budget Results at Monitoring Location SW9</td></tr>
<tr><td>Water Budget Results (Operational Phases 1 & 2):</td><td>The Operational Phases 1 and 2 water budget results from the integrated model at monitoring location SW9 are presented in Figure 3b.
<table>
<tr><td>Condition</td><td>GW Outflow</td><td>GW Inflow</td><td>%Δ GW Outflow</td><td>%Δ GW Inflow</td></tr>
<tr><td>Baseline (Existing)</td><td>23.13%</td><td>0.15%</td><td>-</td><td>-</td></tr>
<tr><td>Phases 1 & 2</td><td>22.51%</td><td>0.00%</td><td>-0.62%</td><td>-0.15%</td></tr>
</table></td><td>Figure 3b</td><td></td><td></td></tr>
<tr><td>Water Budget Results (Operational Phases 3 Through 6):</td><td>The Operational Phases 3 through 6 water budget results from the integrated model at monitoring location SW9 are presented in Figure 3c.
<table>
<tr><td>Condition</td><td>GW Outflow</td><td>GW Inflow</td><td>%Δ GW Outflow</td><td>%Δ GW Inflow</td></tr>
<tr><td>Baseline (Existing)</td><td>23.13%</td><td>0.15%</td><td>-</td><td>-</td></tr>
<tr><td>Phases 3 through 6</td><td>23.27%</td><td>0.10%</td><td>0.14%</td><td>-0.05%</td></tr>
</table></td><td>Figure 3c</td><td></td><td></td></tr>
<tr><td>Water Budget Results (Rehabilitation Scenario 1):</td><td>The Rehabilitation Scenario 1 water budget results from the integrated model at monitoring location SW9 are presented in Figure 3d.
<table>
<tr><td>Condition</td><td>GW Outflow</td><td>GW Inflow</td><td>%Δ GW Outflow</td><td>%Δ GW Inflow</td></tr>
<tr><td>Baseline (Existing)</td><td>23.13%</td><td>0.15%</td><td>-</td><td>-</td></tr>
<tr><td>Rehab Scenario 1</td><td>22.39%</td><td>0.12%</td><td>-0.74%</td><td>-0.03%</td></tr>
</table></td><td>Figure 3d</td><td></td><td></td></tr>
<tr><td>Water Budget Results (Rehabilitation Scenario 2):</td><td>The Rehabilitation Scenario 2 water budget results from the integrated model at monitoring location SW9 are presented in Figure 3d.
<table>
<tr><td>Condition</td><td>GW Outflow</td><td>GW Inflow</td><td>%Δ GW Outflow</td><td>%Δ GW Inflow</td></tr>
<tr><td>Baseline (Existing)</td><td>23.13%</td><td>0.15%</td><td>-</td><td>-</td></tr>
<tr><td>Rehab Scenario 2</td><td>23.81%</td><td>0.28%</td><td>0.68%</td><td>0.13%</td></tr>
</table></td><td>Figure 3e</td><td></td><td></td></tr>
</table>

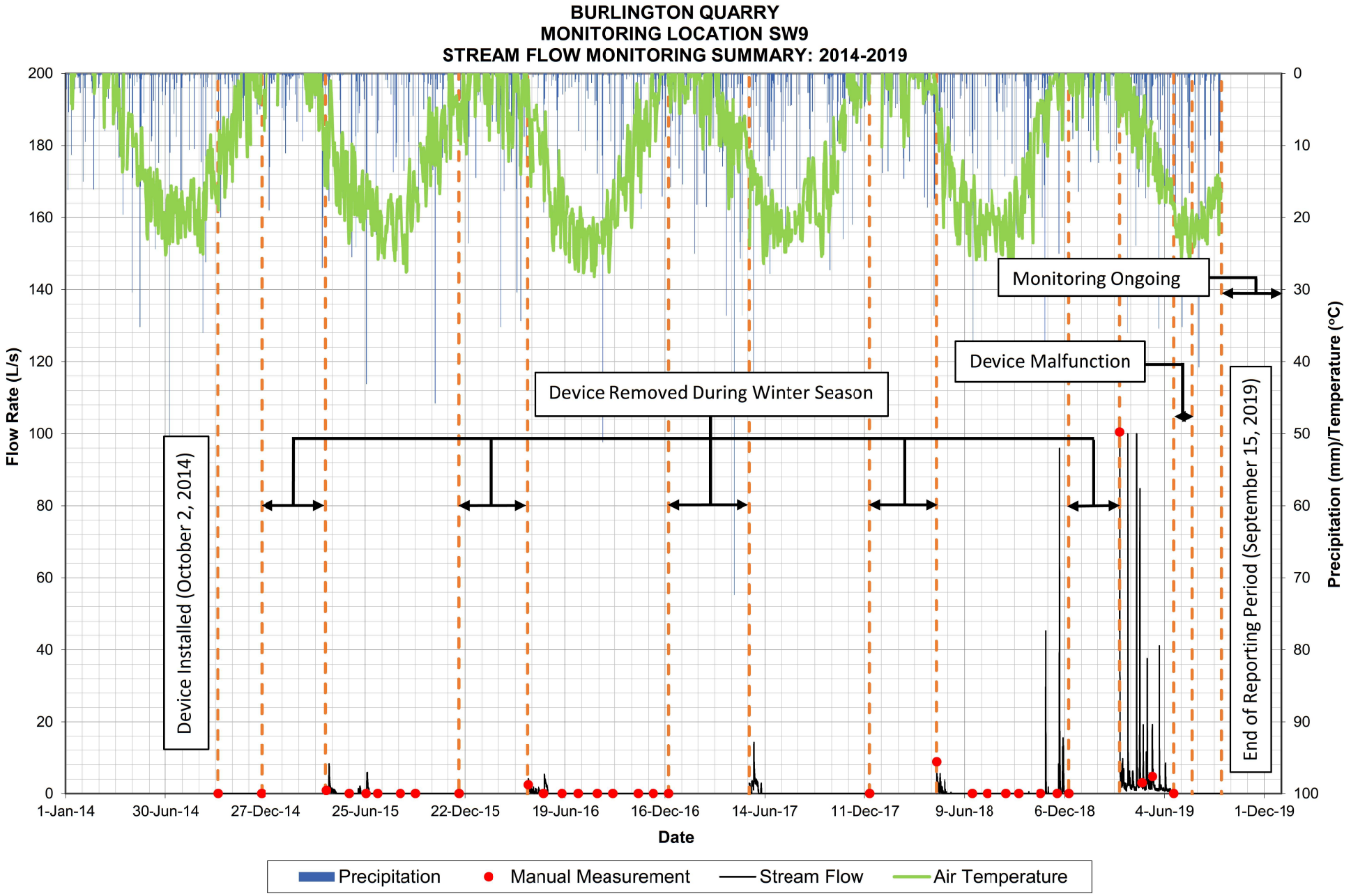
East Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek

<table>
<tr><th>Impact Assessment</th><th>Description</th><th>Figure / Graph / Table</th><th colspan="2">Reference</th></tr>
<tr><th></th><th></th><th></th><th>Report</th><th>Section / Page</th></tr>
<tr><td colspan="5">Water Budget Results 600 m Downstream of Monitoring Location SW9</td></tr>
<tr><td>Water Budget Results (Operational Phases 1 & 2):</td><td>The Operational Phases 1 and 2 water budget results from the integrated model 600 m downstream of monitoring location SW9 are presented in Figure 4b.
<table>
<tr><td>Condition</td><td>GW Outflow</td><td>GW Inflow</td><td>%Δ GW Outflow</td><td>%Δ GW Inflow</td></tr>
<tr><td>Baseline (Existing)</td><td>22.18%</td><td>0.75%</td><td>-</td><td>-</td></tr>
<tr><td>Phases 1 & 2</td><td>22.32%</td><td>0.00%</td><td>0.14%</td><td>-0.75%</td></tr>
</table></td><td>Figure 4b</td><td></td><td></td></tr>
<tr><td>Water Budget Results (Operational Phases 3 Through 6):</td><td>The Operational Phases 3 through 6 water budget results from the integrated model 600 m downstream of monitoring location SW9 are presented in Figure 4c.
<table>
<tr><td>Condition</td><td>GW Outflow</td><td>GW Inflow</td><td>%Δ GW Outflow</td><td>%Δ GW Inflow</td></tr>
<tr><td>Baseline (Existing)</td><td>22.18%</td><td>0.75%</td><td>-</td><td>-</td></tr>
<tr><td>Phases 3 through 6</td><td>22.67%</td><td>0.43%</td><td>0.49%</td><td>-0.32%</td></tr>
</table></td><td>Figure 4c</td><td></td><td></td></tr>
<tr><td>Water Budget Results (Rehabilitation Scenario 1):</td><td>The Rehabilitation Scenario 1 water budget results from the integrated model 600 m downstream of monitoring location SW9 are presented in Figure 4d.
<table>
<tr><td>Condition</td><td>GW Outflow</td><td>GW Inflow</td><td>%Δ GW Outflow</td><td>%Δ GW Inflow</td></tr>
<tr><td>Baseline (Existing)</td><td>22.18%</td><td>0.75%</td><td>-</td><td>-</td></tr>
<tr><td>Rehab Scenario 1</td><td>21.68%</td><td>0.52%</td><td>0.50%</td><td>-0.23%</td></tr>
</table></td><td>Figure 4d</td><td></td><td></td></tr>
<tr><td>Water Budget Results (Rehabilitation Scenario 2):</td><td>The Rehabilitation Scenario 2 water budget results from the integrated model 600 m downstream of monitoring location SW9 are presented in Figure 4e.
<table>
<tr><td>Condition</td><td>GW Outflow</td><td>GW Inflow</td><td>%Δ GW Outflow</td><td>%Δ GW Inflow</td></tr>
<tr><td>Baseline (Existing)</td><td>22.18%</td><td>0.75%</td><td>-</td><td>-</td></tr>
<tr><td>Rehab Scenario 2</td><td>23.16%</td><td>0.61%</td><td>0.98%</td><td>-0.14%</td></tr>
</table></td><td>Figure 4e</td><td></td><td></td></tr>
<tr><td>Change in Groundwater Contributions to Watercourse:</td><td>The Baseline groundwater seepage to the watercourse catchment (to SW9) is shown in Graph 8. Under P12 conditions this seepage is lost. The change in stream leakage between Baseline and P12 conditions is shown in Graph 9. There are short periods of time when leakage under Baseline conditions (blue line) is slightly higher than P12 conditions.</td><td>Graphs 8 and 9</td><td></td><td></td></tr>
<tr><td>Change in Watercourse Thermal Regime:</td><td>Negative changes on water temperature are not expected given that the wetlands and catchment area feeding the East Arm will remain undisturbed.</td><td></td><td></td><td></td></tr>
<tr><td>Change in Water Quality:</td><td>Negative changes on water quality are not expected given that the wetlands and catchment area feeding the East Arm will remain undisturbed.</td><td></td><td></td><td></td></tr>
<tr><td>Potential Impact to Form and Function of Feature:</td><td>A reduction of less than 1% in groundwater contributions to the headwaters will result in immeasurable changes to flows in the feature, but this reduction is not expected to negatively impact direct fish habitat given that the small change is within the range of natural fluctuation.</td><td></td><td></td><td></td></tr>
<tr><td>Potential Impact to Identified Species and Habitat:</td><td>A reduction of less than 1% in groundwater contributions to the headwaters will result in immeasurable changes to flows in the feature, but this reduction is not expected to negatively impact fish species in the watercourse given that the small change is within the range of natural fluctuation.</td><td></td><td></td><td></td></tr>
</table>

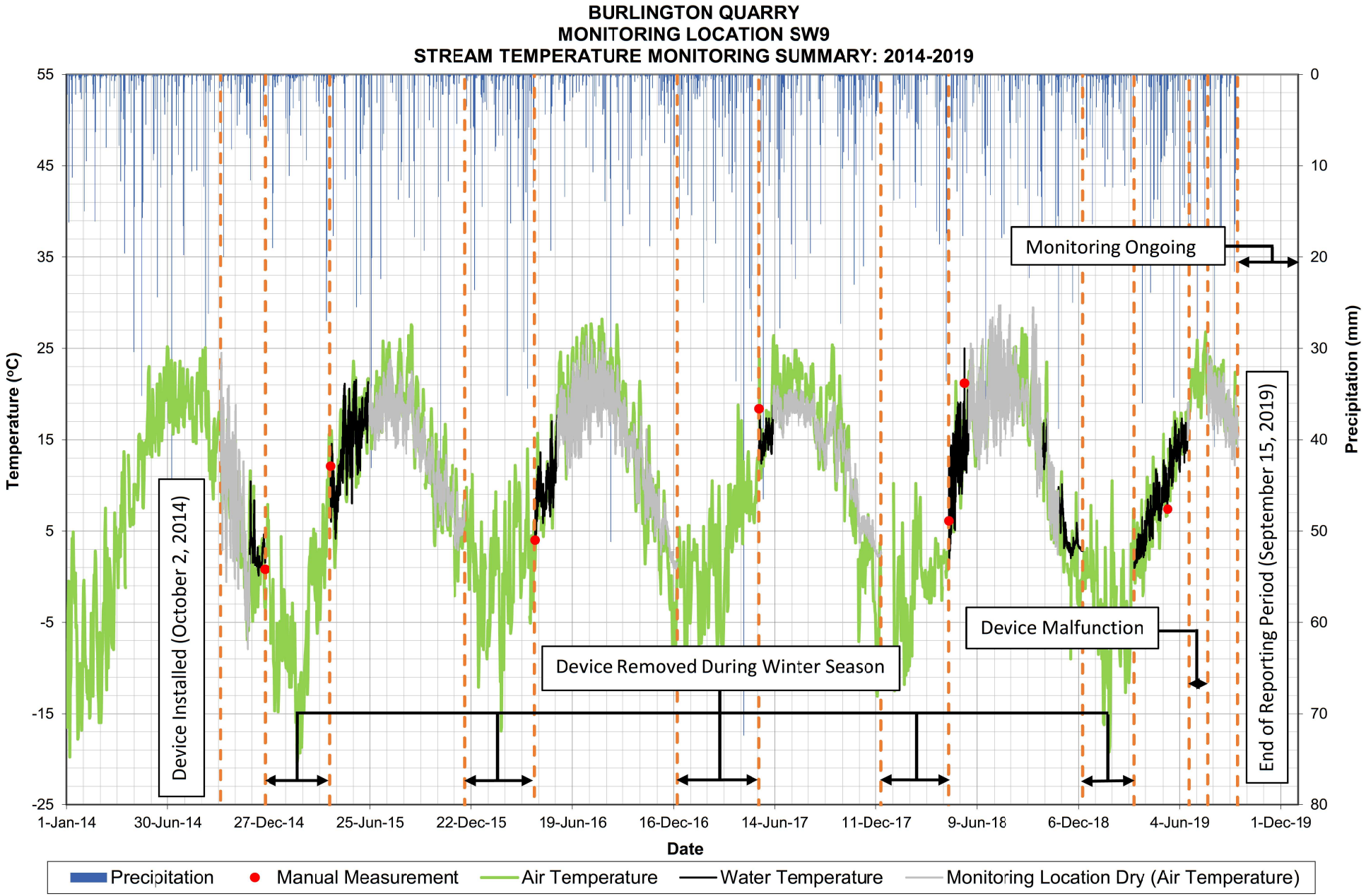
East Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek

Mitigation	Description	Figure / Graph / Table	Reference	
			Report	Section / Page
Direct Alteration Mitigation:	No direct alterations are proposed.		NETR (Savanta, April 2020)	75
Source Water Mitigation:	None required.			
Groundwater Contribution Mitigation:	None required.			
Erosion Mitigation:	None required.			
Thermal Mitigation:	None required.			
Water Quality Mitigation:	None required.			

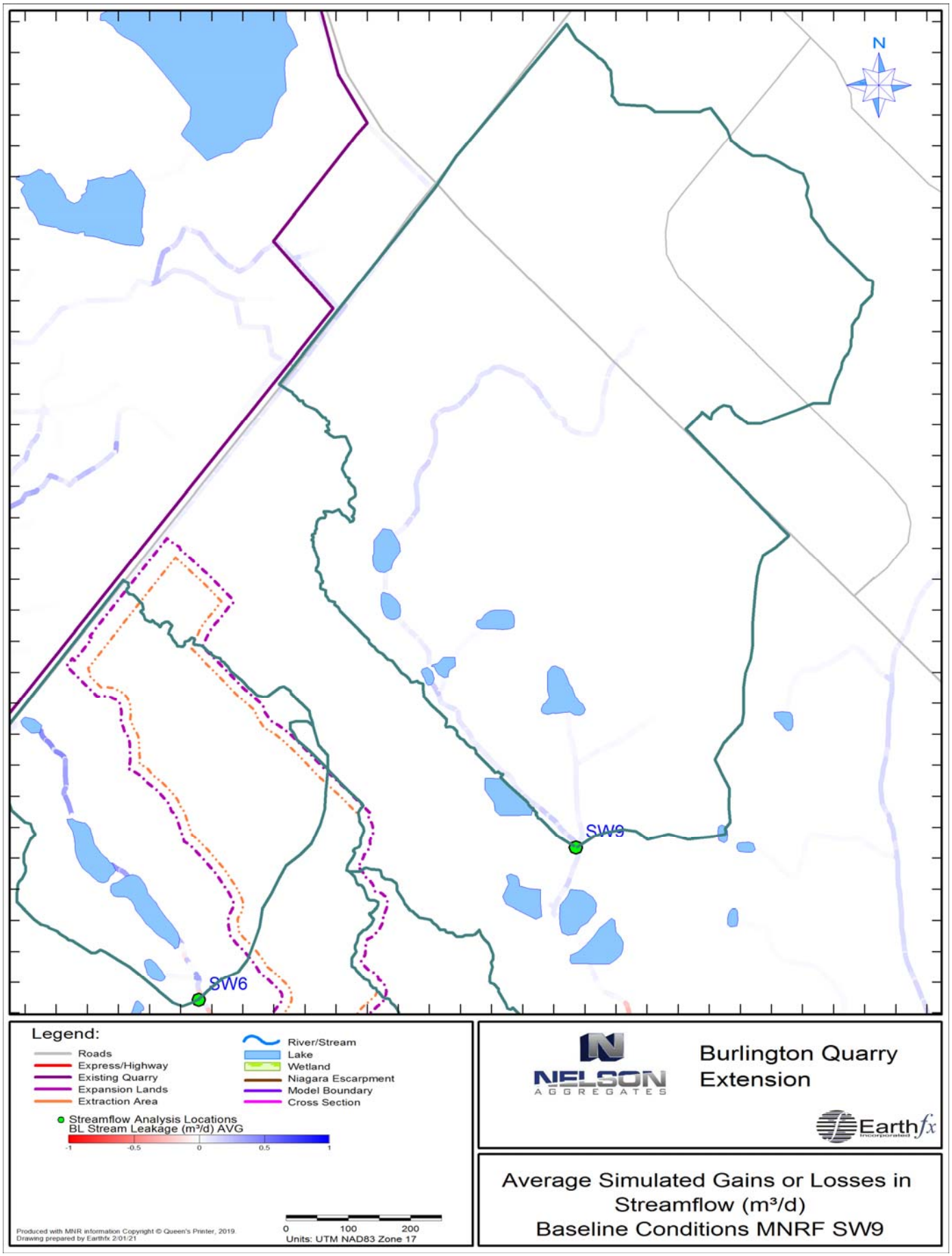
EAST ARM OF THE WEST BRANCH OF THE MOUNT NEMO TRIBUTARY OF GRINDSTONE CREEK - GRAPH 1



EAST ARM OF THE WEST BRANCH OF THE MOUNT NEMO TRIBUTARY OF GRINDSTONE CREEK - GRAPH 2



* Grey data indicates the monitoring location was dry and therefore the recorded values are respresentative of the air temperature.


N
SW9
SW6
Legend:
Roads
Express/Highway
Existing Quarry
Expansion Lands
Extraction Area
River/Stream
Lake
Wetland
Niagara Escarpment
Model Boundary
Cross Section
Streamflow Analysis Locations
BL Stream Leakage (m³/d) AVG
-1
-0.5
0
0.5
1
0
100
200
Units: UTM NAD83 Zone 17
Produced with MNR information Copyright © Queen's Printer, 2019.
Drawing prepared by Earthfx 2/01/21
NELSON AGGREGATES
Burlington Quarry Extension
Earthfx
Average Simulated Gains or Losses in Streamflow (m³/d)
Baseline Conditions MNRF SW9

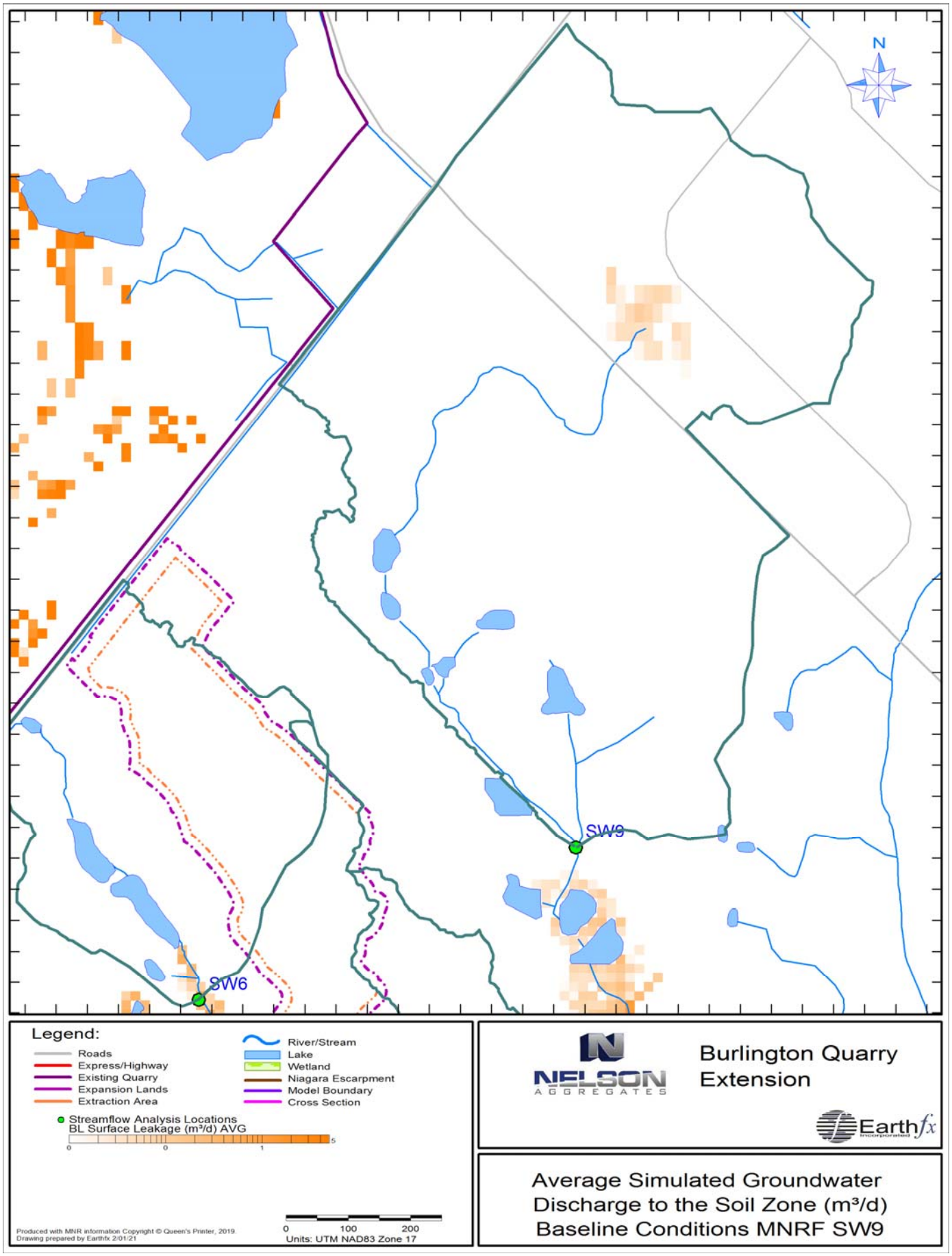

N
SW9
SW6
Legend:
Roads
Express/Highway
Existing Quarry
Expansion Lands
Extraction Area
River/Stream
Lake
Wetland
Niagara Escarpment
Model Boundary
Cross Section
Streamflow Analysis Locations
BL Surface Leakage (m³/d) AVG
0
0
1
5
0
100
200
Units: UTM NAD83 Zone 17
Produced with MNR information Copyright © Queen's Printer, 2019.
Drawing prepared by Earthfx 2/01/21
NELSON AGGREGATES
Burlington Quarry Extension
Earthfx
Average Simulated Groundwater Discharge to the Soil Zone (m³/d)
Baseline Conditions MNRF SW9

FIGURE 3A

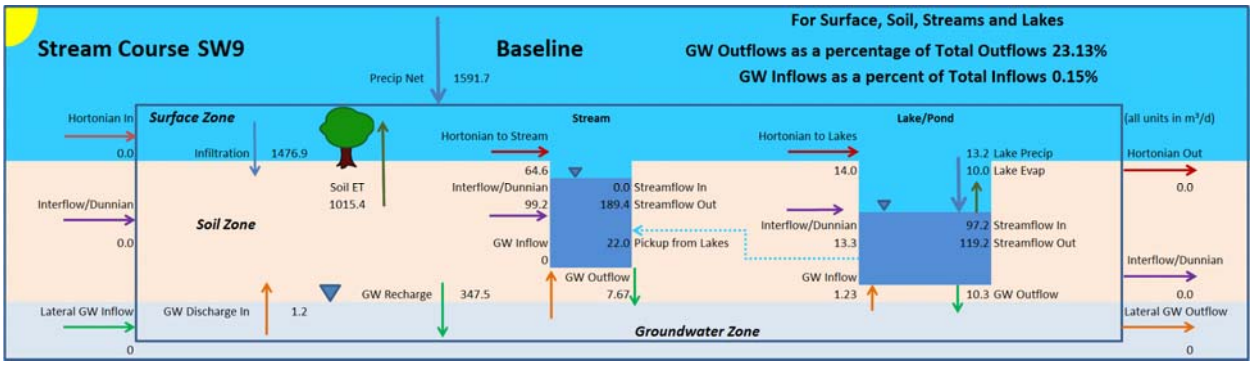


FIGURE 3B

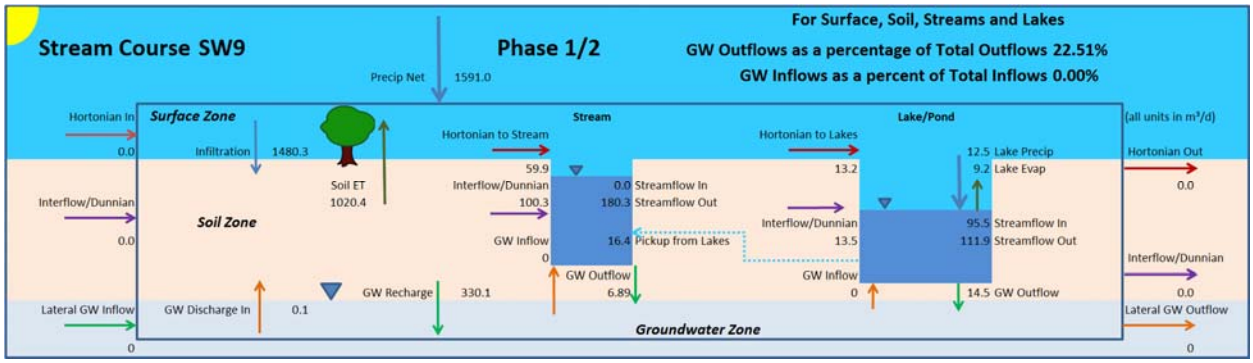


FIGURE 3C

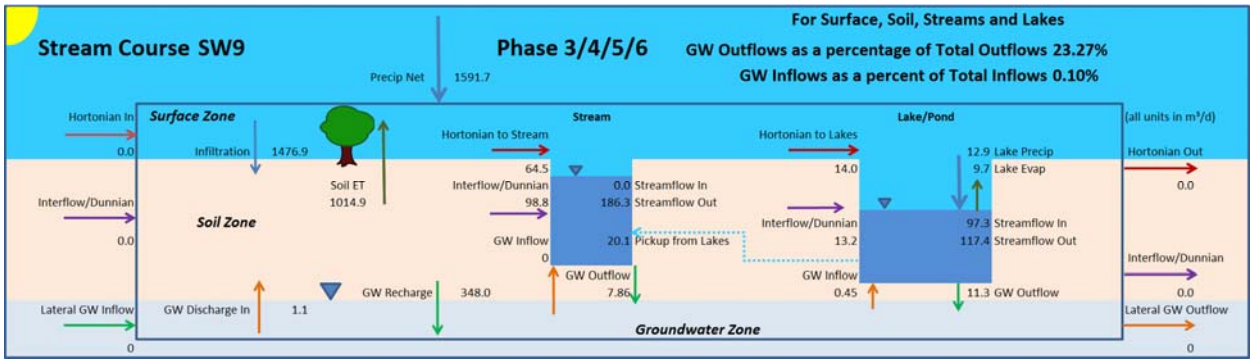


FIGURE 3D

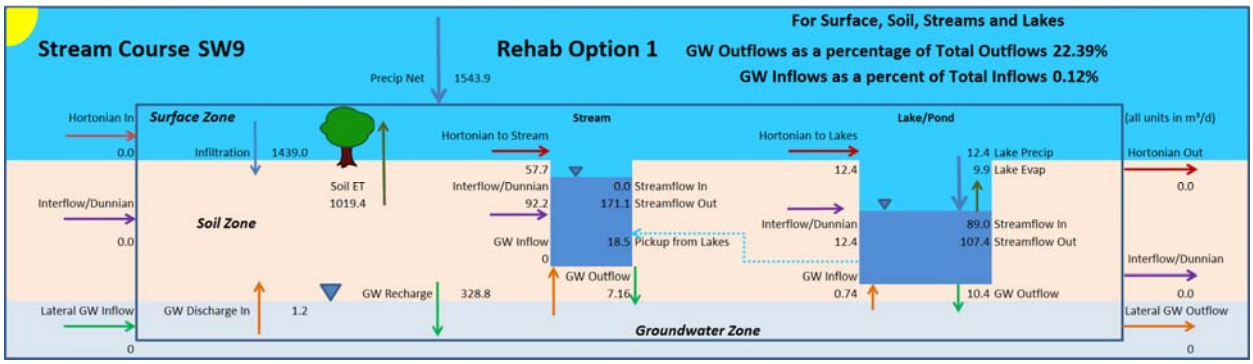


FIGURE 3E

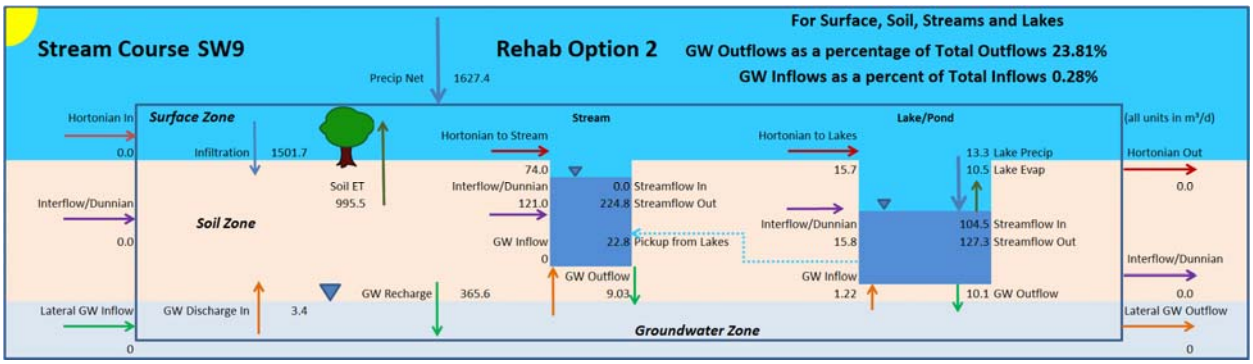


FIGURE 4A

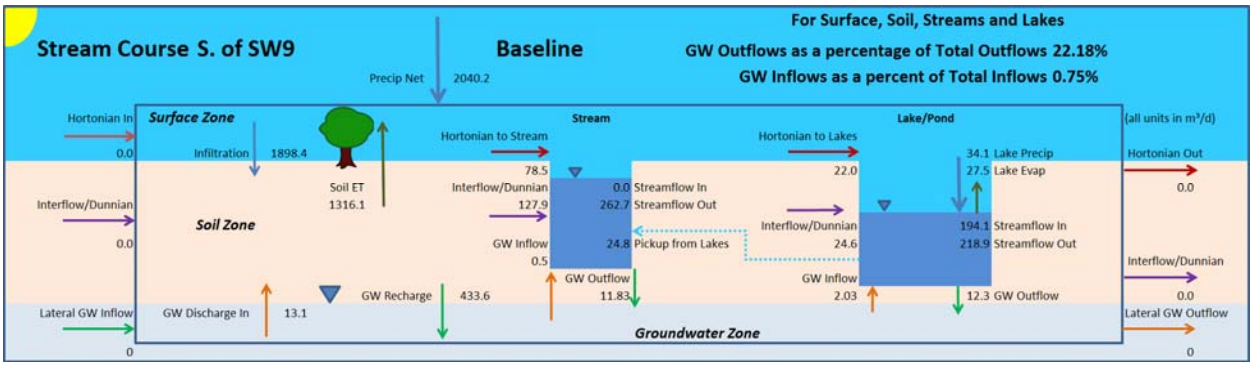


FIGURE 4B

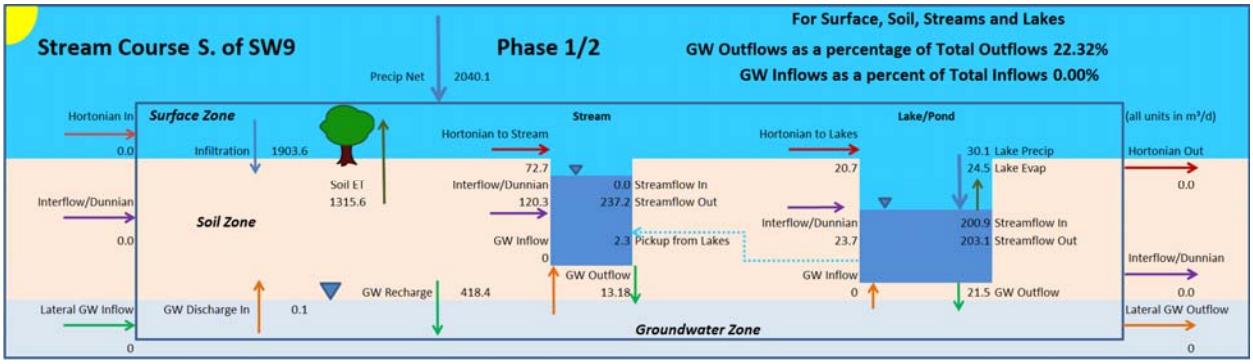


FIGURE 4C

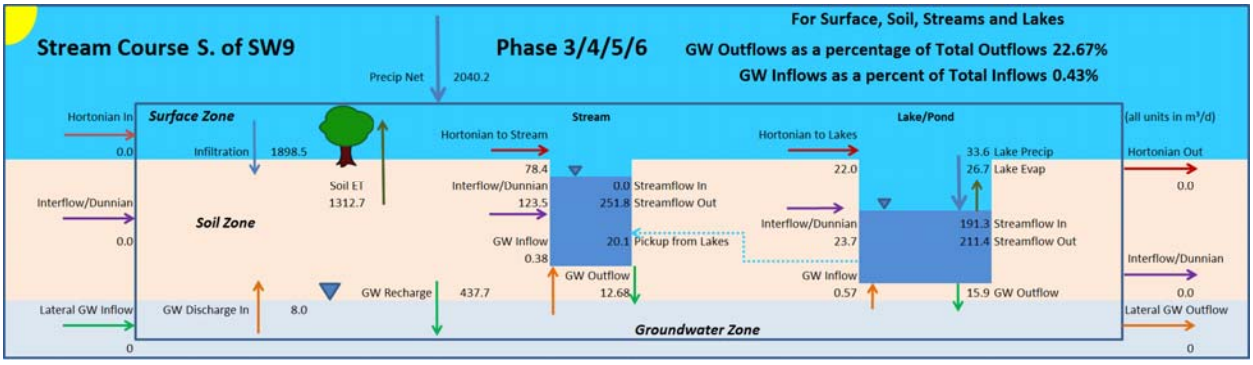


FIGURE 4D

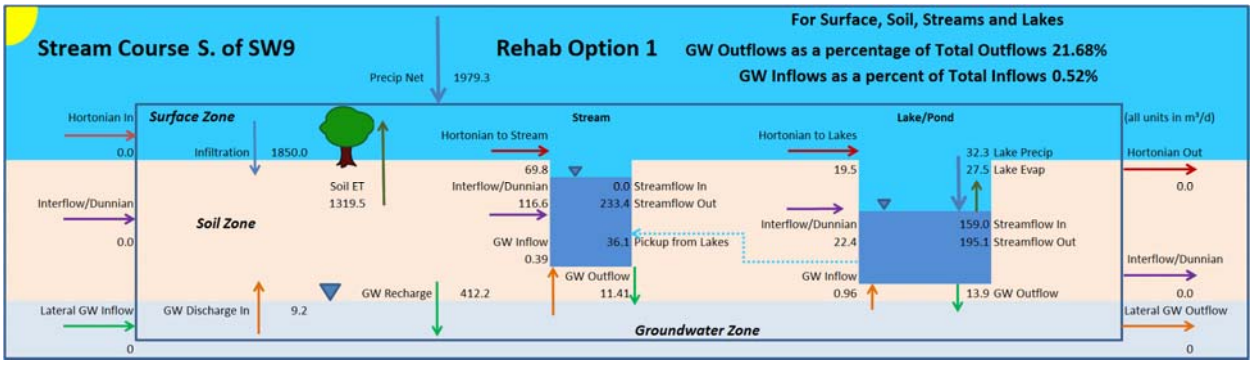
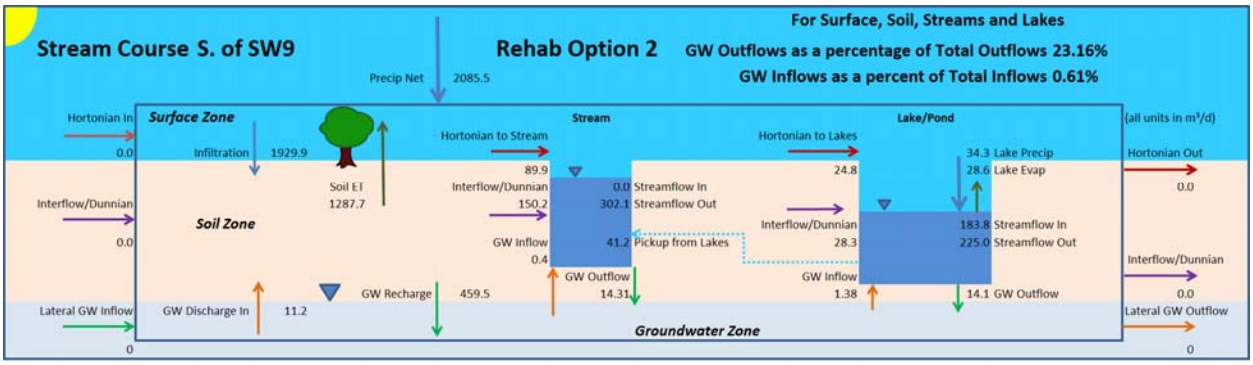
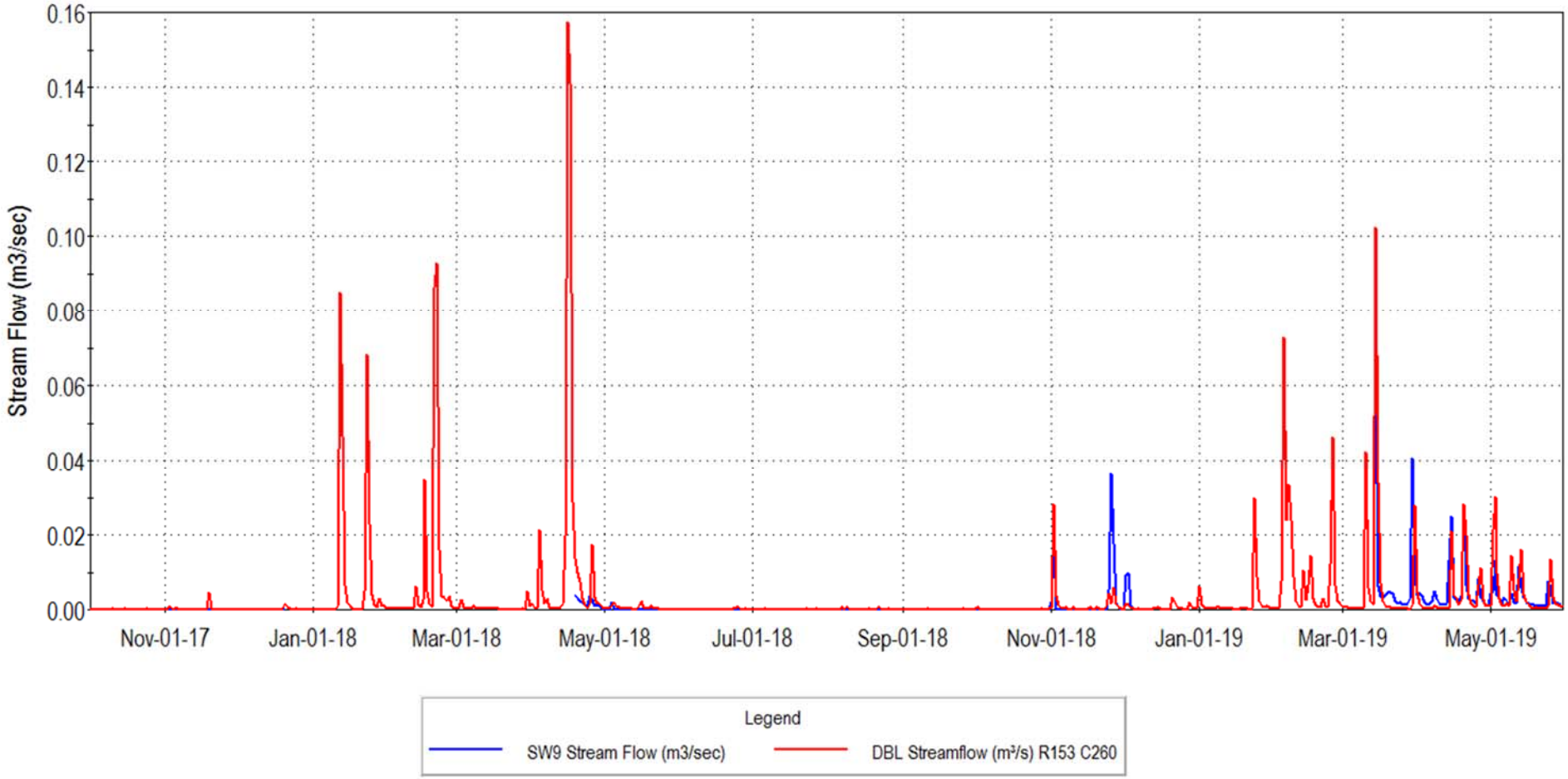


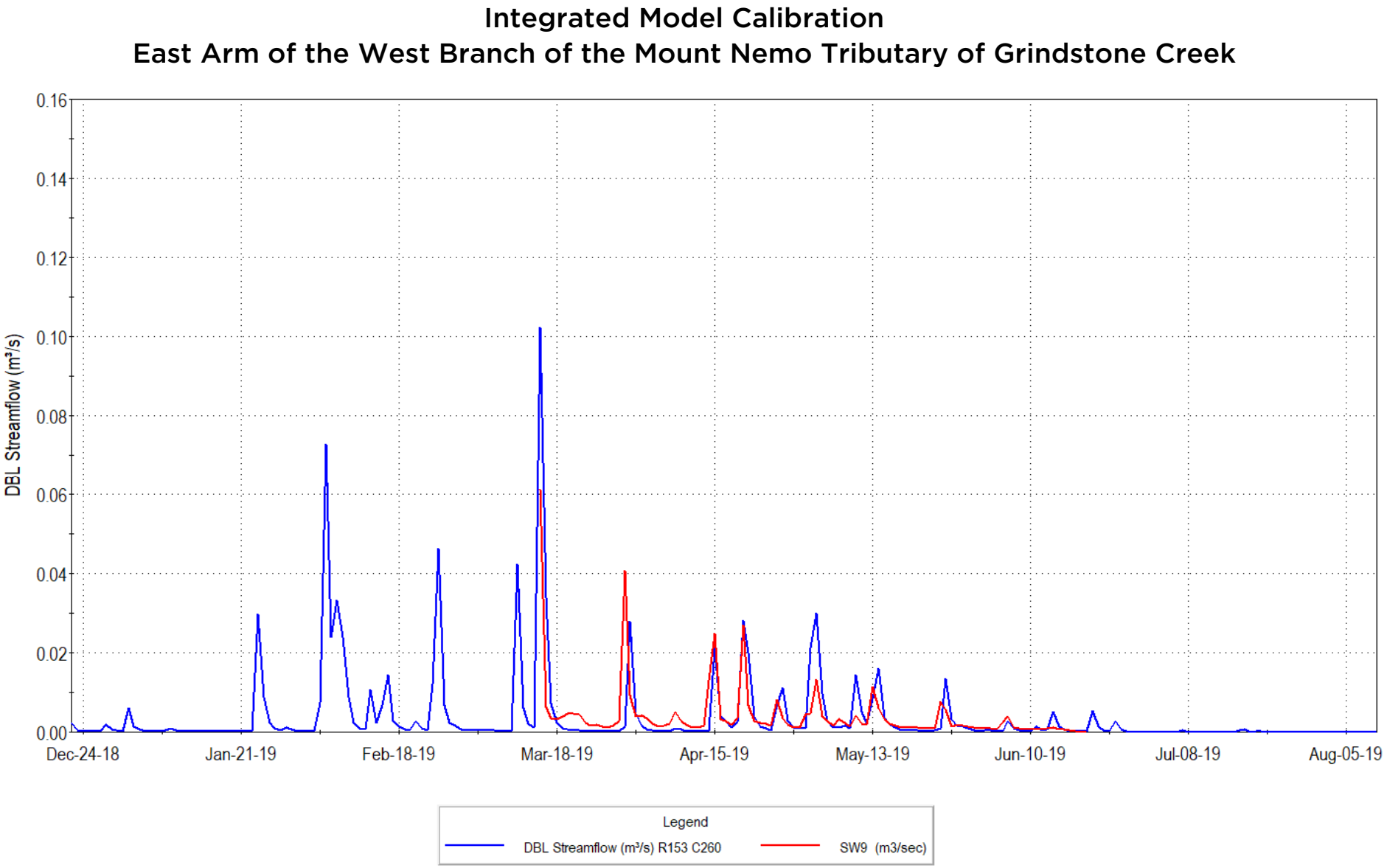
FIGURE 4E



Integrated Model Calibration
East Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek

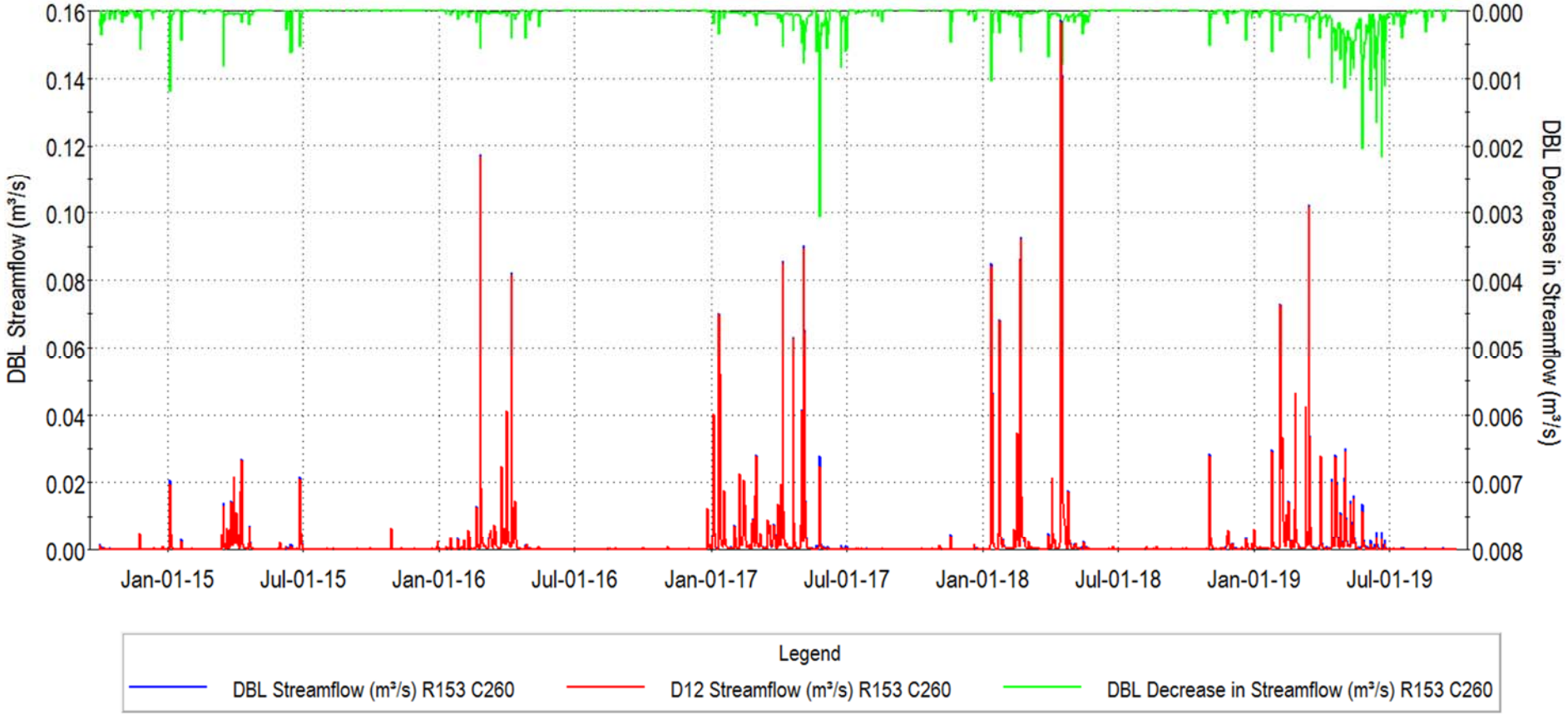


EAST ARM OF THE WEST BRANCH OF THE MOUNT NEMO TRIBUTARY OF GRINDSTONE CREEK - GRAPH 4



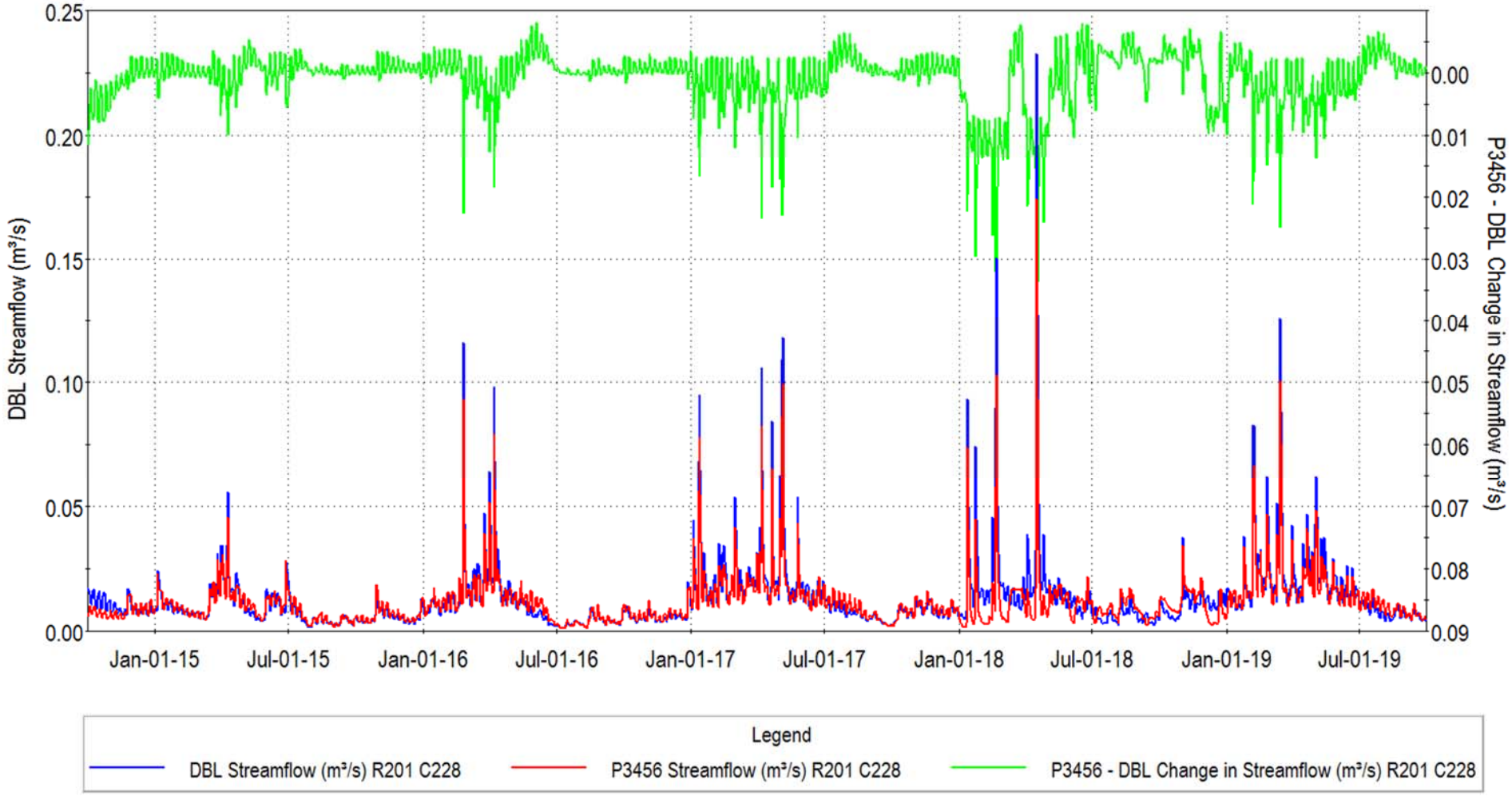
EAST ARM OF THE WEST BRANCH OF THE MOUNT NEMO TRIBUTARY OF GRINDSTONE CREEK - GRAPH 5

Simulated Streamflow Change - Integrated Model
East Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek

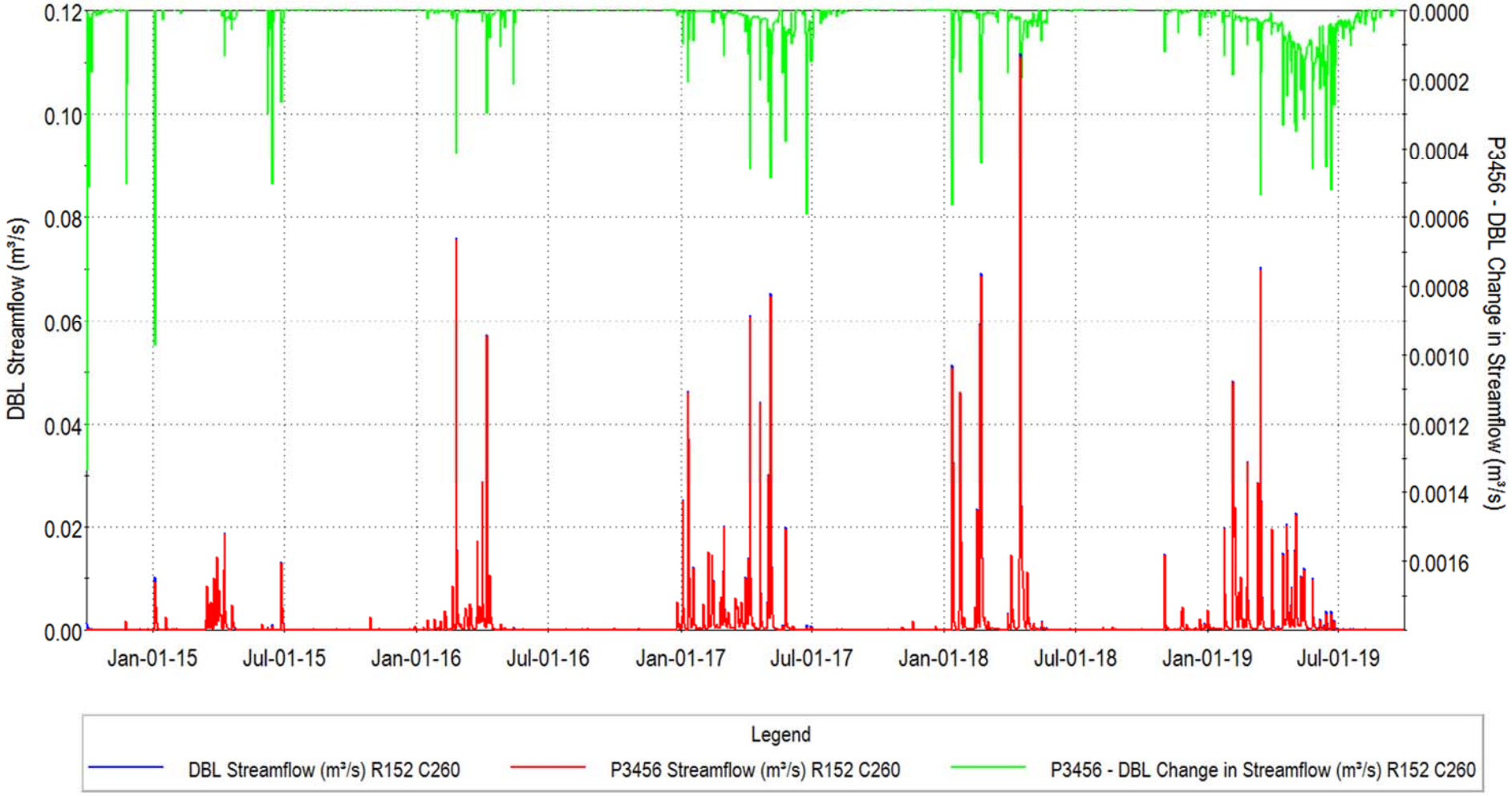


EAST ARM OF THE WEST BRANCH OF THE MOUNT NEMO TRIBUTARY OF GRINDSTONE CREEK - GRAPH 6

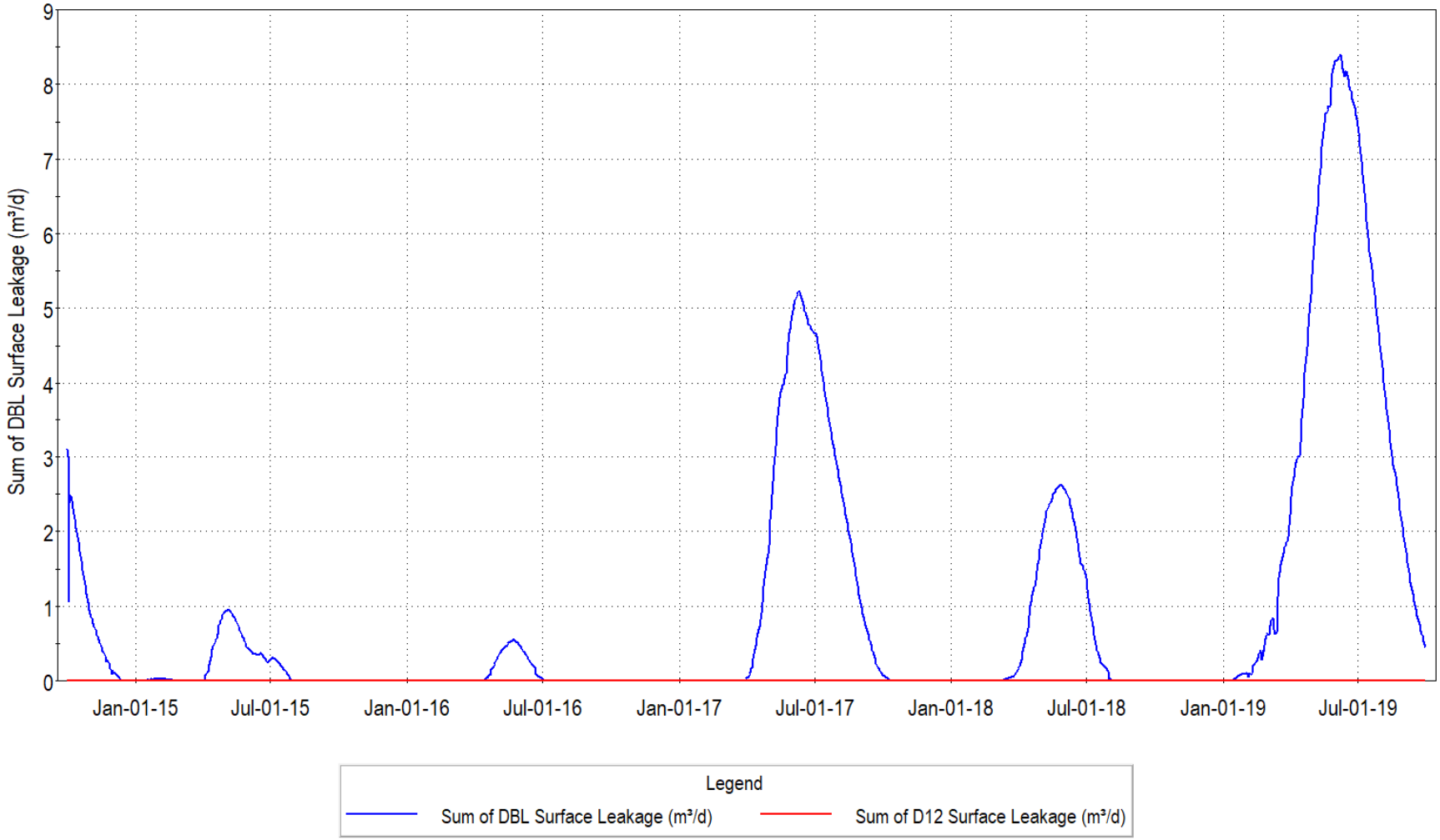
Simulated Streamflow Change - Integrated Model
East Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek



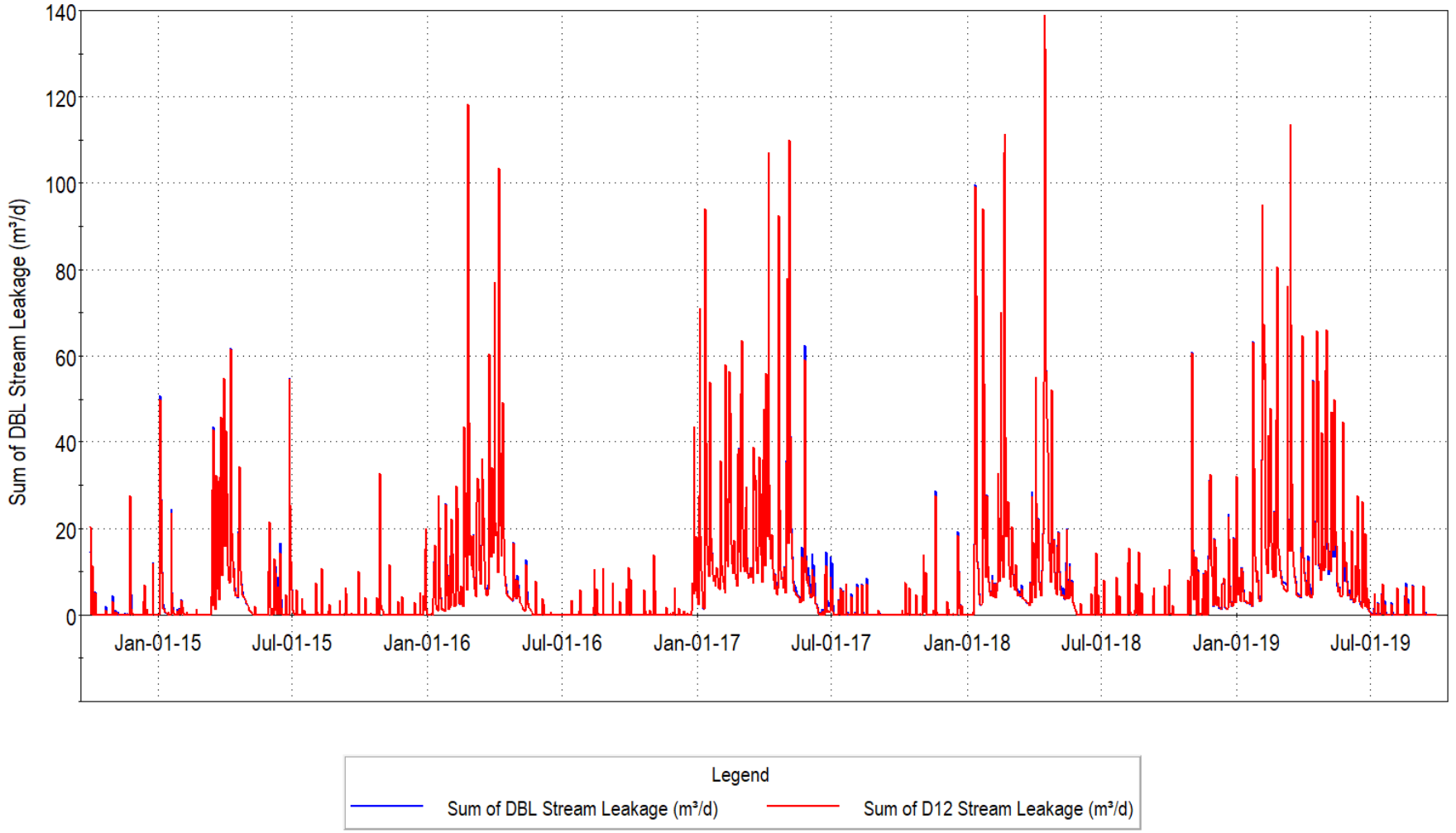
Simulated Streamflow Change - Integrated Model
East Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek



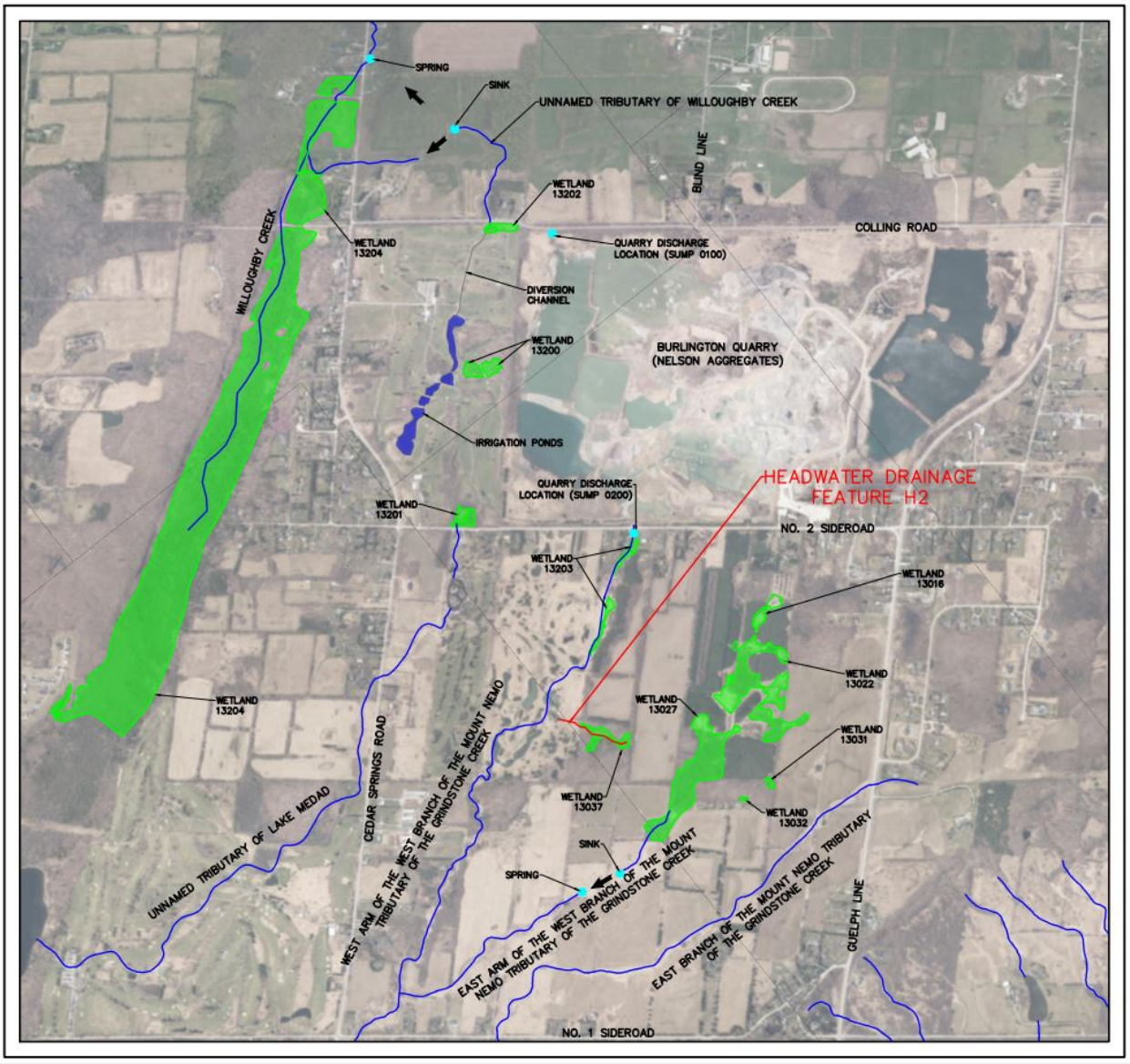
Change in Groundwater Contributions to Watercourse
East Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek

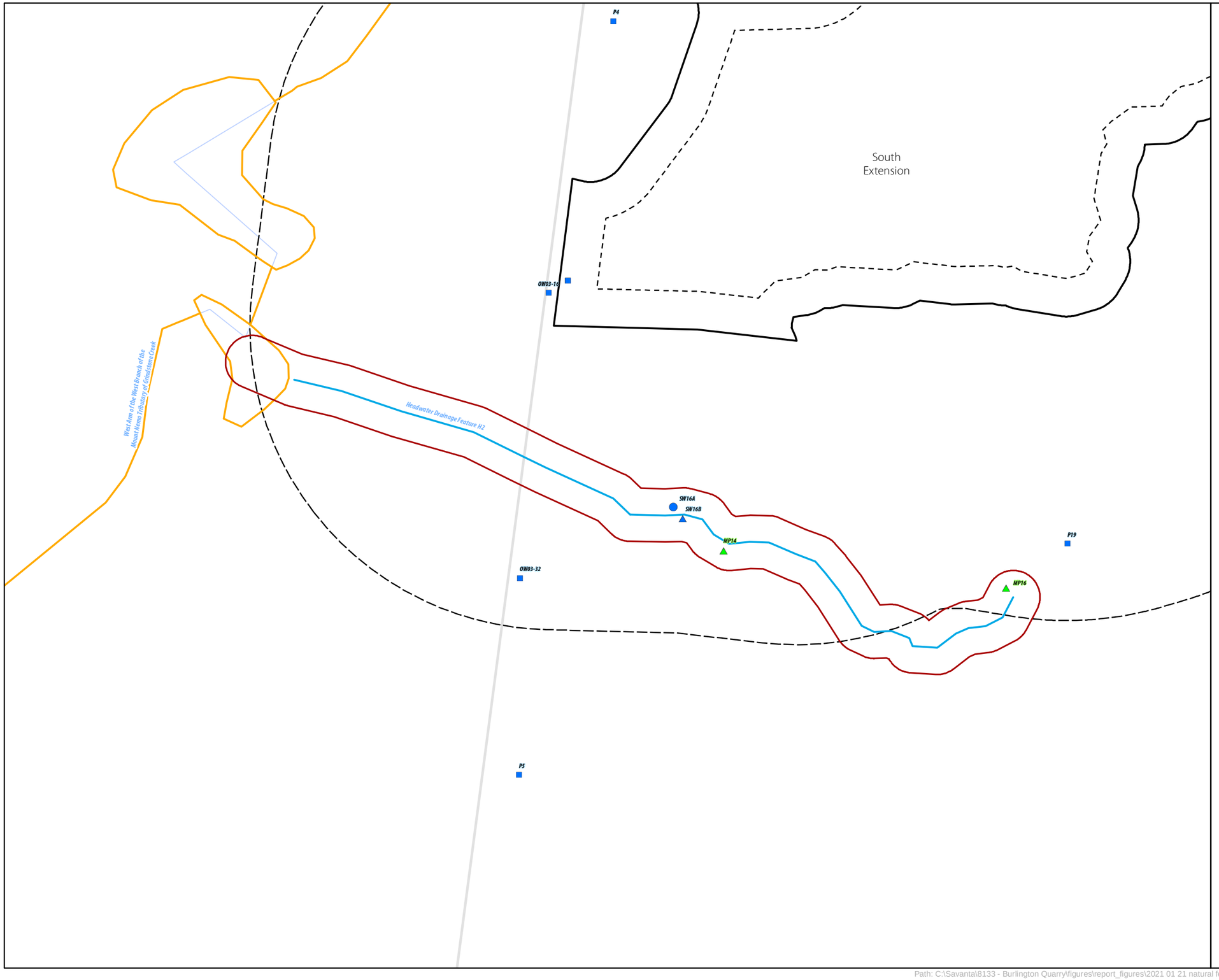


Change in Groundwater Contributions to Watercourse
East Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek



HEADWATER DRAINAGE FEATURE H2





Legend

- Licensed Boundary
- Limit of Extraction
- 120 m Adjacent Lands
- Subject Lands
- Headwater Drainage Feature H2
- Indirect Fish Habitat
- Direct Fish Habitat
- Watercourse
- Wetland (Savanta, 2020)

Current Instrumentation

- Groundwater Monitoring Station (EarthFx)
- Mini Piezometer (Tatham Engineering)
- Staff Gauge & Surface Water Monitoring Station (Tatham Engineering)

Previous Instrumentation

- Mini Piezometer (Golder)

NOTES:

1. Coordinate System: NAD 1983 UTM Zone 17N.
2. Base features produced under license with the Ontario Ministry of Natural Resources and Forestry © Queen's Printer for Ontario, 2021.
3. Orthoimagery © First Base Solutions, 2021. Imagery taken in 2019.

Project 8133

Burlington Quarry Extension
Nelson Aggregates Co.

Figure 17
Watercourse Characterization

Headwater Drainage Feature H2

0 25 m

1:1,500

[redacted]

Headwater Drainage Feature H2

<table>
<tr><th>Surface Water Characteristics</th><th>Description</th><th>Figure / Graph / Table</th><th colspan="2">Reference</th></tr>
<tr><th></th><th></th><th></th><th>Report</th><th>Section / Page</th></tr>
<tr><td>Watercourse Name:</td><td>Headwater Drainage Feature H2</td><td></td><td></td><td></td></tr>
<tr><td>Watershed:</td><td>Grindstone Creek Watershed</td><td></td><td></td><td></td></tr>
<tr><td>Sub-Watershed:</td><td>West Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek</td><td></td><td></td><td></td></tr>
<tr><td>Located in Proposed Limit of Extraction:</td><td>No</td><td></td><td></td><td></td></tr>
<tr><td>Located in Proposed License Boundary:</td><td>No</td><td></td><td></td><td></td></tr>
<tr><td>Catchment Area (ha):</td><td>10 ha</td><td></td><td></td><td></td></tr>
<tr><td>Catchment ID:</td><td>S125 and S126</td><td></td><td>SWA (Tatham, April 2020)</td><td>Drawing DP-1</td></tr>
<tr><td>Primary Source(s) of Flow:</td><td>Surface runoff</td><td></td><td></td><td></td></tr>
<tr><td>Discharge from Quarry / PTTW:</td><td>No</td><td></td><td></td><td></td></tr>
<tr><td>Conditions of PTTW:</td><td>Not applicable</td><td></td><td></td><td></td></tr>
<tr><td>Surface Water Monitoring:</td><td>ID: SW39 (Tatham)
Installation Date: March 25, 2021
Data Collection: Continuous water level and temperature, manual monthly in-situ streamflow measurements and calibration data (water level converted to flow using rating curve)
Coordinates of Monitoring Station: Easting 590856.53, Northing 590856.53</td><td></td><td></td><td></td></tr>
<tr><td>Streamflow Conditions:</td><td>Intermittent</td><td></td><td></td><td></td></tr>
<tr><td>Average Daily Flow:</td><td>To be determined. To date, water levels and temperatures have been collected in Wetland 13037 at the origin of the Headwater Drainage Feature H2. A streamflow monitoring gauge was installed in the spring of 2021 to monitor streamflow in this feature. Average daily flow will be established from the monitoring data collected moving forward. It is noted, Wetland 13037 dries out in the early summer, as early as May 25th, and has remained dry until as late as December 25th. Headwater Drainage Feature H2 runs dry consistent with the upstream wetland.</td><td></td><td></td><td></td></tr>
<tr><td>Watercourse Thermal Regime (SW16A):</td><td>
<table>
<tr><th colspan="4">Average Daily Water Temperature (°C)</th></tr>
<tr><th>Month</th><th>Minimum</th><th>Average</th><th>Maximum</th></tr>
<tr><td>January</td><td>N/A</td><td>N/A</td><td>N/A</td></tr>
<tr><td>February</td><td>N/A</td><td>N/A</td><td>N/A</td></tr>
<tr><td>March</td><td>-6.3</td><td>2.6</td><td>20.5</td></tr>
<tr><td>April</td><td>-5.9</td><td>6.8</td><td>24.4</td></tr>
<tr><td>May</td><td>0.7</td><td>12.0</td><td>31.7</td></tr>
<tr><td>June</td><td>8.2</td><td>16.5</td><td>30.3</td></tr>
<tr><td>July</td><td>Dry</td><td>Dry</td><td>Dry</td></tr>
<tr><td>August</td><td>Dry</td><td>Dry</td><td>Dry</td></tr>
<tr><td>September</td><td>Dry</td><td>Dry</td><td>Dry</td></tr>
<tr><td>October</td><td>Dry</td><td>Dry</td><td>Dry</td></tr>
<tr><td>November</td><td>-5.3</td><td>5.2</td><td>26.4</td></tr>
<tr><td>December</td><td>-1.5</td><td>2.7</td><td>5.5</td></tr>
</table>
Notes:
Minimum - lowest daily average streamflow recorded for period of record
Average - average daily streamflow recorded for period of record
Maximum - maximum daily average streamflow recorded for period of record
N/A - data not available as device removed from watercourse during winter months
</td><td>Graph 1</td><td>SWA (Tatham, April 2020)</td><td>2.1.2 and Appendix C</td></tr>
</table>

Headwater Drainage Feature H2

Fish & Fish Habitat Features	Description	Figure / Graph / Table	Reference	
			Report	Section / Page
Fish Habitat (Direct/Indirect and Assumed/Confirmed):	1) The portion of the Headwater Drainage Feature H2 on the Subject Lands does not appear to provide direct fish habitat, based on the presence of a barrier to movement at the downstream end, intermittent nature (dries out in summer), and generally small size of the feature. No fish were observed in the feature during headwater drainage feature investigations in 2019. 2) The off-site (downstream) reach of this feature consists of an excavated, linear ditch on the adjacent golf course property. It runs for approximately 90 m before draining into an online golf course pond on the West Arm of the West Branch. There is a high probability that this pond contains fish, which could potentially have access to the channelized portion of this headwater drainage feature. However, based on low flows observed in 2019 and lack of suitable wetted width and depth to support fish, it has been assessed as providing indirect fish habitat.		NETR (Savanta, April 2020)	39 and 40
Fish Species Present:	Fish are assumed to not directly use the headwater drainage feature. No information on fish species in the online pond at the downstream end of the feature is known to exist. Pumpkinseed and Brook Stickleback are known to be present in upstream reaches of the West Arm of the West Branch.		NETR (Savanta, April 2020)	39 and 40
Fish Community Thermal Regime:	Fish are assumed to not directly use the headwater drainage feature.		NETR (Savanta, April 2020)	39 and 40
Fish Habitat Types Present:	The feature provides indirect fish habitat contributing to the downstream West Arm of the West Branch. On the Subject Lands, the feature consists of a headwater wetland and an approximately 50-m long, low flow channel running through a wooded area, before flowing into the off-site channelized reach on the adjacent property.		NETR (Savanta, April 2020)	39 and 40
Habitat Uses by Known Fish Community:	No direct use by fish is expected to occur. Indirect habitat functions provided by the feature include water storage and release (headwater wetlands), water quality maintenance, conveyance of flow, sediment transport and organic inputs.		NETR (Savanta, April 2020)	39 and 40
Known Barriers to Fish Movement:	There is a culvert at the Subject Lands property line that provides a barrier to upstream fish movement.		NETR (Savanta, April 2020)	39 and 40

Groundwater Interaction	Description	Figure / Graph / Table	Reference	
			Report	Section / Page
Underlying Deposits:	Halton Till. The harmonic mean hydraulic conductivity, based on testing by Golder (2007) of 10 mini-piezometers, was $1.2x10^{-8}$ m/s. Model value for the vertical hydraulic conductivity was $1.6x10^{-7}$ m/s, about an order of magnitude higher, to account for limited flow through fractures in the till.			
Surface Water / Groundwater Interactions:	Seasonal groundwater contributions to watercourse. Groundwater seepage under baseline conditions during spring months equates to 0.1 L/s or less. Groundwater seepage is at its maximum during and immediately following the spring freshet.	Figures 1 & 2		
Water Budget Results:	The baseline condition water budget results from the integrated model are presented in Figure 3a.	Figure 3a		

Condition	GW Out	GW In
Baseline (Existing)	18.07%	1.11%

Integrated Model Calibration:	This area was not discussed in the model calibration due to the lack of observations.			

Headwater Drainage Feature H2

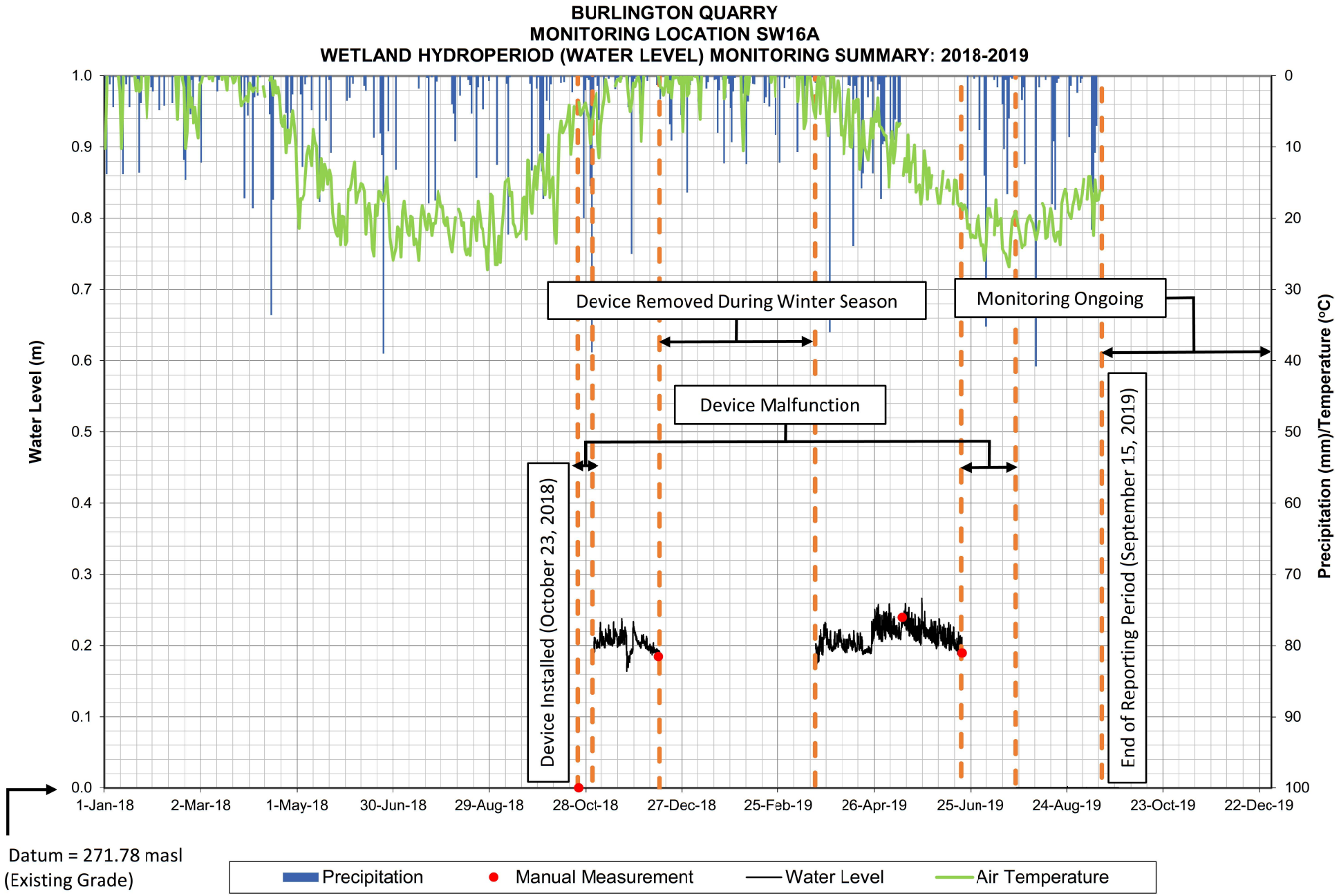
<table>
<tr><th>Impact Assessment</th><th>Description</th><th>Figure / Graph / Table</th><th colspan="2">Reference</th></tr>
<tr><th></th><th></th><th></th><th>Report</th><th>Section / Page</th></tr>
<tr><td>Direct Alterations to Watercourse:</td><td>No direct alterations to this headwater drainage feature are proposed.</td><td></td><td>NETR (Savanta, April 2020)</td><td>80</td></tr>
<tr><td>Change in Primary Source of Flow:</td><td>No change in surface water input as the catchment area of the Headwater Drainage Feature H2 will remain undisturbed. The headwater drainage feature is perched above the water table, generally losing rather than gaining flow from the groundwater system. The headwater drainage feature is primarily located in Halton Till, so the low permeability of the till limits GW/SW interactions.</td><td></td><td></td><td></td></tr>
<tr><td>Change in Watercourse Catchment Area:</td><td>Catchment area to remain undisturbed, no change in catchment area.</td><td></td><td></td><td></td></tr>
<tr><td>Simulated Streamflow Change (Integrated Model Results):</td><td>The Earthfx report discusses changes in simulated streamflow under the different quarry expansion phases. This tributary was not discussed, but Graphs 2 and 3 show simulated baseline(red) and Scenario P12 (blue) flows. Decrease in flow (green) are plotted in reverse on the upper X axis with the scale shown on the right Y axis. Very small decreases in streamflow, primarily in winter and spring, are predicted.</td><td>Graphs 2 & 3</td><td>HHIAR (Earthfx, April 2020)</td><td>198 - 203 and 230 - 237</td></tr>
<tr><td>Water Budget Results (Operational Phases 1 & 2):</td><td>The Operational Phases 1 and 2 water budget results from the integrated model are presented in Figure 3b.
<table>
<tr><td>Condition</td><td>GW Outflow</td><td>GW Inflow</td><td>%Δ GW Outflow</td><td>%Δ GW Inflow</td></tr>
<tr><td>Baseline (Existing)</td><td>18.07%</td><td>1.11%</td><td>-</td><td>-</td></tr>
<tr><td>Phases 1 & 2</td><td>18.57%</td><td>0.00%</td><td>0.50%</td><td>-1.11%</td></tr>
</table></td><td>Figure 3b</td><td></td><td></td></tr>
<tr><td>Water Budget Results (Operational Phases 3 Through 6):</td><td>The Operational Phases 3 through 6 water budget results from the integrated model are presented in Figure 3c. Its noted the rehabilitation of the south extension is complete under this scenario.
<table>
<tr><td>Condition</td><td>GW Outflow</td><td>GW Inflow</td><td>%Δ GW Outflow</td><td>%Δ GW Inflow</td></tr>
<tr><td>Baseline (Existing)</td><td>18.07%</td><td>1.11%</td><td>-</td><td>-</td></tr>
<tr><td>Phases 3 though 6</td><td>19.18%</td><td>19.06%</td><td>1.11%</td><td>17.95%</td></tr>
</table></td><td>Figure 3c</td><td></td><td></td></tr>
<tr><td>Water Budget Results (Rehabilitation Scenario 1):</td><td>The Rehabilitation Scenario 1 water budget results from the integrated model are presented in Figure 3d.
<table>
<tr><td>Condition</td><td>GW Outflow</td><td>GW Inflow</td><td>%Δ GW Outflow</td><td>%Δ GW Inflow</td></tr>
<tr><td>Baseline (Existing)</td><td>18.07%</td><td>1.11%</td><td>-</td><td>-</td></tr>
<tr><td>Rehab Scenario 1</td><td>18.25%</td><td>18.43%</td><td>0.18%</td><td>17.32%</td></tr>
</table></td><td>Figure 3d</td><td></td><td></td></tr>
<tr><td>Water Budget Results (Rehabilitation Scenario 2):</td><td>The Rehabilitation Scenario 2 water budget results from the integrated model are presented in Figure 3e.
<table>
<tr><td>Condition</td><td>GW Outflow</td><td>GW Inflow</td><td>%Δ GW Outflow</td><td>%Δ GW Inflow</td></tr>
<tr><td>Baseline (Existing)</td><td>18.07%</td><td>1.11%</td><td>-</td><td>-</td></tr>
<tr><td>Rehab Scenario 2</td><td>19.04%</td><td>17.37%</td><td>0.97%</td><td>16.26%</td></tr>
</table></td><td>Figure 3e</td><td></td><td></td></tr>
<tr><td>Change in Groundwater Contributions to Watercourse:</td><td>Under Baseline conditions, the H2 catchment receives minimal amounts of groundwater seepage during drought years (more under wet years). Under P12 conditions, this seepage is lost due to the dewatering as shown in Graph 4. Leakage between the stream and groundwater system is shown in Graph 5 for Baseline and P12 conditions. The vast majority of the leakage is from the stream to the groundwater system. Under Baseline conditions there is a very minor amount of upwards leakage into the stream in the late spring (shown as negative leakage in blue).</td><td>Graphs 4 and 5</td><td></td><td></td></tr>
<tr><td>Change in Watercourse Thermal Regime:</td><td>Negative changes on water temperature are not expected given that the wetlands and catchment area feeding the Headwater Drainage Feature H2 will remain undisturbed.</td><td></td><td></td><td></td></tr>
<tr><td>Change in Water Quality:</td><td>Negative changes on water quality are not expected given that the wetlands and catchment area feeding the Headwater Drainage Feature H2 will remain undisturbed.</td><td></td><td></td><td></td></tr>
</table>

Headwater Drainage Feature H2

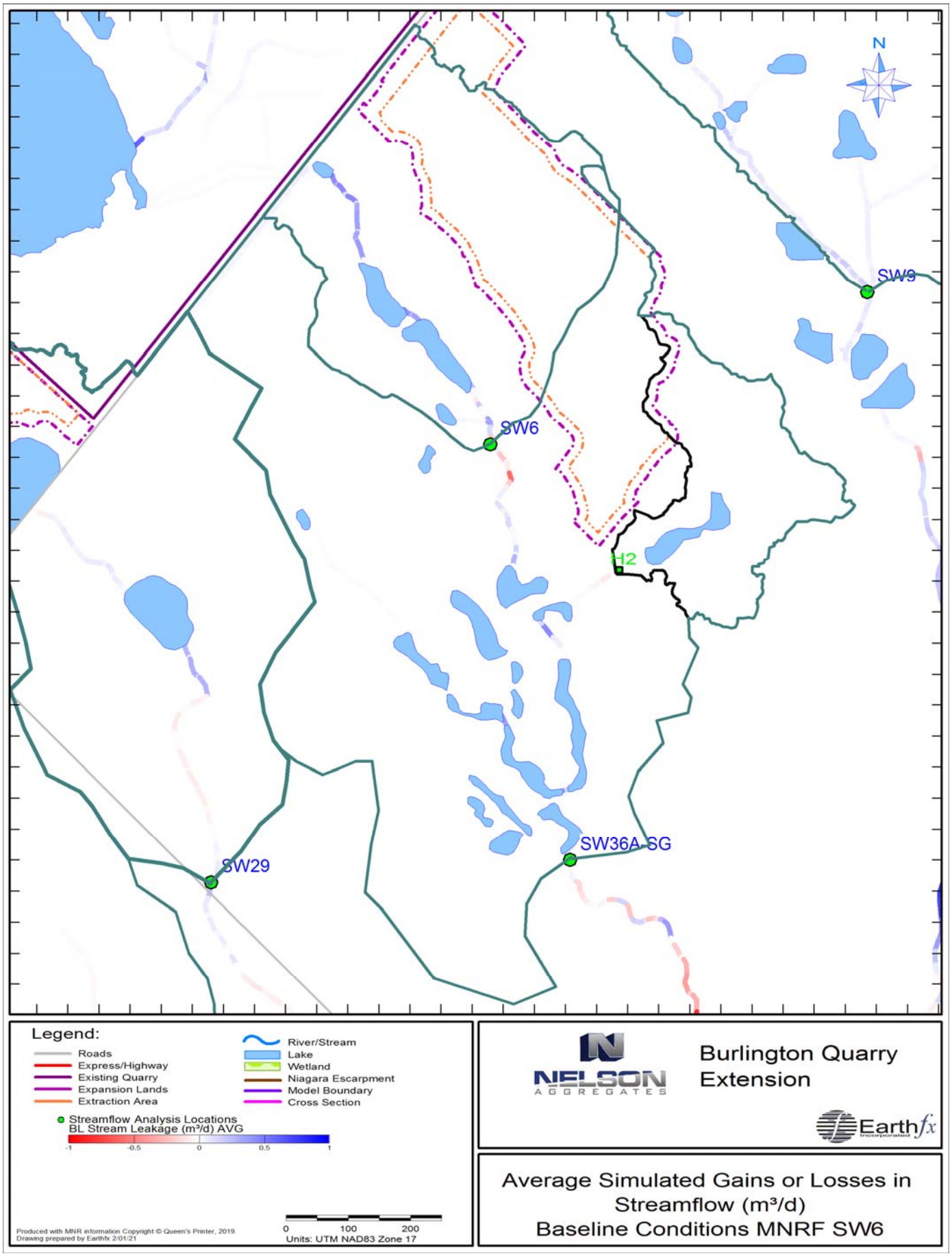
Impact Assessment	Description	Figure / Graph / Table	Reference	
			Report	Section / Page
Potential Impact to Form and Function of Feature:	A 1% or 0.1 L/s reduction in groundwater discharge to the headwater wetland may have a corresponding 1% reduction in the volume of water conveyed downstream to the West Arm of the West Branch. The feature is predicted to continue to provide indirect fish habitat functions supporting the downstream watercourse as it will continue to convey flow downstream on a seasonal basis. The 0.1 L/s reduction in surface flow into the online pond on the West Arm of the West Branch (where Headwater Drainage Feature H2 drains) is not expected to have a measurable effect on direct fish habitat in the pond or watercourse.		NETR (Savanta, April 2020)	80
Potential Impact to Identified Species and Habitat:	No impacts to species or habitat in the downstream West Arm of the West Branch are predicted.		NETR (Savanta, April 2020)	80

Mitigation	Description	Figure / Graph / Table	Reference	
			Report	Section / Page
Direct Alteration Mitigation:	No direct alterations are proposed; therefore, no mitigation is required.		NETR (Savanta, April 2020)	80
Source Water Mitigation:	No alterations to surface water catchment area; therefore, no mitigation is required.		NETR (Savanta, April 2020)	80
Groundwater Contribution Mitigation:	Given the minor nature of proposed changes in groundwater discharge to the wetland, no mitigation is proposed to supplement flows. However, the feature will continue to be monitored throughout the operations period, as specified in the AMP. If adverse effects on flow and/or wetland function are observed as a result of quarry extraction, mitigation (e.g., pumping from the quarry to the headwater wetland) could be implemented, if needed, to maintain ecological and biophysical functions of the feature.		NETR (Savanta, April 2020)	80
Erosion Mitigation:	None required.			
Thermal Mitigation:	None required.			
Water Quality Mitigation:	None required.			

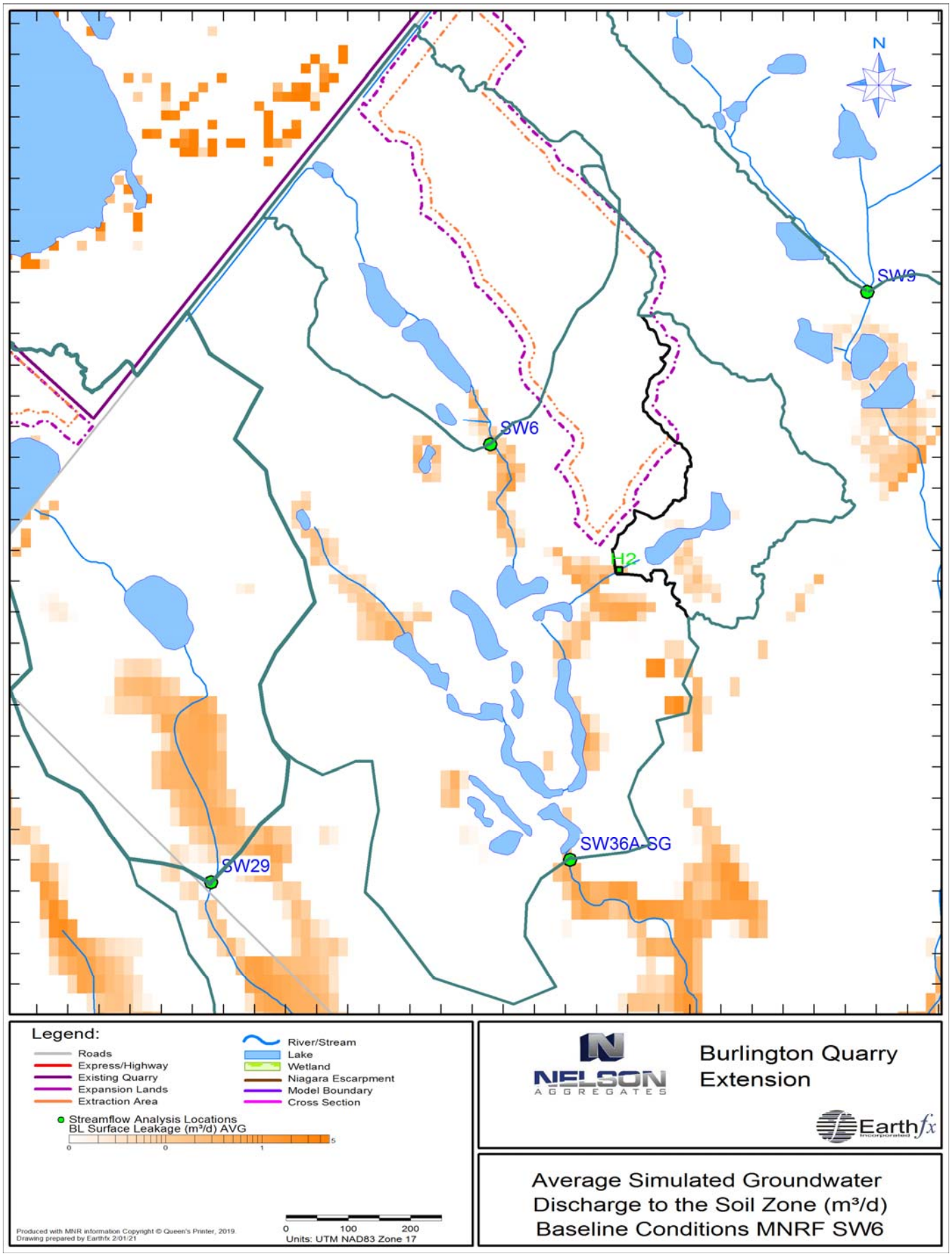
HEADWATER DRAINAGE FEATURE H2 - GRAPH 1



HEADWATER DRAINAGE FEATURE H2 - FIGURE 1



HEADWATER DRAINAGE FEATURE H2 - FIGURE 2



HEADWATER DRAINAGE FEATURE H2

FIGURE 3A

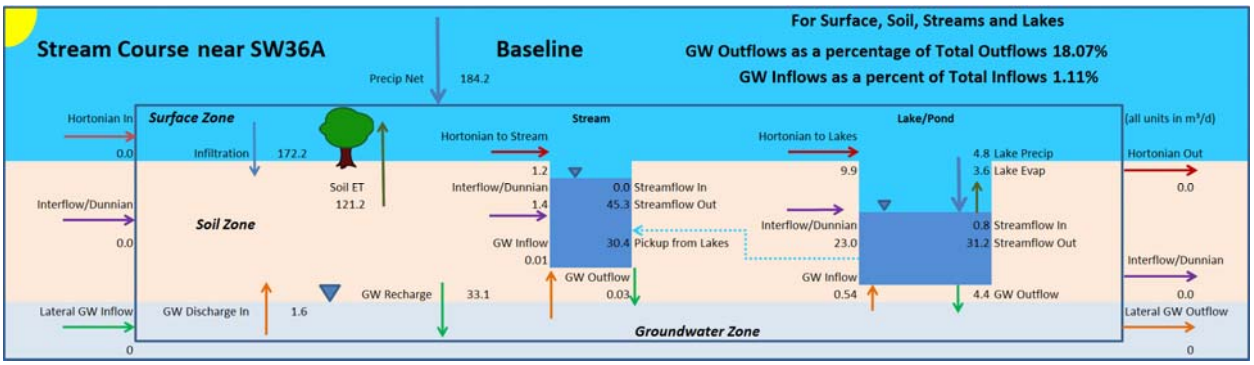


FIGURE 3B

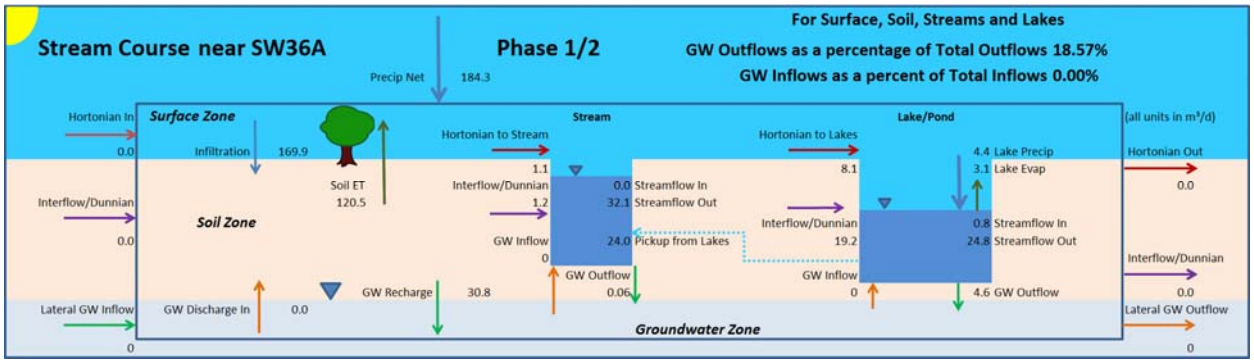


FIGURE 3C

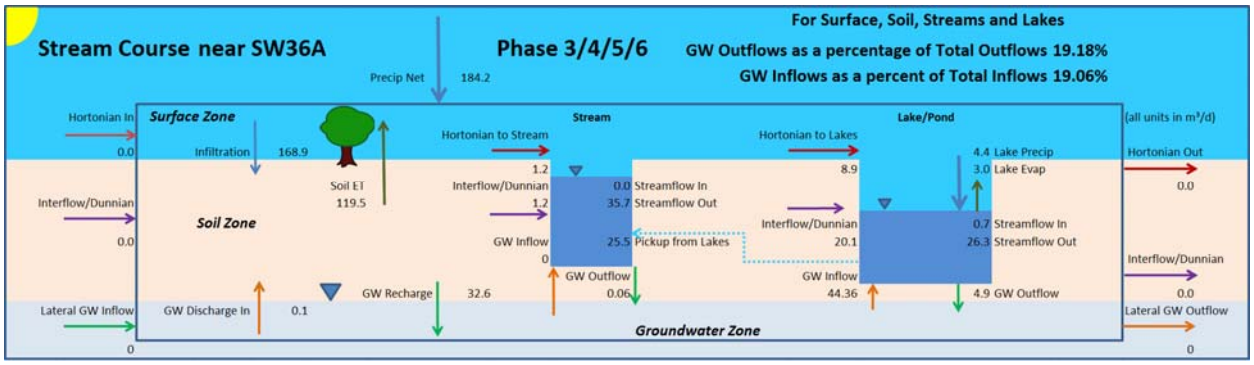


FIGURE 3D

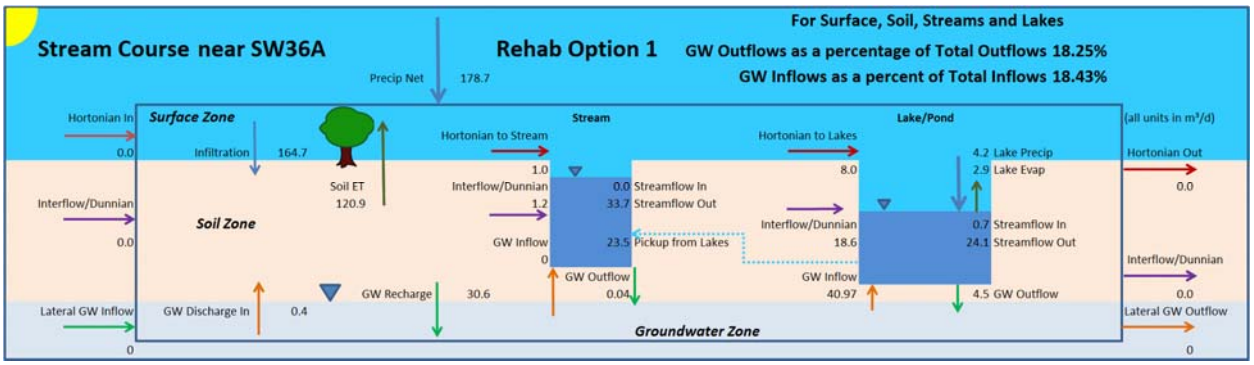
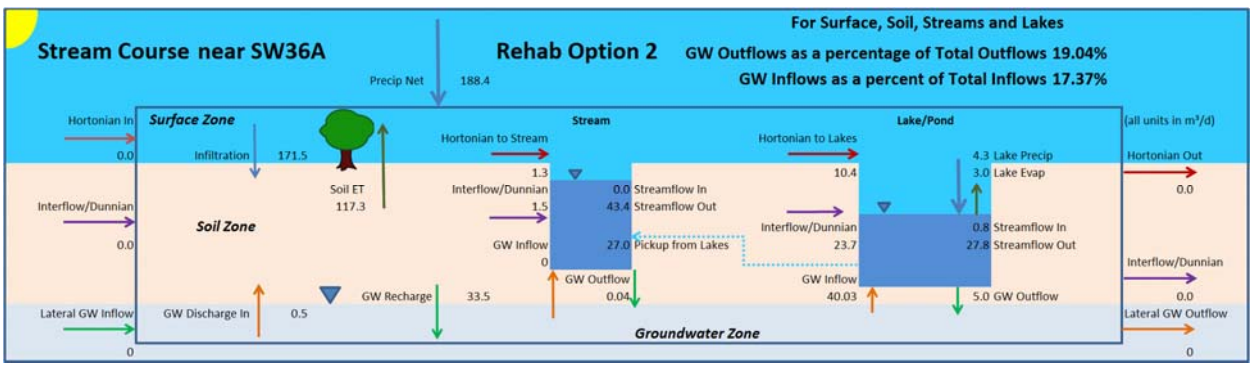
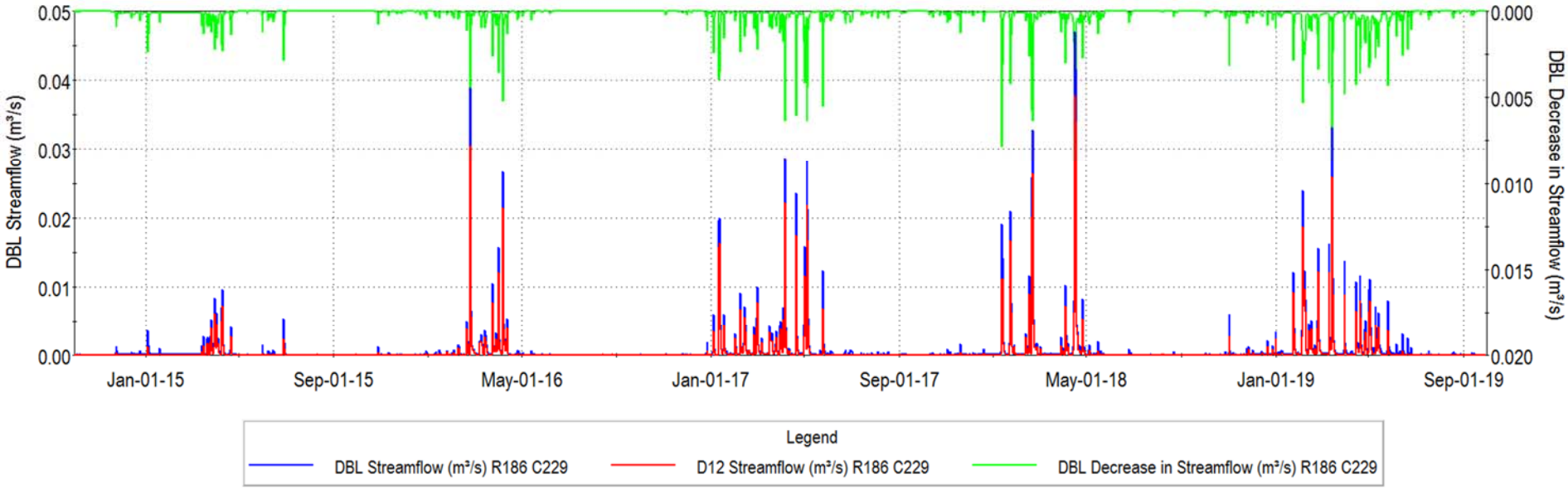


FIGURE 3E



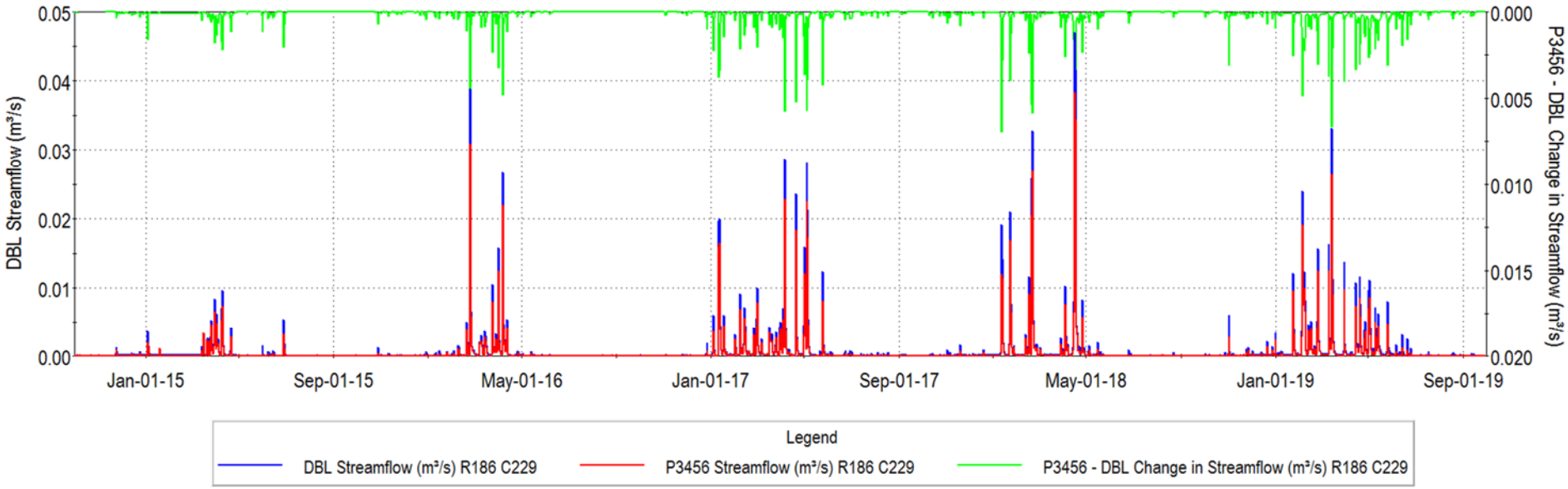
HEADWATER DRAINAGE FEATURE H2 - GRAPH 2

Simulated Streamflow Change - Integrated Model
Headwater Drainage Feature H2

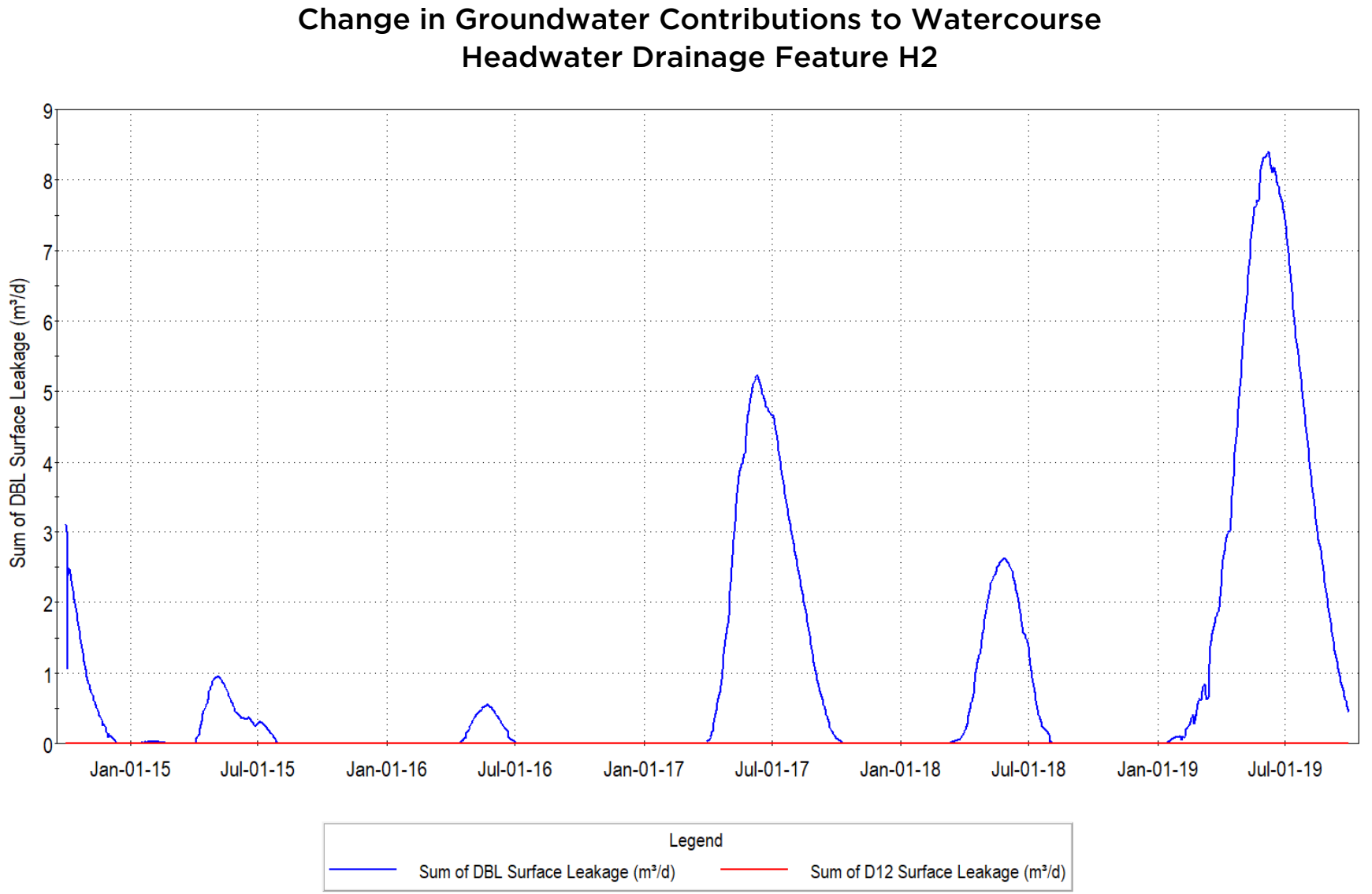


HEADWATER DRAINAGE FEATURE H2 - GRAPH 3

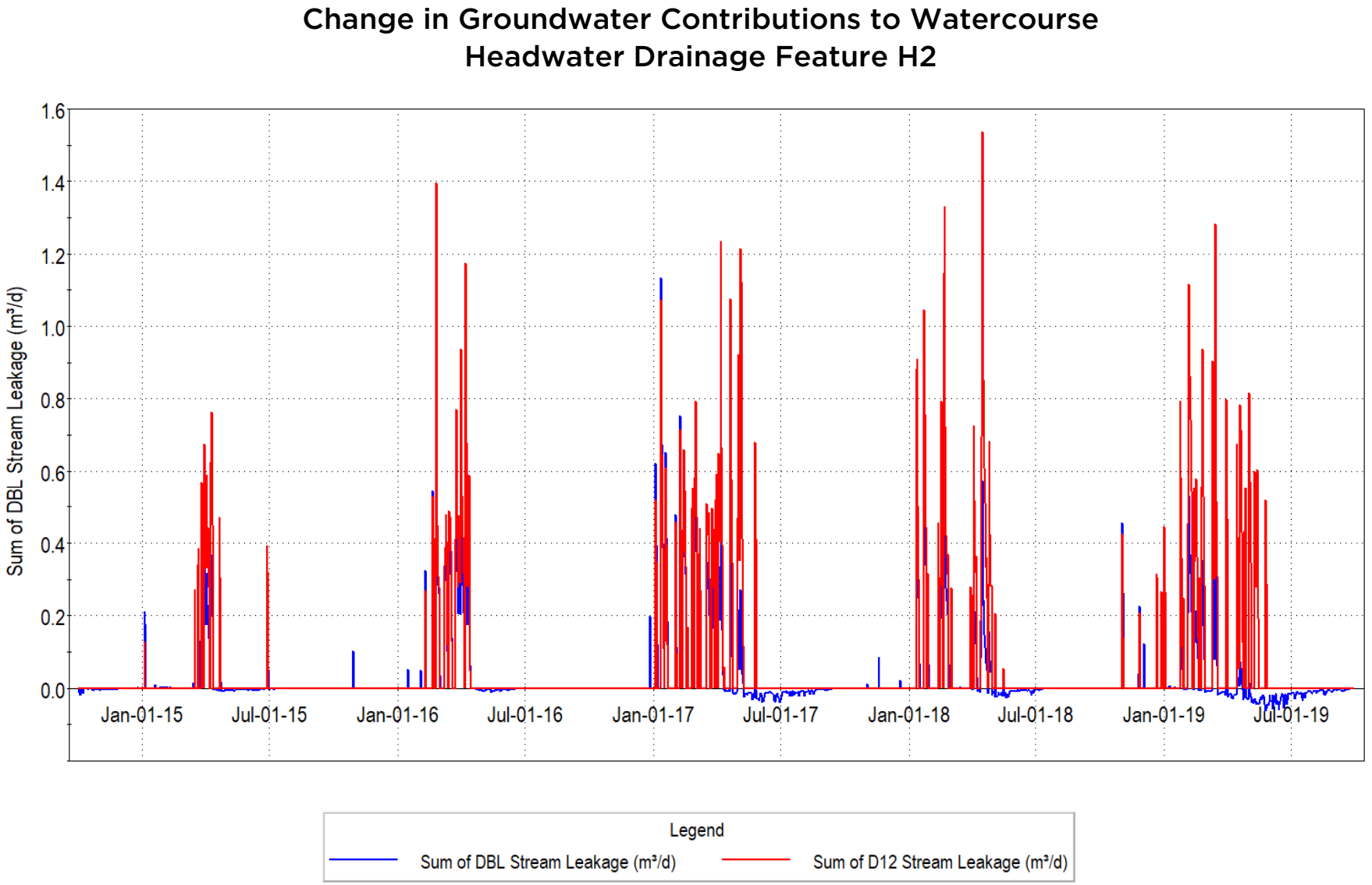
Simulated Streamflow Change - Integrated Model
Headwater Drainage Feature H2



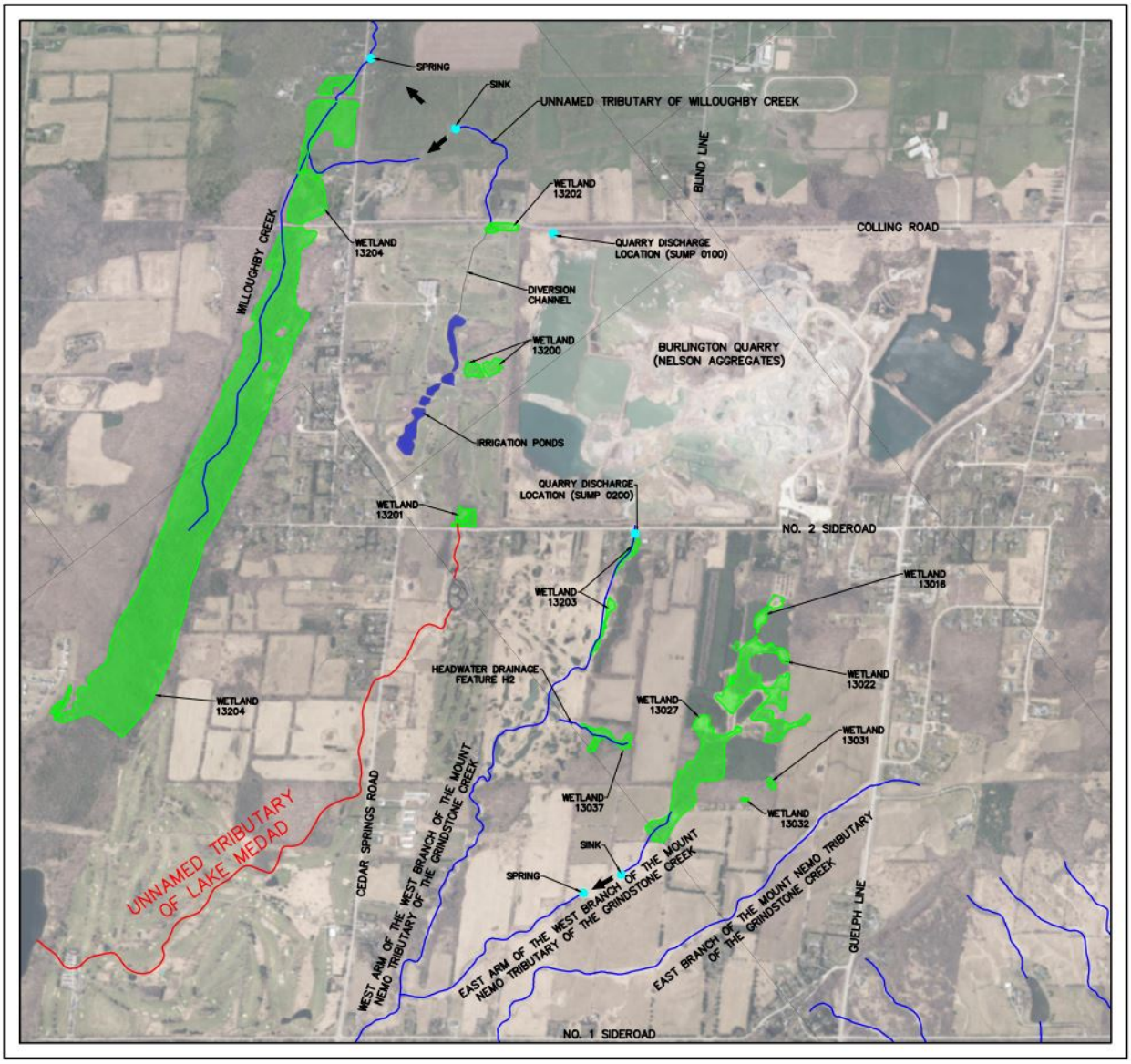
HEADWATER DRAINAGE FEATURE H2 - GRAPH 4



HEADWATER DRAINAGE FEATURE H2 - GRAPH 5



UNNAMED TRIBUTARY OF LAKE MEDAD



West Extension

Willoughby Creek

Unnamed Tributary of Lake Medad

West Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek

Lake Medad

Milloughby Line

Sideroad 2

Cedar Springs Court

Cedar Springs Road

SW14

DW-3

M34

BS-04

SW36

M33

Well 5

SW29

Legend

- Licensed Boundary
- Limit of Extraction
- 120 m Adjacent Lands
- Subject Lands
- Unnamed Tributary of Lake Medad
- Road
- Indirect Fish Habitat
- Direct Fish Habitat
- Watercourse
- Waterbody
- Wetland (Savanta, 2020)

Current Instrumentation

- Groundwater Monitoring Station (EarthFx)
- Mini Piezometer (Tatham Engineering)
- Staff Gauge & Surface Water Monitoring Station (Tatham Engineering)
- Manual Stream Flow Measurement (Tatham Engineering)

Previous Instrumentation

- Groundwater Monitoring Station (Golder)

NOTES:

1. Coordinate System: NAD 1983 UTM Zone 17N.
2. Base features produced under license with the Ontario Ministry of Natural Resources and Forestry © Queen's Printer for Ontario, 2021.
3. Orthoimagery © First Base Solutions, 2021. Imagery taken in 2019.

Project 8133

Burlington Quarry Extension
Nelson Aggregates Co.

Figure 14
Watercourse Characterization

Unnamed Tributary of Lake Medad

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Path: C:\Savanta\8133 - Burlington Quarry\figures\report_figures\2021 01 21 natural feature tech summary\8133_rpt_watercourse_char_mapbook.mxd Date: April 8, 2021

Unnamed Tributary of Lake Medad

Surface Water Characteristics	Description	Figure / Graph / Table	Reference	
			Report	Section / Page
Watercourse Name:	Unnamed Tributary of Lake Medad			
Watershed:	Grindstone Creek Watershed			
Sub-Watershed:	Lake Medad			
Located in Proposed Limit of Extraction:	No			
Located in Proposed License Boundary:	No			
Catchment Area (ha):	138 ha (at Lake Medad)			
Catchment ID:	N/A			
Primary Source(s) of Flow:	Surface runoff			
Discharge from Quarry / PTTW:	No			
Conditions of PTTW:	Not applicable			
Surface Water Monitoring:	ID: SW29 (Tatham) Installation Date: October 25, 2018 Data Collection: Continuous water level and temperature, manual monthly in-situ streamflow measurements and calibration data (water level converted to flow using rating curve) Coordinates of Monitoring Station: Easting 590180.497, Northing 4804363.89	Graphs 1 & 2 and Table 1	SWA (Tatham, April 2020)	2.1.2, Appendix C and Appendix H
Streamflow Conditions:	Intermittent	Graphs 1 & 2 and Table 1	SWA (Tatham, April 2020)	2.1.2 and Appendix C
Average Daily Flow (SW29):	Average Daily Streamflow (L/s)	Graphs 1	SWA (Tatham, April 2020)	2.1.2 and Appendix C

Month	Minimum	Average	Maximum
January	N/A	N/A	N/A
February	N/A	N/A	N/A
March	3.3	7.3	21.1
April	1.9	4.6	8.6
May	1.0	2.8	5.8
June	0.0	0.6	2.2
July	0.0	0.0	0.2
August	0.0	0.0	0.0
September	0.0	0.0	0.0
October	0.0	0.0	0.0
November	0.2	0.9	4.4
December	0.4	0.8	2.2

Notes:

Minimum - lowest daily average streamflow recorded for period of record

Average - average daily streamflow recorded for period of record

Maximum - maximum daily average streamflow recorded for period of record

N/A - data not available as device removed from watercourse during winter months

Unnamed Tributary of Lake Medad

Watercourse Thermal Regime (SW29):

Average Daily Water Temperature (°C)

Month	Minimum	Average	Maximum
January	N/A	N/A	N/A
February	N/A	N/A	N/A
March	-0.6	0.6	9.0
April	-0.1	6.2	14.8
May	4.9	11.4	18.6
June	10.4	15.5	26.4
July	11.6	18.8	28.3
August	Dry	Dry	Dry
September	Dry	Dry	Dry
October	Dry	Dry	Dry
November	-3.9	3.0	8.2
December	1.3	2.2	4.5

Notes:

Minimum - lowest daily average streamflow recorded for period of record

Average - average daily streamflow recorded for period of record

Maximum - maximum daily average streamflow recorded for period of record

N/A - data not available as device removed from watercourse during winter months

Graph 2

SWA (Tatham, April 2020)

2.1.2 and Appendix C

Water Quality (SW29):

Water Quality Sample Results

Parameter	Units	Minimum	Average	Maximum
Turbidity	NTU	11.3	11.8	12.3
TDS	mg/L	437	469	500
TSS	mg/L	7.67	10.49	13.30
COD	mg/L	32	32	32
BOD5	mg/L	1.3	1.4	1.5
DOC	mg/L	8.1	9.8	11.4
pH		7.8	7.9	8
Alkalinity	mg/L	257	312	366
Conductivity	µS/cm	648	763	878
Phosphorus	ug/L	<50	77	104
Ammonia	mg/L	0.01	0.05	0.08
Hardness	mg/L	271	305	338

Table 1

SWA (Tatham, April 2020)

2.4 and Appendix H

Unnamed Tributary of Lake Medad

Fish & Fish Habitat Features	Description	Figure / Graph / Table	Reference	
			Report	Section / Page
Fish Habitat (Direct/Indirect and Assumed/Confirmed):	1) The uppermost reach of the watercourse (i.e., within 150 m downstream from the head of the watercourse at Sideroad No. 2) does not appear capable of providing direct fish habitat, based on aerial photo analysis, given a lack of a defined channel. Therefore, this portion of the watercourse is assumed to provide indirect fish habitat. 2) The remainder of the watercourse (i.e., beyond 150 m downstream from Sideroad No. 2) is assumed to provide direct fish habitat, although no fish community sampling is known to have been completed to confirm this assumption. There is a series of online ponds associated with the adjacent golf course approximately 150 m downstream from Sideroad No. 2 and there is a high probability that these ponds contain fish, as they appear to be permanent features.		NETR (Savanta, April 2020)	45 and Figure 9a
Fish Species Present:	No information on fish species present is known to exist.			
Fish Community Thermal Regime:	No information on fish community thermal regime is known to exist. Based on the presence of large, online ponds on the adjacent golf course, it is expected that a primarily warmwater fish community would be present.			
Fish Habitat Types Present:	No information on fish habitat types is known to be available for this watercourse.			
Habitat Uses by Known Fish Community:	The local fish community likely uses the off-site habitat for the complete range of life history processes including spawning, nursery, foraging and overwintering (in the online ponds or Lake Medad, given the intermittent nature of the watercourse).			
Known Barriers to Fish Movement:	There are no known barriers to fish movement in this watercourse.			

Groundwater Interaction	Description	Figure / Graph / Table	Reference	
			Report	Section / Page
Underlying Deposits:	Halton Till. The harmonic mean hydraulic conductivity, based on testing by Golder (2007) of 10 mini-piezometers, was $1.2x10^{-8}$ m/s. Model value for the vertical hydraulic conductivity was $1.6x10^{-7}$ m/s, about an order of magnitude higher, to account for limited flow through fractures in the till.			
Surface Water / Groundwater Interactions:	Seasonal groundwater contributions to watercourse. Groundwater seepage under baseline conditions during spring months equates to 1 L/s or less. Groundwater seepage is at its maximum during and immediately following the spring freshet.	Figures 1 & 2		
Water Budget Results:	The baseline condition water budget results from the integrated model are presented in Figure 3a. Condition / GW Out / GW In Baseline (Existing) / 21.81% / 5.06%	Figure 3a		
Integrated Model Calibration:	SW29 monitors the watershed west of the South extension. Both the model and the observations suggest an intermittent, flashy watershed response. Simulated and observed streamflow at SW29 are presented in Earthfx (p. 415) for WY2017 to WY2019. The model slightly underpredicts the baseflows and overpredicts the peak flows. Uncertainty regarding the diversions of streamflow to the golf course ponds and rates of irrigation may be contributing to the poorer match at this gauge. Comparisons at the other gauges showed a similar pattern with very good matches to the east and west of the quarry and poorer matches to the southwest.	Graph 3	HHIAR (Earthfx, April 2020)	19.4.2 (page 415)

Unnamed Tributary of Lake Medad

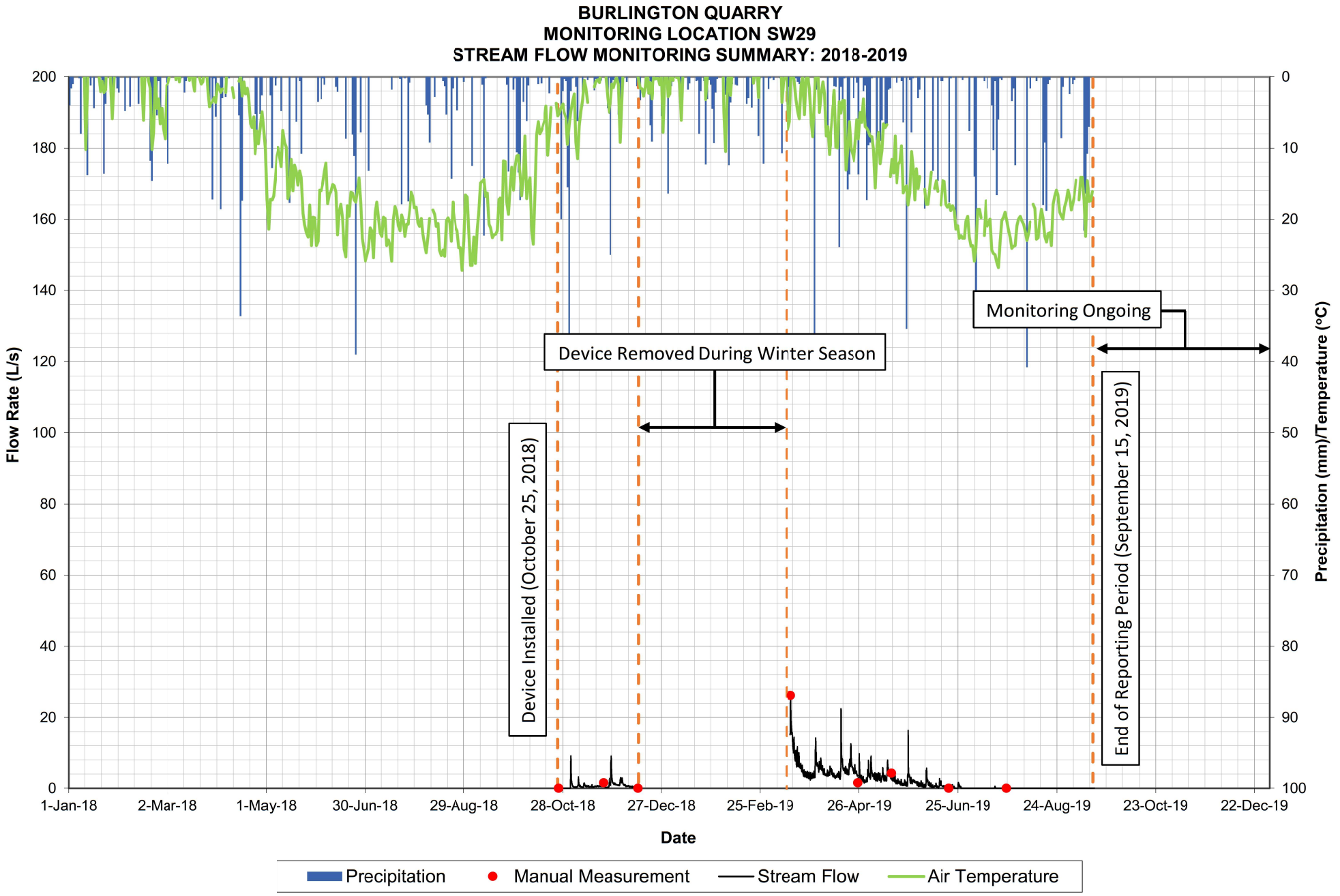
<table>
<tr><th>Impact Assessment</th><th>Description</th><th>Figure / Graph / Table</th><th colspan="2">Reference</th></tr>
<tr><th></th><th></th><th></th><th>Report</th><th>Section / Page</th></tr>
<tr><td>Direct Alterations to Watercourse:</td><td>No direct alterations to this watercourse are proposed.</td><td></td><td>NETR (Savanta, April 2020)</td><td>78</td></tr>
<tr><td>Change in Primary Source of Flow:</td><td>No change in surface water input as culvert under No. 2 Sideroad is plugged and there is no evidence of a connection between Wetland 13201 and the Unnamed Tributary of Lake Medad. Many streams are perched above the water table, they generally lose rather than gain flow from the groundwater system. The streams are primarily located in Halton Till, so the low permeability of the till limits GW/SW interactions.</td><td></td><td></td><td></td></tr>
<tr><td>Change in Watercourse Catchment Area:</td><td>Culvert under No. 2 Sideroad is plugged and there is no evidence of a culvert or watercourse immediately downstream. As such, extraction in west extension will not alter the catchment area of the Unnamed Tributary of Lake Medad.</td><td></td><td></td><td></td></tr>
<tr><td>Simulated Streamflow Change (Integrated Model Results):</td><td>The Earthfx report discusses changes in simulated streamflow under the different quarry expansion phases. Graph 4 reproduces Figure 8.7 (p. 201) and presents simulated baseline(red) and Scenario P12 (blue) flows at location SW29. Decreases in flow (green) are plotted in reverse on the upper X axis with the scale shown on the right Y axis. Very small decreases in streamflow, primarily in winter and spring, are predicted Phase 12 area.</td><td>Graphs 4 & 5</td><td>HHIAR (Earthfx, April 2020)</td><td>198 - 230 and 230 - 237</td></tr>
<tr><td>Water Budget Results (Operational Phases 1 & 2):</td><td>The Operational Phases 1 and 2 water budget results from the integrated model are presented in Figure 3b.
<table><tr><td>Condition</td><td>GW Outflow</td><td>GW Inflow</td><td>%Δ GW Outflow</td><td>%Δ GW Inflow</td></tr><tr><td>Baseline (Existing)</td><td>21.81%</td><td>5.06%</td><td>-</td><td>-</td></tr><tr><td>Phases 1 & 2</td><td>22.22%</td><td>2.30%</td><td>0.41%</td><td>-2.76%</td></tr></table></td><td>Figure 3b</td><td></td><td></td></tr>
<tr><td>Water Budget Results (Operational Phases 3 Through 6):</td><td>The Operational Phases 3 through 6 water budget results from the integrated model are presented in Figure 3c.
<table><tr><td>Condition</td><td>GW Outflow</td><td>GW Inflow</td><td>%Δ GW Outflow</td><td>%Δ GW Inflow</td></tr><tr><td>Baseline (Existing)</td><td>21.81%</td><td>5.06%</td><td>-</td><td>-</td></tr><tr><td>Phases 3 through 6</td><td>23.94%</td><td>1.91%</td><td>2.13%</td><td>-3.15%</td></tr></table></td><td>Figure 3c</td><td></td><td></td></tr>
<tr><td>Water Budget Results (Rehabilitation Scenario 1):</td><td>The Rehabilitation Scenario 1 water budget results from the integrated model are presented in Figure 3d.
<table><tr><td>Condition</td><td>GW Outflow</td><td>GW Inflow</td><td>%Δ GW Outflow</td><td>%Δ GW Inflow</td></tr><tr><td>Baseline (Existing)</td><td>21.81%</td><td>5.06%</td><td>-</td><td>-</td></tr><tr><td>Rehab Scenario 1</td><td>22.35%</td><td>3.34%</td><td>0.54%</td><td>-1.72%</td></tr></table></td><td>Figure 3d</td><td></td><td></td></tr>
<tr><td>Water Budget Results (Rehabilitation Scenario 2):</td><td>The Rehabilitation Scenario 2 water budget results from the integrated model are presented in Figure 3e.
<table><tr><td>Condition</td><td>GW Outflow</td><td>GW Inflow</td><td>%Δ GW Outflow</td><td>%Δ GW Inflow</td></tr><tr><td>Baseline (Existing)</td><td>21.81%</td><td>5.06%</td><td>-</td><td>-</td></tr><tr><td>Rehab Scenario 2</td><td>16.70%</td><td>10.90%</td><td>-4.21%</td><td>5.84%</td></tr></table></td><td>Figure 3e</td><td></td><td></td></tr>
<tr><td>Change in Groundwater Contributions to Watercourse:</td><td>The change in groundwater seepage in the SW29 stream catchment under Baseline conditions is shown in Graph 6. A reduction in seepage will occur under P3456 conditions due to a decline in groundwater levels due to the excavation. The change in stream leakage between Baseline and P3456 is shown in Graph 7. The changes reflect a lowering of the water table. Groundwater seepage under baseline conditions during spring months equates to 1 L/s or less.</td><td>Graphs 6 and 7</td><td></td><td></td></tr>
<tr><td>Change in Watercourse Thermal Regime:</td><td>No negative impacts on temperature expected.</td><td></td><td></td><td></td></tr>
<tr><td>Change in Water Quality:</td><td>No negative impacts on water quality expected.</td><td></td><td></td><td></td></tr>
</table>

Unnamed Tributary of Lake Medad

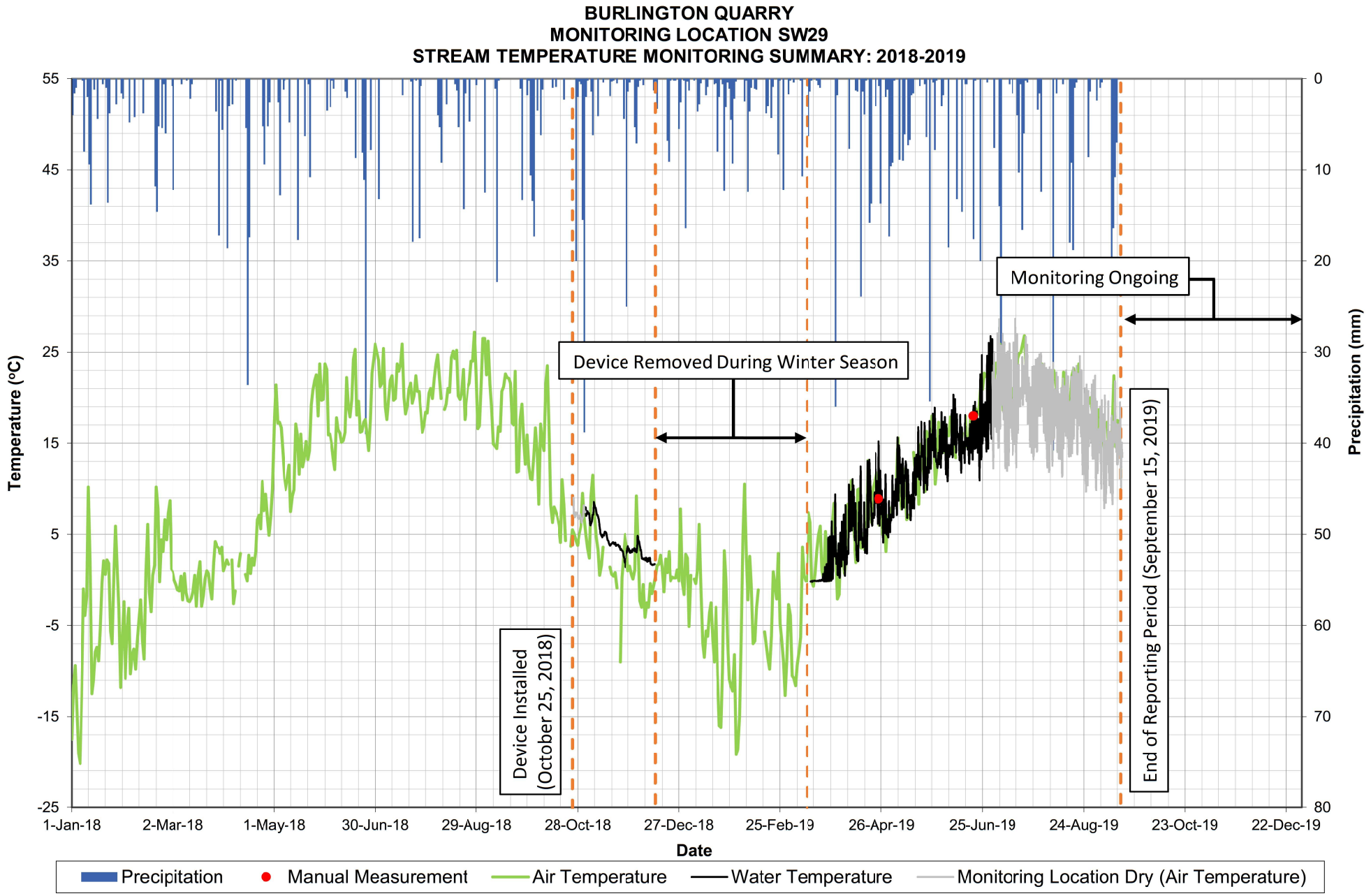
Impact Assessment	Description	Figure / Graph / Table	Reference	
			Report	Section / Page
Potential Impact to Form and Function of Feature:	Unmitigated flow reductions could have negative impacts on habitat availability during low flow (baseflow) periods through reductions in wetted width and depth and limiting movements throughout the watercourse.		NETR (Savanta, April 2020)	78
Potential Impact to Identified Species and Habitat:	Unmitigated flow reductions could have negative impacts on fish species in the watercourse (e.g., lack of access to sufficient habitat, concentrating fish in residual features, increased competition for resources, increased vulnerability to predators).		NETR (Savanta, April 2020)	78

Mitigation	Description	Figure / Graph / Table	Reference	
			Report	Section / Page
Direct Alteration Mitigation:	No direct alterations are proposed; therefore, no mitigation is required.		NETR (Savanta, April 2020)	75
Source Water Mitigation:	None required. Primary source of flow is surface runoff and catchment area will not be altered.			
Groundwater Contribution Mitigation:	None required. Groundwater contributions under baseline conditions equate to 1 L/s or less and overall percent change predicted at approximately 3%.			
Erosion Mitigation:	None required.			
Thermal Mitigation:	None required.			
Water Quality Mitigation:	None required.			

TRIBUTARY OF LAKE MEDAD - GRAPH 1



TRIBUTARY OF LAKE MEDAD - GRAPH 2



* Grey data indicates the monitoring location was dry and therefore the recorded values are respresentative of the air temperature.

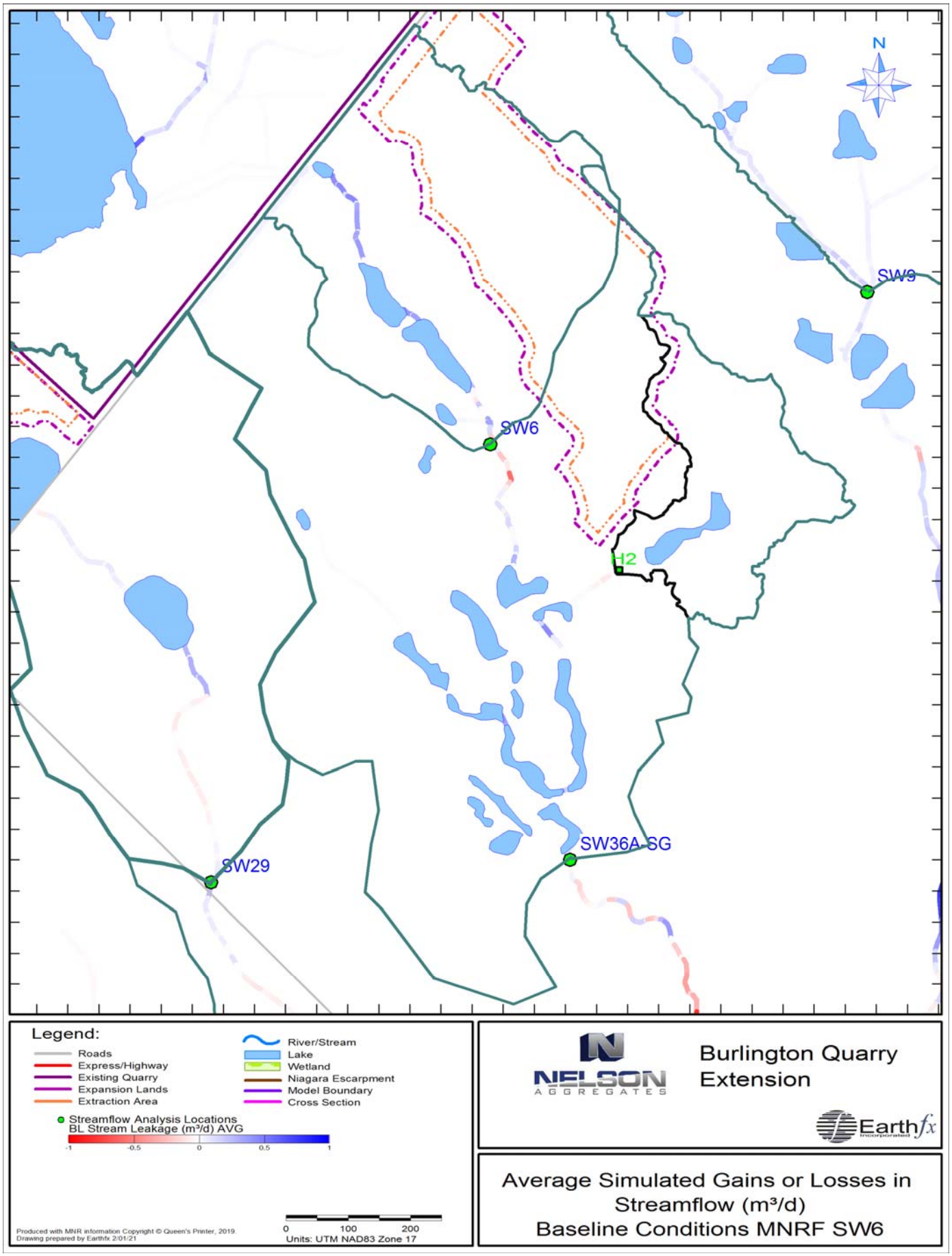
TRIBUTARY OF LAKE MEDAD - TABLE 1

BURLINGTON QUARRY
TATHAM ENGINEERING PROJECT NO.: 113187
SURFACE WATER MONITORING

WATER QUALITY SAMPLE RESULTS

Monitoring Location SW29													
		Sample Date:	24-Oct-18	24-Apr-19	19-Jun-19	25-Sep-19	20-May-20	15-Jul-20	16-Sep-20	11-Nov-20	Maximum	Minimum	Average
Parameter:	Units:	M.D.L.	CM/JG	CM/JG	CM	CM	JG	JG/JH/JM	JH/JM	JG/JH			
M-Alkalinity (pH 4.5)	mg/L as CaCO3	2		257	366						366	257	311.5
Ammonia (as N)	mg/L	0.01		0.01	0.08						0.08	0.01	0.05
BOD (5 day)	mg/L	1		1.3	1.5						1.5	1.3	1.4
Bicarbonate	mg/L as CaCO3	1		255							255	255	255
Carbonate	mg/L as CaCO3	1		2							2	2	2
Conductivity	µS/cm	1		648	878						878	648	763
Dissolved Organic Carbon	mg/L	0.4		8.1	11.4						11.4	8.1	9.8
Field pH	pH	N/A			8.3						8.3	8.3	4.2
Field Temp	°C	N/A			18						18.0	18.0	9.0
Aluminum	ug/L	1		113	79						113	79	96
Antimony	ug/L	0.5		<0.5	<0.5						<0.5	<0.5	0.5
Arsenic	ug/L	1		<1	1						1	1	1
Barium	ug/L	1		36	34						36	34	35
Beryllium	ug/L	0.5		<0.5	<0.5						<0.5	<0.5	0.5
Bismuth	ug/L	1		<1	<1						<1	<1	1
Boron	ug/L	2		10	<2						10	10	6
Cadmium	ug/L	0.1		<0.1	<0.1						<0.1	<0.1	0.1
Calcium	ug/L	500		71900	92100						92100	71900	82000
Cerium	ug/L	1		<1	<1						<1	<1	1
Cesium	ug/L	1		<1	<1						<1	<1	1
Chromium	ug/L	1		5	7						7	5	6
Cobalt	ug/L	0.1		0.2	0.3						0.3	0.2	0.25
Copper	ug/L	1		2	4						4	2	3
Europium	ug/L	1		<1	<1						<1	<1	1
Gallium	ug/L	1		<1	<1						<1	<1	1
Iron	ug/L	20		232	511						511	232	372
Lanthanum	ug/L	1		<1	<1						<1	<1	1
Lead	ug/L	0.1		0.5	0.5						0.5	0.5	0.5
Lithium	ug/L	5		<5	<5						<5	<5	5
Magnesium	ug/L	5		22200	26300						26300	22200	24250
Manganese	ug/L	10	DRY	51	529	DRY	DRY	DRY	DRY	DRY	529	51	290
Mercury	ug/L	0.1		<0.1	<0.1						<0.1	<0.1	0.1
Molybdenum	ug/L	1		<1	1						1	1	1
Nickel	ug/L	1		3	4						4	3	4
Niobium	ug/L	1		<1	<1						<1	<1	1
Phosphorus	ug/L	50		<50	104						104	104	77
Potassium	ug/L	1		2510	324						2510	324	1417
Rubidium	ug/L	1		<1	<1						<1	<1	1
Scandium	ug/L	1		<1	<1						<1	<1	1
Selenium	ug/L	0.5		0.7	<0.5						0.7	0.7	0.6
Silicon	ug/L	2		2600	2280						2600	2280	2440
Silver	ug/L	0.1		<0.1	<0.1						<0.1	<0.1	0.1
Sodium	ug/L	1000		31500	66400						66400	31500	48950
Strontium	ug/L	1		432	483						483	432	458
Sulphur	ug/L	800		11100	5920						11100	5920	8510
Tellurium	ug/L	1		<1	<1						<1	<1	1
Thallium	ug/L	0.1		<0.1	<0.1						<0.1	<0.1	0.1
Thorium	ug/L	1		<1	<1						<1	<1	1
Tin	ug/L	1		<1	<1						<1	<1	1
Titanium	ug/L	1		3	2						3	2	2.5
Tungsten	ug/L	1		<1	<1						<1	<1	1
Uranium	ug/L	1		<1	<1						<1	<1	1
Vanadium	ug/L	1		2	2						2	2	2
Yttrium	ug/L	1		<1	<1						<1	<1	1
Zinc	ug/L	1		<1	21						21	21	11
Zirconium	ug/L	1		<1	<1						<1	<1	1
pH	pH	N/A		7.97	7.8						8.0	7.8	7.9
Total Hardness (as CaCO3)	mg/L	0.1		271	338						338	271	305
Chemical Oxygen Demand	mg/L	5		32	32						32	32	32
Total Dissolved Solids	mg/L	3		437	500						500	437	469
Total Suspended Solids	mg/L	0.67		13.3	7.67						13.30	7.67	10.49
Turbidity	NTU	0.1		12.3	11.3						12.3	11.3	11.8

TRIBUTARY OF LAKE MEDAD - FIGURE 1



TRIBUTARY OF LAKE MEDAD - FIGURE 2

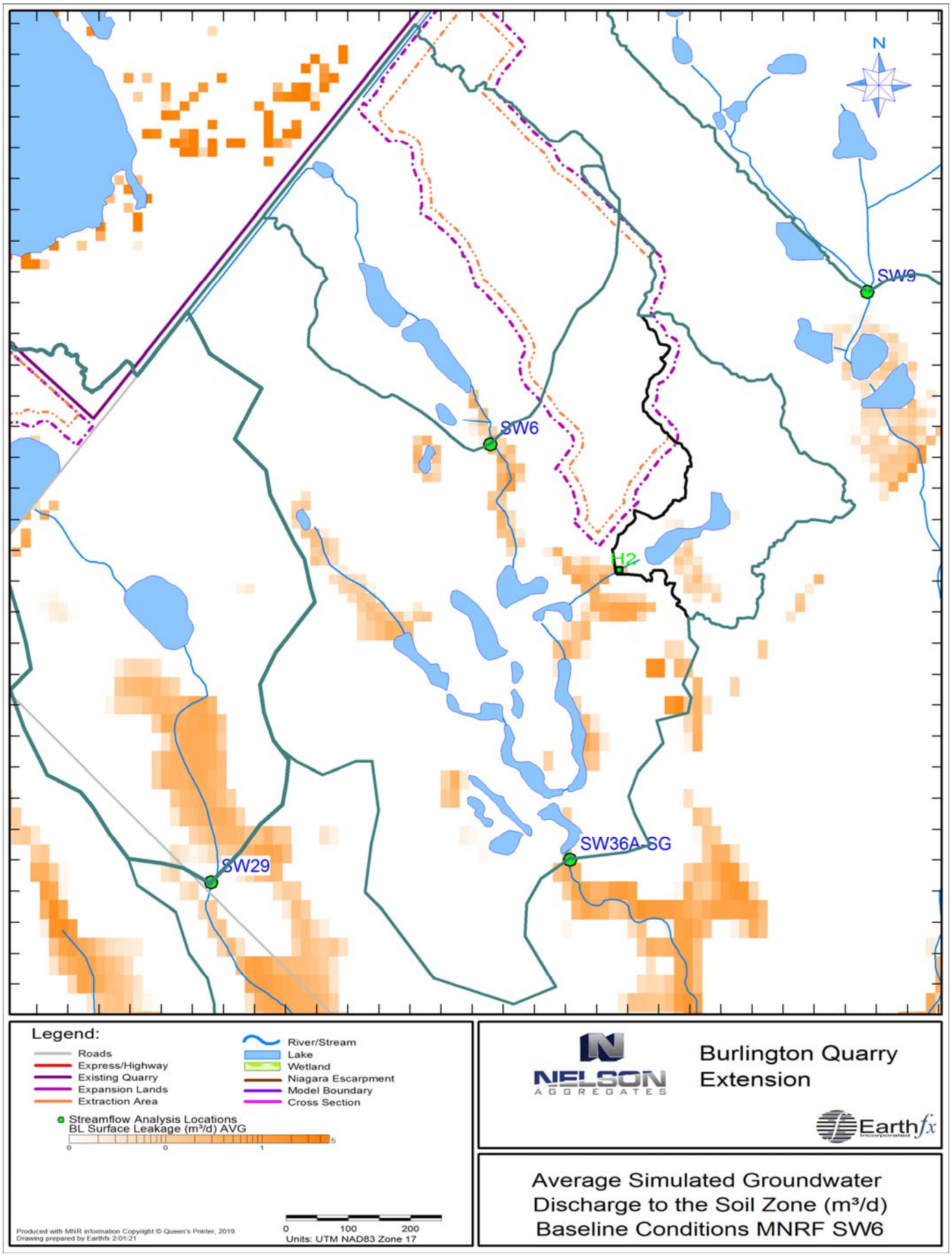


FIGURE 3A

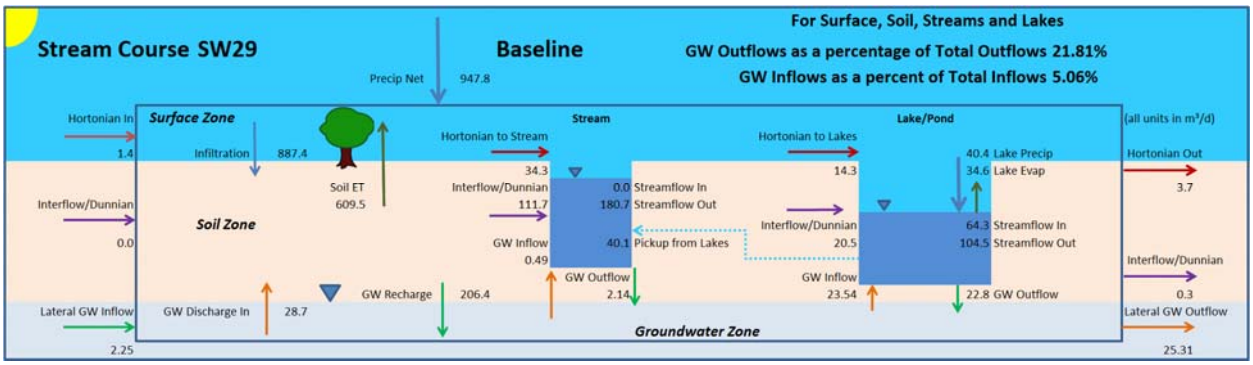


FIGURE 3B

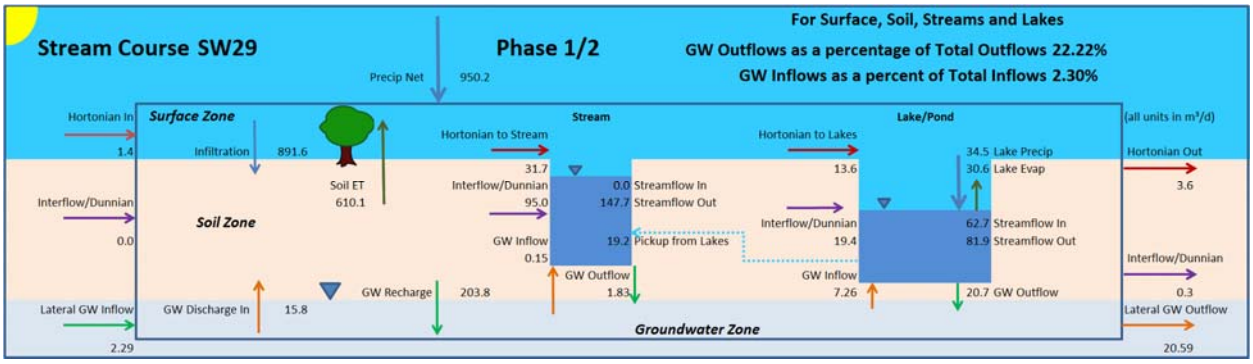


FIGURE 3C

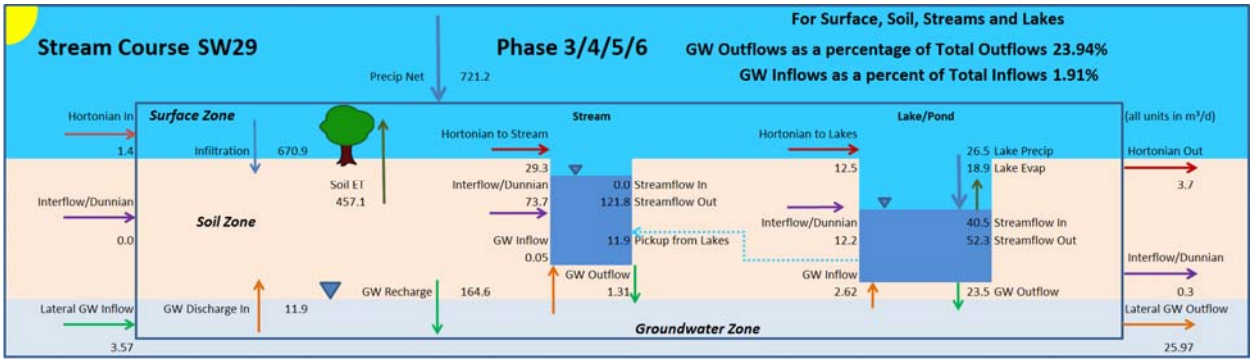


FIGURE 3D

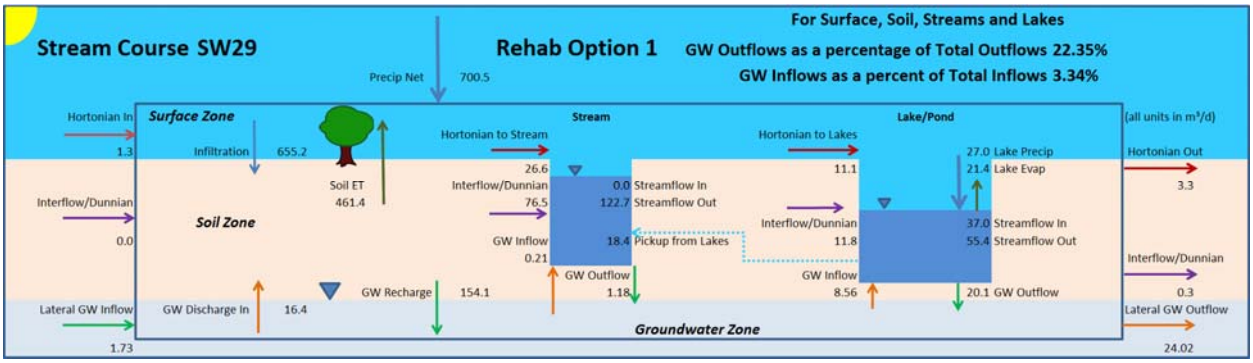
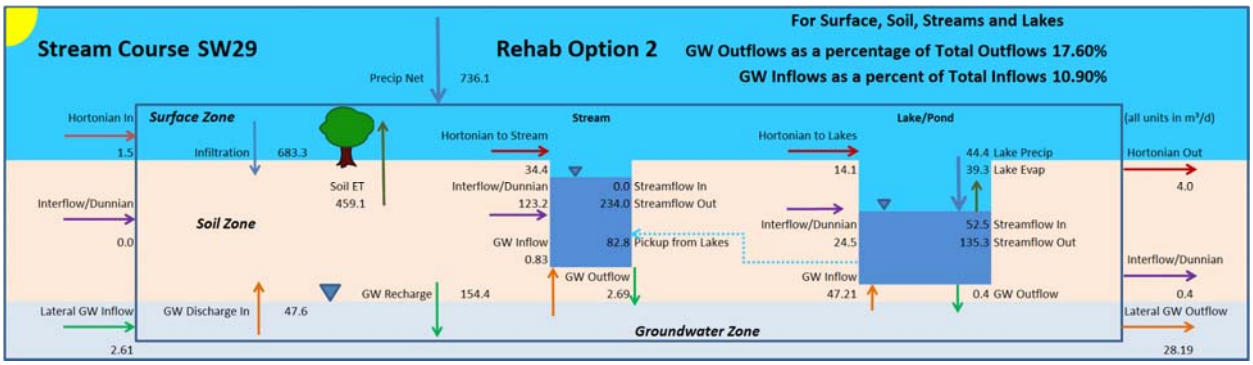
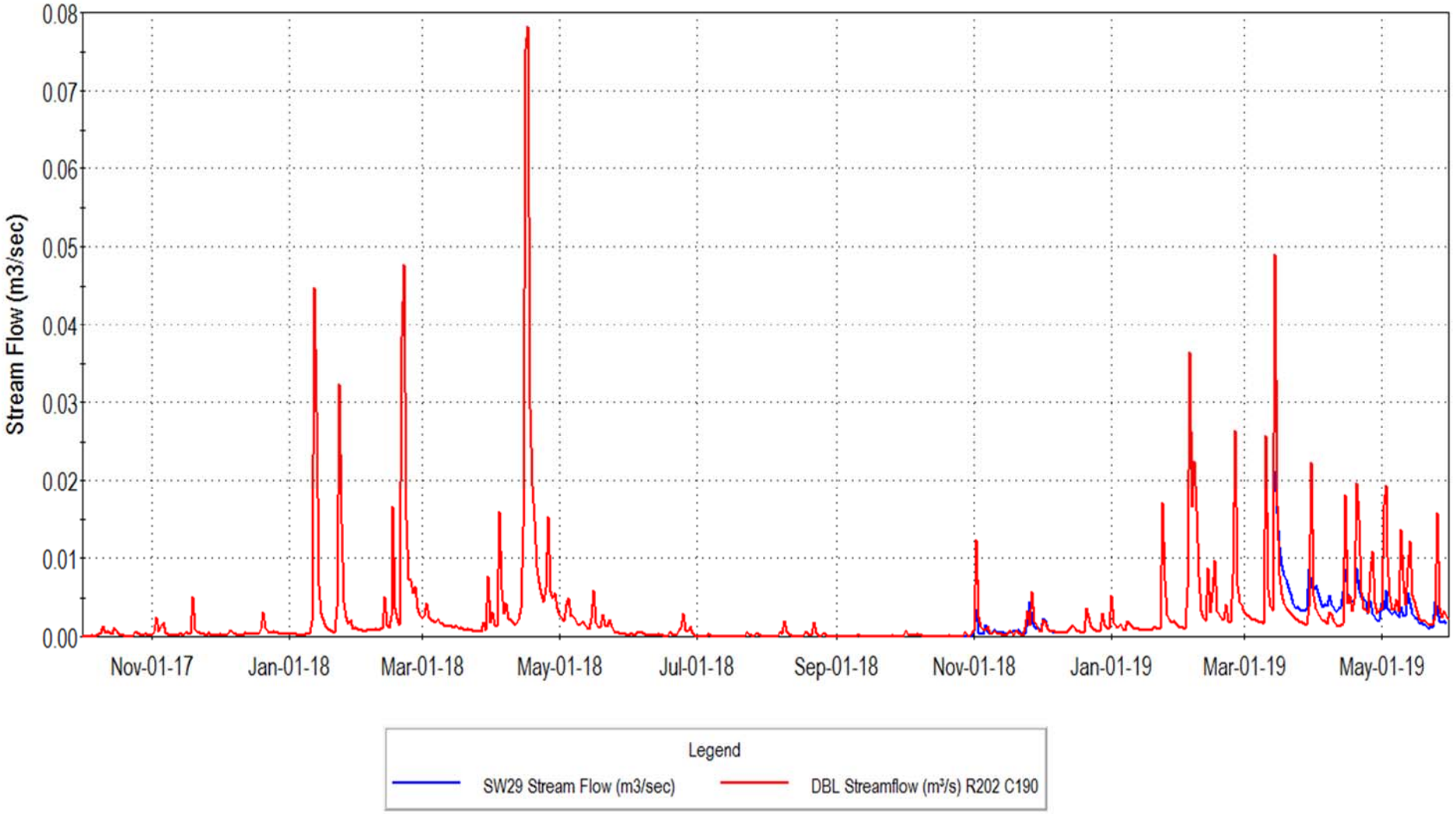


FIGURE 3E

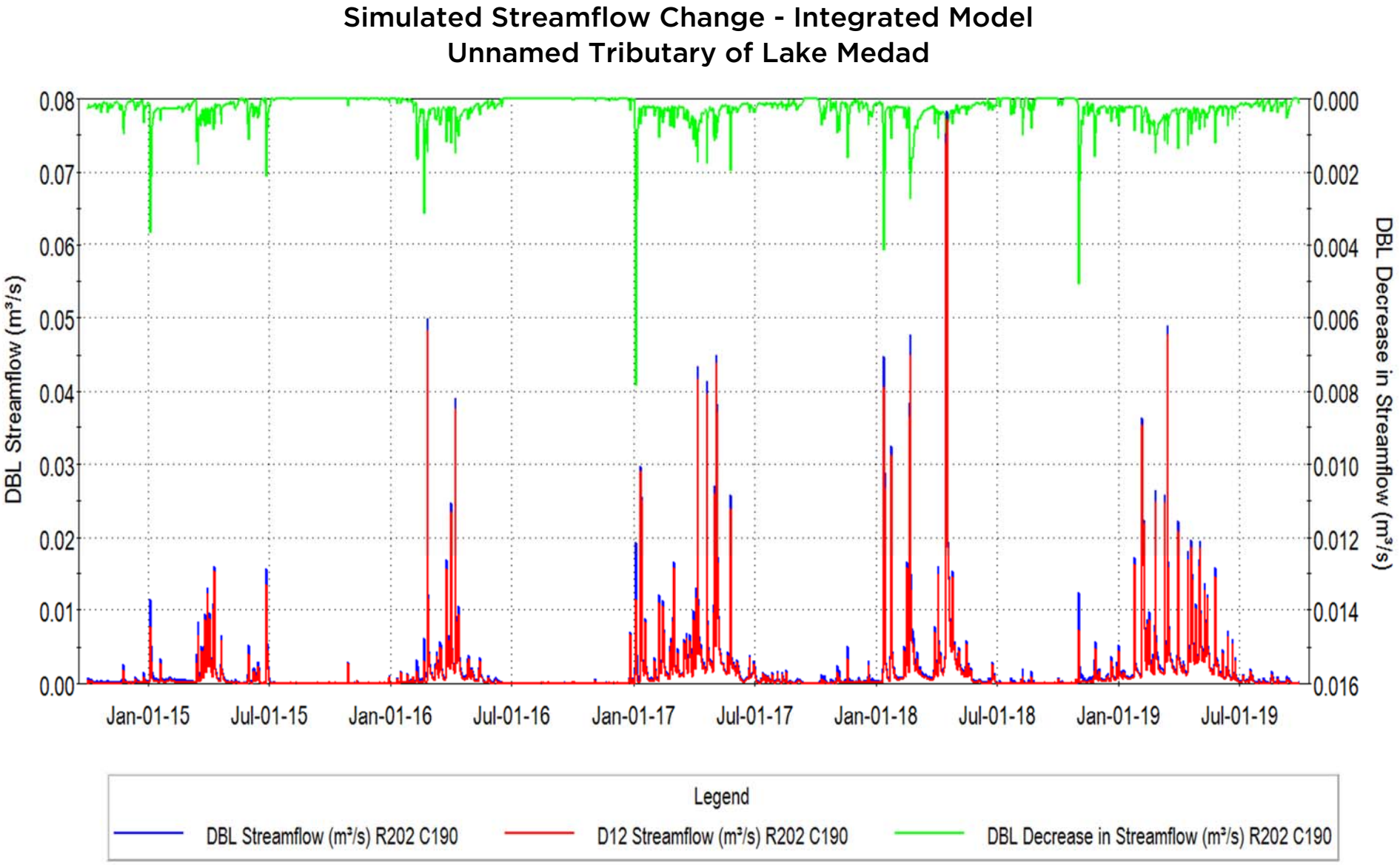


TRIBUTARY OF LAKE MEDAD - GRAPH 3

Integrated Model Calibration
Unnamed Tributary of Lake Medad

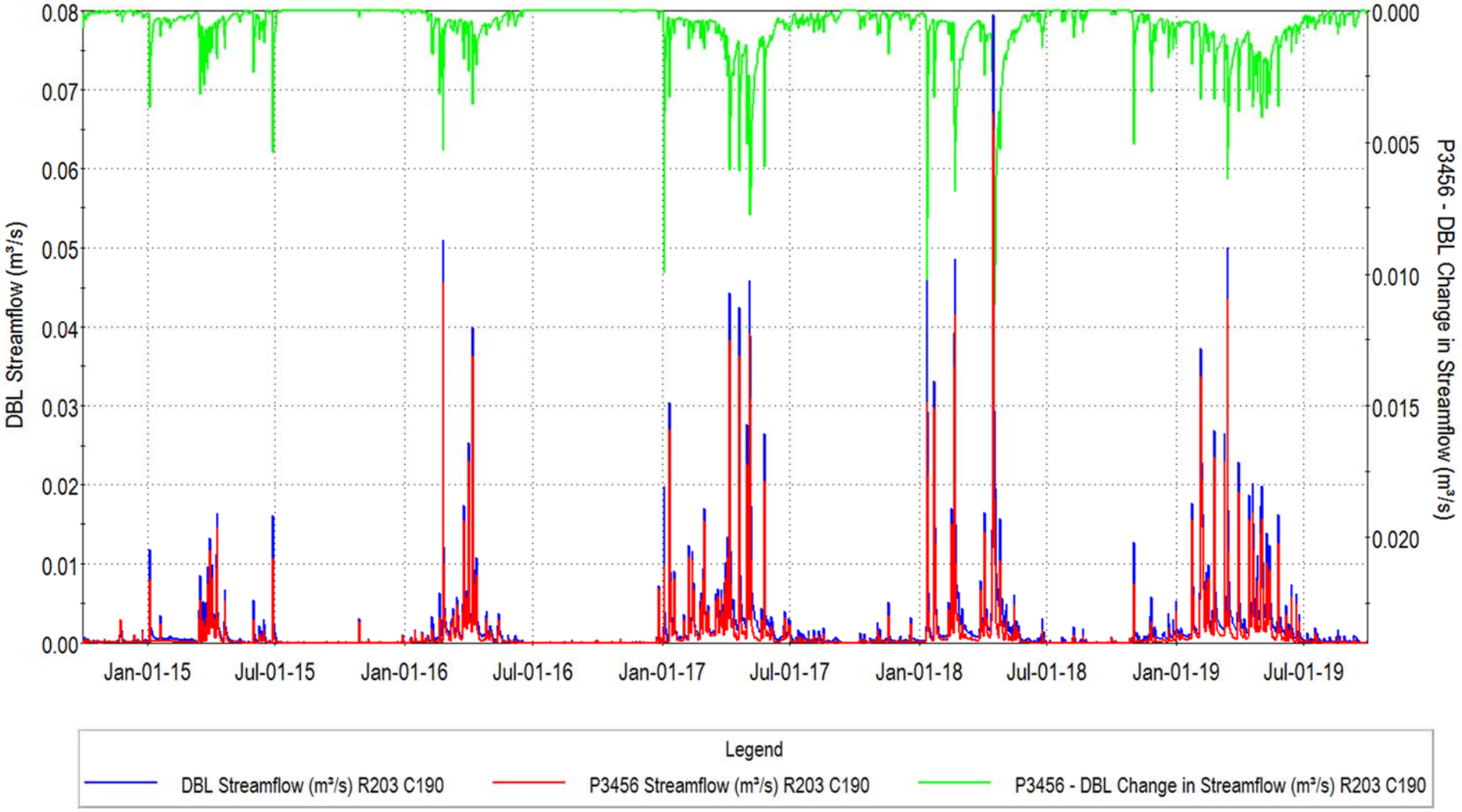


TRIBUTARY OF LAKE MEDAD - GRAPH 4

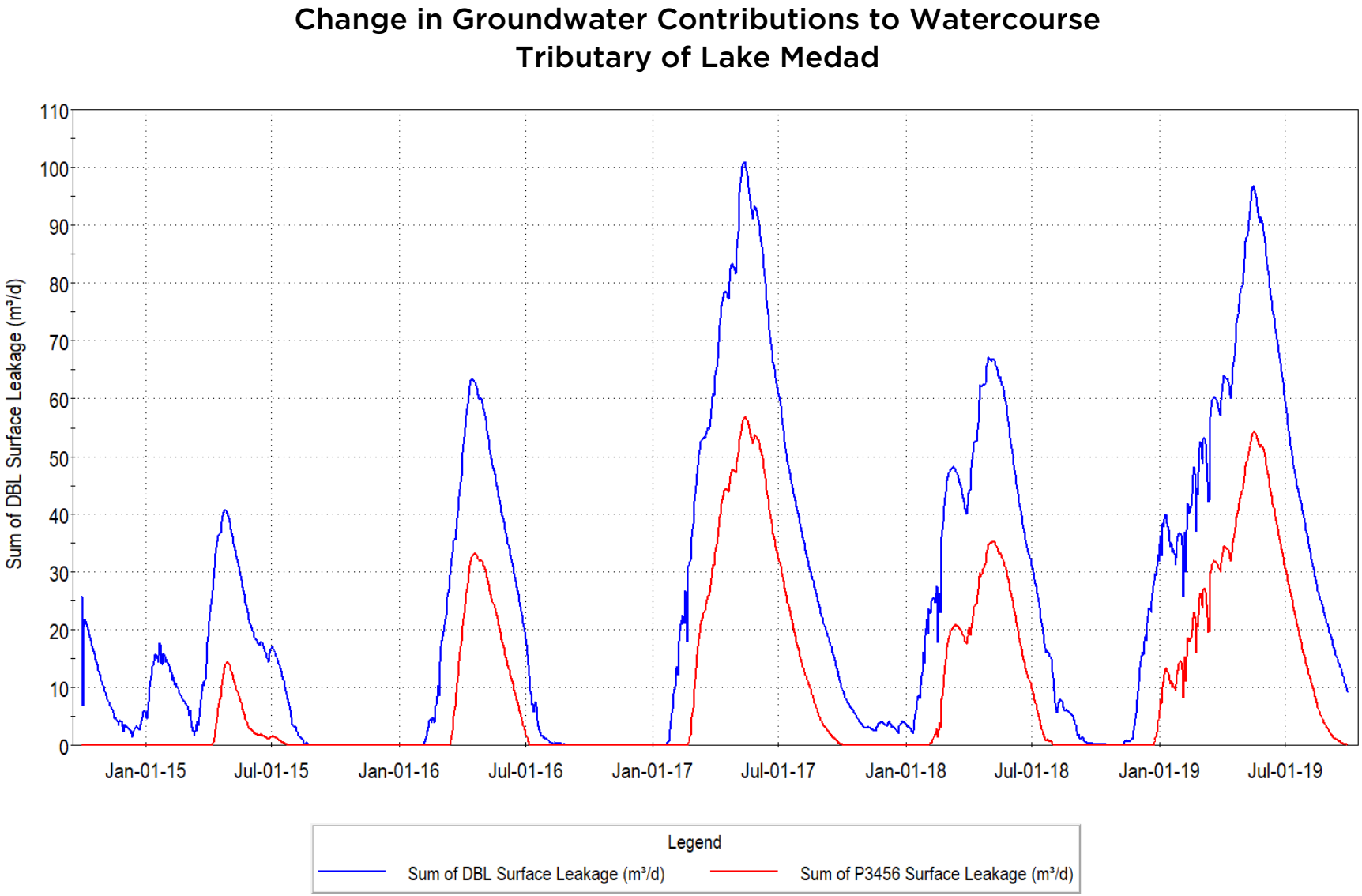


TRIBUTARY OF LAKE MEDAD - GRAPH 5

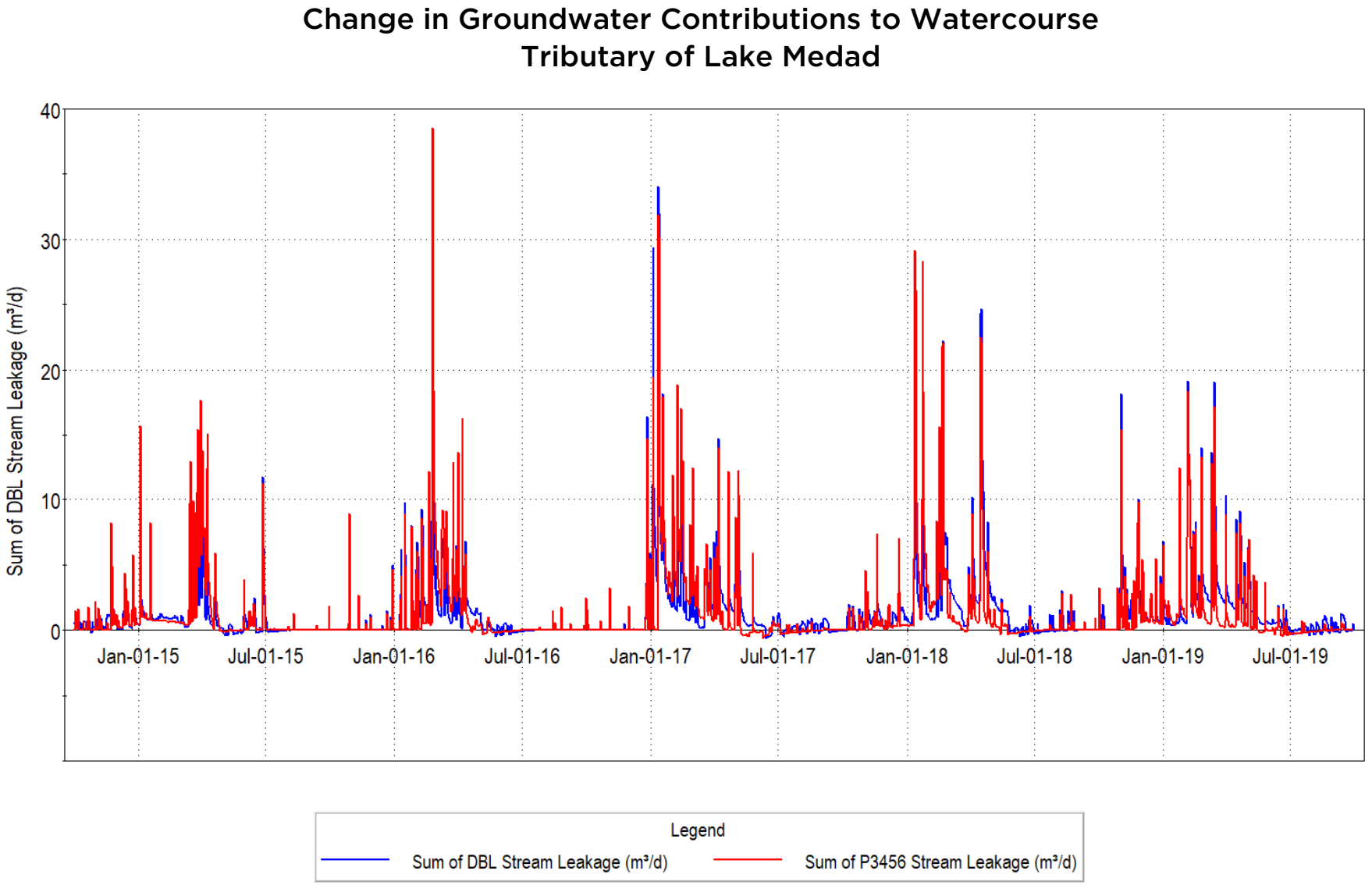
Simulated Streamflow Change - Integrated Model
Unnamed Tributary of Lake Medad



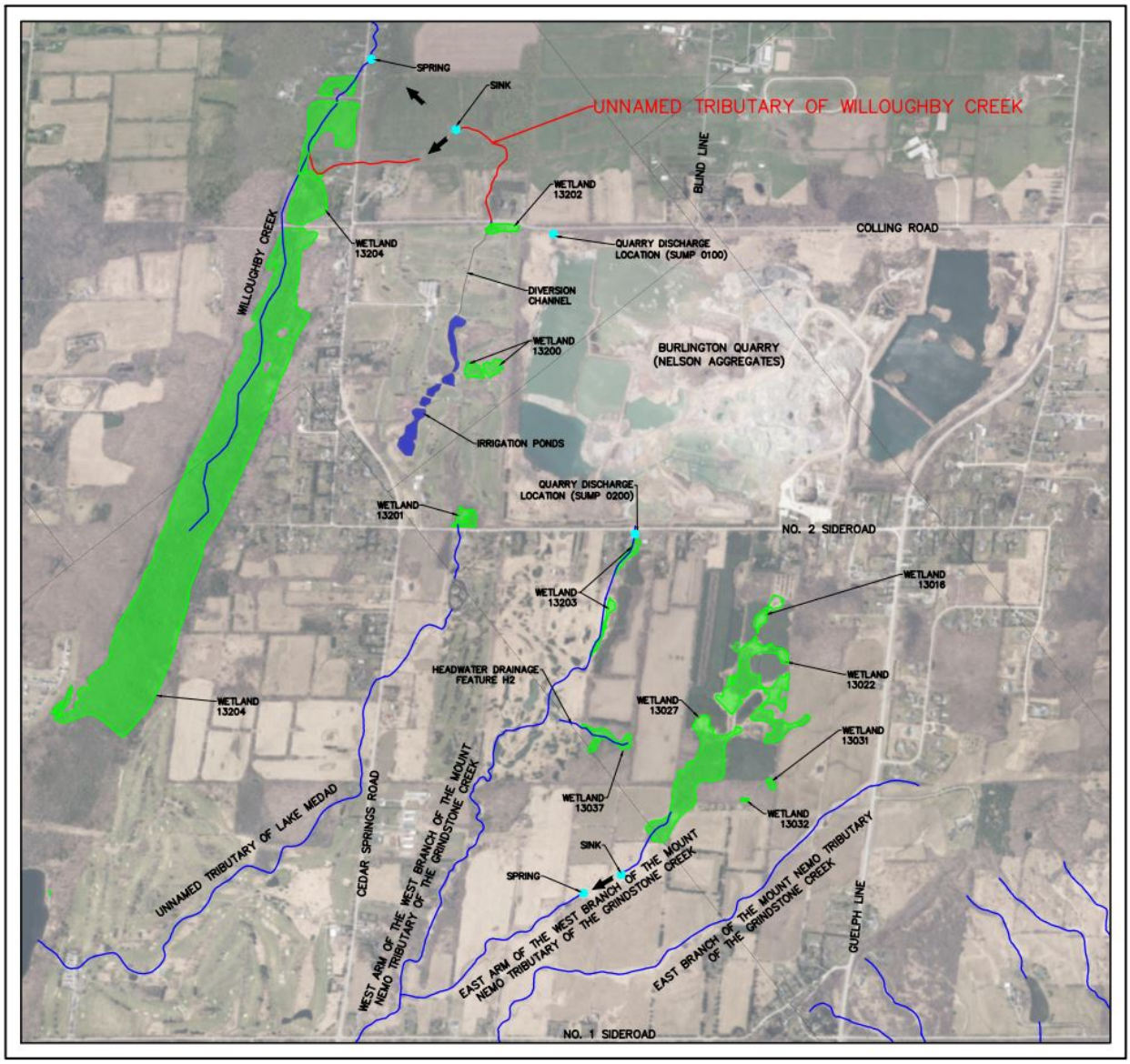
TRIBUTARY OF LAKE MEDAD - GRAPH 6

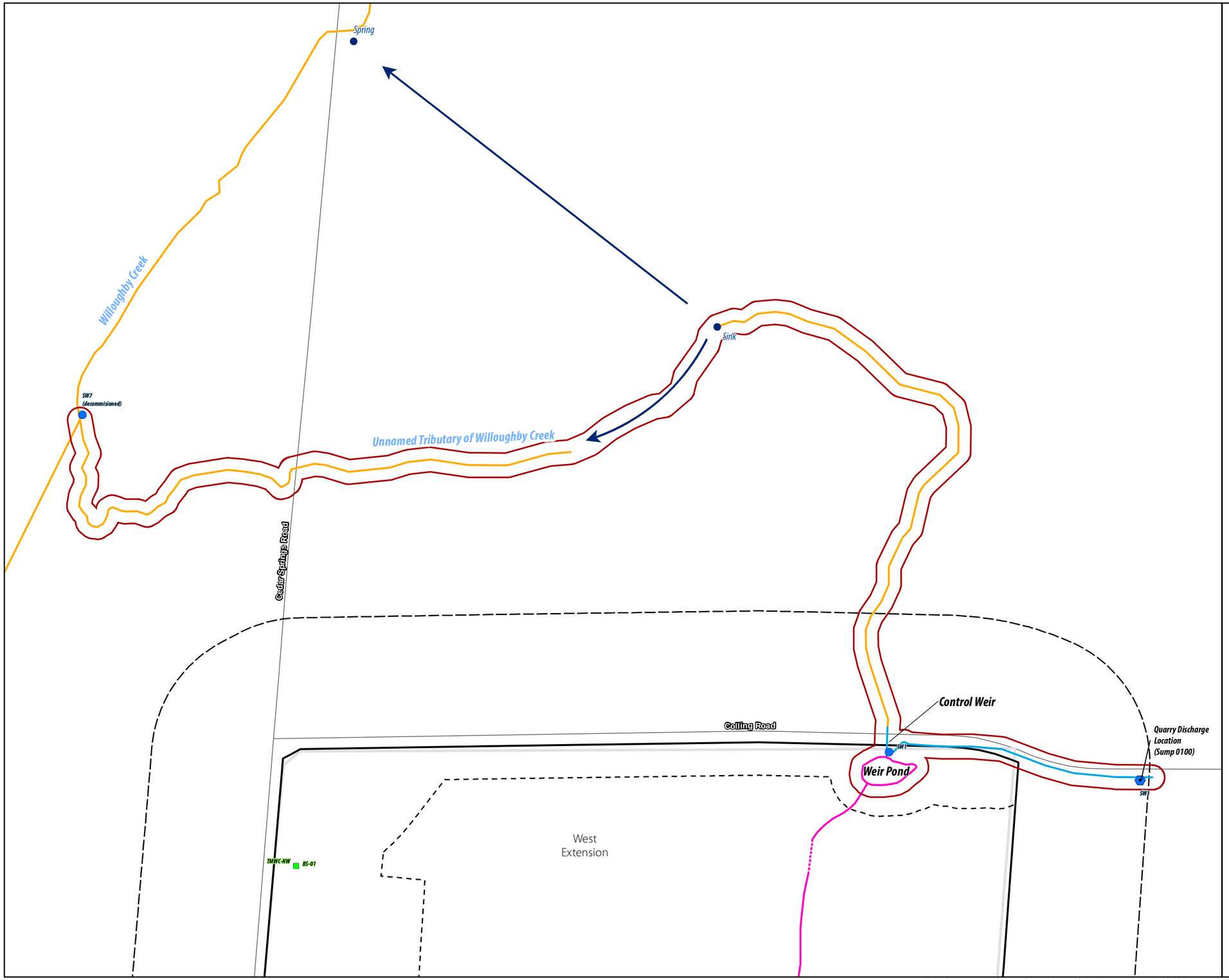


TRIBUTARY OF LAKE MEDAD - GRAPH 7



UNNAMED TRIBUTARY OF WILLOUGHBY CREEK





Legend

- Licensed Boundary
- Limit of Extraction
- 120 m Adjacent Lands
- Subject Lands
- Unnamed Tributary of Willoughby Creek
- Road
- Golf Course Irrigation Ponds and Channel
- Indirect Fish Habitat
- Direct Fish Habitat
- Watercourse
- Wetland (Savanta, 2020)

Current Instrumentation

- Staff Gauge & Surface Water Monitoring Station (Tatham Engineering)
- Manual Stream Flow Measurement (Tatham Engineering)

Previous Instrumentation

- Groundwater Monitoring Station (Golder)

NOTES:

1. Coordinate System: NAD 1983 UTM Zone 17N.
2. Base features produced under license with the Ontario Ministry of Natural Resources and Forestry © Queen's Printer for Ontario, 2021.
3. Orthoimagery © First Base Solutions, 2021. Imagery taken in 2019.

Project 8133

Burlington Quarry Extension
Nelson Aggregates Co.

Figure 13
Watercourse Characterization

Unnamed Tributary of Willoughby Creek

0 60 m

1:3,500

N

Path: C:\Savanta\8133 - Burlington Quarry\figures\report_figures\2021 01 21 natural feature tech summary\8133_rpt_watercourse_char_mapbook.mxd Date: April 8, 2021

Unnamed Tributary of Willoughby Creek

<table>
<tr><th>Surface Water Characteristics</th><th>Description</th><th>Figure / Graph / Table</th><th colspan="2">Reference</th></tr>
<tr><th></th><th></th><th></th><th>Report</th><th>Section / Page</th></tr>
<tr><td>Watercourse Name:</td><td>Unnamed Tributary of Willoughby Creek</td><td></td><td></td><td></td></tr>
<tr><td>Watershed:</td><td>Bronte Creek Watershed</td><td></td><td></td><td></td></tr>
<tr><td>Sub-Watershed:</td><td>Willoughby Creek Watershed</td><td></td><td></td><td></td></tr>
<tr><td>Located in Proposed Limit of Extraction:</td><td>No</td><td></td><td></td><td></td></tr>
<tr><td>Located in Proposed License Boundary:</td><td>Yes</td><td></td><td></td><td></td></tr>
<tr><td>Catchment Area (ha):</td><td>511 ha (at confluence with Willoughby Creek)</td><td></td><td></td><td></td></tr>
<tr><td>Catchment ID:</td><td>N/A</td><td></td><td></td><td></td></tr>
<tr><td>Primary Source(s) of Flow:</td><td>Primary - discharge from Burlington Quarry (Sump 0100)
Intermittent - discharge from Burlington Springs Golf and Country Club irrigation ponds and diversion channel
The outlet from the weir pond consists of a low flow by-pass pipe designed to convey a minimum baseflow of 2 L/s downstream when flow is available and a concrete weir that can be fitted with stop blocks to further control discharge. The concrete weir with stop blocks installed creates a backwater condition upstream, diverting water to the irrigation ponds on the Burlington Springs Golf & Country Club property. Water taking from the weir pond by the Burlington Springs Golf & Country Club occurs under the approval of PTTW Number 0624-8BXML3.</td><td></td><td></td><td></td></tr>
<tr><td>Discharge from Quarry / PTTW:</td><td>Yes - PTTW 96-P-3009</td><td></td><td>SWA (Tatham, April 2020)</td><td>Appendix A</td></tr>
<tr><td>Conditions of PTTW:</td><td>Maximum discharge rate = 4,090 L/min (68.17 L/s)
Maximum discharge amount = 5,889,600 L/day</td><td></td><td>SWA (Tatham, April 2020)</td><td>Appendix A</td></tr>
<tr><td>Surface Water Monitoring:</td><td>ID: SW1 (Tatham)
Installation Date: April 17, 2014
Data Collection: Continuous water level and temperature, manual monthly in-situ streamflow measurements and calibration data (water level converted to flow using rating curve)
Coordinates of Monitoring Station: Easting 589015.325, Northing 4805832.639</td><td>Graphs 1, 2 & 3 and Table 1</td><td>SWA (Tatham, April 2020)</td><td>2.1.1, Appendix B and Appendix H</td></tr>
<tr><td>Streamflow Conditions:</td><td>Intermittent (flow is dependent on quarry discharge); the tributary will dry out when quarry discharge ceases</td><td>Graphs 1, 2 & 3 and Table 1</td><td>SWA (Tatham, April 2020)</td><td>2.1.1 and Appendix B</td></tr>
<tr><td>Average Daily Flow (SW1):</td><td colspan="3">Average Daily Streamflow (L/s)
Month | Minimum | Average | Maximum
January | 0.0 | 92.3 | 226.9
February | 0.0 | 48.8 | 245.0
March | 0.0 | 28.7 | 68.0
April | 0.0 | 75.8 | 203.5
May | 0.0 | 86.6 | 249.6
June | 0.0 | 54.2 | 194.3
July | 0.5 | 48.5 | 313.3
August | 0.0 | 41.9 | 126.9
September | 0.6 | 48.3 | 147.2
October | 0.0 | 61.6 | 225.7
November | 0.0 | 102.9 | 549.8
December | 0.0 | 81.0 | 426.9</td><td>Notes:
Minimum - lowest daily average streamflow recorded for period of record
Average - average daily streamflow recorded for period of record
Maximum - maximum daily average streamflow recorded for period of record
N/A - data not available as device removed from watercourse during winter months</td><td>Graphs 1 & 2</td><td>SWA (Tatham, April 2020)</td><td>2.1.1 and Appendix B</td></tr>
</table>

Unnamed Tributary of Willoughby Creek

Watercourse Thermal Regime (SW1):

Average Daily Water Temperature (°C)

Month	Minimum	Average	Maximum
January	0.8	3.5	6.9
February	-0.9	3.5	6.8
March	-1.1	4.0	8.2
April	-0.8	7.6	14.6
May	7.5	13.5	19.1
June	14.6	19.4	28.9
July	18.9	23.0	28.5
August	17.3	23.6	32.3
September	15.9	21.5	29.5
October	8.4	14.3	21.1
November	1.1	8.5	14.4
December	0.2	4.9	8.5

Notes:

Minimum - lowest daily average water temperature recorded for period of record

Average - average daily water temperature recorded for period of record

Maximum - maximum daily average water temperature recorded for period of record

N/A - data not available as device removed from watercourse during winter months

Graph 3

SWA (Tatham, April 2020)

2.1.1 and Appendix B

Water Quality (SW1):

Water Quality Sample Results

Parameter	Units	Minimum	Average	Maximum
Turbidity	NTU	0.9	2.1	3.5
TDS	mg/L	517	564	597
TSS	mg/L	1	1.92	3.67
COD	mg/L	<5	9	12
BOD5	mg/L	1.0	1.4	2.4
DOC	mg/L	3.1	3.8	4.3
pH		7.97	8.01	8.03
Alkalinity	mg/L	112	152	180
Conductivity	µS/cm	742	784	877
Phosphorus	ug/L	<50	68.5	124
Ammonia	mg/L	0.02	0.04	0.11
Hardness	mg/L	277	318	340

Table 1

SWA (Tatham, April 2020)

2.4 and Appendix H

Unnamed Tributary of Willoughby Creek

Fish & Fish Habitat Features	Description	Figure / Graph / Table	Reference	
			Report	Section / Page
Fish Habitat (Direct/Indirect and Assumed/Confirmed):	1) The reach from the quarry discharge point to the Colling Road culvert has been identified as indirect fish habitat as no fish were captured in this reach during baseline fish community studies in 2019. The reach is directly connected to the Weir Pond on the golf course, which is known to contain a likely introduced population of Largemouth Bass. These fish may have access to portions of this watercourse reach, but these are excluded from the determination of providing indirect habitat, since once the drainage feature on the golf course is removed, the Largemouth Bass population will also be removed. Fish in the downstream portions of the reach (i.e., downstream from Colling Road) would not be able to move upstream into this reach based on the barrier provided by the weir at the downstream end of the Weir Pond. 2) The reach between Colling Road and the mouth of this Tributary at Willoughby Creek has been assumed to provide direct fish habitat. However, no fish community studies were possible in this reach due to private land access constraints. Conservation Halton does not have any information on the fish community of this reach and identifies it as "Unclassified Habitat" in the 2002 Bronte Creek Watershed Study. Although assumed to be present for the purposes of the NETR (Savanta 2020), the actual potential for fish in the upstream portions of this reach is limited by the presence of an underground flow section where the watercourse runs underground through karst features before re-emerging at two different locations. No upstream fish movement is expected to be possible past these two underground flow sections.		NETR (Savanta, April 2020)	19, 41-42 and Figure 9a
Fish Species Present:	1) Largemouth Bass are known to be present in the Weir Pond, although they were not confirmed in the Unnamed Tributary of Willoughby Creek upstream from the Weir Pond during baseline studies in 2019. 2) No information on fish species present downstream from Colling Road is available as no fish community studies are known to have been completed on the private lands where this watercourse flows.		NETR (Savanta, April 2020)	19, 41-42 and Figure 9a
Fish Community Thermal Regime:	N/A – No fish species that would be native to this watercourse have ever been captured (i.e., excluding Largemouth Bass known to be present in the drainage feature on the golf course).		NETR (Savanta, April 2020)	19, 41-42 and Figure 9a
Fish Habitat Types Present:	1) Indirect habitat - reach upstream from Colling Road provides contributing habitat functions (e.g., flow conveyance, water quality maintenance, allochthonous inputs from riparian vegetation, sediment transport) although limited by the presence of the Weir Pond and weir. 2) Fish habitat types present in the reach downstream from Colling Road have not been confirmed due to private land issues. Visual observations from the Colling Road shoulder indicate this portion of the watercourse consists of a natural channel with well-developed riparian vegetation (woodland). If fish are present, the reach would be expected to provide habitat for all necessary life history functions required to support the species (given barriers to upstream and downstream movement).		NETR (Savanta, April 2020)	19, 41-42 and Figure 9a
Habitat Uses by Known Fish Community:	N/A – no known fish community downstream from Colling Road culvert.		NETR (Savanta, April 2020)	19, 41-42 and Figure 9a
Known Barriers to Fish Movement:	1) Karst sink between Colling Road and Cedar Springs road would prevent upstream fish movement. 2) Overflow weir at the outlet of the Weir Pond on the golf course is a barrier to upstream movement.		NETR (Savanta, April 2020)	19, 41-42 and Figure 9a

Unnamed Tributary of Willoughby Creek

Groundwater Interaction	Description	Figure / Graph / Table	Reference	
			Report	Section / Page
Underlying Deposits:	Halton Till. The harmonic mean hydraulic conductivity, based on testing by Golder (2007) of 10 mini-piezometers, was $1.2x10^{-8}$ m/s. Model value for the vertical hydraulic conductivity is $1.6x10^{-7}$ m/s, approximately an order of magnitude higher, to account for limited flow through fractures in the till.			
Surface Water / Groundwater Interactions:	This reach is predominantly a losing stream up to the point where it disappears into the subsurface. There are, however, short periods of the year where the water table rises and discharges into the stream. The GW/SW interactions at a point 250 m downstream of Wetland 13202 are illustrated in Graph 4. The blue line on the graph shows the stage in the stream, which is fairly constant because of the quarry discharge. The red line shows the shallow groundwater levels, which seasonally rise up to (and slightly above) the stream stage. The green dotted line shows the GW discharge (right axis) into the riparian soil zone (this is shown in orange on the maps in Earthfx, 2020). The purple line shows stream leakage (right axis - loss of water from the stream to the GW system). In summary, the stream is mostly a losing stream, except for short periods when the water table is high.	Graph 4, Figures 1 & 2		
Water Budget Results:	The baseline condition water budget results from the integrated model are presented in Figure 3a. Condition / GW Out / GW In Baseline (Existing) / 25.17% / 21.97%	Figure 3a		
Integrated Model Calibration:	Section 19.4.2 (p.415) discusses the calibration of the model to North Quarry discharge. The north sump was simulated with a set of "generalized operating rules" based on information provided by Nelson and the PTTW. The rules define a 7 day per week discharge rate, with an extra stage-dependent discharge rule that kept the internal quarry pond from over-topping a specified level. Actual operations were more intermittent, but it is apparent in the data that the rules were followed more closely after January, 2016, as shown in Earthfx (p. 416) and reproduced below. Overall, the model appears to be effective at representing the north quarry discharge in recent times.	Graph 5	HHIAR (Earthfx, April 2020)	19.4.2 (page 415 & 416)

Unnamed Tributary of Willoughby Creek

Impact Assessment	Description	Figure / Graph / Table	Reference	
			Report	Section / Page
Direct Alterations to Watercourse:	1) The existing temporary weir just upstream from the Colling Road culvert (i.e., at the outflow of the Weir Pond) will be replaced with a permanent overflow weir plate. This will result in a direct alteration to instream habitat and temporary disruption due to in-water work. 2) A new inlet will be constructed at the edge of the Weir Pond to divert flow into the new pond (infiltration pond) proposed on the western side of the West Extension Area. Some encroachment of the inlet into the Weir Pond may occur during installation of the diversion pipe, resulting in potential direct and indirect impacts. 3) Removal of the golf course irrigation ponds and channels could potentially result in indirect effects on the downstream watercourse (e.g., erosion and sedimentation, water quality impacts).		NETR (Savanta, April 2020)	75
Change in Primary Source of Flow:	1) Quarry discharge from Sump 0100 represents the primary source of flow to the Unnamed Tributary of Willoughby Creek. Current quarry approvals permit this discharge to cease once quarry operations are complete. Cessation of quarry discharge into the Unnamed Tributary of Willoughby Creek would be expected to have a substantial negative impact on flow availability to support current fish habitat functions and fish community assumed to be present. As discussed in the Mitigation section below, it has been recommended that quarry discharge continue indefinitely at current levels to prevent these associated negative impacts. 2) Diversion from catchment area S101 (northwest of Colling Road) will alter surface water inputs to the Unnamed Tributary. Currently, this catchment area discharges directly to the quarry and the flow would be discharged to the Unnamed Tributary through Sump 0100. Nelson is proposing to redirect surface water drainage from catchment area S101 directly into the Unnamed Tributary at the existing quarry discharge point. Overall, this diversion will result in the same volume of water being discharged to the tributary, although, given it will no longer pass through the quarry, it is expected that the hydrological regime of this discharge will be more natural, with seasonal peaks. 3) Removal of the golf course irrigation ponds and channels will alter the hydrology of the watercourse, given that no water taking would be required from the watercourse to support irrigation and that during high flow periods, there will be no discharge from the golf course back to the feature. However, the proposed new pond (infiltration pond) west of the West Extension will draw water from the Weir Pond in the same manner as the existing irrigation ponds. Therefore, there will be no net change in source water hydrology.		NETR (Savanta, April 2020)	76 and 77
Change in Watercourse Catchment Area:	Increase in catchment area of 25.8 ha. Additional catchment area will drain to the existing quarry settling ponds and be discharged to the Unnamed Tributary via Sump 0100 at rates consistent with existing. Additional storage will be provided in the settling ponds to accommodate the additional flow as the discharge to the Unnamed Tributary will not change.		SWA (Tatham, April 2020)	Drawings DP-1, DP-2 and DP-3
Simulated Streamflow Change (Integrated Model Results):	The Earthfx report discusses changes in simulated quarry discharge to the North Quarry Pond. No change was expected under Scenario P12. Scenario P3456 is discussed in Section 8.7.5 (p. 243). Under P3456 conditions, current levels of quarry discharge will continue to pass through the 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 as the current golf course ditch and pond system. Figure 8.71(p. 254) shows that there will be an increase in flow through the Unnamed Tributary as a result of the diversion of flow along Colling Road, and that the flow will continue through the karst conduit as under current conditions. The increase in flow will enter the Medad Valley just downstream of SW7, so there will be no significant change downstream at SW2. Under RHB1, discharge continues to the north from the quarry sump 0100 and is similar to that of P3456. Under RHB2, surface water flow in the upper reaches of a Unnamed Tributary of Willoughby Creek and the West Arm of the West Branch of Mount Nemo Tributary of Grindstone Creek will cease when the quarry discharge is discontinued, resulting in possible impact to downstream fish habitat compared to baseline conditions (See Savanta, 2020 and Tatham, 2020 for details).		HHIAR (Earthfx, April 2020)	8.7.5 (page 243)

Unnamed Tributary of Willoughby Creek

<table>
<tr><th>Impact Assessment</th><th>Description</th><th>Figure / Graph / Table</th><th colspan="2">Reference</th></tr>
<tr><th></th><th></th><th></th><th>Report</th><th>Section / Page</th></tr>
<tr><td>Water Budget Results (Operational Phases 1 & 2):</td><td>The Operational Phases 1 and 2 water budget results from the integrated model are presented in Figure 3b.
<table>
<tr><td>Condition</td><td>GW Outflow</td><td>GW Inflow</td><td>%Δ GW Outflow</td><td>%Δ GW Inflow</td></tr>
<tr><td>Baseline (Existing)</td><td>25.17%</td><td>21.97%</td><td>-</td><td>-</td></tr>
<tr><td>Phases 1 & 2</td><td>26.38%</td><td>22.94%</td><td>1.21%</td><td>0.97%</td></tr>
</table></td><td>Figure 3b</td><td></td><td></td></tr>
<tr><td>Water Budget Results (Operational Phases 3 Through 6):</td><td>The Operational Phases 3 through 6 water budget results from the integrated model are presented in Figure 3c.
<table>
<tr><td>Condition</td><td>GW Outflow</td><td>GW Inflow</td><td>%Δ GW Outflow</td><td>%Δ GW Inflow</td></tr>
<tr><td>Baseline (Existing)</td><td>25.17%</td><td>21.97%</td><td>-</td><td>-</td></tr>
<tr><td>Phases 3 through 6</td><td>25.12%</td><td>21.11%</td><td>-0.05%</td><td>-0.86%</td></tr>
</table></td><td>Figure 3c</td><td></td><td></td></tr>
<tr><td>Water Budget Results (Rehabilitation Scenario 1):</td><td>The Rehabilitation Scenario 1 water budget results from the integrated model are presented in Figure 3d.
<table>
<tr><td>Condition</td><td>GW Outflow</td><td>GW Inflow</td><td>%Δ GW Outflow</td><td>%Δ GW Inflow</td></tr>
<tr><td>Baseline (Existing)</td><td>25.17%</td><td>21.97%</td><td>-</td><td>-</td></tr>
<tr><td>Rehab Scenario 1</td><td>26.08%</td><td>22.12%</td><td>0.91%</td><td>0.15%</td></tr>
</table></td><td>Figure 3d</td><td></td><td></td></tr>
<tr><td>Water Budget Results (Rehabilitation Scenario 2):</td><td>The Rehabilitation Scenario 2 water budget results from the integrated model are presented in Figure 3d.
<table>
<tr><td>Condition</td><td>GW Outflow</td><td>GW Inflow</td><td>%Δ GW Outflow</td><td>%Δ GW Inflow</td></tr>
<tr><td>Baseline (Existing)</td><td>25.17%</td><td>21.97%</td><td>-</td><td>-</td></tr>
<tr><td>Rehab Scenario 2</td><td>34.19%</td><td>32.35%</td><td>9.02%</td><td>10.38%</td></tr>
</table></td><td>Figure 3e</td><td></td><td></td></tr>
<tr><td>Change in Groundwater Contributions to Watercourse:</td><td>The unnamed tributary of Willoughby Creek is generally a losing stream. The change in stream stage and groundwater levels under Baseline and P3456 conditions at a point 250 m downstream of Wetland 13202 is shown in Graph 6. The P3456 drawdown in groundwater levels prevents the upwelling of groundwater that occurred intermittently under baseline conditions at this point in the reach. This example illustrates the change in conditions at one point in the stream; the overall change in leakage is discussed next. During P3456 the overall average net stream leakage to groundwater from this tributary will increase from a Baseline rate of 98.23 m^3/d to 143.2 m^3/d; an increase of 44.97 m^3/d. The increase in leakage is caused by the lowering of the water table in the vicinity of the P3456 extension. This change is a very small fraction of the average baseline streamflow of 4106.0 m^3/d (which includes quarry discharge). The baseline and P3456 net stream leakage over time is shown in Graph 7. The dark blue (Baseline) and dark red (P3456) curves represent total daily leakage from the surface stream reach. The light blue and light red represent leakage from the underground karst portion of the stream (flowing along the Layer 4 bedrock interface). The surface stream leakage is less than the karst stream leakage because the surface stream is isolated from the groundwater system by the low permeability Halton Till. Leakage rates from the surface portion of the stream increase under P3456 through the winter and spring because the water table is lower due to P3456. Leakage in the summer and fall remains the same as Baseline during the summer and fall of dry years because the stream is perched above the water table under those conditions. In summary, the average increase in stream leakage under P3456 conditions, 44.97 m3/d, is a very small fraction of the average baseline streamflow of 4106.0 m^3/d.</td><td>Graphs 6 & 7</td><td></td><td></td></tr>
</table>

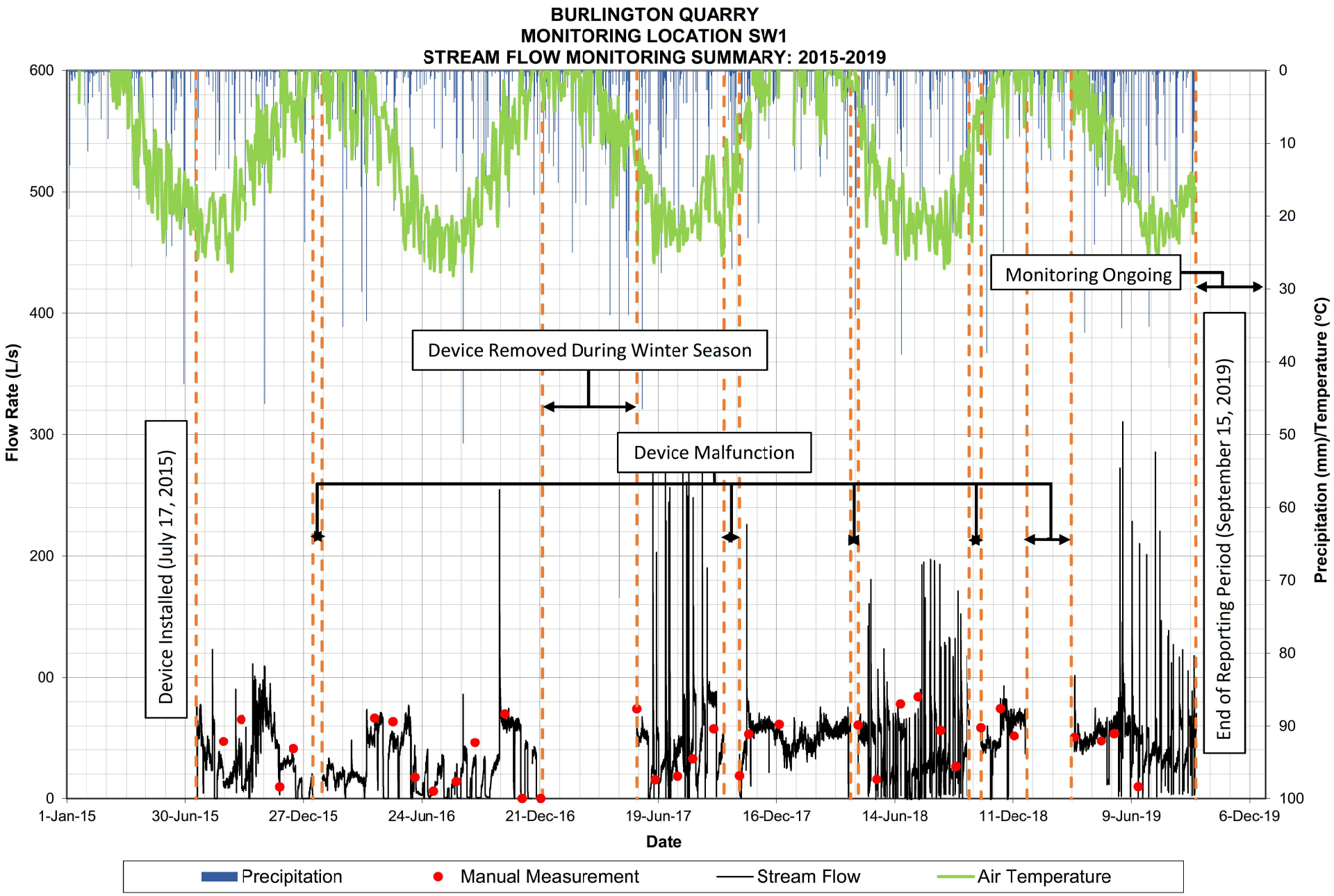
Unnamed Tributary of Willoughby Creek

Impact Assessment	Description	Figure / Graph / Table	Reference	
			Report	Section / Page
Change in Watercourse Thermal Regime:	1) Negative changes in water temperature are not expected given that the watercourse will continue to receive its primary input from quarry discharge. Temperature of water being discharge from Quarry Sump 0100 is not expected to change as a result of the proposed Quarry Extension, therefore, no change in water temperature is anticipated. 2) Artificial warming that may be occurring as a result of discharge of relatively warm surface water from the artificial golf course ponds into the tributary will cease once the golf course ponds are removed. This may result in a beneficial effect in downstream water temperatures, given that the ponds are anthropogenic. 3) The diversion of flow from catchment S101 directly to the Unnamed Tributary will also positively impact the thermal regime in the watercourse as it will no longer pass through the quarry settling ponds.		NETR (Savanta, April 2020)	75 76
Change in Water Quality:	1) Negative changes in water quality are not expected given that the watercourse will continue to receive its primary input from quarry discharge. Quality of water being discharged from Quarry Sump 0100 is not expected to change as a result of the proposed Quarry Extension, therefore, no change in water quality is expected. 2) Water quality impacts that may be occurring as a result of discharge of water from the artificial golf course ponds and irrigation channels into the tributary will cease once the golf course ponds are removed. This may result in a positive effect on downstream water quality, given that golf course discharge may be having a negative impact on water quality (e.g., due to fertilizers, erosion and sedimentation, nutrients).		NETR (Savanta, April 2020)	76
Potential Impact to Form and Function of Feature:	1) Direct impacts associated with permanent weir plate installation and diversion pipe installation are not expected to have any negative effects on the general form and function of this portion of the watercourse, which provides indirect fish habitat. 2) Alterations to quarry discharge (if unmitigated) could potentially have negative impacts on the form and habitat functions of this watercourse. 3) Diversion of upstream catchment S101 is not expected to have negative impacts on the form and function of the watercourse. The more natural hydrograph predicted due to the diversion may enhance fish habitat in downstream reaches of the Tributary.		NETR (Savanta, April 2020)	75 - 77
Potential Impact to Identified Species and Habitat:	1) In-water work could potentially result in indirect negative impacts on downstream fish communities (i.e., in lower reaches of the Unnamed Tributary or in Willoughby Creek) as a result of erosion and downstream sediment and/or accidental spills during construction. 2) Alterations to quarry discharge (if unmitigated) could potentially have negative impacts on the species and habitat functions of this watercourse. 3) Diversion of upstream catchment S101 is not expected to have negative impacts on fish in the watercourse. The more natural hydrograph predicted due to the diversion may enhance fish habitat in downstream reaches of the Tributary.		NETR (Savanta, April 2020)	75 76 77

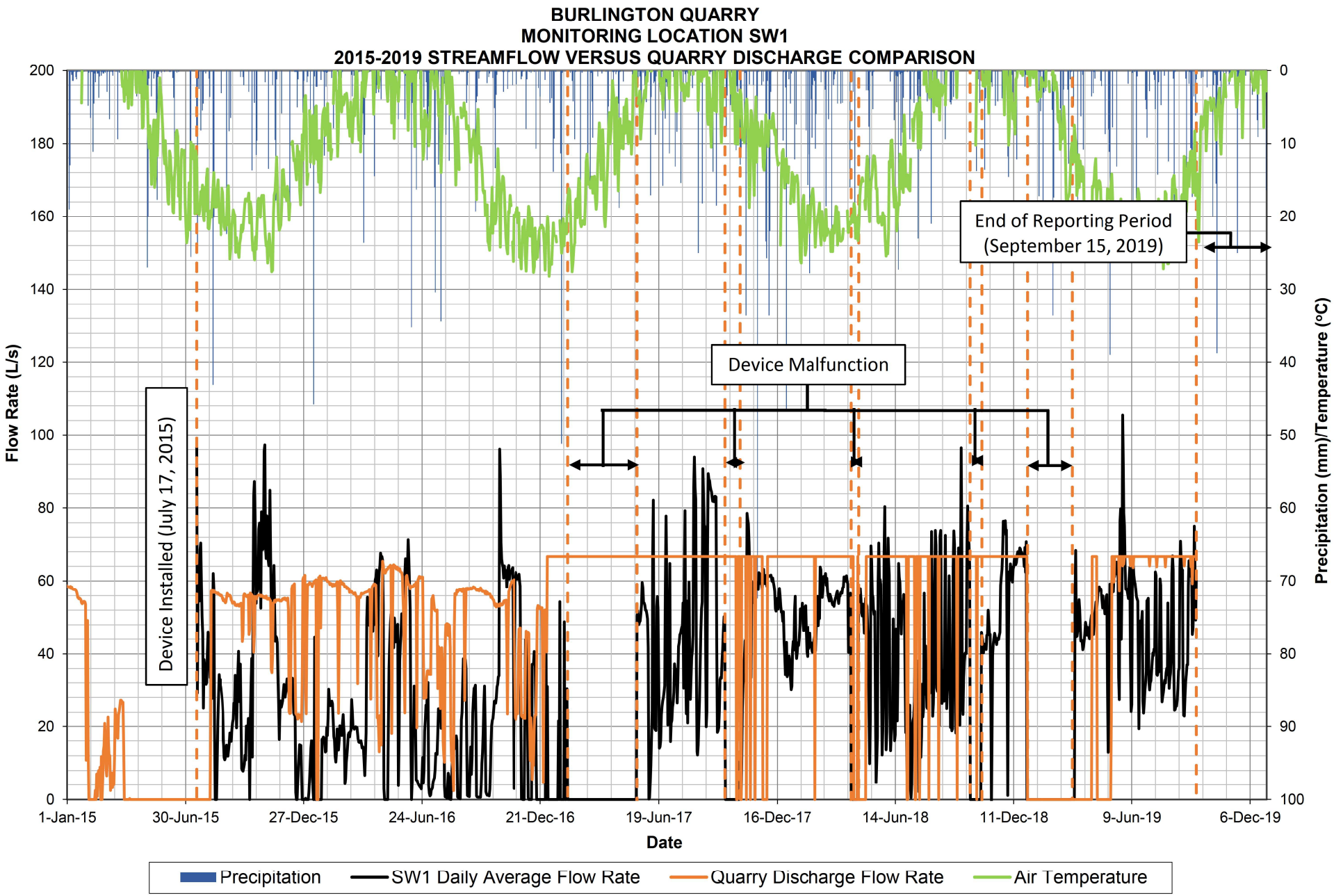
Unnamed Tributary of Willoughby Creek

Mitigation	Description	Figure / Graph	Reference	
			Report	Section / Page
Direct Alteration Mitigation:	1) In-water work required to install the permanent weir plate and the diversion structure inlet will be completed between July 16 and August 30 to minimize the potential for indirect impacts on the reproductive activities of the downstream fish communities in the Unnamed Tributary of Willoughby Creek and in Willoughby Creek itself (e.g., due to sedimentation or accidental spills). 2) Erosion and sedimentation control measures and spill prevention and response measures will be used throughout the duration of any in-stream works in the watercourse. 3) The Limit of Extraction has been set back 30 m from the limit of the bankfull channel of the Unnamed Tributary of Willoughby Creek and the Weir Pond in order to prevent disturbance to the watercourse. No operational activities will occur within the 30 m setback. A visual mitigation berm will be constructed within the 30 m setback (with associated grading encroaching a minimum of 14 m from the edge of the Weir Pond). Erosion and sedimentation control measures will be in place prior to grading for the berm. The berm will be vegetated following completion of grading to ensure soil stability and prevent erosion. 4) Where areas within the 30 m setback are not currently naturally vegetated (i.e., on portions of the active golf course), these areas will be naturalized with native species plantings to assist in maintaining and enhancing riparian functions adjacent to the watercourse. 5) To mitigate potential for negative impacts during removal of the golf course irrigation ponds and channels, it is recommended that the downstream end of the irrigation channel be blocked off at the edge of the Weir Pond in order to isolate the work area from the Unnamed Tributary. If water is to be pumped from the irrigation ponds and channels, it should be appropriately treated, as may be necessary, prior to discharge to the downstream watercourse. This could include pumping to a localized treatment method (e.g., filtration bag) or direct pumping into the quarry (which would be expected to provide suitable level of water quality control, based on the quarry's existing discharge limits). If in-water work is required (e.g., to isolate the irrigation ponds and channels), it should be completed between July 16 and August 30 to minimize potential for disruption of downstream coldwater fish community reproductive activities. The existing golf cart path and culvert at the interface of the irrigation channel and Weir Pond should be removed and the area should be restored to create a naturalized pond bank.		NETR (Savanta, April 2020)	75 66 and 67 74 78
Source Water Mitigation:	In order to mitigate impacts on fish and fish habitat in Willoughby Creek, pumping and discharge from the quarry are recommended to occur at the same location at the upstream end of the Unnamed Tributary of Willoughby Creek and in the same manner as existing pumping in accordance with the existing PTTW and Environmental Compliance Approvals regulating current quarry discharge.		NETR (Savanta, April 2020)	76 and 77
Groundwater Contribution Mitigation:	None required. The Unnamed Tributary is generally a losing stream with minor groundwater contributions typically occuring following spring freshet. During extraction the groundwater contributions are predicted to be reduced by less than 1.0%			
Erosion Mitigation:	Erosion and sedimentation control measures and spill prevention and response measures will be used throughout the duration of any in-stream works in the watercourse.			
Thermal Mitigation:	1) No specific thermal mitigation is proposed given that maintaining existing quarry outflows at Sump 0100 are expected to maintain the existing thermal regime of the watercourse without any additional mitigation. 2) Removal of the golf course ponds and diversion of flow from catchment S101 may have an indirect positive effect on the thermal regime of the watercourse.		NETR (Savanta, April 2020)	76 78
Water Quality Mitigation:	1)No specific water quality mitigation over and above that of the existing quarry operations is proposed given that maintaining existing quarry outflows at Sump 0100 is expected to maintain the existing water quality regime of the watercourse. The quarry extension is not predicted to result in any changes in the quality of water being discharged from Sump 0100. 2) Removal of the golf course ponds may have an indirect positive effect on the water quality of the watercourse.		NETR (Savanta, April 2020)	76 78

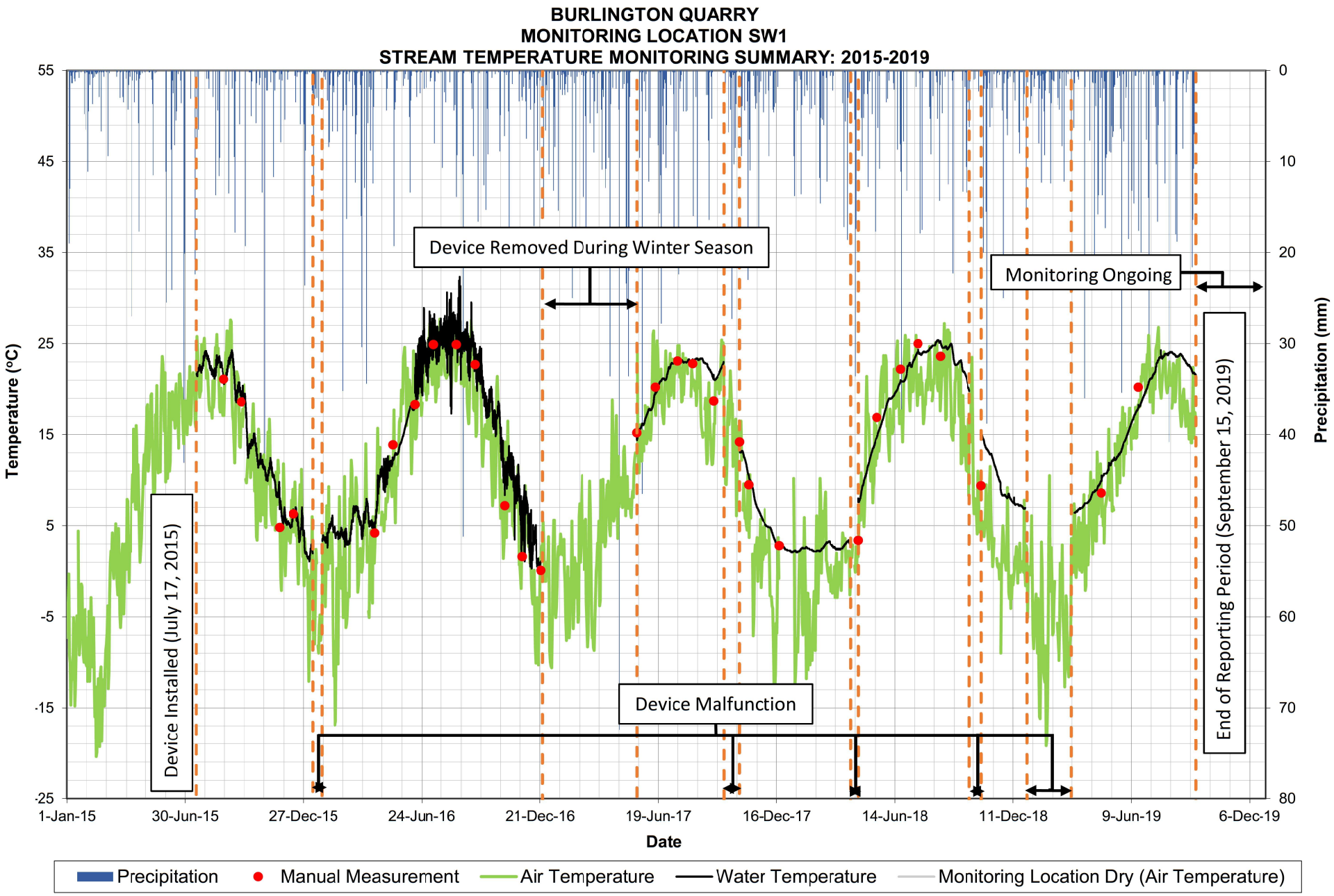
TRIBUTARY OF WILLOUGHBY CREEK - GRAPH 1



TRIBUTARY OF WILLOUGHBY CREEK - GRAPH 2



TRIBUTARY OF WILLOUGHBY CREEK - GRAPH 3



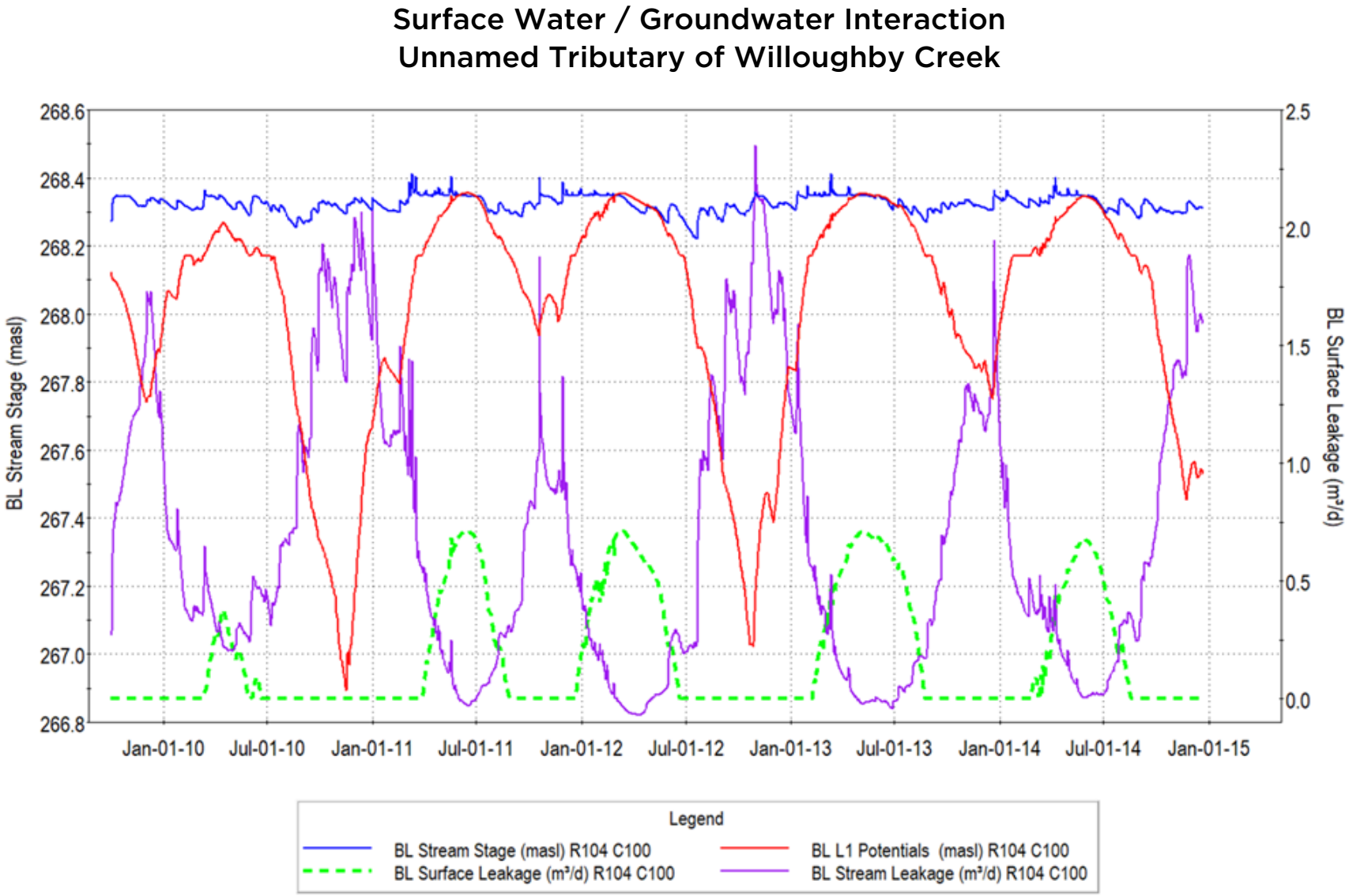
TRIBUTARY OF WILLOUGHBY CREEK - TABLE 1

BURLINGTON QUARRY
TATHAM ENGINEERING PROJECT NO.: 113187
SURFACE WATER MONITORING

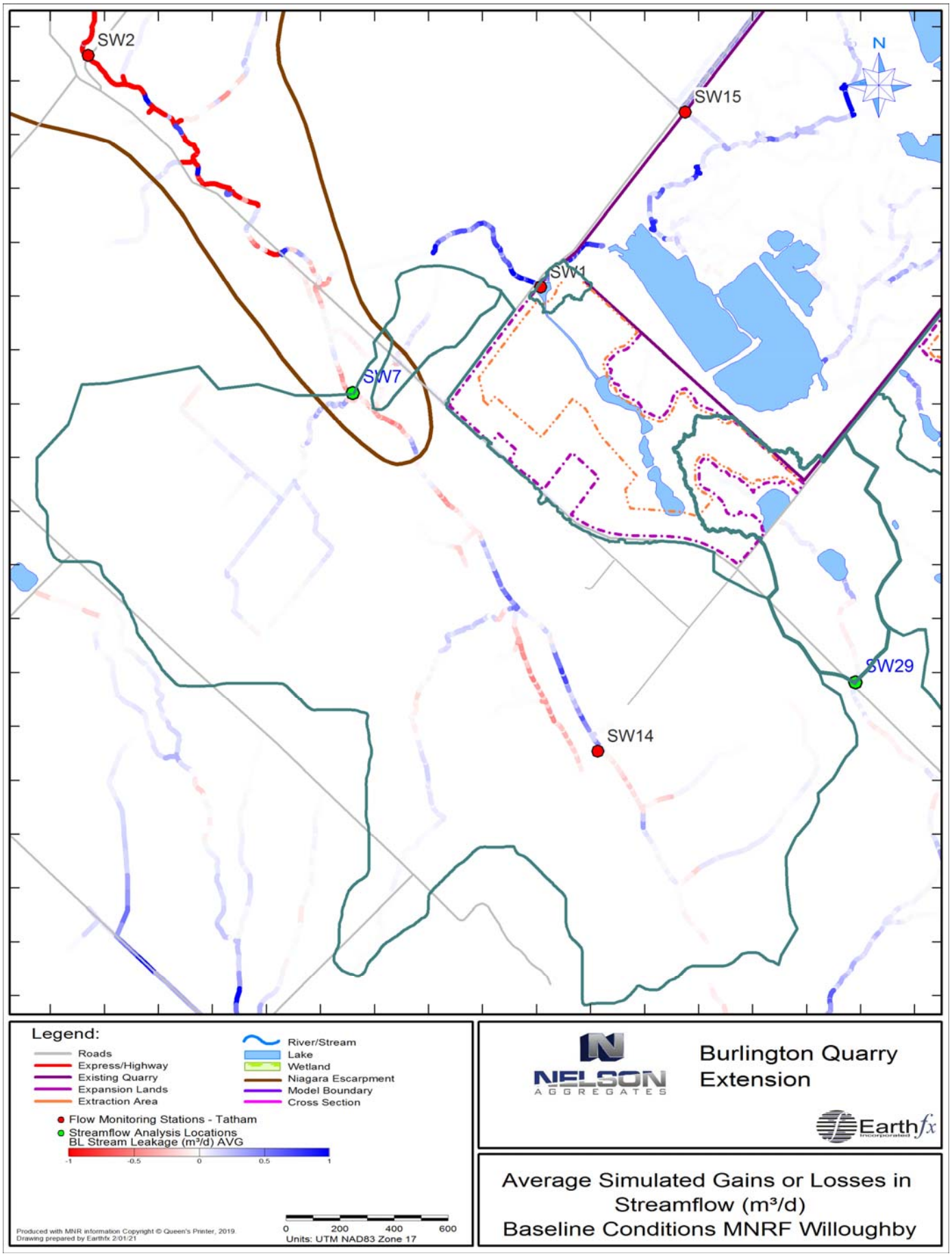
WATER QUALITY SAMPLE RESULTS

Monitoring Location SW1													
		Sample Date:	24-Oct-18	24-Apr-19	19-Jun-19	25-Sep-19	20-May-20	15-Jul-20	16-Sep-20	11-Nov-20	Maximum	Minimum	Average
Parameter:	Units:	M.D.L.	CM/JG	CM/JG	CM	CM	JG	JG/JH/JM	JH/JM	JG/JH			
M-Alkalinity (pH 4.5)	mg/L as CaCO3	2	137	179	180	112	160	94	107	117	180	112	152
Ammonia (as N)	mg/L	0.01	0.11	<0.01	0.03	0.02	<0.01	0.45	<0.01	0.01	0.11	0.02	0.04
BOD (5 day)	mg/L	1	1	2.4	1.3	1	1.6	1.1	1.3	1.2	2.4	1.0	1.4
Bicarbonate	mg/L as CaCO3	1	136	177	-	111		93	106	116	177	111	141
Carbonate	mg/L as CaCO3	1	1	2	-	<1		<1	<1	<1	2	1	1
Conductivity	µS/cm	1	877	742	763	755	790	690	799	886	877	742	784
Dissolved Organic Carbon	mg/L	0.4	4.3	4	3.1	3.7	3.9	2.3	3	3.3	4.3	3.1	3.8
Field pH	pH	N/A	8.8	8.5	8.6	8.8	8.9	8.6	8.9	9.1	8.8	8.5	8.7
Field Temp	°C	N/A	8.6	7.8	20.2	20.4	18.4	24.7	18.5	12.8	20.4	7.8	14.3
Aluminum	ug/L	1	21	64	15	9	10	50	4	2	64	9	27
Antimony	ug/L	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.5
Arsenic	ug/L	1	5	3	4	4	2	4	4	<1	5	3	4
Barium	ug/L	1	38	30	32	29	32	19	29	33	38	29	32
Beryllium	ug/L	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.5
Bismuth	ug/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Boron	ug/L	2	109	56	31	88	59	52	108	123	109	31	71
Cadmium	ug/L	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1
Calcium	ug/L	500		77100	79600	51100	65000	39600	52300	65400	79600	51100	51950
Cerium	ug/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Cesium	ug/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Chromium	ug/L	1	<1	4	3	3	2	<1	2	3	4	3	3
Cobalt	ug/L	0.1	0.2	0.3	0.2	0.1	0.2	0.3	0.1	0.1	0.3	0.1	0.2
Copper	ug/L	1	<1	1	8	1	2	3	1	2	8	1	3
Europium	ug/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Gallium	ug/L	1	<1	<1	<1	<1	<1	<1	<1	1	<1	<1	1
Iron	ug/L	20	40	160	210	140	253	160	160	200	210	40	138
Lanthanum	ug/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Lead	ug/L	0.1	<1	0.1	<0.1	<0.1	<0.1	0.2	<0.1	<0.1	0.1	0.1	0.1
Lithium	ug/L	5	9	7	8	8	8	11	12	12	9	7	8
Magnesium	ug/L	5		30700	34200	36400	34000	28800	36100	41300	36400	30700	25325
Manganese	ug/L	10	9	15	18	15	21	59	9	7	18	9	14
Mercury	ug/L	0.1	<1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1
Molybdenum	ug/L	1	3	2	2	3	2	2	2	3	3	2	3
Nickel	ug/L	1	4	4	3	2	3	2	2	2	4	2	3
Niobium	ug/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Phosphorus	ug/L	50	<50	124	<50	<50	<50	<50	<50	<50	124	124	68.5
Potassium	ug/L	1	5990	4230	4510	5620	4680	3830	5920	6800	5990	4230	5088
Rubidium	ug/L	1	3	2	2	3	2	2	3	2	3	2	3
Scandium	ug/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Selenium	ug/L	0.5	1.6	1.1	<0.5	1.5	1.1	<0.5	1.7	<0.5	1.6	1.1	1.175
Silicon	ug/L	2	1600	1560	888	659	568	447	1010	616	1600	659	1177
Silver	ug/L	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.3	<0.1	<0.1	0.1
Sodium	ug/L	1000	50600	36500	34900	41800	42300	43700	48900	51200	50600	34900	40950
Strontium	ug/L	1	982	942	895	823	807	564	722	982	982	823	911
Sulphur	ug/L	800	63800	49400	59200	59100	50000	40300	56300	79800	63800	49400	57875
Tellurium	ug/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Thallium	ug/L	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1
Thorium	ug/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Tin	ug/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Titanium	ug/L	1	<1	2	<1	<1	<1	1	<1	<1	2	2	1.25
Tungsten	ug/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Uranium	ug/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Vanadium	ug/L	1	<1	1	1	<1	<1	<1	<1	<1	1	1	1
Yttrium	ug/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Zinc	ug/L	1	5	<1	7	4	4	9	5	2	7	4	4
Zirconium	ug/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
pH	pH	N/A	8.02	8.03	8	7.97	8.34	7.97	7.86	7.88	8.0	8.0	8.0
Total Hardness (as CaCO3)	mg/L	0.1	335	319	340	277	302	217	279	333	340.000	277.000	317.750
Chemical Oxygen Demand	mg/L	5	8	12	8	<5	12	11	16	15	12	8	8
Total Dissolved Solids	mg/L	3	597	517	564	576	525	460	536	574	597	517	564
Total Suspended Solids	mg/L	0.67	1.3	3.67	1	1.7	5	4	2.3	2.7	3.67	1.00	1.92
Turbidity	NTU	0.1	2.4	3.5	1.4	0.9	2.4	2	0.5	1.2	3.5	0.9	2.1

TRIBUTARY OF WILLOUGHBY CREEK - GRAPH 4



TRIBUTARY OF WILLOUGHBY CREEK - FIGURE 1



TRIBUTARY OF WILLOUGHBY CREEK - FIGURE 2

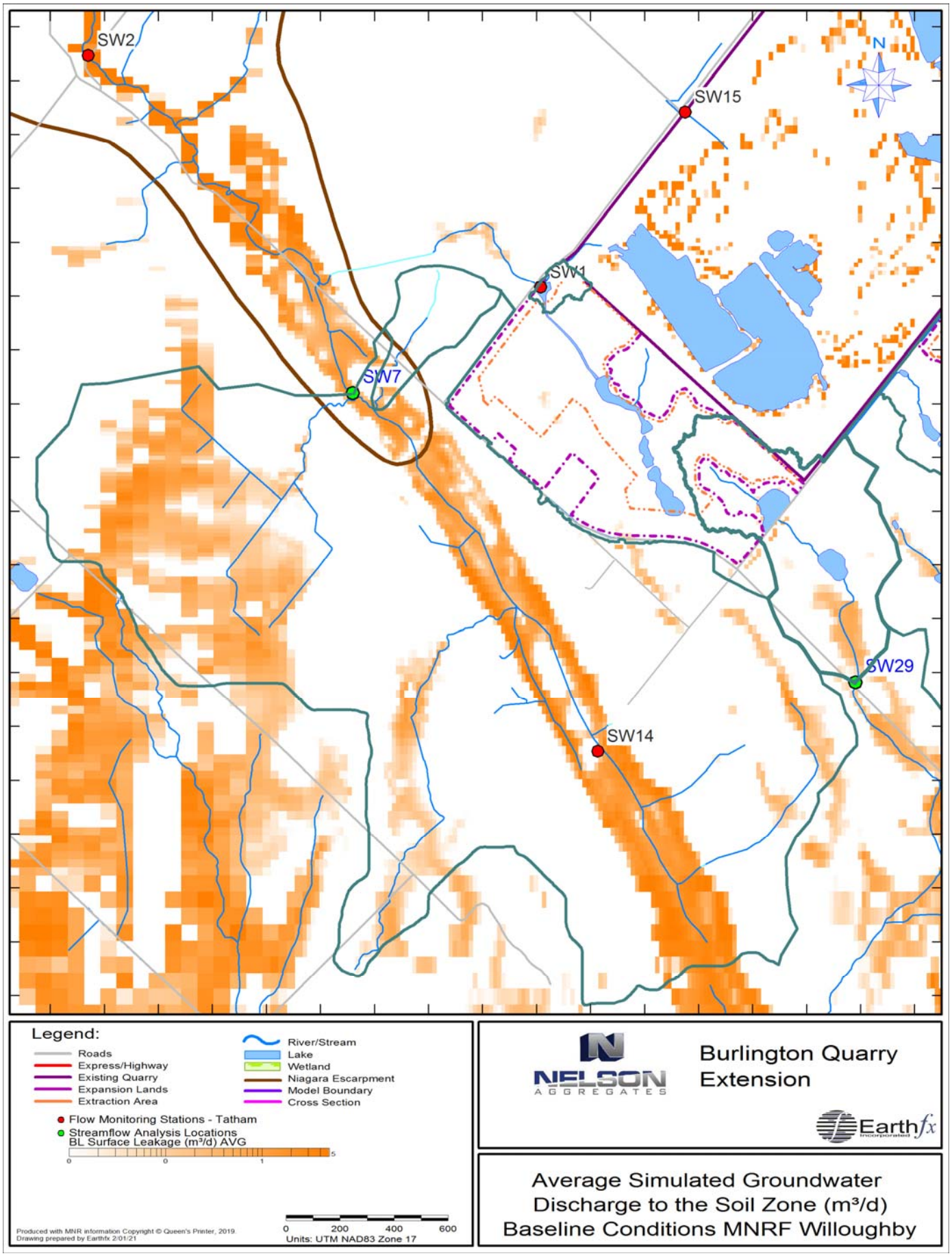


FIGURE 3A

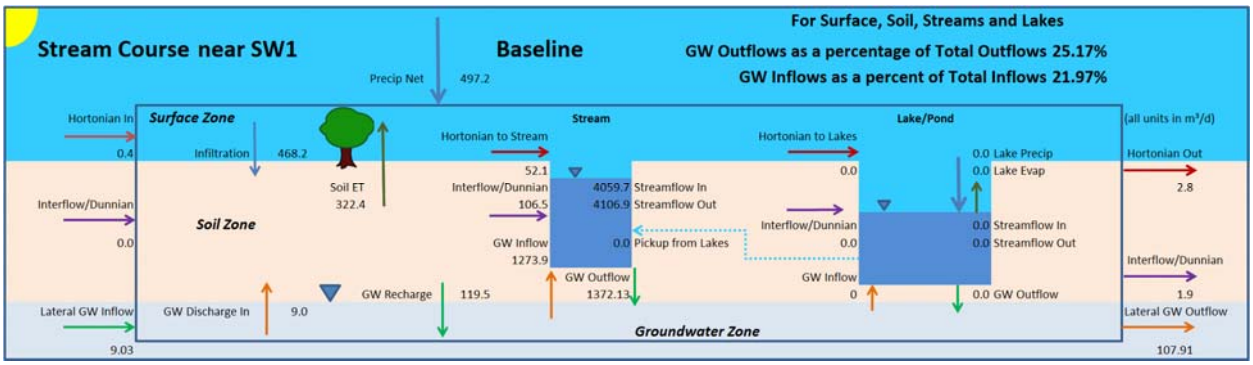


FIGURE 3B

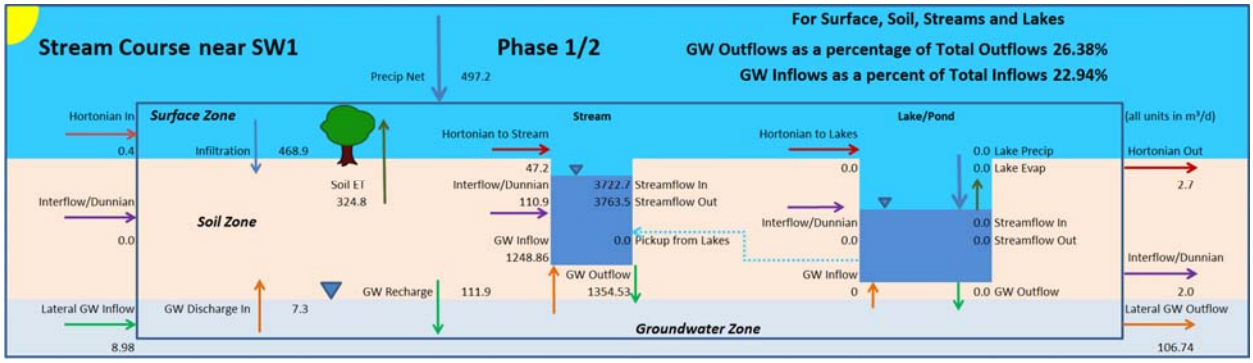


FIGURE 3C

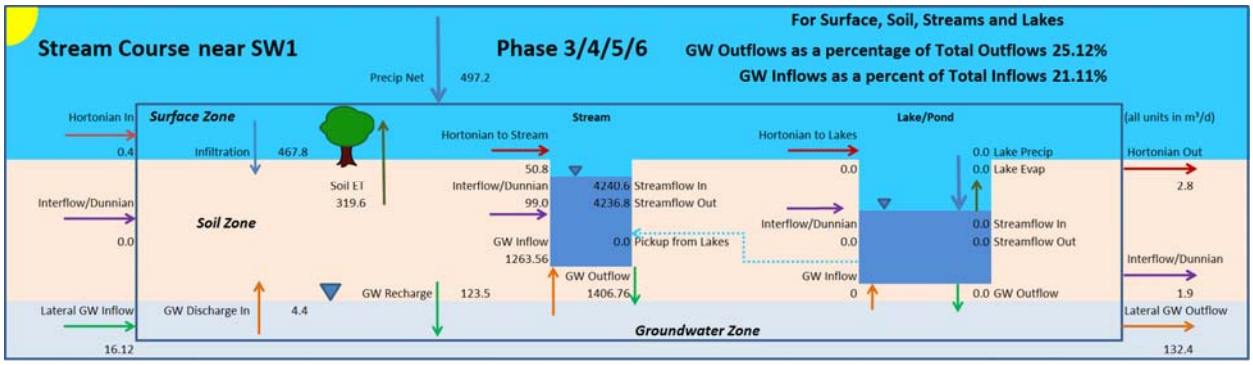


FIGURE 3D

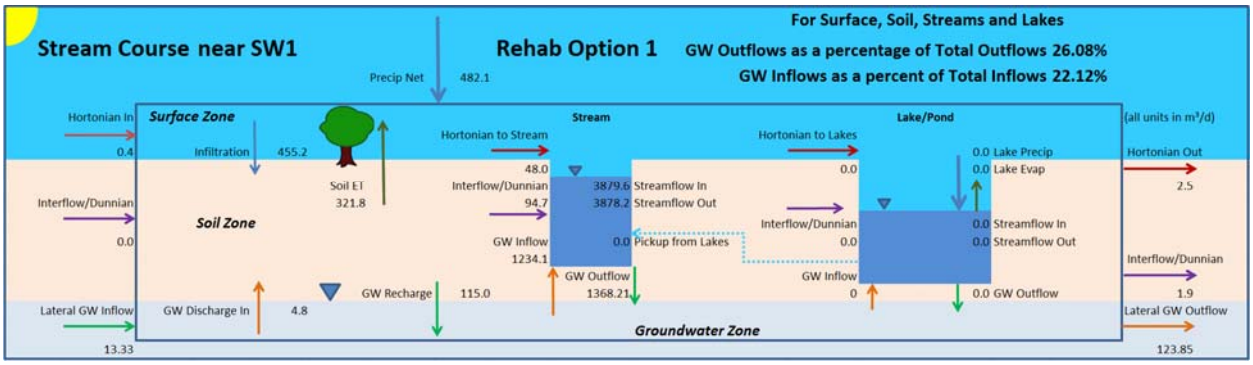
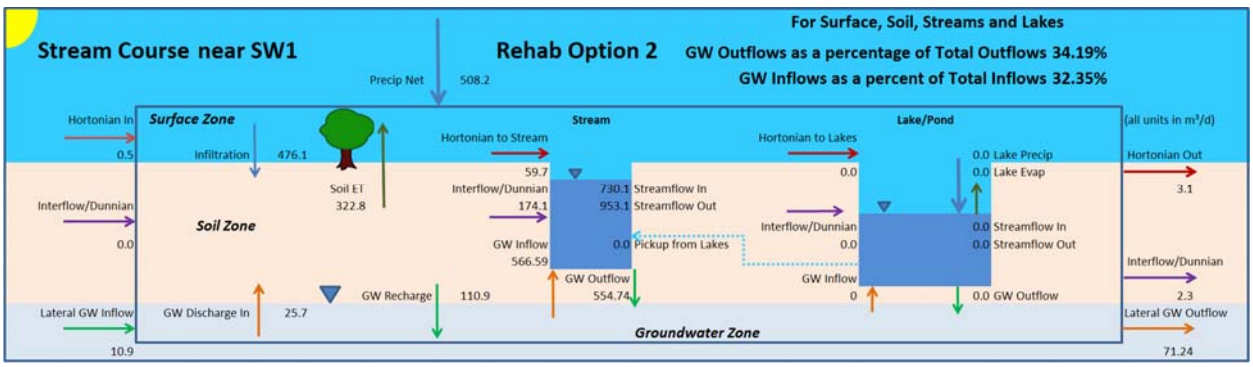
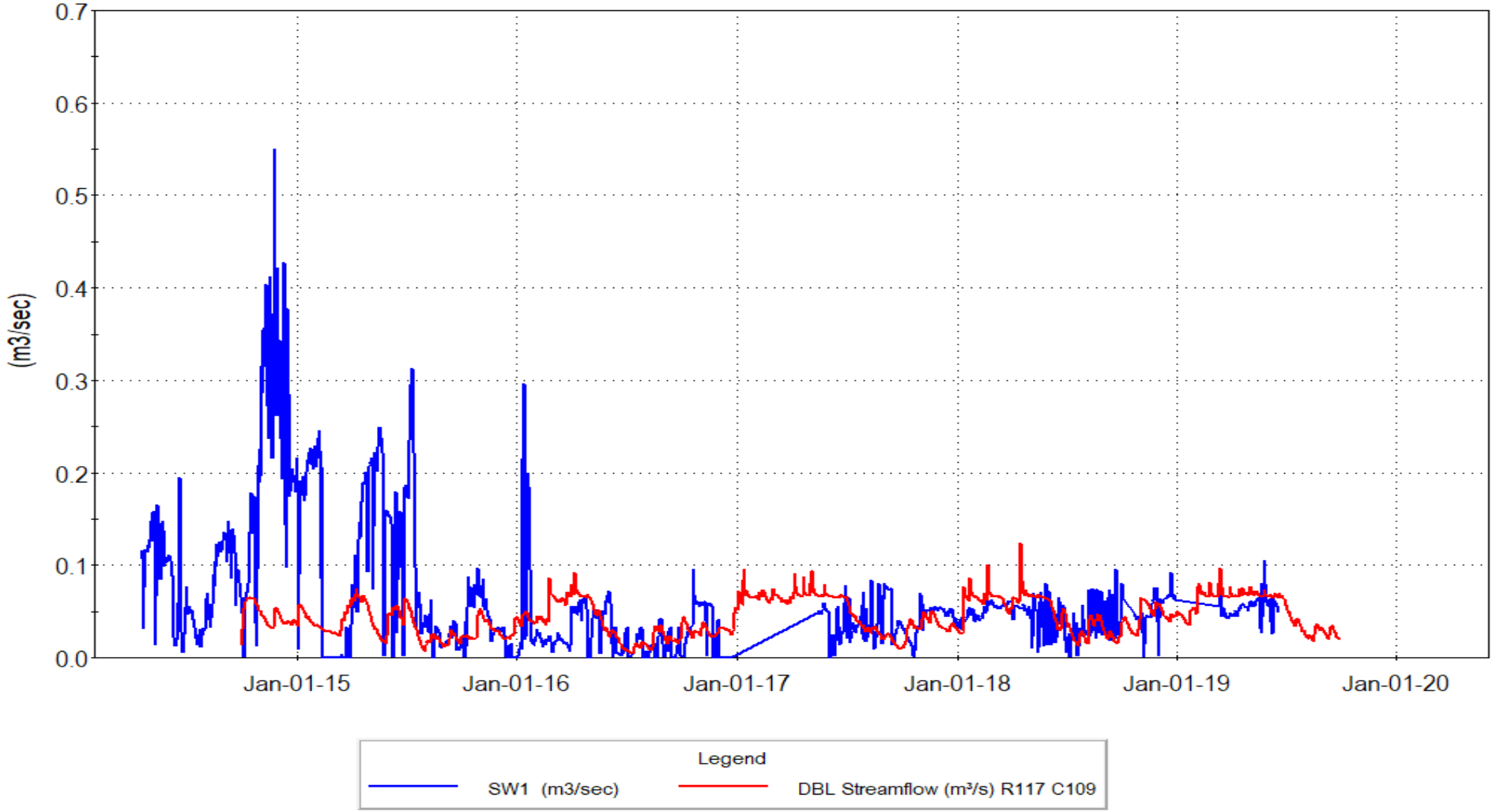


FIGURE 3E



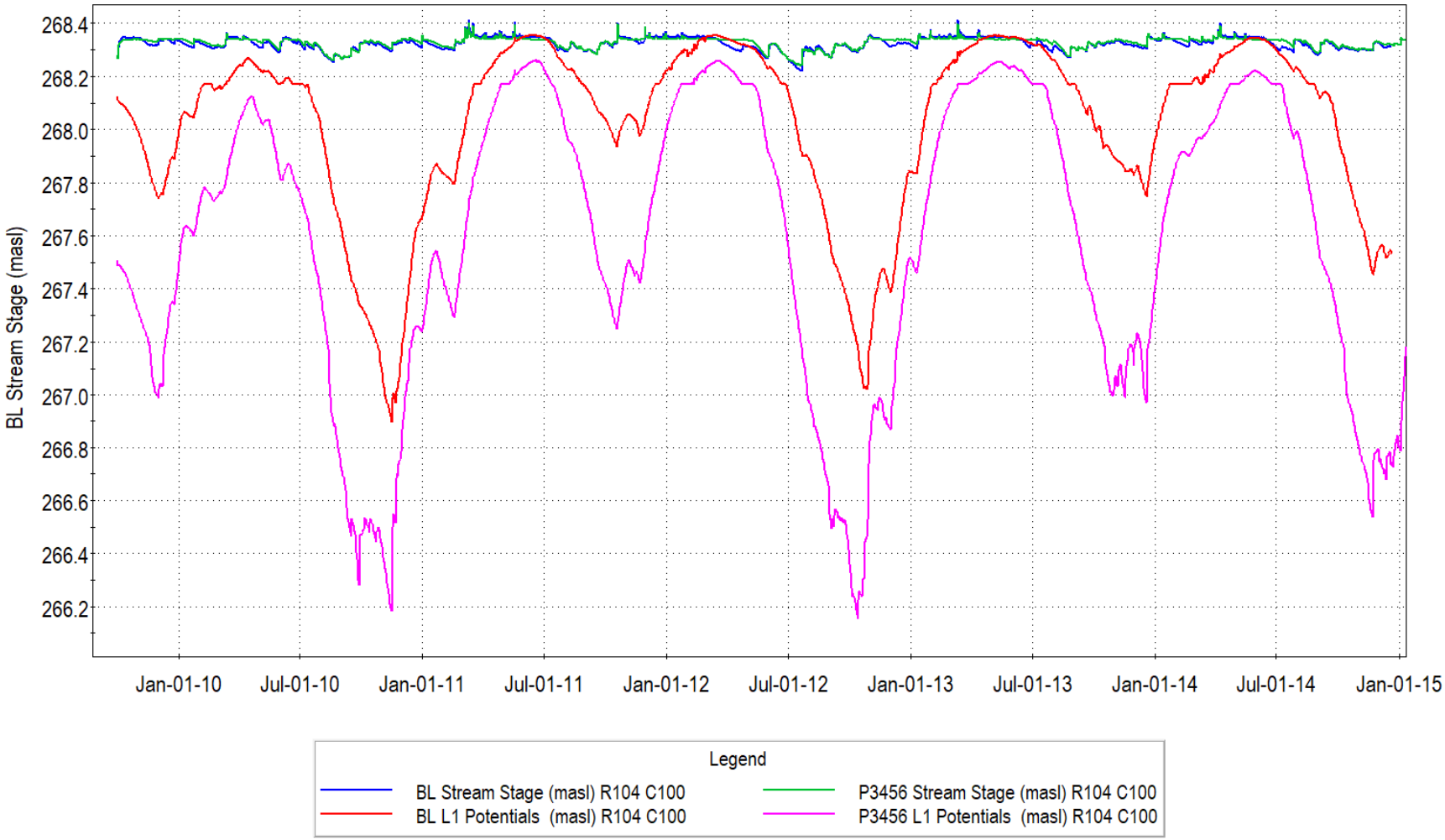
TRIBUTARY OF WILLOUGHBY CREEK - GRAPH 5

Integrated Model Calibration
Unnamed Tributary of Willoughby Creek

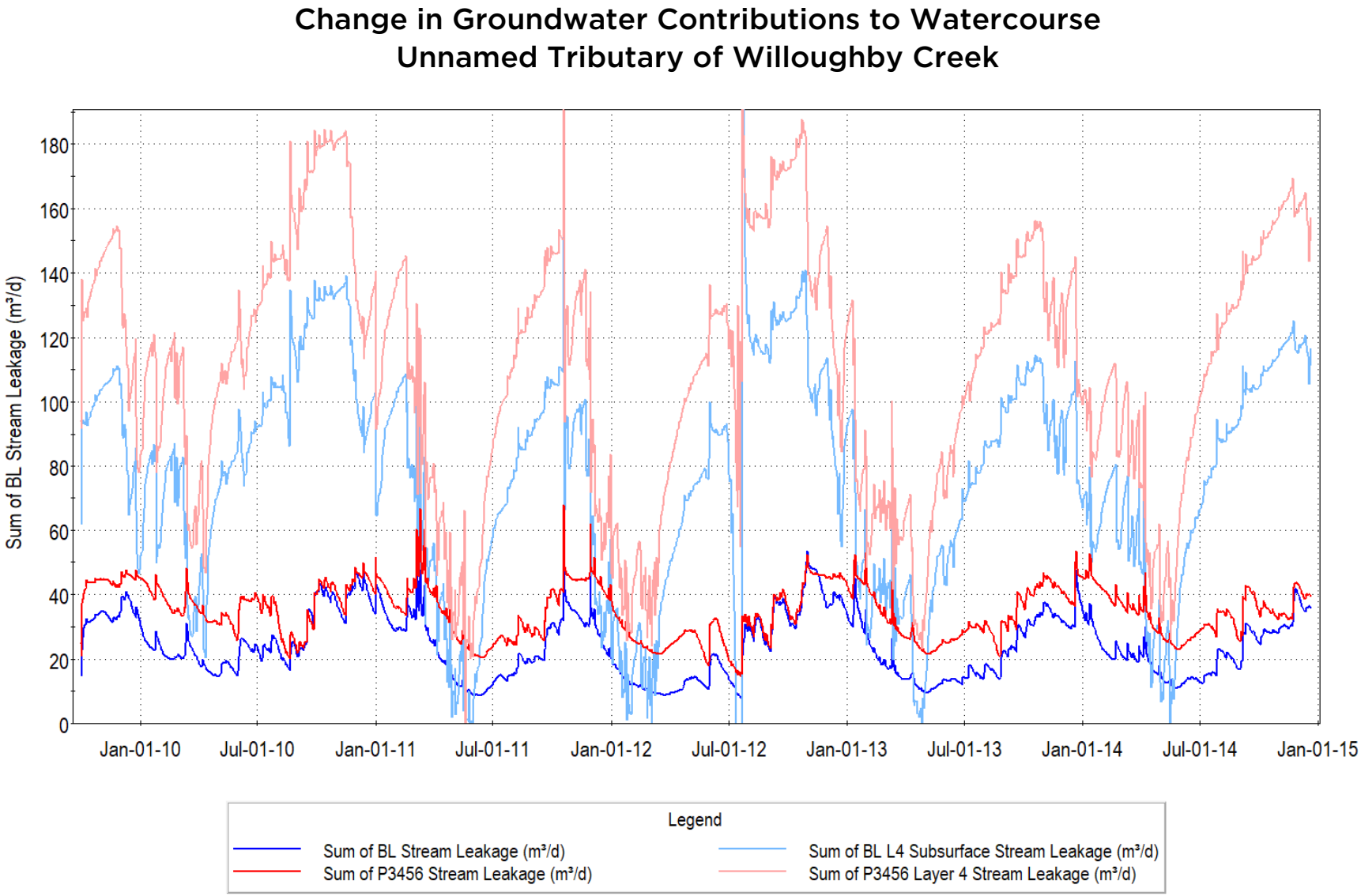


TRIBUTARY OF WILLOUGHBY CREEK - GRAPH 6

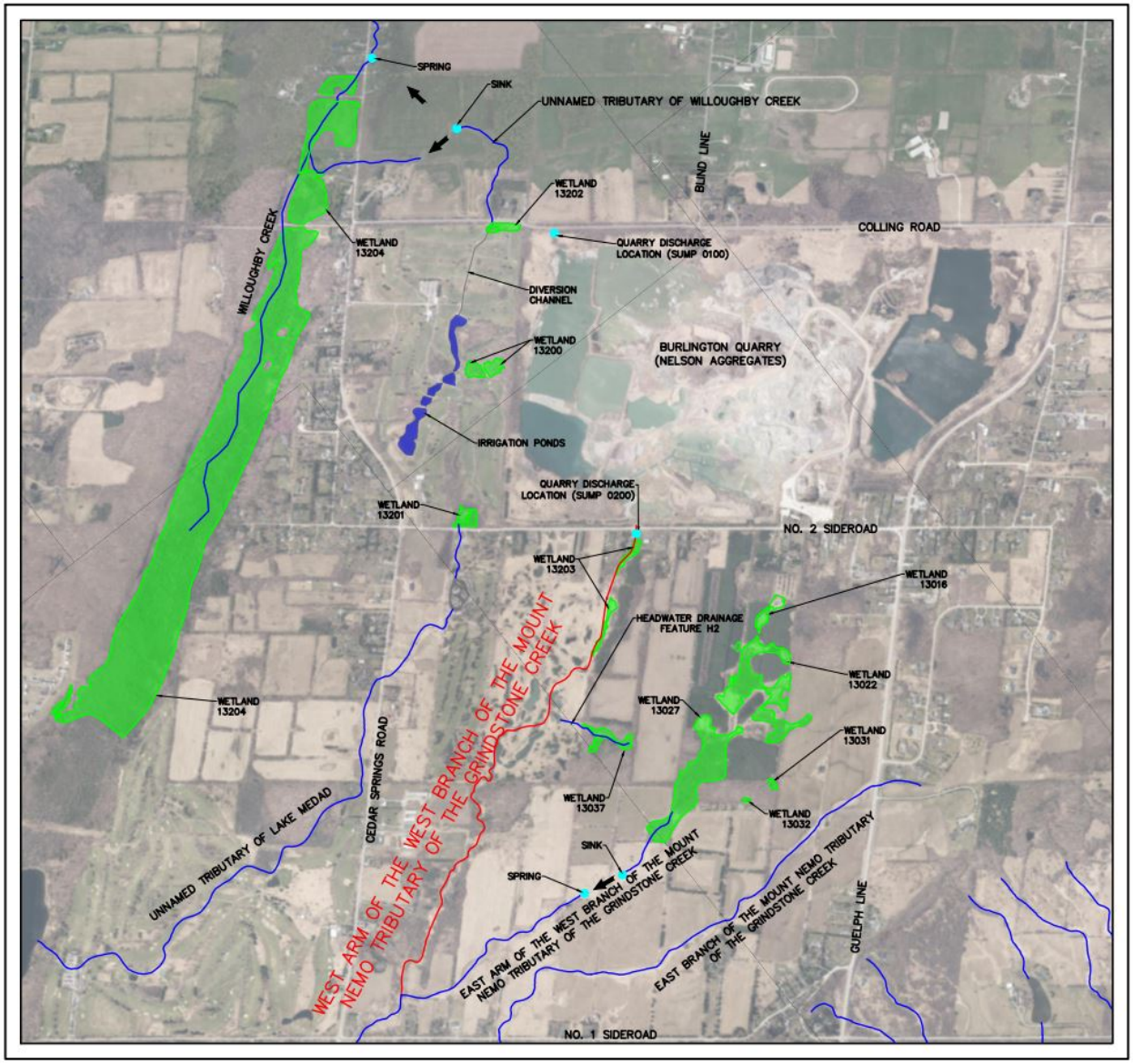
Change in Groundwater Contributions to Watercourse
Unnamed Tributary of Willoughby Creek

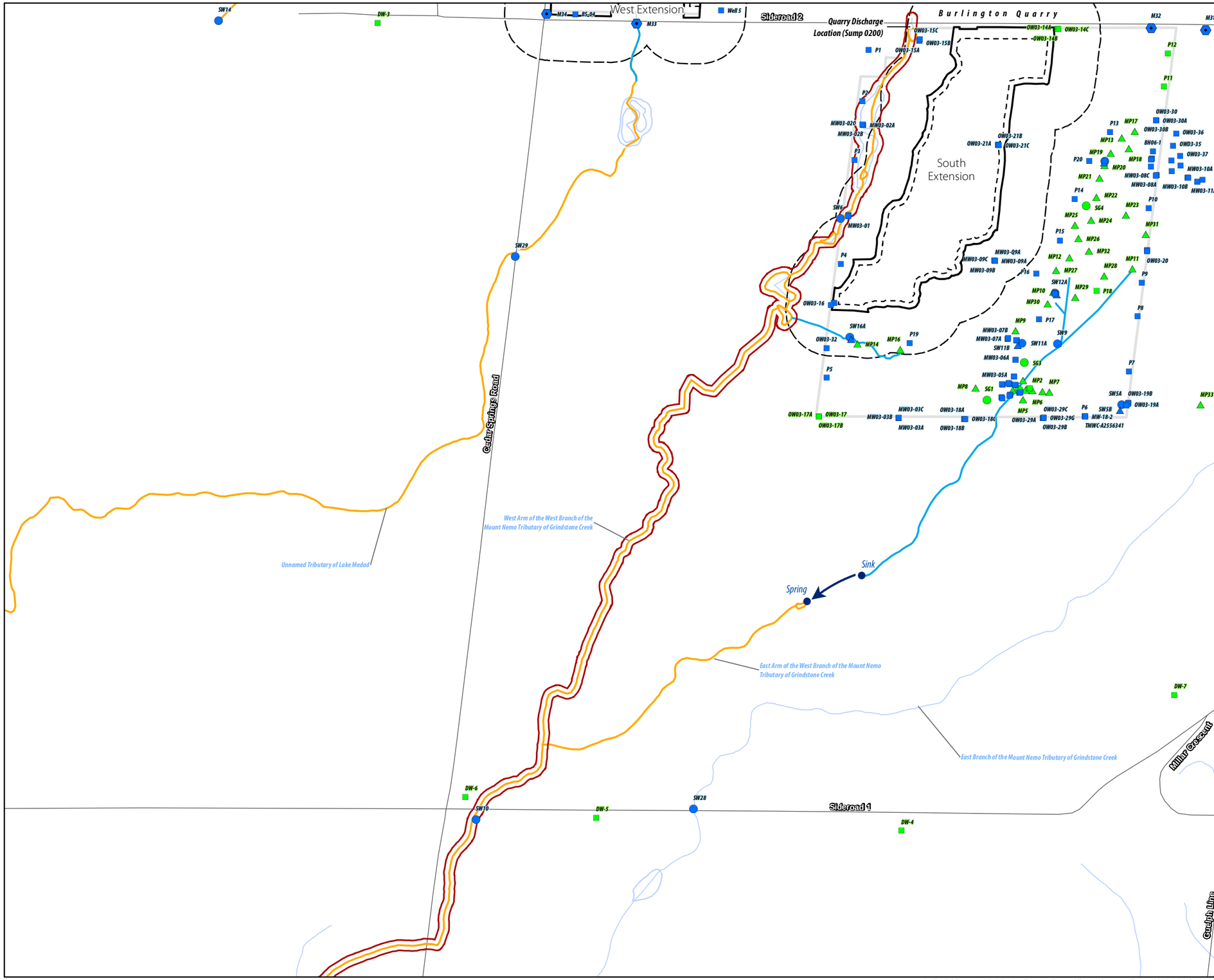


TRIBUTARY OF WILLOUGHBY CREEK - GRAPH 7



WEST ARM OF THE WEST BRANCH





Legend

- Licensed Boundary
- Limit of Extraction
- 120 m Adjacent Lands
- Subject Lands
- West Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek
- Road
- Indirect Fish Habitat
- Direct Fish Habitat
- Watercourse
- Waterbody
- Wetland (Savanta, 2020)

Current Instrumentation

- Groundwater Monitoring Station (EarthFx)
- Mini Piezometer (Tatham Engineering)
- Staff Gauge & Surface Water Monitoring Station (Tatham Engineering)
- Manual Stream Flow Measurement (Tatham Engineering)

Previous Instrumentation

- Groundwater Monitoring Station (Golder)
- Mini Piezometer (Golder)
- Staff Gauge & Surface Water Monitoring Station (Golder)

NOTES:

1. Coordinate System: NAD 1983 UTM Zone 17N.
2. Base features produced under license with the Ontario Ministry of Natural Resources and Forestry © Queen's Printer for Ontario, 2021.
3. Orthoimagery © First Base Solutions, 2021. Imagery taken in 2019.

Project 8133

Burlington Quarry Extension
Nelson Aggregates Co.

Figure 15
Watercourse Characterization

West Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek

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Path: C:\Savanta\8133 - Burlington Quarry\figures\report_figures\2021 01 21 natural feature tech summary\8133_rpt_watercourse_char_mapbook.mxd D April 8, 2021

West Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek

Surface Water Characteristics	Description	Figure / Graph / Table	Reference	
			Report	Section / Page
Watercourse Name:	West Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek			
Watershed:	Grindstone Creek			
Sub-Watershed:	Mount Nemo Tributary of Grindstone Creek			
Located in Proposed Limit of Extraction:	No			
Located in Proposed License Boundary:	No			
Catchment Area (ha):	135 ha (at confluence with East Arm); 26.2 ha (at streamflow monitoring location SW6)			
Catchment ID:	N/A			
Primary Source(s) of Flow:	Discharge from Burlington Quarry (Sump 0200)			
Discharge from Quarry / PTTW:	Yes - PTTW 96-P-3009		SWA (Tatham, April 2020)	Appendix A
Conditions of PTTW:	Maximum discharge rate = 945 L/min (15.75 L/s) Maximum discharge amount = 1,360,800 L/day		SWA (Tatham, April 2020)	Appendix A
Surface Water Monitoring:	ID: SW6 (Tatham) Installation Date: September 19, 2014 Data Collection: Continuous water level and temperature, manual monthly in-situ streamflow measurements and calibration data (water level converted to flow using rating curve) Coordinates of Monitoring Station: Easting 590629.123, Northing 4805071.124	Graphs 1, 2 & 3 and Table 1	SWA (Tatham, April 2020)	2.1.2, Appendix C and Appendix H
Streamflow Conditions:	Intermittent (flow is dependent on quarry discharge); the tributary will dry out when quarry discharge ceases	Graphs 1, 2 & 3	SWA (Tatham, April 2020)	2.1.2 and Appendix C
Average Daily Flow (SW6):	Average Daily Streamflow (L/s)	Graphs 1 & 2	SWA (Tatham, April 2020)	2.1.2 and Appendix C

Month	Minimum	Average	Maximum
January	N/A	N/A	N/A
February	N/A	N/A	N/A
March	3.6	7.4	15.3
April	0.1	6.4	14.3
May	0.0	4.6	33.8
June	0.0	6.5	31.0
July	0.0	5.3	17.7
August	0.0	5.2	23.6
September	0.0	2.4	21.6
October	0.0	2.1	16.0
November	0.0	4.1	21.9
December	0.0	7.8	44.6

Notes:

Minimum - lowest daily average streamflow recorded for period of record

Average - average daily streamflow recorded for period of record

Maximum - maximum daily average streamflow recorded for period of record

N/A - data not available as device removed from watercourse during winter months

West Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek

Watercourse Thermal Regime (SW6):

Average Daily Water Temperature (°C)

Month	Minimum	Average	Maximum
January	N/A	N/A	N/A
February	N/A	N/A	N/A
March	4.7	6.0	8.0
April	5.6	9.5	12.3
May	7.3	14.4	25.0
June	9.4	17.7	26.5
July	12.3	21.0	27.2
August	12.2	21.1	28.9
September	9.5	17.8	25.1
October	2.7	12.2	20.2
November	0.2	7.2	13.2
December	0.5	4.9	9.6

Notes:

Minimum - lowest daily average streamflow recorded for period of record

Average - average daily streamflow recorded for period of record

Maximum - maximum daily average streamflow recorded for period of record

N/A - data not available as device removed from watercourse during winter months

Figure / Graph / Table: Graph 3

Reference: SWA (Tatham, April 2020), 2.1.2 and Appendix C

Water Quality (SW6):

Water Quality Sample Results

Parameter	Units	Minimum	Average	Maximum
Turbidity	NTU	0.2	0.4	0.5
TDS	mg/L	593	640	695
TSS	mg/L	<0.67	1.11	2.00
COD	mg/L	<5	8	12
BOD5	mg/L	<0.9	0.9	0.9
DOC	mg/L	2.7	3.0	3.4
pH		7.7	7.9	8.2
Alkalinity	mg/L	137	160	172
Conductivity	µS/cm	798	858	934
Phosphorus	ug/L	<50	<50	<50
Ammonia	mg/L	<0.01	0.02	0.04
Hardness	mg/L	357	364	376

Figure / Graph / Table: Table 1

Reference: SWA (Tatham, April 2020), 2.4 and Appendix H

West Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek

Fish & Fish Habitat Features	Description	Figure / Graph / Table	Reference	
			Report	Section / Page
Fish Habitat (Direct/Indirect and Assumed/Confirmed):	The West Arm is known to provide direct fish habitat, based on fish community sampling completed in 2019 by Savanta. Fish were captured in a small, online pond approximately 400 m downstream from Sideroad No. 2. For the purposes of the NETR, the entire watercourse up to the quarry discharge point at Sideroad No. 2 is assumed to provide direct fish habitat.		NETR (Savanta, April 2020)	44 and Figure 9b
Fish Species Present:	1) Savanta captured Brook Stickleback in the watercourse in 2019. 2) Stantec (2010) previously reported that Brook Stickleback and Pumpkinseed were captured in the West Arm.		NETR (Savanta, April 2020)	44 and Figure 9b
Fish Community Thermal Regime:	Cool to Warmwater (based on fish species present)		NETR (Savanta, April 2020)	44 and Figure 9b
Fish Habitat Types Present:	The reach of the watercourse between the upstream end at Sideroad No. 2 and the Nelson property line generally consists of a poorly defined to well-defined natural low flow channel within a low-lying, densely vegetated floodplain. With some reaches, the low flow channel is barely observable and only approximates a shallow depression amongst dense emergent wetland vegetation. In other reaches, the low flow channel is more well defined, with observable bed and banks that are distinguishable from the riparian vegetation community. The average wetted width of the channel is approximately 2 m, with abundant vegetation and multiple flow paths through wetland areas. Water depth on June 3, 2019 ranged from 0.1 to 0.5 m. Morphology is generally uniform, consisting of long runs with soft substrate, although several deeper scour pools are present, as well as one approximately 18 m long by 10 m wide online pond. A larger (~40 m by 20 m) online pond (which receives the inflow from the quarry Sump 0200) is present immediately adjacent to Sideroad No. 2. Riparian vegetation is generally meadow marsh and cultural meadow, although shrub thickets are present at various points.		NETR (Savanta, April 2020)	44 and Figure 9b
Habitat Uses by Known Fish Community:	The local fish community likely uses the habitat for the complete range of life history processes including spawning, nursery, foraging and overwintering (primarily in the online ponds at the upstream end and mid-point of the reach). Larger online ponds are also present on the downstream golf course property and these may also provide overwintering and refuge functions for the local fish community.		NETR (Savanta, April 2020)	44 and Figure 9b
Known Barriers to Fish Movement:	A culvert is present at the downstream Subject Lands property boundary. Fish may be able to pass upstream through this culvert under lower flow rates, although at higher flows, when velocities are expected to be higher, the culvert may provide some barrier effect.		NETR (Savanta, April 2020)	44 and Figure 9b

West Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek

<table>
<tr><th rowspan="2">Groundwater Interaction</th><th rowspan="2">Description</th><th rowspan="2">Figure / Graph / Table</th><th colspan="2">Reference</th></tr>
<tr><th>Report</th><th>Section / Page</th></tr>
<tr><td>Underlying Deposits:</td><td>Halton Till. The harmonic mean hydraulic conductivity, based on testing by Golder (2007) of 10 mini-piezometers, was 1.2x10^{-8} m/s. Model value for the vertical hydraulic conductivity was 1.6x10^{-7} m/s, about an order of magnitude higher, to account for limited flow through fractures in the till.</td><td></td><td></td><td></td></tr>
<tr><td>Surface Water / Groundwater Interactions:</td><td>Seasonal groundwater contributions to watercourse. Groundwater seepage under baseline conditions during spring months equates to 0.08 L/s or less. Groundwater seepage is at its maximum during and immediately following the spring freshet.</td><td>Figures 1 & 2</td><td></td><td></td></tr>
<tr><td>Water Budget Results (300 m Upstream of SW6):</td><td>The baseline condition water budget results from the integrated model 300 m upstream of monitoring location SW6 are presented in Figure 3a.<table><tr><td>Condition</td><td>GW Out</td><td>GW In</td></tr><tr><td>Baseline (Existing)</td><td>8.77%</td><td>0.00%</td></tr></table></td><td>Figure 3a</td><td></td><td></td></tr>
<tr><td>Water Budget Results (SW6):</td><td>The baseline condition water budget results from the integrated at monitoring location SW6 are presented in Figure 4a.<table><tr><td>Condition</td><td>GW Out</td><td>GW In</td></tr><tr><td>Baseline (Existing)</td><td>9.70%</td><td>0.32%</td></tr></table></td><td>Figure 4a</td><td></td><td></td></tr>
<tr><td>Integrated Model Calibration:</td><td>A graph comparing simulated and observed flows at SW6 is provided in Graph 4. It should be noted that quarry discharge amounts are not specified in the model but are estimated based on simulated inflows to the quarry. As noted in Section 19.4.2 (p. 416) of the Earthfx report, the discharge to the south sump (upstream of SW6) was simulated with a set of “operating rules” and therefore also may not match the variations in the observed data. The rules defined a 5 day per week discharge rate, with an extra stage-dependent discharge rule that kept the internal quarry pond at a specified level. Actual operations were more intermittent, with spring pumping rates varied on a manual basis</td><td>Graph 4</td><td>HHIAR (Earthfx, April 2020)</td><td>19.4.2 (page 416)</td></tr>
</table>

<table>
<tr><th rowspan="2">Impact Assessment</th><th rowspan="2">Description</th><th rowspan="2">Figure / Graph / Table</th><th colspan="2">Reference</th></tr>
<tr><th>Report</th><th>Section / Page</th></tr>
<tr><td>Direct Alterations to Watercourse:</td><td>The only direct impact on this watercourse will be due to installation of an outlet from the temporary settling pond/sump outlet from the adjacent South Extension area. The outlet is expected to be constructed at the channel bank, although no detailed design has been completed to date. The outlet could be as simple as a pipe laid on the ground (given that it won’t be buried where it runs through the adjacent woodland), or it could require some structural measures (e.g., a headwall) to keep the outlet in place. Therefore, some minor disruption to the bed and banks of the watercourse could occur.</td><td></td><td>NETR (Savanta, April 2020)</td><td>75</td></tr>
<tr><td>Change in Primary Source of Flow:</td><td>Quarry discharge from Sump 0200 represents the major source of flow to the West Arm. Current quarry approvals permit this discharge to cease once quarry operations are complete. Cessation of quarry discharge into the West Arm would have a negative impact on flow available to support current fish habitat and fish community. As discussed in the Mitigation section below, it has been recommended that quarry discharge continue indefinitely at current levels to prevent these associated negative impacts.</td><td></td><td>NETR (Savanta, April 2020)</td><td>79</td></tr>
<tr><td>Change in Watercourse Catchment Area:</td><td>Reduction in catchment area of 11.7 ha. Quarry discharge from Sump 0200 represents the major source of flow to the West Arm. During Phase 1 operations, an additional source of flow will be from dewatering the Phase 1 and 2 extraction area. The quarry discharge from Sump 0200 is to continue throughout Phases 1 and 2 and no impacts are anticipated as a result of the reduction in catchment area.</td><td></td><td>SWA (Tatham, April 2020)</td><td>Drawings DP-1, DP-2 and DP-3</td></tr>
</table>

West Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek

<table>
<tr><th rowspan="2">Impact Assessment</th><th rowspan="2">Description</th><th rowspan="2">Figure / Graph / Table</th><th colspan="2">Reference</th></tr>
<tr><th>Report</th><th>Section / Page</th></tr>
<tr><td>Simulated Streamflow Change (Integrated Model Results):</td><td>The Earthfx report discusses changes in simulated streamflow under the different quarry expansion phases. Graph 5 reproduces Figure 8.8 (p. 202) and presents simulated baseline(red) and Scenario P12 (blue) flows at location approximately 800 m downstream of SW6. Increase in flow (green) are plotted in reverse on the upper X axis with the scale shown on the right Y axis. Streamflow is predicted to increase due to the discharge of water from dewatering the Phase 12 area. A similar figure (Graph 6) is reproduced for Phase 3456 (Figure 8.46, p. 236), although the upper X axis shows the decrease in streamflow (with positive values indicating an decrease in flow relative to baseline). Flows are generally lower in the winter and spring but higher in the summer and fall periods.</td><td>Graphs 5 & 6</td><td>HHIAR (Earthfx, April 2020)</td><td>198 - 203 and 230 - 237</td></tr>
<tr><td colspan="5">Water Budget Results 300 m Upstream of Monitoring Location SW6</td></tr>
<tr><td>Water Budget Results (Operational Phases 1 & 2):</td><td>The Operational Phases 1 and 2 water budget results from the integrated model 300 m upstream of monitoring location SW6 are presented in Figure 3b.
<table>
<tr><td>Condition</td><td>GW Outflow</td><td>GW Inflow</td><td>%Δ GW Outflow</td><td>%Δ GW Inflow</td></tr>
<tr><td>Baseline (Existing)</td><td>8.77%</td><td>0.00%</td><td>-</td><td>-</td></tr>
<tr><td>Phases 1 & 2</td><td>4.81%</td><td>0.00%</td><td>-3.96%</td><td>0.00%</td></tr>
</table></td><td>Figure 3b</td><td></td><td></td></tr>
<tr><td>Water Budget Results (Operational Phases 3 Through 6):</td><td>The Operational Phases 3 through 6 water budget results from the integrated model 300 m upstream of monitoring location SW6are presented in Figure 3c.
<table>
<tr><td>Condition</td><td>GW Outflow</td><td>GW Inflow</td><td>%Δ GW Outflow</td><td>%Δ GW Inflow</td></tr>
<tr><td>Baseline (Existing)</td><td>8.77%</td><td>0.00%</td><td>-</td><td>-</td></tr>
<tr><td>Phases 3 through 6</td><td>5.66%</td><td>0.00%</td><td>-3.17%</td><td>0.00%</td></tr>
</table></td><td>Figure 3c</td><td></td><td></td></tr>
<tr><td>Water Budget Results (Rehabilitation Scenario 1):</td><td>The Rehabilitation Scenario 1 water budget results from the integrated model 300 m upstream of monitoring location SW6are presented in Figure 3d.
<table>
<tr><td>Condition</td><td>GW Outflow</td><td>GW Inflow</td><td>%Δ GW Outflow</td><td>%Δ GW Inflow</td></tr>
<tr><td>Baseline (Existing)</td><td>8.77%</td><td>0.00%</td><td>-</td><td>-</td></tr>
<tr><td>Rehab Scenario 1</td><td>4.83%</td><td>0.00%</td><td>-3.94%</td><td>0.00%</td></tr>
</table></td><td>Figure 3d</td><td></td><td></td></tr>
<tr><td>Water Budget Results (Rehabilitation Scenario 2):</td><td>The Rehabilitation Scenario 2 water budget results from the integrated model 300 m upstream of monitoring location SW6are presented in Figure 3e.
<table>
<tr><td>Condition</td><td>GW Outflow</td><td>GW Inflow</td><td>%Δ GW Outflow</td><td>%Δ GW Inflow</td></tr>
<tr><td>Baseline (Existing)</td><td>8.77%</td><td>0.00%</td><td>-</td><td>-</td></tr>
<tr><td>Rehab Scenario 2</td><td>6.56%</td><td>0.00%</td><td>-2.21%</td><td>0.00%</td></tr>
</table></td><td>Figure 3e</td><td></td><td></td></tr>
</table>

West Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek

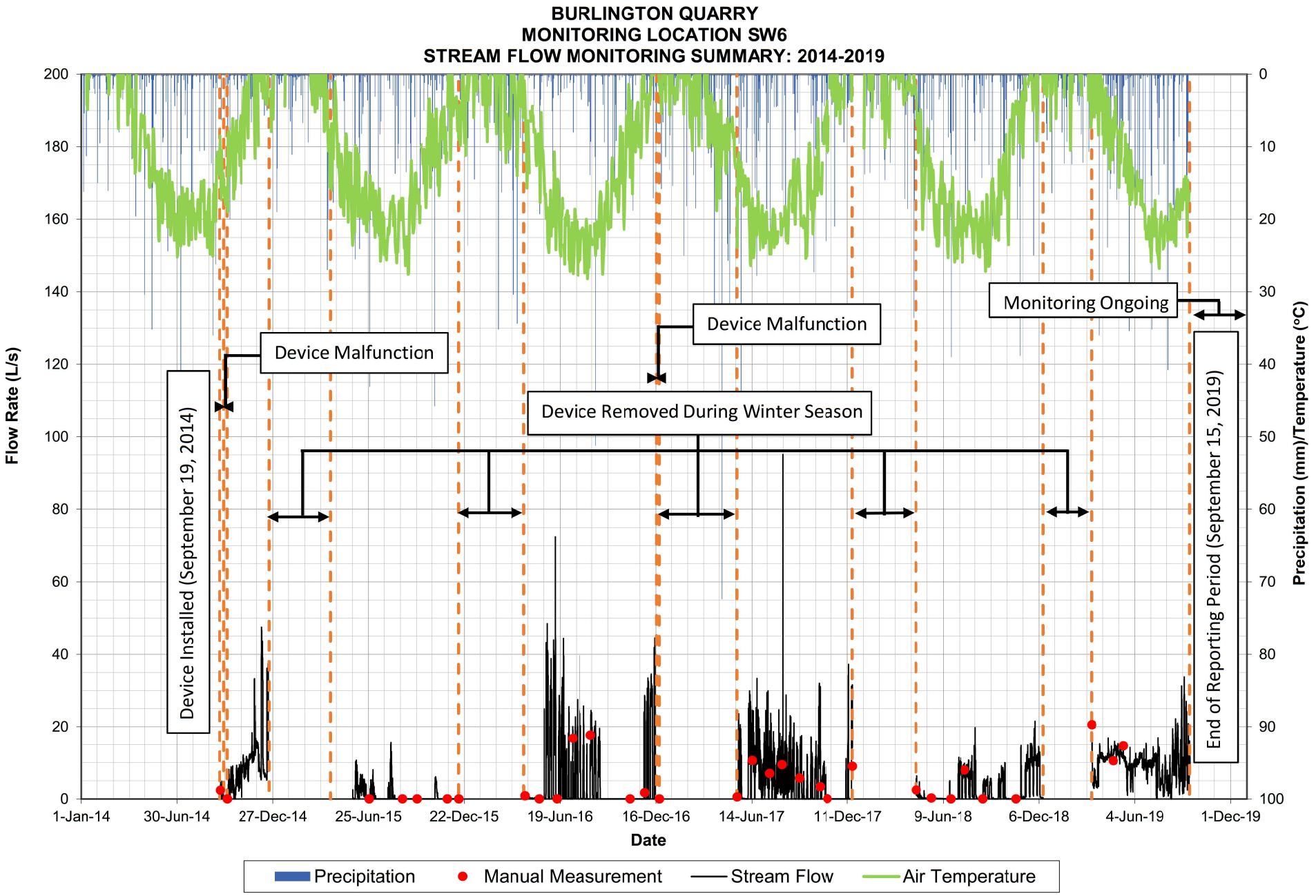
<table>
<tr><th>Impact Assessment</th><th>Description</th><th>Figure / Graph / Table</th><th colspan="2">Reference</th></tr>
<tr><th></th><th></th><th></th><th>Report</th><th>Section / Page</th></tr>
<tr><td colspan="5">Water Budget Results at Monitoring Location SW6</td></tr>
<tr><td>Water Budget Results (Operational Phases 1 & 2):</td><td>The Operational Phases 1 and 2 water budget results from the integrated model at monitoring location SW6 are presented in Figure 4b.
<table><tr><td>Condition</td><td>GW Outflow</td><td>GW Inflow</td><td>%Δ GW Outflow</td><td>%Δ GW Inflow</td></tr><tr><td>Baseline (Existing)</td><td>9.70%</td><td>0.32%</td><td>-</td><td>-</td></tr><tr><td>Phases 1 & 2</td><td>10.07%</td><td>0.00%</td><td>0.37%</td><td>-0.32%</td></tr></table></td><td>Figure 4b</td><td></td><td></td></tr>
<tr><td>Water Budget Results (Operational Phases 3 Through 6):</td><td>The Operational Phases 3 through 6 water budget results from the integrated model at monitoring location SW6 are presented in Figure 4c.
<table><tr><td>Condition</td><td>GW Outflow</td><td>GW Inflow</td><td>%Δ GW Outflow</td><td>%Δ GW Inflow</td></tr><tr><td>Baseline (Existing)</td><td>9.70%</td><td>0.32%</td><td>-</td><td>-</td></tr><tr><td>Phases 3 through 6</td><td>7.92%</td><td>0.02%</td><td>-1.78%</td><td>-0.30%</td></tr></table></td><td>Figure 4c</td><td></td><td></td></tr>
<tr><td>Water Budget Results (Rehabilitation Scenario 1):</td><td>The Rehabilitation Scenario 1 water budget results from the integrated model at monitoring location SW6 are presented in Figure 4d.
<table><tr><td>Condition</td><td>GW Outflow</td><td>GW Inflow</td><td>%Δ GW Outflow</td><td>%Δ GW Inflow</td></tr><tr><td>Baseline (Existing)</td><td>9.70%</td><td>0.32%</td><td>-</td><td>-</td></tr><tr><td>Rehab Scenario 1</td><td>6.13%</td><td>0.09%</td><td>-3.57%</td><td>-0.23%</td></tr></table></td><td>Figure 4d</td><td></td><td></td></tr>
<tr><td>Water Budget Results (Rehabilitation Scenario 2):</td><td>The Rehabilitation Scenario 2 water budget results from the integrated model at monitoring location SW6 are presented in Figure 4e.
<table><tr><td>Condition</td><td>GW Outflow</td><td>GW Inflow</td><td>%Δ GW Outflow</td><td>%Δ GW Inflow</td></tr><tr><td>Baseline (Existing)</td><td>9.70%</td><td>0.32%</td><td>-</td><td>-</td></tr><tr><td>Rehab Scenario 2</td><td>8.76%</td><td>2.06%</td><td>-0.94%</td><td>1.74%</td></tr></table></td><td>Figure 4e</td><td></td><td></td></tr>
<tr><td>Change in Groundwater Contributions to Watercourse:</td><td>Groundwater seepage to the watercourse catchment under Baseline conditions is shown in Graph 7. Under P12 conditions, the dewatering associated with the excavation will reduce that seepage to zero. Under P12 conditions, the leakage from the watercourse will increase. This includes the effect of changes in the south quarry discharge.</td><td>Graphs 7 and 8</td><td></td><td></td></tr>
<tr><td>Change in Watercourse Thermal Regime:</td><td>Negative changes in water temperature are not expected given that the watercourse will continue to receive its primary input from quarry discharge. Temperature of water being discharge from Quarry Sump 0200 is not expected to change as a result of the proposed Quarry Extension, therefore, no change in water temperature is anticipated.</td><td></td><td>NETR (Savanta, April 2020)</td><td>79</td></tr>
<tr><td>Change in Water Quality:</td><td>1) Negative changes on water quality are not expected given that the watercourse will continue to receive its primary input from quarry discharge. Quality of water being discharged from Quarry Sump 0200 is not expected to change as a result of the proposed Quarry Extension, therefore, no change in water quality in the major source of inflow is expected.

2) Discharge from the temporary settling pond/sump from the South Extension will meet water quality discharge objectives. Therefore, no negative impacts on water quality are expected.</td><td></td><td>NETR (Savanta, April 2020)</td><td>79</td></tr>
<tr><td>Potential Impact to Form and Function of Feature:</td><td>Alterations to quarry discharge (if unmitigated) could potentially have negative impacts on the form and habitat functions of this watercourse.</td><td></td><td>NETR (Savanta, April 2020)</td><td>79</td></tr>
<tr><td>Potential Impact to Identified Species and Habitat:</td><td>Alterations to quarry discharge (if unmitigated) could potentially have negative impacts on the species and habitat functions of this watercourse.</td><td></td><td>NETR (Savanta, April 2020)</td><td>79</td></tr>
</table>

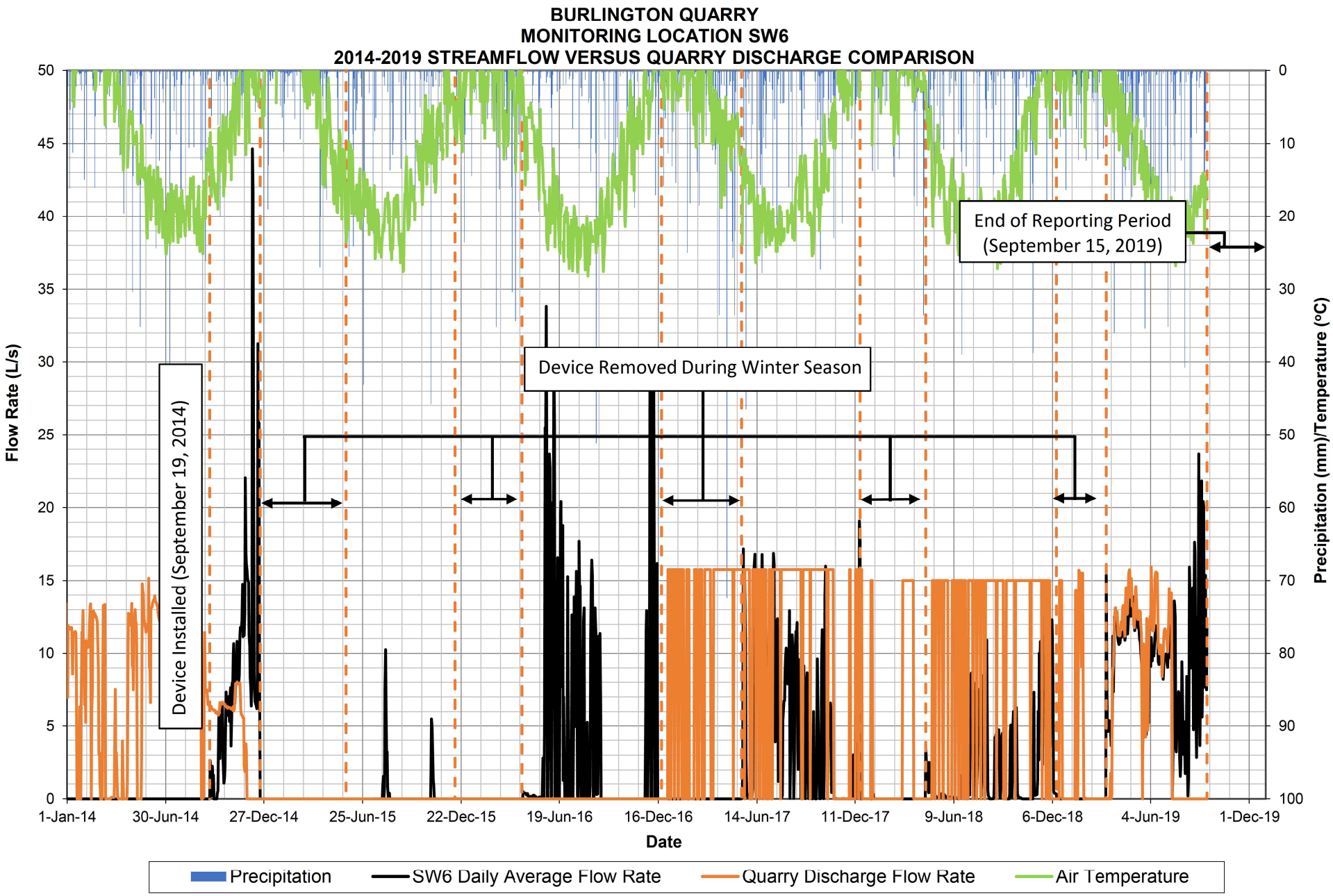
West Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek

Mitigation	Description	Figure / Graph / Table	Reference	
			Report	Section / Page
Direct Alteration Mitigation:	1) In-water work required to install the settling pond/sump outlet is recommended to be completed between July 16 and March 14 to minimize the potential for direct and indirect impacts on the reproductive activities of the fish community in the West Arm. 2)Erosion and sedimentation control measures and spill prevention and response measures will be used throughout the duration of any in-stream works in the watercourse. Work-site isolation measures should be considered depending on the final design of the outlet and proposed installation methodology and location. 3) Any riparian areas disturbed during installation of the outlet should be rehabilitated with appropriate native vegetation species following installation of the outlet structure.		NETR (Savanta, April 2020)	75
Source Water Mitigation:	In order to mitigate impacts on fish and fish habitat in the West Arm, pumping and discharge are recommended to occur at the same location at the upstream end of watercourse and in the same manner as existing pumping in accordance with the existing PTTW and Environmental Compliance Approvals regulating current quarry discharge.		NETR (Savanta, April 2020)	79
Groundwater Contribution Mitigation:	None required. Predicted reductions in groundwater contribution to the West Arm are 0.32% or 0.08 L/s or less.			
Erosion Mitigation:	Erosion and sedimentation control measures and spill prevention and response measures will be used throughout the duration of any in-stream works in the watercourse. Work-site isolation measures should be considered depending on the final design of the outlet and proposed installation methodology and location.			
Thermal Mitigation:	No specific thermal mitigation is proposed given that maintaining existing quarry outflows at Sump 0200 are expected to maintain the existing thermal regime of the watercourse without any additional mitigation.		NETR (Savanta, April 2020)	79
Water Quality Mitigation:	1) No specific water quality mitigation over and above that of the existing quarry operations is proposed given that maintaining existing quarry outflows at Sump 0200 are expected to maintain the existing water quality regime of the watercourse without any additional mitigation. The quarry extension is not predicted to result in any changes in the quality of water being discharged from Sump 0200. 2) The temporary settling pond and longer-term sump that will discharge to the West Arm will be required to meet discharge water quality criteria with respect to total suspended solids and other potential contaminants.		NETR (Savanta, April 2020)	79

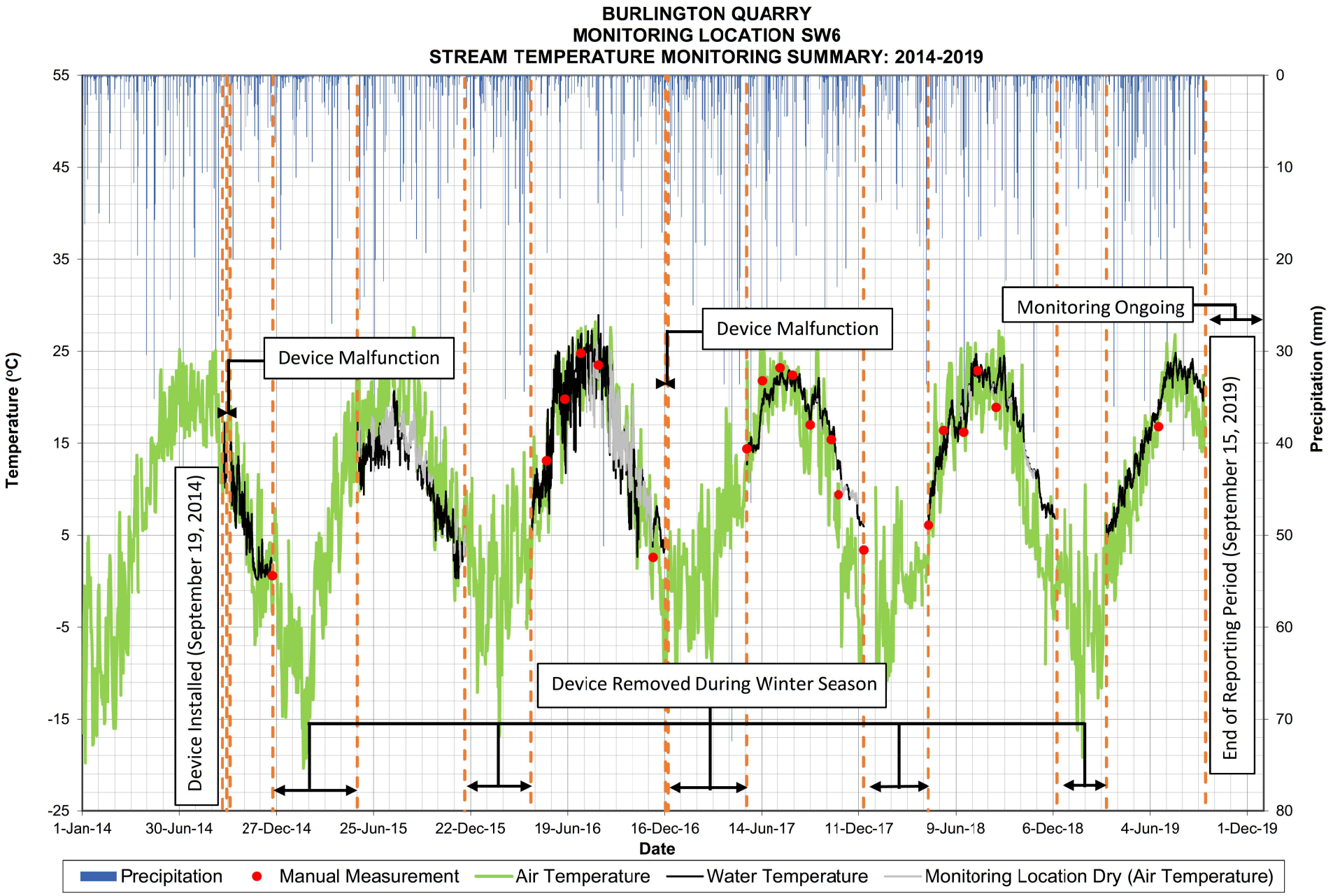
WEST ARM OF THE WEST BRANCH OF THE MOUNT NEMO TRIBUTARY OF GRINDSTONE CREEK - GRAPH 1



WEST ARM OF THE WEST BRANCH OF THE MOUNT NEMO TRIBUTARY OF GRINDSTONE CREEK - GRAPH 2



WEST ARM OF THE WEST BRANCH OF THE MOUNT NEMO TRIBUTARY OF GRINDSTONE CREEK - GRAPH 3



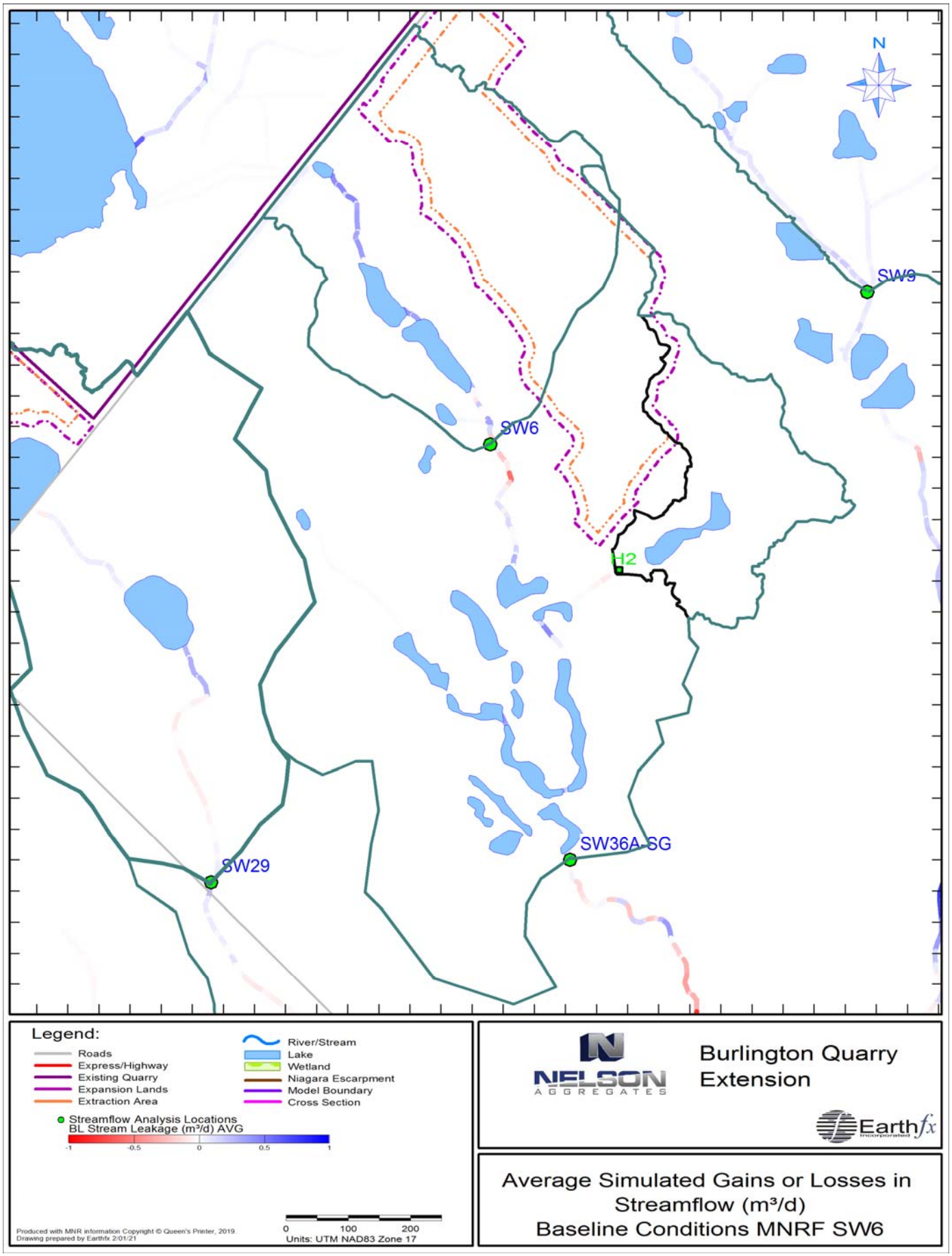
* Grey data indicates the monitoring location was dry and therefore the recorded values are respresentative of the air temperature.

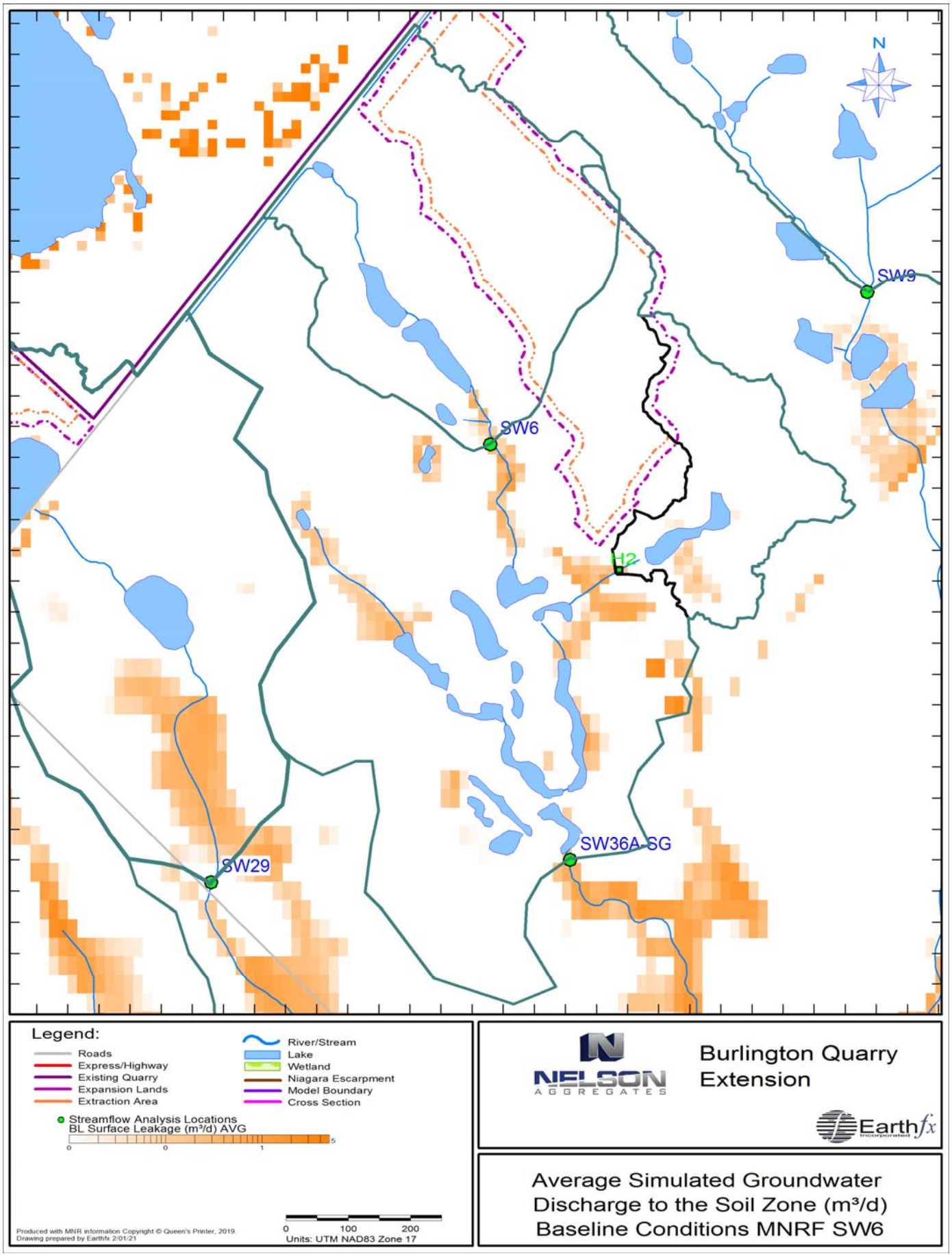
WEST ARM OF THE WEST BRANCH OF THE MOUNT NEMO TRIBUTARY OF GRINDSTONE CREEK - TABLE 1

BURLINGTON QUARRY
TATHAM ENGINEERING PROJECT NO.: 113187
SURFACE WATER MONITORING

WATER QUALITY SAMPLE RESULTS

Monitoring Location SW6													
		Sample Date:	24-Oct-18	24-Apr-19	19-Jun-19	25-Sep-19	20-May-20	15-Jul-20	16-Sep-20	11-Nov-20	Maximum	Minimum	Average
Parameter:	Units:	M.D.L.	CM/JG	CM/JG	CM	CM	JG	JG/JH/JM	JH/JM	JG/JH			
M-Alkalinity (pH 4.5)	mg/L as CaCO3	2		170	172	137	169	125			172	137	160
Ammonia (as N)	mg/L	0.01		<0.01	0.04	0.02	<0.01	<0.01			0.04	0.02	0.02
BOD (5 day)	mg/L	1		0.9	<0.9	0.9	<1	<1			0.9	0.9	0.9
Bicarbonate	mg/L as CaCO3	1		169		136		124			169	136	102
Carbonate	mg/L as CaCO3	1		1		<1		<1			1	1	1
Conductivity	µS/cm	1		798	843	934	975	1020			934	798	858
Dissolved Organic Carbon	mg/L	0.4		2.7	3	3.4	2.2	3.4			3.4	2.7	3.0
Field pH	pH	N/A			8.4	8.7	8.4				8.7	8.4	5.7
Field Temp	°C	N/A			15.1	16.1	17.2				16.1	15.1	10.4
Aluminum	ug/L	1		6	2	<1	<1	<1			6	2	3
Antimony	ug/L	0.5		<0.5	<0.5	<0.5	<0.5	<0.5			<0.5	<0.5	0.5
Arsenic	ug/L	1		2	3	4	2	6			4	2	3
Barium	ug/L	1		31	30	32	33	23			32	30	31
Beryllium	ug/L	0.5		<0.5	<0.5	<0.5	<0.5	<0.5			<0.5	<0.5	0.5
Bismuth	ug/L	1		<1	<1	<1	<1	<1			<1	<1	1
Boron	ug/L	2		66	71	160	116	157			160	66	99
Cadmium	ug/L	0.1		<0.1	<0.1	<0.1	<0.1	<0.1			<0.1	<0.1	0.1
Calcium	ug/L	500		85600	85900	74700	87100	80800			85900	74700	82067
Cerium	ug/L	1		<1	<1	<1	<1	<1			<1	<1	1
Cesium	ug/L	1		<1	<1	<1	<1	<1			<1	<1	1
Chromium	ug/L	1		3	3	3	2	1			3	3	3
Cobalt	ug/L	0.1		0.2	0.2	0.1	0.2	0.2			0.2	0.1	0.2
Copper	ug/L	1		<1	4	<1	2	2			4	4	2
Europium	ug/L	1		<1	<1	<1	<1	<1			<1	<1	1
Gallium	ug/L	1		<1	<1	<1	<1	<1			<1	<1	1
Iron	ug/L	20		89	211	180	282	180			211	89	160
Lanthanum	ug/L	1		<1	<1	<1	<1	<1			<1	<1	1
Lead	ug/L	0.1		<0.1	<0.1	<0.1	<0.1	<0.1			<0.1	<0.1	0.1
Lithium	ug/L	5		10	11	13	14	23			13	10	11
Magnesium	ug/L	5		35500	39100	41300	45500	42300			41300	35500	38633
Manganese	ug/L	10	DRY	<1	31	15	8	37	DRY	DRY	31	15	19
Mercury	ug/L	0.1		<0.1	<0.1	<0.1	<0.1	<0.1			<0.1	<0.1	0.1
Molybdenum	ug/L	1		4	4	3	4	5			4	3	4
Nickel	ug/L	1		4	4	3	4	3			4	3	4
Niobium	ug/L	1		<1	<1	<1	<1	<1			<1	<1	1
Phosphorus	ug/L	50		<50	<50	<50	<50	<50			<50	<50	50
Potassium	ug/L	1		3980	4380	6510	4950	6480			6510	3980	4957
Rubidium	ug/L	1		2	2	3	2	3			3	2	2
Scandium	ug/L	1		<1	<1	<1	<1	<1			<1	<1	1
Selenium	ug/L	0.5		1.7	1.1	0.9	2.2	<0.5			1.7	0.9	1.2
Silicon	ug/L	2		670	900	1230	500	1550			1230	670	933
Silver	ug/L	0.1		<0.1	<0.1	<0.1	<0.1	<0.1			<0.1	<0.1	0.1
Sodium	ug/L	1000		30400	36800	46100	48200	44500			46100	30400	37767
Strontium	ug/L	1		1270	1190	1380	1310	1440			1380	1190	1280
Sulphur	ug/L	800		63600	74400	79100	82400	83800			79100	63600	72367
Tellurium	ug/L	1		<1	<1	<1	<1	<1			<1	<1	1
Thallium	ug/L	0.1		<0.1	<0.1	<0.1	<0.1	<0.1			<0.1	<0.1	0.1
Thorium	ug/L	1		<1	<1	<1	<1	<1			<1	<1	1
Tin	ug/L	1		<1	<1	<1	<1	<1			<1	<1	1
Titanium	ug/L	1		2	<1	<1	<1	<1			2	2	1
Tungsten	ug/L	1		<1	<1	<1	<1	<1			<1	<1	1
Uranium	ug/L	1		<1	<1	<1	1	1			<1	<1	1
Vanadium	ug/L	1		<1	<1	<1	<1	<1			<1	<1	1
Yttrium	ug/L	1		<1	<1	<1	<1	<1			<1	<1	1
Zinc	ug/L	1		<1	3	1	3	3			3	1	2
Zirconium	ug/L	1		<1	<1	<1	<1	<1			<1	<1	1
pH	pH	N/A		7.89	7.82	7.85	8.24	7.66			7.9	7.8	7.9
Total Hardness (as CaCO3)	mg/L	0.1		360	376	357	405	376			376	357	364
Chemical Oxygen Demand	mg/L	5		8	12	<5	<5	<5			12	8	8
Total Dissolved Solids	mg/L	3		593	631	695	709	724			695	593	640
Total Suspended Solids	mg/L	0.67		<0.67	<0.67	2	1	<0.67			2.00	2.00	1.11
Turbidity	NTU	0.1		0.5	0.4	0.2	0.4	0.2			0.5	0.2	0.4


N
SW9
SW6
H2
SW36A-SG
SW29
Legend:
Roads
Express/Highway
Existing Quarry
Expansion Lands
Extraction Area
River/Stream
Lake
Wetland
Niagara Escarpment
Model Boundary
Cross Section
Streamflow Analysis Locations
BL Stream Leakage (m³/d) AVG
-1
-0.5
0
0.5
1
0
100
200
Units: UTM NAD83 Zone 17
Produced with MNR information Copyright © Queen's Printer, 2019.
Drawing prepared by Earthfx 2/01/21
NELSON AGGREGATES
Burlington Quarry Extension
Earthfx Incorporated
Average Simulated Gains or Losses in Streamflow (m³/d)
Baseline Conditions MNRF SW6


N
SW9
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H2
SW36A-SG
SW29
Legend:
Roads
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Streamflow Analysis Locations
BL Surface Leakage (m³/d) AVG
0
0
1
5
0
100
200
Units: UTM NAD83 Zone 17
Produced with MNR information Copyright © Queen's Printer, 2019.
Drawing prepared by Earthfx 2/01/21
NELSON AGGREGATES
Burlington Quarry Extension
Earthfx Incorporated
Average Simulated Groundwater Discharge to the Soil Zone (m³/d)
Baseline Conditions MNRF SW6

FIGURE 3A

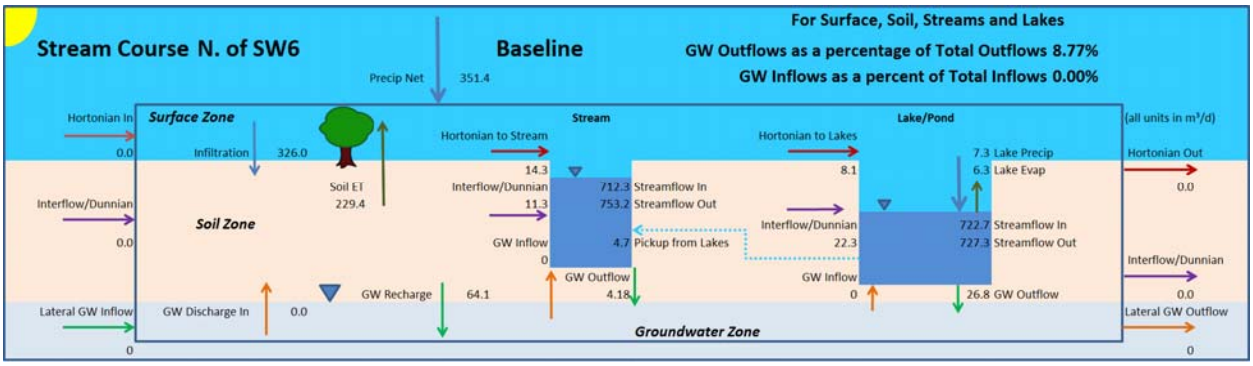


FIGURE 3B

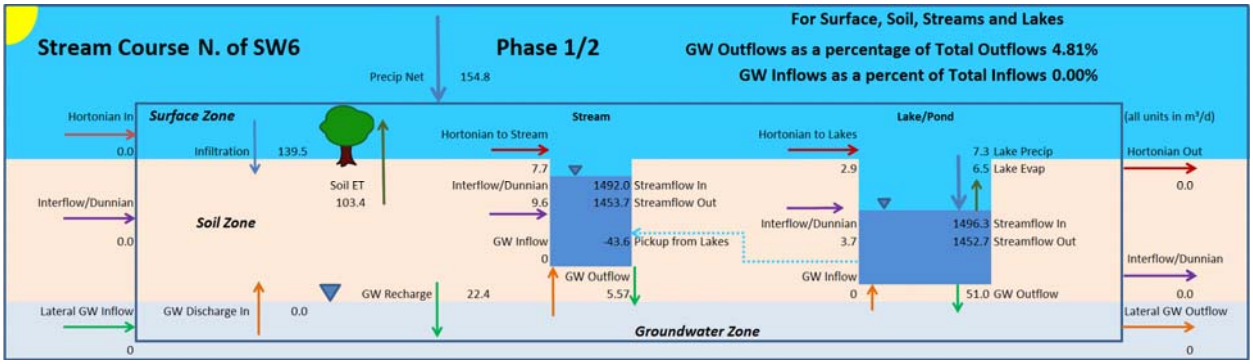


FIGURE 3C

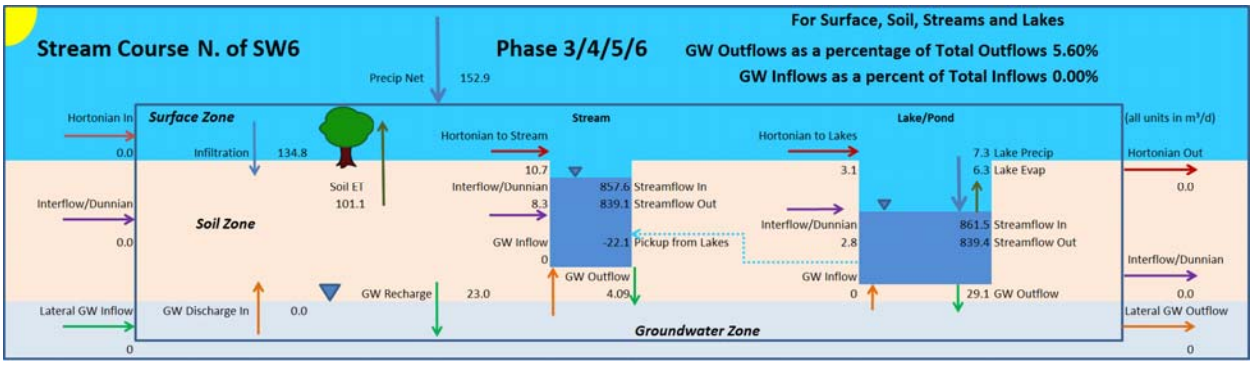


FIGURE 3D

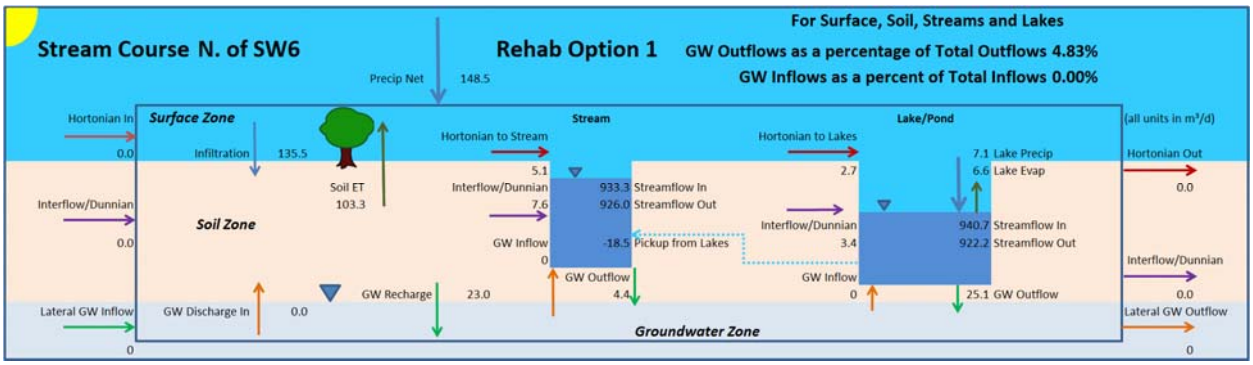


FIGURE 3E

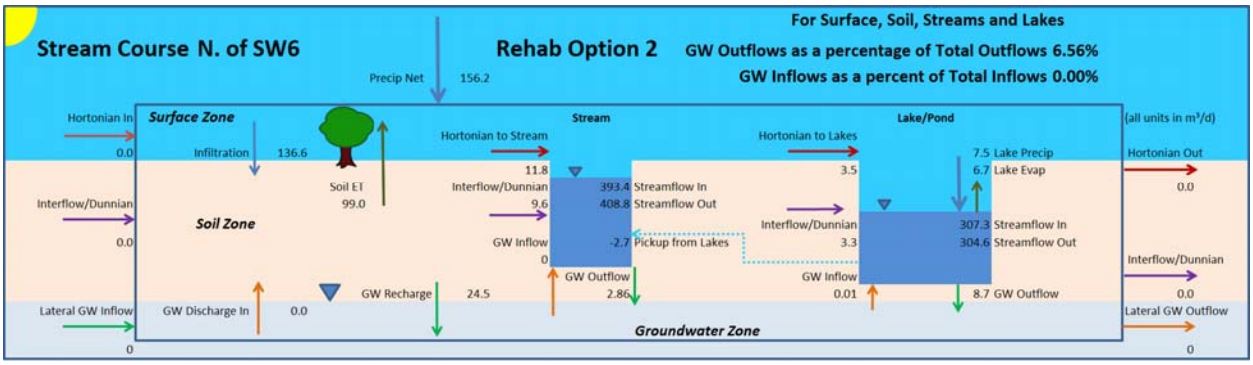


FIGURE 4A

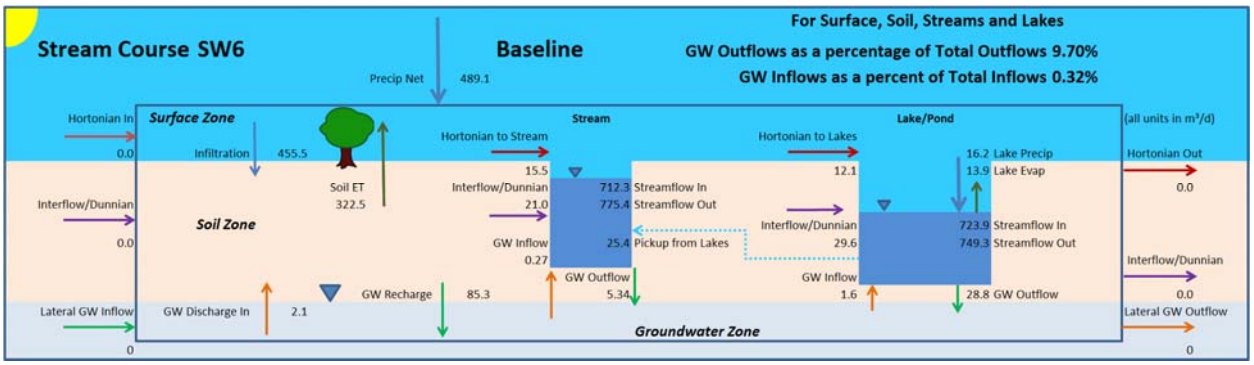


FIGURE 4B

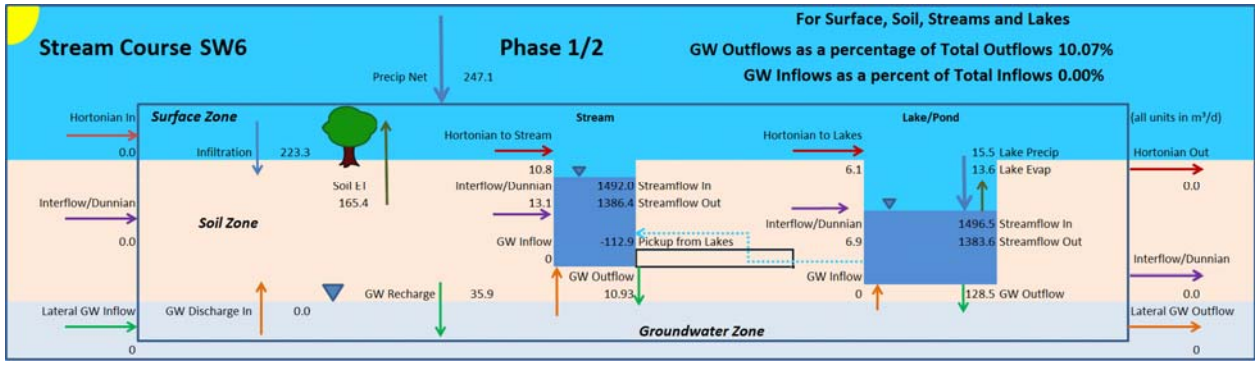


FIGURE 4C

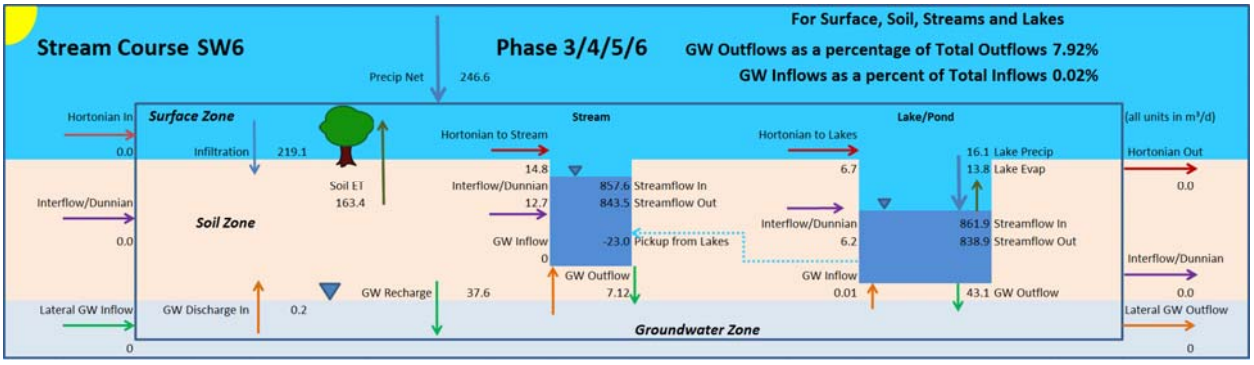


FIGURE 4D

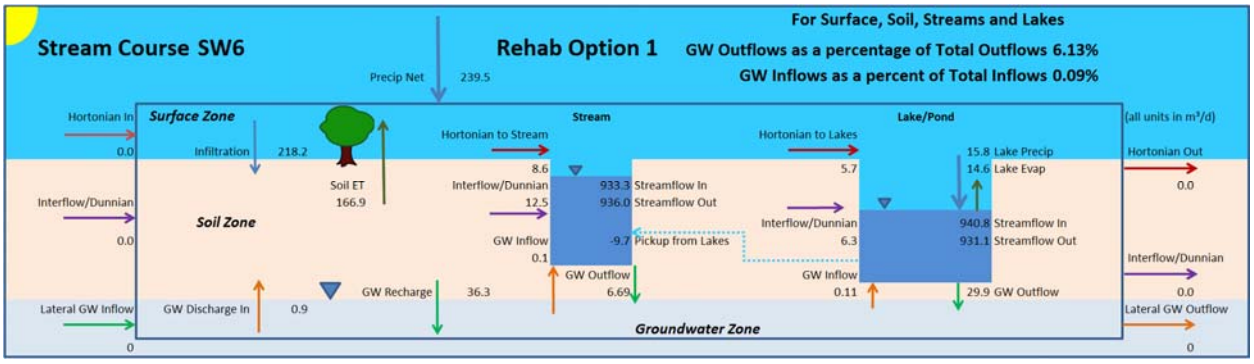
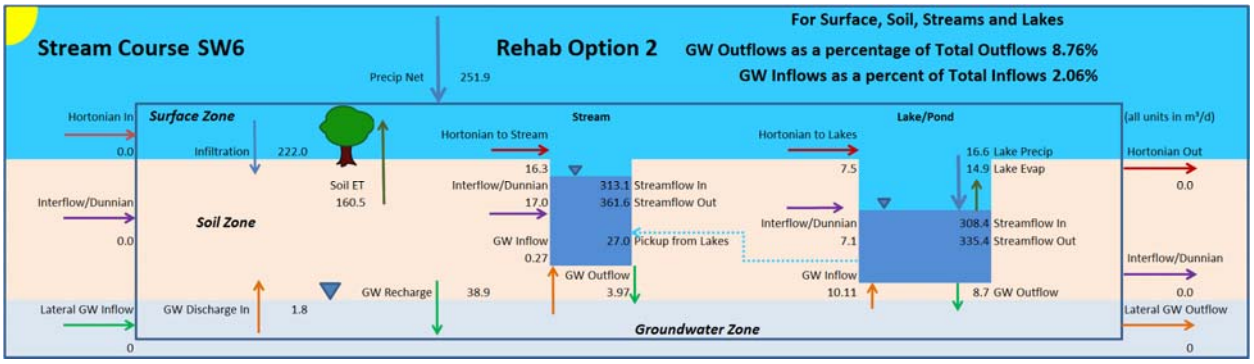
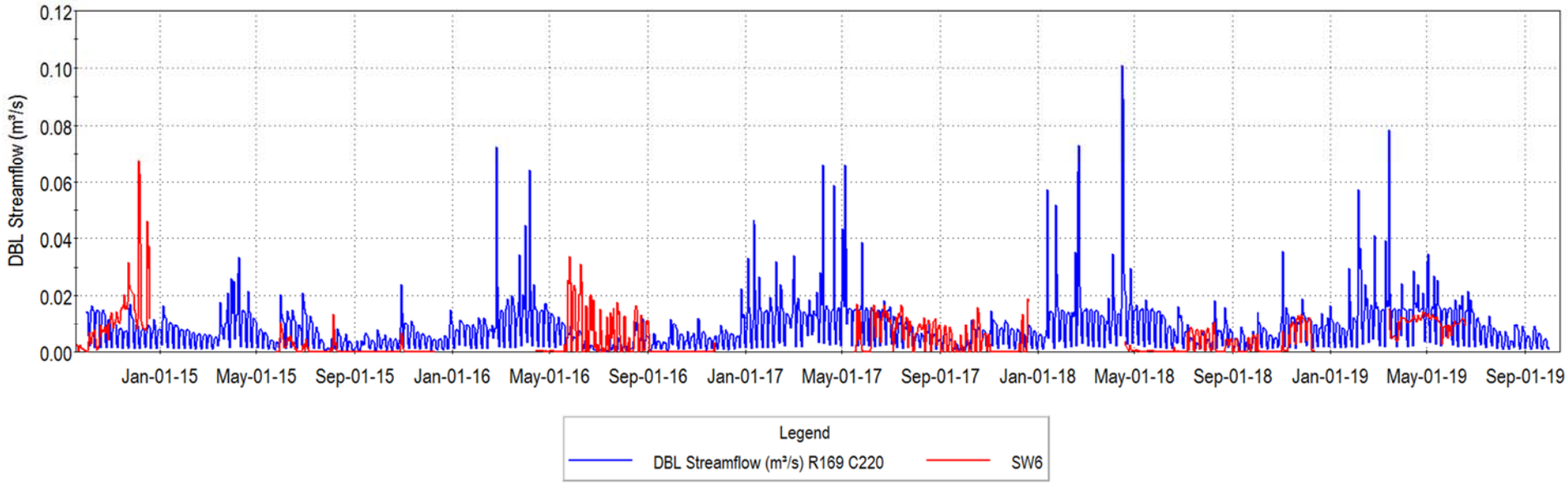


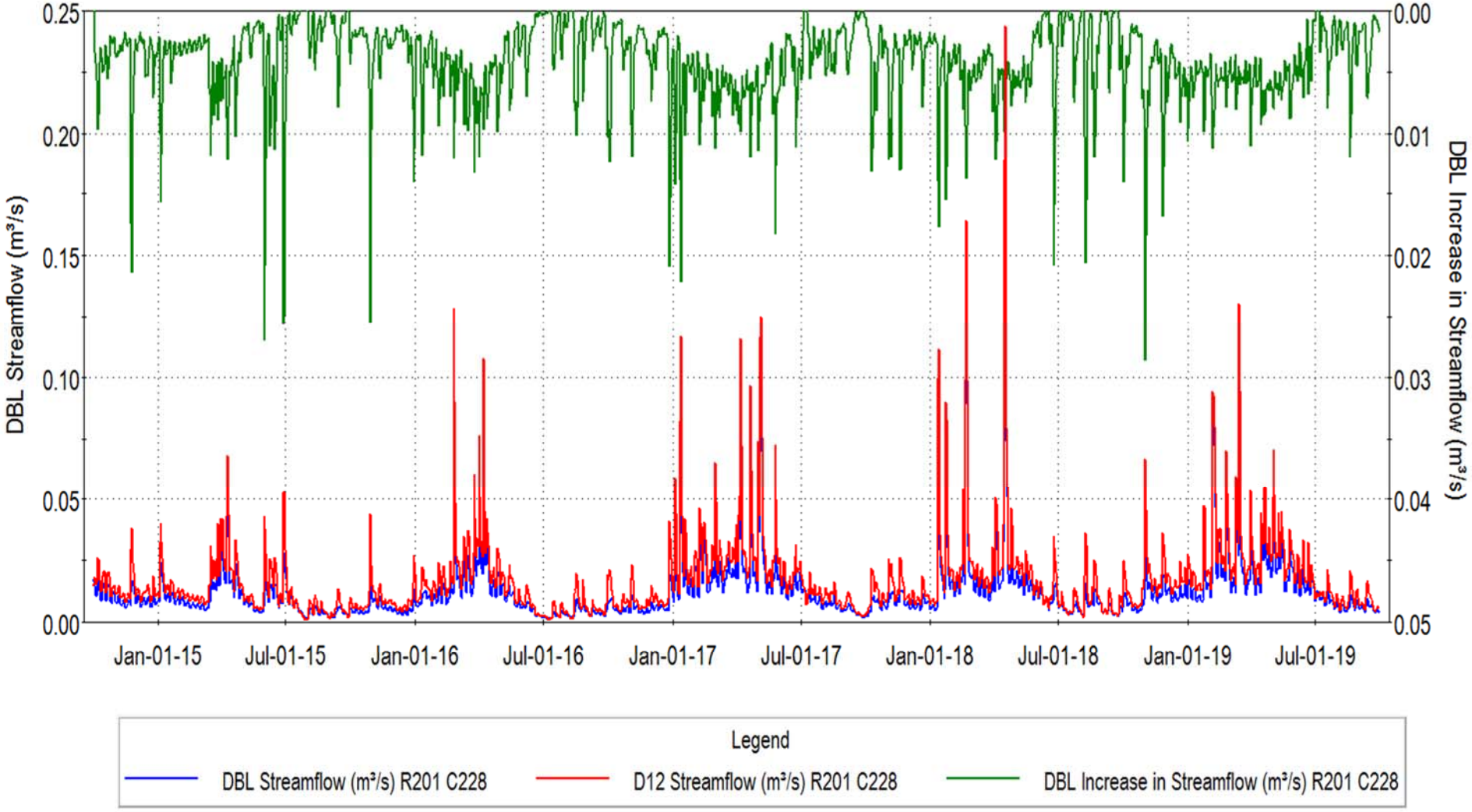
FIGURE 4E



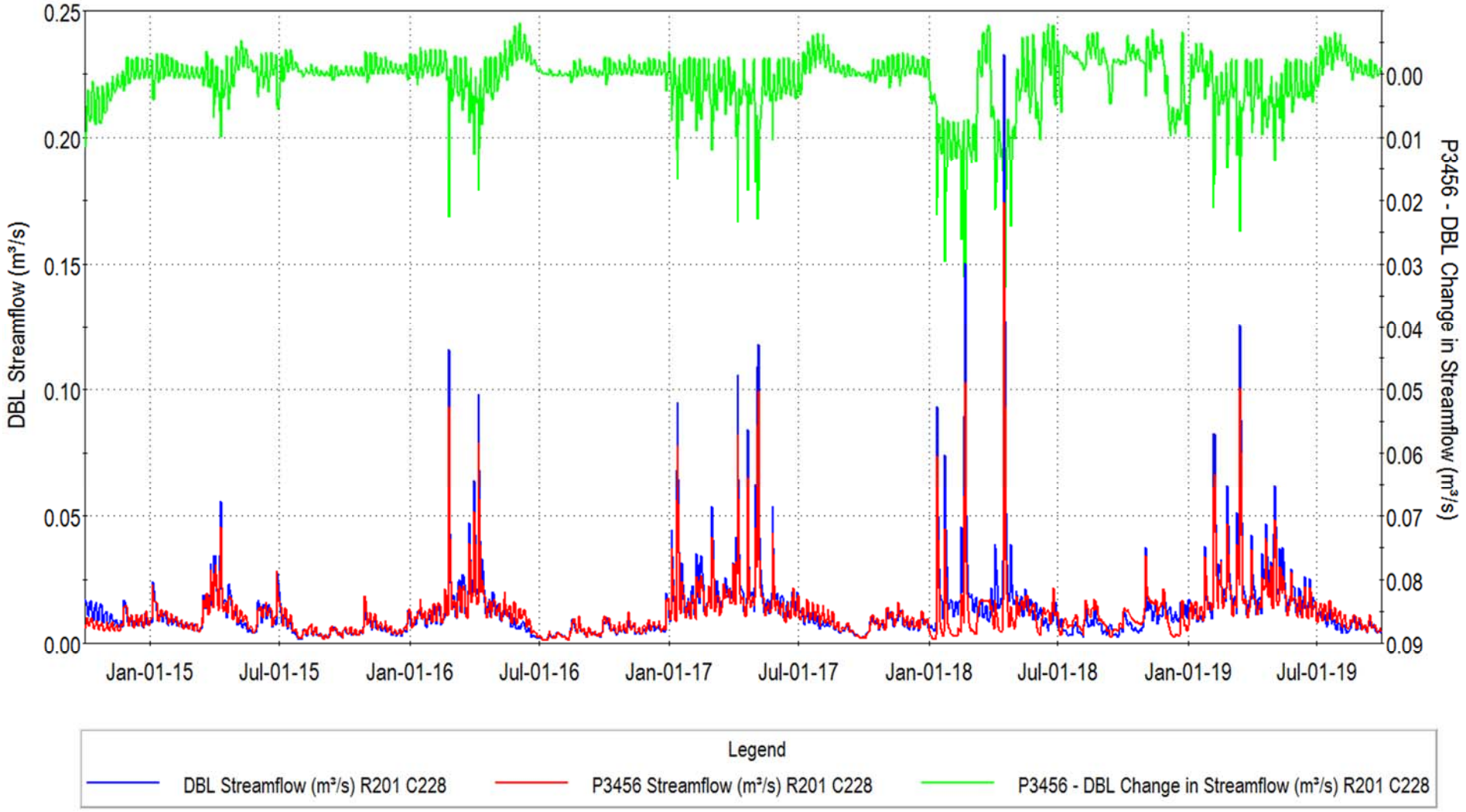
Integrated Model Calibration
West Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek



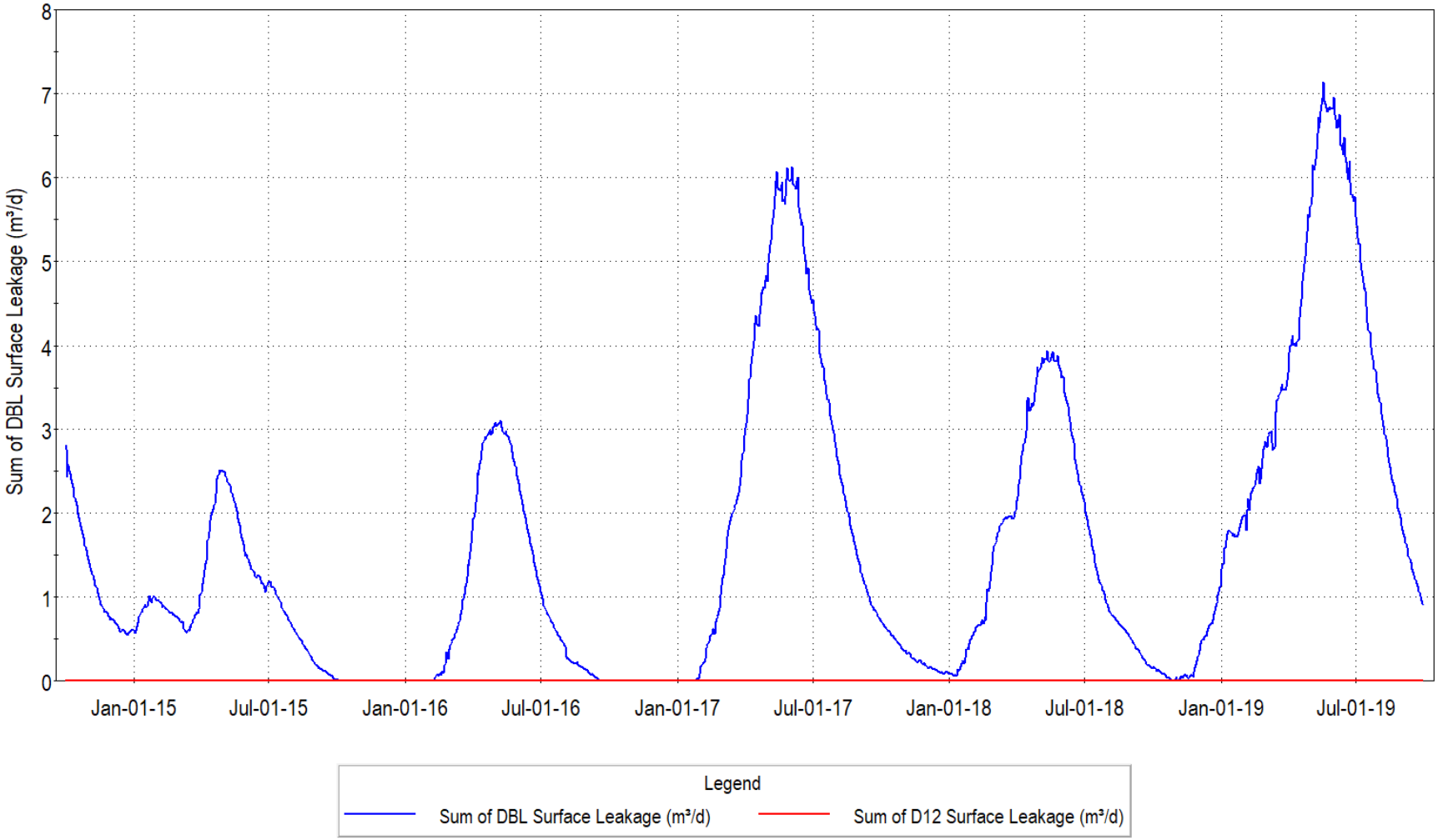
Simulated Streamflow Change - Integrated Model
West Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek



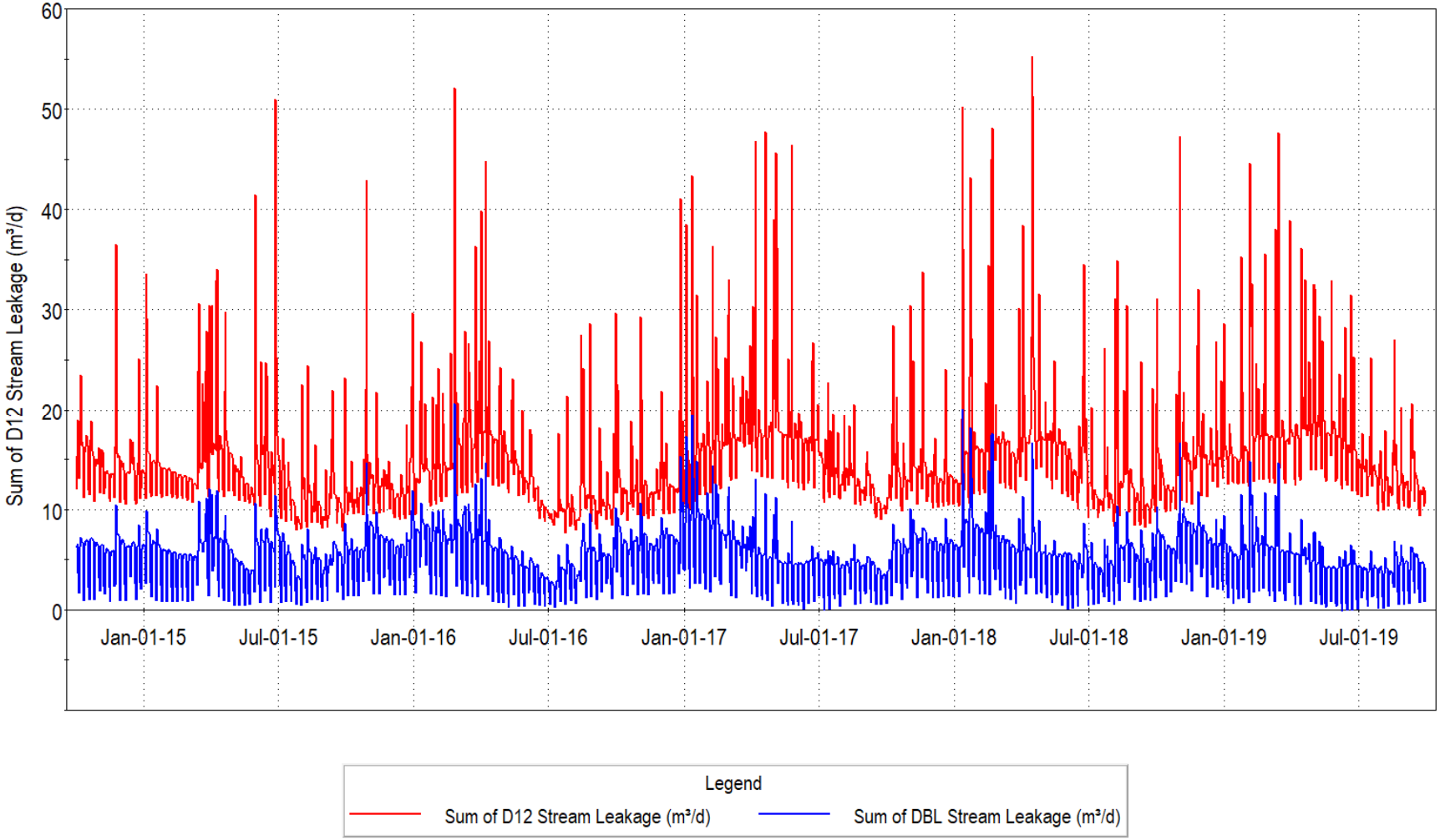
Simulated Streamflow Change - Integrated Model
West Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek



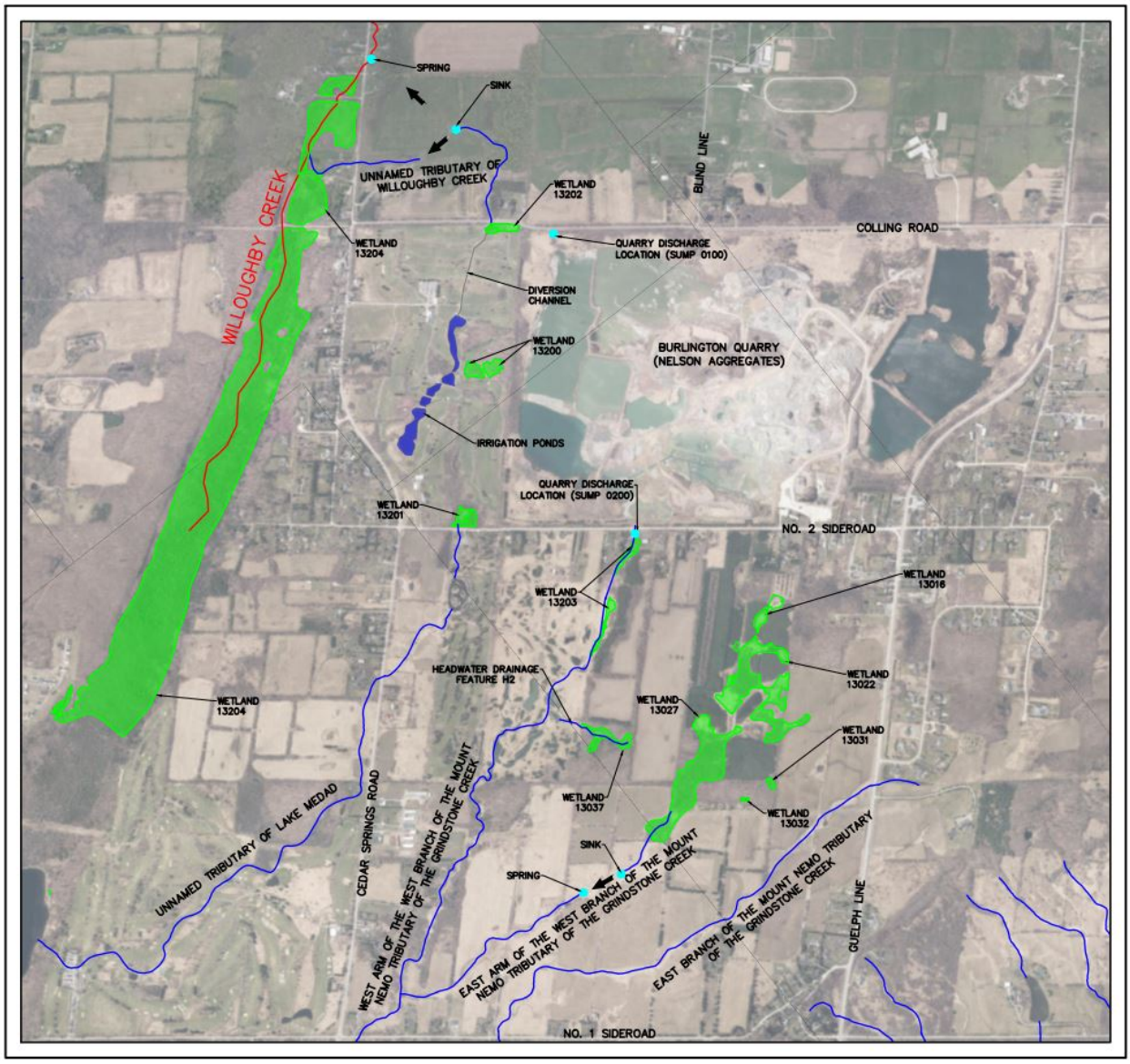
Change in Groundwater Contributions to Watercourse
West Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek

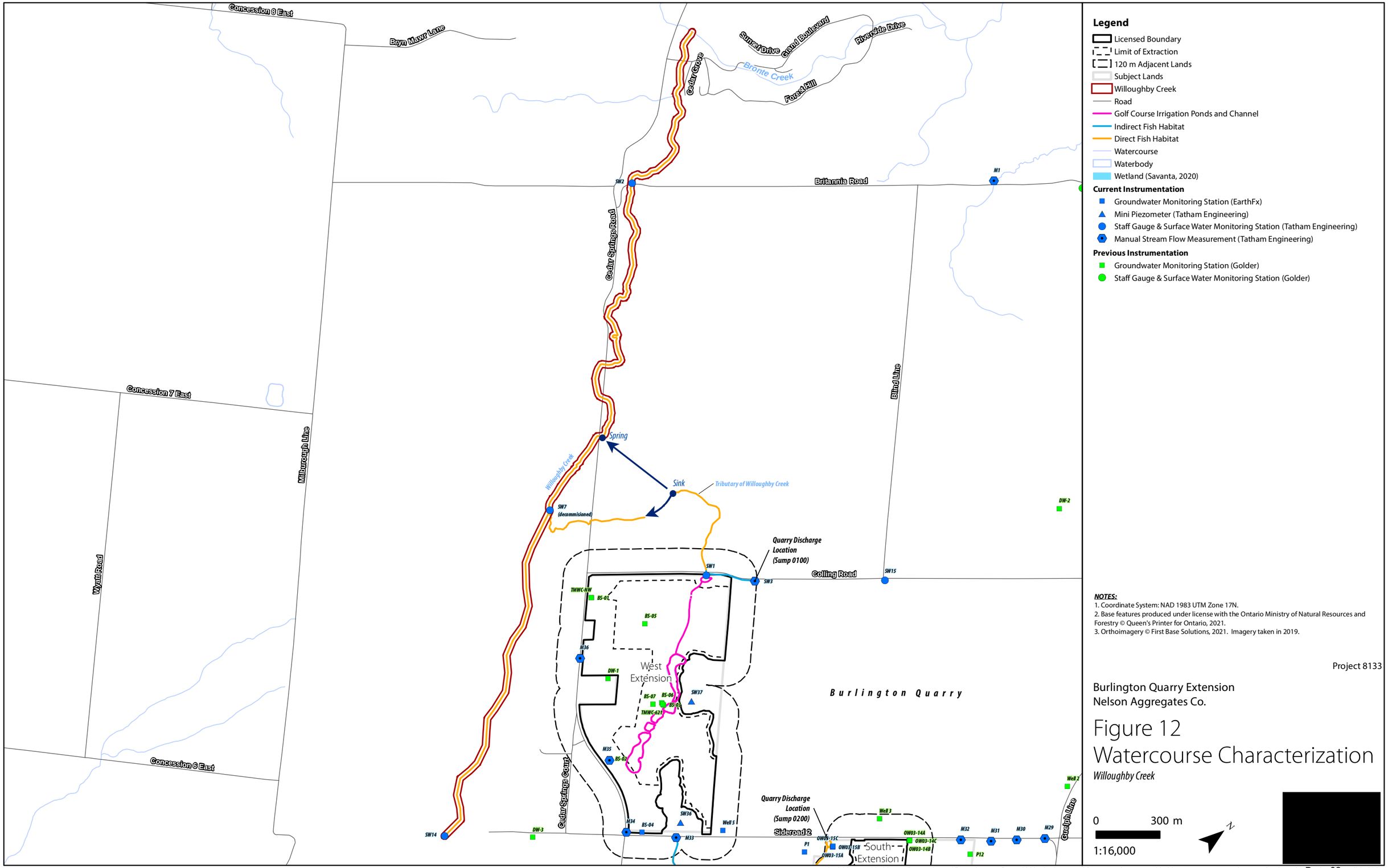


Change in Groundwater Contributions to Watercourse
West Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek



WILLOUGHBY CREEK





Legend

- Licensed Boundary
- Limit of Extraction
- 120 m Adjacent Lands
- Subject Lands
- Willoughby Creek
- Road
- Golf Course Irrigation Ponds and Channel
- Indirect Fish Habitat
- Direct Fish Habitat
- Watercourse
- Waterbody
- Wetland (Savanta, 2020)

Current Instrumentation

- Groundwater Monitoring Station (EarthFx)
- Mini Piezometer (Tatham Engineering)
- Staff Gauge & Surface Water Monitoring Station (Tatham Engineering)
- Manual Stream Flow Measurement (Tatham Engineering)

Previous Instrumentation

- Groundwater Monitoring Station (Golder)
- Staff Gauge & Surface Water Monitoring Station (Golder)

NOTES:

1. Coordinate System: NAD 1983 UTM Zone 17N.
2. Base features produced under license with the Ontario Ministry of Natural Resources and Forestry © Queen's Printer for Ontario, 2021.
3. Orthoimagery © First Base Solutions, 2021. Imagery taken in 2019.

Project 8133

Burlington Quarry Extension
Nelson Aggregates Co.

Figure 12
Watercourse Characterization

Willoughby Creek

0 300 m

1:16,000

Willoughby Creek

Surface Water Characteristics	Description	Figure / Graph / Table	Reference	
			Report	Section / Page
Watercourse Name:	Willoughby Creek			
Watershed:	Bronte Creek Watershed			
Sub-Watershed:	Willoughby Creek Watershed			
Located in Proposed Limit of Extraction:	No			
Located in Proposed License Boundary:	No			
Catchment Area (ha):	1091 ha (at Britannia Road)			
Catchment ID:	N/A			
Primary Source(s) of Flow:	Primary - discharge from Burlington Quarry (Sump 0100) Secondary - surface runoff Tertiary - groundwater seepage			
Discharge from Quarry / PTTW:	Yes - PTTW 96-P-3009		SWA (Tatham, April 2020)	Appendix A
Conditions of PTTW:	Maximum discharge rate = 4,090 L/min (68.17 L/s) Maximum discharge amount = 5,889,600 L/day		SWA (Tatham, April 2020)	Appendix A
Surface Water Monitoring:	ID: SW2 (Tatham) Installation Date: April 17, 2014 Data Collection: Continuous water level and temperature, manual monthly in-situ streamflow measurements and calibration data (water level converted to flow using rating curve) Coordinates of Monitoring Station: Easting 589015.325, Northing 4805832.639	Graphs 1 & 2 and Table 1	SWA (Tatham, April 2020)	2.1.1, Appendix B and Appendix H
	ID: SW7 (Tatham) Installation Date: September 19, 2014 Data Collection: Continuous water level and temperature, manual monthly in-situ streamflow measurements and calibration data (water level converted to flow using rating curve) Location Coordinates: Easting 588319.945, Northing 4805441.072	Graphs 3 & 4	SWA (Tatham, April 2020)	2.1.1 and Appendix B
	ID: SW14 (Tatham) Installation Date: October 2, 2014 Data Collection: Continuous water level and temperature, manual monthly in-situ streamflow measurements and calibration data (water level converted to flow using rating curve) Location Coordinates: Easting 589226.754, Northing 4804106.857	Graphs 5 & 6 and Table 2	SWA (Tatham, April 2020)	2.1.1, Appendix B and Appendix H
Streamflow Conditions:	Permanent watercourse at Britannia Road (SW2), intermittent watercourse at monitoring locations SW7 and SW14. Watercourse dependent on quarry discharge downstream of confluence with Unnamed Tributary of Willoughby Creek.	Graphs 1, 3 & 5	SWA (Tatham, April 2020)	2.1.1 and Appendix B

Surface Water Characteristics	Description					Figure / Graph / Table	Reference	
							Report	Section / Page
Average Daily Flow (SW2):	Average Daily Streamflow (L/s)				Notes:	Graph 1	SWA (Tatham, April 2020)	2.1.1 and Appendix B
	Month	Minimum	Average	Maximum	Minimum - lowest daily average streamflow recorded for period of record			
	January	37.3	119.9	512.7				
	February	39.8	116.5	779.3				
	March	35.1	150.0	989.1	Average - average daily streamflow recorded for period of record			
	April	86.1	219.0	697.8				
	May	36.4	207.8	1275.7	Maximum - maximum daily average streamflow recorded for period of record			
	June	41.5	117.7	939.1				
	July	35.3	81.0	402.5				
	August	27.8	91.2	1511.3	N/A - data not available as device removed from watercourse during winter months			
	September	29.3	83.9	300.2				
	October	31.6	86.2	282.9				
	November	38.8	105.8	513.3				
	December	30.8	90.7	230.6				
Average Daily Flow (SW7):	Average Daily Streamflow (L/s)				Notes:	Graph 3	SWA (Tatham, April 2020)	2.1.1 and Appendix B
	Month	Minimum	Average	Maximum	Minimum - lowest daily average streamflow recorded for period of record			
	January	N/A	N/A	N/A				
	February	N/A	N/A	N/A				
	March	102.1	217.9	665.9	Average - average daily streamflow recorded for period of record			
	April	31.8	115.1	314.4				
	May	16.7	75.0	285.2	Maximum - maximum daily average streamflow recorded for period of record			
	June	9.1	41.7	329.4				
	July	3.3	19.4	78.3				
	August	0.9	15.0	58.1	N/A - data not available as device removed from watercourse during winter months			
	September	1.8	16.0	87.2				
	October	1.8	24.1	99.3				
	November	7.5	38.0	288.3				
	December	7.1	35.0	140.4				
Average Daily Flow (SW14):	Average Daily Streamflow (L/s)				Notes:	Graph 5	SWA (Tatham, April 2020)	2.1.1 and Appendix B
	Month	Minimum	Average	Maximum	Minimum - lowest daily average streamflow recorded for period of record			
	January	N/A	N/A	N/A				
	February	N/A	N/A	N/A				
	March	N/A	N/A	N/A	Average - average daily streamflow recorded for period of record			
	April	6.1	25.3	67.5				
	May	2.7	17.0	56.6	Maximum - maximum daily average streamflow recorded for period of record			
	June	0.0	8.4	45.3				
	July	0.0	3.1	23.9				
	August	0.0	2.8	28.4	N/A - data not available as device removed from watercourse during winter months			
	September	0.0	1.7	19.3				
	October	0.0	5.8	34.6				
	November	0.0	6.3	74.3				
	December	0.0	2.9	10.0				

<table>
<tr><th>Surface Water Characteristics</th><th>Description</th><th>Figure / Graph / Table</th><th colspan="2">Reference</th></tr>
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<tr><td>Watercourse Thermal Regime (SW2):</td><td>Average Daily Water Temperature (°C)
<table><tr><th>Month</th><th>Minimum</th><th>Average</th><th>Maximum</th></tr><tr><td>January</td><td>-1.4</td><td>1.8</td><td>5.0</td></tr><tr><td>February</td><td>-1.6</td><td>1.9</td><td>7.9</td></tr><tr><td>March</td><td>-1.1</td><td>3.1</td><td>9.6</td></tr><tr><td>April</td><td>0.6</td><td>6.7</td><td>16.0</td></tr><tr><td>May</td><td>3.5</td><td>12.0</td><td>21.7</td></tr><tr><td>June</td><td>10.0</td><td>16.2</td><td>23.8</td></tr><tr><td>July</td><td>13.2</td><td>18.9</td><td>25.9</td></tr><tr><td>August</td><td>12.9</td><td>18.7</td><td>24.5</td></tr><tr><td>September</td><td>11.4</td><td>17.1</td><td>23.2</td></tr><tr><td>October</td><td>6.2</td><td>12.3</td><td>19.4</td></tr><tr><td>November</td><td>1.1</td><td>6.7</td><td>13.7</td></tr><tr><td>December</td><td>-1.5</td><td>3.3</td><td>8.9</td></tr></table></td><td>Notes:
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<tr><td>Watercourse Thermal Regime (SW7):</td><td>Average Daily Water Temperature (°C)
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N/A - data not available as device removed from watercourse during winter months</td><td>Graph 4</td><td>SWA (Tatham, April 2020)</td><td>2.1.1 and Appendix B</td></tr>
<tr><td>Watercourse Thermal Regime (SW14):</td><td>Average Daily Water Temperature (°C)
<table><tr><th>Month</th><th>Minimum</th><th>Average</th><th>Maximum</th></tr><tr><td>January</td><td>N/A</td><td>N/A</td><td>N/A</td></tr><tr><td>February</td><td>N/A</td><td>N/A</td><td>N/A</td></tr><tr><td>March</td><td>N/A</td><td>N/A</td><td>N/A</td></tr><tr><td>April</td><td>-0.2</td><td>3.1</td><td>10.2</td></tr><tr><td>May</td><td>3.5</td><td>10.3</td><td>19.4</td></tr><tr><td>June</td><td>8.8</td><td>14.2</td><td>23.3</td></tr><tr><td>July</td><td>11.2</td><td>16.9</td><td>25.0</td></tr><tr><td>August</td><td>11.4</td><td>17.3</td><td>23.8</td></tr><tr><td>September</td><td>4.5</td><td>15.3</td><td>23.5</td></tr><tr><td>October</td><td>0.9</td><td>10.8</td><td>17.6</td></tr><tr><td>November</td><td>-1.4</td><td>6.2</td><td>14.6</td></tr><tr><td>December</td><td>-0.5</td><td>3.9</td><td>11.7</td></tr></table></td><td>Notes:
Minimum - lowest daily average water temperature recorded for period of record
Average - average daily water temperature recorded for period of record
Maximum - maximum daily average water temperature recorded for period of record
N/A - data not available as device removed from watercourse during winter months</td><td>Graph 6</td><td>SWA (Tatham, April 2020)</td><td>2.1.1 and Appendix B</td></tr>
</table>

Surface Water Characteristics	Description					Figure / Graph / Table	Reference	
							Report	Section / Page
Water Quality (SW2):	Water Quality Sample Results					Table 1	SWA (Tatham, April 2020)	2.4 and Appendix H
	Parameter	Units	Minimum	Average	Maximum			
	Turbidity	NTU	0.9	2.2	3.6			
	TDS	mg/L	433	521	589			
	TSS	mg/L	1	3	6			
	COD	mg/L	8	9	12			
	BOD5	mg/L	0.8	0.9	1			
	DOC	mg/L	0.4	3	4.7			
	pH		8.1	8.1	8.2			
	Alkalinity	mg/L	166	218	261			
	Conductivity	µS/cm	668	771	881			
	Phosphorus	ug/L	<50	<50	<50			
	Ammonia	mg/L	<0.01	0.02	0.04			
	Hardness	mg/L	309	327	346			
Water Quality (SW14):	Water Quality Sample Results					Table 2	SWA (Tatham, April 2020)	2.4 and Appendix H
	Parameter	Units	Minimum	Average	Maximum			
	Turbidity	NTU	1.3	1.8	2.1			
	TDS	mg/L	313	395	479			
	TSS	mg/L	3.67	4.59	5.70			
	COD	mg/L	20	21	24			
	BOD5	mg/L	0.8	1.0	1.0			
	DOC	mg/L	5.1	5.9	10.7			
	pH		8	8.1	8.2			
	Alkalinity	mg/L	239	292	324			
	Conductivity	µS/cm	457	587	696			
	Phosphorus	ug/L	<50	<50	<50			
	Ammonia	mg/L	0.03	0.04	0.07			
	Hardness	mg/L	239	302	347			

Fish & Fish Habitat Features	Description	Figure / Graph / Table	Reference	
			Report	Section / Page
Fish Habitat (Direct/Indirect and Assumed/Confirmed):	Willoughby Creek is known to provide direct fish habitat, based on fish community sampling information from Conservation Halton (2002, 2013, 2018). Fish community sampling is not known to be have been completed in the upper reaches of Willoughby Creek, although for the purposes of this assessment, the entire watercourse (as mapped by MNRF in the Land Information Ontario database) is assumed to provide direct fish habitat. Willoughby Creek is known to provide direct fish habitat, based on fish community sampling information from Conservation Halton (2002, 2013, 2018). Fish community sampling is not known to be have been completed in the upper reaches of Willoughby Creek, although for the purposes of this assessment, the entire watercourse (as mapped by MNRF in the Land Information Ontario database) is assumed to provide direct fish habitat.		NETR (Savanta, April 2020)	19 and 20
Fish Species Present:	1) Conservation Halton Station BRO-219 (600 m downstream from the mouth of the Unnamed Tributary): a)Blacknose Dace, Brook Stickleback, Creek Chub, Fantail Darter, White Sucker b)"Poor" index of Biotic Integrity assigned to the overall fish community at this station by Conservation Halton in 2018 2) Conservation Halton Station BRO-42 (approximately 1 km downstream from the mouth of the Unnamed Tributary): a)Atlantic Salmon (Young-of-the-year), Brook Trout, Blacknose Dace and Fantail Darter b)Reach stocked with Atlantic Salmon eggs in 2012 c)"Good" index of Biotic Integrity assigned to the overall fish community at this station by Conservation Halton in 2018		NETR (Savanta, April 2020)	19 and 20
Fish Community Thermal Regime:	Cool to coldwater		NETR (Savanta, April 2020)	19 and 20
Fish Habitat Types Present:	Site specific investigations were not completed in Willoughby Creek as part of the NETR as a result of private property access issues. However, based on the presence of a generally diverse fish community, it is assumed a range of habitat is available to support life history processes.		NETR (Savanta, April 2020)	19 and 20
Habitat Uses by Known Fish Community:	The local fish community likely uses the habitat for the complete range of life history processes including spawning, nursery, foraging and overwintering. Lower reaches of the creek may provide spawning and nursery habitat for migratory fish from Bronte Creek.		NETR (Savanta, April 2020)	19 and 20
Known Barriers to Fish Movement:	None confirmed. Numerous culverts and private online ponds may provide some barriers to localized movement, but this was not confirmed as part of the NETR.		NETR (Savanta, April 2020)	19 and 20

<table>
<tr><th>Groundwater Interaction</th><th>Description</th><th>Figure / Graph / Table</th><th colspan="2">Reference</th></tr>
<tr><th></th><th></th><th></th><th>Report</th><th>Section / Page</th></tr>
<tr><td>Underlying Deposits:</td><td>The Medad Valley is a partly-buried gorge that carried meltwater from the receding ice for a period of time (Karrow, 1987). The infill deposits are likely coarse-grained glaciofluvial deposits overlain by organic deposits. While there is limited data for the Medad Valley, there is some evidence that the sand deposits are thicker in the valley to the north and south of the site. Model value for the horizontal hydraulic conductivity of the MIS sands was $5.0x10^{-5}$ m/s and $2.5x10^{-5}$ m/s for vertical hydraulic conductivity.</td><td></td><td></td><td></td></tr>
<tr><td>Surface Water / Groundwater Interactions:</td><td>Gaining Stream</td><td>Figures 1 & 2</td><td></td><td></td></tr>
<tr><td>Water Budget Results (SW14):</td><td>The baseline condition water budget results from the integrated model at monitoring location SW14 are presented in Figure 3a.<table><tr><td>Condition</td><td>GW Out</td><td>GW In</td></tr><tr><td>Baseline (Existing)</td><td>17.42%</td><td>26.50%</td></tr></table></td><td>Figure 3a</td><td></td><td></td></tr>
<tr><td>Water Budget Results (5328 Cedar Springs Road Driveway Crossing):</td><td>The baseline condition water budget results from the integrated model at the driveway crossing for 5328 Cedar Springs Road are presented in Figure 4a.<table><tr><td>Condition</td><td>GW Out</td><td>GW In</td></tr><tr><td>Baseline (Existing)</td><td>17.82%</td><td>24.11%</td></tr></table></td><td>Figure 4a</td><td></td><td></td></tr>
<tr><td>Water Budget Results (SW7):</td><td>The baseline condition water budget results from the integrated model at monitoring location SW7 are presented in Figure 5a.<table><tr><td>Condition</td><td>GW Out</td><td>GW In</td></tr><tr><td>Baseline (Existing)</td><td>15.72%</td><td>21.10%</td></tr></table></td><td>Figure 5a</td><td></td><td></td></tr>
<tr><td>Water Budget Results (Road Culvert Crossing at 5535 Cedar Springs Road):</td><td>The baseline condition water budget results from the integrated model at the road culvert crossing at 5535 Cedar Springs Road are presented in Figure 6a.<table><tr><td>Condition</td><td>GW Out</td><td>GW In</td></tr><tr><td>Baseline (Existing)</td><td>17.98%</td><td>28.27%</td></tr></table></td><td>Figure 6a</td><td></td><td></td></tr>
<tr><td>Integrated Model Calibration:</td><td>Section 19.4.3 (p. 418-419) in the Earthfx report describes the model calibration to flows in Willoughby Creek. The section focused on the SW2 gauge which represents the total streamflow exiting the northern portion of the Medad Valley. Hydrographs illustrate the model matches to flow peak timing for the period of record and WY2017, but the model may underestimate low flows from Feb. 2018 to Feb. 2019. Several reasons were discussed.</td><td>Graphs 7, 8 & 9</td><td>HHIAR (Earthfx, April 2020)</td><td>19.4.3 (page 418 - 419)</td></tr>
</table>

Impact Assessment	Description	Figure / Graph / Table	Reference	
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Direct Alterations to Watercourse:	1) No direct alterations to this watercourse will occur as a result of the proposed Quarry Extension. 2) Potential direct effects on the Unnamed Tributary of Willoughby Creek (e.g., due to weir plate, diversion channel inlet, golf course pond/irrigation channel removal) could potentially cause indirect effects on Willoughby Creek (e.g., sedimentation), as discussed in more detail in the Unnamed Tributary of Willoughby Creek summary table.		NETR (Savanta, April 2020)	75
Change in Primary Source of Flow:	1) Quarry discharge from Sump 0100 represents a major source of flow to Willoughby Creek. Current quarry approvals permit this discharge to cease once quarry operations are complete. Cessation of quarry discharge into the Unnamed Tributary of Willoughby Creek and ultimately Willoughby Creek itself would have a negative impact on flow availability to support existing fish habitat and the current fish community. As discussed in the Mitigation section below, it has been recommended that quarry discharge continue indefinitely at current levels to prevent these associated negative impacts. 2) Diversion from catchment area S101 (northwest of Colling Road) will alter surface water inputs. Currently, this catchment area discharges directly to the quarry and the flow is eventually discharged to the Unnamed Tributary through Sump 0100 (and ultimately to Willoughby Creek). Nelson is proposing to redirect surface water drainage from catchment area S101 directly into the Unnamed Tributary at the existing quarry discharge point. Overall, this diversion will result in the same volume of water from catchment area S101 being discharged to the tributary and ultimately Willoughby Creek, although, given it will no longer pass through the quarry, it is expected that the hydrological regime of this discharge will be more natural, with seasonal peaks as opposed to being discharged at a generally more constant rate through the quarry sump. 3) Removal of the golf course irrigation ponds and channels will alter the hydrology of the watercourse, given that no water taking would be required from the watercourse to support golf course irrigation and that during high flow periods, there will be no discharge from the golf course back to the feature. However, the proposed new pond (infiltration pond) west of the West Extension will draw water from the Weir Pond in the same manner as the existing irrigation ponds. Therefore, there will be no net change in source water hydrology.		NETR (Savanta, April 2020)	76 and 77
Change in Watercourse Catchment Area:	Increase in catchment area of 7.2 ha. Additional catchment area will drain to the existing quarry settling ponds and be discharged to the Unnamed Tributary via Sump 0100 at rates consistent with existing. Additional storage will be provided in the settling ponds to accommodate the additional flow.		SWA (Tatham, April 2020)	Drawings DP-1, DP-2 and DP-3
Simulated Streamflow Change (Integrated Model Results):	The Earthfx report discusses changes in simulated quarry discharge to the North Quarry Pond. No change was expected under Scenario P12. Scenario P3456 is discussed in Section 8.7.5 (p. 243). Under P3456 conditions, current levels of quarry discharge will continue to pass through the 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 as the current golf course ditch and pond system. Figure 8.71(p. 254) showed that there will be an increase in flow through the north quarry discharge stream, and that the flow will continue through the karst conduit as under current conditions. The increase in flow will enter the Medad Valley just downstream of SW7, so there will be no significant change downstream at SW2. Under RHB1, discharge continues to the north from the quarry sump 0100 and is similar to that of P3456. Under RHB2, surface water flow in the upper reaches of the Unnamed Tributary of Willoughby Creek and the West Arm of the West Branch of Mount Nemo Tributary of Grindstone Creek will cease when the quarry discharge is discontinued, resulting in possible impact to downstream fish habitat compared to baseline conditions (See Savanta, 2020 and Tatham, 2020 for details).	Graphs 10 & 11	HHIAR (Earthfx, April 2020)	198 - 230 and 230 - 237

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<tr><td>Water Budget Results (Operational Phases 3 Through 6):</td><td>The Operational Phases 3 through 6 water budget results from the integrated model at monitoring location SW14 are presented in Figure 3c.<table><tr><td>Condition</td><td>GW Outflow</td><td>GW Inflow</td><td>%Δ GW Outflow</td><td>%Δ GW Inflow</td></tr><tr><td>Baseline (Existing)</td><td>17.42%</td><td>26.50%</td><td>-</td><td>-</td></tr><tr><td>Phases 3 through 6</td><td>17.90%</td><td>25.75%</td><td>0.48%</td><td>-0.75%</td></tr></table></td><td>Figure 3c</td><td></td><td></td></tr>
<tr><td>Water Budget Results (Rehabilitation Scenario 1):</td><td>The Rehabilitation Scenario 1 water budget results from the integrated model at monitoring location SW14 are presented in Figure 3d.<table><tr><td>Condition</td><td>GW Outflow</td><td>GW Inflow</td><td>%Δ GW Outflow</td><td>%Δ GW Inflow</td></tr><tr><td>Baseline (Existing)</td><td>17.42%</td><td>26.50%</td><td>-</td><td>-</td></tr><tr><td>Rehab Scenario 1</td><td>17.06%</td><td>26.44%</td><td>-0.36%</td><td>-0.06%</td></tr></table></td><td>Figure 3d</td><td></td><td></td></tr>
<tr><td>Water Budget Results (Rehabilitation Scenario 2):</td><td>The Rehabilitation Scenario 2 water budget results from the integrated model at monitoring location SW14 are presented in Figure 3e.<table><tr><td>Condition</td><td>GW Outflow</td><td>GW Inflow</td><td>%Δ GW Outflow</td><td>%Δ GW Inflow</td></tr><tr><td>Baseline (Existing)</td><td>17.42%</td><td>26.50%</td><td>-</td><td>-</td></tr><tr><td>Rehab Scenario 2</td><td>18.26%</td><td>26.59%</td><td>0.84%</td><td>0.09%</td></tr></table></td><td>Figure 3e</td><td></td><td></td></tr>
<tr><td colspan="5">Water Budget Results at 5328 Cedar Springs Road Driveway Crossing</td></tr>
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<tr><td>Water Budget Results (Rehabilitation Scenario 2):</td><td>The Rehabilitation Scenario 2 water budget results from the integrated model at 5328 Cedar Springs Road Driveway Crossing are presented in Figure 4e.<table><tr><td>Condition</td><td>GW Outflow</td><td>GW Inflow</td><td>%Δ GW Outflow</td><td>%Δ GW Inflow</td></tr><tr><td>Baseline (Existing)</td><td>17.82%</td><td>24.11%</td><td>-</td><td>-</td></tr><tr><td>Rehab Scenario 2</td><td>18.54%</td><td>25.30%</td><td>0.72%</td><td>1.19%</td></tr></table></td><td>Figure 4e</td><td></td><td></td></tr>
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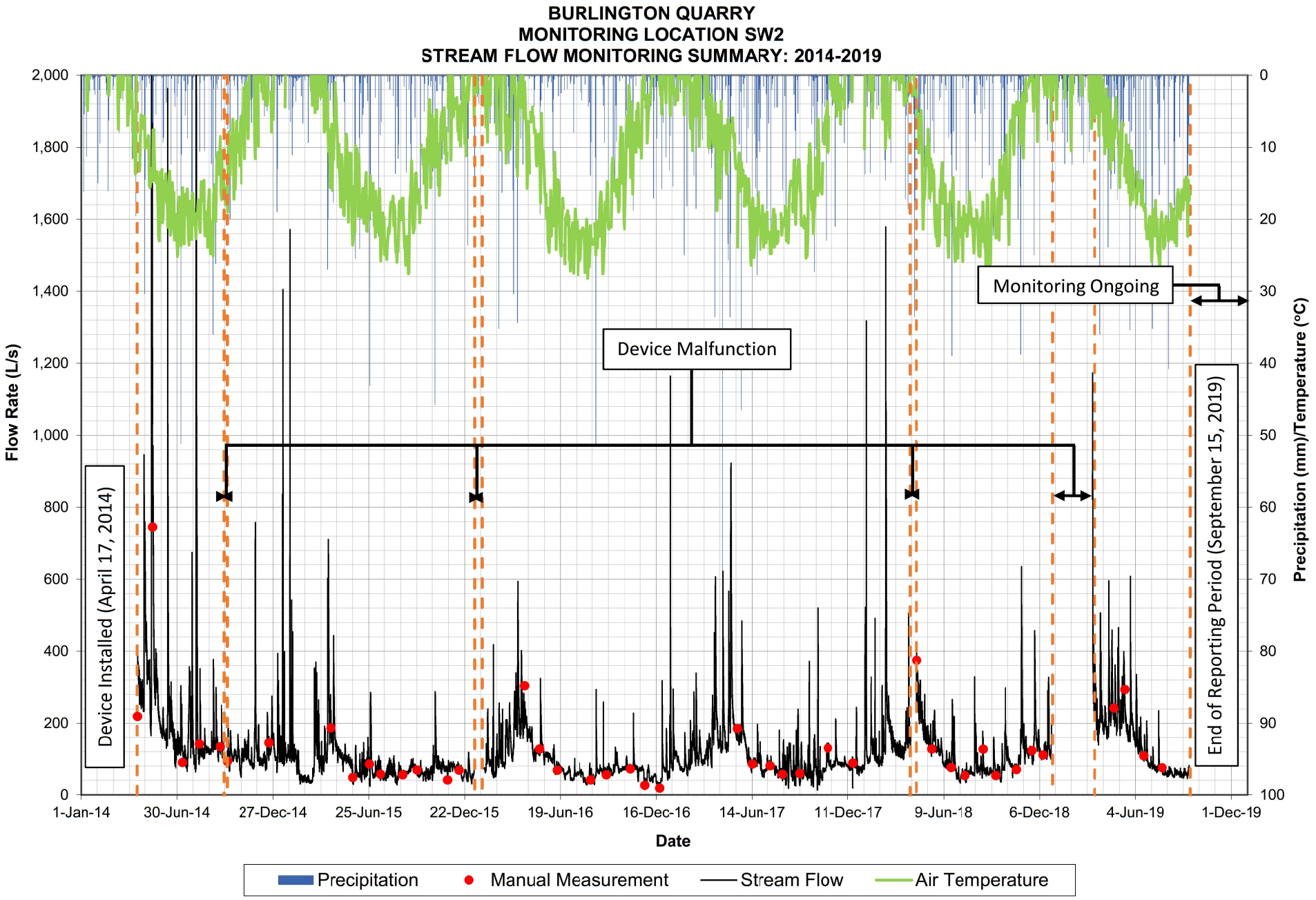
<tr><td colspan="5">Water Budget Results at Monitoring Location SW7</td></tr>
<tr><td>Water Budget Results (Operational Phases 1 & 2):</td><td>The Operational Phases 1 and 2 water budget results from the integrated model at monitoring location SW7 are presented in Figure 5b.<table><tr><td>Condition</td><td>GW Outflow</td><td>GW Inflow</td><td>%Δ GW Outflow</td><td>%Δ GW Inflow</td></tr><tr><td>Baseline (Existing)</td><td>15.27%</td><td>21.10%</td><td>-</td><td>-</td></tr><tr><td>Phases 1 & 2</td><td>14.95%</td><td>20.37%</td><td>-0.32%</td><td>-0.73%</td></tr></table></td><td>Figure 5b</td><td></td><td></td></tr>
<tr><td>Water Budget Results (Operational Phases 3 Through 6):</td><td>The Operational Phases 3 through 6 water budget results from the integrated model at monitoring location SW7 are presented in Figure 5c.<table><tr><td>Condition</td><td>GW Outflow</td><td>GW Inflow</td><td>%Δ GW Outflow</td><td>%Δ GW Inflow</td></tr><tr><td>Baseline (Existing)</td><td>15.27%</td><td>21.10%</td><td>-</td><td>-</td></tr><tr><td>Phases 3 through 6</td><td>15.58%</td><td>18.83%</td><td>0.31%</td><td>-2.27%</td></tr></table></td><td>Figure 5c</td><td></td><td></td></tr>
<tr><td>Water Budget Results (Rehabilitation Scenario 1):</td><td>The Rehabilitation Scenario 1 water budget results from the integrated model at monitoring location SW7 are presented in Figure 5d.<table><tr><td>Condition</td><td>GW Outflow</td><td>GW Inflow</td><td>%Δ GW Outflow</td><td>%Δ GW Inflow</td></tr><tr><td>Baseline (Existing)</td><td>15.27%</td><td>21.10%</td><td>-</td><td>-</td></tr><tr><td>Rehab Scenario 1</td><td>14.83%</td><td>19.84%</td><td>-0.44%</td><td>-1.26%</td></tr></table></td><td>Figure 5d</td><td></td><td></td></tr>
<tr><td>Water Budget Results (Rehabilitation Scenario 2):</td><td>The Rehabilitation Scenario 2 water budget results from the integrated model at monitoring location SW7 are presented in Figure 5e.<table><tr><td>Condition</td><td>GW Outflow</td><td>GW Inflow</td><td>%Δ GW Outflow</td><td>%Δ GW Inflow</td></tr><tr><td>Baseline (Existing)</td><td>15.27%</td><td>21.10%</td><td>-</td><td>-</td></tr><tr><td>Rehab Scenario 2</td><td>15.85%</td><td>22.19%</td><td>0.58%</td><td>1.09%</td></tr></table></td><td>Figure 5e</td><td></td><td></td></tr>
<tr><td colspan="5">Water Budget Results at Road Culvert Crossing at 5535 Cedar Springs Road</td></tr>
<tr><td>Water Budget Results (Operational Phases 1 & 2):</td><td>The Operational Phases 1 and 2 water budget results from the integrated model at the road culvert crossing at 5535 Cedar Springs Road are presented in Figure 6b.<table><tr><td>Condition</td><td>GW Outflow</td><td>GW Inflow</td><td>%Δ GW Outflow</td><td>%Δ GW Inflow</td></tr><tr><td>Baseline (Existing)</td><td>17.98%</td><td>28.27%</td><td>-</td><td>-</td></tr><tr><td>Phases 1 & 2</td><td>18.01%</td><td>21.73%</td><td>0.03%</td><td>-6.54%</td></tr></table></td><td>Figure 6b</td><td></td><td></td></tr>
<tr><td>Water Budget Results (Operational Phases 3 Through 6):</td><td>The Operational Phases 3 through 6 water budget results from the integrated model at the road culvert crossing at 5535 Cedar Springs Road are presented in Figure 6c.<table><tr><td>Condition</td><td>GW Outflow</td><td>GW Inflow</td><td>%Δ GW Outflow</td><td>%Δ GW Inflow</td></tr><tr><td>Baseline (Existing)</td><td>17.98%</td><td>28.27%</td><td>-</td><td>-</td></tr><tr><td>Phases 3 through 6</td><td>18.28%</td><td>20.24%</td><td>0.30%</td><td>-8.03%</td></tr></table></td><td>Figure 6c</td><td></td><td></td></tr>
<tr><td>Water Budget Results (Rehabilitation Scenario 1):</td><td>The Rehabilitation Scenario 1 water budget results from the integrated model at the road culvert crossing at 5535 Cedar Springs Road are presented in Figure 6d.<table><tr><td>Condition</td><td>GW Outflow</td><td>GW Inflow</td><td>%Δ GW Outflow</td><td>%Δ GW Inflow</td></tr><tr><td>Baseline (Existing)</td><td>17.98%</td><td>28.27%</td><td>-</td><td>-</td></tr><tr><td>Rehab Scenario 1</td><td>17.96%</td><td>21.19%</td><td>-0.02%</td><td>-7.08%</td></tr></table></td><td>Figure 6d</td><td></td><td></td></tr>
<tr><td>Water Budget Results (Rehabilitation Scenario 2):</td><td>The Rehabilitation Scenario 2 water budget results from the integrated model at the road culvert crossing at 5535 Cedar Springs Road are presented in Figure 6e.<table><tr><td>Condition</td><td>GW Outflow</td><td>GW Inflow</td><td>%Δ GW Outflow</td><td>%Δ GW Inflow</td></tr><tr><td>Baseline (Existing)</td><td>17.98%</td><td>28.27%</td><td>-</td><td>-</td></tr><tr><td>Rehab Scenario 2</td><td>17.63%</td><td>24.06%</td><td>-0.35%</td><td>-4.21%</td></tr></table></td><td>Figure 6e</td><td></td><td></td></tr>
</table>

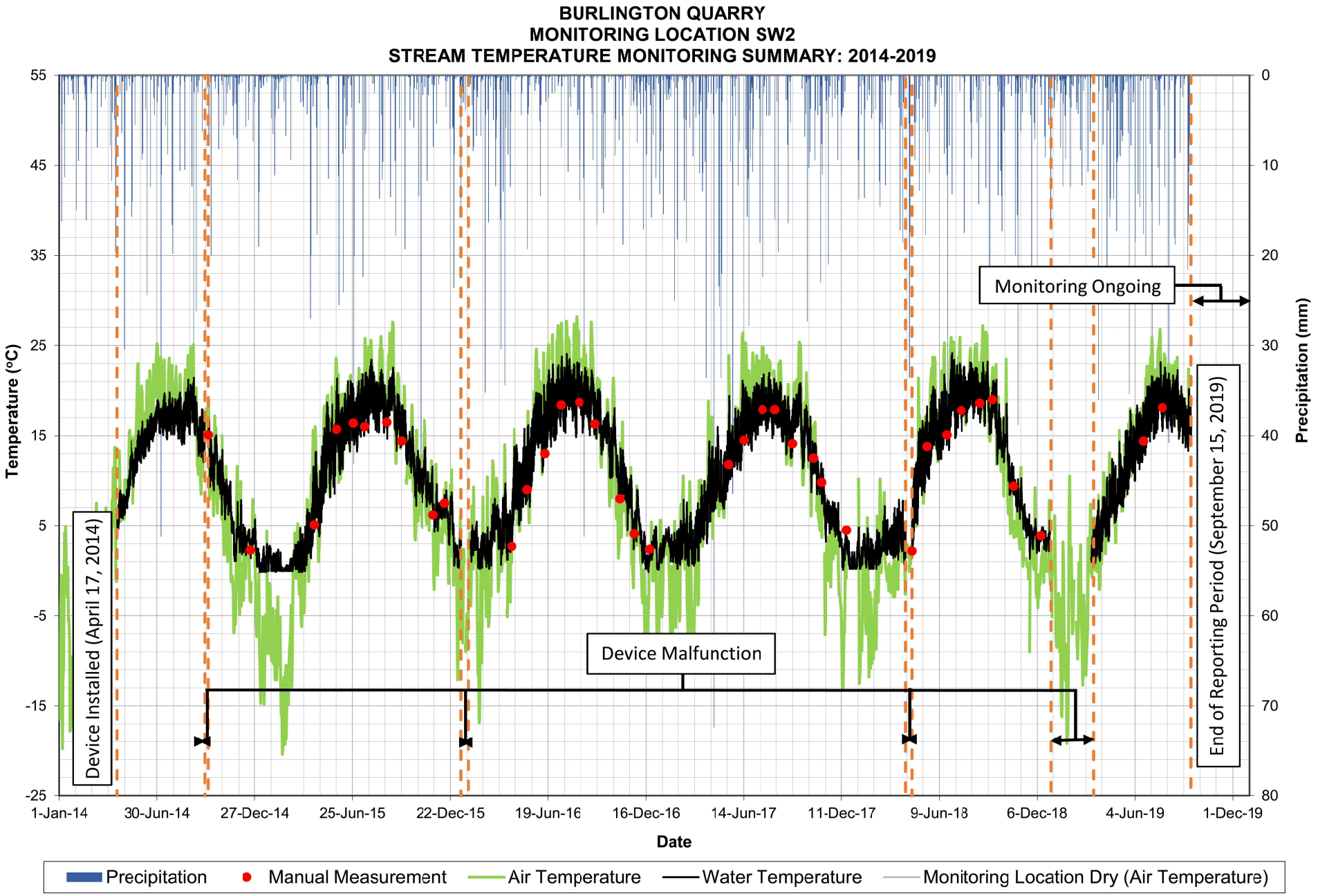
Impact Assessment	Description	Figure / Graph / Table	Reference	
			Report	Section / Page
Change in Groundwater Contributions to Watercourse:	The total change in surface leakage (seepage) between Baseline and P3456 in catchment SW7 is shown in Graph 12. A small percentage of groundwater seepage will be intercepted by P3456 and discharged to the Medad Valley just downstream of SW7. This change in seepage is relatively uniform over time. The loss of seepage is diffuse and will not be observable. Additional maps and discussion are included in Earthfx, 2020. The stream leakage under Baseline and P3456 conditions is nearly identical, as shown in Graph 13.	Graphs 12 & 13		
Change in Watercourse Thermal Regime:	1)Negative changes in water temperature are not expected given that the watercourse will continue to receive its primary input from quarry discharge. Temperature of water being discharge from Quarry Sump 0100 is not expected to change as a result of the proposed Quarry Extension, therefore, no change in water temperature is anticipated. 2) Artificial warming that may be occurring as a result of discharge of relatively warm surface water from the artificial golf course ponds into the tributary will cease once the golf course ponds are removed. This may result in a beneficial effect in downstream water temperatures, given that the ponds are anthropogenic.		NETR (Savanta, April 2020)	75 - 78
Change in Water Quality:	1) Negative changes in water quality are not expected given that the watercourse will continue to receive its primary input from quarry discharge. Quality of water being discharged from Quarry Sump 0100 is not expected to change as a result of the proposed Quarry Extension, therefore, no change in water quality is expected. 2) Water quality impacts that may be occurring as a result of discharge of water from the artificial golf course ponds and irrigation channels into the tributary will cease once the golf course ponds are removed. This may result in a beneficial effect in downstream water quality, given that golf course discharge may be having a negative impact on water quality (e.g., due to fertilizers, erosion and sedimentation, nutrients).		NETR (Savanta, April 2020)	76 and 77
Potential Impact to Form and Function of Feature:	1) Alterations to quarry discharge (if unmitigated) could potentially have negative impacts on the form and habitat functions of this watercourse. 2) Diversion of upstream catchment S101 is not expected to have negative impacts on the form and function of the watercourse. The more natural hydrograph predicted due to the diversion may enhance fish habitat in downstream reaches of the Tributary. 3) Predicted decreases in streamflow are very minor and are not expected to have any negative impact on form and function of the watercourse.		NETR (Savanta, April 2020)	76 and 77
Potential Impact to Identified Species and Habitat:	1) Alterations to quarry discharge (if unmitigated) could potentially have negative impacts on the species and habitat functions of this watercourse. 2) Diversion of upstream catchment S101 is not expected to have negative impacts on fish in the watercourse. The more natural hydrograph predicted due to the diversion may enhance fish habitat in downstream reaches of the Tributary. 3) Predicted decreases in streamflow are very minor and are not expected to have any negative impact on form and function of the watercourse.		NETR (Savanta, April 2020)	76 and 77

Mitigation	Description	Figure / Graph / Table	Reference	
			Report	Section / Page
Direct Alteration Mitigation:	1) In-water work required to install the permanent weir plate and the diversion structure inlet will be completed between July 16 and August 30 to minimize the potential for indirect impacts on the reproductive activities of the downstream fish communities in the Unnamed Tributary of Willoughby Creek and in Willoughby Creek itself (e.g., due to sedimentation or accidental spills). 2) Erosion and sedimentation control measures and spill prevention and response measures will be used throughout the duration of any in-stream works in the watercourse. 3) The Limit of Extraction has been set back 30 m from the limit of the bankfull channel of the Unnamed Tributary of Willoughby Creek and the Weir Pond in order to prevent disturbance to the watercourse. No operational activities will occur within the 30 m setback. A visual mitigation berm will be constructed within the 30 m setback (with associated grading encroaching a minimum of 14 m from the edge of the Weir Pond). Erosion and sedimentation control measures will be in place prior to grading for the berm. The berm will be vegetated following completion of grading to ensure soil stability and prevent erosion. 4) Where areas within the 30 m setback are not currently naturally vegetated (i.e., on portions of the active golf course), these areas will be naturalized with native species plantings to assist in maintaining and enhancing riparian functions adjacent to the watercourse.		NETR (Savanta, April 2020)	75 66 and 67
Source Water Mitigation:	In order to mitigate impacts on fish and fish habitat in Willoughby Creek, pumping and discharge are recommended to occur at the same location at the upstream end of the Unnamed Tributary of Willoughby Creek and in the same manner as existing pumping in accordance with the existing PTTW and Environmental Compliance Approvals regulating current quarry discharge.		NETR (Savanta, April 2020)	76
Groundwater Contribution Mitigation:	Infiltration pond is intended to maintain seepage to GW in the vicinity of the West Expansion to maintain levels and GW discharge to the Medad Valley.			
Erosion Mitigation:	Erosion and sedimentation control measures and spill prevention and response measures will be used throughout the duration of any in-stream works in the watercourse.			
Thermal Mitigation:	1) No specific thermal mitigation is proposed given that maintaining existing quarry outflows at Sump 0100 are expected to maintain the existing thermal regime of the watercourse without any additional mitigation. 2) Removal of the golf course ponds may have an indirect positive effect on the thermal regime of the watercourse.		NETR (Savanta, April 2020)	78
Water Quality Mitigation:	1) No specific water quality mitigation over and above that of the existing quarry operations is proposed given that maintaining existing quarry outflows at Sump 0100 are expected to maintain the existing water quality regime of the watercourse without any additional mitigation. The quarry extension is not predicted to result in any changes in the quality of water being discharged from Sump 0100. 2) Removal of the golf course ponds may have an indirect positive effect on the water quality of the watercourse.		NETR (Savanta, April 2020)	78

WILLOUGHBY CREEK - GRAPH 1



WILLOUGHBY CREEK - GRAPH 2



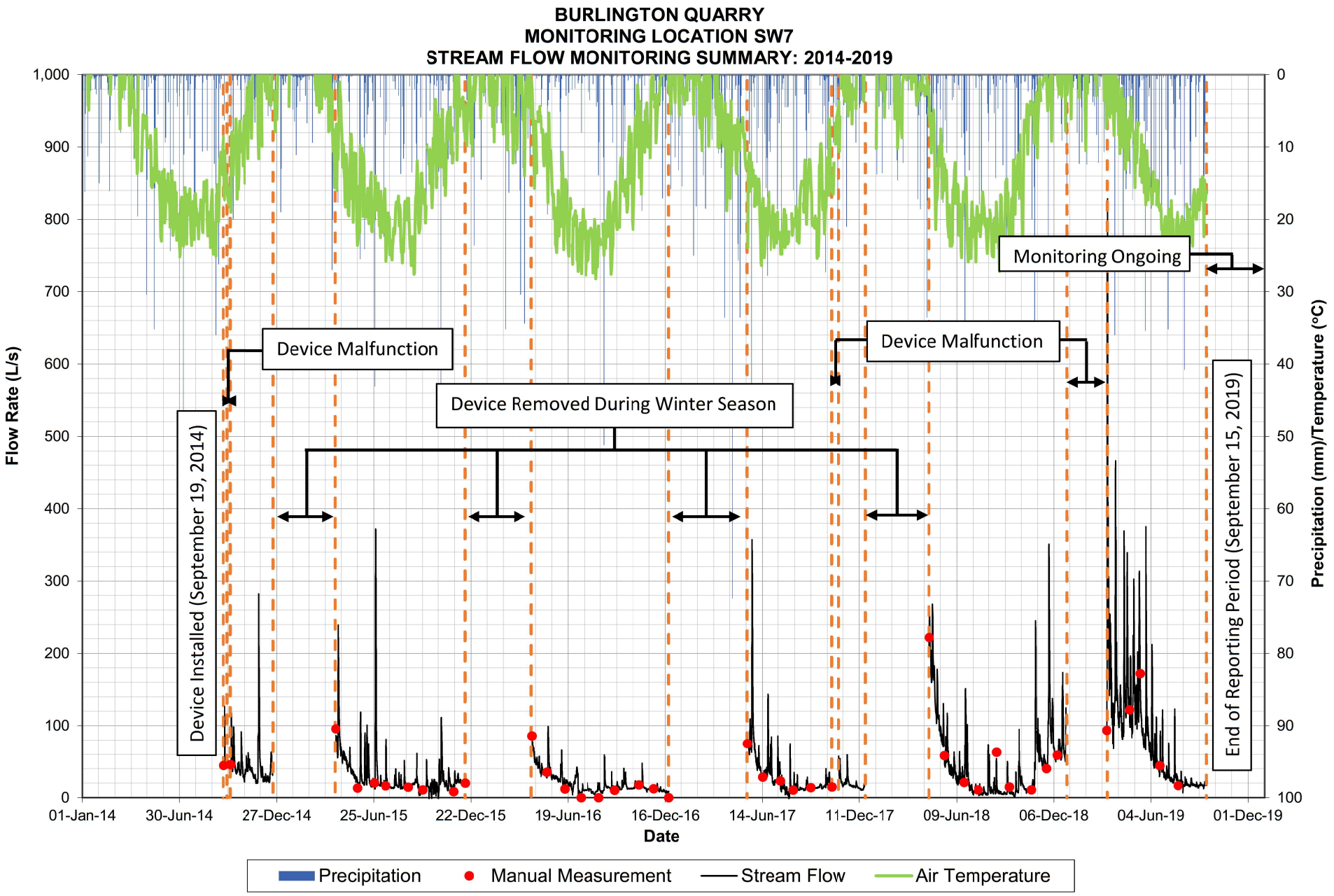
WILLOUGHBY CREEK - TABLE 1

BURLINGTON QUARRY
TATHAM ENGINEERING PROJECT NO.: 113187
SURFACE WATER MONITORING

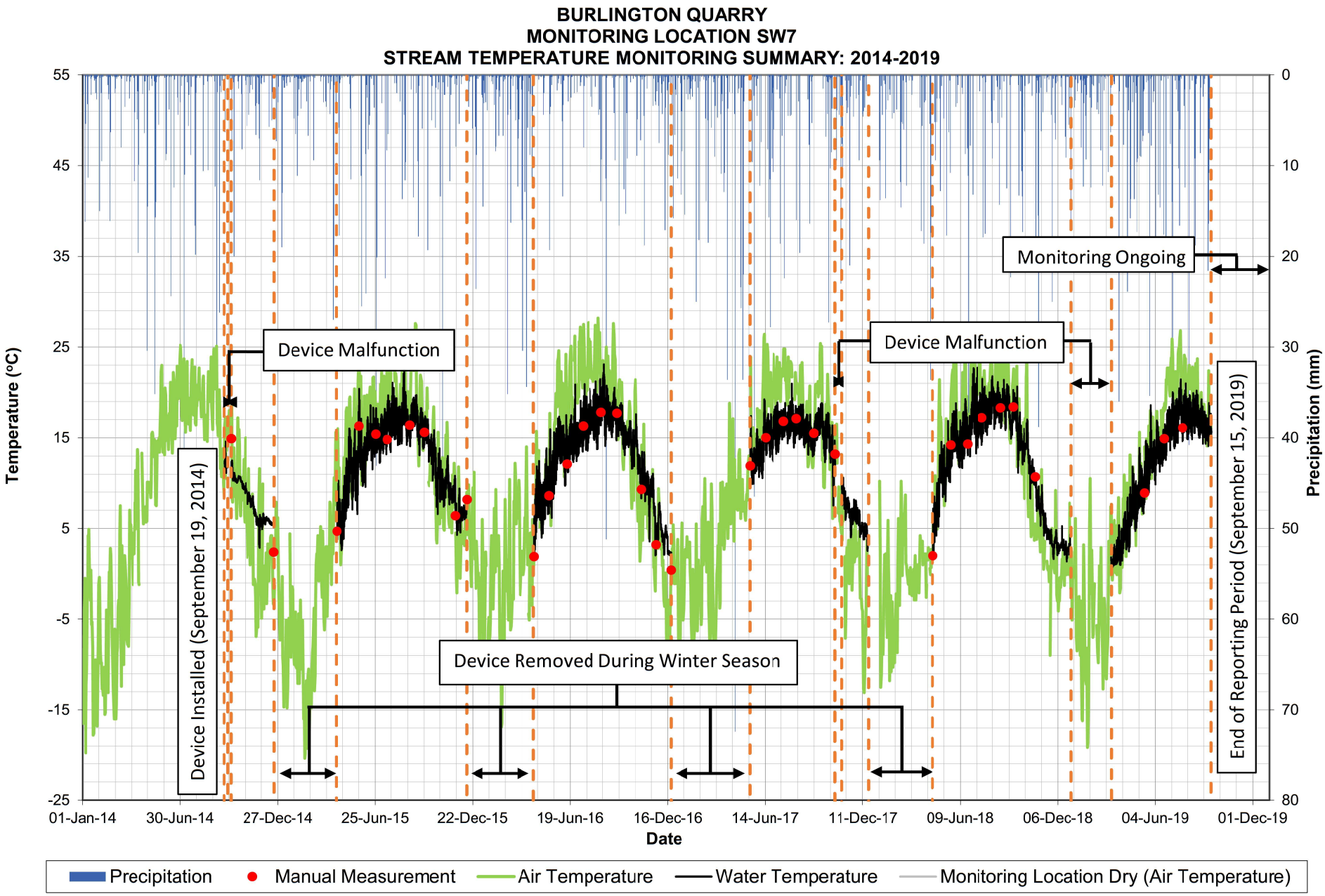
WATER QUALITY SAMPLE RESULTS

Monitoring Location SW2													
		Sample Date:	24-Oct-18	24-Apr-19	19-Jun-19	25-Sep-19	20-May-20	15-Jul-20	16-Sep-20	11-Nov-20	Maximum	Minimum	Average
Parameter:	Units:	M.D.L.	CM/JG	CM/JG	CM	CM	JG	JG/JH/JM	JH/JM	JG/JH			
M-Alkalinity (pH 4.5)	mg/L as CaCO3	2	196	250	261	166	238	180	152	178	261	166	218.25
Ammonia (as N)	mg/L	0.01	0.04	<0.01	0.02	0.02	<0.01	<0.01	<0.01	<0.01	0.04	0.02	0.02
BOD (5 day)	mg/L	1	1	0.9	0.9	0.8	1	<1	1.4	1.8	1.0	0.8	0.9
Bicarbonate	mg/L as CaCO3	1	194	247	-	164		178		176	247	164	202
Carbonate	mg/L as CaCO3	1	3	3	-	2		2		2	3	2	3
Conductivity	µS/cm	1	881	668	740	793	768	758	150	900	881	668	771
Dissolved Organic Carbon	mg/L	0.4	4	4.7	0.4	2.8	4.9	3.6	2	2.8	4.7	0.4	3.0
Field pH	pH	N/A	8.7	8.7	8.7	8.9	8.9	8.6	858	8.1	8.9	8.7	8.8
Field Temp	°C	N/A	8.3	6.7	15.2	16.6	12.9	18.9	4	9.4	16.6	6.7	11.7
Aluminum	ug/L	1	<1	11	17	<1	14	60	8	<1	17	11	8
Antimony	ug/L	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.5
Arsenic	ug/L	1	2	1	1	2	<1	2	2	2	2	1	1.5
Barium	ug/L	1	55	48	57	55	54	46	51	53	57	48	54
Beryllium	ug/L	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.5
Bismuth	ug/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Boron	ug/L	2	77	28	7	73	37	39	87	94	77	7	46.25
Cadmium	ug/L	0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	0.1	0.1
Calcium	ug/L	500	-	74800	85200	66700	73800	60000	65200	78700	85200	66700	56800
Cerium	ug/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Cesium	ug/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Chromium	ug/L	1	<1	5	5	3	3	1	3	4	5	3	4
Cobalt	ug/L	0.1	0.1	0.2	0.1	<0.1	0.2	0.1	0.1	0.1	0.2	0.1	0.125
Copper	ug/L	1	<1	<1	2	<1	2	2	1	2	2	2	1
Europium	ug/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Gallium	ug/L	1	<1	1	1	<1	1	2	2	2	1	1	1
Iron	ug/L	20	<20	157	237	170	317	251	233	232	237	157	146
Lanthanum	ug/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Lead	ug/L	0.1	<0.1	<0.1	0.2	<0.1	0.2	0.3	<0.1	<0.1	0.2	0.2	0.125
Lithium	ug/L	5	7	<5	6	8	6	9	11	10	8	6	6.5
Magnesium	ug/L	5	-	29600	32300	35200	32800	28800	34300	41500	35200	29600	24276
Manganese	ug/L	10	9	17	26	7	22	45	7	5	26	7	15
Mercury	ug/L	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1
Molybdenum	ug/L	1	2	<1	1	2	1	2	2	2	2	1	2
Nickel	ug/L	1	4	3	3	3	3	2	2	3	4	3	3
Niobium	ug/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Phosphorus	ug/L	50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	50
Potassium	ug/L	1	4490	2490	2840	4630	3420	2970	4940	5220	4630	2490	3613
Rubidium	ug/L	1	2	1	1	2	1	2	2	2	2	1	2
Scandium	ug/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Selenium	ug/L	0.5	0.9	0.8	<0.5	<0.5	0.7	<0.5	1.5	0.8	0.9	0.8	0.675
Silicon	ug/L	2	2100	2640	2700	1960	2380	1790	1820	2260	2700	1960	2350
Silver	ug/L	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1
Sodium	ug/L	1000	48600	27800	31800	43500	38700	41500	47800	51400	48600	27800	37925
Strontium	ug/L	1	715	417	510	678	499	478	653	800	715	417	580
Sulphur	ug/L	800	47400	20300	32500	48100	31400	30000	49200	65200	48100	20300	37075
Tellurium	ug/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Thallium	ug/L	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1
Thorium	ug/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Tin	ug/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Titanium	ug/L	1	<1	1	<1	<1	<1	1	<1	<1	1	1	1
Tungsten	ug/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Uranium	ug/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Vanadium	ug/L	1	<1	1	1	1	1	<1	1	1	1	1	1
Yttrium	ug/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Zinc	ug/L	1	9	<1	4	2	5	6	3	<1	9	2	4
Zirconium	ug/L	1	9	<1	<1	<1	<1	<1	<1	<1	9	9	3
pH	pH	N/A	8.16	8.14	8.18	8.09	8.4	8.13	8.09	8.08	8.2	8.1	8.1
Total Hardness (as CaCO3)	mg/L	0.1	342	309	346	312	319	268	304	367	346.000	309.000	327.250
Chemical Oxygen Demand	mg/L	5	8	12	12	<5	8	11	<5	15	12	8	9
Total Dissolved Solids	mg/L	3	589	433	515	548	508	484	533	580	589	433	521
Total Suspended Solids	mg/L	0.67	1	2	6	3	7.33	5.3	1.7	1.3	6.00	1.00	3.00
Turbidity	NTU	0.1	0.9	1.7	3.6	2.6	1.9	2.4	0.8	1.2	3.6	0.9	2.2

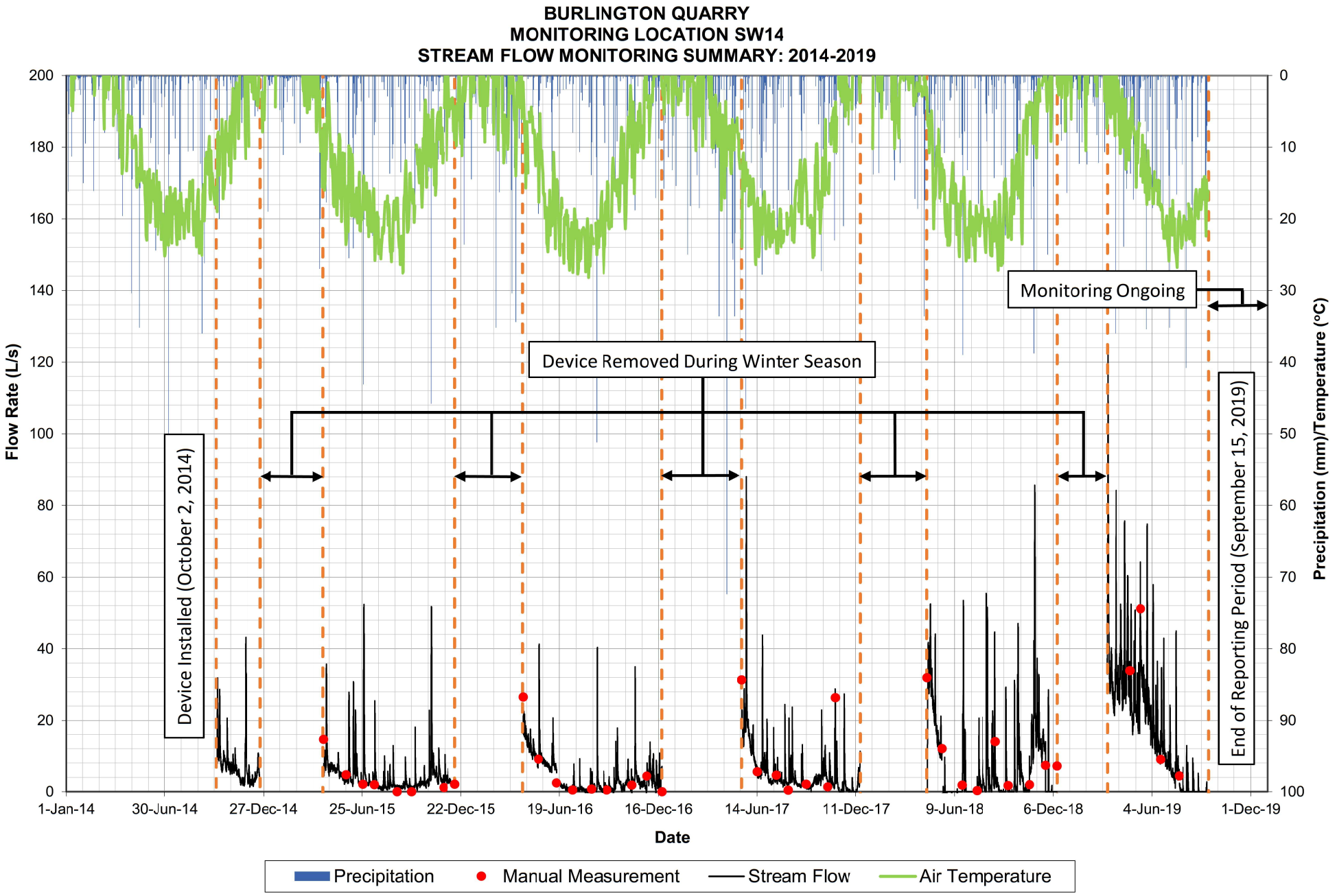
WILLOUGHBY CREEK - GRAPH 3

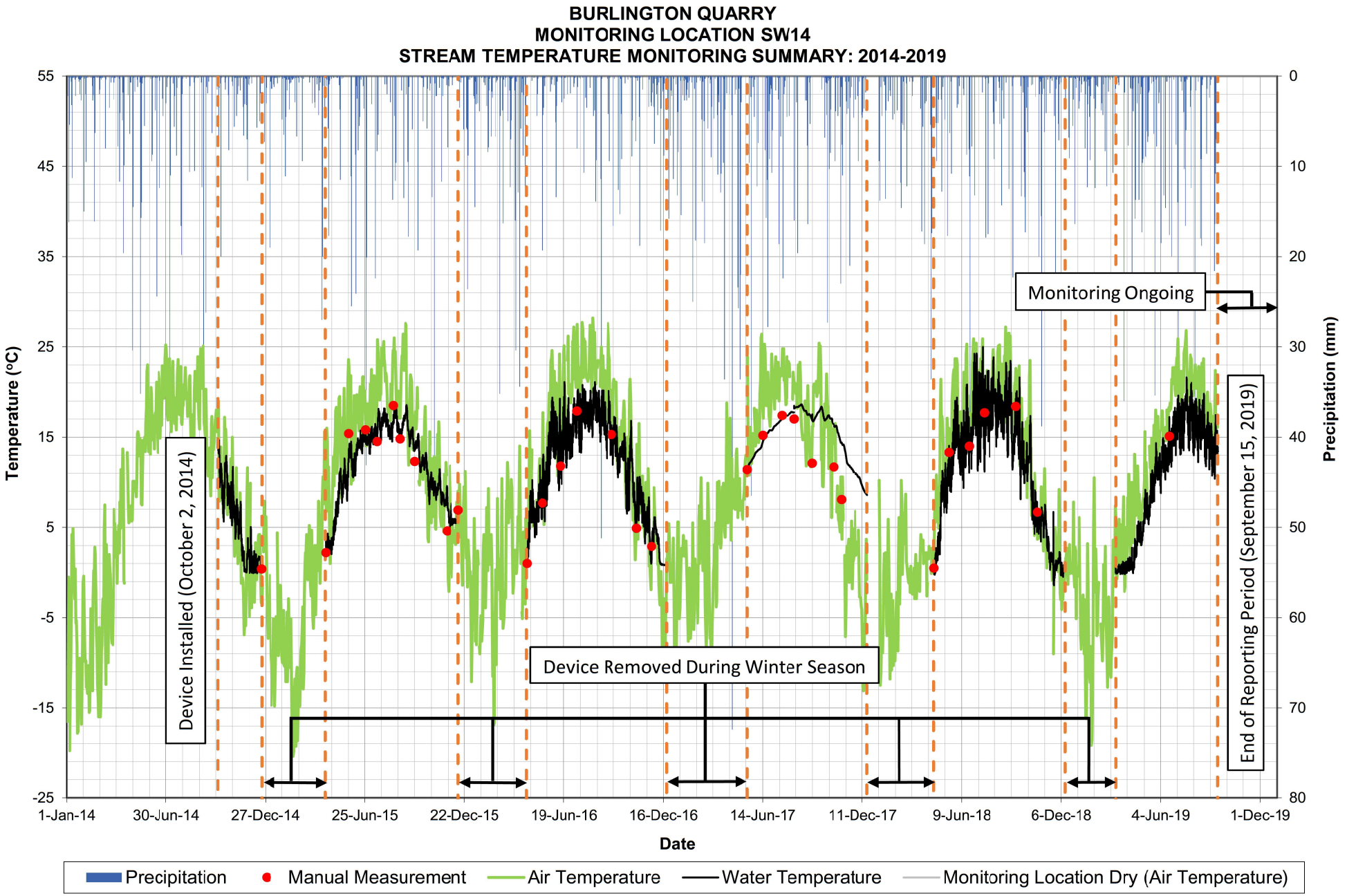


WILLOUGHBY CREEK - GRAPH 4



WILLOUGHBY CREEK - GRAPH 5




BURLINGTON QUARRY
MONITORING LOCATION SW14
STREAM TEMPERATURE MONITORING SUMMARY: 2014-2019
Temperature (°C)
Precipitation (mm)
55
45
35
25
15
5
-5
-15
-25
0
10
20
30
40
50
60
70
80
1-Jan-14
30-Jun-14
27-Dec-14
25-Jun-15
22-Dec-15
19-Jun-16
16-Dec-16
14-Jun-17
11-Dec-17
9-Jun-18
6-Dec-18
4-Jun-19
1-Dec-19
Date
Device Installed (October 2, 2014)
Device Removed During Winter Season
Monitoring Ongoing
End of Reporting Period (September 15, 2019)
Precipitation
Manual Measurement
Air Temperature
Water Temperature
Monitoring Location Dry (Air Temperature)

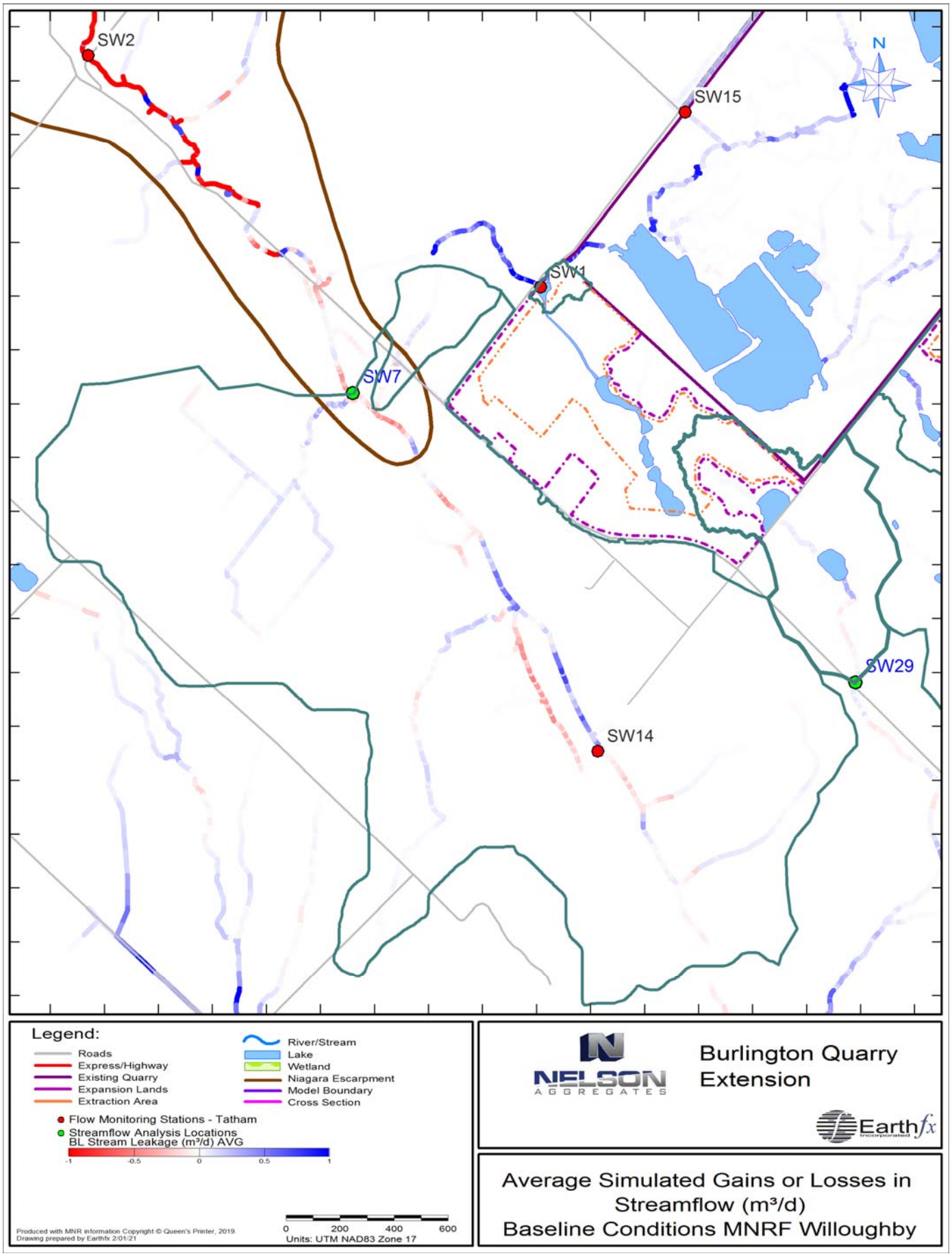
WILLOUGHBY CREEK - TABLE 2

BURLINGTON QUARRY
TATHAM ENGINEERING PROJECT NO.: 113187
SURFACE WATER MONITORING

WATER QUALITY SAMPLE RESULTS

Monitoring Location SW14													
		Sample Date:	24-Oct-18	24-Apr-19	19-Jun-19	25-Sep-19	20-May-20	15-Jul-20	16-Sep-20	11-Nov-20	Maximum	Minimum	Average
Parameter:	Units:	M.D.L.	CM/JG	CM/JG	CM	CM	JG	JG/JH/JM	JH/JM	JG/JH			
M-Alkalinity (pH 4.5)	mg/L as CaCO3	2	303	239	302	324	265	320	329	296	324	239	292
Ammonia (as N)	mg/L	0.01	0.04	<0.01	0.07	0.03	<0.01	<0.01	<0.01	0.1	0.07	0.03	0.04
BOD (5 day)	mg/L	1	<1	0.8	<0.9	1	<1	1.1	1.5	<1	1.0	0.8	1.0
Bicarbonate	mg/L as CaCO3	1	300	237		319		315	325	293	319	237	214
Carbonate	mg/L as CaCO3	1	3	2		4		5	4	3	4	2	2.25
Conductivity	µS/cm	1	646	457	549	696	566	683	770	664	696	457	587
Dissolved Organic Carbon	mg/L	0.4	10.7	7.4	<0.4	5.1	6.3	6.4	5	10	10.7	5.1	5.9
Field pH	pH	N/A	8.6	8.8	8.8	8.8	8.8		9	8.9	8.8	8.6	8.8
Field Temp	°C	N/A	5.4	4.2	15.1	17	11.9		15.7	11.2	17.0	4.2	10.4
Aluminum	ug/L	1	<1	5	5	19	4	26	6	5	19	5	8
Antimony	ug/L	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.5
Arsenic	ug/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Barium	ug/L	1	63	48	64	82	57	59	73	63	82	48	64
Beryllium	ug/L	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.5
Bismuth	ug/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Boron	ug/L	2	6	8	<2	17	<2	3	21	19	17	6	8.25
Cadmium	ug/L	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1
Calcium	ug/L	500	-	57000	72500	80000	65200	83600	94300	79400	80000	57000	52500
Cerium	ug/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Cesium	ug/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Chromium	ug/L	1	<1	3	5	7	4	3	5	5	7	3	4
Cobalt	ug/L	0.1	0.2	<0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.125
Copper	ug/L	1	<1	<1	1	<1	<1	1	<1	3	1	1	1
Europium	ug/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Gallium	ug/L	1	1	<1	1	1	1	2	2	2	1	1	1
Iron	ug/L	20	150	137	191	319	248	246	275	281	319	137	199
Lanthanum	ug/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Lead	ug/L	0.1	<0.1	0.4	0.2	1	0.3	0.5	0.1	0.2	1	0.2	0.425
Lithium	ug/L	5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	5
Magnesium	ug/L	5	-	23400	29300	35800	31100	32300	37000	35700	35800	23400	22126
Manganese	ug/L	10	69	17	19	61	22	42	9	13	69	17	42
Mercury	ug/L	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1
Molybdenum	ug/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Nickel	ug/L	1	3	2	2	2	2	2	2	3	3	2	2
Niobium	ug/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Phosphorus	ug/L	50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	50
Potassium	ug/L	1	1430	1160	892	1140	1160	1140	1100	1740	1430	892	1156
Rubidium	ug/L	1	<1	<1	<1	1	<1	1	1	2	1	1	1
Scandium	ug/L	1	<1	<1	<1	<1	<1	1	1	1	<1	<1	1
Selenium	ug/L	0.5	0.5	<0.5	<0.5	<0.5	1.2	<0.5	0.8	<0.5	0.5	0.5	0.5
Silicon	ug/L	2	3550	2300	3260	4020	2830	3430	3980	4420	4020	2300	3283
Silver	ug/L	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1
Sodium	ug/L	1000	15000	6600	8680	18800	11300	15400	20900	17800	18800	6600	12270
Strontium	ug/L	1	116	98	108	127	108	123	135	137	127	98	112
Sulphur	ug/L	800	2700	5290	5710	10100	5900	7100	11300	11900	10100	2700	5950
Tellurium	ug/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Thallium	ug/L	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1
Thorium	ug/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Tin	ug/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Titanium	ug/L	1	1	<1	<1	2	<1	<1	<1	<1	2	1	1.25
Tungsten	ug/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Uranium	ug/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Vanadium	ug/L	1	<1	1	2	2	1	1	2	2	2	1	1.5
Yttrium	ug/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Zinc	ug/L	1	11	<1	3	12	4	14	4	20	12	3	7
Zirconium	ug/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
pH	pH	N/A	8.06	7.96	8.11	8.17	8.24	8.18	8.15	8	8.2	8.0	8.1
Total Hardness (as CaCO3)	mg/L	0.1	318	239	302	347	291	342	388	345	347	239	302
Chemical Oxygen Demand	mg/L	5	20	24	20	20	19	38	8	464	24	20	21
Total Dissolved Solids	mg/L	3	416	313	371	479	342	433	459	23	479	313	395
Total Suspended Solids	mg/L	0.67	5.7	4	3.67	5	4.7	19.7	5.7	1	5.70	3.67	4.59
Turbidity	NTU	0.1	1.9	2	1.3	2.1	0.9	0.8	1.4	13.8	2.1	1.3	1.8

WILLOUGHBY CREEK - FIGURE 1



WILLOUGHBY CREEK - FIGURE 2

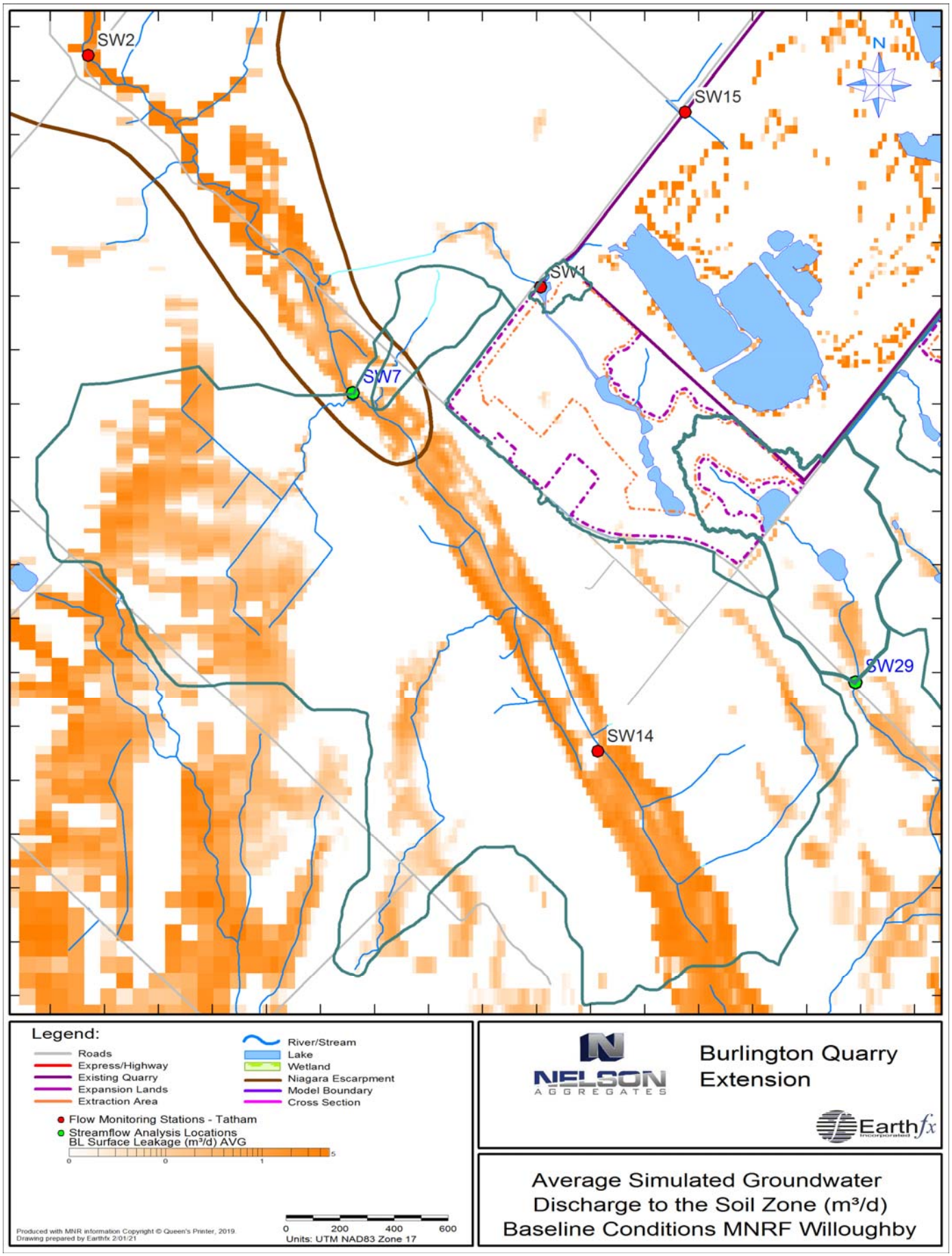
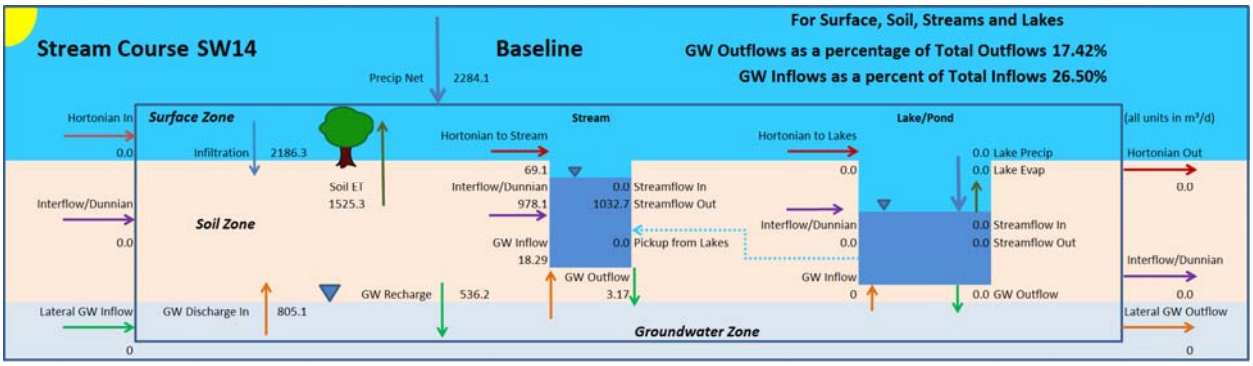


FIGURE 3A



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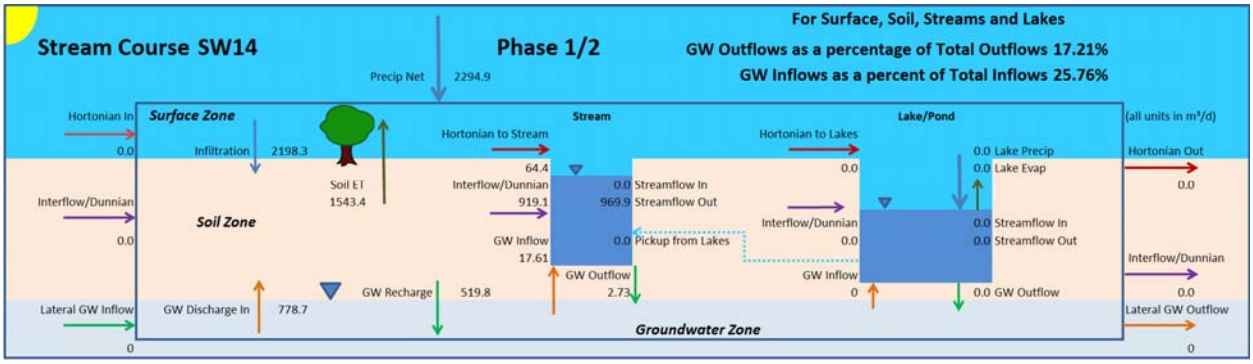


FIGURE 3C

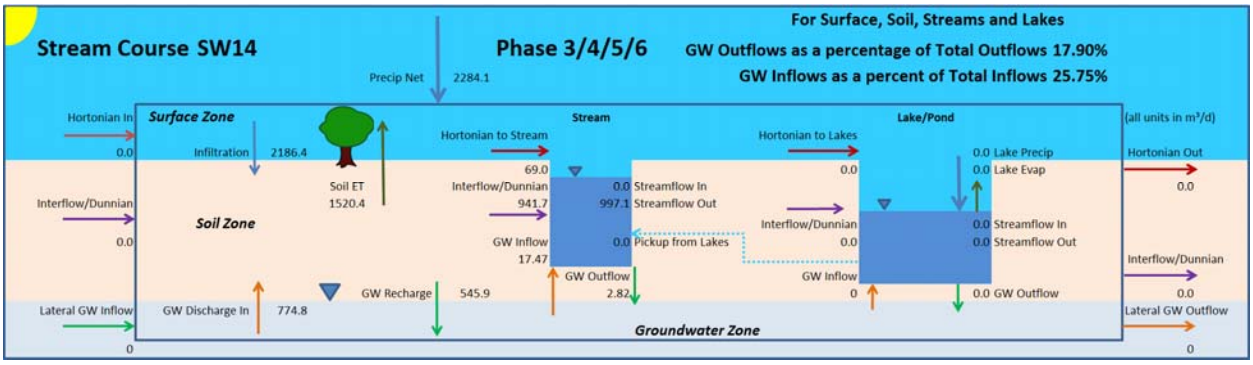
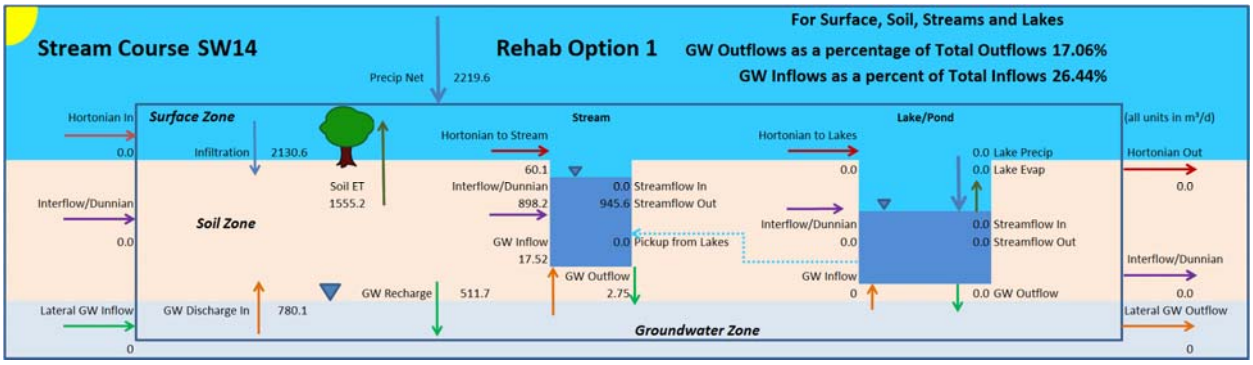


FIGURE 3D



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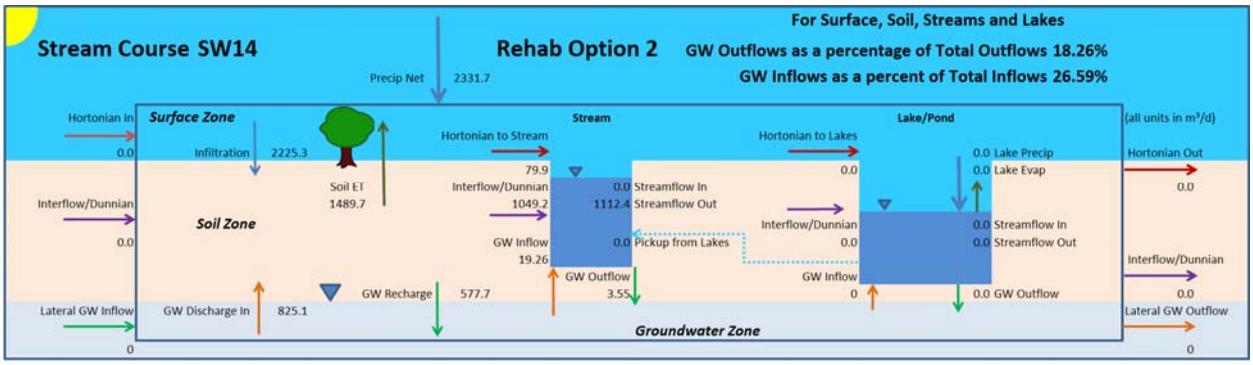

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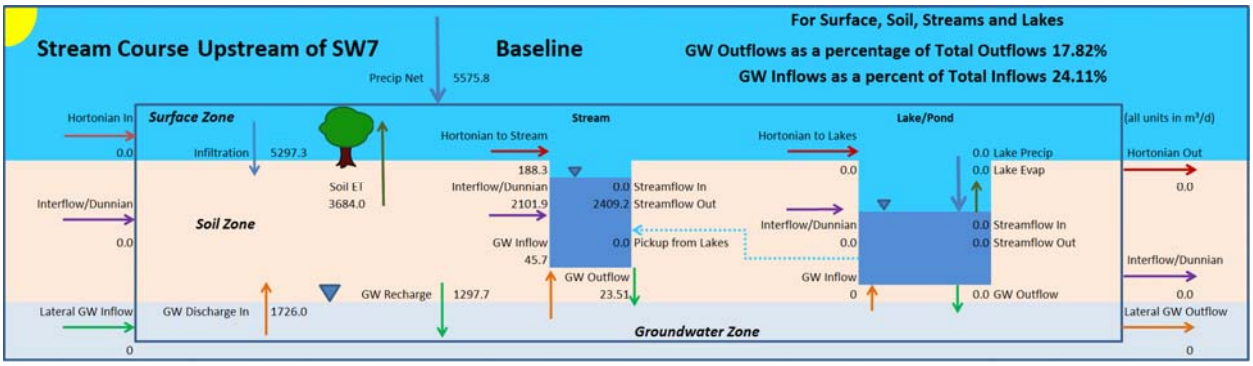

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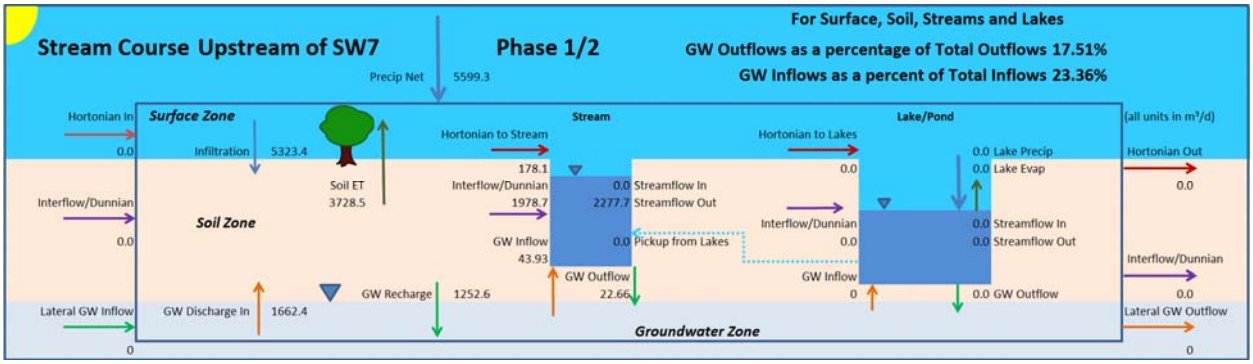

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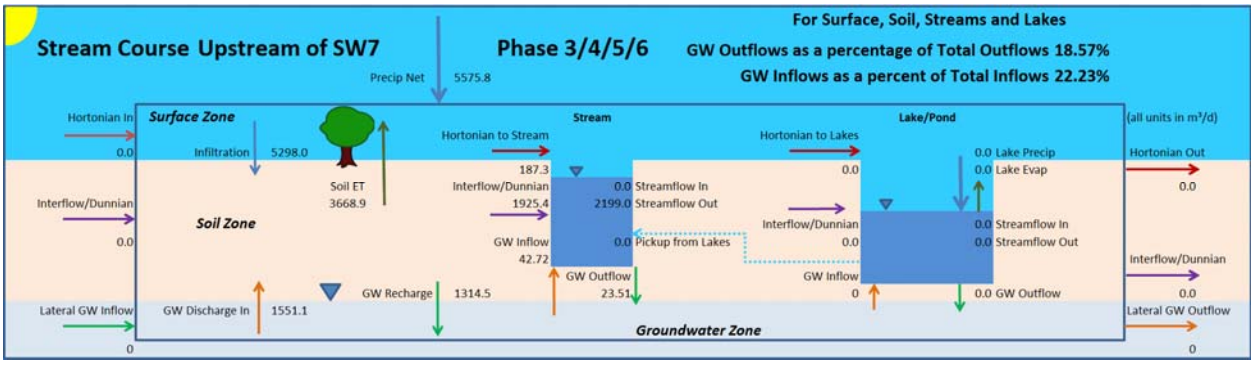

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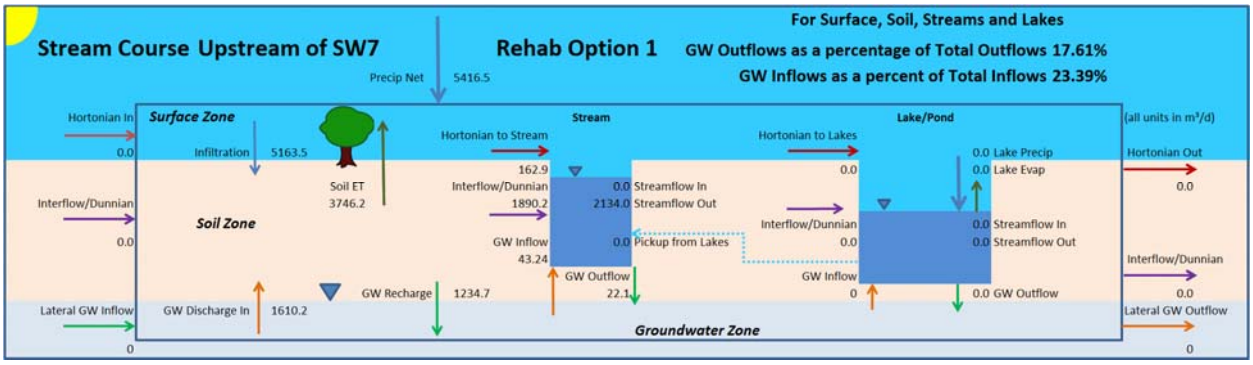

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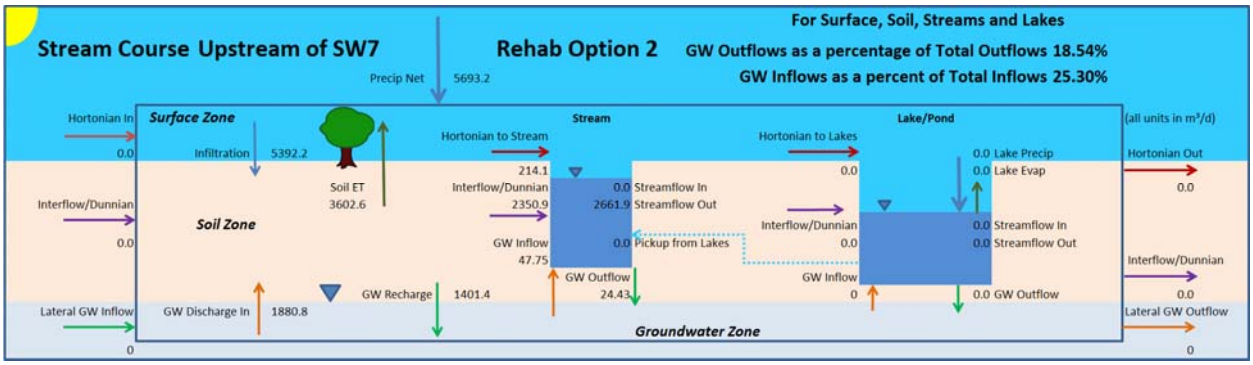
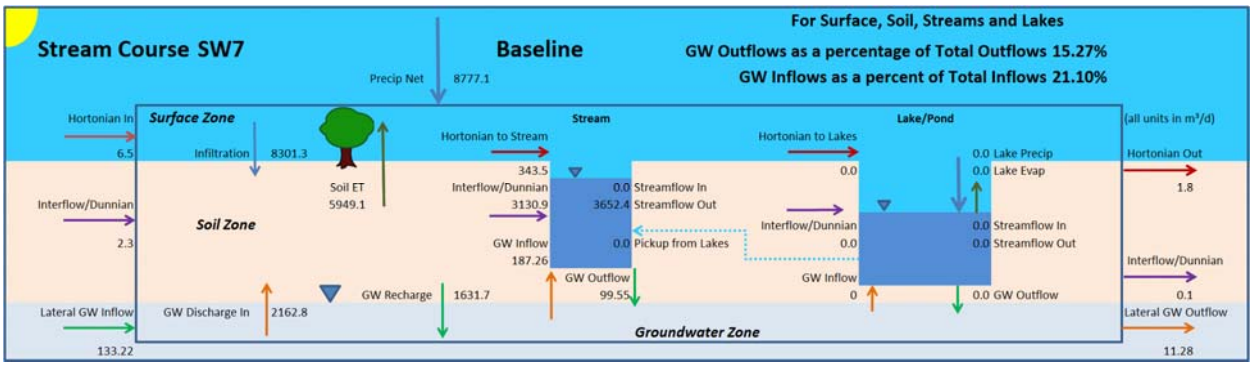


WILLOUGHBY CREEK

FIGURE 5A



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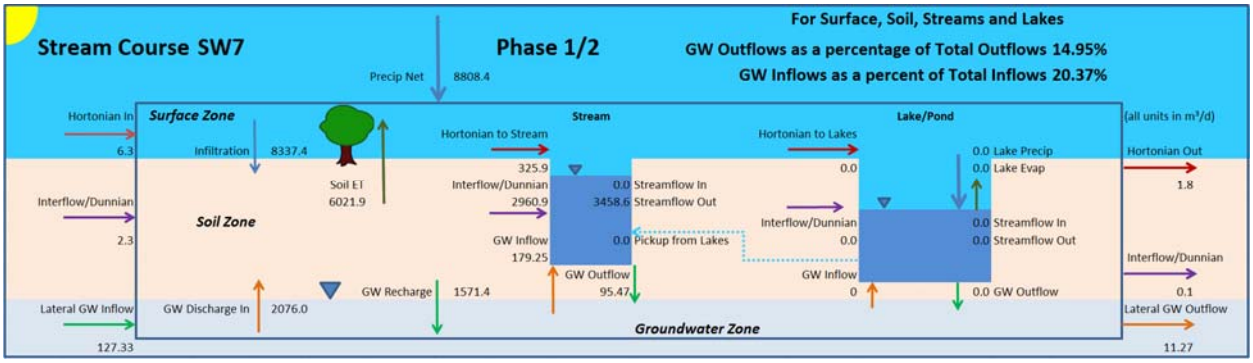

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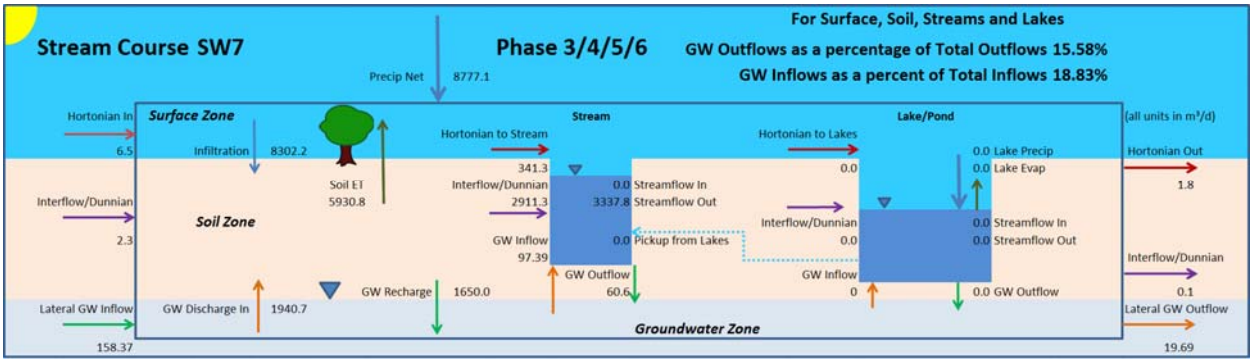

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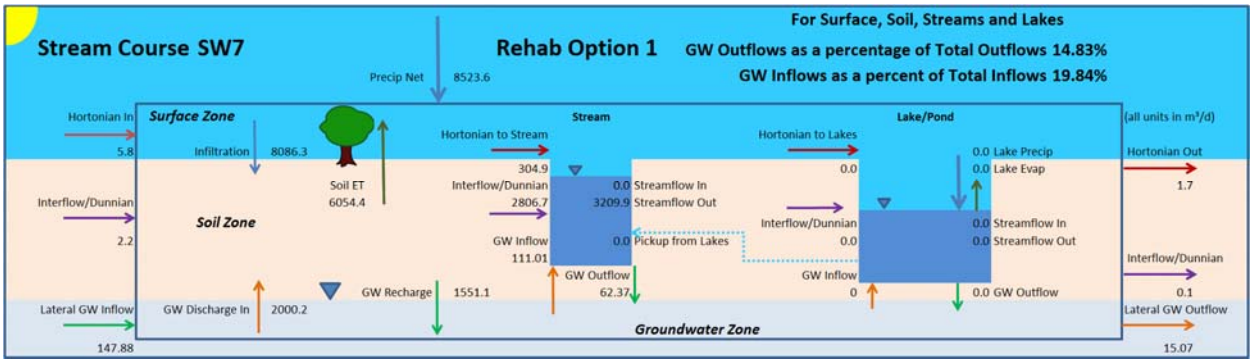

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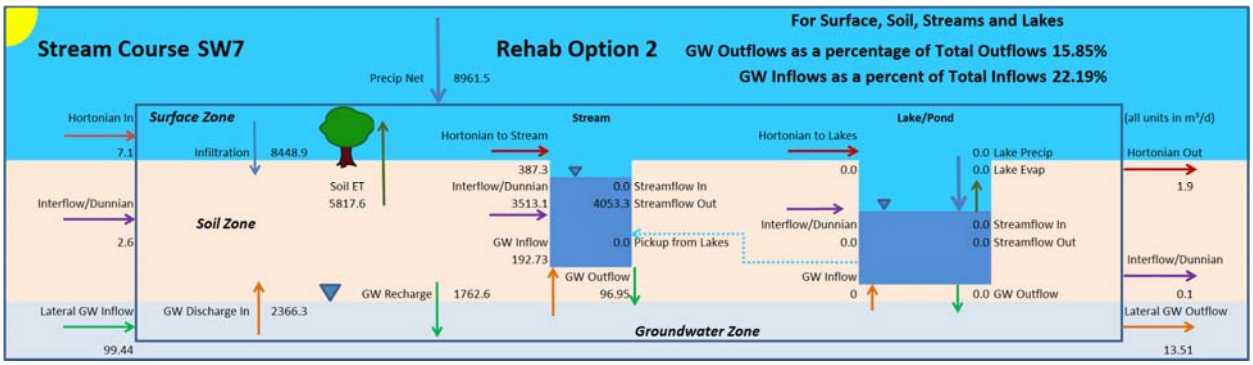
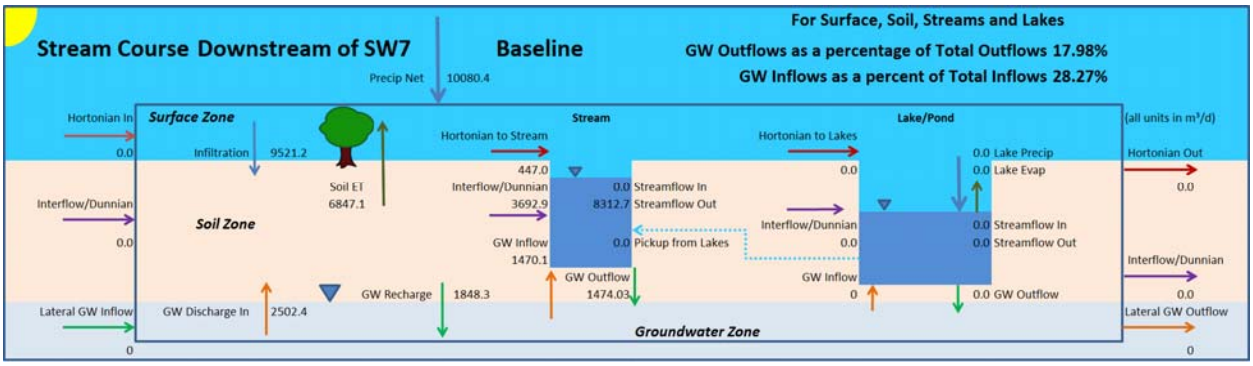


WILLOUGHBY CREEK

FIGURE 6A



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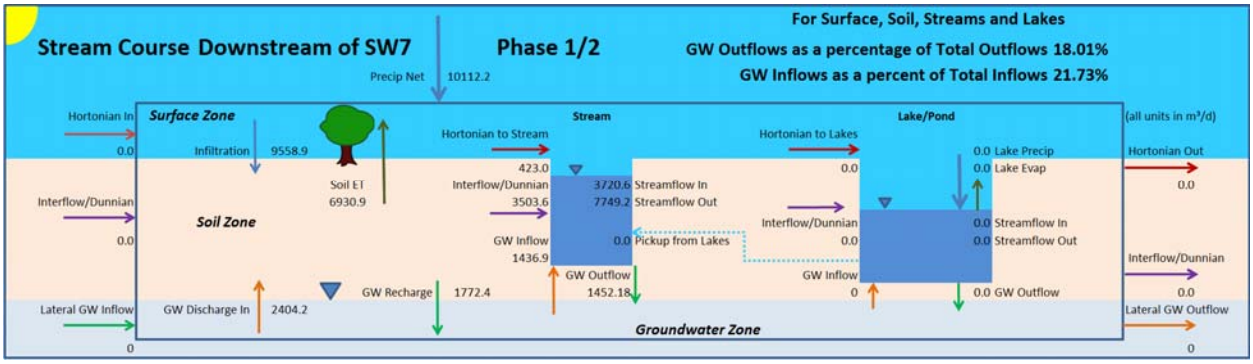

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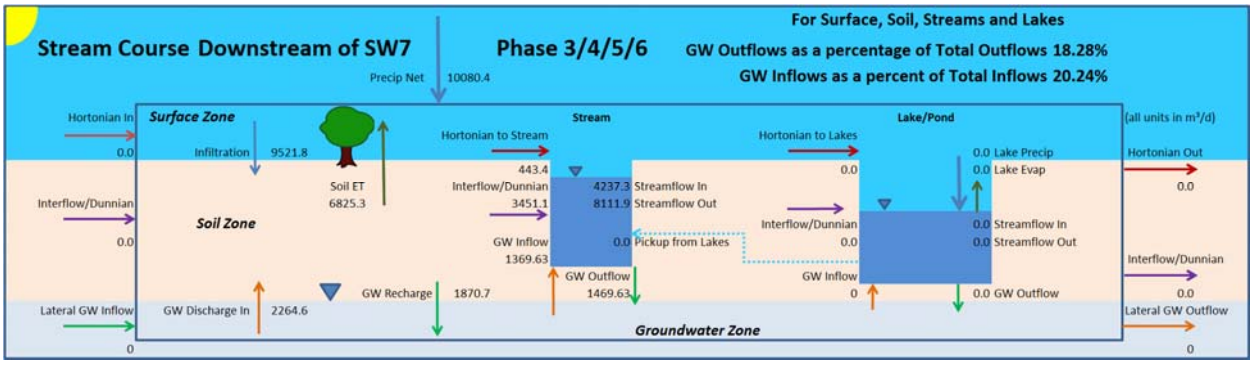

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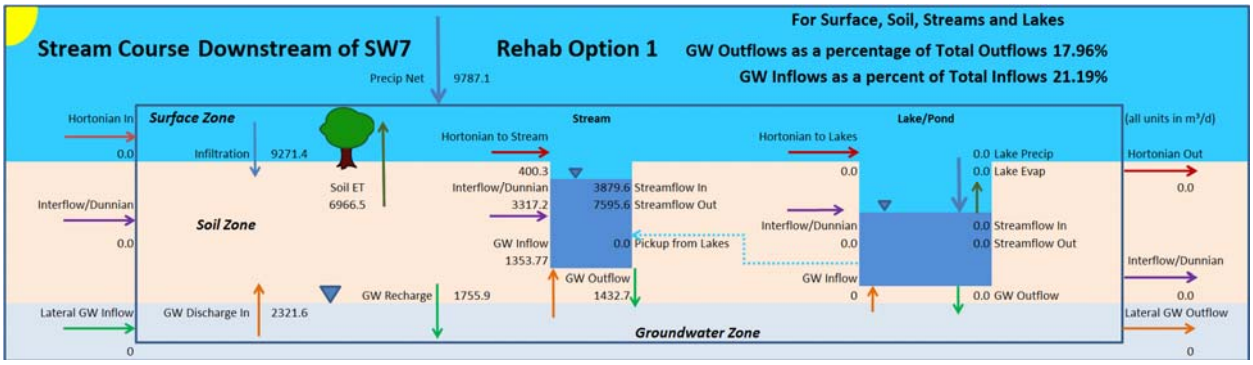

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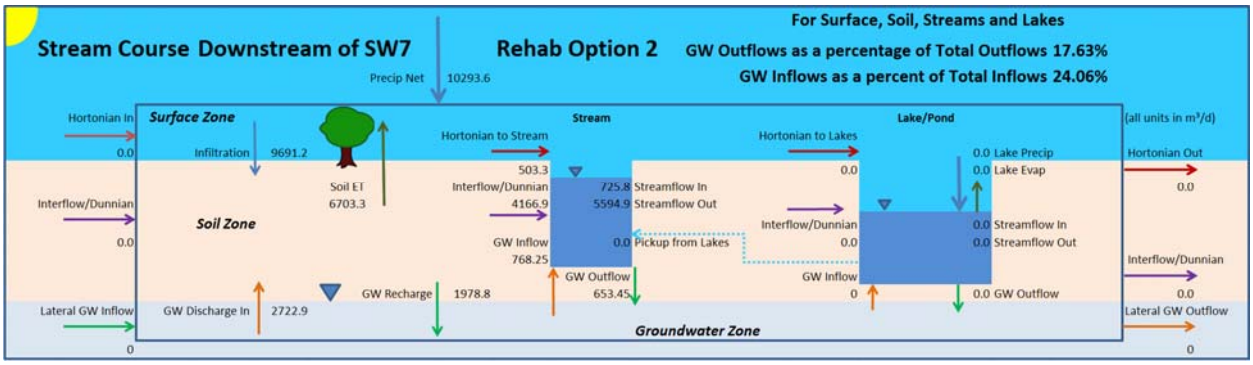
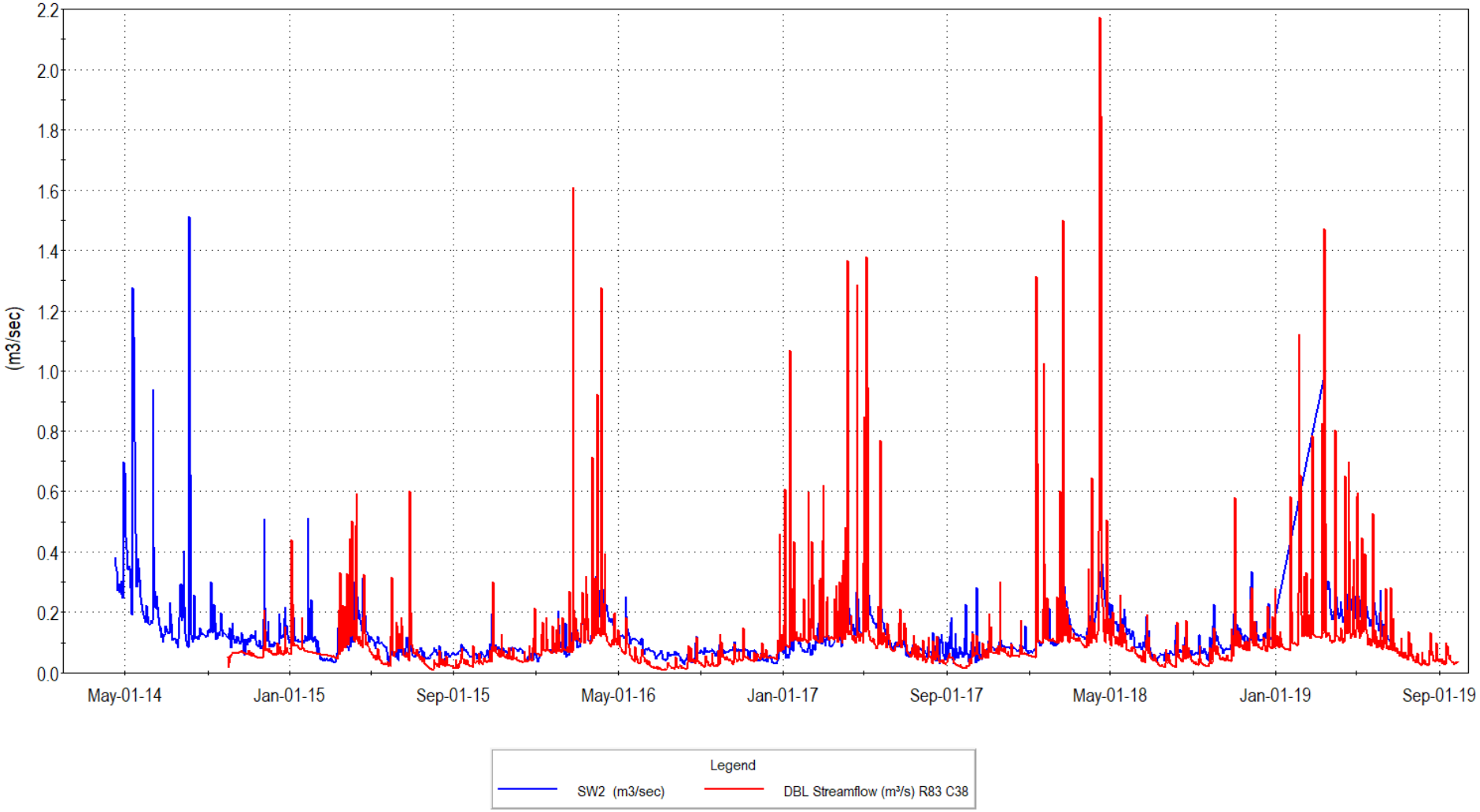


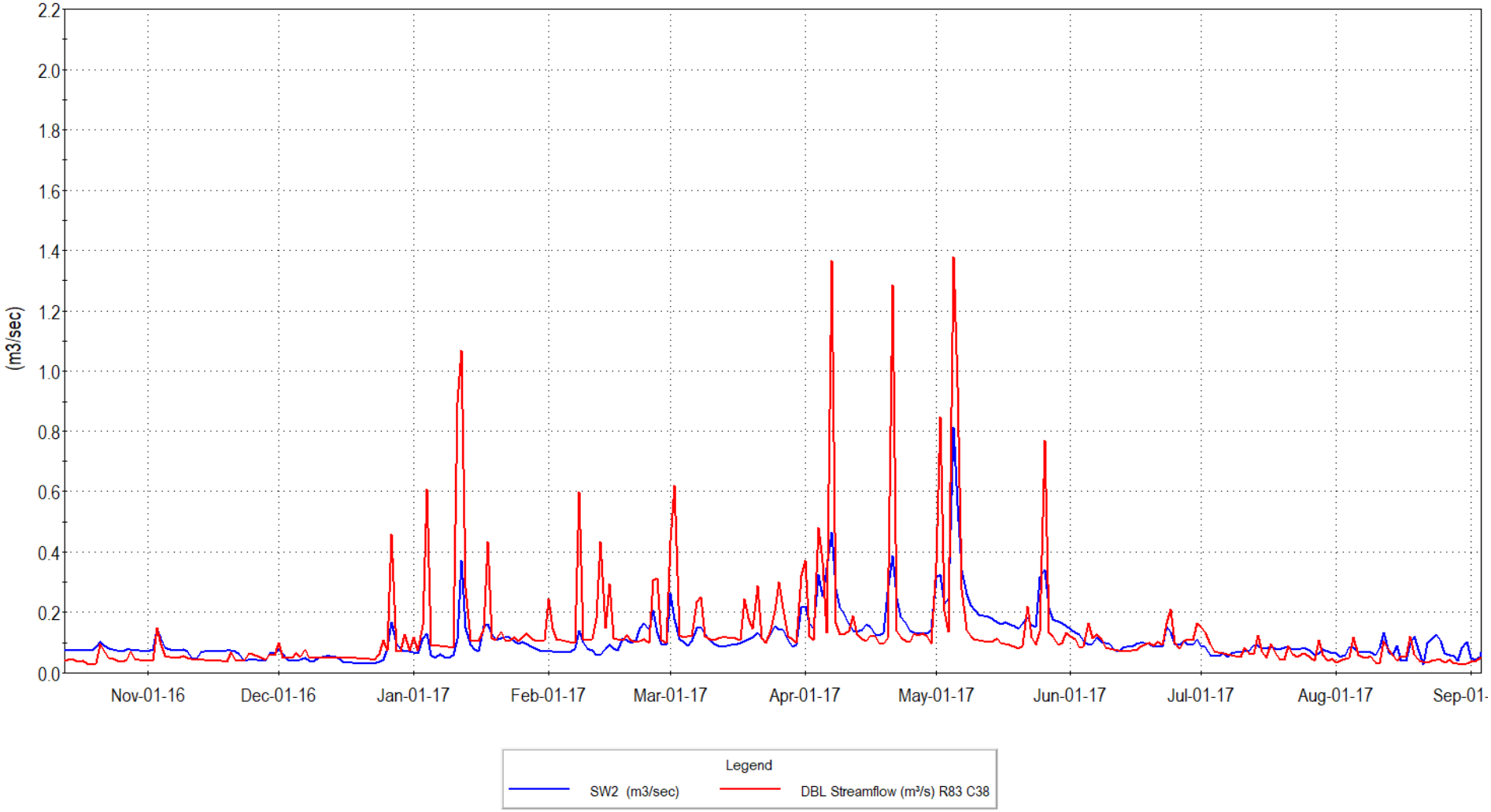
WILLOUGHBY CREEK - GRAPH 7

Integrated Model Calibration
Willoughby Creek

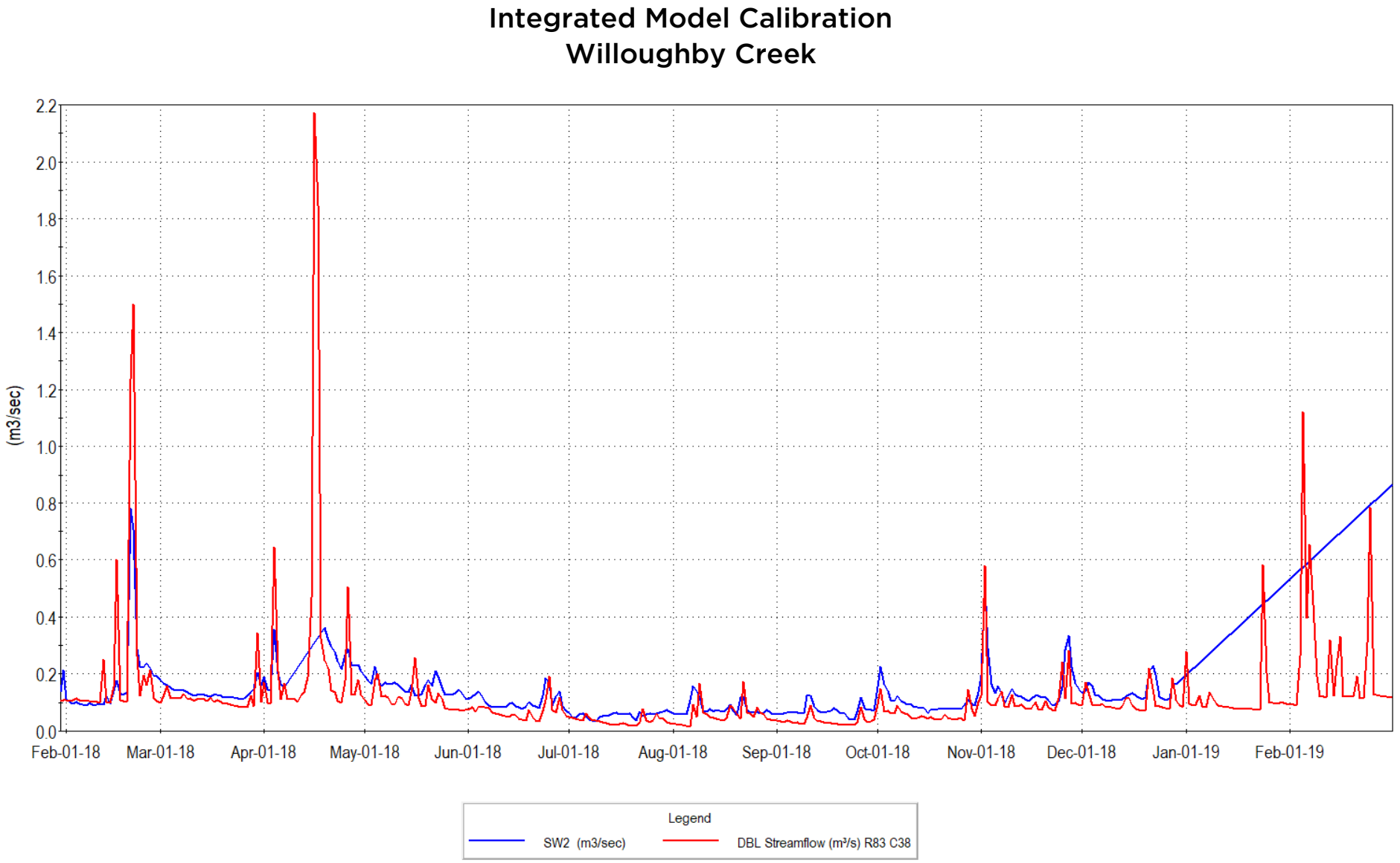


WILLOUGHBY CREEK - GRAPH 8

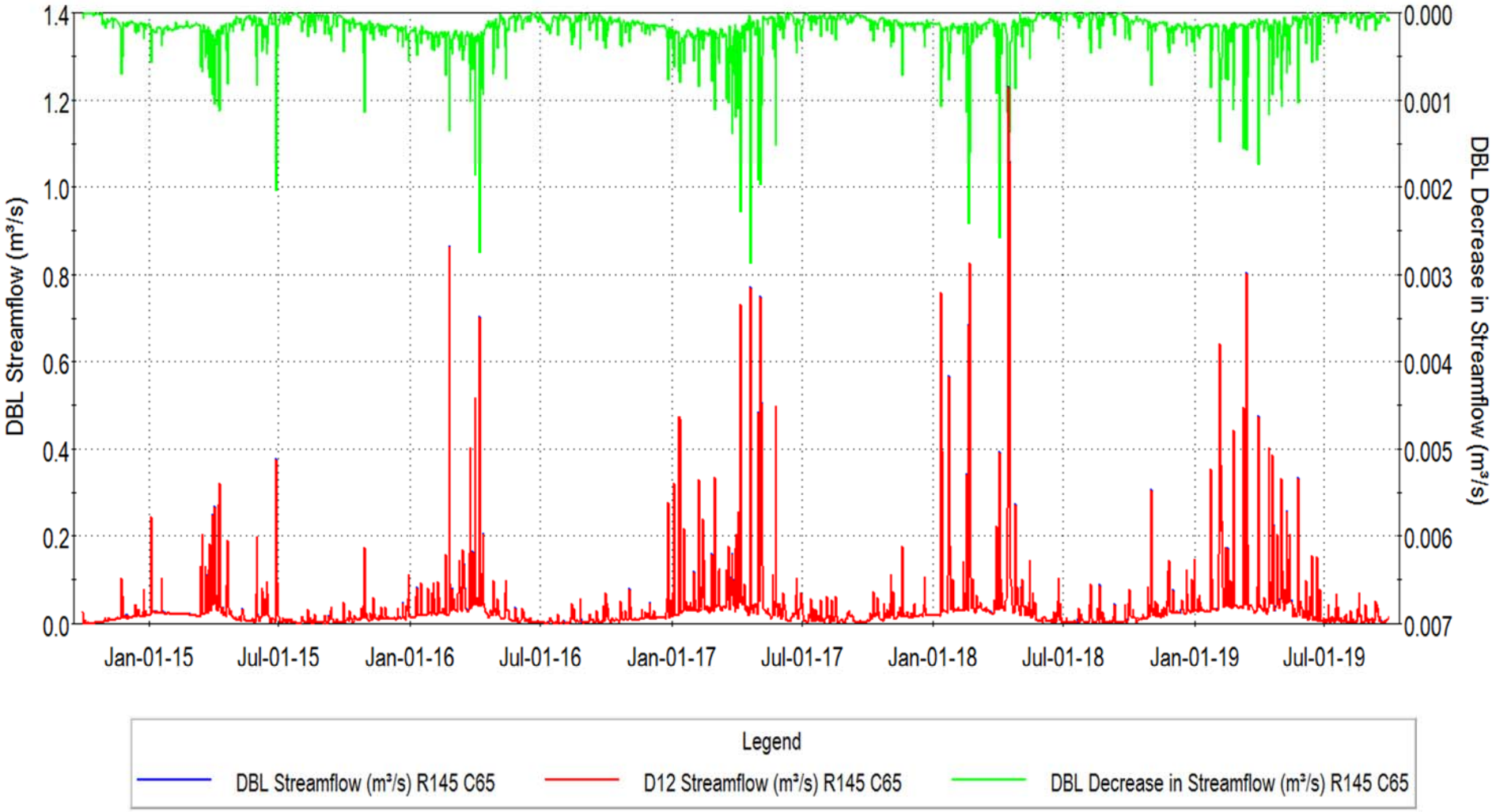
Integrated Model Calibration
Willoughby Creek



WILLOUGHBY CREEK - GRAPH 9

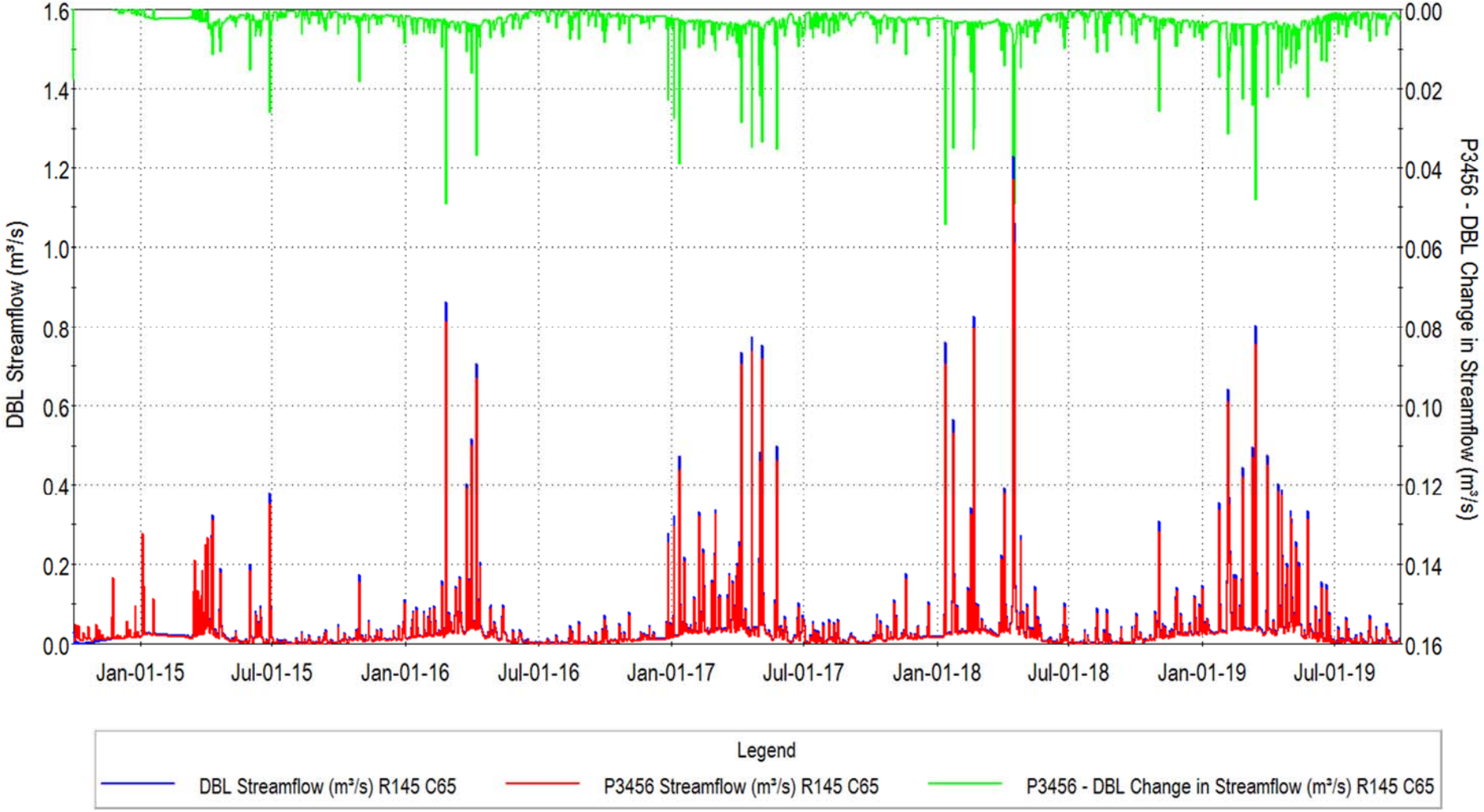


Simulated Streamflow Change - Integrated Model
Willoughby Creek

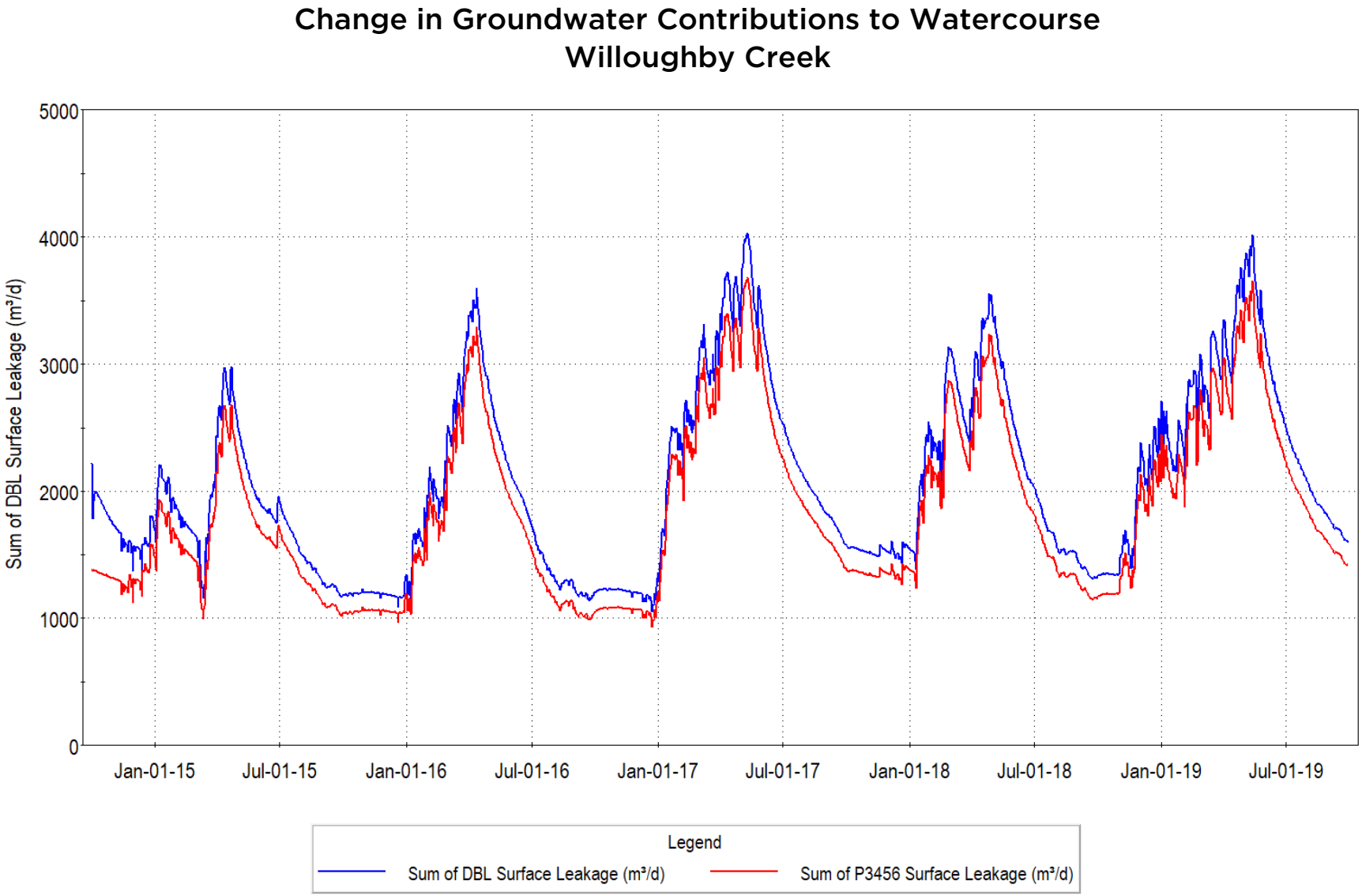


WILLOUGHBY CREEK - GRAPH 11

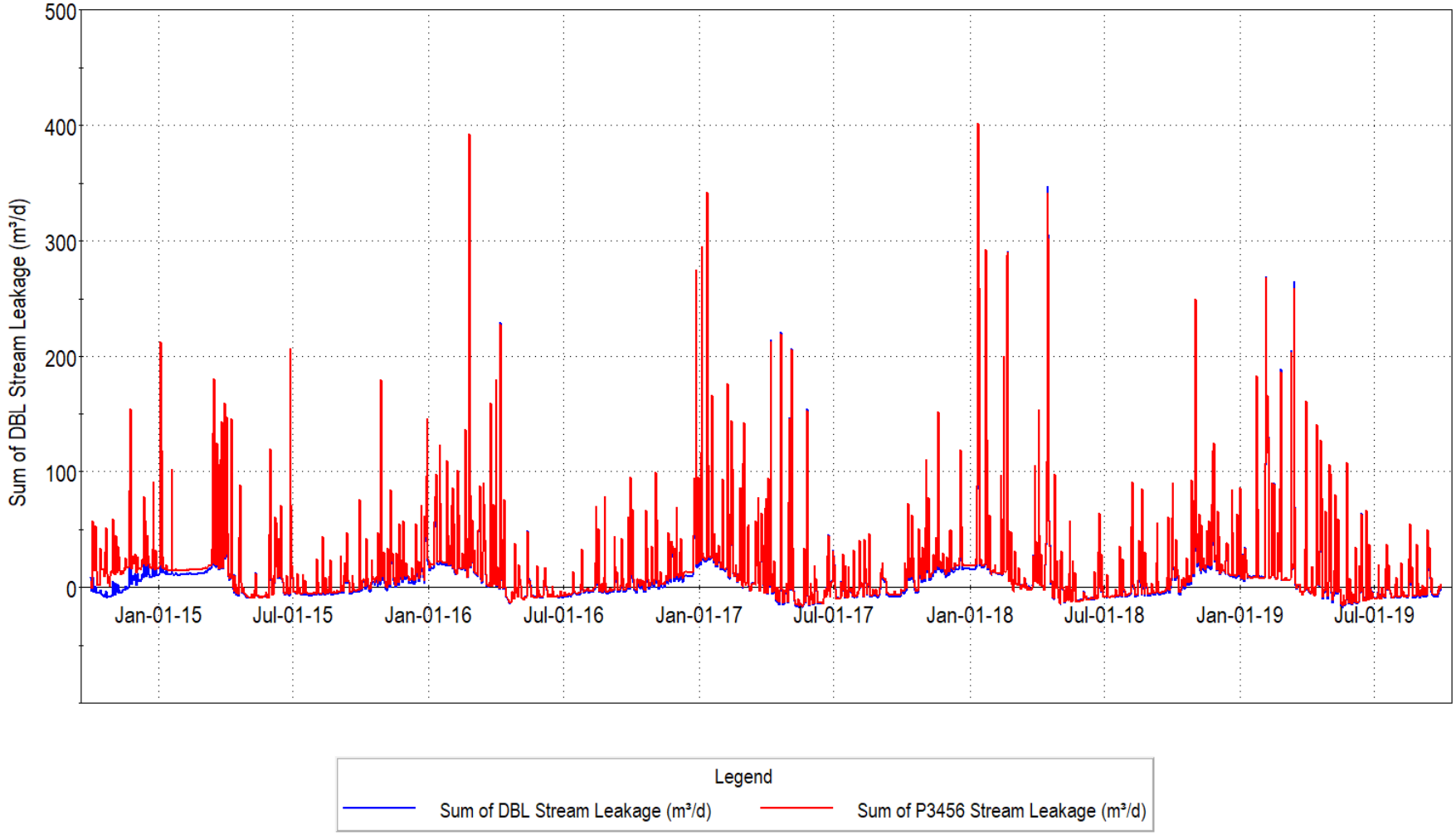
Simulated Streamflow Change - Integrated Model
Willoughby Creek



WILLOUGHBY CREEK - GRAPH 12



Change in Groundwater Contributions to Watercourse
Willoughby Creek



Proposed Burlington Quarry Extension

Response to MNRF Comments

Prepared for:

Nelson Aggregates Company
P.O. Box 1070
Burlington, Ontario L7P 0G8

Prepared by:

3363 Yonge Street
Toronto, Ontario M4N 2M6

March 2021

Earthfx Incorporated

Earth Science Information Systems

Saturday, March 27, 2021

Nelson Aggregates Co.
P.O. Box 1070
Burlington, Ontario
L7P 0G8

Attention: Mr. Quinn Moyer, President

RE: Proposed Burlington Quarry Extension Response to MNRF Comments

Dear Mr. Moyer:

Earthfx Incorporated is pleased to submit the following response to the January, 2021, MNRF Comments.

If you have any questions, please do not hesitate to call.

Yours truly
Earthfx Incorporated

Dirk Kassenaar, M.Sc., P.Eng.
President

E.J. Wexler, M.Sc., M.S.E., P.Eng.
Director of Modelling Services

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www.earthfx.com

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1 Introduction/Overview

A number of common questions arise in the MNRF review, and to address those issues a more comprehensive, integrated response is useful. This following is an **overview** of our response to the most common questions. Additional technical information on each of these issues is provided in the following sections.

1.1 Companion Wetland and Watercourse Characterization Tables

An integrated collection of tables has been prepared summarizing all of the surface water, ecology and groundwater information for each of the wetlands and watercourses. These tables, provided under separate cover, combine all of the relevant information from each of the application reports, and in some cases (where noted), provide a response to a specific question in *thi*s MNRF comment response. There is, however some overlap between the Wetland Characterization Tables and this document. The overlap can occur where this document needs to integrate additional information about specific monitors and model response.

1.2 Wetland and Shallow System Characterization: Overview

There are a number of requests for "wetland characterization". Fortunately, a clear pattern exists in the data and this pattern is central to the Earthfx model representation and overall understanding of the wetlands. In summary, the complex and wide variation in the field measurements reflects a pattern of till weathering that is commonly observed at the site and across the broader Region of Halton till plain.

A very extensive program of shallow wetland characterization was undertaken between 2002 and 2010 by Golder Associates. Golder provided an integrated compilation of the multiple field investigations in their 2010 report, and presented an overall interpretation of the shallow subsurface. Appendix K of Golder (2010) is specifically titled "Wetland Characterization" and provides many of the details for our MNRF response. (Key information as been drawn from that report and included here for ease of reference.)

The 62 minipiezometer, shallow sampling points and cores collected in the wetland areas indicate that the shallow subsurface are overwhelmingly comprised clayey silt till (i.e. Halton Till). The Golder report groups the wetlands into 4 spatial areas, but no horizontal trend or pattern in material properties between these groups areas is identified. (No significant horizontal change is expected, given that the unit was deposited by a regional-scale glacial ice advance.)

The only significant pattern in the data collected at the site is vertical weathering and desiccation fracturing. Golder (2010) subdivides the data into two layers, and refers to these units as follows:

1. An upper layer of "loose", weathered, grey, clayey silt materials
2. A lower layer of a "dense", stiff, unweathered clayey silt.

Golder uses the terms "loose" and "dense" throughout the 2010 report. In general, the depth to the "dense" till is as deep as 2.0 m, and as shallow as 0.20 m (Golder, 2010, Section K4.2). The Halton Till at the site is up to 10 m thick.

In our detailed discussion, below, the Golder conceptual model is compared to that proposed by Dr. Walter Illman (Figure 1), a previous site peer reviewer, and the Earthfx (2020) model layers. The conceptual models are entirely consistent, and explain the variation in observed hydraulic conductivity values. *In summary, the native till matrix is very dense and has low intrinsic permeability, but local scale variation in shallow fracturing may result in a wide range of observed hydraulic conductivity.* Many of the Golder field tests were made at a local scale, and Dr. Illman suggests these might be biased towards lower values because they may preferentially reflect the native till matrix (and not the collective fracture network). The Earthfx model builds on the detailed Golder analysis, but the calibrated values are higher than the Golder estimates and consistent with comments made by Dr. Illman.

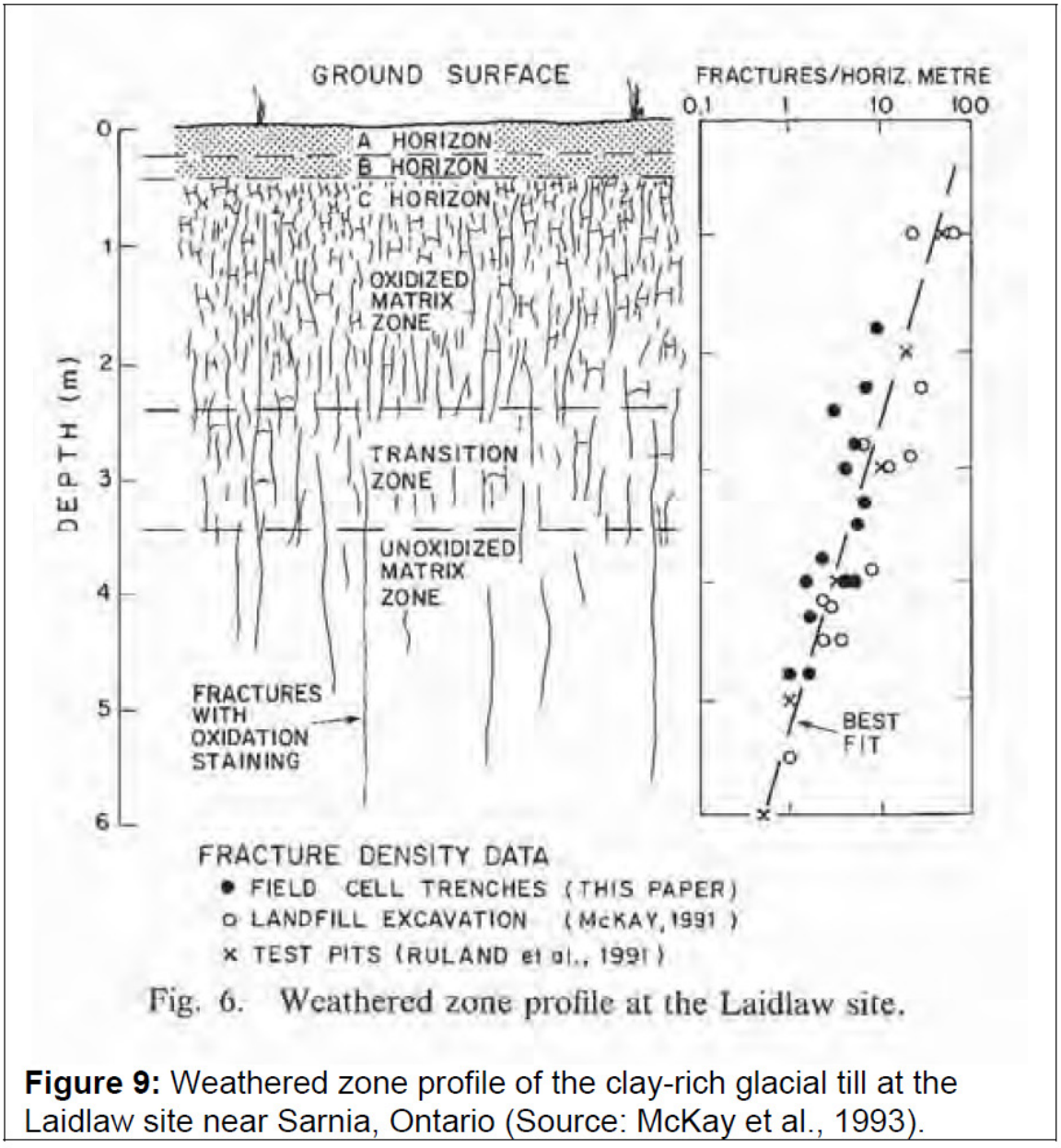

Figure 1: Conceptual Model (from OCH, 2010)

1.3 Layer 2 Response Offset (lag): Overview

A number of MNRF comments (i.e. 4.1, 4.2, 4.3, and 4.8) note that the simulated water level response in Layer 2 exhibits a time offset (lag) relative to the minipiezometer field measurements. MNRF requests that we "provide comment on whether this offset in hydroperiod allows for using this model for predictive simulations to evaluate the wetland hydroperiod".

In summary, the offset is due to a somewhat misleading (in hindsight) comparison of shallow monitoring data to deeper model response. The minipiezometers measure conditions in the shallow soil and weathered till zone, while the simulated Layer 2 water levels represent the unweathered till, which responds more slowly. (The reasons, and the selection of model parameters, are discussed in detail below.)

A better comparison is between shallow observations and model results from the soil zone. The PRMS soil zone is more representative of shallow wetland conditions. For example, a comparison between minipiezometer MP6 water levels (red) and the simulated soil moisture (green) (Figure 2) shows that the simulated soil moisture response closely matches the observed shallow water levels. The soil moisture response does not have the offset or lag observed (and expected) in Layer 2.

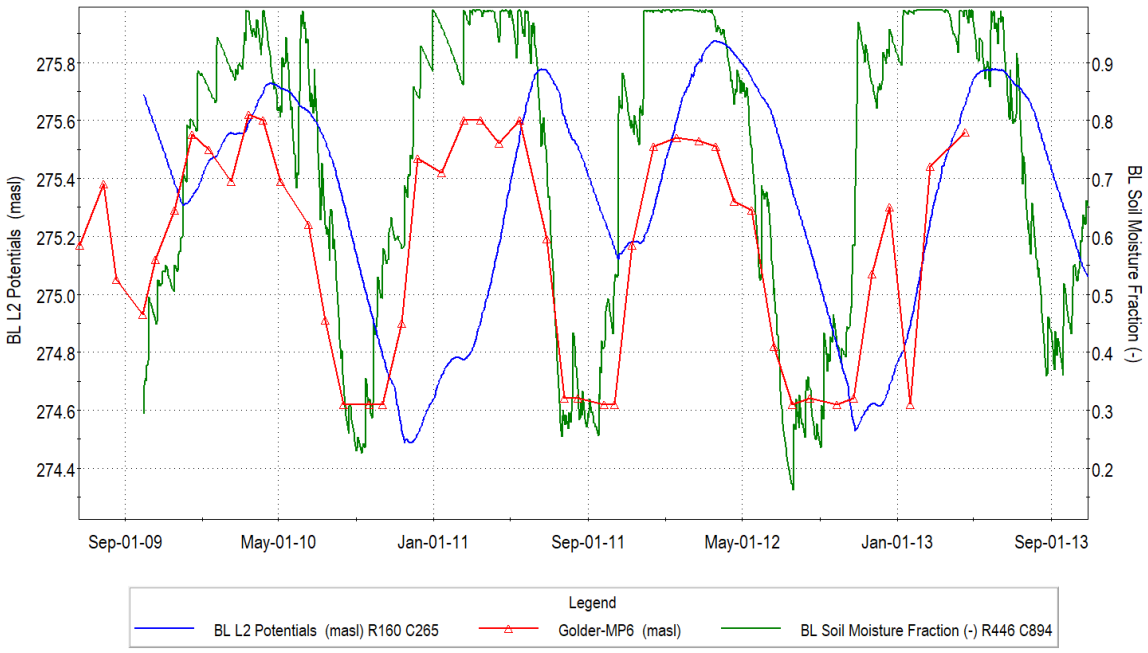

Figure 2: Water Levels (at MP6) and Soil Moisture response near Wetland EFX17 (MNRF 13033)

Section 3 of this document compares observed minipiezometers data to simulated soil moisture results at 18 locations across the study area. For example, a comparison of simulated soil moisture to continuous data from minipiezometer MP10 in Wetland EFX 16 (MNRF 13022) shows that the model simulation of hydroperiod timing is very close (Figure 3). A similar match is shown in Figure 4. This close match is observed at all the field locations and confirms that the model is representing shallow wetland processes and timing without any lag in response.

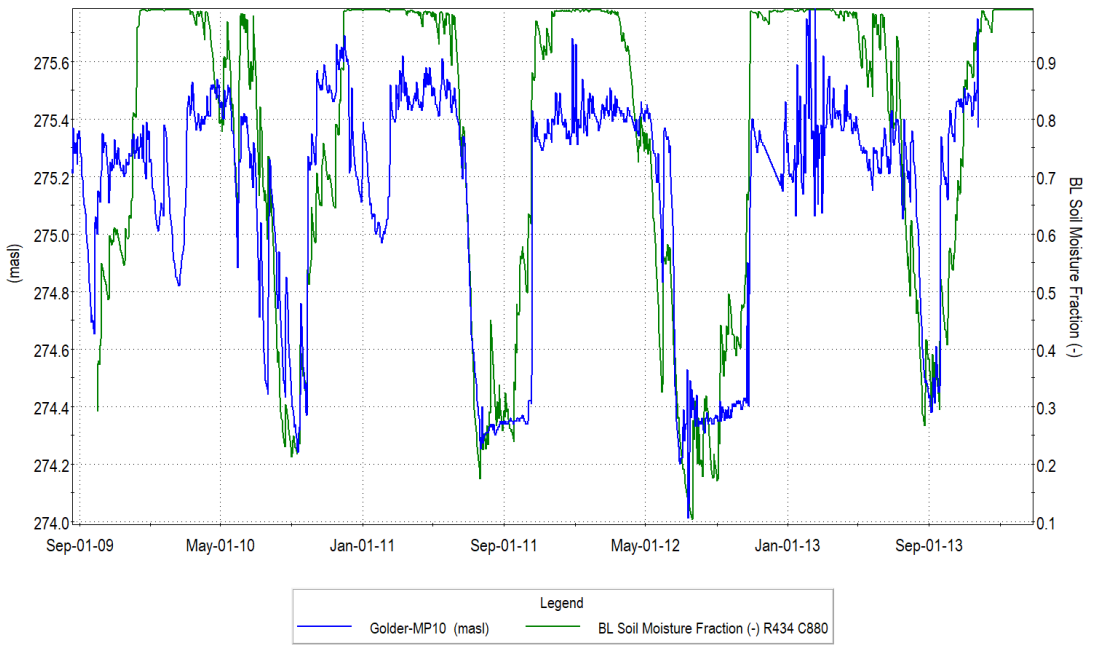

Figure 3: Water levels and soil moisture at MP10 (near SW12) in Wetland EFX 16 (MNRF 13022)

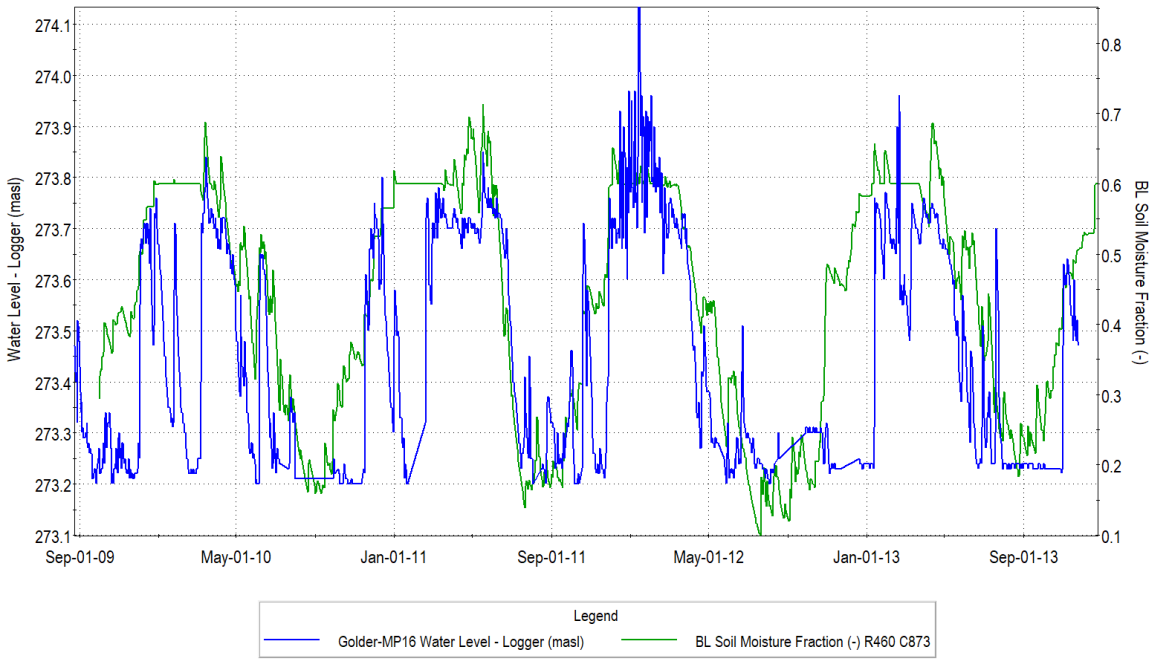

Figure 4: Comparison of simulated soil moisture to minipiezometer MP16 at Wetland EFX20 (MNRF 13036-13039):

1.4 Long Term Observations of Wetland and Quarry Interaction

The effects of quarry development can be evaluated by reviewing long-term monitoring data collected from wetlands near the existing quarry face. Earthfx Wetland 10 (MNRF 13015) provides particular insight, for continuous monitoring data was collected as the current quarry face advanced towards the wetland. The monitoring data clearly shows that the wetland water levels and hydroperiod were unaffected by a decline in groundwater levels beneath the wetland (Figure 5) as the face advanced after 2009. This observational proof is consistent with the analysis and modelling results both at Wetland 10 and other nearby wetlands.

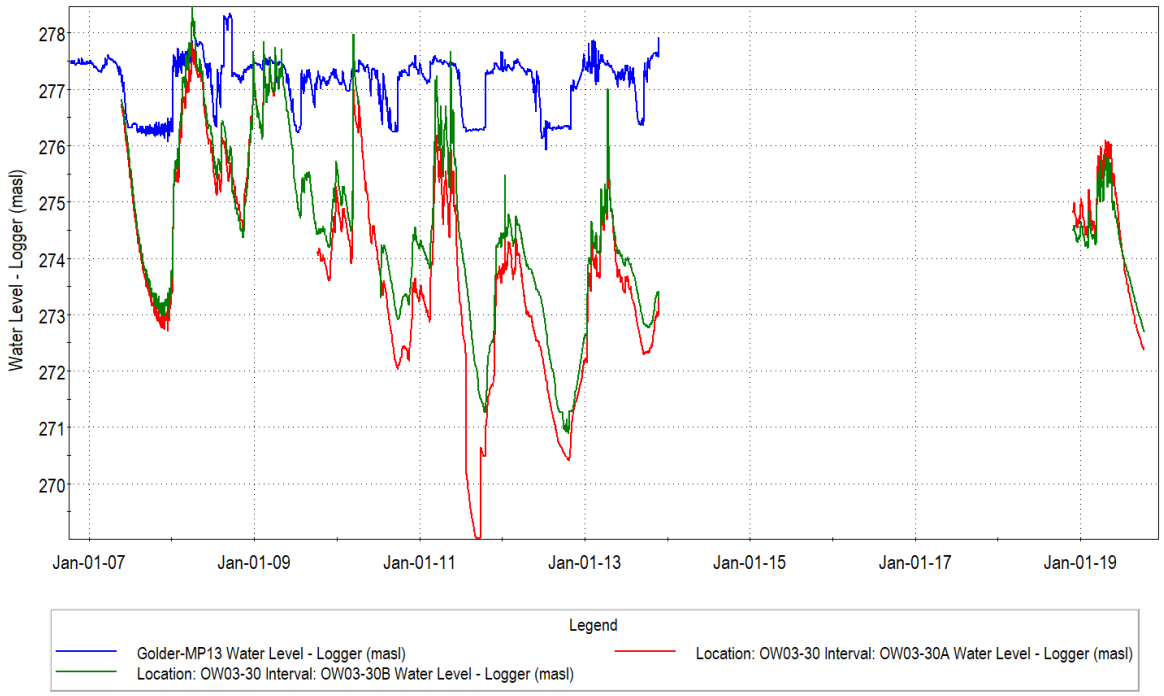

Figure 5: Monitoring data from Wetland 10 shows that shallow minipiezometer water levels (MP13) are unaffected by a decline in groundwater levels observed in monitor OW3-30 as the quarry face advanced towards the wetland.

1.5 Wetland Impact Assessment Overview

Additional feature-based water budgets have been included for all of the requested wetlands (Section 5). These water budgets are supplemented by detailed transient hydrographs of soil moisture, groundwater seepage and wetland pond leakage (see Section 6). The hydrographs (for example, Figure 6) compare average Baseline soil moisture (blue line) to P12 soil moisture levels (red line) under a range of inter-annual climate conditions. The Baseline groundwater seepage (surface leakage) into the wetland is shown as a green line. The hydrographs illustrate that the loss of groundwater seepage to the soil zone during quarry development will have only a minor effect on soil moisture conditions in the summer and fall (difference between blue and red lines).

Together, the feature-based water budget summaries and seepage hydrographs build on the detailed soil moisture and minipiezometer data to clearly illustrate the effects of quarry development across a range of climate conditions.

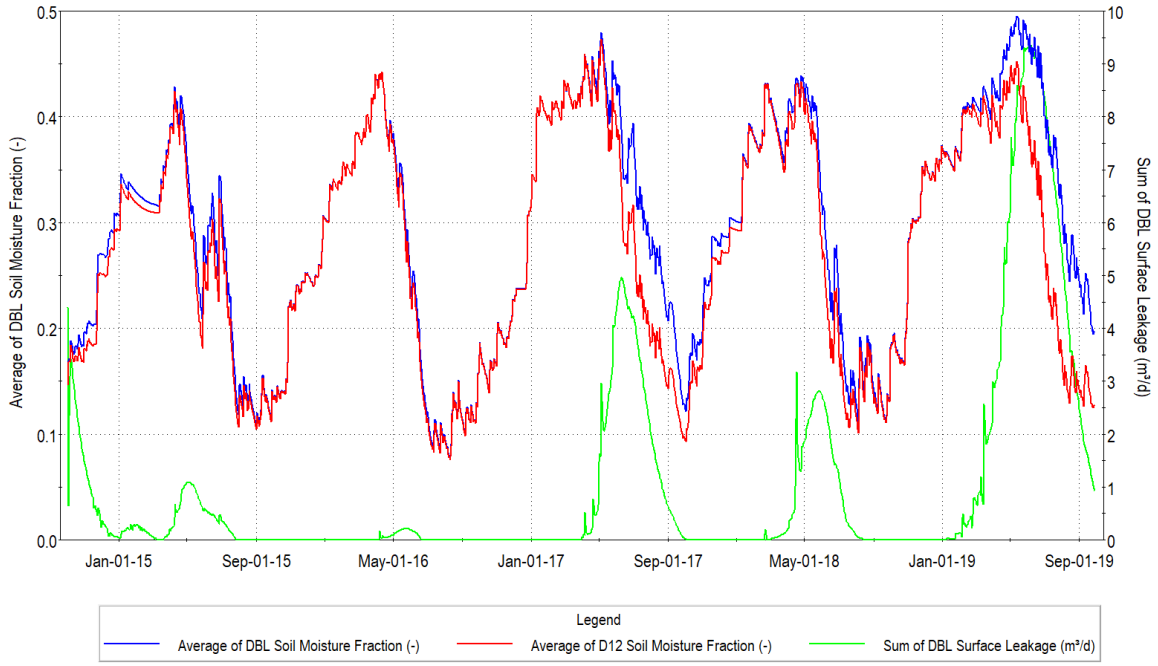

Figure 6: Soil moisture under Baseline and P12 development conditions at Wetland 17 (MNRF 13033)

2 Wetland Characterization and Hydraulic Conductivity Testing

A number of MNRF comments request additional information on the wetland characterization. The following information summarizes the extensive characterization and monitoring completed at the site over the last 15 years.

Extensive characterization of the geology, hydrogeology and hydrology of the wetlands has been undertaken in previous investigations and in the current study, including:

- Borehole drilling
- Monitoring well installations
- Groundwater level monitoring
- Geophysical surveying (EM31 to estimate overburden thickness)
- Grain size analyses
- Laboratory and field (Guelph) permeameter testing
- Staff Gauges
- Mini-piezometers
- Field inspections
- Pumping tests

A focused wetland testing program was initiated and documented in Golder, 2007 and Golder, 2010. Additional investigations, monitoring and multiple wetland characterization reports are summarized in Golder (2010), Section 8 and Appendix K.

2.1 Wetland Areas

Golder (2010, Section 8), summarizes the field assessment of the geologic and hydrogeologic wetland characterization according to the following areas:

1. Eastern Wetland, including:
    a. MNRF 13014, 13024
    b. Earthfx Wetland 9
2. South-central Wetland system, including:
    a. MNRF 13015, 13016, 13017, 13018, 13019, 13020, 13020, 13020, 13020, 13021, 13022, 13023, 13025, 13027, 13029, 13030, 13031, 13032, 13033, 13034, 13035, 13048, 13049, 13051
    b. Earthfx Wetlands 10, 11, 12, 13, 14, 15, 16, 17, 19
3. Southwest Wetland/Woodlot area, including:
    a. MNRF 13036, 13037, 13038, 13039
    b. Earthfx Wetland 20
4. background areas outside of the delineated wetland and woodlot areas.
    a. Including temporary staff gauge in MNRF13032

While these wetlands are presented as separate groups, there were no significant differences in the wetland characteristics observed between the wetland groups.

For reference, the Table 1 provides a listing of the MNRF and corresponding Earthfx wetland numbers.

Table 1: MNRF and Earthfx Wetland Numbers

Earthfx ID	MNRF Wetland ID Numbers
8	Between Guelph Line and Bluff's way
9	13014
10	13015
11	13016
12	13017, 13018
13	13030
14	13019
15	13021
16	13022
17	13033
18	13203
19	13032
20	13036, 13037, 13038, 13039
21	13201
22	13200
23	13202 (Weir Pond)
24	Medad Valley Wetland Complex 13204

2.2 Shallow Monitoring Network

Borehole logs and monitoring details have been requested for multiple wetlands. To address this request, the monitoring locations, well construction and logs are provided below. A discussion of the findings in included following the presentation of the data.

2.2.1 Minipiezometer Locations and Logs

The shallow subsurface has been characterized and monitored by a network of more than 62 minipiezometers, soil cores boreholes and Guelph permeameter tests (including some in excavated depressions to evaluate the deeper system). An additional three mini-piezometers (MP-33, MP-34 and MP-35) were temporarily installed on properties adjacent to the Nelson properties. This shallow network is in addition to the bedrock well nests, which include deeper overburden and bedrock wells.

A list of the minipiezometer locations and depths is included in Table 2. Additional details and borehole logs are included in Golder, 2010 (Page 1433-1494). As requested, the borehole logs are appended in Appendix B (Section 12)

- Minipiezometer Logs: See Section 12.1
- Pond and Trib Soil Sample Logs: See Section 12.2

- Soil Sample Logs: See Section 12.3
- GMP Series Logs: See Section 12.4

The dominant material in the borehole logs is clayey silt. The geologic findings and conceptual model is discussed below.

2.2.2 Other Shallow Monitoring Locations

In addition to the minipiezometer network a number of other sampling and monitoring locations have been collected. These include:

- GP03 Series wells (6 locations- See Table 3 and Table 4)
- SA Series wells (8 locations – See Table 5 and Table 6)
- Other SW focused locations (TRIB and Pond locations – See Table 5 and Table 6)

2.2.3 Guelph Permeameter Test Sites and Logs

A total of six Guelph Permeameter tests were conducted across the Eastern, Southcentral and Southwest wetland areas. The geologic description for these sites is included in Table 7, below.

Table 2: Piezometer Construction Details - Golder (2007) Table 1

September [illegible]7 — Table [illegible] — [illegible]-1238

Summary of Piezometer Construction Details

Piezometer ID	Ground Surface Elevation	Stickup	Well Depth	Groundwater Level in Piezometer					
				Depth	Elevation	Depth	Elevation	Depth	Elevation
	(masl)	(m)	(m bgs)	(m bgs)	(masl)	(m bgs)	(masl)	(m bgs)	(masl)
				20-Apr-07		6-Jun-07		11-Jul-07	
MP-1	275.05	0.84	1.1			0.12	274.925	Dry (1.30)	< 273.95
MP-2	275.30	0.56	1.27			0.21	275.09	Dry (0.80)	< 274.03
MP-3	275.17	1.28	0.86			Dry (0.86)	< 274.31	Dry (0.81)	< 274.31
MP-4	275.13	1.1	0.9			0.27	274.855	Dry (0.95)	< 274.23
MP-5	275.15	1.3	1			0.25	274.9	Dry (0.98)	< 274.15
MP-6	275.59	0.87	0.97			0.23	275.36	0.90	274.69
MP-7	275.59	1.02	1.12			0.6	274.99	Dry (1.10)	< 274.47
MP-8	275.50	0.47	0.99			0.98	274.515	Dry (0.98)	< 274.51
MP-9	275.51	1.28	0.91			0.74	274.77	Dry (0.90)	< 274.60
MP-10	275.57	1.1	1.05			0.538	275.03	Dry (1.05)	< 274.52
MP-11	276.89	1.41	0.95			0.665	276.22	Dry (0.95)	< 275.94
MP-12	275.79	1.05	1.04			0.409	275.38	Dry (1.00)	< 274.75
MP-13	277.43	0.99	1.12			0.395	277.03	Dry (1.10)	< 276.31
MP-14	271.34	1.57	1.39			0.08	271.26	1.12	270.22
MP-16		1.04	0.54			0.43		Dry (0.54)	
MP-17	277.71	0.36	1.13	0.78	276.94	0.88	276.83	Dry (1.10)	< 276.58
MP-18	277.58	0.61	0.92	0.71	276.87	0.72	276.86	Dry (0.91)	< 276.66
MP-19	277.62	0.37	1.12	0.33	277.29	1.03	276.585	Dry (1.08)	< 276.50
MP-20	277.45	0.42	1.07	0.61	276.84	0.68	276.77	Dry (1.03)	< 276.38
MP-21	277.51	0.49	1	0.89	276.62	0.89	276.615	Dry (0.99)	< 276.51
MP-22	276.84	0.44	1.08	0.98	275.86	1.02	275.82	Dry (1.07)	< 275.76
MP-23	277.68	0.95	0.49	0.14	277.54	Dry (0.49)	< 277.19	Dry (0.43)	< 277.19
MP-24	276.57	0.34	1.18	0.96	275.61	0.83	275.74	Dry (1.16)	< 275.39
MP-25	276.28	0.35	1.13	0.79	275.50	0.58	275.7	Dry (1.13)	< 275.15
MP-26	276.07	0.54	1.38	0.83	275.24	0.44	275.63	Dry (0.96)	< 274.69
MP-27	275.77	0.37	1.14	0.60	275.17	0.81	274.955	Dry (1.10)	< 274.63
MP-28	277.03	0.55	0.94	0.79	276.25	0.34	276.69	Dry (0.94)	< 276.09
MP-29	276.62	0.37	1.12	0.19	276.43	0.7	275.92	Dry (1.07)	< 275.50
MP-30	275.92	0.55	0.93	0.87	275.05	0.85	275.065	Dry (0.93)	< 274.99
MP-31	277.96	0.65	0.87	0.68	277.28	Dry (0.87)	< 277.09	Dry (0.87)	< 277.09
MP-32	276.60	0.41	1.07	0.83	275.77	0.53	276.065	Dry (1.06)	< 275.53

Table 3: GP03 Series Monitor Location Details

Table A.1
Monitoring Well Installation Details
Proposed Nelson Aggregate Co. Burlington Quarry Extension

Borehole	Borehole/Well No.	Survey Coordinates NAD 83		Stick Up (m)	Top of Pipe Elevation (masl)	Ground Surface Elevation (masl)	Total Completion Depth (m)	Date Drilled (Day/Mo/Yr)	Bedrock Surface Elevation (masl)	Overburden Thickness (m)
		Northing	Easting							
OW03-21	OW03-21A	4805512.56	590730.39	0.82	280.56	279.74	31.1	Feb-03	277.4	2.32
	OW03-21B	4805512.60	590730.41	0.79	280.53	279.74	8.9	Feb-03	277.4	2.32
	OW03-21C	4805514.29	590731.75	1.07	280.88	279.81	2.3	Feb-03	277.5	2.32
OW03-22	OW03-22A	4805159.75	591275.16	0.86	275.87	275.01	28.3	Feb-03	271.7	3.28
	OW03-22B	4805159.74	591275.12	0.82	275.84	275.02	11.2	Feb-03	271.7	3.28
	OW03-22C	4805162.78	591275.27	1.22	276.14	274.92	3.3	Feb-03	271.6	3.28
OW03-23	OW03-23A	4805138.01	591264.20	0.97	275.93	274.96	26.7	Feb-03	271.8	3.14
	OW03-23B	4805138.01	591264.16	1.00	275.91	274.91	10.7	Feb-03	271.8	3.14
	OW03-23C	4805135.13	591264.21	1.09	275.87	274.78	3.1	Feb-03	271.6	3.14
OW03-24	OW03-24A	4805115.97	591256.37	0.90	275.78	274.88	27.0	28-Feb-03	271.4	3.44
	OW03-24B	4805115.96	591256.33	0.84	275.72	274.88	10.6	28-Feb-03	271.4	3.44
	OW03-24C	4805116.16	591258.56	0.98	275.72	274.74	3.4	28-Feb-03	271.3	3.44
OW03-25	OW03-25A	4805139.08	591230.62	0.89	275.89	275.00	28.6	28-Feb-03	271.7	3.35
	OW03-25B	4805139.05	591230.61	0.86	275.85	274.99	10.8	28-Feb-03	271.6	3.35
	OW03-25C	4805137.52	591229.38	1.00	275.99	274.99	3.4	28-Feb-03	271.6	3.35
OW03-26	OW03-26A	4805153.96	591240.44	0.99	276.01	275.02	28.9	4-Mar-03	271.1	3.92
	OW03-26B	4805153.96	591240.48	0.98	276.01	275.03	11.3	4-Mar-03	271.1	3.92
	OW03-26C	4805152.78	591238.40	0.68	275.68	275.01	3.9	4-Mar-03	271.1	3.92
OW03-27	OW03-27A	4805165.17	591252.50	0.99	276.04	275.05	28.9	5-Mar-03	271.1	3.91
	OW03-27B	4805165.17	591252.53	0.95	276.01	275.06	11.2	5-Mar-03	271.2	3.91
	OW03-27C	4805164.08	591249.81	0.82	275.86	275.04	3.9	5-Mar-03	271.1	3.91
OW03-28	OW03-28A	4805239.47	591163.21	0.89	276.35	275.46	27.3	Mar-03	272.4	3.06
	OW03-28B	4805239.45	591163.16	0.86	276.32	275.46	9.8	Mar-03	272.4	3.06
	OW03-28C	4805238.13	591161.39	1.04	276.44	275.40	3.1	Mar-03	272.3	3.06
OW03-29	OW03-29A	4805168.08	591363.56	0.95	278.01	277.06	29.5	Mar-03	275.2	1.85
	OW03-29B	4805168.05	591363.55	0.92	277.97	277.05	10.2	Mar-03	275.2	1.85
	OW03-29C	4805169.67	591365.08	1.08	278.10	277.02	1.9	Mar-03	275.2	1.85
OW03-30	OW03-30A	4805878.15	590933.08	1.10	279.16	278.06	19.4	15-Aug-03	275.3	2.78
	OW03-30B	4805878.15	590933.08	1.08	279.42	278.34	8.5	15-Aug-03	275.6	2.78
OW03-31	OW03-31A	4805806.42	591005.30	0.94	279.40	278.47	15.2	15-Aug-03	276.8	1.67
	OW03-31B	4805806.42	591005.30	0.89	278.73	277.84	7.3	15-Aug-03	276.2	1.67
OW03-32	OW03-32A	4804834.61	590873.86	0.69	272.15	271.46	23.4	19-Aug-03	270.4	1.02
	OW03-32B	4804834.61	590873.86	0.64	272.10	271.46	9.7	19-Aug-03	270.4	1.02
GP03-33	GP03-33	4805829.17	591062.39	0.64	279.01	278.38	2.8	8-Dec-03	275.6	2.82
GP03-34	GP03-34	4805844.77	591040.20	0.77	278.73	277.96	3.7	8-Dec-03	274.3	3.66
GP03-35	GP03-35	4805872.25	591011.75	0.88	278.83	277.95	3.1	8-Dec-03	274.9	3.05
GP03-36	GP03-36	4805898.42	590992.48	1.04	278.98	277.94	4.1	8-Dec-03	273.9	4.08
GP03-37	GP03-37	4805871.14	591043.96	0.91	278.86	277.95	3.2	9-Dec-03	274.7	3.20
GP03-38	GP03-38	4805855.40	591064.96	0.84	278.87	278.03	2.8	9-Dec-03	275.2	2.82
PUMPING WELL	PW-1	4805175.80	591273.65	0.69	275.67	274.98	25.9	3-Mar-03	271.0	3.96

Table 4: GP03 Series Monitoring Interval Details

Table A.2
Monitoring Well Intervals
Proposed Nelson Aggregate Co. Burlington Quarry Extension

Borehole	Borehole/Well No.	Ground Surface Elevation (masl)	Monitoring Interval Depth		Monitoring Interval Elevation		Date Installed (Day/Mo/Yr)	Geologic Units Monitored
			Top (mbgs)	Bottom (mbgs)	Top (masl)	Bottom (masl)		
MW03-01	MW03-01A	270.94	19.05	23.24	251.89	247.7	17/02/03	Reynales and Thorold Formations
	MW03-01B	270.94	9.14	14.10	261.80	256.84	17/02/03	Amabel Formation
	MW03-01C	270.97	0.61	1.46	270.36	269.51	17/02/03	Overburden
MW03-02	MW03-02A	272.48	20.73	24.69	251.75	247.79	19/02/03	Reynales and Thorold Formations
	MW03-02B	272.48	11.58	15.85	260.90	256.63	19/02/03	Amabel Formation
	MW03-02C	272.54	2.51	4.10	270.03	268.44	19/02/03	Overburden
MW03-03	MW03-03A	274.78	19.20	23.17	255.58	251.61	27/02/03	Amabel and Reynales Formations
	MW03-03B	274.78	10.06	14.02	264.72	260.76	27/02/03	Amabel Formation
	MW03-03C	274.73	0.62	2.65	274.11	272.08	27/02/03	Overburden
MW03-04	MW03-04A	274.92	17.68	21.64	257.24	253.28	03/07/03	Amabel and Reynales Formations
	MW03-04B	274.92	8.23	12.50	266.69	262.42	03/07/03	Amabel Formation
	MW03-04C	274.86	1.40	3.20	273.46	271.66	03/07/03	Overburden
MW03-05	MW03-05A	275.01	2.59	3.35	272.42	271.66	03/10/03	Overburden
	MW03-05B	275.01	1.07	2.13	273.94	272.88	03/10/03	Overburden
MW03-06	MW03-06A	275.01	1.98	2.41	273.03	272.60	03/10/03	Overburden
	MW03-06B	275.01	1.22	1.68	273.79	273.33	03/10/03	Overburden
MW03-07	MW03-07A	275.37	14.48	18.77	260.89	256.60	13/03/03	Amabel Formation
	MW03-07B	275.38	5.64	7.92	269.74	267.46	13/03/03	Amabel Formation
	MW03-07C	275.37	1.83	3.81	273.54	271.56	13/03/03	Overburden
MW03-08	MW03-08A	278.04	16.10	20.07	261.94	257.97	18/03/03	Amabel Formation
	MW03-08B	278.05	6.93	11.15	271.12	266.90	18/03/03	Amabel Formation
	MW03-08C	278.16	0.91	2.90	277.25	275.26	18/03/03	Overburden
MW03-09	MW03-09A	280.09	19.18	21.77	260.91	258.32	24/03/03	Amabel Formation
	MW03-09B	280.10	5.49	9.37	274.61	270.73	24/03/03	Amabel Formation
	MW03-09C	280.20	1.01	2.90	279.19	277.30	24/03/03	Overburden
MW03-10	MW03-10A	278.12	17.96	20.27	260.16	257.85	27/03/03	Amabel Formation
	MW03-10B	278.14	5.18	9.60	272.96	268.54	27/03/03	Amabel Formation
	MW03-10C	278.08	1.12	2.92	276.96	275.16	27/03/03	Overburden
OW03-11	MW03-11A	278.00	2.26	2.87	275.74	275.13	28/03/03	Overburden
	MW03-11B	278.00	1.37	2.03	276.63	275.97	28/03/03	Overburden
OW03-12	MW03-12	278.15	0.97	1.60	277.18	276.55	28/03/03	Overburden
OW03-14	OW03-14A	280.06	19.00	29.19	261.06	250.87	-	Amabel, Reynales and Thorold Formations
	OW03-14B	280.07	2.00	7.35	278.07	272.72	-	Amabel Formation
	OW03-14C	279.89	0.10	1.60	279.79	278.29	-	Overburden
OW03-15	OW03-15A	275.12	18.32	25.10	256.80	250.02	-	Amabel, Reynales and Thorold Formations
	OW03-15B	275.12	5.92	10.24	269.20	264.88	-	Amabel Formation
	OW03-15C	275.11	1.90	3.50	273.21	271.61	-	Overburden
OW03-16	OW03-16A	272.20	17.82	25.60	254.38	246.60	-	Amabel, Reynales and Thorold Formations
	OW03-16B	272.20	2.92	9.97	269.28	262.23	-	Amabel Formation
	OW03-16C	272.33	2.30	3.90	270.03	268.43	-	Overburden
OW03-17	OW03-17A	272.09	15.10	22.77	256.99	249.32	15/04/04	Amabel, Reynales and Thorold Formations
	OW03-17B	272.09	3.67	11.44	268.43	260.65	15/04/04	Amabel Formation
OW03-18	OW03-18A	275.64	16.70	27.00	258.94	248.64	-	Amabel, Reynales and Thorold Formations
	OW03-18B	275.65	5.48	11.90	270.17	263.75	-	Amabel Formation
	OW03-18C	275.25	2.99	4.57	272.26	270.68	-	Overburden
OW03-19	OW03-19A	284.87	22.78	29.50	262.09	255.37	-	Amabel Formation
	OW03-19B	284.87	10.99	17.55	273.88	267.32	-	Amabel Formation
	OW03-19C	284.98	8.30	9.90	276.68	275.08	-	Overburden
OW03-20	OW03-20A	277.68	18.65	25.50	259.03	252.18	-	Amabel, Reynales, Thorold and Grimsby Formations
	OW03-20B	277.69	2.50	9.54	275.19	268.15	-	Amabel Formation
	OW03-20C	277.66	2.20	3.80	275.46	273.86	-	Overburden
OW03-21	OW03-21A	279.74	22.95	28.40	256.79	251.34	-	Amabel and Reynales Formations
	OW03-21B	279.74	3.52	8.90	276.22	270.84	-	Amabel Formation
	OW03-21C	279.81	0.70	2.30	279.11	277.51	-	Overburden
OW03-22	OW03-22A	275.01	19.60	27.70	255.41	247.31	-	Amabel, Reynales, Thorold and Grimsby Formations
	OW03-22B	275.02	3.83	11.20	271.19	263.82	-	Amabel Formation
	OW03-22C	274.92	1.70	3.30	273.22	271.62	-	Overburden
OW03-23	OW03-23A	274.96	18.65	25.30	256.31	249.66	-	Amabel, Reynales and Thorold Formations
	OW03-23B	274.91	4.03	10.70	270.88	264.21	-	Amabel Formation
	OW03-23C	274.78	1.50	3.10	273.28	271.68	-	Overburden
OW03-24	OW03-24A	274.88	18.13	24.75	256.75	250.13	-	Amabel and Reynales Formations
	OW03-24B	274.88	4.00	10.64	270.88	264.24	-	Amabel Formation
	OW03-24C	274.74	1.77	3.35	272.97	271.39	-	Overburden
OW03-25	OW03-25A	275.00	19.10	27.52	255.90	247.48	-	Amabel, Reynales and Thorold Formations
	OW03-25B	274.99	4.30	10.77	270.69	264.22	-	Amabel Formation
	OW03-25C	274.99	1.80	3.40	273.19	271.59	-	Overburden
OW03-26	OW03-26A	275.02	19.20	26.80	255.82	248.42	-	Amabel, Reynales and Thorold Formations
	OW03-26B	275.03	2.99	11.33	272.04	263.70	-	Amabel Formation
	OW03-26C	275.01	2.30	3.90	272.71	271.11	-	Overburden
OW03-27	OW03-27A	275.05	19.00	27.77	256.05	247.28	-	Amabel, Reynales and Thorold Formations
	OW03-27B	275.06	4.15	11.18	270.91	263.88	-	Amabel Formation
	OW03-27C	275.04	2.30	3.90	272.74	271.14	-	Overburden
OW03-28	OW03-28A	275.46	18.70	26.50	256.76	248.96	-	Amabel, Reynales and Thorold Formations
	OW03-28B	275.46	3.10	9.80	272.36	265.66	-	Amabel Formation
	OW03-28C	275.40	1.50	3.10	273.90	272.30	-	Overburden
OW03-29	OW03-29A	277.06	20.60	28.14	256.46	248.92	-	Amabel, Reynales and Thorold Formations
	OW03-29B	277.05	3.12	10.22	273.93	266.83	-	Amabel Formation
	OW03-29C	277.02	0.30	1.90	276.72	275.12	-	Overburden
OW03-30	OW03-30A	278.06	15.10	19.39	262.96	258.67	15/04/04	Amabel Formation
	OW03-30B	278.34	3.80	8.45	274.54	269.90	15/04/04	Amabel Formation
OW03-31	OW03-31A	278.47	9.70	15.16	268.77	263.30	15/04/04	Amabel Formation
	OW03-31B	277.84	3.83	7.41	274.00	270.42	15/04/04	Amabel Formation
OW03-32	OW03-32A	271.46	12.81	23.40	258.65	248.06	15/04/04	Amabel, Reynales and Thorold Formations
	OW03-32B	271.46	1.86	9.69	269.60	261.78	15/04/04	Amabel Formation
GP03-33	GP03-33	278.38	1.30	2.82	277.08	275.56	08/12/04	Overburden
GP03-34	GP03-34	277.96	2.13	3.66	275.83	274.30	08/12/04	Overburden
GP03-35	GP03-35	277.95	1.52	3.05	276.43	274.90	08/12/04	Overburden
GP03-36	GP03-36	277.94	1.03	4.08	276.91	273.86	08/12/04	Overburden
GP03-37	GP03-37	277.95	1.68	3.20	276.27	274.75	09/12/04	Overburden
GP03-38	GP03-38	278.03	1.30	2.82	276.73	275.21	09/12/04	Overburden
PUMPING WELL	PW-1	274.98	-	-	-	-	-	Amabel and Reynales Formations

N/A- not applicable

Table 5: SA Series Soil Sample Location Details (Part 1 of 2)

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Table K.1
Summary of Soil Sampling for Grain Size Analysis
Proposed Nelson Aggregate Co. Burlington Quarry Extension

Sample ID	UTM Coordinates NAD83 17T		Wetland Area	Thickness of Topsoil above Sample (cm)	Soil Sample Description	Sample Interval Top (cm bgs)	Sample Interval Bottom (cm bgs)	Sample Thickness (cm)	Depth to "Dense" Material [1] (cm)
	Northing	Easting							
MW03-12	4805878	591130	13014	23	stiff, sandy silt, some clay and gravel	80	160	80	not determined
GPM-4-2	4805779	591057	13024	25	very stiff, silt with clay, trace gravel	30	50	20	25
Other									
SA10	4805318	591135	tree plantation	10	brown, damp to moist, very stiff, clayey silt, some fine to medium sand, trace gravel	10	40	30	30
SA10-3	4805318	591135	tree plantation	10	brown and grey mottled, moist, very stiff, clayey silt, some sand, trace fine gravel	52	71	19	30
SA11	4805327	591363	tree plantation	26	brown, moist, very stiff, clayey silt, some fine to course sand, trace gravel	26	53	27	70
SA11-5	4805327	591363	tree plantation	14	brown and grey mottled, moist, very stiff, sandy silt, some clay, trace fine gravel	104	117	13	70
SA13	4805170	591159	tree plantation	40	brown, moist, stiff, clayey silt, some fine to medium sand, trace gravel, some rootlets	40	55	15	74
SA13-2	4805170	591159	tree plantation	41	brown and grey mottled, moist, very stiff, clayey silt, some sand	74	84	10	74
SA14	4805455	591191	tree plantation	10	brown, moist, very stiff to stiff, clayey silt, some fine to coarse sand, trace gravel	10	45	35	25
SA14-2	4805455	591191	tree plantation	10	brown and grey mottled, moist, stiff to very stiff, clayey silt, some sand, trace gravel	25	42	17	25
TR1B-01 [3]	4805285	590486	N/A	25	very stiff, mottled brown and grey, wet, silt with sand, some clay, trace gravel	0	60	60	25
TR1B-02 [3]	4805285	590486	N/A	10	very stiff, mottled brown and grey, wet, silt with sand, trace clay and gravel	0	40	40	10
TR1B-03 [3]	4805334	590427	N/A	20	very stiff, mottled brown and grey, wet, silt with sand, some clay, trace gravel	0	60	60	20
Offsite									
MP33	4805514	591589	13025	30	brown, moist, stiff, silt with clay, some sand, trace gravel, some organics and rootlets	0	64	64	64

Table 6: SA Series Soil Sample Location Details (Part 2 of 2)

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Table K.1
Summary of Soil Sampling for Grain Size Analysis
Proposed Nelson Aggregate Co. Burlington Quarry Extension

Sample ID	UTM Coordinates NAD83 17T		Wetland Area	Thickness of Topsoil above Sample (cm)	Soil Sample Description	Sample Interval Top (cm bgs)	Sample Interval Bottom (cm bgs)	Sample Thickness (cm)	Depth to "Dense" Material [1] (cm)
	Northing	Easting							
MP33	4805514	591589	13025	30	brown and grey mottled, moist, very stiff, sandy silt, some clay, trace fine gravel	64	97	33	64
Pond1-A	4805514	591570	N/A	pond bottom sample	brown, wet, soft, silt with clay, trace sand	84	165	81	not determined
Pond1-B	4505513	591544	N/A	31	brown and grey mottled, wet, very stiff, clayey silt, trace sand	30	70	40	30
Pond1-B	4505513	591544	N/A	31	brown and grey mottled, wet, very stiff, sandy silt, some gravel, trace clay	70	104	34	30
Pond 2	4805420	591752	N/A	-	stiff, dark brown and grey, moist, silt with clay, trace sand and gravel	0	90	90	not determined
MP-34	4804974	589858	N/A	25	stiff, mottled brown and grey with some rusty colour, moist, silt with sand, some clay, trace gravel	25	30	5	not determined
MP-35	4807119	590002	N/A	20	stiff, mottled brown and grey with some rusty colour, moist, silt, some clay, trace sand	20	100	80	97
MP-35	4807119	590002	N/A	20	very stiff, moist, silt, trace clay and gravel	100	120	20	97

Notes:
[1] "Dense" material herein refers to till material that is relatively high in silt and clay content, and noticeably more consolidated. Determined for samples collected in 2010.
[2] Sample depth determined from site photo, not measured in the field
[3] Sample collected along tributary that runs along western side of Proposed Nelson Aggregate Co. Burlington Quarry Extension Property

Table 7: Guelph Permeameter Test Site Conditions (Golder 2010, Table K5)

Table K.5
Summary of Guelph Permeameter Testing
Proposed Nelson Aggregate Co. Burlington Quarry Extension

Location ID	Northing	Easting	Sample	Soil Profile Description (cm bgs)	GPM Test depth	GP Test Within "Dense" Material
Southcentral Wetland system						
GPM-1 Wetland Area 13033	4805215	591293	GPM-1a	0 - 30 cm - Dark brown very soft clayey silt, organics and rootlets, moist (topsoil)	Base set at 22.9 cm bgs	No
			GPM-1b	30 - 50 cm - Grey and brown mottled, stiff, clayey silt, some sand, trace gravel, moist	Base set at 50 cm bgs	No
GPM-2 Wetland Area 13017 Willow Pond	4805606	590997	GPM-2a	0 - 43.2cm - Dark brown, very soft, clayey silt, organics and rootlets, moist-wet, slightly stiff near base of test (topsoil)	Base set at 30.5 cm bgs	Partial
			GPM-2b	43.2 - 72.4cm - Grey and brown mottled, moist, very stiff, silt, some clay, some fine and coarse sand, trace gravel	Base set at 72.4 cm bgs	Yes
GPM-3 Wetland Area 13015	4805813	590913	GPM-3a	0 - 43.5cm - Dark brown, very soft, clayey silt, organics and rootlets, moist (topsoil)	Base set at 25.4 cm bgs	No
			GPM-3b	43.5 - 102cm - Grey and brown mottled, moist, firm, sandy silt, some clay, wet at 80 cmbgs	Base set at 62 cm bgs	Partial
				102 - 117cm - Grey-brown mottled very stiff clayey silt, wet	Not Tested	Not tested
GPM-5 Wetland Area 13019	4805494	591065		0 - 25cm - Dark brown, very soft, clayey silt, organics and rootlets, moist	Not Tested	Not tested
			GPM-5a	25 - 47cm - Grey and brown mottled, moist, firm, clayey silt, some fine Sand, trace rootlets	Base set at 47 cm bgs	No
			GPM-5b	47 - 120cm - Grey and brown mottled, moist, firm, clayey silt, trace fine sand, trace rootlets, fining downwards toward depth of 120 cm	Base set at 120 cm bgs	No
			GPM-5c	120 - 152cm - Grey and brown mottled, moist, firm to stiff, silt, some clay and trace fine sand	Base set at 152 cm bgs Single-Head Analysis	No [1]
Southwest Wetland/Woodlot						
GPM-6 Wetland Area 13037	4804899	590916		0 - 25cm - Dark brown, soft, clayey silt, organics and rootlets, moist (topsoil)	Not Tested	Not tested
			GPM-6a	25 - 52 cm - Grey and brown mottled, moist, firm, sandy silt, some clay, trace gravel	Base set at 52 cm bgs	No
Eastern Wetland						
GPM-4 Wetland Area 13024	4805779	591057		0 - 25cm - Dark brown, very soft, clayey silt, organics and rootlets, moist (topsoil)	Not Tested	Not tested
			GPM-4a	25 - 53cm - Grey and brown mottled, moist, very stiff, silt with clay, trace sand	Base set at 53 cm bgs	Yes

Notes:

[1] Although material sampled at this depth was observed to be firm to stiff, the composition differed from other tested sites and is not considered as "Dense" material

2.3 Overburden Layer Characterization

2.3.1 Golder Field Investigation Findings: "Loose" and "Dense" Material layers

The minipiezometer logs and test sites indicate that the shallow subsurface is predominantly (overwhelmingly) clayey silt till (i.e., Halton Till). Golder (2010) refers to these units as follows:

3. An upper layer of "loose", weathered, grey, clayey silt materials
4. A lower layer of a "dense", stiff, unweathered clayey silt.

Golder uses the terms "loose" and "dense" throughout the 2010 reporting to refer to these layers.

The thickness (depth) of the upper loose till is listed in Table 7 and Table 8. The depth to the dense till is as deep as 2.0 m, and as shallow as 0.20 m (Golder, 2010, Section K4.2). The Halton Till at the site is up to 10 m thick.

The testing and monitoring intervals span the loose and dense layer, but most minipiezometers are completed in the upper 1.5 m of materials. Guelph permeameter tests were completed in shallow excavations to test the lower sediment properties, and a large-scale pumping test was completed to measure the vertical connection between the shallow wetlands and the bedrock aquifer.

2.3.2 Dr. Walter Illman - Conceptual Model

Dr. Walter Illman, in his Witness Statement review of the 2010 Nelson ARA application (OCH, 2010, Page 32) presented a generalized conceptual model of the shallow Halton Till (as shown in Figure 1). The conceptual model presented by Dr. Illman is based on extensive research at the Laidlaw landfill in Southwestern Ontario. This conceptual model is consistent with the Golder layering and field investigations and the Earthfx (2020) numerical model (discussed below).

Note that much of the Golder observed variation in the depth to the dense till likely reflects the gradational nature of the "transition zone". The main factors that influence the depth of weathering are freeze-thaw processes in the winter and desiccation of the till in the summer. Tills in the upland may dry out sooner than tills in the low-lying wetland areas, and therefore be subject to more weathering.

Table 8: Hydraulic Conductivity Test Results and Depth to Dense Till (Golder 2010, Table K4)

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Table K.4
Soil Sampling and Permeameter Summary
Proposed Nelson Aggregate Co. Burlington Quarry Extension

Sample ID	UTM Coordinates NAD83 17T		Wetland Area	Sample Interval Top (cm bgs)	Sample Interval Bottom (cm bgs)	Constant Head Test Hydraulic Conductivity (cm/s)	Depth to "Dense" Material [1] (cm)	Constant Head Test Within "Dense" Material Horizon
	Northing	Easting						
Southcentral Wetland system								
SA1	4805792	590927	13015	36	66	7.00E-08	74	No
SA2	4805700	590941	13016	26	48	1.00E-07	50	No
SA3	4805680	591103	13018	38	67	8.00E-06	112	No
SA4-2	4805569	591019	13020	91	127	1.00E-06	91	Yes
SA5	4805488	591125	13019	16	50	6.00E-07	65	No
SA6	4805610	591199	13023	18	46	9.00E-06	88	No
SA7	4805476	591267	13029	21	42	4.00E-08	20	Yes
SA8	4805479	591350	13030	43	61	5.00E-08	110	No
SA9	4805392	591119	13022	35	57	2.00E-07	30	Yes
SA12	4805247	591139	13027	26 [2]	46 [2]	5.00E-06	64	No
MP-1	4805182	591278	13033	50	70	4.00E-08	30	Yes
MP-2	4805196	591289	13033	50	70	1.00E-08	24	Yes
MP-3	4805191	591254	13033	50	70	2.00E-08	25	Yes
MP-5	4805161	591294	13033	50	70	2.00E-07	30	Yes
MP-9	4805392	591119	13027	50	100	5.00E-06	64	Partial
MP-10	4805318	591135	13022	50	100	9.00E-08	30	Yes
MP-17	4805819	590917	13015	50	100	6.00E-06	96	Partial
MP-18	4805781	590944	13015	50	100	2.00E-07	96	Partial
MP-19	4805735	590926	13016	50	100	1.00E-07	45	Yes
MP-21	4805702	590940	13016	50	100	6.00E-06	32	Yes[3]
MP-22	4805674	590957	13020	50	100	2.00E-07	40	Yes
MP-23	4805632	590995	13018	50	100	3.00E-05	112	No
MP-28	4805668	591076	13019	50	100	2.00E-06	77	Partial
MP-32	4805530	591094	13019/13020	50	100	2.00E-06	65	Partial
Southwest Wetland/Woodlot								
SA17-3	4805004	590907	Edge of Woodlot	95	127	4.00E-07	32	Yes
Other								
SA10 [4]	4805318	591135	tree plantation	10	40	5.00E-06	30	Partial
SA11 [4]	4805327	591363	tree plantation	26	53	4.00E-05	70	No
SA14 [4]	4805455	591191	tree plantation	10	45	2.00E-05	25	Partial

Notes

[1] Relative higher density material herein refers to till material that generally consists of clayey silt and is noticeably more consolidated (or "Dense"). Locations labelled with MP were not directly observed for relative higher density however a soil profile was collected in 2010 at locations in close proximity to MPs.

[2] Sample depth determined from site photo, not measured in the field.

[3] Though the density of this material was similar to the typical 'Dense' material encountered elsewhere, there was less clay content observed in the sample.

[4] Sample collected from area outside of MNR delineated wetland boundary.

2.3.3 GSFLOW Model Layering

The GSFLOW model layers are as follows:

- **PRMS soil zone**: The thickness in the soil zone varies between 0.25 to 1.219 m depending on soil type (Table 17.2, Earthfx, 2020).

- **MODFLOW Layer 1**: Beneath the soil zone is a 1 m thick layer of weathered overburden (predominantly weathered Halton Till in the wetland areas). In the central portions of the larger wetlands, Layer 1 is assigned as MODFLOW Lake cells that simulate the ponding of water in the wetland.

- **MODFLOW Layer 2**: Up to 10 m of unweathered Halton Till

In summary, the GSFLOW model approximates the layering observations of Golder and the conceptual model presented by Dr. Walter Illman. The GSFLOW model represents the soil and Layer 1 with higher hydraulic conductivity using an EPM approach. MODFLOW Layer 2 represents the unoxidized matrix zone with reduced fracturing. An Equivalent Porous Media (EPM) approach was used to represent the fracturing in the till (i.e., the cumulative effect of the fractures was represented by the bulk hydraulic conductivity of the layer).

2.4 Shallow Hydraulic Conductivity Test Results

An extensive program of field and laboratory hydraulic conductivity testing was undertaken in the overburden sediments. A number of tests were completed across a range of scales, including:

- Laboratory core permeameter test;
- In-situ rising/falling head tests (see Table 9 and Table 10); and
- Guelph permeameter field tests (see Table 11);
- Large-scale pumping test.

2.4.1 Golder Test Summary

Golder (2010) summarizes the test results as follows:

Overall:

The geometric mean of hydraulic conductivity obtained from all laboratory and Guelph Permeameter (GPM) field testing (excluding tests completed in topsoil) consisted of 33 samples and was approximately 5.5 x 10^{-7} cm/s **(see Table 12 - attached**)*.*

Loose Materials:

The geometric mean of the hydraulic conductivity calculated from all 19 permeameter test results completed within the Loose material was 1.5 x 10^{-6} cm/s **(see Table 12).**

Dense Materials:

There were 14 tests completed within the Dense material which resulted in a geometric mean of 1.4 x 10^{-7} cm/s for the vertical hydraulic conductivity (see Table 12)*.*

Golder (2010) Figure K.14 (Figure 7) is a histogram that summarizes the results of the permeameter testing completed at the site. *The overall conclusion is that the loose materials are approximately 1 order of magnitude more permeable than the dense materials.*

Dr. Illman, in his peer review of the 2007 Golder field testing made the following comment in his witness statement (Page 32, Oct 1, 2010):

> *"Overall, in my view, Golder's laboratory analysis of core samples could have been biased towards lower hydraulic conductivity values than are actually at the site."*

It is possible that laboratory tests may not capture the complex and irregular nature of the vertical fracturing that exists in the overburden. This issue was addressed by the in-situ slug tests, Guelph permeameter tests, and finally by the large-scale pumping test discussed below.

2.4.2 Golder In-situ Tests and Wetland Pumping Test

The lab and local-scale overburden testing by Golder, while very insightful, may not fully represent the larger-scale collective effects of the complex weathering and fracturing patterns.

The Golder pumping test, completed in the Southcentral wetland (Earthfx Wetland 17, MNRF 13033) was conducted to assess the large-scale vertical interconnection between the wetland and the bedrock aquifer (Golder, 2010, Appendix K, PDF page 1242).

The test consisted of 4 days of pumping from the bedrock aquifer with water level monitoring at the staff gauges, minipiezometers and bedrock wells. The hydrographs presented in Figure 8 and Figure 9 show that there was no measurable effect on the wetland and shallow minipiezometer levels during pumping.

Golder evaluated the bulk hydraulic conductivity of the overburden by simulating the pumping test response with a transient "box" model simulation (Golder, 2010, Section K8.0). Three scenarios were evaluated to bracket the range of hydraulic response, but a definitive estimate of hydraulic conductivity could not be made because no actual response was observed in the wetland. The following conclusions were made:

> *The model demonstrates that if the hydraulic conductivity of the overburden at the mini-piezometers monitored during the previously reported pump test was approximately 1 x 10^{-6} or 1 x 10^{-7} cm/s, a measurable drawdown would have been expected during the duration of the pump test. If the hydraulic conductivity of the overburden at the monitored mini-piezometers was in the order of 2 x 10^{-8} cm/s, a measurable drawdown would not have been expected during the duration of the pump test. These results are consistent with the permeameter test results that were completed in the vicinity of the pump test mini-piezometers, which were also in the order of 10^{-8} cm/s.*

Golder concluded that the results from the pump test are consistent with the other test results. The results relative to the Earthfx model are discussed in more detail in the following sections.

2.5 Conclusions

The Golder testing program represents more than eight years of wetland characterization and monitoring (monitoring continued after 2010). The primary finding of this work is that the Halton Till consists of an upper loose, weathered layer, up to 2 m thick, overlying a lower, dense, unweathered clayey silt till. The overall thickness of the unit varies with topography and undulations in the bedrock surface. The hydraulic conductivity of the upper unit is estimated to be approximately an order of magnitude more permeable than the lower unit (Figure 7). The hydraulic conductivity of the layers represented in the GSFLOW model are further discussed in the Section 3 of this document.

The wetland monitoring network includes numerous minipiezometers installed in the upper 1.5 m of the subsurface. The bedrock units are monitored by a number of multi-level monitoring nests. Many of the locations have been monitored, an ongoing basis after the Golder work, for over 10 years. There is limited monitoring information from the unweathered Halton Till; however; given its expected lack of response, monitoring the more active zones above and below provides more insight into the behaviour of the unit.

The Earthfx (2020) report builds on this work and evaluates the effect of the movement of the quarry face over time (Section 6.11.3). The extended monitoring of wetlands near the quarry provides field observations that confirm the modelling interpretation. More detail in Section 4 of this document.

Table 9: Summary of Rising/Falling Head Test (from Golder 2010, Table C3, Part 1/2)

September 2010

Table C.3
Summary of Rising/Falling Head Tests
Proposed Nelson Aggregate Co. Burlington Quarry Extension

021-1238

Well ID	Static W.L. (mbgs)	Water Column (m)	Stickup (m)	Top of Sand Pack (mbgs)	Bottom of Sand Pack (mbgs)	Length of Screen (m)	Date of Test	# of Test	Start Time	End Time	Recovery	Test Method	Formation	Hydraulic Conductivity Analysis (cm/sec) Bouwer-Rice
MW03-04C	0.23	1.28	1.05	1.40	3.20	1.80	August 7, 2003	Test 1	6:49:00		7:03:00	Falling Heads	Overburden	1.5E-04
MW03-04C	0.21	1.26	1.05	1.40	3.20	1.80	August 5, 2003	Test 1	9:27:00	9:27:35		Rising Heads	Overburden	1.6E-04
MW03-04C	0.23	1.28	1.05	1.40	3.20	1.80	August 5, 2003	Test 2	9:39:00	9:39:41		Rising Heads	Overburden	1.7E-04
MW03-07C	0.34	1.29	0.95	1.83	3.81	1.98	August 7, 2003	Test 1	7:20:20		7:40:00	Falling Heads	Overburden	6.6E-06
MW03-05A	0.53	1.46	0.93	2.59	3.35	0.76	August 7, 2003	Test 1	7:01:00		7:34:00	Falling Heads	Overburden	1.2E-04
MW03-05B	1.13	2.03	0.9	1.07	2.13	1.07	August 7, 2003	Test 1	11:11:10		12:55:00	Falling Heads	Overburden	1.6E-05
MW03-06A	0.47	1.37	0.9	1.98	2.41	0.43	August 6, 2003	Test 1	15:40:05		16:32:00	Falling Heads	Overburden	7.1E-05
MW03-06B	0.55	1.4	0.85	1.22	1.68	0.46	August 7, 2003	Test 1	9:37:50		11:04:00	Falling Heads	Overburden	2.7E-05
OW03-16C	2	2.84	0.84	2.30	3.90	1.60	August 8, 2003	Test 1	8:46:32	10:04:00		Rising Heads	Overburden	9.0E-04
OW03-18C	1.1	2.3	1.2	2.99	4.57	1.58	August 7, 2003	Test 1	8:49:00			Test Failed[1]	Overburden	Test Failed[1]
OW03-20C	0.98	1.87	0.89	2.20	3.80	1.60	August 7, 2003	Test 1	12:29:50		12:42:00	Rising Heads	Overburden	4.8E-04
OW03-22C	0.43	1.65	1.22	1.70	3.30	1.60	August 5, 2003	Test 1	11:03:05	11:05:30	11:26:00	Rising Heads	Overburden	1.7E-03
OW03-22C	0.44	1.66	1.22	1.70	3.30	1.60	August 6, 2003	Test 1	8:56:32		9:00:50	Falling Heads	Overburden	3.2E-03
OW03-23C	0.33	1.42	1.09	1.50	3.10	1.60	August 5, 2003	Test 1	12:14:40	12:15:48	12:20:00	Rising Heads	Overburden	1.7E-02
OW03-23C	0.33	1.42	1.09	1.50	3.10	1.60	August 6, 2003	Test 1	9:05:16		9:08:00	Falling Heads	Overburden	2.0E-03
OW03-24C	0.39	1.37	0.98	1.77	3.35	1.58	August 6, 2003	Test 1	9:11:29			Falling Heads	Overburden	2.6E-03
OW03-25C	0.67	1.67	1	1.80	3.40	1.60	August 6, 2003	Test 1	9:24:20		9:25:15	Falling Heads	Overburden	4.4E-03
OW03-26C	0.615	1.29	0.675	2.30	3.90	1.60	August 6, 2003	Test 1	10:42:17		10:45:39	Falling Heads	Overburden	3.5E-03
OW03-27C	0.58	1.4	0.82	2.30	3.90	1.60	August 6, 2003	Test 1	10:09:27		10:36:00	Falling Heads	Overburden	1.3E-04
OW03-28C	0.23	1.27	1.04	1.50	3.10	1.60	August 6, 2003	Test 1	15:24:40		15:34:00	Falling Heads	Overburden	1.5E-04
GP03-33	1.22	2.23	1.01	1.30	2.82	1.52	July 2, 2004	Test 1				Falling Heads	Overburden	6.2E-04
GP03-33	1.22	2.23	1.01	1.30	2.82	1.52	July 2, 2004	Test 2				Falling Heads	Overburden	6.7E-04
GP03-34	1.07	1.86	0.79	2.13	3.66	1.53	July 2, 2004	Test 1				Falling Heads	Overburden	1.5E-04
GP03-35	1.09	2.02	0.93	1.52	3.05	1.53	July 2, 2004	Test 1				Falling Heads	Overburden	6.0E-02
GP03-35	1.09	2.02	0.93	1.52	3.05	1.53	July 2, 2004	Test 2				Falling Heads	Overburden	6.9E-02
GP03-36	1.1	2.19	1.09	1.03	4.08	3.05	July 2, 2004	Test 1				Falling Heads	Overburden	5.3E-04
GP03-36	1.1	2.19	1.09	1.03	4.08	3.05	July 2, 2004	Test 2				Falling Heads	Overburden	4.6E-04
GP03-37	1.02	1.97	0.95	1.68	3.20	1.52	July 2, 2004	Test 1				Falling Heads	Overburden	3.8E-05
GP03-38	1.1	1.98	0.88	1.30	2.83	1.53	July 2, 2004	Test 1				Falling Heads	Overburden	2.5E-03
GP03-38	1.1	1.98	0.88	1.30	2.83	1.53	July 2, 2004	Test 2				Falling Heads	Overburden	2.4E-03
													GEOMETRIC MEAN	**5.7E-04**
OW03-15B	5.45	6.38	0.93	5.92	10.24	4.32	August 8, 2003	Test 1	10:56:18		11:45:00	Falling Heads	Amabel Formation	8.5E-05
OW03-16B	1.56	2.4	0.84	2.92	9.97	7.05	August 8, 2003	Test 1	8:15:42	8:16:03	8:40:00	Rising Heads	Amabel Formation	3.7E-04
OW03-16B	1.56	2.4	0.84	2.92	9.97	7.05	August 8, 2003	Test 2	8:30:26	8:30:43	8:40:00	Rising Heads	Amabel Formation	8.1E-04
OW03-17B				3.66	11.44	7.78						Rising Heads	Amabel Formation	2.5E-03
OW03-18B	1.48	2.14	0.66	5.48	11.90	6.42	August 7, 2003	Test 1	8:10:50	8:11:09		Rising Heads	Amabel Formation	8.9E-04
OW03-18B	1.48	2.14	0.66	5.48	11.90	6.42	August 7, 2003	Test 2	8:15:20	8:17:38	8:20:00	Rising Heads	Amabel Formation	8.9E-04
OW03-19A	8.5	9.42	0.92	22.78	29.50	6.72	August 6, 2003	Test 1	13:46:40			Rising Heads	Amabel Formation	1.1E-03
OW03-19A	8.56	9.48	0.92	22.78	29.50	6.72	August 8, 2003	Test 1	12:30:00			Test Failed[1]	Amabel Formation	Test Failed[1]
OW03-19B	8.49	9.39	0.9	10.99	17.55	6.56	August 6, 2003	Test 1	12:49:35	12:50:23	12:51:00	Rising Heads	Amabel Formation	1.2E-03
OW03-19B	8.56	9.46	0.9	10.99	17.55	6.56	August 8, 2003	Test 1	12:52:00			Falling Heads	Amabel Formation	3.5E-04
OW03-20B	0.96	1.87	0.91	2.50	9.54	7.04	August 7, 2003	Test 1	12:14:05	12:14:22	12:23:00	Rising Heads	Amabel Formation	7.8E-04
OW03-21B	3.72	4.51	0.79	3.52	8.90	5.38	August 7, 2003	Test 1	2:30:40	2:30:59	2:41:00	Rising Heads	Amabel Formation	1.6E-03
OW03-22B	0.41	1.3	0.89	3.83	11.20	7.37	August 5, 2003	Test 1	10:42:30	10:42:54		Rising Heads	Amabel Formation	1.4E-03
OW03-23B	0.34	1.43	1.09	4.03	10.70	6.67	August 5, 2003	Test 1	12:05:36	12:06:10	12:09:00	Rising Heads	Amabel Formation	4.4E-04
OW03-24A	0.28	1.26	0.98	18.13	24.75	6.62	August 5, 2003	Test 1	13:32:45	13:33:24	13:39:00	Rising Heads	Amabel Formation	1.3E-04
OW03-24B	0.28	1.26	0.98	4.00	10.64	6.64	August 5, 2003	Test 1	13:46:40	13:47:00	13:32:00	Rising Heads	Amabel Formation	2.2E-04
OW03-25B	0.43	1.34	0.91	4.30	10.77	6.47	August 5, 2003	Test 1	14:29:49	14:30:17	14:32:00	Rising Heads	Amabel Formation	2.3E-04
OW03-26B	0.52	1.5	0.98	2.99	11.33	8.34	August 6, 2003	Test 1	6:47:25		6:53:00	Rising Heads	Amabel Formation	2.6E-04
OW03-27B	0.53	1.44	0.91	4.15	11.18	7.03	August 6, 2003	Test 1	8:00:31		8:02:00	Rising Heads	Amabel Formation	4.9E-04
OW03-28B	0.3	1.15	0.85	3.10	9.80	6.70	August 6, 2003	Test 1	15:09:54			Rising Heads	Amabel Formation	4.1E-04
OW03-29B	2.14	3.06	0.92	3.12	10.22	7.10	August 6, 2003	Test 1	12:13:03		12:30:00	Rising Heads	Amabel Formation	1.4E-04
OW03-30A				15.10	19.39	4.29						Rising Heads	Amabel Formation	1.5E-03
OW03-30B				3.80	8.45	4.65						Rising Heads	Amabel Formation	2.6E-03
OW03-31A				9.70	15.16	5.46						Rising Heads	Amabel Formation	2.2E-03
OW03-31B				3.83	7.41	3.58						Rising Heads	Amabel Formation	1.9E-03
OW03-32B				1.86	9.69	7.83						Rising Heads	Amabel Formation	2.9E-04
													GEOMETRIC MEAN	**6.1E-04**

Table 10: Summary of Rising/Falling Head Test (from Golder 2010, Table C3, Part 2/2)

September 2010

Table C.3
Summary of Rising/Falling Head Tests
Proposed Nelson Aggregate Co. Burlington Quarry Extension

021-1238

Well ID	Static W.L. (mbgs)	Water Column (m)	Stickup (m)	Top of Sand Pack (mbgs)	Bottom of Sand Pack (mbgs)	Length of Screen (m)	Date of Test	# of Test	Start Time	End Time	Recovery	Test Method	Formation	Hydraulic Conductivity Analysis (cm/sec) Bouwer-Rice
OW03-15A	15.135	16.06	0.925	18.32	25.10	6.78	August 8, 2003	Test 1	10:47	10:53		Falling Heads	Amabel, Reynales and Thorold Formations	2.7E-04
OW03-17A				15.09	22.76	7.67						Rising Heads	Amabel, Reynales and Thorold Formations	5.2E-04
OW03-18A	1.41	2.11	0.7	16.70	27.00	10.30	August 7, 2003	Test 1	10:14:53	10:15:33	10:31:00	Rising Heads	Amabel, Reynales and Thorold Formations	6.2E-04
OW03-18A	1.41	2.11	0.7	16.70	27.00	10.30	August 7, 2003	Test 2	10:20:50	10:21:38	10:31:00	Rising Heads	Amabel, Reynales and Thorold Formations	4.1E-04
OW03-18A	1.41	2.11	0.7	16.70	27.00	10.30	August 7, 2003	Test 3	10:20:50	10:21:38	10:31:00	Rising Heads	Amabel, Reynales and Thorold Formations	6.8E-04
OW03-32A				12.81	23.40	10.59						Rising Heads	Amabel, Reynales and Thorold Formations	8.7E-05
OW03-21A	3.83	4.59	0.76	22.95	28.40	5.45	August 7, 2003	Test 1	1:45:25	1:46:26	1:41:00	Rising Heads	Amabel and Reynales Formations	4.3E-04
OW03-23A	0.27	1.4	1.13	18.65	25.30	6.65	August 5, 2003	Test 1	11:42:05	11:44:47		Rising Heads	Amabel, Reynales and Thorold Formations	3.1E-04
OW03-23A	0.27	1.4	1.13	18.65	25.30	6.65	August 5, 2003	Test 2	11:50:12	11:50:48	11:59:00	Rising Heads	Amabel, Reynales and Thorold Formations	1.7E-04
OW03-26A	0.51	1.5	0.99	19.20	26.60	7.40	August 5, 2003	Test 1	14:45:20		16:30	Rising Heads	Amabel, Reynales and Thorold Formations	4.4E-06
OW03-27A	0.59	1.5	0.91	19.00	27.77	8.77	August 6, 2003	Test 1	7:27:35		7:57:00	Rising Heads	Amabel, Reynales and Thorold Formations	5.8E-05
OW03-28A	0.4	1.25	0.85	18.70	26.50	7.80	August 6, 2003	Test 1	14:52:36		15:07:00	Rising Heads	Amabel, Reynales and Thorold Formations	1.3E-04
OW03-29A	2.48	3.43	0.95	20.60	28.14	7.54	August 6, 2003	Test 1	11:10:10		12:32:00	Rising Heads	Amabel, Reynales and Thorold Formations	7.9E-05
OW03-20A	0.41	1.36	0.95	18.65	25.50	6.85	August 7, 2003	Test 1	11:38:55	11:39:27	12:09:00	Rising Heads	Amabel, Reynales, Thorold and Grimsby Formations	1.9E-04
OW03-22A	0.44	1.33	0.89	19.60	27.70	8.10	August 5, 2003	Test 1	10:23:00	10:23:27	10:33:00	Rising Heads	Amabel, Reynales, Thorold and Grimsby Formations	7.5E-05
OW03-25A	0.46	1.37	0.91	19.10	27.52	8.42	August 5, 2003	Test 1	14:14:40	14:15:44		Rising Heads	Amabel, Reynales, Thorold and Grimsby Formations	1.8E-04
OW03-25A	0.46	1.37	0.91	19.10	27.52	8.42	August 5, 2003	Test 2	14:20:10	14:20:35	14:22:00	Rising Heads	Amabel, Reynales, Thorold and Grimsby Formations	4.8E-04
OW03-14A	7.88	8.8	0.92	19.00	29.19	10.19	August 8, 2003	Test 1	12:00:20	12:05:00		Test Failed[1]	Amabel, Reynales, Thorold and Grimsby Formations	Test Failed[1]
OW03-16A	0.66	1.59	0.93	17.82	25.60	7.78	August 8, 2003	Test 1	7:30:45	7:31:29	8:11:00	Rising Heads	Amabel, Reynales, Thorold and Grimsby Formations	7.4E-05
													GEOMETRIC MEAN	**1.7E-04**

Note:
1) Test failed due to insufficient displacement for analysis.

Table 11: Summary of Guelph Permeameter Testing (from Golder 2010, Table K6)

Table K.6
Summary of Guelph Permeameter Test Results
Proposed Nelson Aggregate Co. Burlington Quarry Extension

Location ID	UTM NAD83 17T		Sample	Calculated Field Saturated Conductivity (Kfs in cm/s)	GPM Test Within "Dense" Material
	Northing	Easting			
Southcentral Wetland system					
GPM-1 Wetland Area 13033	4805215	591293	GPM-1a	$6x10^{-6}$ (1)	No
			GPM-1b	$1x10^{-6}$ (2)	No
GPM-2 Wetland Area 13017 Willow Pond	4805606	590997	GPM-2a	$3x10^{-7}$ (1)	Partial
			GPM-2b	$4x10^{-7}$ (1)	Yes
GPM-3 Wetland Area 13015	4805813	590913	GPM-3a	$6x10^{-7}$ (1)	No
			GPM-3b	$4x10^{-7}$ (2)	Partial
				Not tested	Not tested
GPM-5 Wetland Area 13019	4805494	591065		Not tested	Not tested
			GPM-5a	$7x10^{-6}$ (2)	No
			GPM-5b	$7x10^{-6}$ (2)	No
			GPM-5c	$2x10^{-6}$ (2)	No (3)
Southwest Wetland/Woodlot					
GPM-6 Wetland Area	4804899	590916		Not tested	Not tested
			GPM-6a	$6x10^{-7}$ (2)	No
Eastern Wetland					
GPM-4 Wetland Area 13024	4805779	591057		Not tested	Not tested
			GPM-4a	$1x10^{-7}$ (1)	Yes

Notes:
(1) Results obtained during May-June 2010 field testing

(2) Results obtained during July 2010 field testing.

(3) Although material sampled at this depth was observed to be firm to stiff, the composition differed from other sites and is not considered as"Dense" material.

Table 12: Summary of all Permeameter Test Results (from Golder 2010, Table K7)

September 2010

Table K.7
Summary of Permeameter Results
Proposed Nelson Aggregate Co. Burlington Quarry Extension

021-1238

Sample ID	Laboratory Permeameter[1]		Guelph Permeameter [2]		Laboratory and Guelph Permeameter Combined		All Combined
	"Loose"	"Dense"	"Loose"	"Dense"	"Loose"	"Dense"	
	(cm/s)		(cm/s)		(cm/s)		(cm/s)
Southcentral Wetland system							
SA1	7.0E-08				7.0E-08		7.0E-08
SA2	1.0E-07				1.0E-07		1.0E-07
SA3	8.0E-06				8.0E-06		8.0E-06
SA5	6.0E-07				6.0E-07		6.0E-07
SA6	9.0E-06				9.0E-06		9.0E-06
SA8	5.0E-08				5.0E-08		5.0E-08
SA12	5.0E-06				5.0E-06		5.0E-06
MP-9	5.0E-06				5.0E-06		5.0E-06
MP-17	6.0E-06				6.0E-06		6.0E-06
MP-18	2.0E-07				2.0E-07		2.0E-07
MP-23	3.0E-05				3.0E-05		3.0E-05
MP-28	2.0E-06				2.0E-06		2.0E-06
MP-32	2.0E-06				2.0E-06		2.0E-06
SA4-2		1.0E-06				1.0E-06	1.0E-06
SA7		4.0E-08				4.0E-08	4.0E-08
SA9		2.0E-07				2.0E-07	2.0E-07
MP-1		4.0E-08				4.0E-08	4.0E-08
MP-2		1.0E-08				1.0E-08	1.0E-08
MP-3		2.0E-08				2.0E-08	2.0E-08
MP-5		2.0E-07				2.0E-07	2.0E-07
MP-10		9.0E-08				9.0E-08	9.0E-08
MP-19		1.0E-07				1.0E-07	1.0E-07
MP-21		6.0E-06				6.0E-06	6.0E-06
MP-22		2.0E-07				2.0E-07	2.0E-07
GPM-1b			1.0E-06		1.0E-06		1.0E-06
GPM-3b			4.0E-07		4.0E-07		4.0E-07
GPM-5a			7.0E-06		7.0E-06		7.0E-06
GPM-5b			7.0E-06		7.0E-06		7.0E-06
GPM-5c			2.0E-06		2.0E-06		2.0E-06
GPM-2b				4.0E-07		4.0E-07	4.0E-07
Southwest Wetland/Woodlot							
GPM-6a			6.0E-07		6.0E-07		6.0E-07
SA17-3		4.0E-07				4.0E-07	4.0E-07
Eastern Wetland							
GPM-4a				1.0E-07		1.0E-07	1.0E-07
Geomean	**1.4E-06**	**1.4E-07**	**1.7E-06**	**2.0E-07**	**1.5E-06**	**1.5E-07**	**5.5E-07**
# of Samples	**13**	**12**	**6**	**2**	**19**	**14**	**33**

Note:
(1) Laboratory permeameter samples do not include results from SA10, SA11 and SA14
(2) Guelph Permeameter results from topsoil not included in summary.

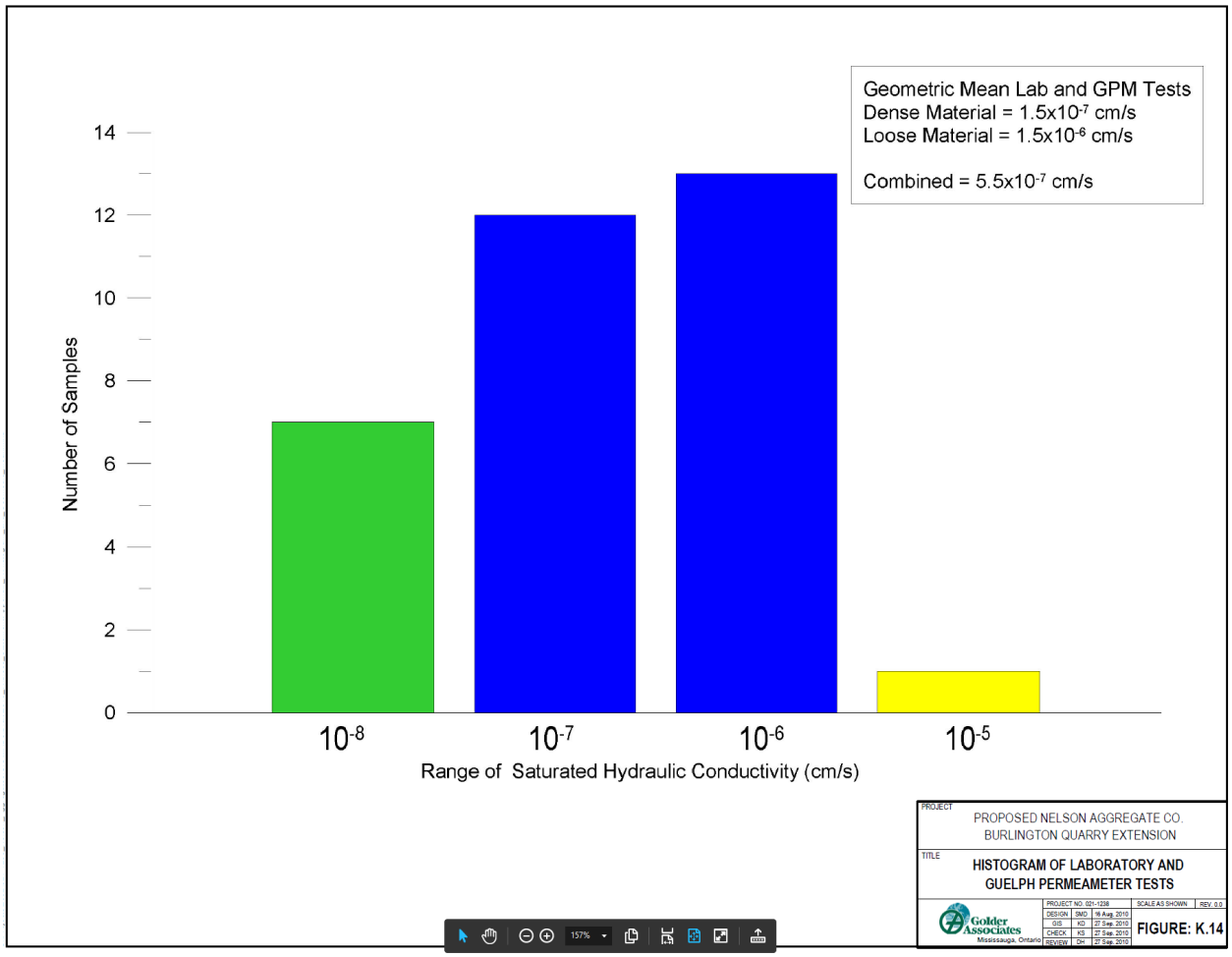


Figure 7: Summary of permeability testing (from Golder, 2010, Figure K14)

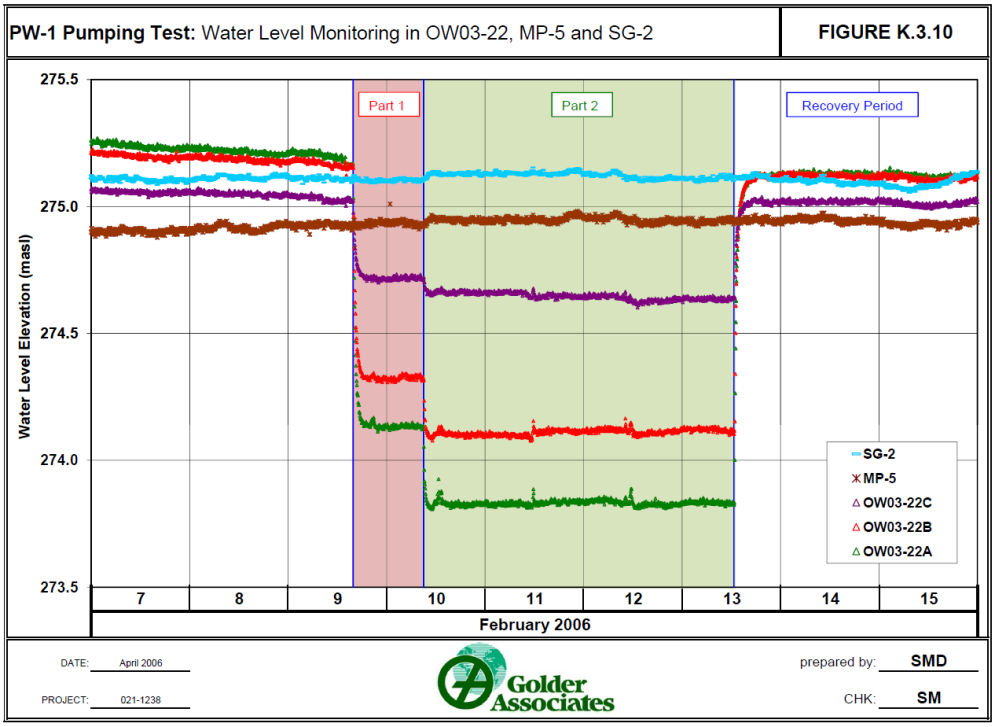


Figure 8: Results of Golder pumping test in Wetland 13033 (Earthfx 17). No response recorded in staff gauge SG-2 and minipiezometer MP-5 after 4 days of pumping.

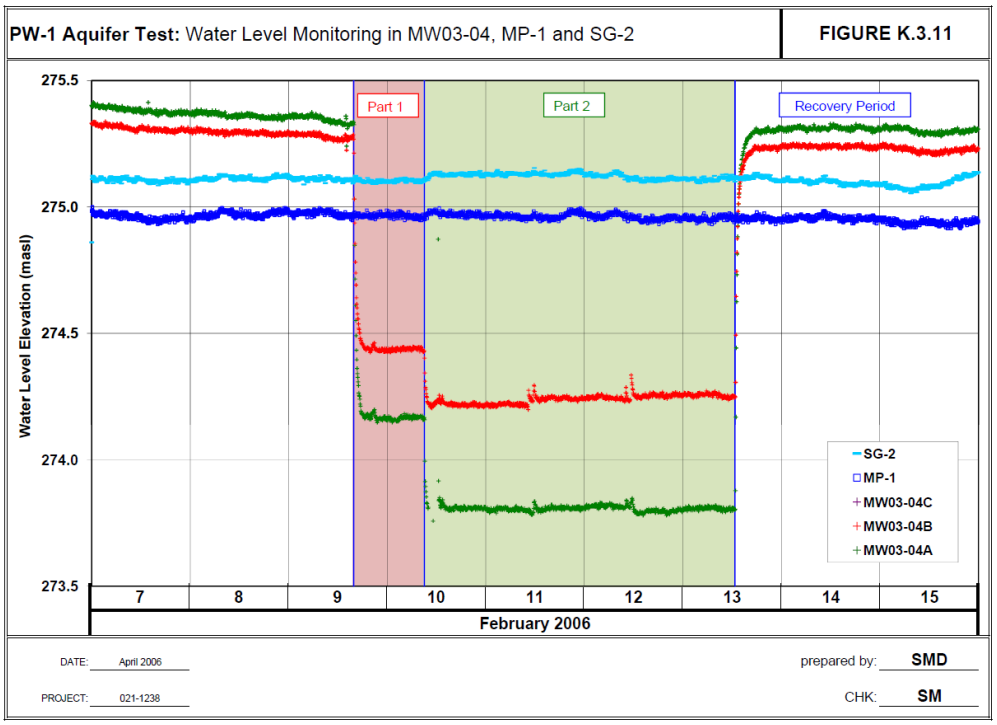


Figure 9: Results of Golder pumping test in Wetland 13033 (Earthfx 17). No response recorded in staff gauge SG-2 and minipiezometer MP-1 after 4 days of pumping.

3 Wetland Response and Hydrograph Offset

3.1 Introduction

MNRF comments 4.1, 4.2, 4.3, and 4.8 note that the simulated water level response in Layer 2 exhibits a time offset (lag) relative to the minipiezometer field measurements. MNRF requests that we *"provide comment on whether this offset in hydroperiod allows for using this model for predictive simulations to evaluate the wetland hydroperiod".*

The Earthfx graphs mentioned in the review show the compare the *shallow* minipiezometer to the *deep* simulated heads in Layer 2. The reasons for this reporting choice included:

- Layer 2 is continuous under the wetlands and entire study area
- Layer 1 represents both weathered Halton and open water ponds (as MODFLOW lakes).
    - Where appropriate, Layer 1 water levels in the MODFLOW lakes are compared to the Staff Gauge measurements.
        - Note: Representing the areas of standing water as Layer 1 MODFLOW lakes allows for a better simulation of the GW/SW interaction because the "lakes" can receive inflows from both the sides and bottom of the surrounding groundwater model layers (in addition to lateral interflow from the soil zone and overland runoff).
- Layer 1 is intermittently saturated both seasonally and spatially (i.e., local topographic high areas are better drained).

In summary, the variable nature of Layer 1 made for a more complex comparison, and so Layer 2 heads were used in a consistent manner in the Earthfx report.

3.2 Minipiezometer Monitoring Zone

The minipiezometer logs, well construction and hydraulic conductivity data presented in the preceding section demonstrate that most of the minipiezometers are completed in the upper 1-2 m of the subsurface, and primarily reflect the conditions in the soil zone and loose Halton till. The deeper minipiezometers may also respond to shallow water level and moisture conditions as they are not grouted or sealed in place. Deeper minipiezometers intersecting a vertical fracture may also respond more quickly than the unfractured part of the aquitard.

3.3 MODFLOW Layer 2 Properties and Response

The response of the dense Halton Till depends on the hydraulic conductivity and specific yield (effective porosity) of the unit. A low permeability aquitard will exhibit a degree of lag in response to recharge events (see Hvorslev, 1951, for a discussion of time lag response in an aquitard, or Rowe and Nadarajah, 1993, for details about the lag in monitoring well response in an aquitard due to a water level stress in an adjacent aquifer). The lag in the water table response in the Halton will be influenced by specific yield. The following discussion compares the calibrated Layer 2 hydraulic conductivity and specific yield to measured and estimated values.

3.3.1 Hydraulic Conductivity

The final calibrated vertical hydraulic conductivity of the Layer 2 unweathered Halton Till is $1.6x10^{-7}$ m/s. The value is at the higher range of the Golder measured values but is consistent with the statement by Dr. W. Illman in his 2010 peer review (See Section 2.4).

The Golder measured values may be low for the following possible reasons:

- Many of the Golder estimates are determined from local-scale core tests, falling head and Guelph permeameter tests. These tests are localized and may not fully capture the larger scale bulk effect of the vertical fractures.

- While the Golder pumping tests were undertaken to evaluate the larger-scale hydraulic properties of the Halton Till, the pumping drawdown under the wetland would need to deplete the high storage (high effective porosity) in the *upper weathered* till and induce flow through the low permeability (and low storage) *unweathered* till before an effect might be observed. Given the complex layer storage, and underlying low permeability, this can be difficult to achieve within the time frame of a pumping test.

  The rapid response in the bedrock aquifer shows the relatively low storage in the bedrock aquifer. The flattening of the drawdowns in the bedrock observed during the test is likely due to induced leakage from below in the layered bedrock system combined with limited leakage through the unweathered Halton Till. The lack of response in the weathered till is indicative of the low rate of leakage across the till.

The Earthfx hydraulic conductivity was determined from a comprehensive simulation of the transient natural system (including daily, seasonal and interannual storage effects) and calibrated to multiple years of daily monitoring data. Ultimately, this is superior to even a multi-day pumping test, for it evaluates the large-scale system response to complex natural stresses.

In addition to the evaluation and simulation of natural daily, seasonal, and inter-annual response, the model was also compared, in detail, to the complex effects observed near the existing quarry face. (See Earthfx, 2020 Section 6.11.3). Three key cross sections (see locations in Figure 6.21) are used to illustrate the effects with distance from the existing pit. These conditions have been monitored for a number of years, and are consistent with 70 years of quarry operations. Further, the recent advancement of the quarry face provides real-world insight into both the magnitude and timing of the processes (See Section 4, below for additional discussions).

3.3.2 Specific Yield

The lag, or offset, in the Layer 2 response can be significantly affected by the specific yield of the unit. The following discussion addresses the question: Is the model specified layer 2 specific yield too high and thus causing an un-realistic lag in the response in that layer?

Specific yield is difficult to measure, particularly for a unit with decreasing weathering and fracturing with depth. The specific yield of the till matrix material is likely low because it has been compressed by the glacial ice. However, the bulk specific yield (effective porosity) of the upper weathered till is

likely high, due to the presence of desiccation fracturing. (The specific yield of the unweathered till is likely low, as fracturing is limited.)

Grain size analysis (specifically clay and silt content) can provide insight into the hydraulic conductivity, effective porosity and specific yield of the till matrix. Extensive testing of the grain size is documented in Section K4.0 of Golder (2010). The average clay and silt content of the four wetland areas ranges from 68% to 84.9%. The specific yield (effective porosity) of this clayey silt matrix material is low, particularly if it has been compressed by glacial ice.

The literature indicates that the specific yield of a "till, predominantly silt" is listed as 0.06 (Morris and Johnson, 1967). The same USGS study lists the specific yield of unconsolidated clay as 0.06, and silt as 0.2.

The model calibrated specific yield of the Layer 2 clayey silt till is 0.035 (Earthfx, 2020 Table 18.4). This value is approximately half the value suggested by the USGS. This value reflects the combined specific yield of the soil matrix and the limited vertical fractures that may occur in the unweathered till.

A low value of specific yield will result in less offset or lag in the Layer 2 response.

3.3.3 Conclusions

The model calibrated value of hydraulic conductivity for Layer 2 is at the higher range of the field measurements and is consistent with other peer review opinions. A higher value will reduce lag in the aquitard response.

The model calibrated specific yield is, for comparison, approximately half the USGS estimated value for a silt till. A low value of specific yield will reduce the lag in the Layer 2 aquitard response.

In summary, the model parameters will not result in an excessive lag or offset in the Layer 2 response. A more likely explanation is that the simulated lag is realistic, but is not observed in the monitoring record because the minipiezometer network is primarily measuring the response in the upper soil zone and weathered till (Layer 1).

3.4 Comparison of minipiezometers to simulated soil zone moisture content

Fortunately, another model output can provide significant insight into the model response and behaviour in the shallower system.

The GSFLOW model provides daily output of the soil moisture fraction (0 to 1, representing 0% to 100% saturation) in the soil zone. In intermittently saturated, topographically complex and perched wetlands such as those at the site, soil moisture can provide more insight into hydroperiod and ecological function.

(Note: The GSFLOW soil moisture results could be converted into an equivalent water level, but they are presented as moisture content to better reflect the complex soil moisture reservoir modelling in PRMS (Please refer to Earthfx, 2020, Section 17.2 and Figure 17.3 for more details).)

Figure 10 compares the measured water level response in minipiezometer MP6 (red curve, left axis) to the simulated soil moisture fraction (green curve, right axis). For reference, the water level

response in the dense Layer 2 Halton Till is also shown in blue. **The fluctuations in the soil moisture correlate very closely with the measured changes in water level in minipiezometer MP6. There is virtually no time lag or offset between the observed minipiezometer response and the simulated soil moisture.**

The water level in the deeper Layer 2 (unweathered Halton Till) exhibit the offset as noted in the MNRF review comments. This lag is expected, as the low permeability Halton Till responds slowly to leakage from the shallow system above.

While many of the minipiezometers have a long-term record of manual water levels, the timing of the shallow model response can be more closely compared to monitors with continuous data loggers. For example, a comparison of simulated soil moisture to continuous data from minipiezometer MP9 (Figure 11) shows that the model timing is very close.

A similarly strong correlation between simulated soil moisture and minipiezometer response is exhibited in the other wetlands (Table 13). The response at other wetlands is shown in Figure 15 through Figure 28. In all cases there is no lag in the simulated soil zone response (green line) when compared to the minipiezometer measurements (red line).

Table 13: Earthfx (and MNRF) Wetland Numbers and Minipiezometer

Earthfx ID	MNRF Wetland ID Numbers	Minipiezometer
8	Between Guelph Line and Bluff's way	(No MP)
9	13014	GP03-33
10	13015	MP18
11	13016	MP19, MP20, MP21
12	13017, 13018	ZMP-22
13	13030	MP11, MP28
14	13019	MP12
15	13021	MP29
16	13022	MP10
17	13033	MP3, MP6, MP7, MP8, MP9
18	13203	(No MP)
19	13032	(No MP)
20	13036, 13037, 13038, 13039	MP14, MP16
21	13201	(MP elev. error)
22	13200	(No MP)
23	13202 (Weir Pond)	(No MP)
24	Medad Valley Wetland Complex 13204	(No MP)
na	13025	MP33

A number of additional soil moisture comparison graphs, based on specific requests or comments, are included in the main comment response table. In all cases the soil moisture matches closely, without lag, to the minipiezometer reading.

3.4.1 Wetland EFX 17 (MNRF 13033)

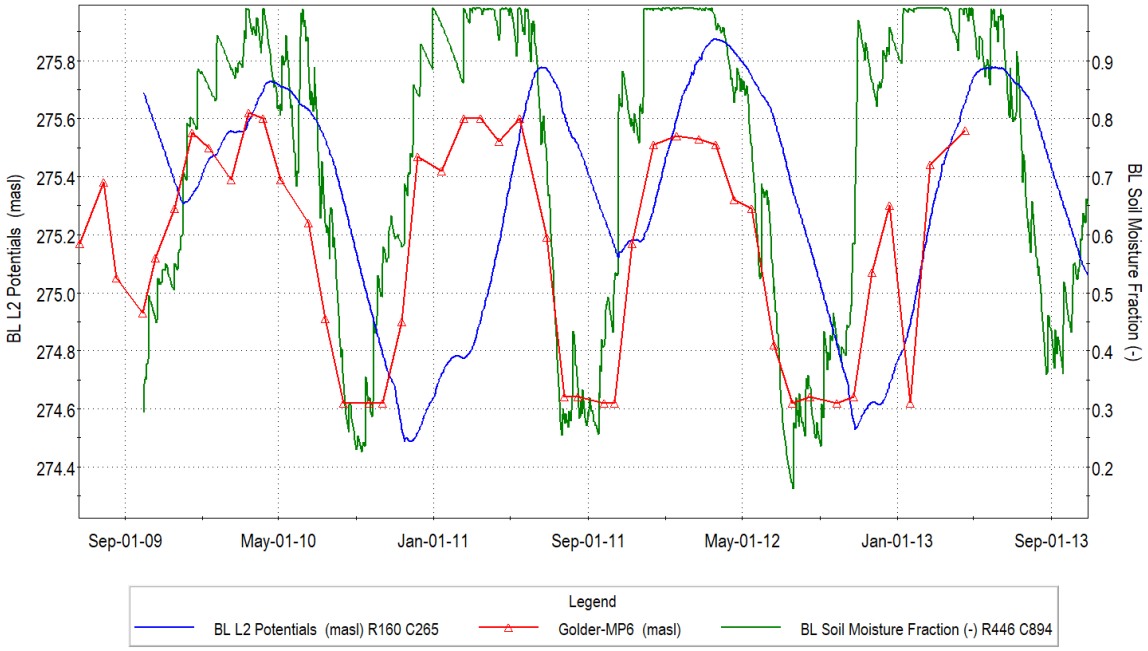


Figure 10: Water Levels (at MP6) and Soil Moisture response near Wetland EFX17 (MNRF 13033)

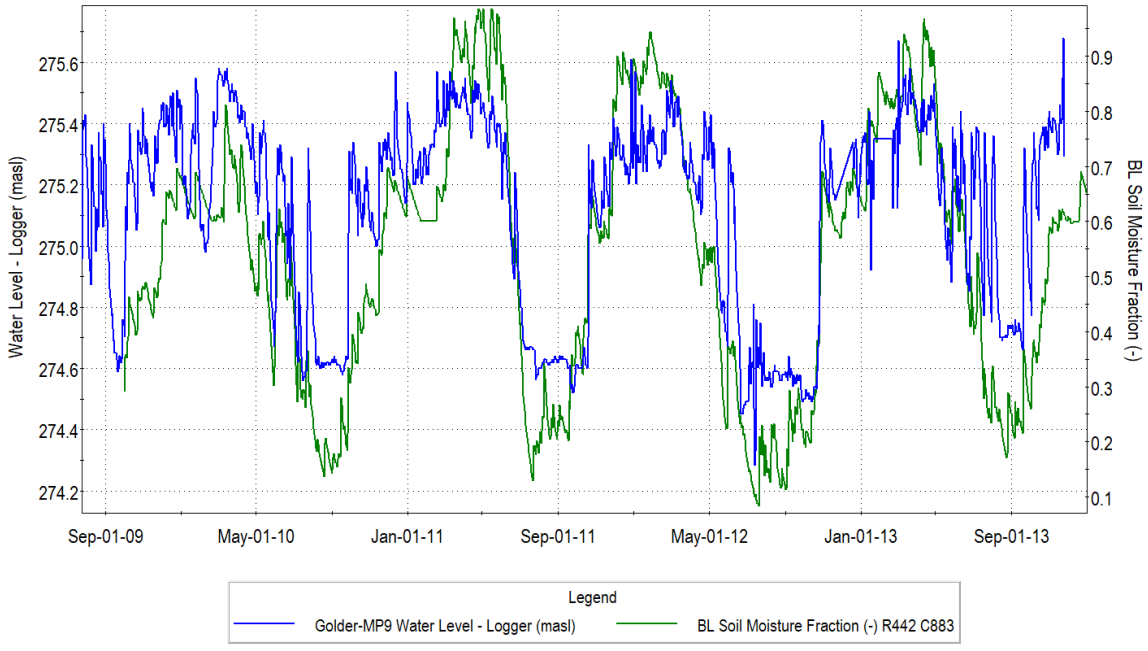


Figure 11: Comparison of simulated soil moisture to minipiezometer MP9 at Wetland EFX17 (MNRF 13033)

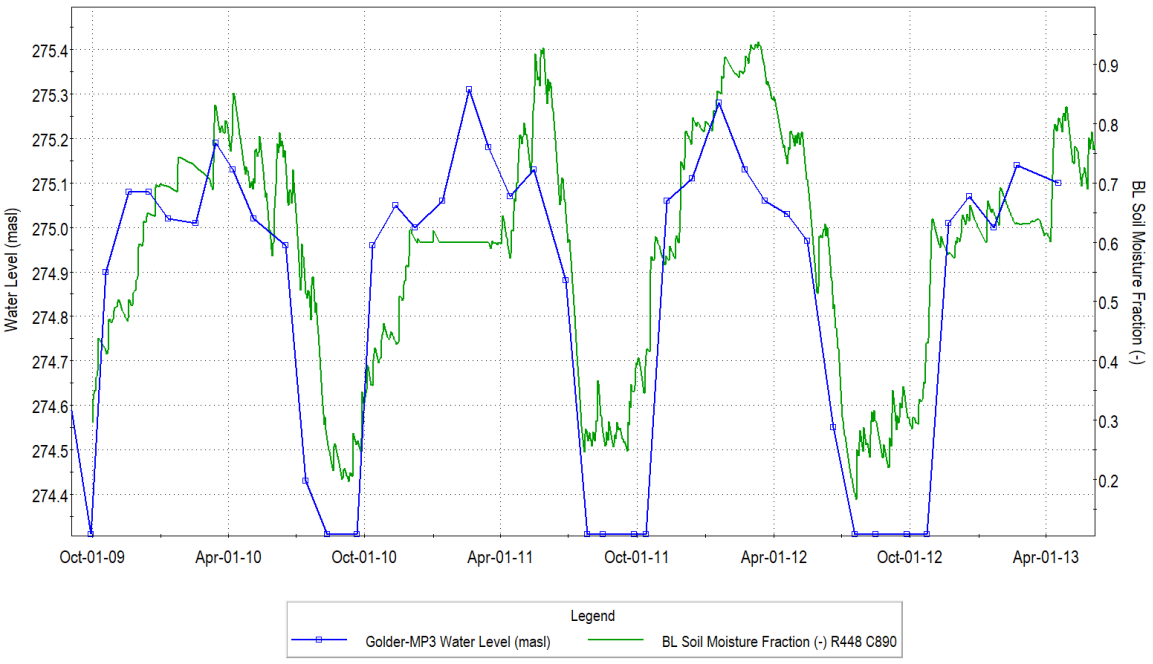


Figure 12: Comparison of simulated soil moisture to minipiezometer MP3 at Wetland EFX17 (MNRF 13033)

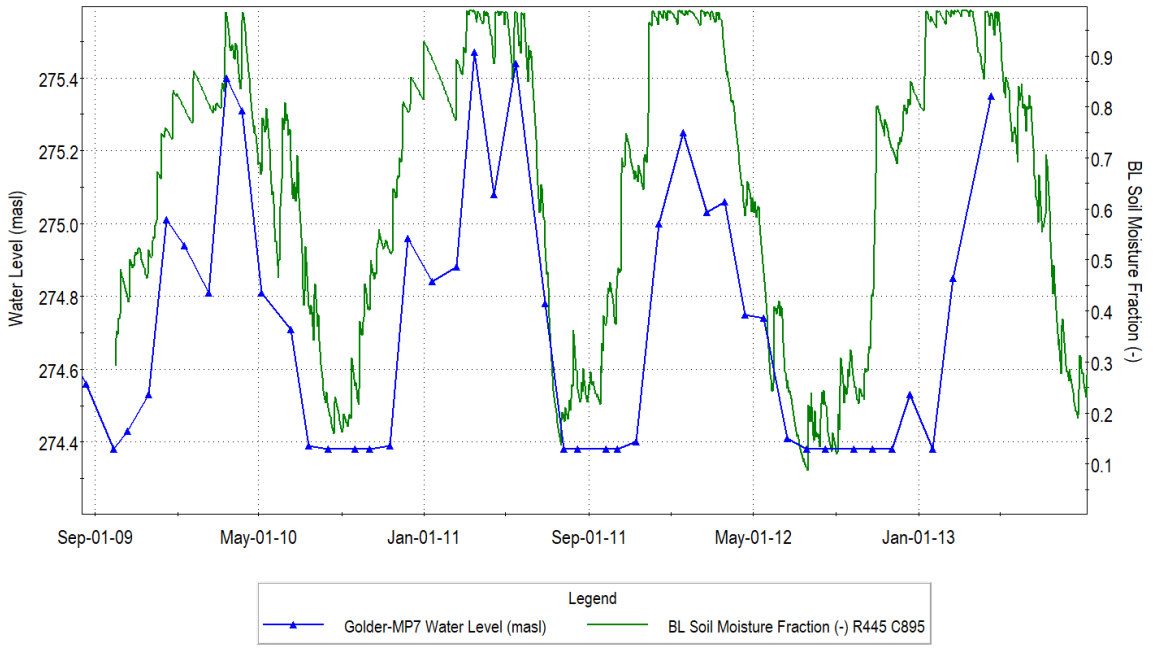


Figure 13: Comparison of simulated soil moisture to minipiezometer MP7 at Wetland EFX17 (MNRF 13033)

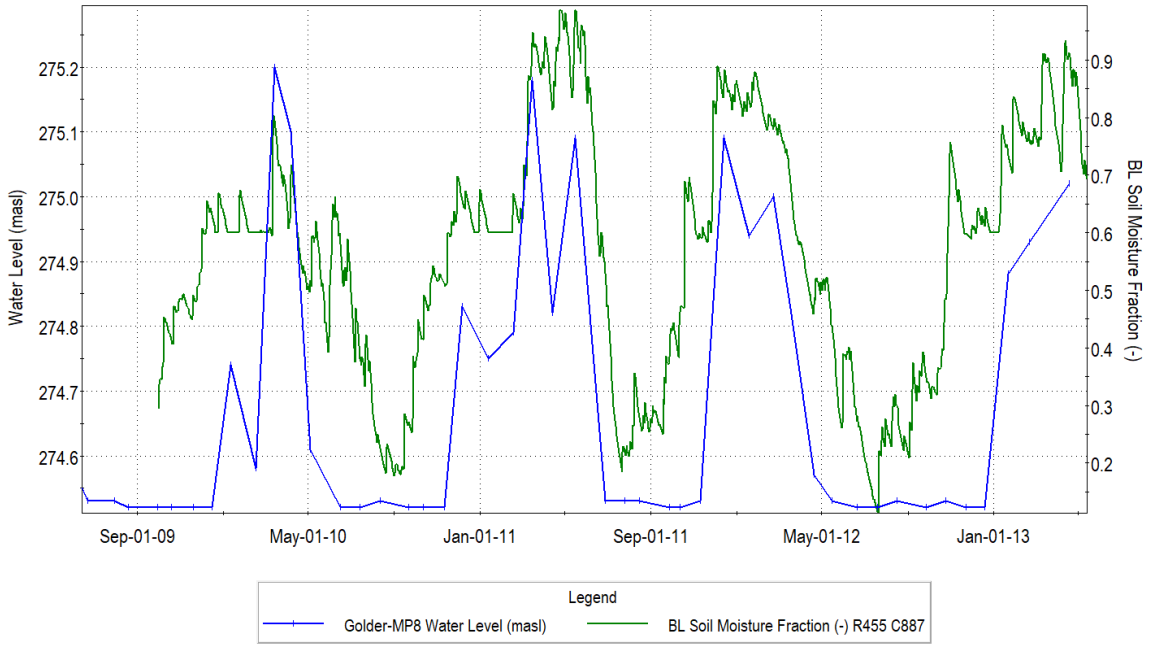


Figure 14: Comparison of simulated soil moisture to minipiezometer MP8 at Wetland EFX17 (MNRF 13033)

3.4.2 Wetland EFX 9 (MNRF 13014)

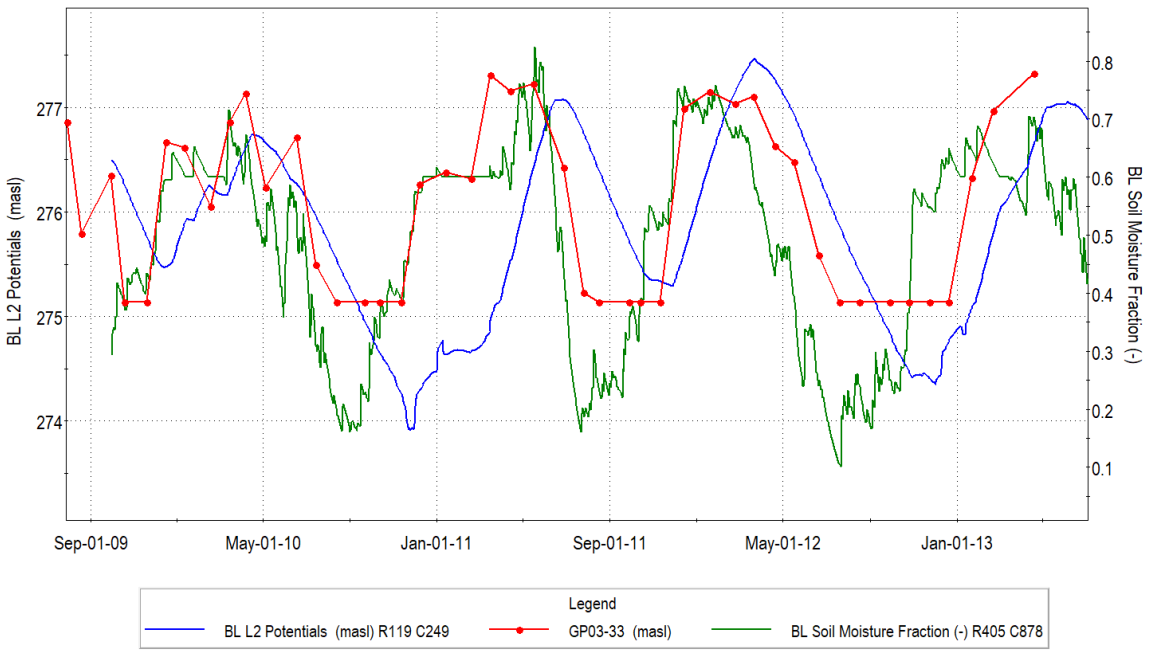


Figure 15: Comparison of simulated soil moisture to minipiezometer GP03-33 at Wetland EFX9 (MNRF 13014)

3.4.3 Wetland EFX 10 (MNRF 13015)

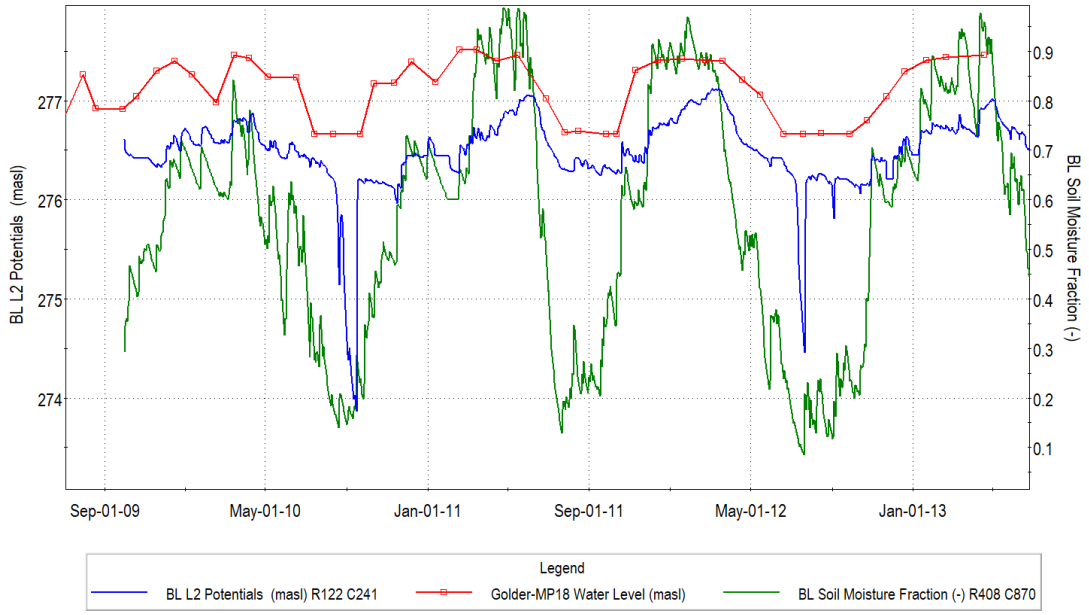


Figure 16: Comparison of simulated soil moisture to minipiezometer MP18 at Wetland EFX10 (MNRF 13015)

3.4.4 Wetland EFX 11 (MNRF 13016)

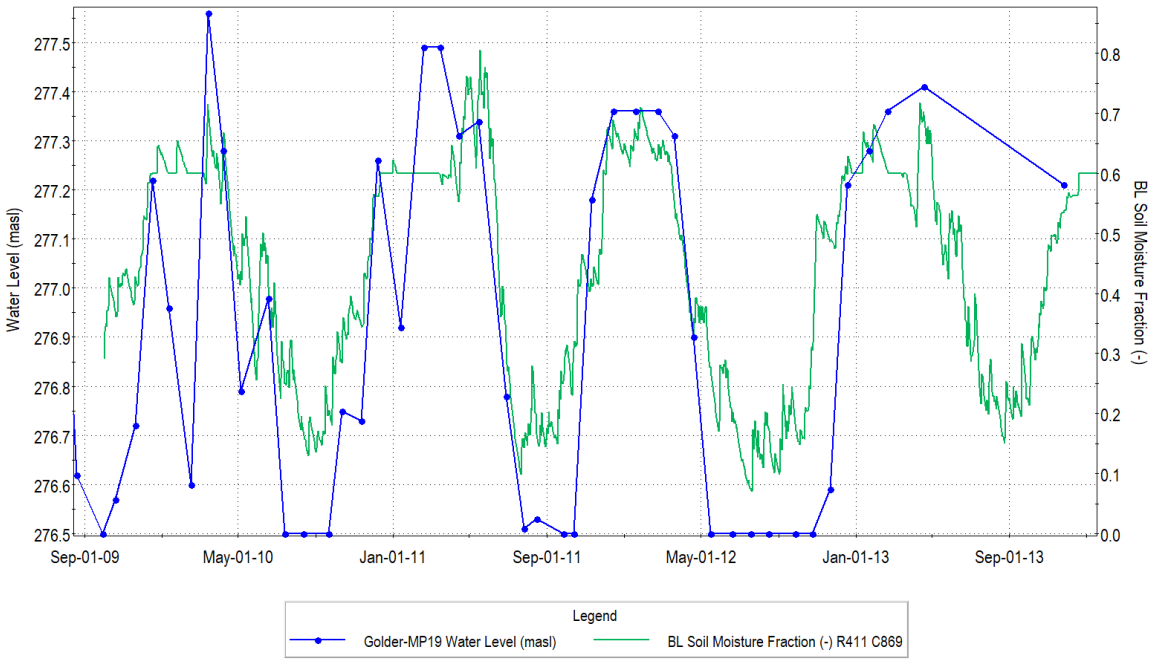


Figure 17: Comparison of simulated soil moisture to minipiezometer MP19 at Wetland EFX11 (MNRF 13016)

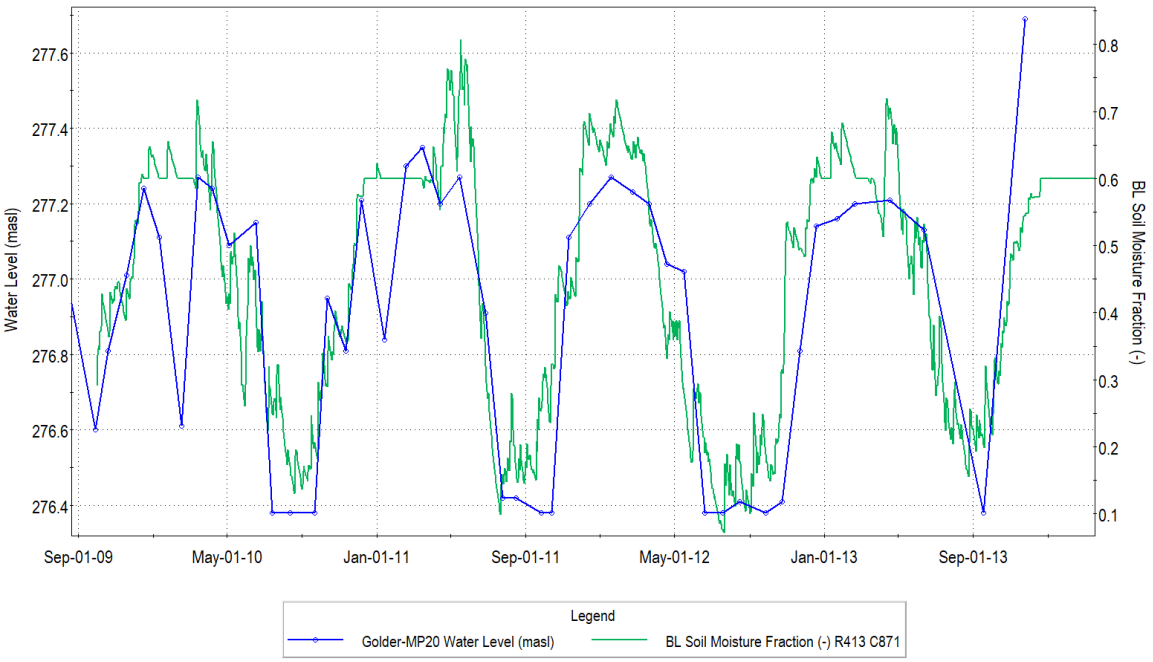


Figure 18: Comparison of simulated soil moisture to minipiezometer MP20 at Wetland EFX11 (MNRF 13016)

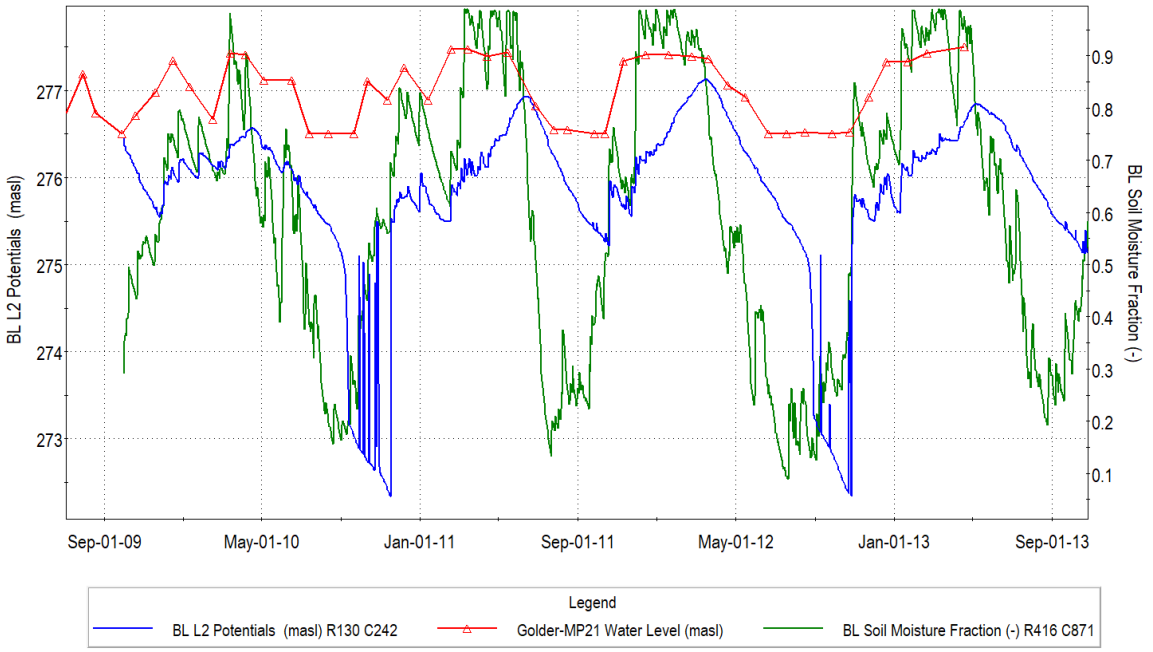


Figure 19: Comparison of simulated soil moisture to minipiezometer MP21 at Wetland EFX11 (MNRF 13016)

3.4.5 Wetland EFX 12 (MNRF 13017, 13018)

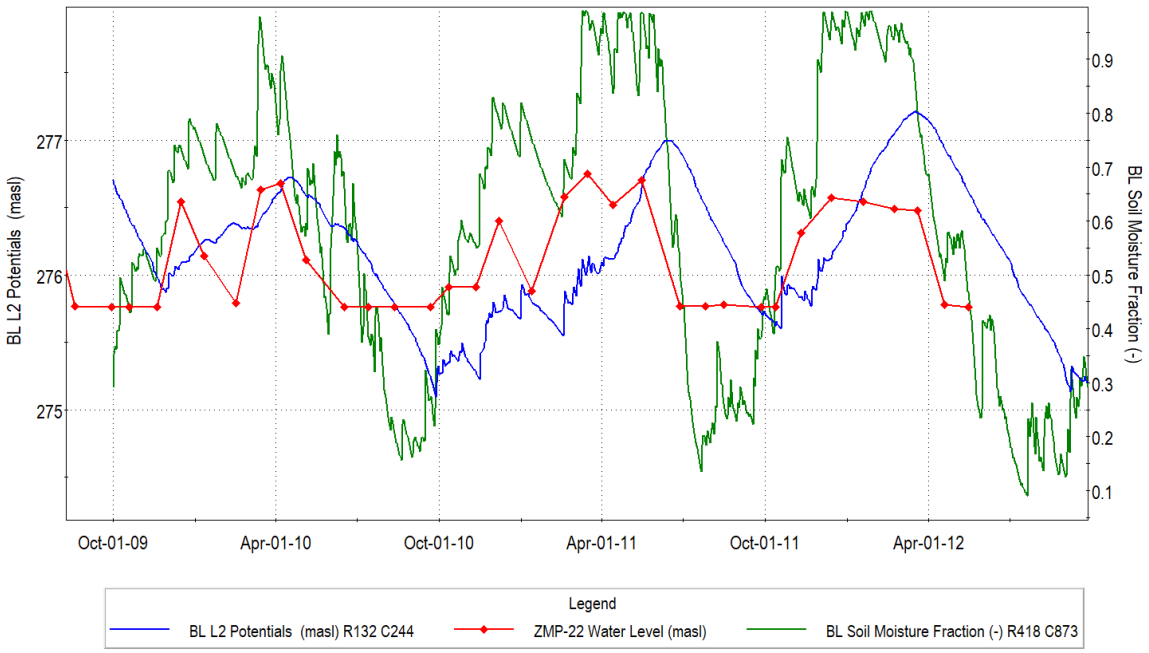


Figure 20: Comparison of simulated soil moisture to minipiezometer ZMP-22 at Wetland EFX12 (MNRF 13017, 13018).

3.4.6 Wetland EFX 13 (MNRF 13030)

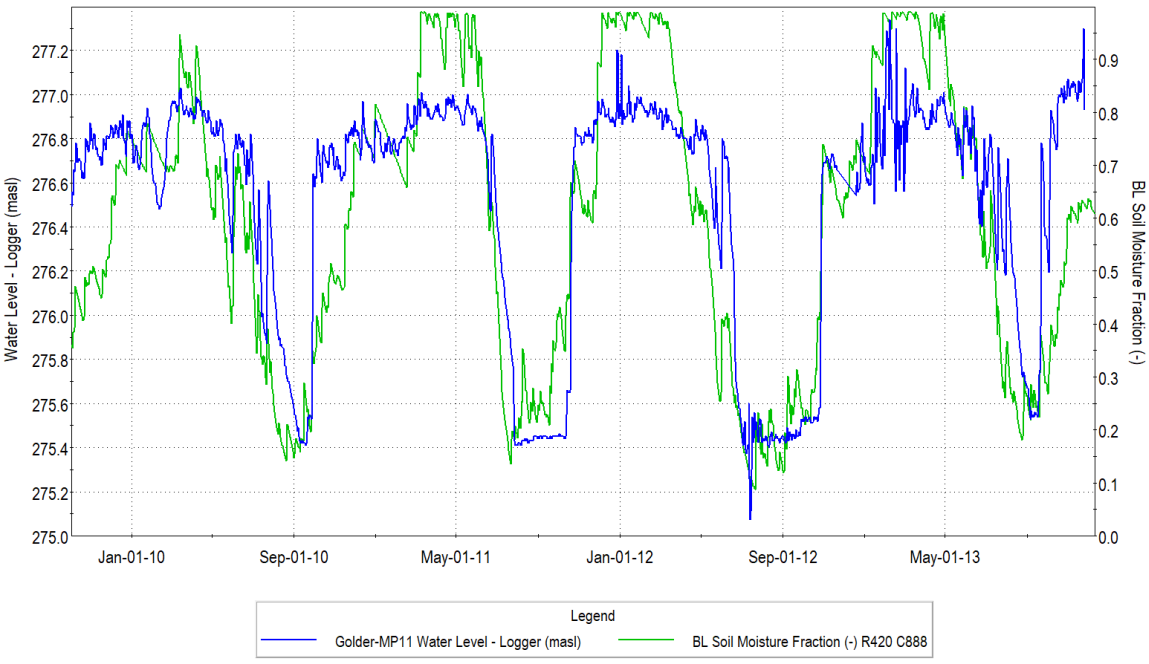


Figure 21: Comparison of simulated soil moisture to minipiezometer MP11 at Wetland EFX13 (MNRF 13030).

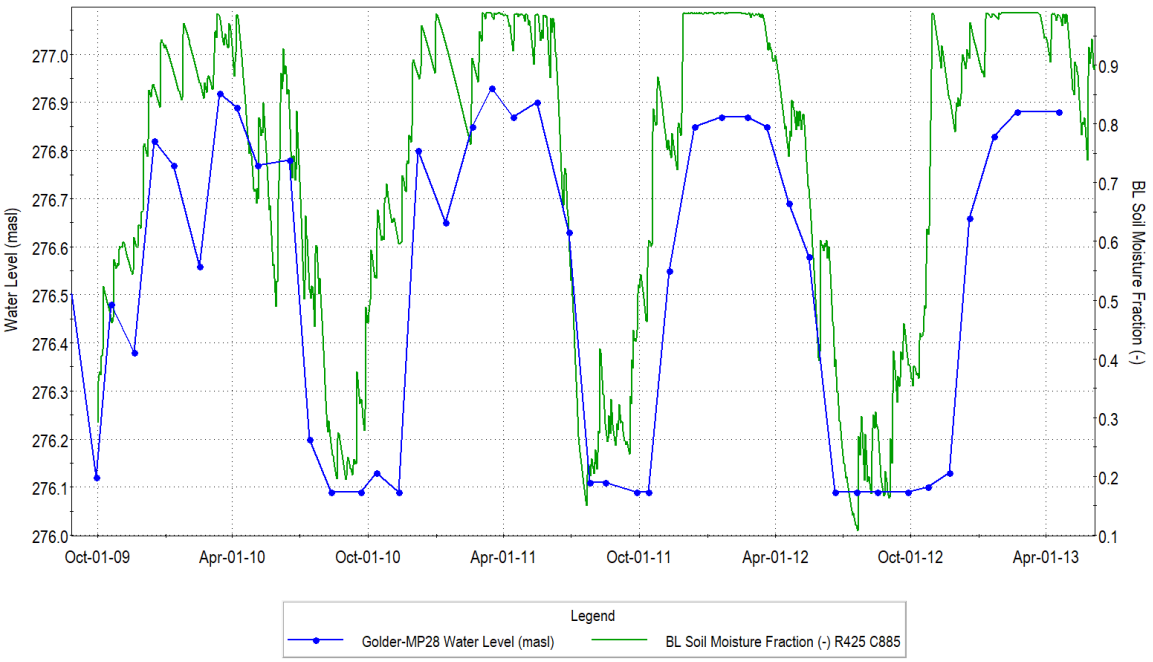


Figure 22: Comparison of simulated soil moisture to minipiezometer MP28 at Wetland EFX13 (MNRF 13030).

3.4.7 Wetland EFX 14 (MNRF 13019)

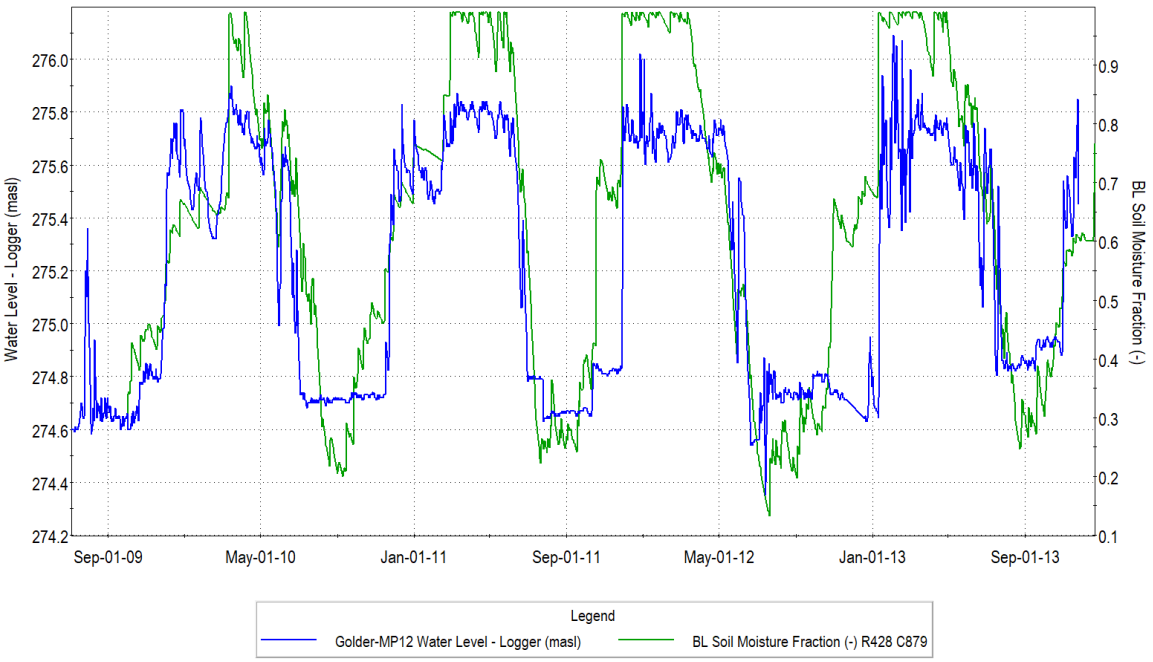


Figure 23: Comparison of simulated soil moisture to minipiezometer MP12 at Wetland EFX14 (MNRF 13019).

3.4.8 Wetland EFX 15 (MNRF 13021)

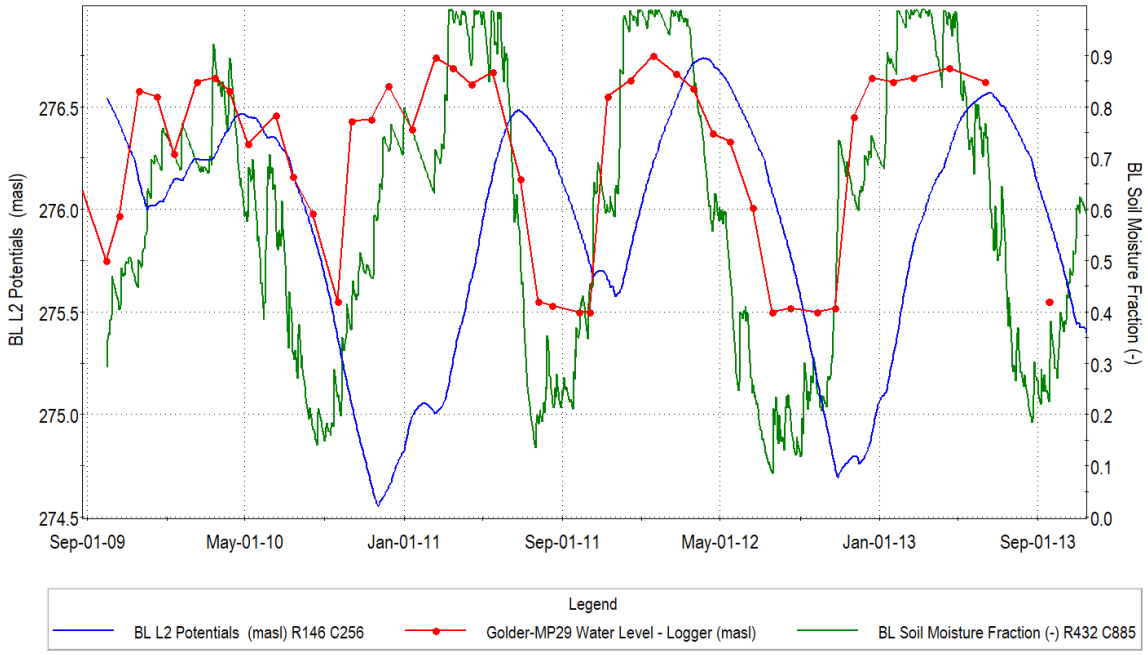


Figure 24: Comparison of simulated soil moisture to minipiezometer MP29 at Wetland EFX15 (MNRF 13021)

3.4.9 Wetland EFX 16 (MNRF 13022)

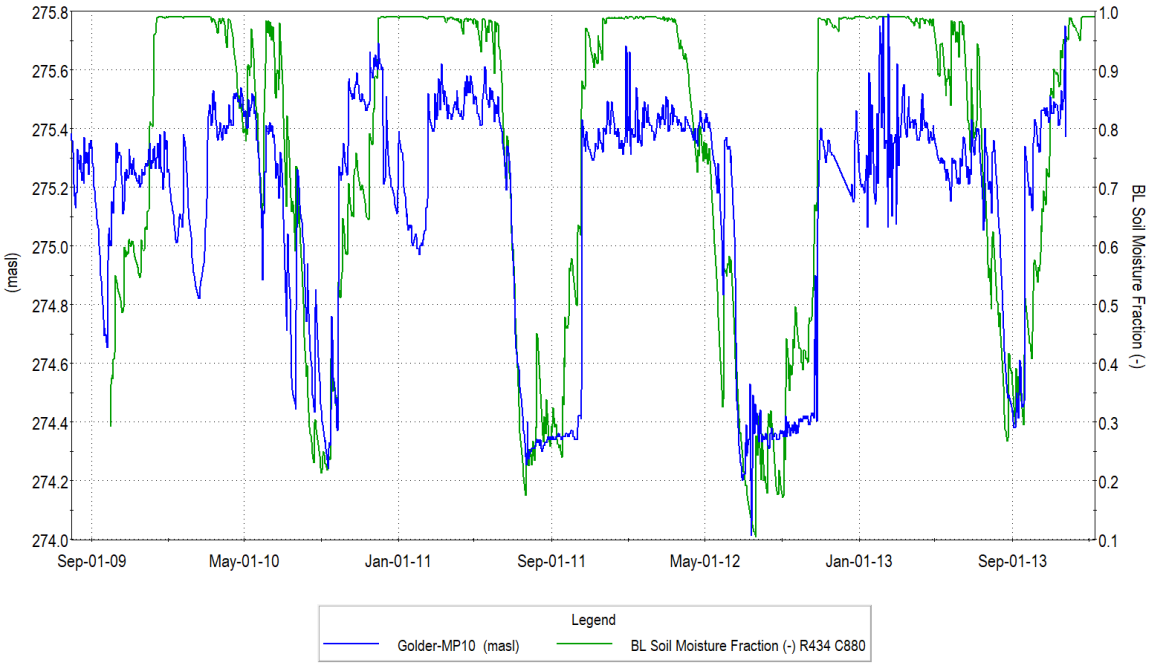


Figure 25: Comparison of simulated soil moisture to minipiezometer MP10 at Wetland EFX16 (MNRF 13022)

3.4.10 Wetland EFX 20 (MNRF 13036-13039)

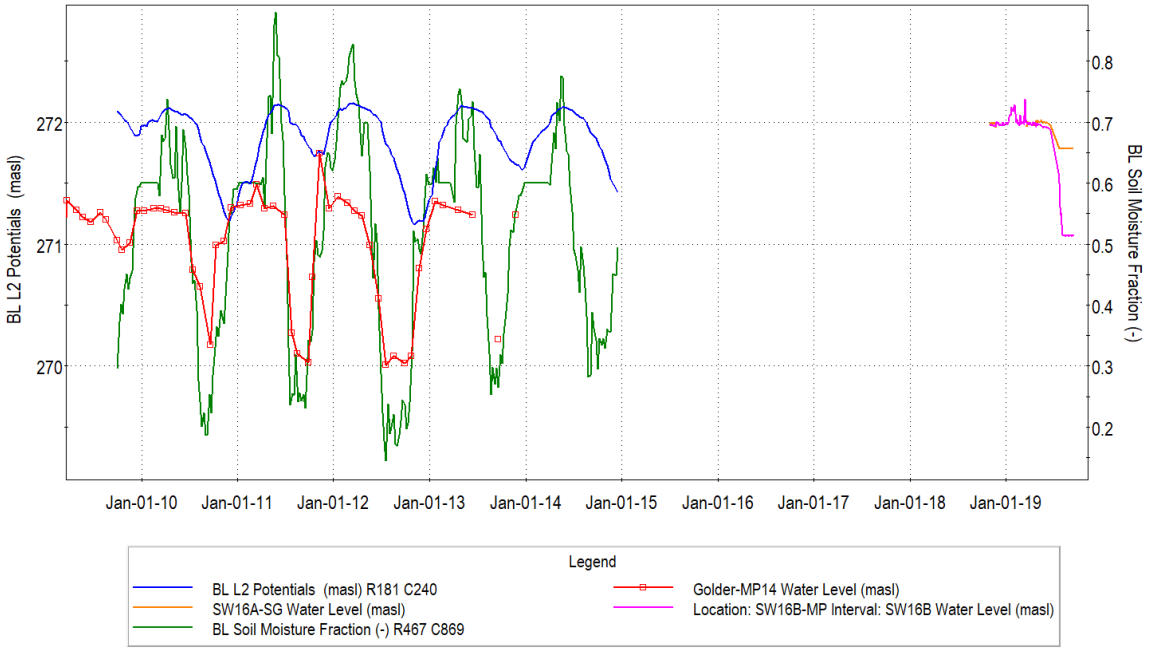


Figure 26: Comparison of simulated soil moisture to minipiezometer MP14 at Wetland EFX20 (MNRF 13036-13039): Based on recent measurements at SW16BMP, it appears that the historic data at MP14 may have an elevation offset.

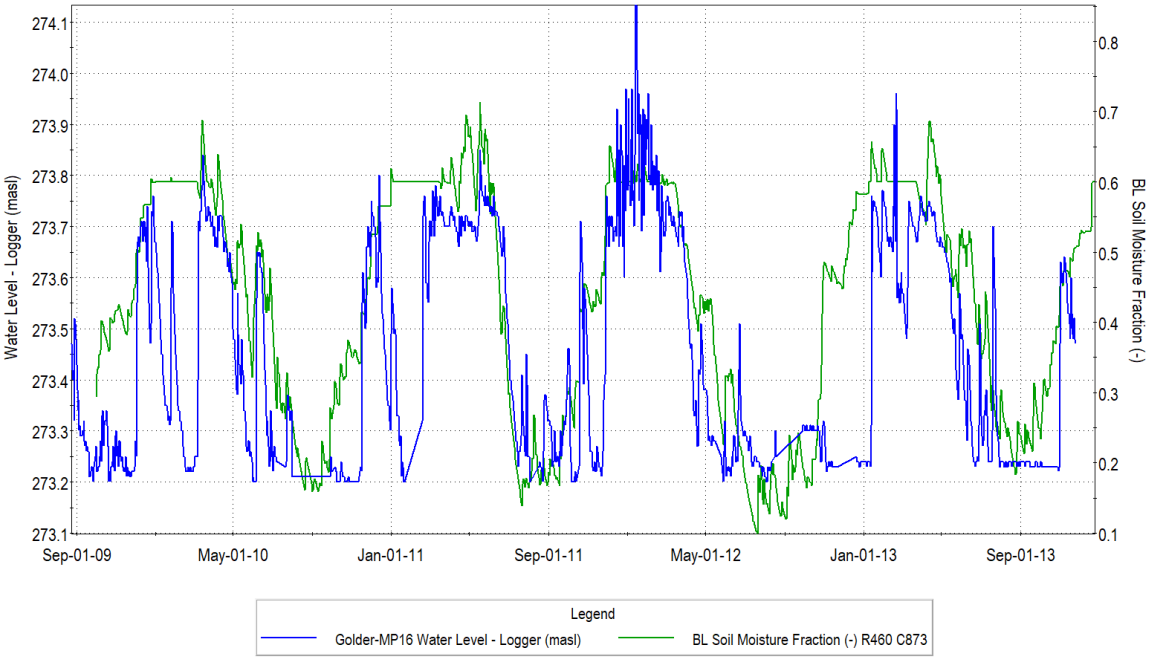


Figure 27: Comparison of simulated soil moisture to minipiezometer MP16 at Wetland EFX20 (MNRF 13036-13039):

3.4.11 Wetland MNRF 13025

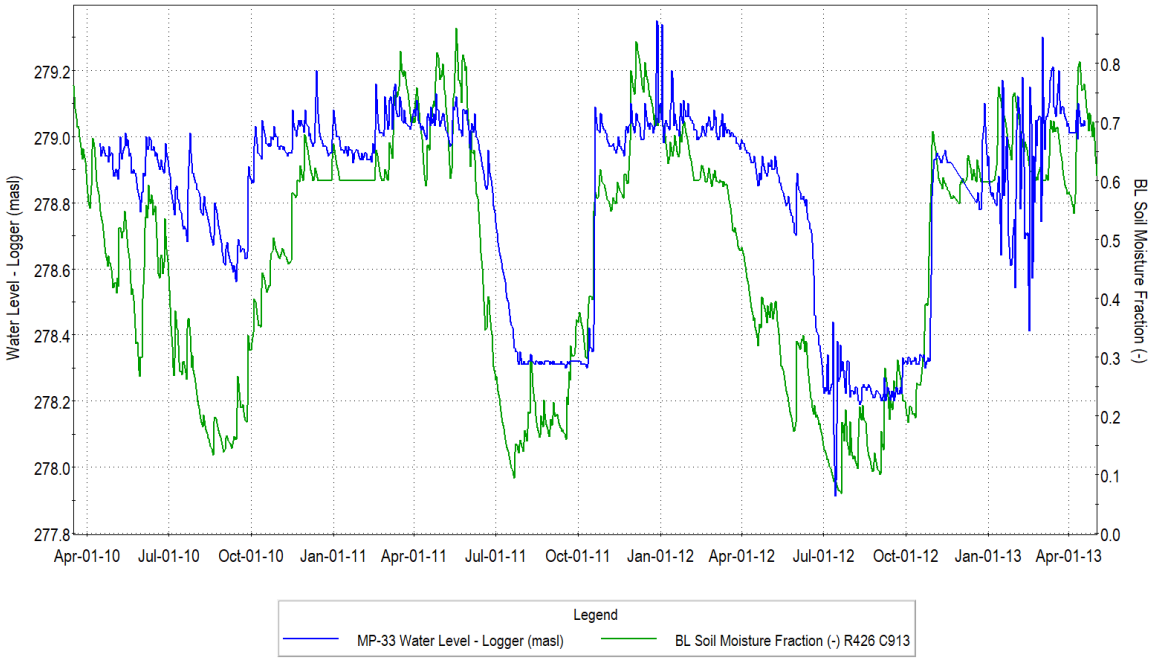


Figure 28: Comparison of simulated soil moisture to minipiezometer MP33 at Wetland MNRF 13025

3.5 Conclusions

To conclude, the close match between simulated soil moisture and measured minipiezometer levels indicate that the model is closely replicating conditions in the shallow subsurface and that there is no significant lag or offset in the model response. Comparing soil moisture to the intermittently saturated minipiezometers provides significant insight into the wetland conditions.

The hydraulic conductivity and specific yield values used for the Layer 2 simulation is reasonable and conservative compared to measured and estimated values. A lag in the dense aquitard response is expected in this layer. Overall, the model provides a good approximation of the shallow subsurface, wetland conditions, and soil hydroperiod, as indicated by the comparison between the minipiezometers and the simulated soil moisture response.

4 Long Term Observations of Wetland and Quarry Interaction

4.1 Introduction

The effects of quarry development can be evaluated by reviewing long term monitoring data collected from wetlands near the existing quarry face. Two wetlands, Earthfx 3 and 10, provide particular insight. Wetland 18, which is also near the face, cannot be used because it receives the south quarry discharge flows and is not fully representative of natural conditions.

4.2 Wetland 10 Quarry Advancement Analysis

Wetland 10 (MNRF 13015) (Figure 29) provides useful insight into the effect of quarry development on nearby wetlands. Continuous monitoring at minipiezometers and monitoring wells record, in detail, the conditions as the existing quarry face locally advanced towards this wetland.

The advancement of the face in the vicinity of Wetland 10 is discussed in Section 3.3.3 of the Earthfx (2020) report. Figures 3.8 and 3.9 in that report show the change in the extraction area. In 2009 the quarry face was approximately 475 m from Wetland 10, and by 2013 the face had advanced to approximately 320 m from the wetland (Figure 29). The effects of this advance are clearly observed in the monitoring data.

Background: The Earthfx, 2020 report evaluates the effect of the existing quarry in Section 6.11.3. Three key cross sections (see locations in Figure 6.21) are used to illustrate the effects with distance from the existing pit. The observed and simulated effects are discussed in detail. The following discussion builds on that analysis, but focuses on the conditions at Wetland 10, which is closest wetland to the existing pit. (Note: One of the cross sections presented in Section 6.11.3 passes under Wetland 18, but the influence of the south quarry discharge to that wetland means that Wetland 18 is not representative of other wetlands in the study area).

4.2.1 Monitoring Data collected during Quarry Advance

Minipiezometer MP13 (located in Wetland 10) and bedrock monitoring nest OW03-30 provide continuous water level data over this 2006-2019 time period. (OW03-30 is 100 m north of Wetland 10, but is approximately the same distance from the 2013 quarry face.) The data from MP13 and bedrock monitors OW03-30A (in the middle Amabel) and OW03-30B (in the shallow bedrock), are shown in Figure 30.

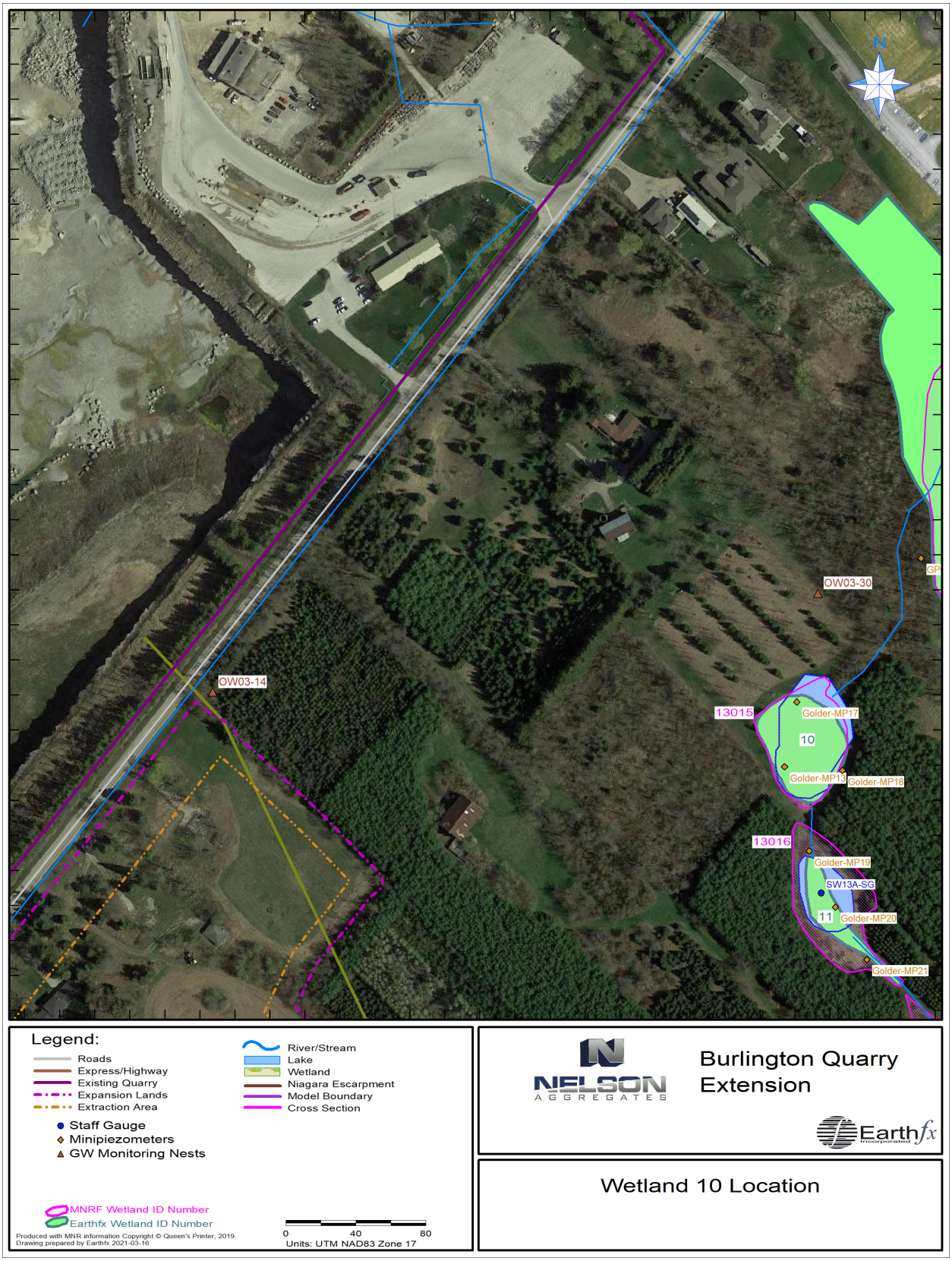


Figure 29: Wetland 10 location relative to current quarry face location.

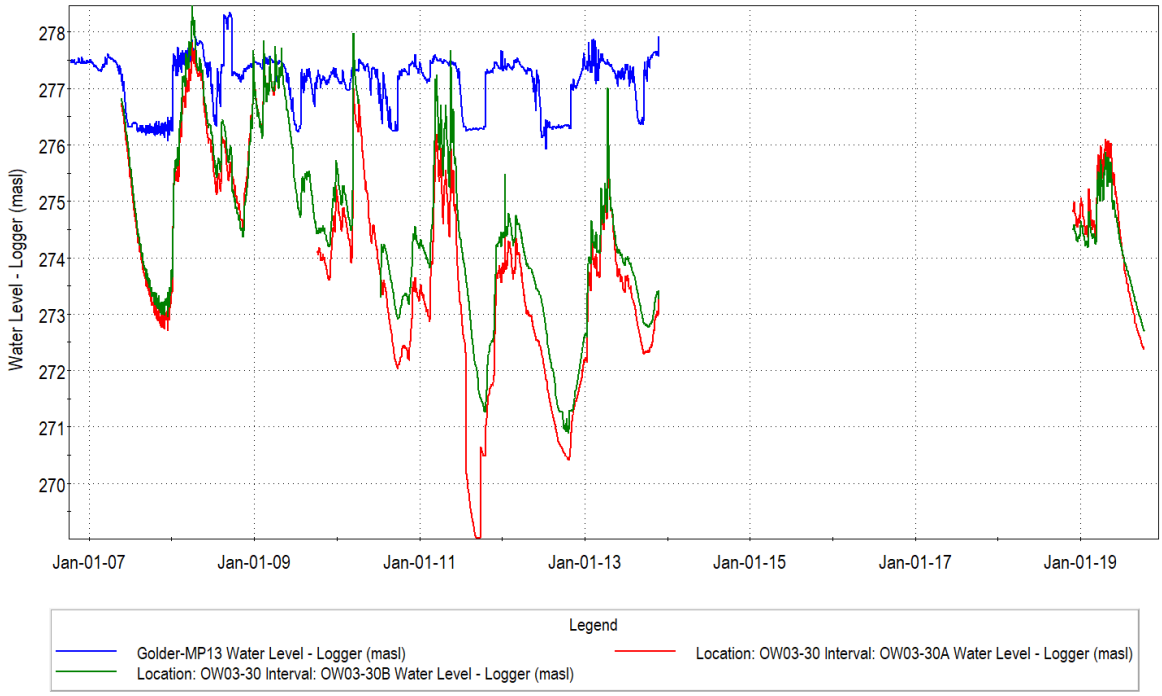


Figure 30: Monitoring Data from Wetland 10 and nearby monitor OW03-30

Figure 30 illustrates a few key events, beginning with the significant (natural) climate drought that occurred in 2007. Water levels in the wetland and bedrock both decline significantly during the drought, and fully recover during the 2008 wet year that followed. This illustrates the range of natural water level variation that can be observed in the wetland and bedrock.

4.2.1.1 Bedrock Effects

As the quarry face advanced towards Wetland 10 in 2009 - 2011 the water levels in the bedrock start to decline in a pattern that is evident in other monitors closer to the quarry face (See Earthfx, 2020 Section 6.11.3). The water level in OW03-30A exhibits a particularly clear response in September, 2011. Recent (2019) monitoring confirms that the long-term water levels show an average impact of approximately 2 m in the bedrock.

4.2.1.2 Wetland Conditions

The continuous monitoring from MP13 is particularly insightful. Water levels continue to respond in a similar manner both before and after the advancement of the quarry face. There is no observable decline in water levels in the wetland. This continuous seasonal pattern is also observed at minipiezometers MP17 and MP18 which are also located in Wetland 10.

The wetland hydroperiod at MP13 is similar both before and after the quarry advance. For example, the long 2013 hydroperiod, which occurred after quarry advance, is similar to the long 2008 and 2009 hydroperiods that occurred under pre-development conditions.

In summary, the monitoring data clearly illustrates that the wetland is not impacted by the advance of the quarry face, yet a clear response is observed in the bedrock beneath the wetland.

4.2.2 Model Simulation of Post-Advance Conditions

The ability of the model to predict the effects of the quarry development on wetlands can be evaluated by reviewing the simulation results at Wetland 10. The model must match the unaffected shallow wetland conditions, yet also represent the impacted Amabel formation. The fully transient GSFLOW model must match both the magnitude and timing of the water level patterns. The key issues are as follows:

- The infiltration is highly constrained, as too much recharge or too low a Halton Till hydraulic conductivity will over-fill the wetland and shallow system. Precipitation is not a calibration parameter, but is taken directly from the observations at local climate stations
- Seasonal and inter-annual rates of leakage through the Halton Till must be very precisely matched, for they must re-create the timing and magnitude of the Amabel response, which shows nearly 5 m of annual water level fluctuation.
- The horizontal flow in the Amabel formation towards the quarry must also be accurately represented so as to recreate the drainage effects of the quarry face located 320 m from the wetland. The Amabel aquifer fills in response to recharge from above, and slowly drains over the course of a few months.

The simulation of actual temporal advancement of the quarry face is not necessary; the baseline model scenario focusses on the conditions after 2011.

4.2.2.1 Shallow System Simulation Results

Minipiezometer MP13 is 1.2 m deep and reflects water levels in the soil zone and upper portion of the weathered Halton Till. The ground elevation is 277.43 and water levels are at or near this elevation during wet periods. The flat response (at approximately 276.25) reflects “dry” conditions (water levels below the monitor) and not actual water levels.

MP13 spans both the PRMS soil zone and upper portion of Layer 1 of the GSFLOW model. For this reason, water levels at MP13 are best compared to simulated shallow soil moisture conditions in the model. (While soil moisture could be converted to an approximate water level in the soil zone, the advanced soil moisture accounting processes represented in the PRMS model (described in Earthfx, 2020, Section 17.2 and Figure 17.3) are best presented as moisture content.)

Figure 31 shows that the simulated soil moisture closely matches the shallow water level recorded at MP13. Periods of 100% saturation correspond with MP13 water levels at ground surface (277.43 masl). Periods of low saturation reflect residual moisture (wilting point) held in the soil when the MP13 is dry. In summary, the results indicate that the model is replicating the shallow system processes at Wetland 10.

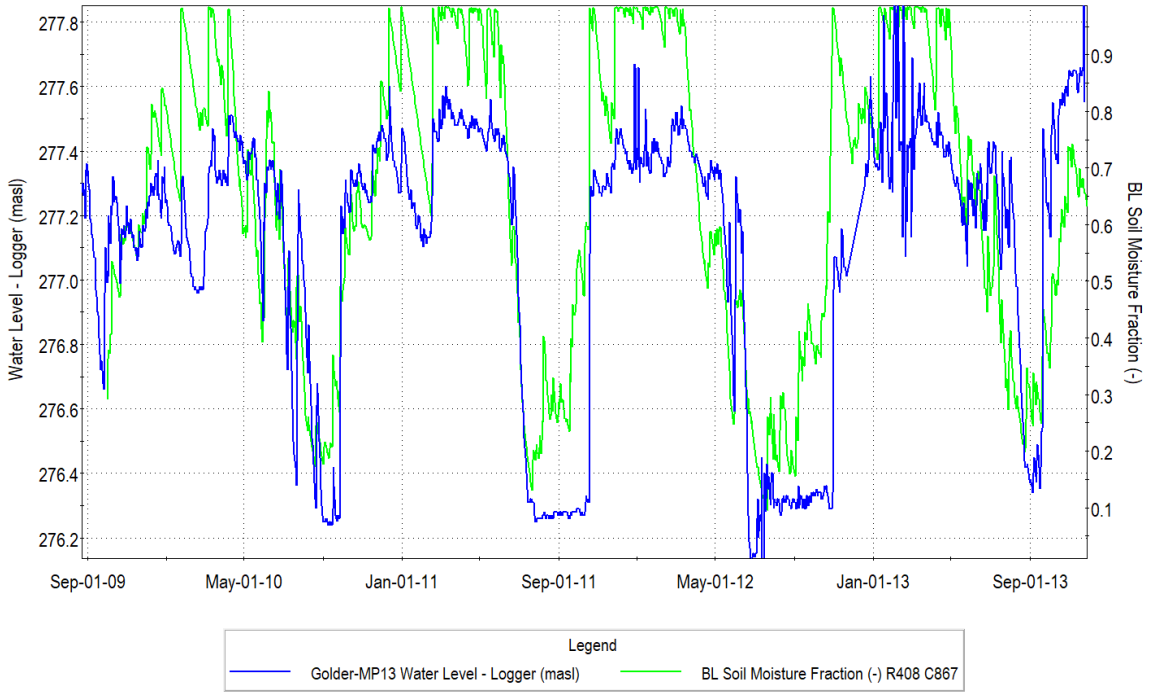


Figure 31: Observed water levels at MP13 compared to simulated soil moisture conditions (Earthfx Wetland 10 (MNRF 13015)).

4.2.2.2 Amabel Aquifer Simulation Results

The model simulation begins in October, 2010, and represents the fully-developed existing Nelson quarry (the quarry face has advanced to within 320 m of Wetland 10).

Model results generally match the observed timing and range of fluctuations. (Note that since OW30 is approximately 100 m from MP13, there is some error in comparing observed and predicted results from these two locations, but the overall the patterns are correct).

The simulated water levels in Layer 1 (weathered Halton Till – light green dotted line) compare reasonably closely to the observations at MP13 (dark green line). Note that MP13 levels "flatline" during dry periods (no measurement observed), while the model indicates that the water levels would actually fall into the bedrock during those dry periods. During wetter periods the simulated Layer 1 levels rise to those observed in MP13, but with some lag as Layer 1 is replenished from the soil zone above (see Figure 31). (The soil moisture better matches the very shallow system, as noted above.)

Observed water levels in OW03-30A (solid blue line) are comparable to simulated results from the middle Amabel (dotted blue line). The timing and range of water level fluctuations are close, although some even larger fluctuations are observed in the monitor. Observed water levels in the shallow bedrock (OW03-30B, red line) generally fall between the Layer 1 and Layer 5 results, but fluctuate widely.

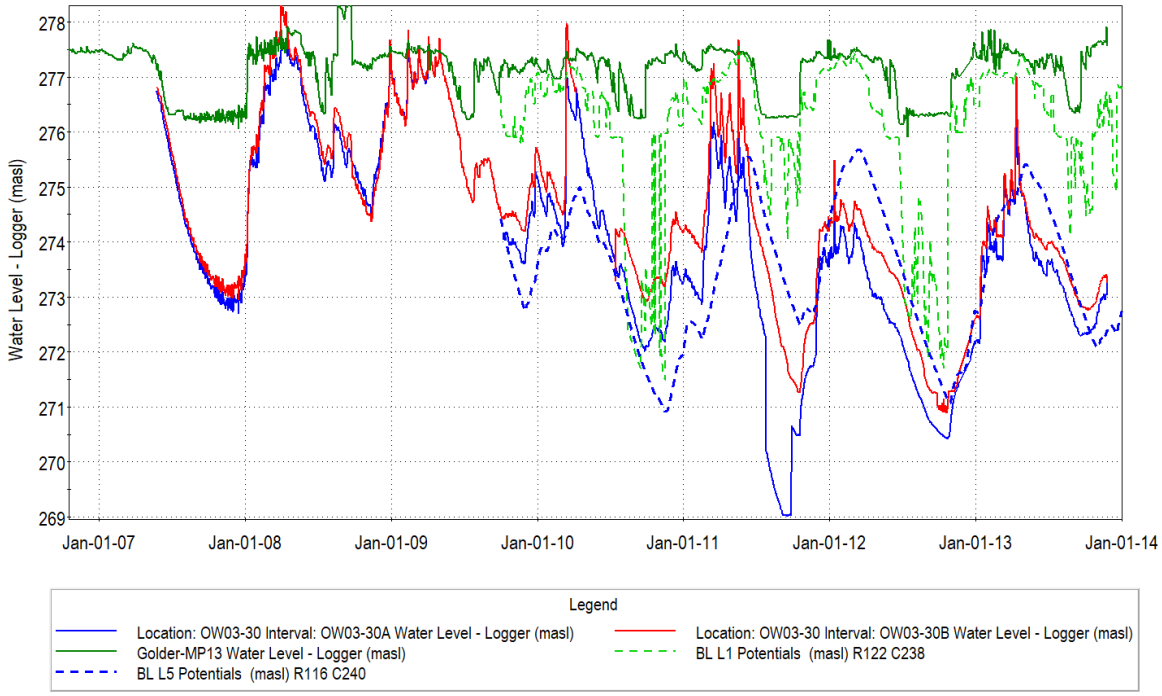


Figure 32: Observed and simulated water levels in the Amabel formation.

Most important, however, is that the model results are exhibiting the wide fluctuations in water levels that are observed to occur in the bedrock. In addition, the timing of the predicted fluctuations is generally good, particularly in the 2012–2013 time frame.

4.3 Earthfx Wetland 3 and MP35 Hydrograph Comparison

Earthfx Wetland 3, located approximately 50 m from the former north quarry face (Figure 33) has been monitored for a number of years by minipiezometer MP35.

Comparison of the hydrograph from MP35 with that from an unaffected wetland can provide insight into the effects of quarry development. Attached are two hydrographs:

- Figure 34 shows water levels from MP35, which is 50 m from the former north quarry face
- For comparison, Figure 35 shows water levels from MP9, which is 820 m from the south quarry face (and unaffected by current operations)

The figures show that the observed hydroperiod, and range of water level fluctuations, at 50m and 820m are very similar. This suggests that the MP35 and Wetland 5 is unaffected by the quarry development.

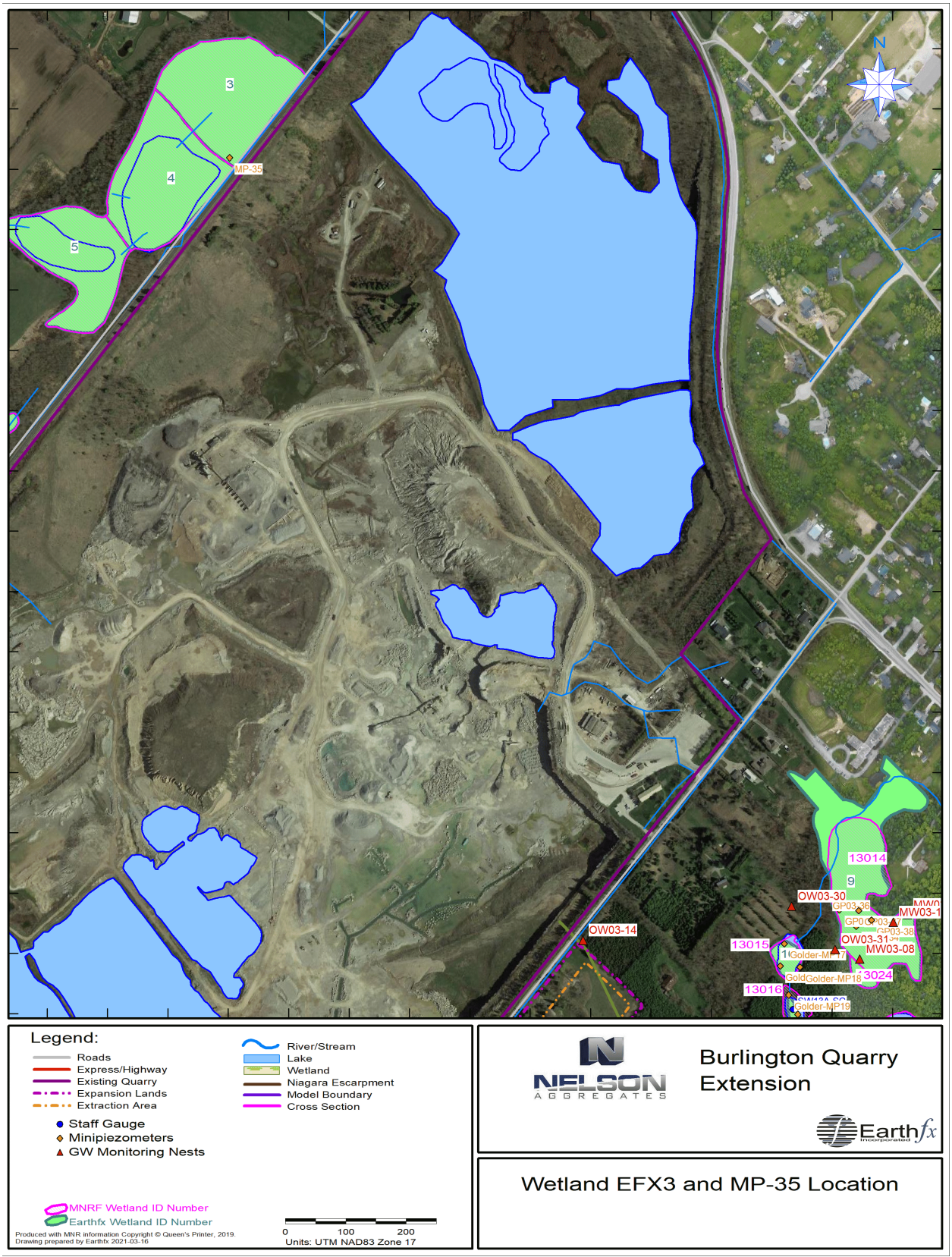


Figure 33: Location of Earthfx Wetland 3 and MP-35 near the north quarry face

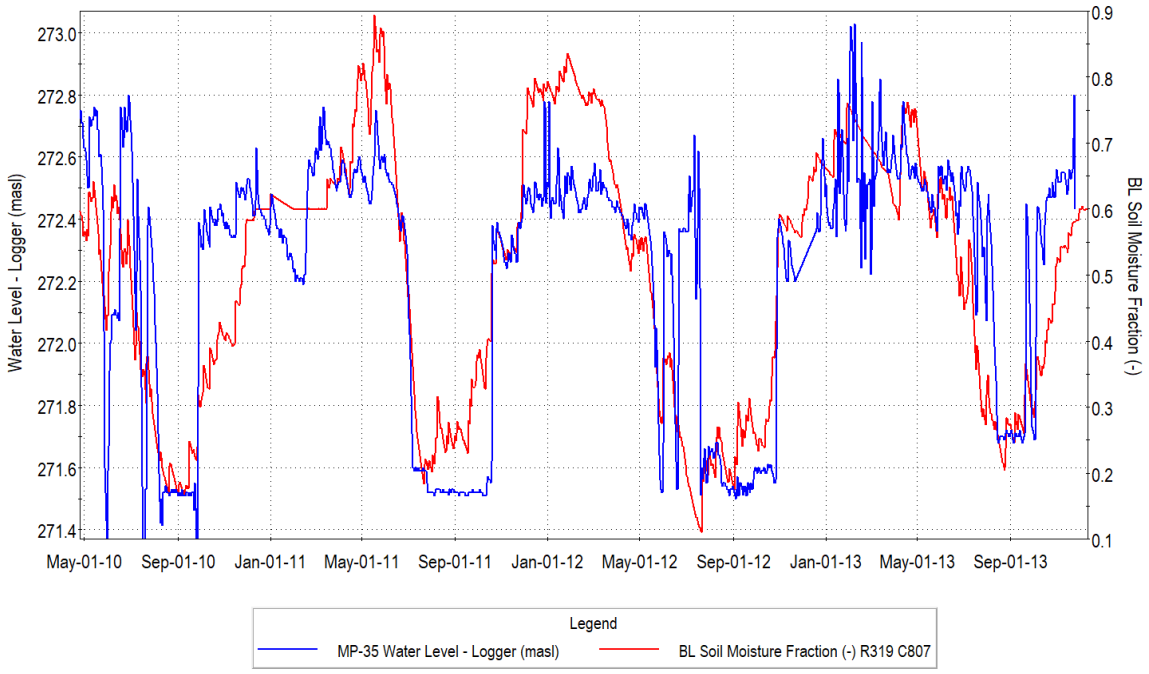


Figure 34: Observed Water Levels at MP35 (50 m from North quarry face) compared to simulated Moisture Content

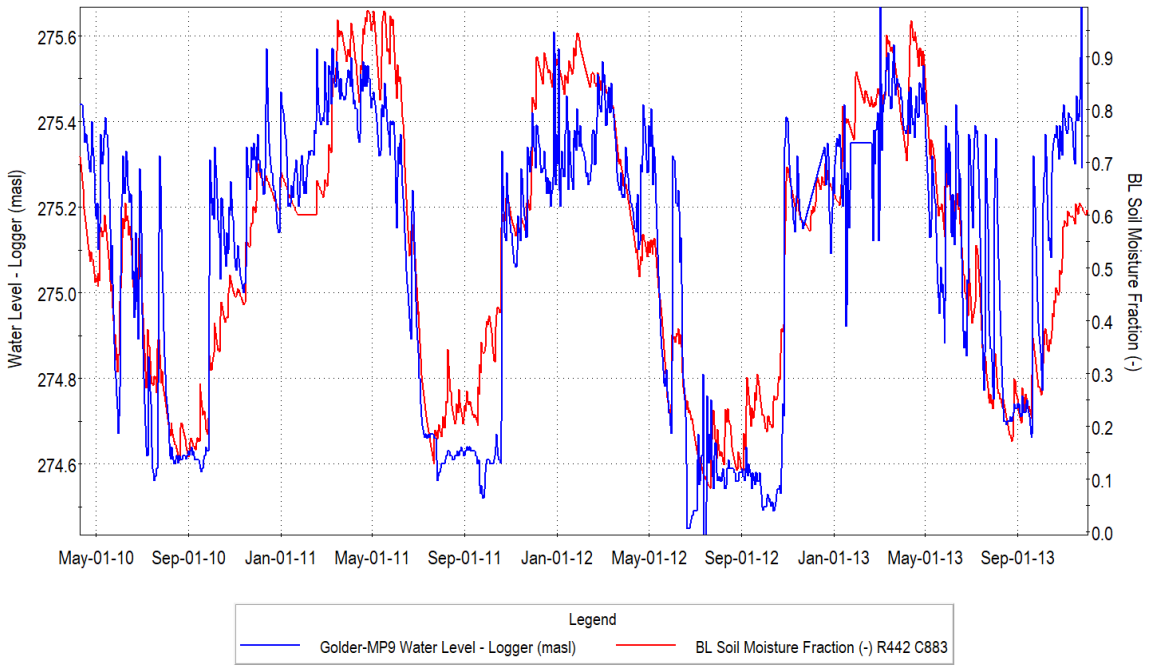


Figure 35: Observed Water Levels at MP9 (820 m from South quarry face) compared to simulated Moisture Content

4.4 Conclusions

The long-term detailed monitoring at Wetlands 5 and 10 provides real insight into the effect of quarry development on an existing wetland. The Wetland 10 data provides insight into both pre- and post-development effects, as well as wetland response to a significant natural drought.

The Wetland 10 monitoring data clearly demonstrates that the shallow wetland water levels and hydroperiod remain unchanged as the quarry face advanced towards the wetland. Water levels in the bedrock generally decline, but fluctuate widely in response to seasonal recharge from above and drainage towards the quarry.

Overall, the model is replicating both the ongoing high-water levels observed in MP13, and the wide fluctuations in water levels observed in the Amabel formation. The parameters used in the model have not been optimized to specifically match conditions at Wetland 10, so the model will be able to predict effects at other wetlands in the study area.

Both the field observations and simulations confirm that the wetland will remain unaffected by nearby development. The analysis of this wetland is consistent with the more detailed assessment of impact presented in Earthfx (2020) Section 6.11.3.

5 Wetland Water Budgets

5.1 Introduction/Summary

Feature-based water budgets were presented in Earthfx (2020) for the wetlands with groundwater interaction. Based on the MNRF request, additional water budgets have been prepared and summarized in the following tables. The water budgets for the P12 proximity wetlands are summarised in Table 14, and for those in the vicinity of P3456 in Table 15. The full water budgets are presented graphically in Figure 83 through Figure 112.

Additional details and time series hydrographs illustrating the timing and function of the wetland processes are included in Section 6 and the comment response table.

Table 14: Wetland Water Budget Summary Table: P12

Earthfx ID	MNRF Wetland ID Numbers	Baseline GW Outflow %	Baseline GW Inflow %	P12 GW Outflow %	P12 GW Inflow %
8	Between Guelph Line and Bluff's way	24.31%	1.25%	26.20%	0.07%
9	13014	10.19%	0.00%	9.67%	0.00%
10	13015	3.16%	0.00%	3.10%	0.00%
11	13016	3.97%	0.00%	3.90%	0.00%
12	13017, 13018	6.03%	0.00%	8.87%	0.00%
13	13030	10.62%	1.32%	11.67%	0.00%
14	13019	0.98%	0.01%	0.99%	0.00%
15	13021	0.23%	0.00%	0.24%	0.00%
16	13022	1.25%	0.34%	1.31%	0.00%
17	13033	2.51%	1.31%	5.71%	0.00%
18	13203	5.98%	2.42%	9.95%	0.00%
19	13032	19.82%	0.00%	19.35%	0.00%
20	13036, 13037, 13038, 13039	12.84%	1.79%	15.90%	0.00%

Note:

- GW Outflow = GW outflow as a percentage of total wetland outflows
- GW Inflow = GW inflow as a percentage of total wetland inflows

Table 15: Wetland Water Budget Summary Table: P3456

Earthfx ID	MNRF Wetland ID Numbers	Baseline GW Outflow %	Baseline GW Inflow %	P3456 GW Outflow %	P3456 GW Inflow %
21	13201	29.78%	2.98%	51.69%	0.01%
22	13200	26.31%	0.0%	26.31%	0.0%
23	13202 (Weir Pond)	Note 1			
24	Medad Valley Wetland Complex 13204	Note 2			

Note:

- Note 1: The Wetland 23 receives significant discharge from the quarry and is also intermittently used to divert water for golf course irrigation.
- Note 2: Due to the large size of this wetland, the effects of development are discussed in significant detail in Earthfx (2020) and the attached Watercourse Characterization Table
- GW Outflow = GW outflow as a percentage of total wetland outflows
- GW Inflow = GW inflow as a percentage of total wetland inflows

5.2 Detailed Water Budgets for Wetlands 8 through 22

Water budgets are included in Appendix A.

6 Wetland Impact Assessment: Process Timing

6.1 Introduction

MNRF requested additional wetland impact assessment details in the comment table. While specific responses are included in the response table, the following discussion presents detailed information about the timing and effect of the processes that make up the feature-based water budgets. This discussion builds on the preceding sections:

- Section 3 of this document demonstrates that the model simulation of shallow moisture conditions closely matches the observed conditions in the wetland minipiezometers. Both the magnitude and hydroperiod timing of the shallow system calibration is excellent (no offset or lag).

- Section 4 of this document provides field observations from two wetlands in close proximity to the quarry face. The field data clearly demonstrates that the conditions in the wetlands did not change as the quarry face advanced towards the wetland, despite groundwater levels in the bedrock beneath the wetland responding to the advancing quarry face. This physical evidence supports the analysis, model simulations, impact assessment conclusions.

- Section 5 of this document, and Earthfx (2020), present feature-based water budgets summarizing all aspects of the wetland function and impact. The water budgets indicate that groundwater inflows are a small percentage of the total water budget, and that the loss of that inflow will have limited effect on the wetlands.

While the feature-based water budget summary figures illustrate the overall effects, the following hydrographs have been prepared to illustrate the timing and overall change in the water budget. These include:

1. Changes in the average soil moisture in the wetland. Building on the soil moisture analysis presented in Section 3, the following graphs show how P12 changes in groundwater seepage to the soil zone will have a limited effect on average soil moisture conditions.

2. Changes in leakage in and out of the ponded water portions of the wetlands. Section 4 of this document demonstrated that drawdown in groundwater levels beneath the wetlands has a limited effect, and the hydrographs presented below illustrate how and when leakage in the ponded water portions of the wetlands will change in response to a decline in groundwater levels.

6.2 Wetland 17 (MNRF 13033)

The effects of development can be illustrated by comparing the average soil moisture in Wetland 170 under Baseline and P12 development conditions.

Figure 36 shows average daily soil moisture for Baseline conditions as a blue line. The soil moisture under P12 development is shown in red, and it overlies (covers) the Baseline for much of the time period. Under P12 development, soil moisture is essentially identical in the winter and spring, but slightly dryer in the summer and fall.

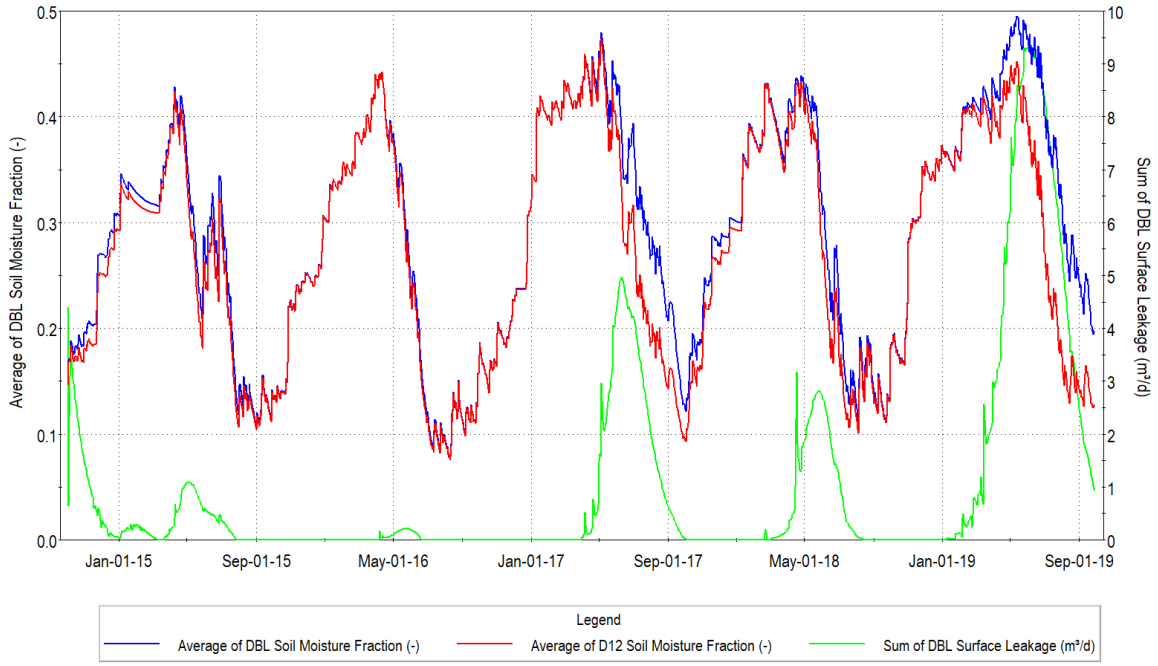


Figure 36: Soil moisture under Baseline and P12 development conditions at Wetland 17 (MNRF 13033)

The Baseline groundwater discharge into Wetland 17 (seepage or "surface leakage" in GSFLOW) is shown as a green line on the graph (right hand scale). The decline in soil moisture under P12 is due to the loss of this groundwater discharge (due to the drawdown in groundwater levels near the excavation).

Under baseline conditions, groundwater seepage occurs as water levels rise in the late spring in response to snowmelt. Seepage fluctuates significantly, however, due to natural inter-annual climate variability.

- During a dry year (2015-2016) groundwater levels are naturally low, there is no groundwater seepage, and so there is no difference in soil moisture between Baseline and P12.
- During an average year (2017-2018) there is small change in the late summer soil moisture conditions due to the loss of groundwater discharge during P12 development
- During a wet year there is a modest loss of soil moisture in the May-September time frame.

The water budget summary for Wetland 17 (Earthfx, 2020) indicates that groundwater inflows account for only 1.31% of all inflows (Table 14), and that this will be lost with development. Figure 36 illustrates how and when that loss of groundwater inflow will occur. The loss will primarily occur during the late summer of a *wet year*. There will be no impact during dry years when the wetland already experiences limited groundwater inflow.

Additional surface water and ground water interaction occurs through the bottom of the ponded water portions of Wetland 17 (Figure 37). The ponded water areas within the wetland are represented in the model as MODFLOW "Lakes". "Lake" seepage is positive when the lake or pond

is leaking water to the deeper groundwater system. Negative lake seepage indicates groundwater is upwelling into the pond.

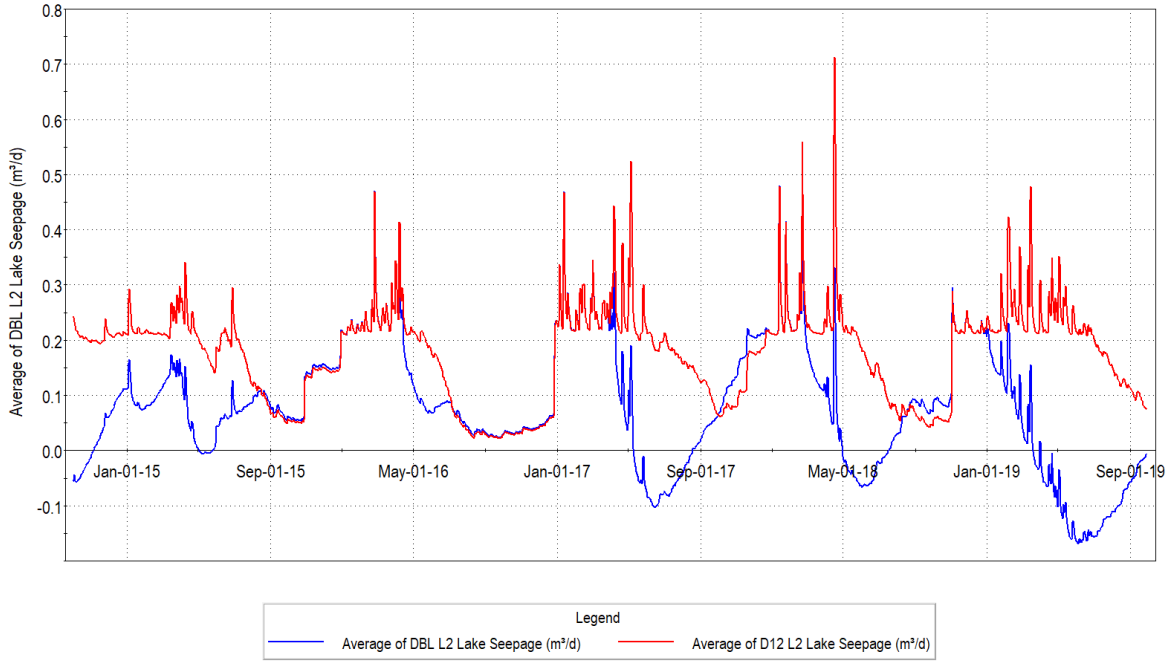


Figure 37: Lake seepage under Baseline and P12 conditions in Wetland 17 (MNRF 13033)

The lake seepage under Baseline (Blue) and P12 conditions (Red) are shown in Figure 37. Under Baseline conditions, the ponds leak water to the groundwater system for most of the year, and only receive upwelling (negative leakage or seepage) for short periods of the wetter years when the water table is higher (generally in late spring).

Under P12 conditions (red line), the ponds leak water to the groundwater system at varying rates throughout the year; generally higher in the spring and declining through the summer.

Overall, the pond leakage patterns under Baseline and P12 conditions are similar to that of soil moisture response. Again, it is very important to note that the groundwater inflow as a percentage of total inflows into the wetland is only 1.31%.

The following graphs present the change in soil moisture, surface discharge and pond leakage for the other wetlands that exhibit at least some groundwater discharge. Overall, the patterns are similar to Wetland 17.

6.3 Wetland 20 (13036, 13037, 13038, 13039)

The soil moisture and surface discharge patterns in Wetland 20 are shown in Figure 38, and pond leakage is shown in Figure 39. Groundwater inflow as a percentage of total inflows is only 1.79%.

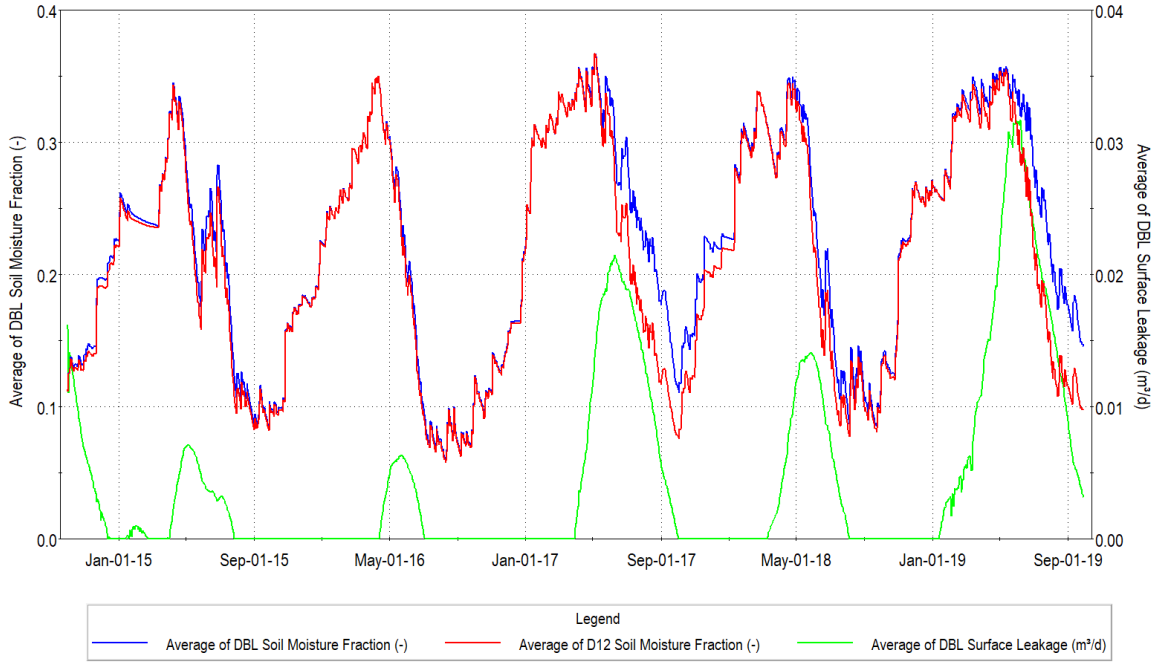


Figure 38: Soil moisture under Baseline and P12 development conditions at Wetland 20 (MNRF 13036-13039)

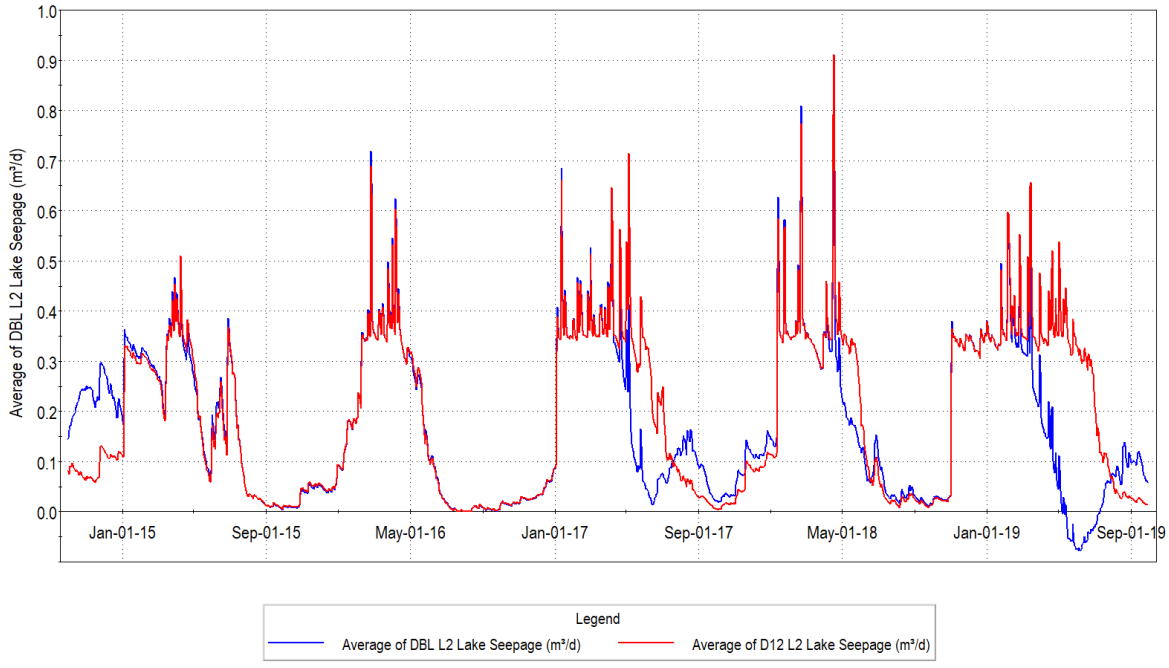


Figure 39: Lake seepage under Baseline and P12 conditions in Wetland 20 (MNRF 13036-13039)

6.4 Wetland 13 (MNRF 13030)

The soil moisture and surface discharge patterns in Wetland 13 are shown in Figure 40, and pond leakage is shown in Figure 41 (Note the scale range is very small). Groundwater inflow as a percentage of total inflows is only 1.32%.

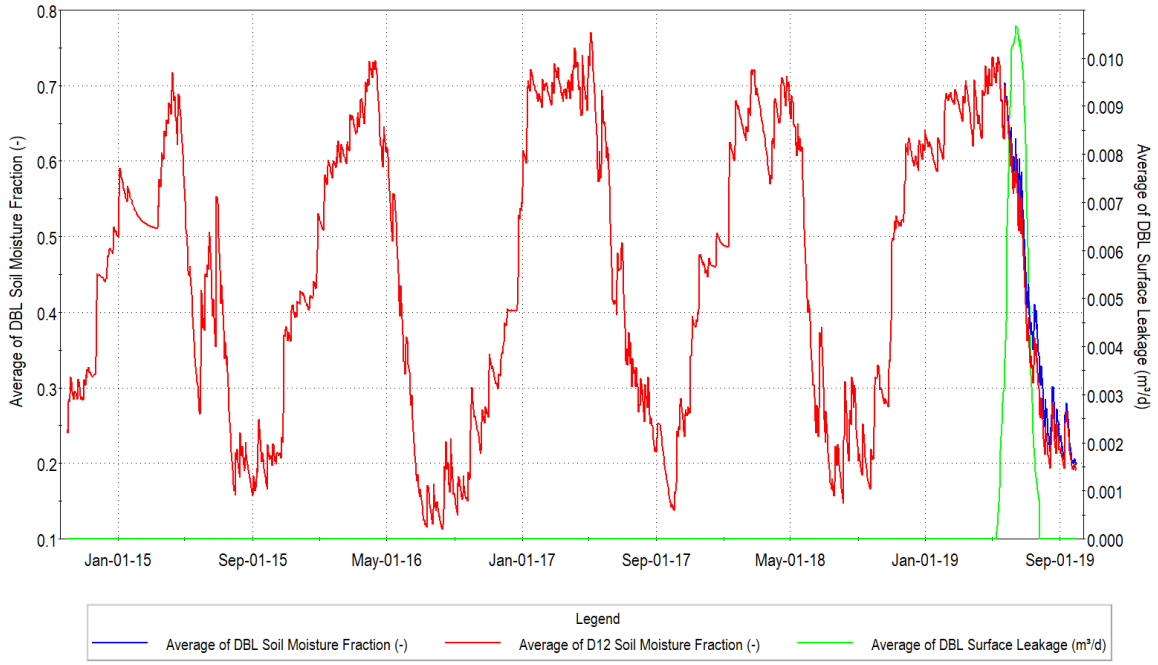


Figure 40: Soil moisture and Surface Leakage under Baseline and P12 conditions in Wetland 13 (MNRF 13030)

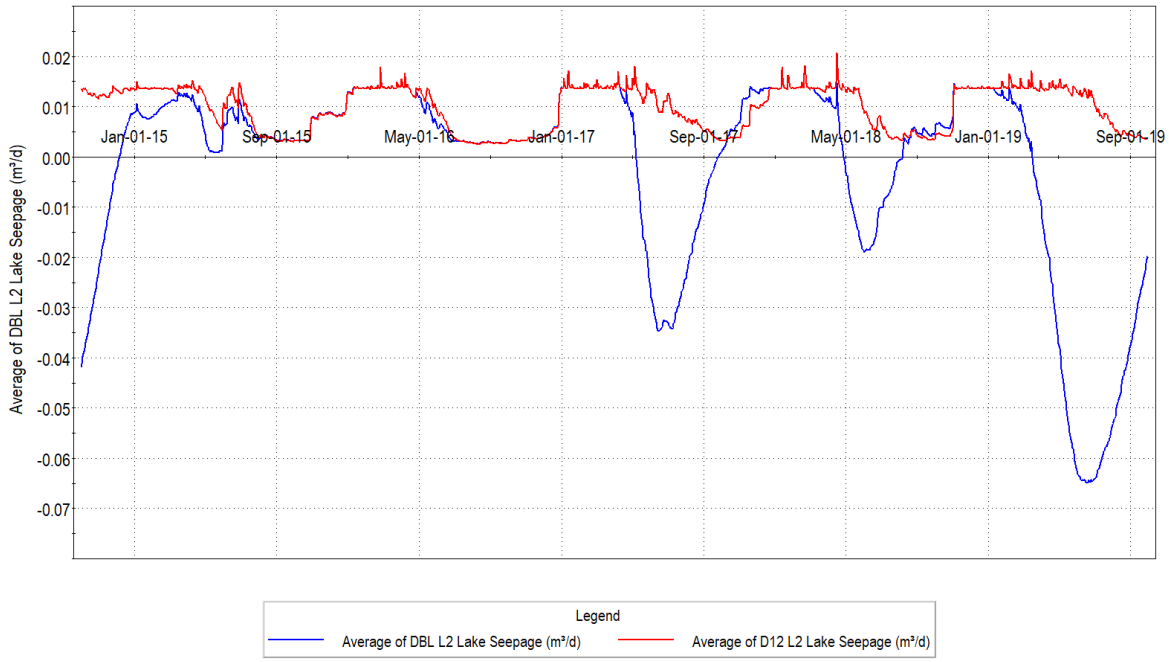


Figure 41: Lake seepage under Baseline and P12 conditions in Wetland 13 (MNRF 13030)

6.5 Wetland 18 (MNRF 13203)

The soil moisture and surface discharge patterns in Wetland 18 are shown in Figure 42. There are no lake cells in this wetland. Groundwater inflow as a percentage of total inflows is only 2.42%.

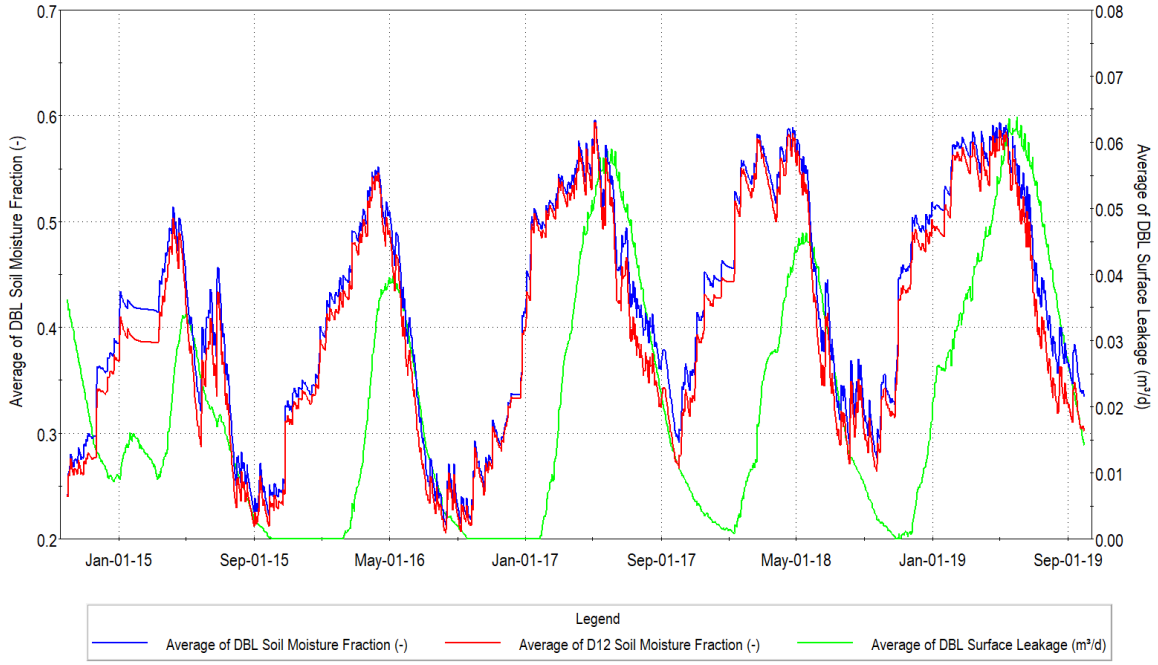


Figure 42: Soil moisture and Surface Leakage under Baseline and P12 conditions in Wetland 18 (MNRF 13203)

6.6 Wetland 21 (MNRF 13201)

The soil moisture and surface discharge patterns in Wetland 21 are shown in Figure 43. The pond leakage for Wetland 21 is shown in Figure 44.

The change in soil moisture and pond seepage is somewhat more complex in Wetland 21 than the other wetlands because the headwater catchment area of this wetland will be reduced by the development of P3456. Under Baseline conditions, the wetland receives runoff and interflow from a larger catchment resulting in higher average soil moisture conditions. Under P3456 conditions the change in catchment area reduces the soil moisture and groundwater seepage. These changes, including lower water availability and the drop in the water table, cause higher pond leakage in the spring, and lower leakage in the fall (Figure 44).

Again, it is important to note that groundwater inflow as a percentage of total inflows is only 2.98%. Also note that Wetland 21 may be adversely impacted by road and culvert issues.

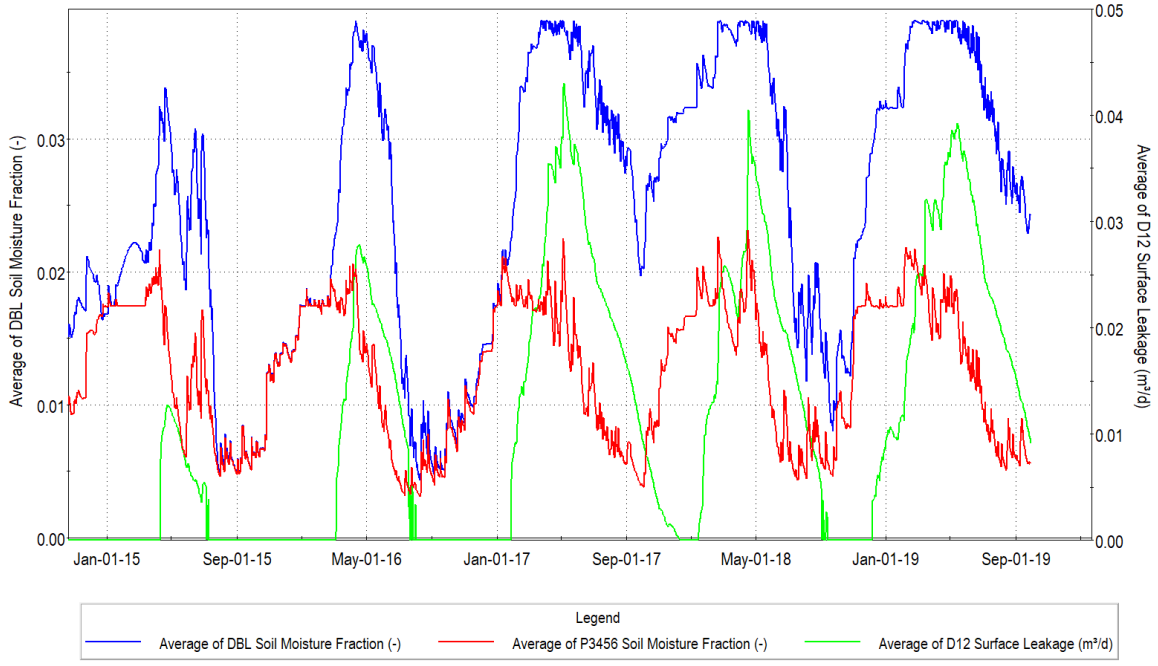


Figure 43: Soil moisture and Surface Leakage under Baseline and P12 conditions in Wetland 21 (MNRF 13201)

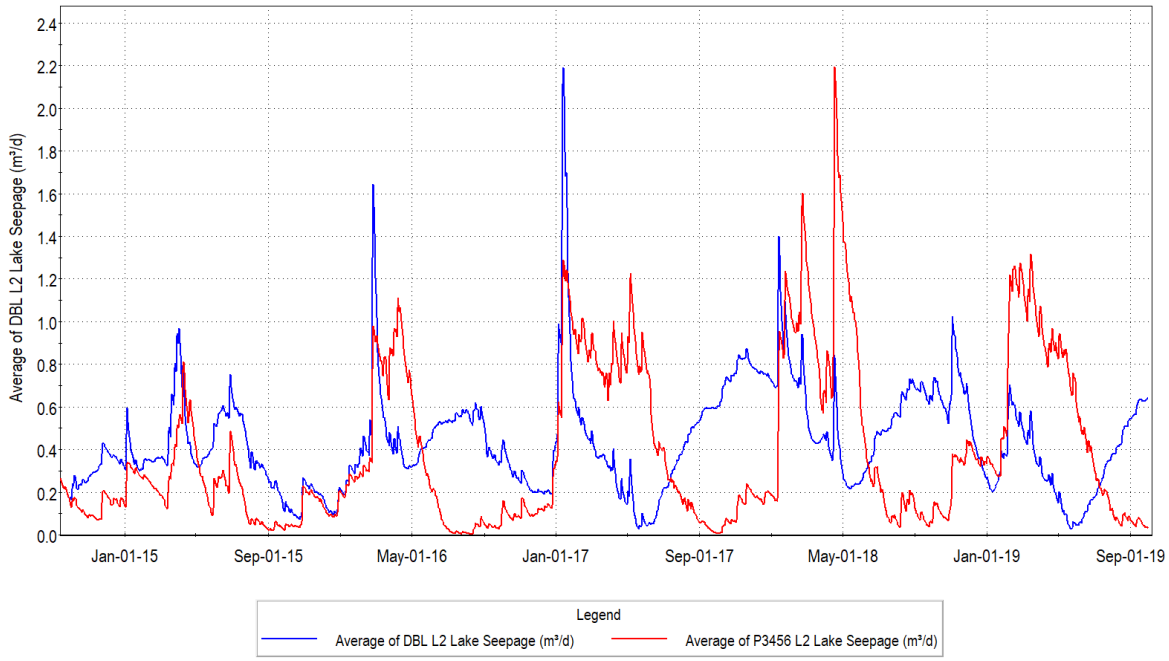


Figure 44: Lake seepage under Baseline and P3456 conditions in Wetland 21 (MNRF 13201)

6.7 Conclusions

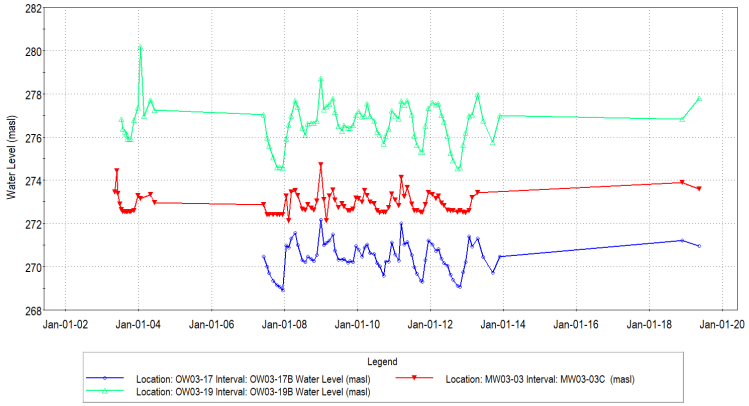
The hydrographs of soil moisture and surface discharge illustrate the groundwater discharge (seepage) provides only a minor portion of the overall soil moisture budget for the wetlands. The highest rates of seepage occur during the late spring of the wetter years. This conclusion is consistent with the observed minipiezometer hydroperiod.

Both soil seepage and pond inflow are generally higher during wetter years when the water table is elevated relative to the ponds.

Finally, it is once again very important to note that groundwater interaction represents a very small portion of overall wetland water budget, as summarised Table 14 and Table 15.

7 MNRF Comments Sections 1-4

MNRF Comment		
3.1	Groundwater model calibration results provided for the flow stations show graphs of actual measured flow and predicted calculated flow. The calibration graphs presented in the report show varying levels of calibration (i.e., some results demonstrate good calibration, others are not well calibrated). In order to assess if the calibration achieved is acceptable for the predictive simulations, the applicant should provide calibration graphs for all the flow monitoring stations as well as the entire period of flow measurements.	This comment is addressed in detail in Section 3, above, and in additional hydrographs presented in this table.
3.2	The Ministry notes that several wetlands outside of the 120-metre study area may be impacted by the proposed quarry expansion. Please assess for potential impacts on all wetlands, streams and springs located within the quarry's groundwater zone of influence. This information can subsequently be used to ensure that appropriate mitigation targets and thresholds are included in the adaptive management plan.	It should be noted that we analyzed all nearby wetlands and streams whether they were in or outside the 120 m boundary. The model and analysis extend more than 2000 m from the existing and proposed quarry extents, including areas below the escarpment face. Additional wetland characterization, water budget and hydrograph analysis are presented.
3.3	The current cut-off drawdown of 2.0 metres for the Zone of Influence may not be appropriate to evaluate potential impacts to the wetlands and watercourses from the proposed expansion. Further discussion will be required.	The 2.0 m threshold was not used as a cut-off for analyses or to limit the evaluation of the effects of the proposed development on the wetlands and watercourses. Detailed wetland water budgets, hydroperiod analysis, and change in discharge and streamflow analysis were used to evaluate effects. Significant portions of the Medad valley wetland, located well outside of the 2.0 m threshold, were evaluated in detail (see Figure 8.70, for example). Similarly, the effects of development on stream reaches outside the 2 m zone were evaluated both along the reach (See Earthfx, 2020 Figure 8.5), and at stream gauges as much as 1000 m outside of the 2m zone (Stream gauge SW10B, as shown in Figure 8.10). The *presentation* of drawdowns at a 2 m threshold was based on the methodology used for Source Water Protection Tier 3 WHPA-Q1 Delineation. This methodology recognises that

		natural seasonal variability in water levels should be taken into account when evaluating and managing the extent of Municipal wellfield impacts. The methodology requires that local conditions and water level fluctuations should be considered when determining the impact assessment threshold, and for the Halton-Milton Tier 3 study, the natural seasonal variability threshold was determined to be 1.4 m in the Kelso area. We used a similar methodology to identify natural seasonal variability in the Nelson quarry area. For example, the long-term natural fluctuations in three wells located more than 1000 m from the existing quarry are shown in Figure 45. Each of the wells show more than 2 m of natural water level fluctuations.  Figure 45: Long term water level fluctuations Based on this and other local information the 2.0 metre threshold was selected for the display of development effects. Both natural variability and available aquifer drawdown (see Figure 8.20, for example) were considered and discussed in detail.
3.4	In addition to water quantity and quality, thermal impacts to the nearby streams, wetlands and springs within the quarry's zone of influence should be assessed.	The changes in the thermal regime are expected to be small, as the design of the proposed expansion preserves existing surface water and groundwater management operations and flow patterns. The north and south quarry discharge points will

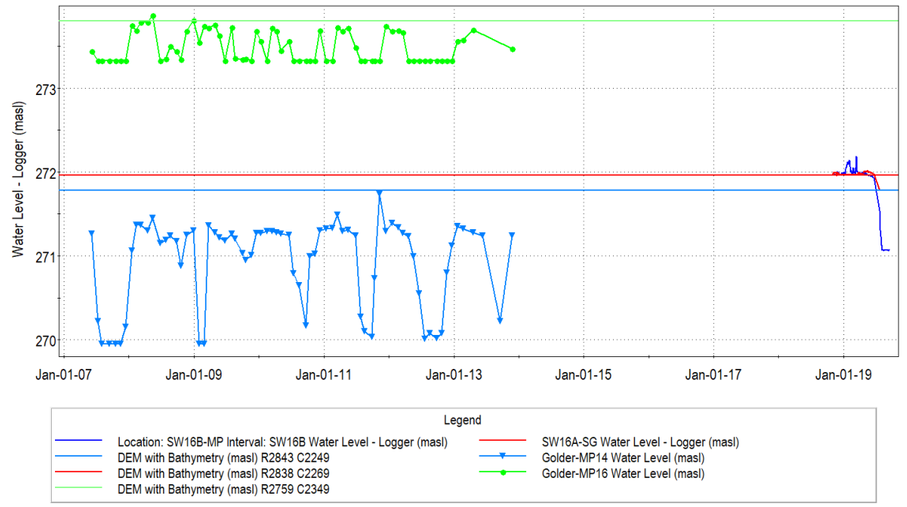
		remain the same as current operations. The proposed P3456 infiltration system will replace the existing managed golf course pond system.
3.5	Please describe surficial deposits underlaying the wetlands based on field investigations at the scale of a particular wetland. If the subsurface information is not available, the installation of additional monitoring wells may be required. Installation of multi-level monitoring nests is recommended to understand vertical movement of groundwater and its relationship with surface water. Depending on the size of the wetland, more than one monitoring well may be necessary to characterize a feature.	Wetland characterization, monitoring and hydraulic conductivity testing is discussed in detail in Section 2 of this document and documented in Golder (2006, 2007, 2010).
3.6	The Ministry notes that evaluation of potential impacts to the wetlands are based on applying a uniform hydraulic conductivity for Halton Till. We require further information on local variability of till hydraulic conductivity at a wetland-specific scale.	Wetland characterization, monitoring and hydraulic conductivity testing is discussed in detail in Section 2 of this document and documented in Golder (2006, 2007, 2010). The conceptual model of the Halton Till is also discussed. The hydraulic conductivity of the Halton Till model layers is further discussed in Section 3. The discussion concludes that the variability in hydraulic conductivity is explained by the variation in testing of the matrix and fracture network. The variation in hydraulic conductivity is explained by the depth of weathering. No patterns of lateral spatial variation have been observed, and given that the Halton Till was deposited by a regional scale ice advance, a high degree of matrix variation is not expected.
3.7	In order to ensure that all wetlands are assessed for potential impacts as a result of the quarry expansion, please provide maps showing calculated drawdowns within Layer 1 and Layer 2 for surficial deposits of the groundwater model in predictive calculations. Further, an appropriate drawdown cut-off for each wetland needs to be selected. The Ministry notes even a small change in groundwater level below a wetland may impact the wetland's	Layer 6 was selected for drawdown analysis as it is the most permeable and most likely to experience change. The drawdown for Layer 1 under Scenario P3456 is shown in the figure below (Figure 69). The figure is similar to Figure 8.43. The 2.0 m drawdown for Layer 6 is shown in red and encompasses the Layer 1 drawdowns (indicating that Layer 6 drawdowns are higher). Layer 2 drawdowns are similar to Layer 1. See previous answer to Question 3.3 regarding the drawdown thresholds. As noted, wetlands were not excluded based on

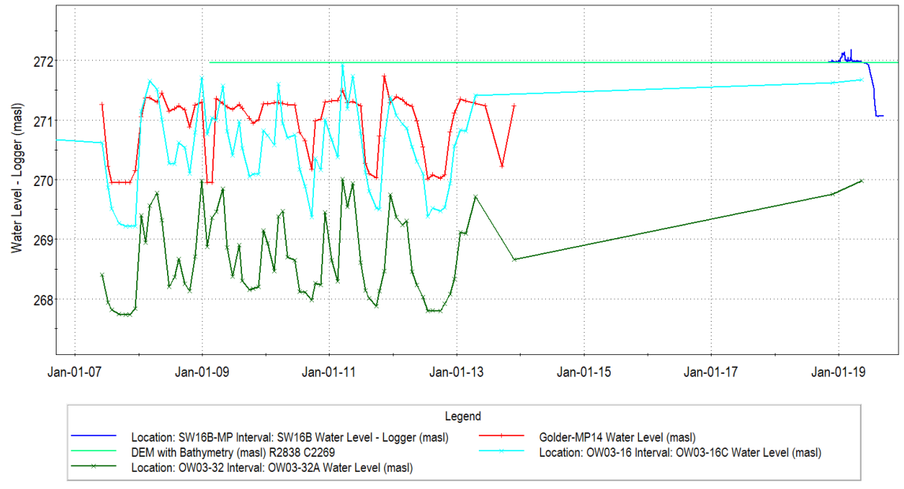
	hydroperiod and groundwater-surface water interaction.	drawdown - we analyzed all nearby wetlands whether they were in or outside the 2.0 m threshold. That said, it must be noted that most of the wetlands are perched and that groundwater interaction is a minor part of the overall water budget. This was determined in the original Golder studies and is consistent with results of the groundwater modelling. Additional wetland water budgets, showing the limited GW inputs, are included in Section 5.
3.8	For wetlands within the Zone of Influence, wetland hydroperiod, water level and temperature thresholds for each of the wetlands should be assessed to determine the potential for impacts from the quarry expansion and identify appropriate mitigation.	Wetlands both within and outside the zone of influence were evaluated, as discussed in the response to Question 3.3. Wetland Characterization Tables have been prepared (and provided separately) to integrate and summarize the effects analysis from the various reports.
3.9	Please provide additional information on seasonal surface/groundwater interaction patterns for the streams located within the zone of influence by completing additional monitoring wells near the streams. Please develop seasonal flow and temperature thresholds for all the streams that may be impacted (based on stream function).	Daily simulations of seasonal and inter-annual (wet year/dry year) SW/GW interaction were compared to more than 10 years of measured streamflow and water levels from wetland, pond staff gauge, minipiezometers and groundwater monitoring nests. SW/GW interactions are discussed and shown on numerous figures (e.g., Section 8.5.3, Figure 8.24 and 8.25 and numerous hydrographs and feature-based water budgets). We have presented average and dry condition water level and streamflow maps, together with multi-year hydrographs showing the daily variability. We can provide flows and levels from any model cell, stream reach, or pond in the model domain as hydrographs or maps and are not limited to a pre-determined zone of influence. We feel we have presented a detailed, yet concise, summary of the potential effects of the development, but if there are specific wetlands, stream reaches or other points of interest please provide a specific location and issue for us to address.
3.10	Please provide additional assessment on how lowering of the groundwater divide as a result of the western quarry expansion could impact water levels to the Medad Valley Provincially Significant Wetland complex (and specifically Wetland 24) to ensure there is no negative impacts to the wetland. The Ministry notes that lowering of the groundwater divide has the potential	Under baseline conditions, the divide in the west is located midway between the quarry face and the Medad Valley. Under P3456, the divide shifts to lie under the infiltration pond. Little change is seen to the north or south. This highlights that the infiltration pond will function to maintain flow to the Medad Valley (Wetland 24).

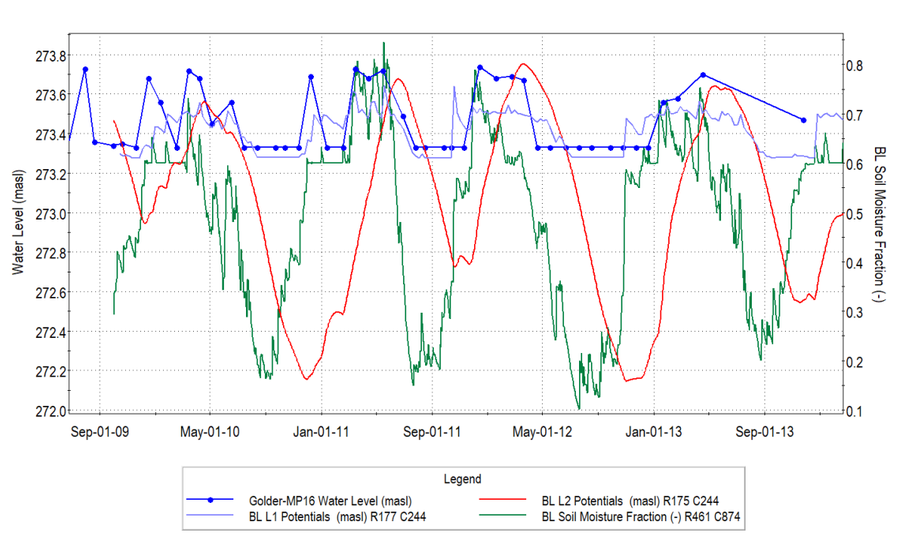
	reduce the flow to the valley and the spring flows. A water balance assessment of this wetland may also be required to determine potential impacts.	Given the large size and unique valley geometry of this wetland a single water budget was not compiled, however detailed maps showing changes in groundwater levels, streamflow and groundwater discharge were included. We had limited access to this extensive wetland complex. Monitoring of flow was conducted to determine, as best as possible, the natural function of this feature. We feel that the maps and hydrographs presented in Section 8.7.6 best illustrate the spatial distribution of changes in the system as a result of quarry expansion. We could prepare a water budget summary if necessary.
3.11	In some of the documentation, the wetland boundaries are not well delineated or described. Further, the boundaries and designation of the wetlands vary between reports and, occasionally, within the reports themselves. We request revised figures clearly showing wetland boundaries and monitoring points used to characterize the wetlands. The reports should be updated to reflect consistent designation of monitoring points so conclusions can be more easily reviewed.	Wetland Characterization Tables have been prepared to show wetland boundaries and designations, monitoring points, and other information in a format to ease review of the report. It should be noted that as part of the modelling effort, wetlands had to be approximated using grid cells and wetland boundaries in the model differ from the map extent. To not confuse our wetland mapping with the natural feature mapping, Earthfx used a different numbering scheme.
3.12	Potential impacts to the springs located at the east slope of the Medad valley and Niagara escarpment should be characterized and appropriately assessed to ensure the springs' flows are not impacted. Monitoring data for the flow of the springs should also be collected as part of characterizing these features.	The model extended well beyond the Medad Valley to the west and past the base of the Niagara Escarpment in all directions. All Escarpment tributaries were simulated and none were found to be measurable impacted. Our groundwater and streamflow change assessment points extended over 2 km from the site and into the Medad Valley. Several of the springs emanating from the face of the Medad valley were explicitly represented in the model.
3.13	The Adaptive Management Plan identifies Wetland 13034/13035 for mitigation; however, no information is provided with respect to a hydrogeological or surface water assessment of these features. Additional information related to the characterization of the wetland is required.	Wetlands 13034/13035 were grouped within our Wetland 17. A separate Wetland Characterization Table has been prepared, and Wetland 17 is discussed in detail below.
3.14	Alternative mitigation measures for the western expansion infiltration ponds is required in the event the water levels in the bedrock do not reach the anticipated final elevation levels. Additional information and monitoring is required to demonstrate	The existing western golf course ponds are more than 50 years old. These were constructed as golf course features, and not infiltration ponds. While they likely continue to support local groundwater water levels, they likely contain fine grained

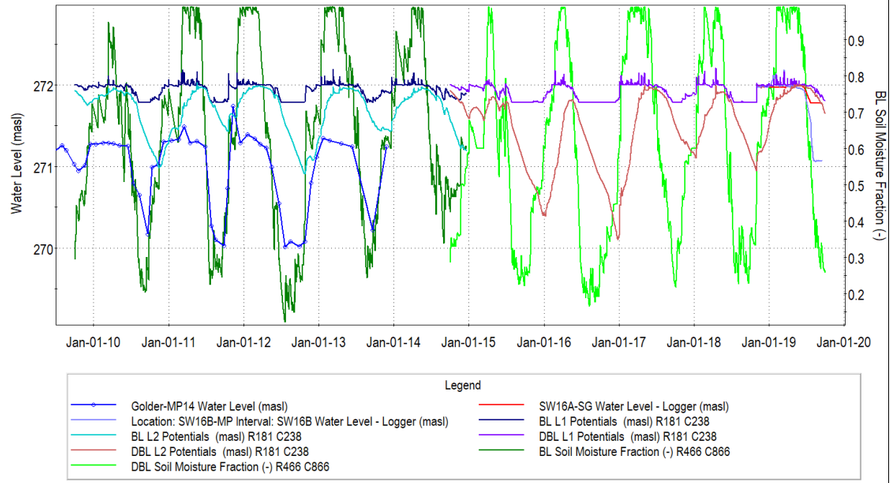
	that the proposed mitigation measures will work as intended.	sediments that limit leakage to the water table. The proposed infiltration ponds will be designed specifically to enhance and maintain leakage over the long term. The effectiveness of the infiltration system will be monitored and optimized over the active life of P3456. The groundwater levels in the vicinity will be monitored by five monitoring well locations. It is expected that the new infiltration system will be more effective than the golf course ponds.
3.15	Attached Table 1 identifies more technical details to be addressed.	

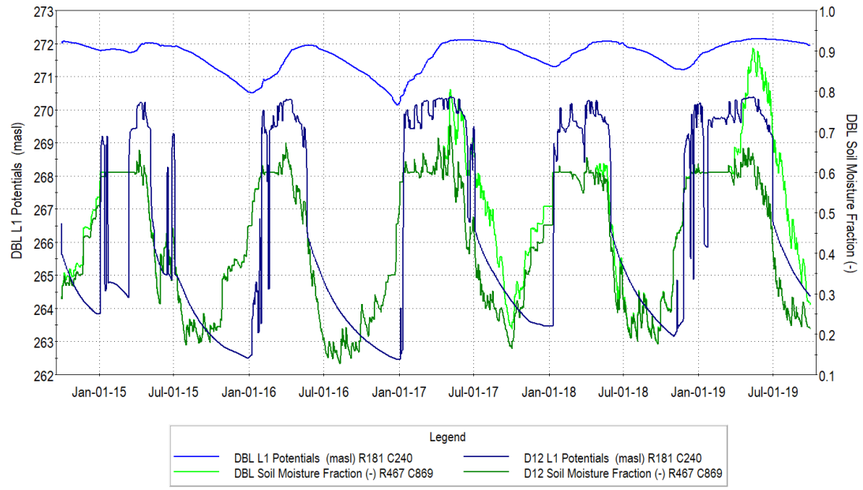
8 MNRF Comments Table 1 (Section 4)

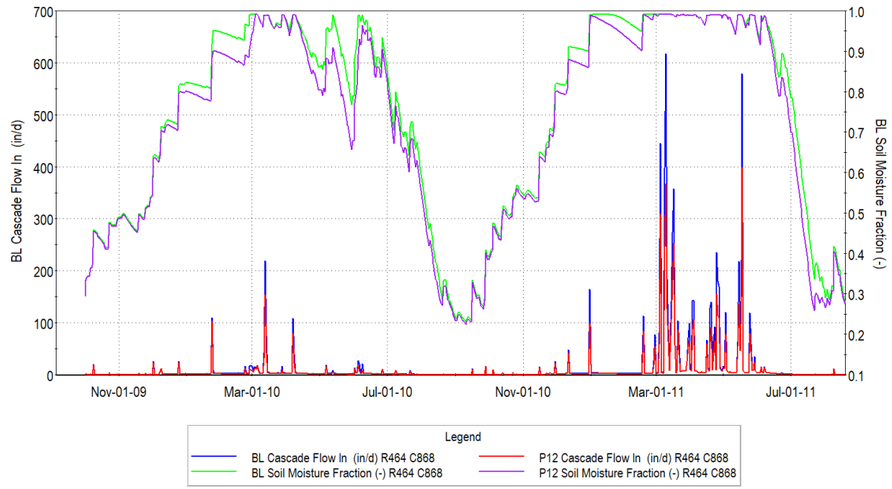
	MNRF Wetland No.	EarthFX Wetland ID No.	Tatham Wetland No.	Monitoring Points	Comments	Response
4.1	13037	20	13037	SW 16A-SG, Golder MP16, SW16B	1. Table 7.2 of hydrogeological report shows that MNRF wetlands numbered 13036, 13037, 13038, 13039 are grouped together under Earthfx number 20. Please show clear boundaries of the wetlands 13036, 13037, 13038, 13039 and how they were grouped together. If all the wetlands are grouped under wetland 1337, please show clear boundaries of wetland 13037. 2. Please show location of SW 16A-SG and MP16 within the wetland. 3. Please provide subsurface logs and completion details for the SW16B and Golder MP16. 4. Please provide information on subsurface conditions recorded in the field and field hydraulic conductivity estimates of the overburden below the wetland. 5. Please show comparison of water levels recorded by SW16-A-SG, Golder MP16 and SW16B.	1. Map showing requested the polygons and monitoring locations are shown in Figure 70. A Wetland Characterization table is also being provided under separate cover. 2. The locations of SW 16A-SG and MP16 are shown in Figure 70, above. Monitor construction details and logs are summarized in Section 2. 3. The borehole logs for 62 minipiezometer and soil core logs (including the requested log) are provided in Section 2. SW16A-SG is a staff gauge and does not have subsurface information, but MP-14 is very close by and is included. 4. Field hydraulic conductivity testing is described in detail in Golder, 2007, 2010, and discussed in detail in Section 2. 5. The requested hydrographs are shown in Figure 46. Horizontal reference lines illustrate DEM elevation in the vicinity of the monitors. Note the wide range in DEM elevation between monitors in this wetland.  Figure 46: Earthfx Wetland 20 Monitoring Data

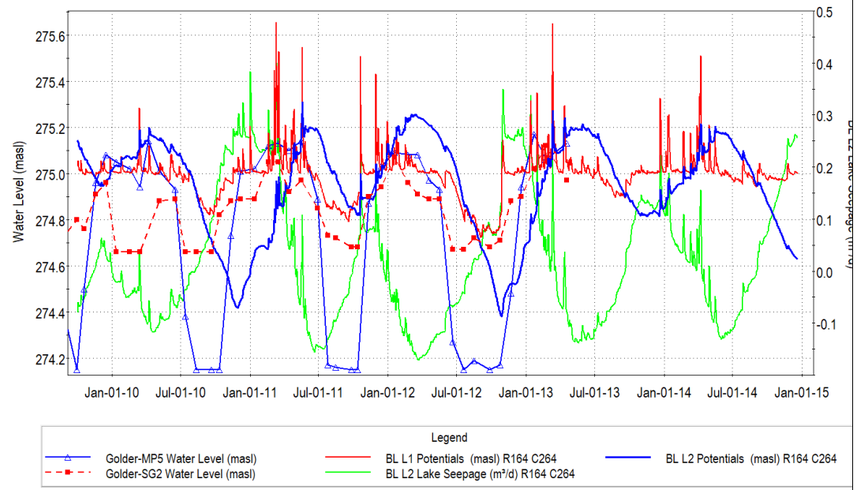
					6. Please provide information on groundwater- surface water interaction	6. An overview of GW/SW interactions is presented in Earthfx (2020) Section 8.5.3. When evaluating GW/SW interactions it is important to note that the wetland complex has considerable topographic variation (approximately 2 m, from 271.7 masl to 273.8 masl as shown in Figure 71). The south-western core of EFX Wetland 20 has a ground elevation of approximately 271.7 masl. Additional survey control points (Figure 70, Figure 71) were collected to delineate the local terrain elevation, but the sloping wetland has a complex and shallow bathymetry with limited local ponding. **Overview:** The water budget for Wetland 20 is shown in Earthfx (2020) Figure 7.28. Groundwater inflows as a percentage of total inflows is 1.76%, while outflows as a percentage of total is 12.84%. This indicates that the wetland is predominately runoff dominated and is not supported by significant groundwater inflows. The groundwater monitoring data, presented below, support this statement. A detailed discussion of surface water and groundwater interaction processes is included in Section 6. **Runoff Catchment Area:** The Wetland 20 DEM catchment area is shown in Figure 72. The figure shows that the northwestern catchment divide is located approximately coincident with the edge of the P12 excavation, so the excavation will not affect the subcatchment area and runoff processes. This is further illustrated in the GSFLOW overland flow cascade network as shown in Figure 72 **Groundwater interactions:** Water levels in groundwater monitor nearby OW03-16C and OW03-32B are shown in Figure 47. The hydrograph shows that the water table, as measured in the shallow bedrock well OW03-16C, is below ground surface and minipiezometer elevation. MP14 water levels are also below ground surface. The water budget comparison, shown in Earthfx (2020) Table 8.5, indicates groundwater inflow into the wetland accounts for just 1.76% of total inflows. This estimate is consistent with measured water levels relative to ground surface. Additional discussion of groundwater and minipiezometer levels is presented below.  Figure 47: Shallow groundwater monitor data in the vicinity of Wetland 20

					7. Observed and simulated water levels for MP16 shown in Figure 19.44 do not show a good calibration and there is an offset in maximum levels of approximately 3 months. Please provide comment on whether this offset in hydroperiod allows for using this model for predictive simulations to evaluate the wetland hydroperiod 8. Please provide predictive calculations of water level elevations in the wetland and model layers 1 and 2 and compare them with the baseline and recorded conditions.	7. The issue of hydrograph response *offset* is raised multiple times in this comment table, so a detailed discussion and overall reply is presented in Discussion Section 3. The discussion concludes that Layer 2 heads in the *deeper*, low permeability, unweathered Halton Till are expected to be somewhat lagged relative to the *shallow* minipiezometer measurements. The numerous hydrographs presented in Section 3 (from multiple wetlands) show that the model simulation of soil moisture (a good better measure of the shallow hydrologic conditions), correlate very closely with the observed minipiezometer data and do not exhibit an offset or lag in response. This correlation demonstrates that the model is capable of replicating shallow wetland conditions and providing useful insight into the water budget and hydroperiod. The specific hydrograph for MP16, located at the top of the wetland, is shown in Figure 48. The soil moisture response is shown in green, and correlates closely with the field measurements at MP16, and does not have an offset in response. MP16 is located at the high edge of a cluster of MODFLOW lake cells. The simulated water level in the MODFLOW lake (which is at a slightly lower elevation) is shown as a lighter blue line and correlates closely, with no temporal offset, with MP16 patterns. In summary, the shallow system, as represented by the MODFLOW Lake and soil moisture response, correlate closely with the MP16 response.  Figure 48: Hydrograph for MP16 near the upper portion of Wetland 20 8. The groundwater levels, minipiezometer and staff gauge readings for Wetland 20 are presented in Figure 46 through Figure 49. Figure 49, below, presents a long-term hydrograph of observed and simulated water levels at SW16A and MP14, located near the outfall of Wetland 20. (Figure 48, above, compares the water level elevations in Layer 1 and 2 to the field measurements at MP16 and represents conditions near the

					9. Please comment on potential impacts based on the predicted water levels.	top of Wetland 20.) Figure 49 compares the water levels at Staff Gauge SW16A-SG to the simulated water levels in the Layer 1 Modflow Lake. While the monitoring period is shorter, the model simulations match closely. Simulated water levels in Layer 2 broadly match SW16B-MP, but are a little high relative to MP14, indicating the model might be slightly overestimating the groundwater inputs. The simulated soil moisture correlates closely (with no offset or lag) to the minipiezometer MP14 response. The water levels in the deeper Layer 2 Halton till exhibit a lag, as noted, in response.  Figure 49: Hydrograph of observed and simulated water levels at SW16A In summary, the model soil moisture and water level response is representing this complex sloping wetland with a good degree of accuracy. Given that this wetland receives little groundwater inflow, the soil moisture patterns, which represent infiltration, runoff and interflow inputs, provide an excellent estimate of the water budget. 9. The groundwater levels beneath the wetland will decline with the development of P12. The water budget comparison shown in Earthfx (2020) Table 8.5, notes that the groundwater inflow into the wetland will drop from 1.76% of total inflows to 0% of total inflows. Hydrographs showing the effects of development on soil moisture and pond leakage are included in Section 6. The effect development on water levels and soil moisture is illustrated in Figure 50. During P12 extraction the water levels under the wetland will drop, but the soil moisture conditions will only change during the wetter years. During drought years (2015 and 2016), the wetland soil moisture values are nearly identical.

					10. The MNRF Grindstone Creek Headwaters PSW Evaluation notes that the larger wetland of the 13037 is seepage-fed and contains a seep that can be seen discharging to the surface. Please provide comments on potential impacts to the seeps contributing to the wetland 13037	 Figure 50: Change in water levels and soil moisture near MP14 under baseline and development conditions 10. The source of the seep is likely runoff and interflow moving through the soil zone and shallow weathered overburden. The DEM (Figure 71) and overland flow cascade network (Figure 72) show that seepage may enter from the north, east and south. It is expected that there will be no decline in runoff entering from the north. The overall effect can be evaluated by comparing the water budget figures in Figure 7.28 and Figure 8.35 in Earthfx (2020). The temporal effect on seepage can be illustrated by comparing the simulated runoff and soil moisture at the northern edge of the Wetland 20 (13037) under baseline and P12 conditions (Figure 51). The hydrograph shows conditions at a point immediately north of the Wetland 20 label on Figure 72, and represents a large area of catchment inflow from the north. The hydrograph illustrates that interflow and runoff *peaks* will be reduced (cascade flow in), but soil moisture conditions will be only slightly reduced (due to natural storage and buffering in the soil zone). The soil moisture levels will be reduced, but runoff and interflow events remain large enough to continue to intermittently saturate the soil. In summary, the overall hydroperiod and seepage patterns will remain similar.

						 Figure 51: Comparison of runoff and soil moisture fraction under baseline and P12 conditions at the northern boundary of Wetland 20.
4.2	13033	17	13027	SW11, SW11-B, Golder MP5, Golder MP6, Golder SG-1, Golder SG-2, Golder SG-3	1. Please use clear and consistent reference to this wetland and instrumentation in all reports submitted. Tatham refers to this wetland as No. 13027 however EarthFX does not discuss this wetland, however I maybe referring to the wetland as 13033. From the Figure 6.21 of the EarthFx report It can be seen that there are three small wetlands in this area. Please provide information whether these wetlands were grouped together. 2. Please provide clear boundary of the wetland showing location of the monitoring points. 3. Please provide logs describing subsurface conditions for this wetland. 4. Please provide information on subsurface conditions recorded in the field and field hydraulic conductivity estimates of the overburden below the wetland. 5. Please provide comparison and discussions of groundwater - surface water relationship, clearly identifying periods when wetland recharges groundwater and when groundwater recharges wetland. MP5 and SG2 water levels are compared in Figure 19.43 of the report however no discussions are provided with regards to the groundwater/surface water relationship using the rest of monitoring points.	1. A map showing the wetland polygons and MNRF Wetland numbers is shown in Figure 73. Earthfx Wetland 17 covers portions of Wetland 13027, 13048, 13049, and 13033. 2. The MNRF and Earthfx wetland boundaries are shown in Figure 73. 3. The minipiezometer logs for this wetland are discussed in Section 2. The logs indicate that the overburden geologic materials under the wetland are predominantly “clayey silt”. 4. Field hydraulic conductivity testing is described in detail in Golder (2010), and discussed in detail in Section 2. 5. An extensive program of groundwater monitor, minipiezometer, and staff gauge installation, followed by pumping tests, was undertaken in this wetland (see Section 2) (Golder, 2006, 2010). The primary purpose was to investigate if there was an interconnection between the wetland and the shallow bedrock aquifer. The Golder conclusions of the field investigations were: *“As shown on Figure 10, water level hydrographs of the piezometers showed no discernable response to PW-1 pumping. Hydrographs of piezometers located within the wetland area (e.g. MP-1 through MP-5) maintained a*

					6. Comparison of observed and calculated water levels for MP5 and SG2 presented in Figure 19.43 show that the water level in fact do not match very well and cannot be used for predictive simulations. Groundwater levels calculated show offset of maximums and minimums by approximately 2-3 months which could be important factor in evaluating groundwater/surface water interaction in predictive simulations. Surface water levels match better than the groundwater levels however there is elevation difference up to 20-30 cm which could be significant for species that maybe relying on availability of the surface water.	*consistent elevation throughout the aquifer testing period."* *"… The staff gauge hydrographs generally maintain a consistent water level elevation throughout the aquifer testing period. Subtle fluctuations ranging from I to 2 cm are apparent, however, reflecting daily fluctuations. The staff gauge hydrographs, including SG-4 and SG-5 that were located on the neighbouring property, show no response to PW-I pumping." (Golder, 2006, page 9)* In summary, the field investigations concluded that there was no *measurable* SW/GW interconnection in this wetland. A detailed discussion of surface water and groundwater interaction processes is included in Section 6. The model can provide insight into the GW/SW interaction by graphing the water flux passing down through the wetland into the weathered till at a cell corresponding to SG2. Figure 52 shows that the pond generally looses water to the underlying till but does, during portions of the year, gain very small amounts of water in the central portion of the wetland.  Figure 52: Water levels and vertical flux from the SG2 pond into the till 6. A detailed discussion of the hydrograph offset issue is presented in Section 3. The discussion concludes that Layer 2 heads in the *deeper*, low permeability, unweathered Halton Till are expected to be lagged relative to the *shallow* minipiezometer measurements. The hydrographs presented in Section 3 show that the model simulation of soil moisture correlates very closely with the observed minipiezometer data (without lag). This is also the case at MP5 (Figure 53, below), MP6 (**Error! Reference source not found.**), MP7 (Figure 13), MP8 (Figure 14) and MP9 (Figure 11). This demonstrates that the model is capable of replicating shallow wetland conditions and providing useful insight into the water budget and hydroperiod.

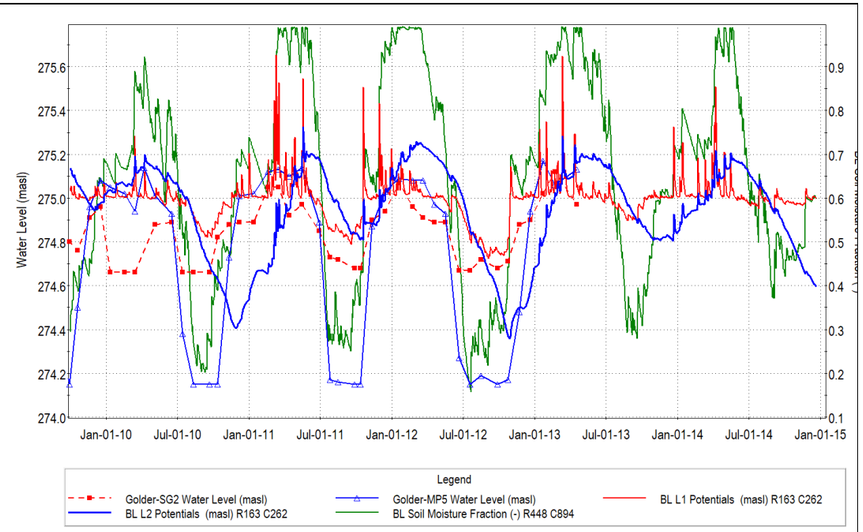


Figure 53: Water levels and soil moisture at MP5 and SG2

As you note, surface water levels match better. The absolute value of the predicted surface water levels depends on accurate wetland bathymetry, which is difficult to measure. Soil moisture content is less dependent on precise bathymetry, and the numerous graphs noted above shows that the model is simulating shallow processes well.

7. Please provide predictive calculations of water level elevations in the wetland and model layers 1 and 2 and compare them with the baseline and recorded conditions.

7. The water levels in Layer 1 (the SG2 pond), minipiezometer MP5, and simulated results in layer 1 and 2 are shown in Figure 53 (along with the soil moisture content). The simulated soil moisture correlates closely with the longer-term measurements at MP5, however the Layer 2 water levels are lagged discussed above and in Section 3.

8. Please comment on potential impacts based on the predicted water levels.

8. The water levels will decline in the wetland during the development of P12 (Figure 54). Spring water levels are generally unaffected, as are drought period water levels, but late summer and fall levels are approximately 10 cm lower. Hydrographs showing the effects of development on soil moisture and pond leakage are included in Section 6.

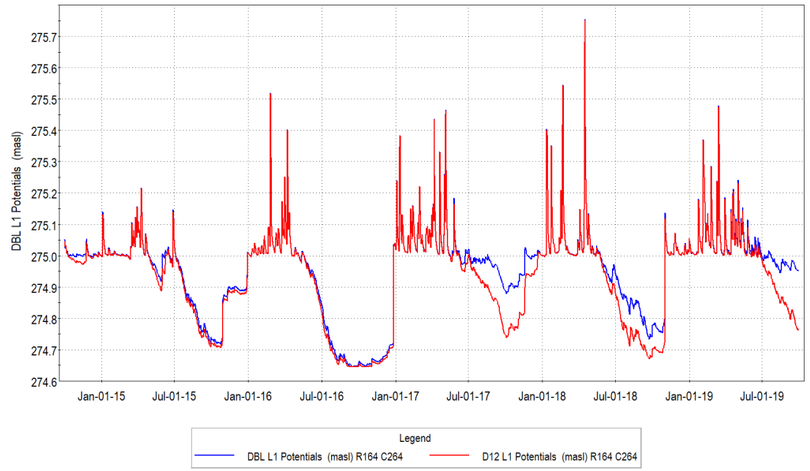


Figure 54: Comparison of simulated pond water levels during baseline and P12 development, including a drought period.

The effect of development on shallow water levels and soil moisture is illustrated in Figure 55. During P12 extraction the water levels under the wetland will drop (dark blue), but the soil moisture conditions will only change noticeably during the wetter years (compare light green baseline to dark green P12 conditions). During drought years (2015 and 2016), the wetland soil moisture values are nearly identical.

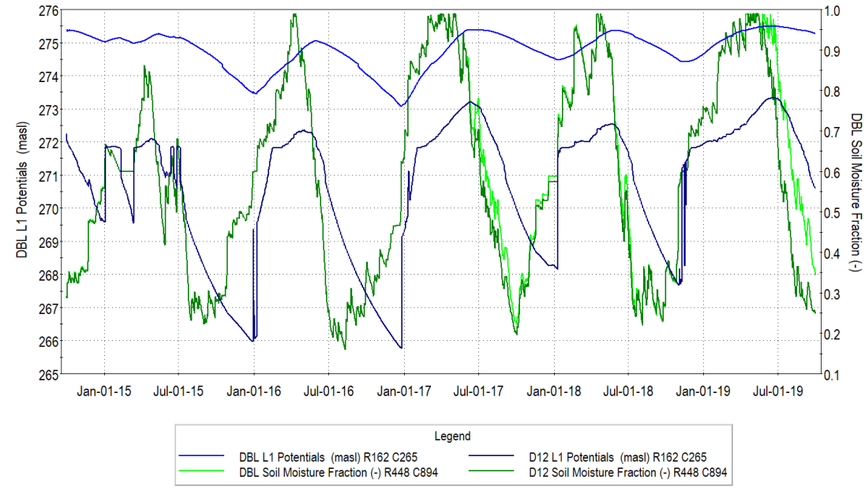


Figure 55: Water levels and soil moisture in Wetland 17 under long term conditions, including 2015 and 2016 drought periods

					9. Please evaluate how species relying on the water in this wetland and woodlands maybe impacted as a result of the development.	9. Please consult the companion Wetland Characterization tables for the integrated impact assessment
4.3	13022	16	13022	SW12, SW12BMP, Golder MP29, Golder MP11	1. Please provide clear and consistent boundary of this wetland throughout the reports and figures. In hydrological report (Figure SW2), the wetland identified as 13022 has very different boundaries than in the hydrogeological report (Figure 7.22). In fact several wetlands would be within the limits of 13022 wetland, namely wetlands No. 13019, 13021, 13017, 13018, 13030 and maybe other if the two above mentioned maps are compared. 2. There is no wetland characterization was found for the wetlands No. 13019, 13021, 13017, 13018, 13030 in either reports. Please characterize those wetlands and evaluate potential impacts. 3. Please provide subsurface information associated with this wetland (or group of wetlands) including providing monitoring well logs, field determined hydraulic conductivity of the underlying material. 4. Please comment on surface / groundwater interaction based on the results from the field program. 5. From the Figures 19.38 and 19.39 of hydrogeological report it can be seen that the calculated and measures water levels at MP11 and MP29 do not match very well and cannot be used for the purpose of predictive simulations because of the offset by approximately 3 months in timing when the maximum water level occur. This can be very significant for the species that rely on the presence of water in the wetland.	1. See attached map: Figure 74 2. New water budgets have been prepared for these wetlands. See Section 5 for a presentation of the water budgets and a comparison of Baseline and P12 water budget conditions (Table 14). 3. Please refer extended Wetland Characterization discussion in Section 2. 4. The numerical model water budget indicated GW/SW interaction for Wetland 16 is very limited. Table 14 notes that the groundwater inflow into the wetland will drop from 0.34% of total inflows to 0% of total inflows. 5. A detailed discussion of the hydrograph offset is presented in Section 3. The discussion concludes that Layer 2 heads in the *deeper*, low permeability, unweathered Halton Till are expected to be lagged relative to the *shallow* minipiezometer measurements. The hydrographs presented in Section 3 show that the model simulation of soil moisture correlates very closely with the observed minipiezometer data (without lag). This is also the case at MP11 and MP29, as shown in Figure 56 and Figure 57, below. This demonstrates that the model is capable of replicating shallow wetland conditions and providing useful insight into the water budget and hydroperiod.

6. Please show how the model was calibrated to surface water recorded at staff gauge SW12 or other staff gauge installed in this wetland.

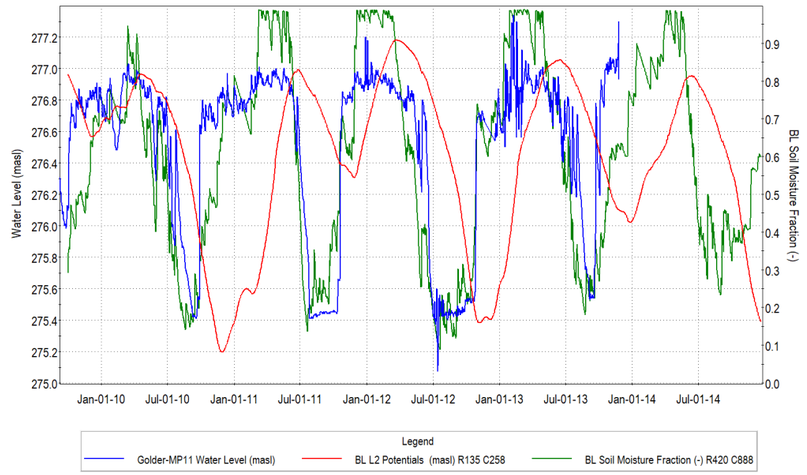


Figure 56: Continuous water levels and soil moisture at MP11

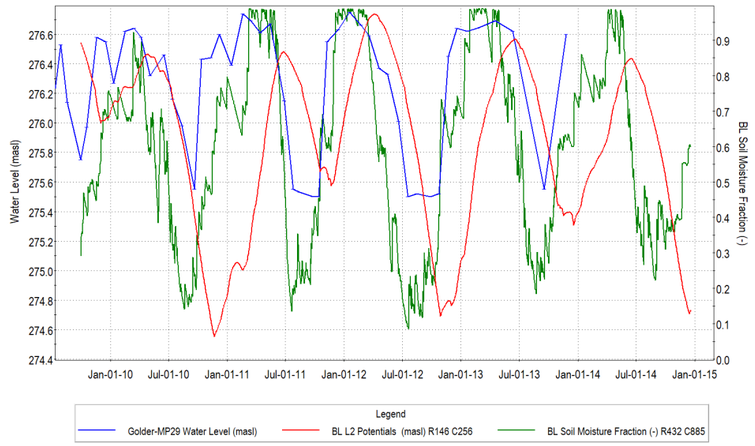
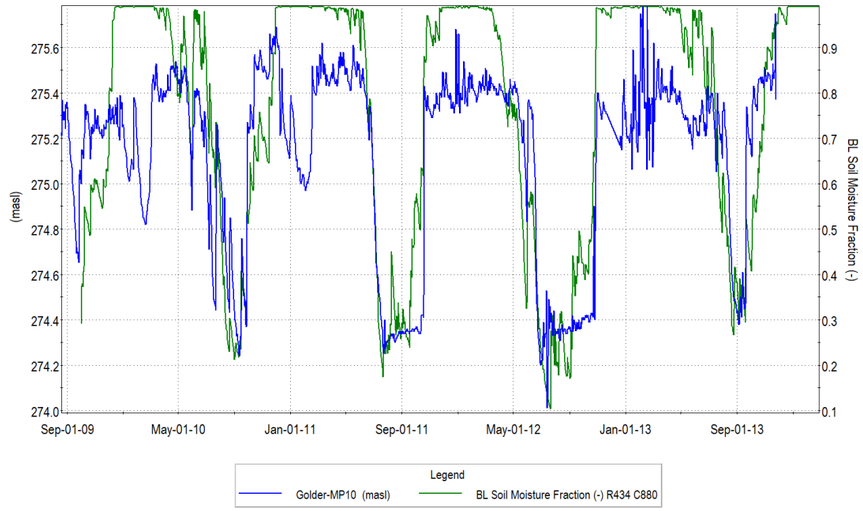
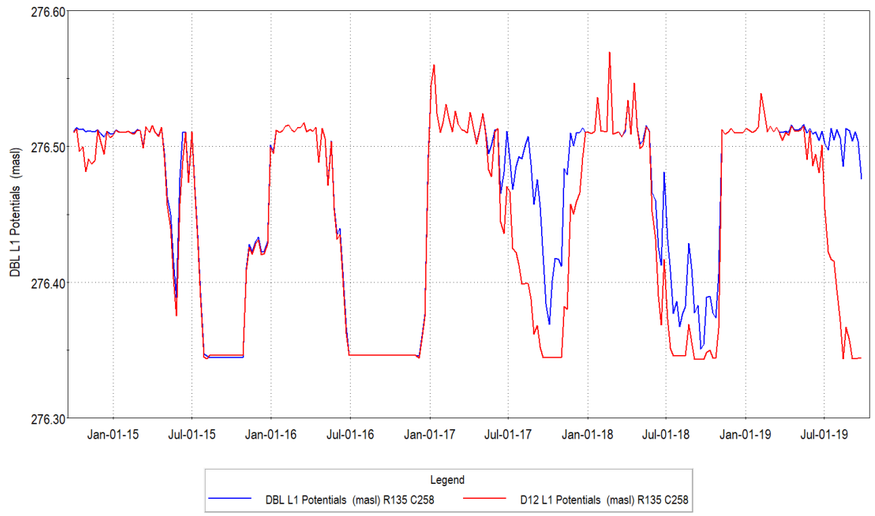
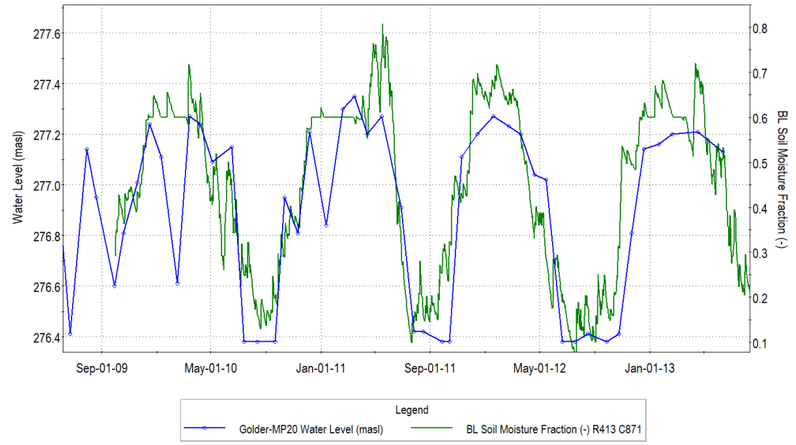
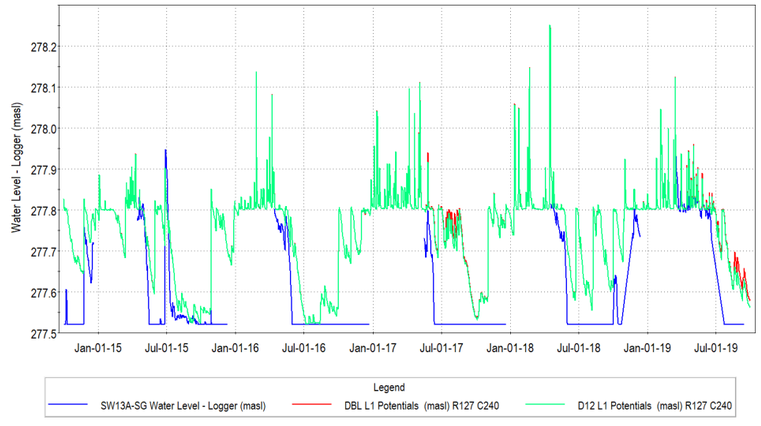


Figure 57: Water levels and soil moisture at MP29

6. The period of record at SW12 is short, so a better calibration comparison is between water levels and soil moisture at nearby MP10, as shown in Figure 58. MP10 has a long-term monitoring record using a continuous data logger, which can be compared closely to the daily soil moisture output from the model. The timing of the soil moisture response when compared to MP10 water levels is extremely close.

					7. Please consider completion of additional monitoring wells to characterize subsurface conditions and obtain water level information in this wetland (or wetlands) 8. Please comment on potential impacts based on the predicted water levels.	 Figure 58: Continuous water levels and soil moisture at MP10 (near SW12) 7. An extensive network of monitoring wells is already installed in this location, and these have been monitored for a number of years, as illustrated in Figure 58. For more details about the wetland characterization, please refer to Section 2 8. Water level and impact at MP11 is shown in Figure 59. The simulations indicate that the water levels under P12 conditions will continue to be very similar to baseline, even within a drought period such as 2016. Other years show a decline in water levels of approximately 10 cm in the late summer and fall.

					9. Please evaluate how species relying on the water in this wetland and woodlands maybe impacted as a result of the development.	 Figure 59: Comparison of baseline and P12 water levels at MP11 9. Please consult the companion Wetland Characterization tables for the integrated impact assessment
4.4	13016	11	13016	SW13A, SW13B	1.Please provide clear and consistent mapping of the wetland throughout the reports and use consistent designation for monitoring points. Please clearly show location of monitoring points. 2. Please provide subsurface information associated with this wetland including providing monitoring well logs, field determined hydraulic conductivity of the underlying material. 3. Please comment on surface / groundwater interaction based on the analysis of surface water level and groundwater level obtained as a result from the field program. 4. From the Figure 19.41 of hydrogeological report it can be seen that the calculated and measures water levels SW13A do not match very well and cannot be used for the purpose of predictive simulations because at some times the discrepancy in water levels is approximately 30 cm. This amount could be significant for species relying on the water in this wetland.	1. See attached map: Figure 75 2. Please see characterization discussion in Section 2. 3. Water budgets have been prepared for all wetlands. See Section 5 for a presentation of the water budgets and a comparison of Baseline and P12 water budget conditions. Under baseline conditions, the GW outflows account for 3.97% of total outflows, and GW outflows as a percent of total outflows is 0.0% (Table 14). 4. The staff gauge SW13a indicates the wetland is very intermittently saturated (Figure 19.41). The model generally follows this pattern. A better estimate of wetland conditions is shown in the comparison of MP20 and simulated soil moisture conditions. The timing and magnitude of the soil moisture matches the fluctuations in MP20 without lag, indicating that the model is matching the shallow wetland conditions.

					5. Please comment on potential impacts based on the predicted surface water and groundwater levels. 6. Please evaluate how species relying on the water in this wetland and woodlands maybe impacted as a result of the development.	 Figure 60: Water levels at MP20 compared to shallow soil moisture conditions. 5. A comparison of baseline and P12 water levels is shown in Figure 61. There are minor differences, as expected given that the wetland receives limited groundwater (Table 14).  Figure 61: Comparison of baseline and P12 water levels in Wetland 11 6. Please consult the companion Wetland Characterization tables for the integrated impact assessment
4.5	13032	19	13032	SW5a - also used as a	1. Please provide a map clearly showing boundary of the wetland. The map can show two wetlands 13032 and 13031.	1. See attached map: Figure 77

				monitoring point to monitor wetland 13031		
4.6	13025			MP33	1. Please provide a map showing clearly boundary of the wetland and location of the monitoring point. Please complete a monitoring well to understand degree of surface water- groundwater interaction for [potential impact evaluation and to confirm subsurface conditions. 2. Please clarify whether MP33 is a surface water monitoring point or groundwater. Please provide completion details of MP33	1. See attached map: Figure 77 2. MP33 is a minipiezometer – please refer to the borehole log discussion in Section 2.
4.7	13015	10		Golder MP17, Golder MP13	1.Please provide clear and consistent mapping of the wetland throughout the reports and use consistent designation for monitoring points. Please clearly show location of monitoring points. 2. This wetland was not characterized. Please provide information on the water level in this wetland, how it relates to groundwater level, groundwater-surface water interaction, subsurface conditions and evaluate potential impacts. 3. Shallow groundwater levels recorded in MP17 and calculated levels for the same location presented in Figure 19.36 of EarthFx report do not show acceptable calibration for the purpose of accessing potential impacts to the wetland. The calculated and observed water level do not match well and there could be up to 0.7 m difference between them when the water levels are high. During low water level periods, the difference between measured and calculated water levels could be up to 5 m.	1. See attached map: Figure 75 2. New water budgets figures have been prepared for Wetlands 10. See Section 5 for a presentation of the water budgets and a comparison of Baseline and P12 water budget conditions. Under baseline conditions, the GW outflows account for 3.16% of total outflows, and GW outflows as a percent of total outflows is 0.0% (Table 14). Please see characterization discussion in Section 2. Water levels are shown in Figure 62 and Figure 63 and discussed below. 3. A detailed discussion of the hydrograph offset is presented in Section 3. The discussion concludes that Layer 2 heads in the *deeper*, low permeability, unweathered Halton Till are expected to be lagged relative to the *shallow* minipiezometer measurements. The hydrographs presented in Section 3 show that the model simulation of soil moisture correlates very closely with the observed minipiezometer data (without lag). This is also the case at MP17 (Figure 62) which shows that model is closely matching the shallow soil moisture conditions at this location. The difference in water level between the shallow MP17 and the simulated water levels in the deeper till is expected, and does not indicate a calibration error. This figure demonstrates that the model is capable of replicating shallow wetland conditions and providing useful insight into the water budget and hydroperiod.

4. Shallow groundwater levels recorded in MP13 also do not show acceptable calibration when compared with calculated levels shown in Figure 19.37 of the hydrogeological report. The difference between calculated and measured water levels is approximately 1 m.

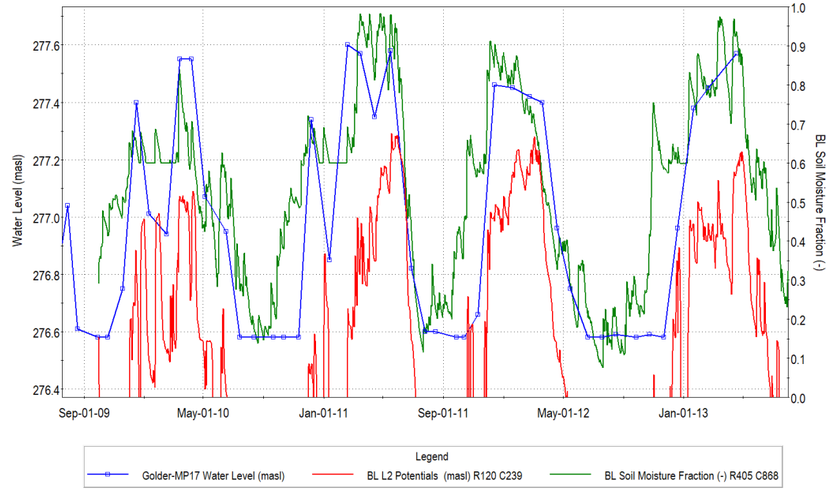


Figure 62: Water levels and soil moisture at MP17

4. Comparison of the water levels at MP13 (Figure 63) shows that model is closely matching the shallow soil moisture conditions at this location. The simulation of soil moisture follows the MP13 water level rise and fall very closely. While the Layer 2 water levels show a delayed response (as expected) the water levels do rise to the nearly the same elevation as shown in MP13, so the offset is not 1 m, as suggested.

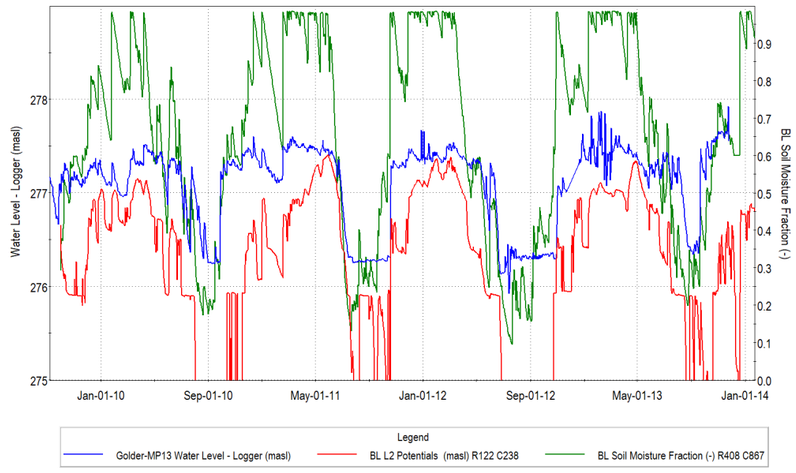
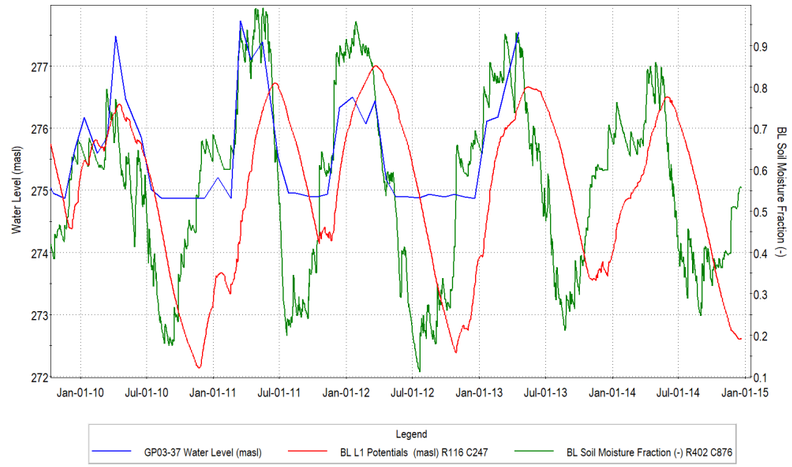


Figure 63: Water levels and soil moisture at MP13

4.8	13014	9		GP03-37	1.Please provide clear and consistent mapping of the wetland throughout the reports and use consistent designation for monitoring points. Please clearly show location of monitoring points. 2. This wetland was not characterized. Please provide information on the water level in this wetland, how it relates to groundwater level, groundwater-surface water interaction, subsurface conditions and evaluate potential impacts. 3. Please provide completion details for GP-03-37. Please comment on whether this monitoring location measure water level in the wetland or shallow groundwater. 4. Shallow water levels recorded in GP03-37 and calculated levels for the same location presented in Figure 19.35 of hydrogeological report do not show acceptable calibration for the purpose of accessing potential impacts to the wetland. Neither maximums nor elevations of the measured and calculated water levels show an acceptable match. The difference in water levels could be around 2 metres and the timing of occurrence of maximum water levels is offset by approximately 3 months.	1. See attached map: Figure 76 2. New water budgets figures have been prepared for Wetland 9. See Section 5 for a presentation of the water budgets and a comparison of Baseline and P12 water budget conditions. Under baseline conditions, the GW outflows account for 10.19% of total outflows, and GW outflows as a percent of total outflows is 0.0% (Table 14). Please see characterization discussion in Section 2. Water levels are shown in Figure 64. Please see the wetland characterization, borehole logs and hydraulic conductivity discussions in Section 2. 3. Please see borehole log characterization discussion in Section 2. GP03-37 is a minipiezometer. 4. Comparison of the water levels at GP03-37 (Figure 64) shows that model is closely matching the shallow soil moisture conditions at this location. The simulation of soil moisture follows the shallow water level rise and fall very closely. The difference in water level between the shallow GP03-37 and the simulated water levels in the deeper till is expected, and does not indicate a calibration error.  Figure 64: Water levels in GP03-37 compared to water levels and soil moisture
4.9		8			1. This wetland was included in Figure 7.22 of the hydrogeological report as significant wetland feature selected for budget analysis however no information about this wetland is contained in the report. Please characterize this wetland and provide evaluation of potential impacts as a result of the quarry development.	1. New water budgets figures have been prepared for Wetland 8. See Section 5 for a presentation of the water budgets and a comparison of Baseline and P12 water budget conditions. Under baseline conditions, the GW outflows account for 24.31% of total outflows, and GW outflows as a percent of total outflows is 1.25% (Table 14). Under P12 conditions, the GW outflows account for 26.2% of total outflows, and GW outflows

						as a percent of total outflows is 0.07%. Please see characterization discussion in Section 2. Wetland 8 is located some distance from the P12 development and is not instrumented. Wetland 9, a large wetland located between Wetland 8 and P12, is instrumented and provides insight into the effects of development.
4.10	13203	18	13203		1. Please show boundaries of this wetland, characterize the wetland and evaluate potential impacts.	1. See attached map: Figure 78 MNRF Wetland 13203 (Earthfx 18) is an elongated wetland that is the receiving feature for the existing South Quarry discharge. (See Earthfx, 2020, Section 19.4.2 for details about estimated discharge and the simulation of the South Quarry Discharge using a rule-based approach to account for gaps in the discharge monitoring record.) The subsurface conditions and water levels in the wetland are characterized by Monitors MW03-01 (Figure 79), MW03-02 (Figure 80), OW03-15 (Figure 81). The borehole log for MW03-02 (Figure 80) indicates that the overburden consists of 0.76m of weathered clayey silt till overlying 3.0 m of unweathered clayey silt till. A cross section under the wetland is shown in Earthfx (2020) Figure 19.18, and is included here as Figure 82. Continuous quarry discharge records were not available for the 2010-2014 time period and so a rules-based approach was used to simulate the discharge. This could result in some discrepancies between the observed and predicted water levels discussed below. A comparison of the observed and simulated water levels and soil moisture values at MW03-01, near the outlet of the wetland, is shown in Figure 65. Simulated groundwater levels respond more slowly than the observed levels and are likely influenced by the MODFLOW streamflow nearby. Soil moisture values correlate more closely with the shallow monitoring well.

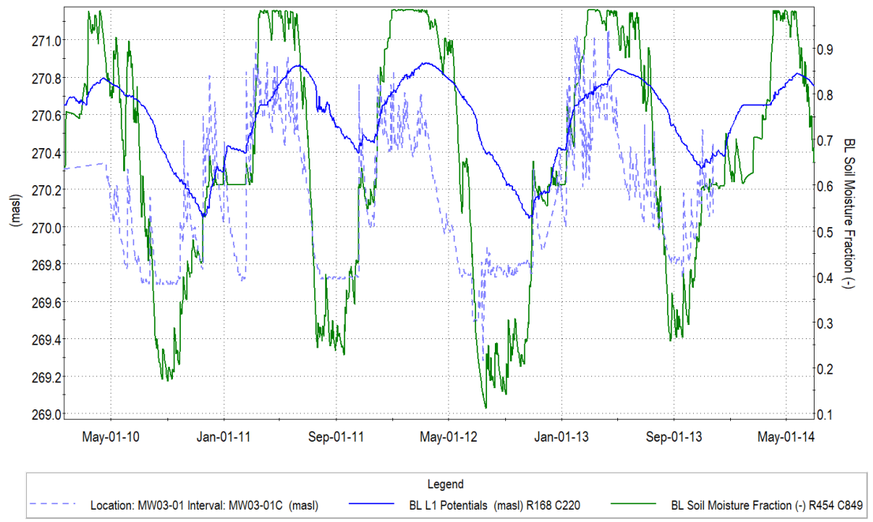


Figure 65: Observed and predicted water levels at MW03-01 (Wetland 18)

Water levels and soil moisture at MW03-02 exhibit similar patterns. Again, the influence of the quarry discharge is difficult to isolate. The simulated soil moisture correlates well with the shallow monitoring data.

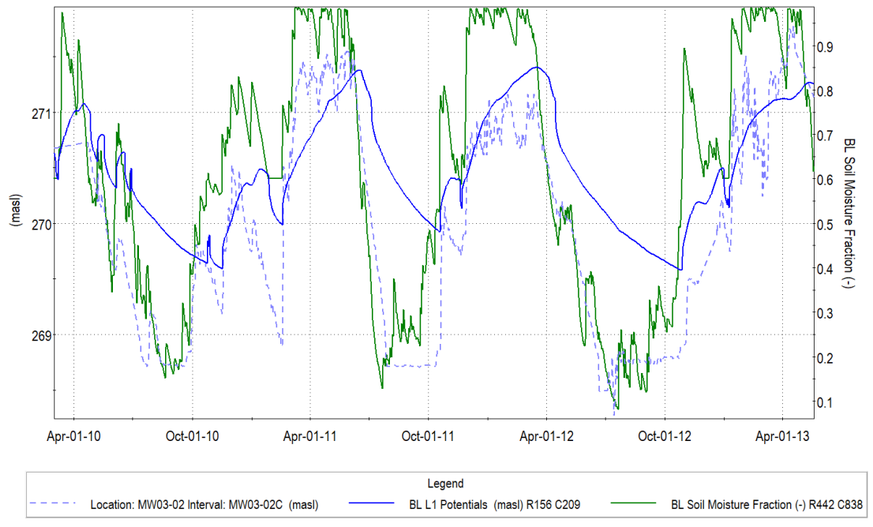
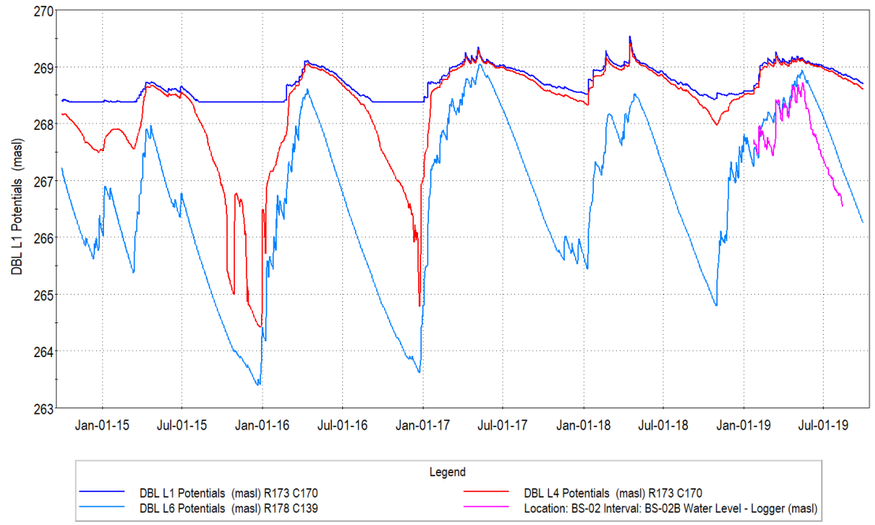
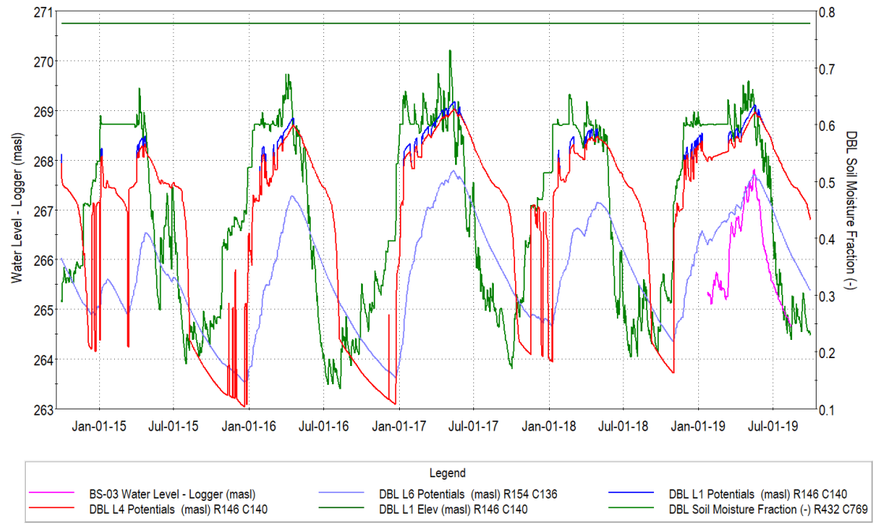


Figure 66: Observed and predicted water levels at MW03-02 (Wetland 18)

						Water budgets figures have been prepared for Wetland 18 - see Section 5 for a comparison of Baseline and P12 water budget conditions. Under baseline conditions, the GW outflows account for 5.98% of total outflows, and GW inflows as a percent of total inflows is 2.42% (Table 14). Under P12 conditions, GW outflows will grow to 9.95% of total outflows (increased leakage to the P12 excavation nearby), and GW inflows as a percent of total inflows will drop to 0.0% A detailed discussion of surface water and groundwater interaction processes for this wetland is included in Section 6. Hydrographs showing the effects of development on soil moisture and pond leakage are also included in Section 6.
4.11	13201	21	13201		1. This wetland was not fully characterized. Please provide information on the water level in this wetland, how it relates to groundwater level, groundwater-surface water interaction, subsurface conditions and evaluate potential impacts. Please provide details of mitigation measures during operations and post-operations.	Water budgets figures have been prepared for Wetland 21 - see Section 5 for a comparison of Baseline and P12 water budget conditions. Under baseline conditions, the GW outflows account for 29.78% of total outflows, and GW inflows as a percent of total outflows is 2.98% (Table 14). Under P12 conditions, the GW outflows will rise to 30.38% of total outflows, and GW inflows as a percent of total outflows will drop to 0.0% The geologic conditions at Wetland 21 are provided by monitors MP-34 (see Section 12.1) and BS04 (see Earthfx, 2020, Page 362). Both indicate the presence of Halton Till. There appears to be some error in the MP-34 historic data. The 2010-2014 water level recordings for MP-34 are all above 273 masl, while the recent drone survey shows the ground elevation as 268.57. It is impossible that the water levels are 5 m above ground surface and so that data has not been used. The monitoring period of record at nest BS-04 is short, so a longer-term record from BS02 is included on Figure 67, below, to show the seasonal rise and fall of the water levels in the Amabel (purple line). The model simulation of water levels in the Wetland 20 pond (Layer 1 potentials) and levels in the shallow bedrock under the wetland are also shown. The simulations indicate that the wetland will dry out during a 2015-2016 drought condition. A detailed discussion of surface water and groundwater interaction processes for this wetland is included in Section 6. Hydrographs showing the effects of development on soil moisture and pond leakage are also included in Section 6.

						 Figure 67: Water levels at Wetland 21 and BS02
4.12	13200	22	13200		1. This wetland was not fully characterized. Please provide information on the water level in this wetland, how it relates to groundwater level, groundwater-surface water interaction, subsurface conditions and evaluate potential impacts. the EarthFx report states that the wetland is "perched" however no support for this statement is provided. Please provide details of mitigation measures during operations and post-operations.	Water budgets figures have been prepared for Wetland 22 - see Section 5 for a comparison of Baseline and P12 water budget conditions. Under baseline conditions, the GW outflows account for 26.31% of total outflows, and GW inflows as a percent of total outflows is 0.0% (Table 14). Under P12 conditions, the GW outflows will drop to rise to 25.24% of total outflows, and GW inflows as a percent of total outflows will remain as 0.0%. Wetland 22 is already close to the edge of the existing quarry, and groundwater levels are already predicted to be below the wetland base. P3456 cannot change groundwater inpots. The geologic conditions at Wetland 22 are provided by nearby well BS03 (see Earthfx, 2020, Page 361). The log indicates a silty clay till at surface. The BS03 monitor is completed in the middle Amabel and simulations match the rise and peak in the observed data (Figure 68). BS03 is located near the golf course ponds and is likely influenced by leakage from the ponds. Simulated water levels at Wetland 22 are never less than 1.7m from ground surface in the wetland (L1 Elev shown in the figure). Simulated water levels in the lower overburden/ weathered bedrock suggest a decline between BS03 and the existing quarry, as expected. There is a high degree of seasonal variability in both the observed and predicted water levels, in a similar manner to other wells such as OW03-21 and OW03-14 which are also influenced by the nearby quarry.

						 Figure 68: Water levels at Wetland 22 and BS03
4.13	13202		13202		1. This wetland was not fully characterized. Please provide information on the water level in this wetland, how it relates to groundwater level, groundwater-surface water interaction, subsurface conditions and evaluate potential impacts. Please provide details of mitigation measures during operations and post-operations.	Wetland 13202 is particularly complex as it receives the North Quarry Discharge and is also used as a diversion to support golf course pond and irrigation systems. For this reason, the Wetland Characterization Table prepared for Wetland 13202 integrates and summarizes the effects analysis from the various reports for this complex wetland. See Earthfx, 2020, Section 19.4.1 for details about the simulation of the North Quarry Discharge

9 Figures

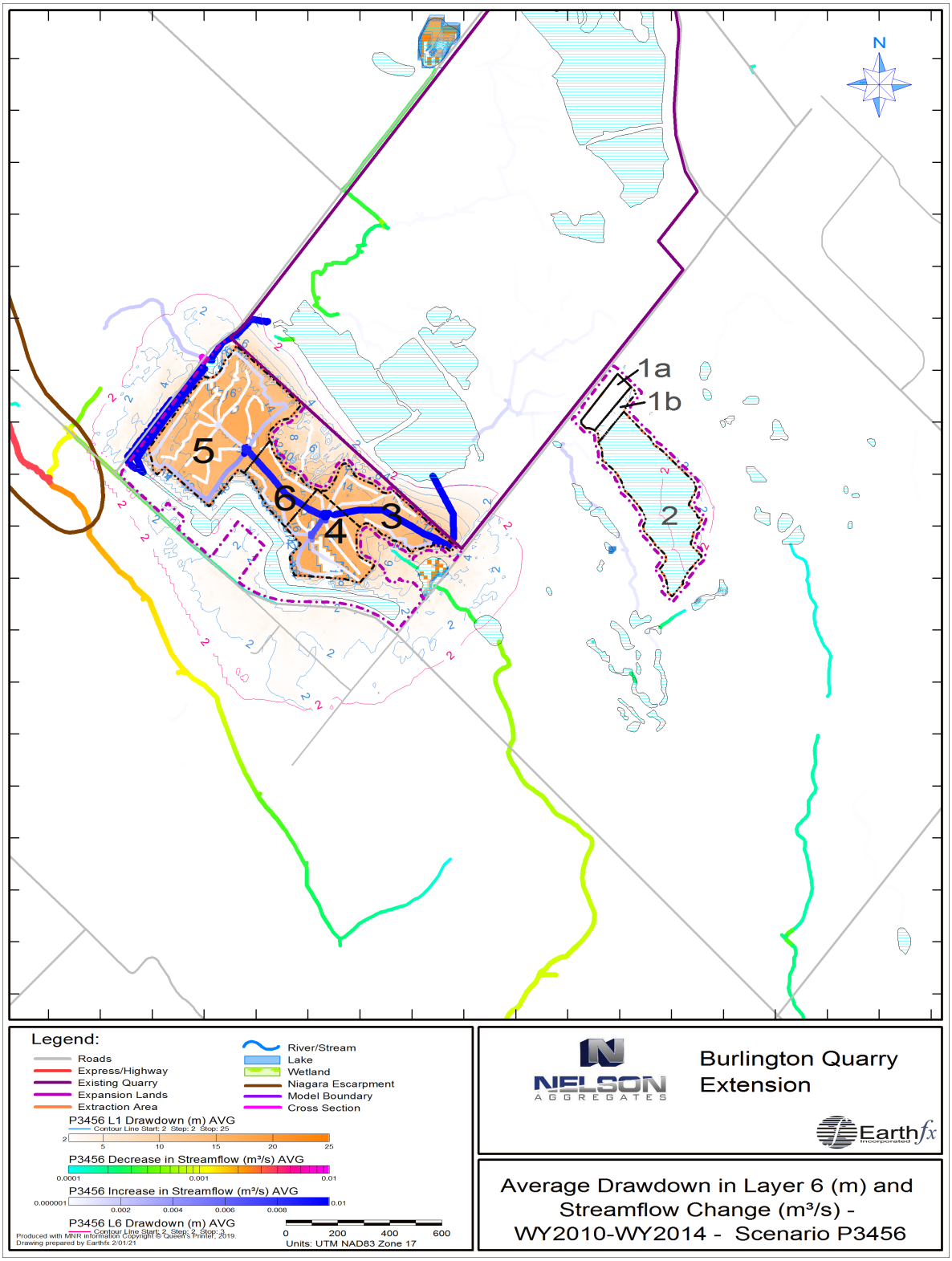


Figure 69: Drawdowns in Layer 1 (blue contours) and 6 (red contour)

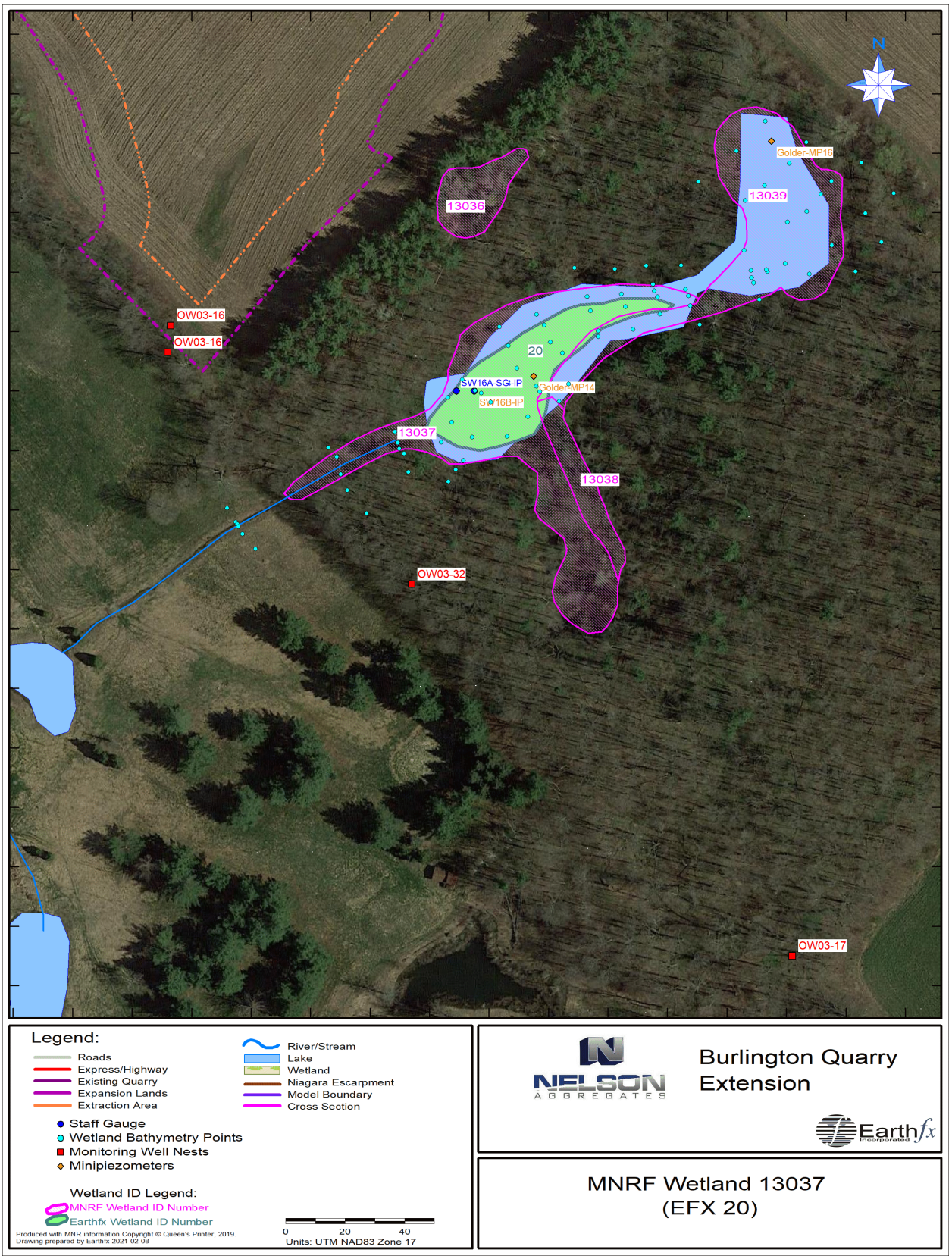


Figure 70: MNRF Wetland 13037 (Earthfx 20) Location Map

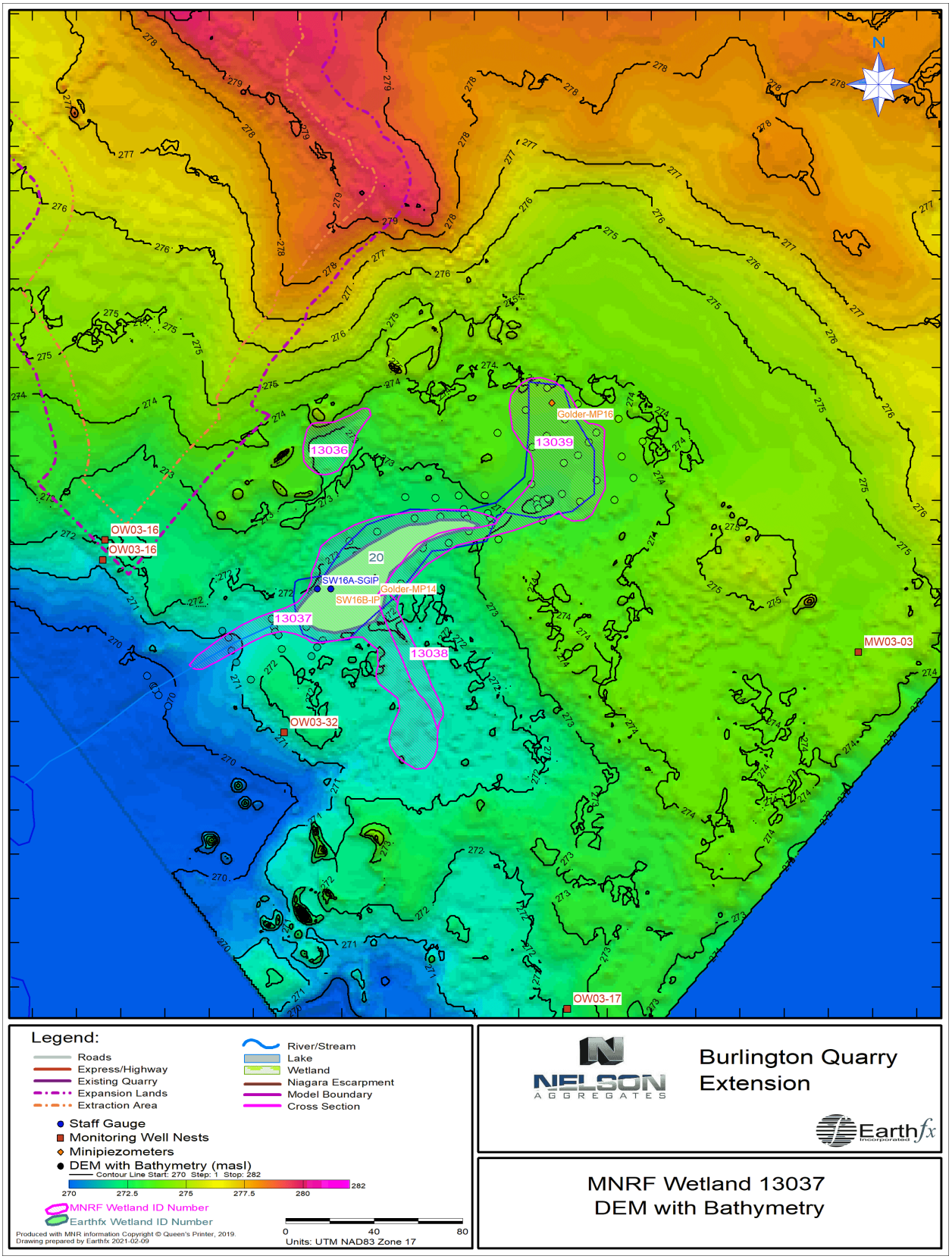


Figure 71: Wetland 20 topography with bathymetry

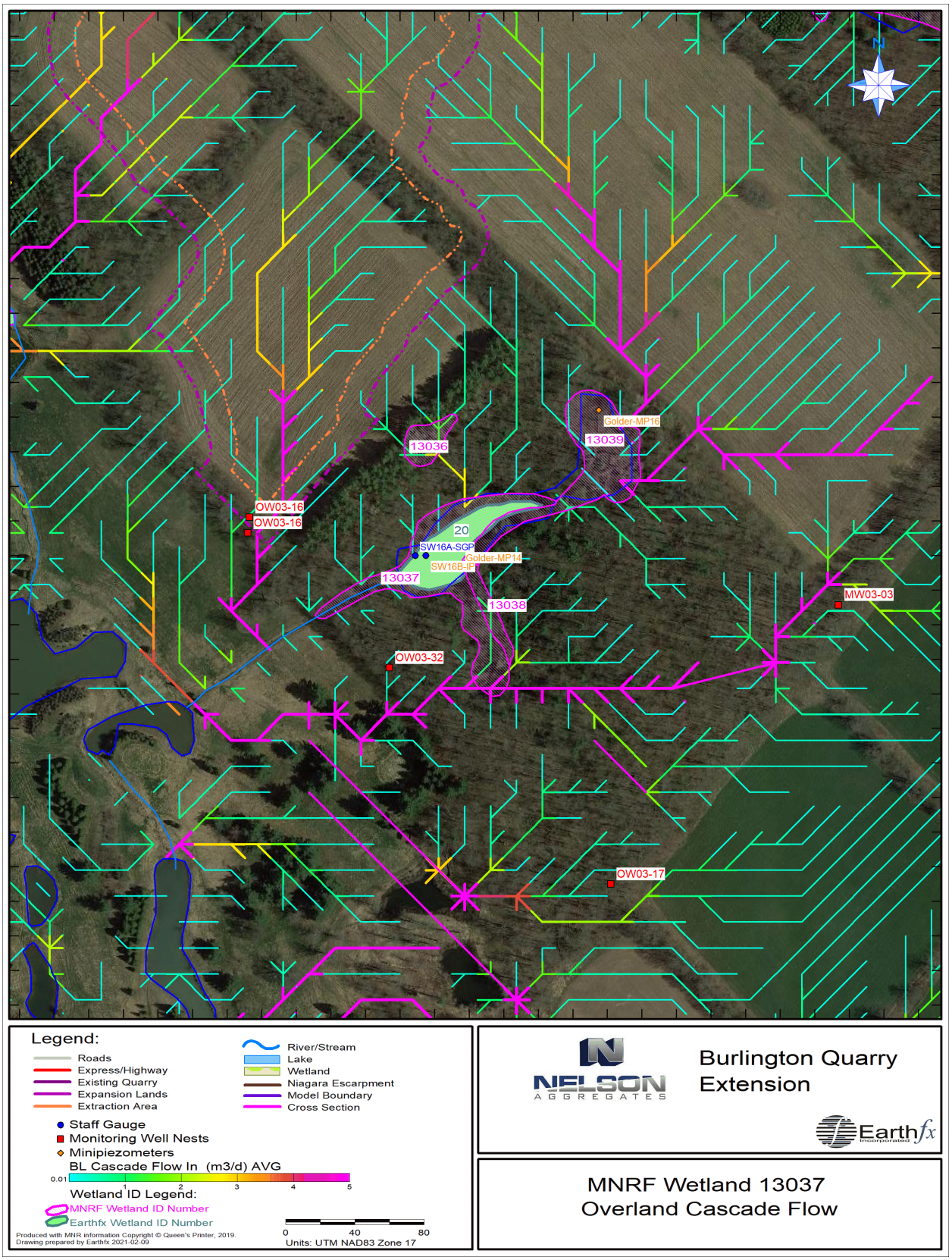


Figure 72: Wetland 20 overland flow cascade

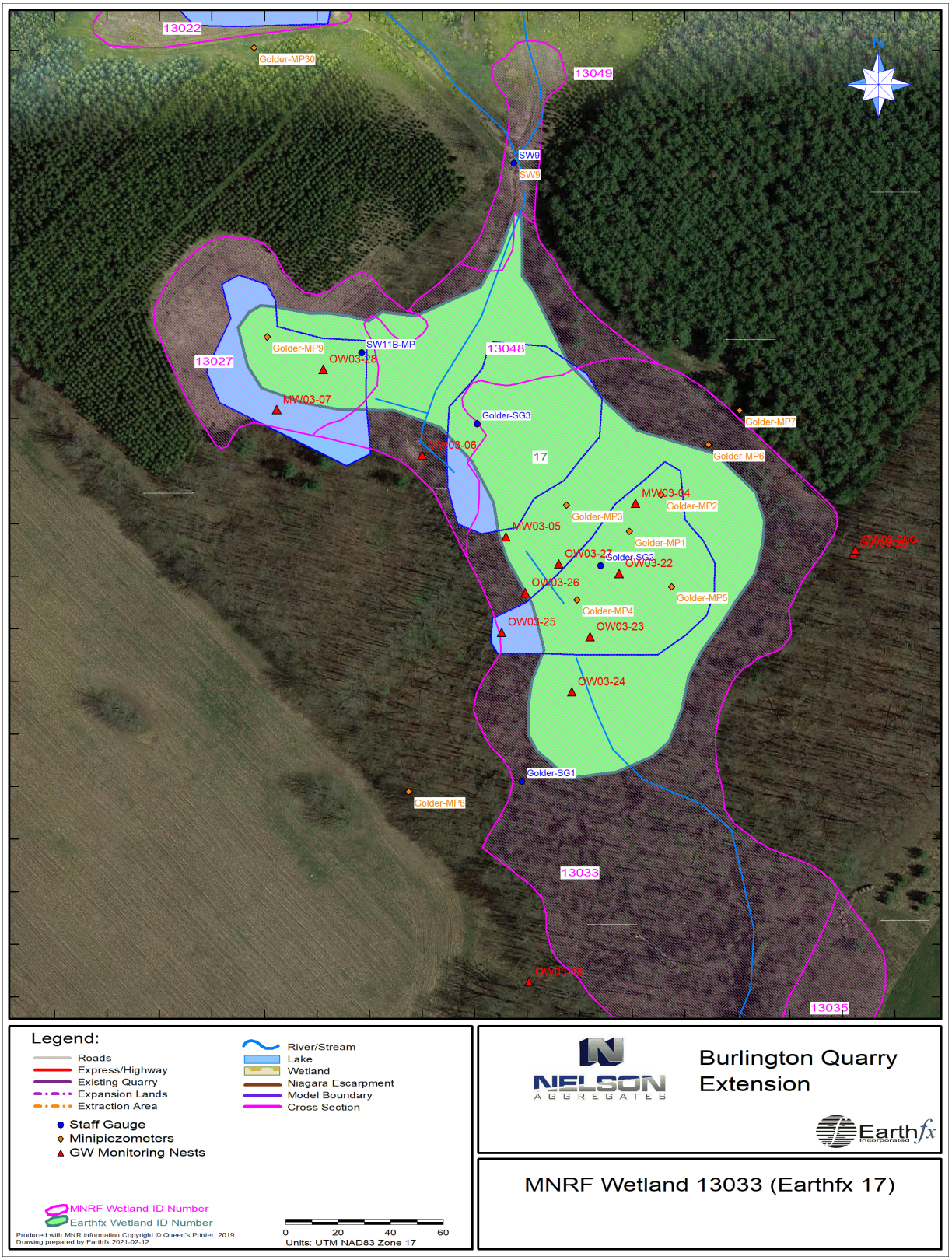


Figure 73: MNRF Wetland 13033 (Earthfx 17)

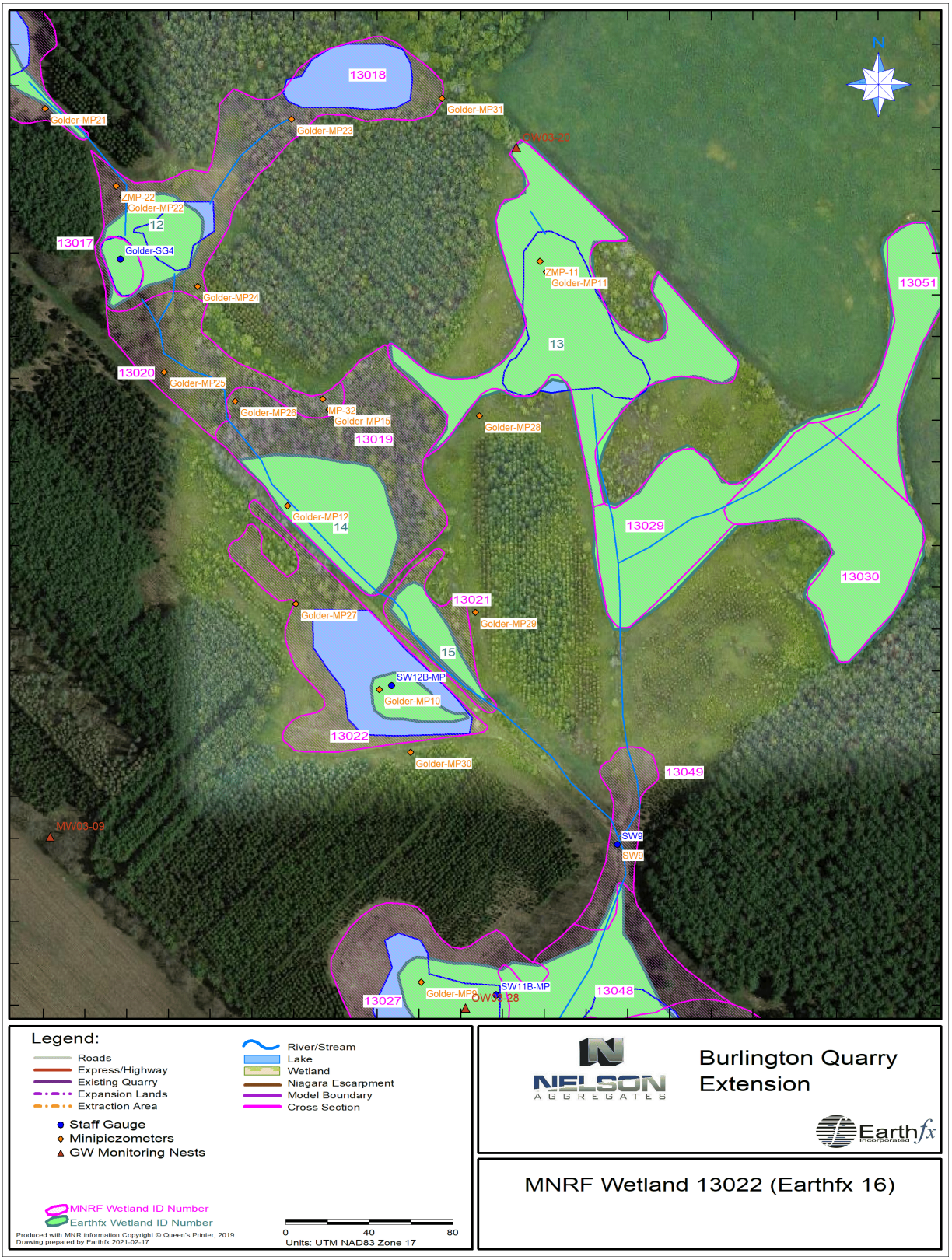


Figure 74: MNRF Wetland 13022 (Earthfx 16)

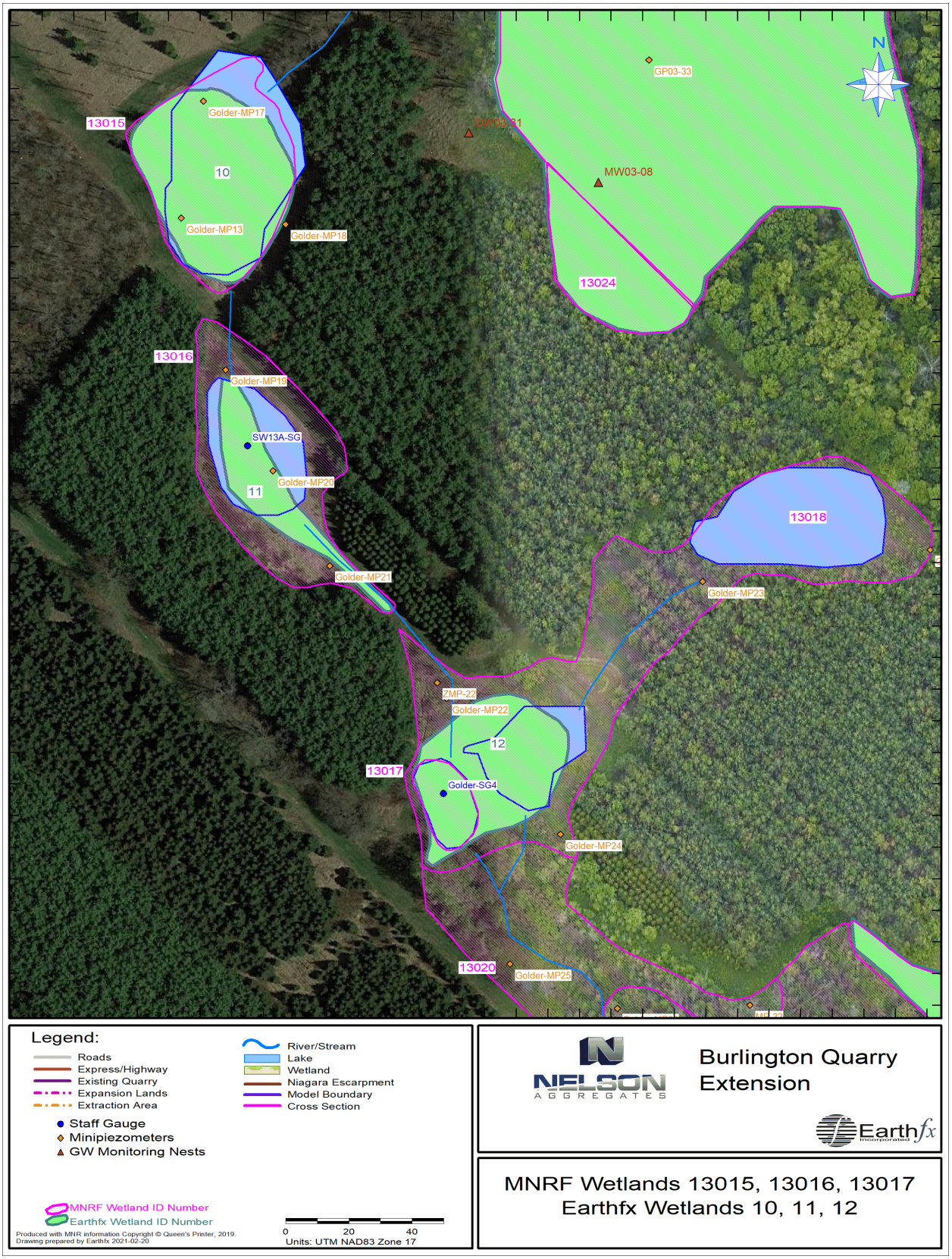


Figure 75: MNRF Wetlands 13015, 13016, 13017 (Earthfx 10, 11, 12)

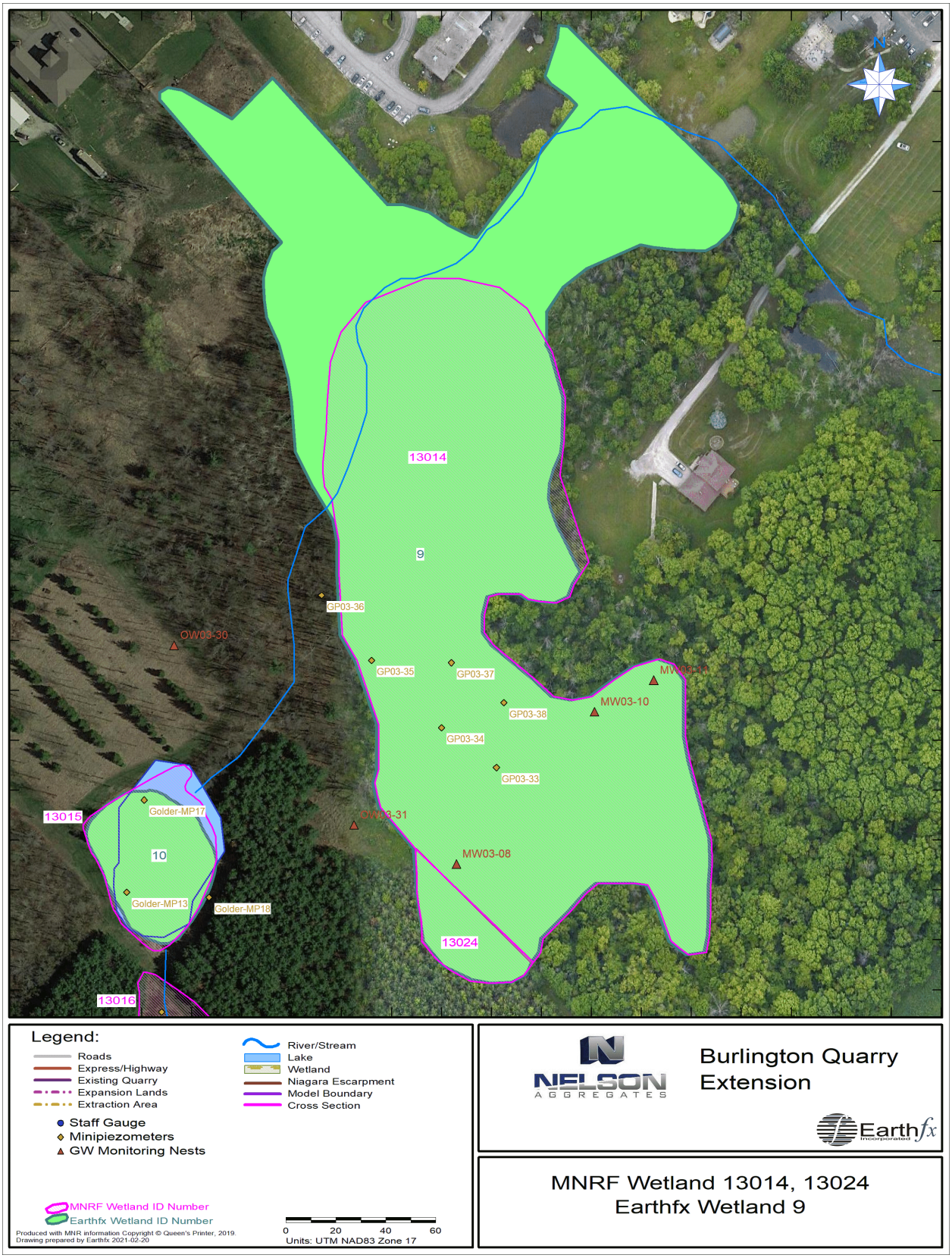


Figure 76: MNRF Wetland 13014 13024 (Earthfx Wetland 9)

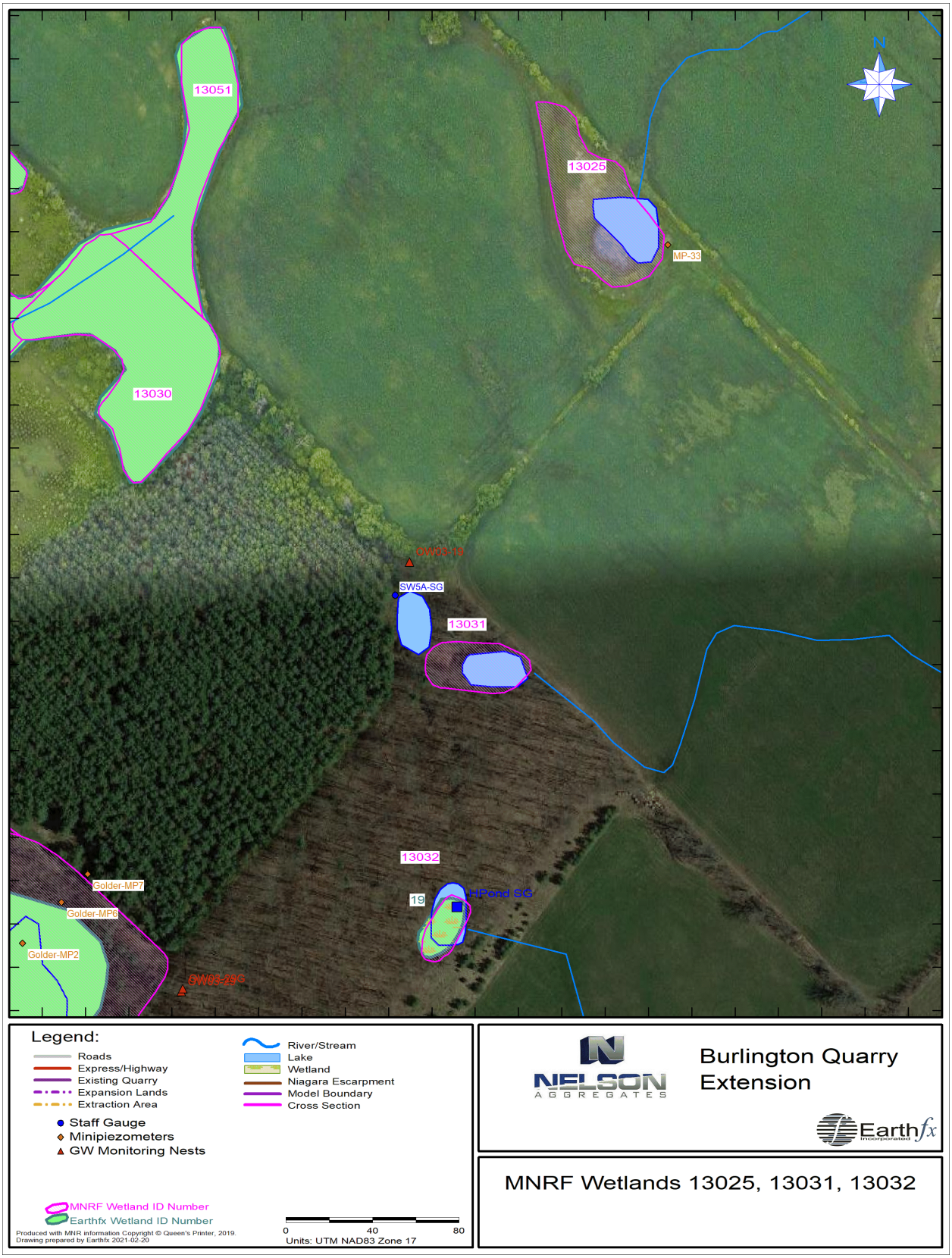


Figure 77: MNRF Wetlands 13025 13031 13032

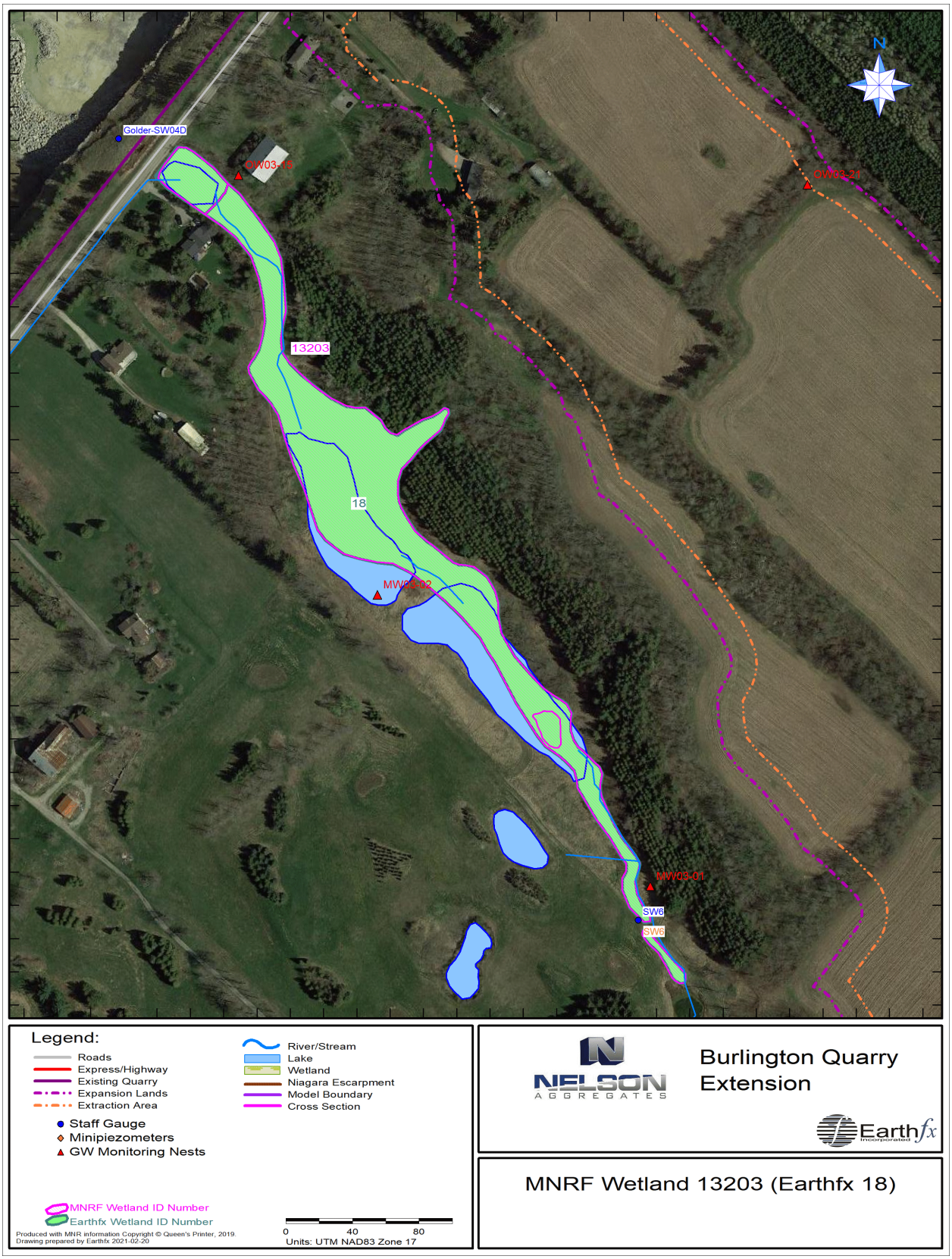


Figure 78:MNRF Wetland 13203 (Earthfx 18)

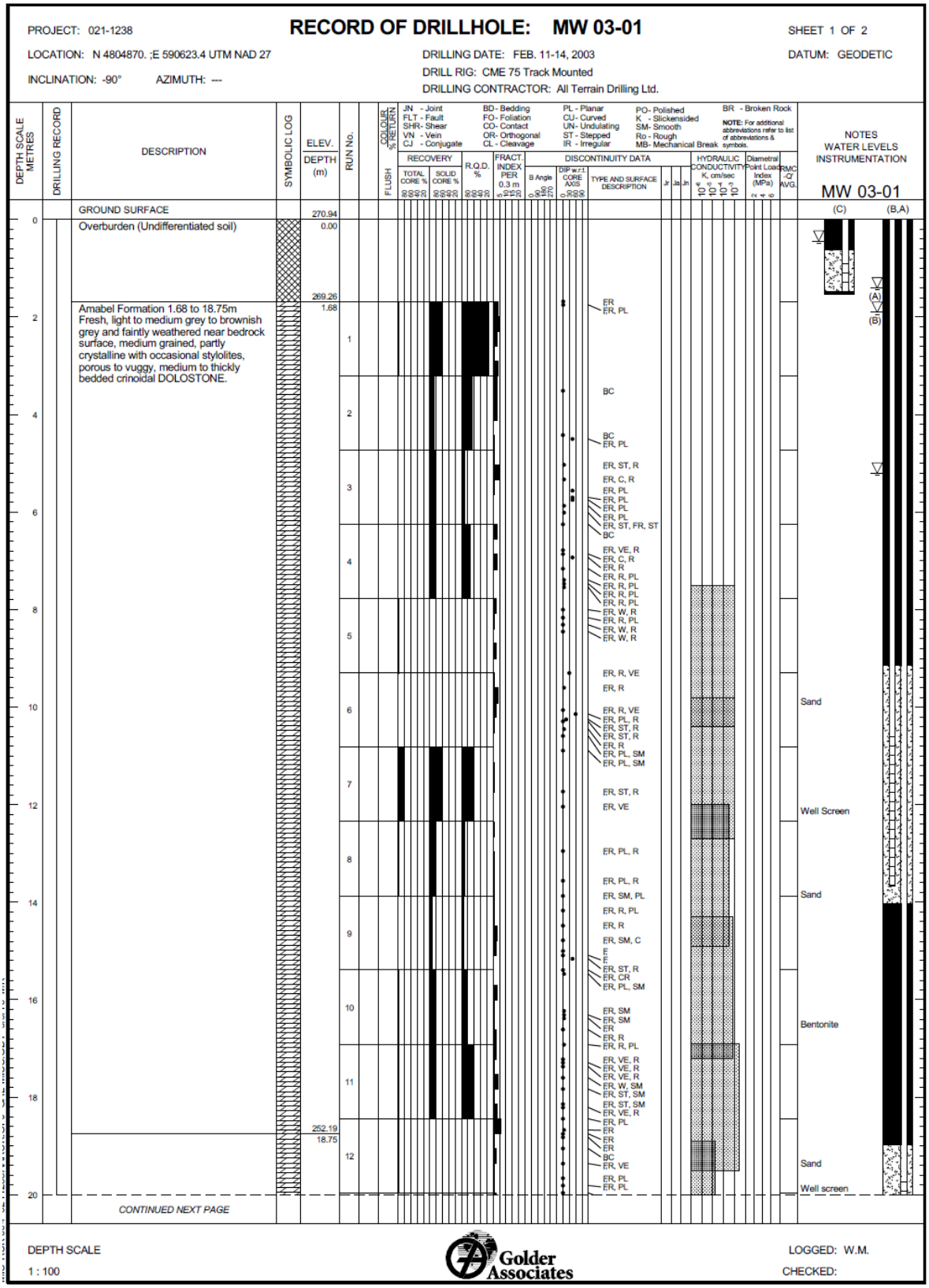


Figure 79: Borehole Log for MW03-01 (See Golder, 2010 for additional details)

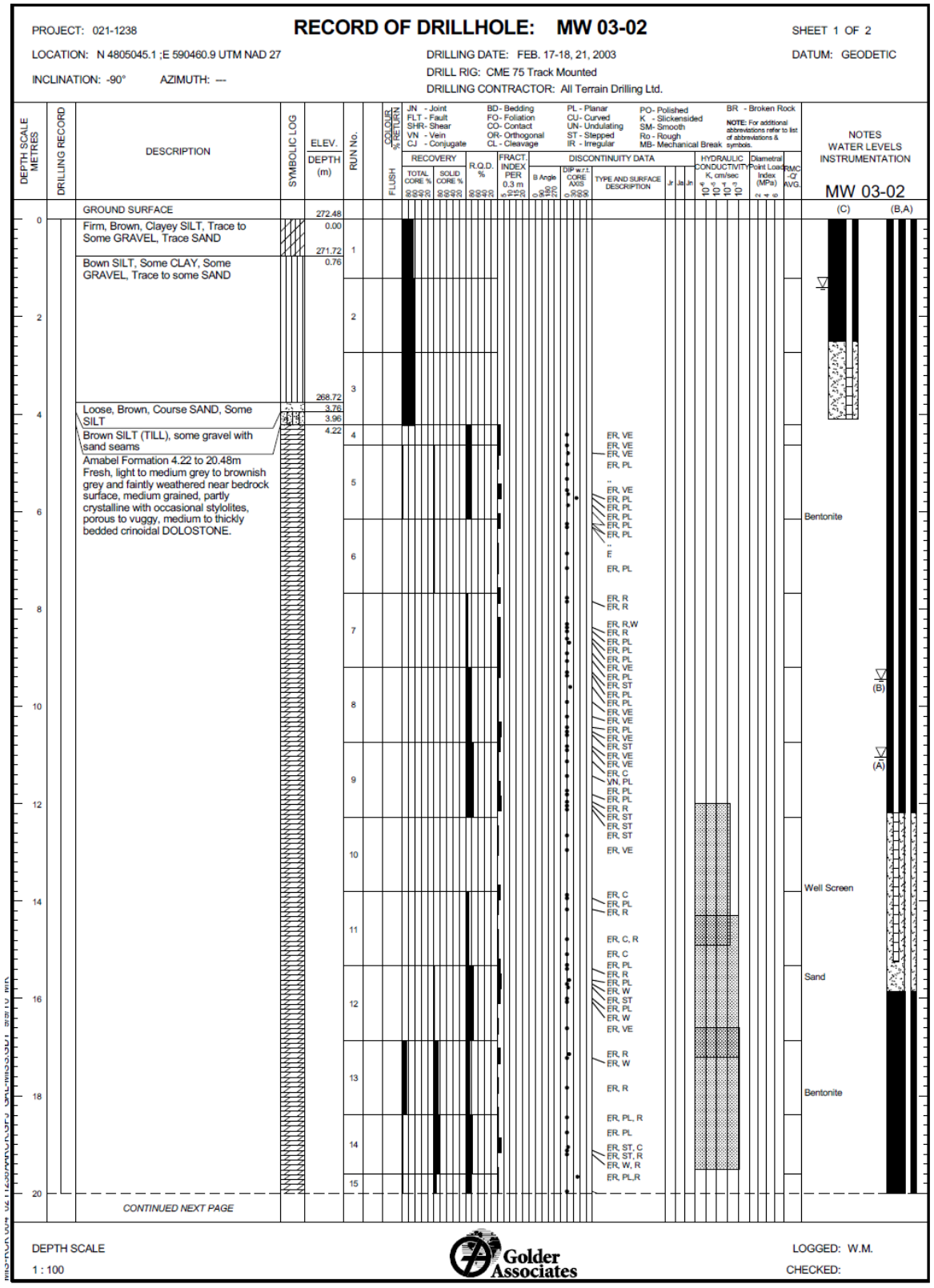


Figure 80: Borehole Log for MW03-02 (See Golder, 2010 for additional details)

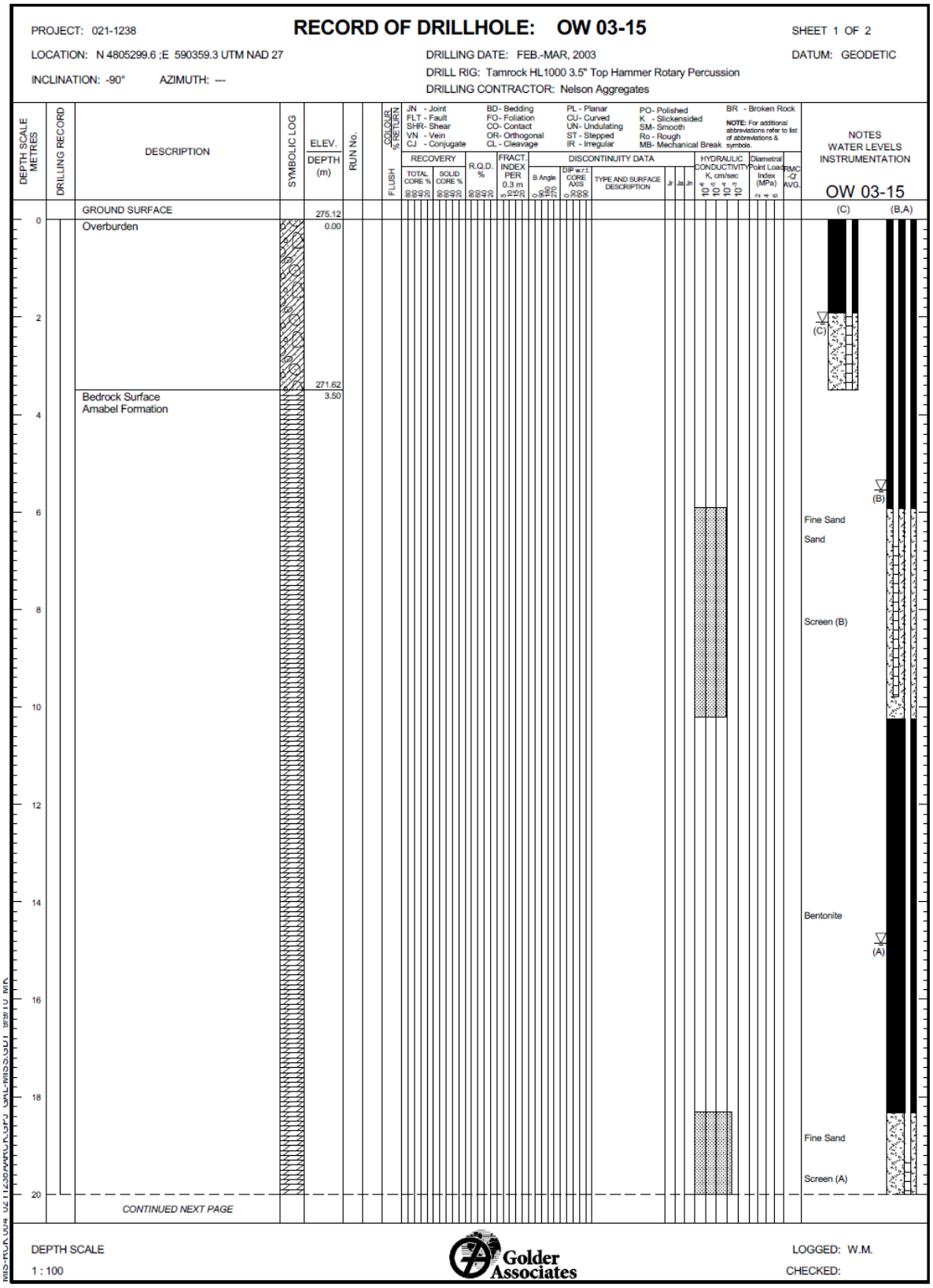


Figure 81: Borehole Log for OW03-15 (See Golder, 2010 for additional details)

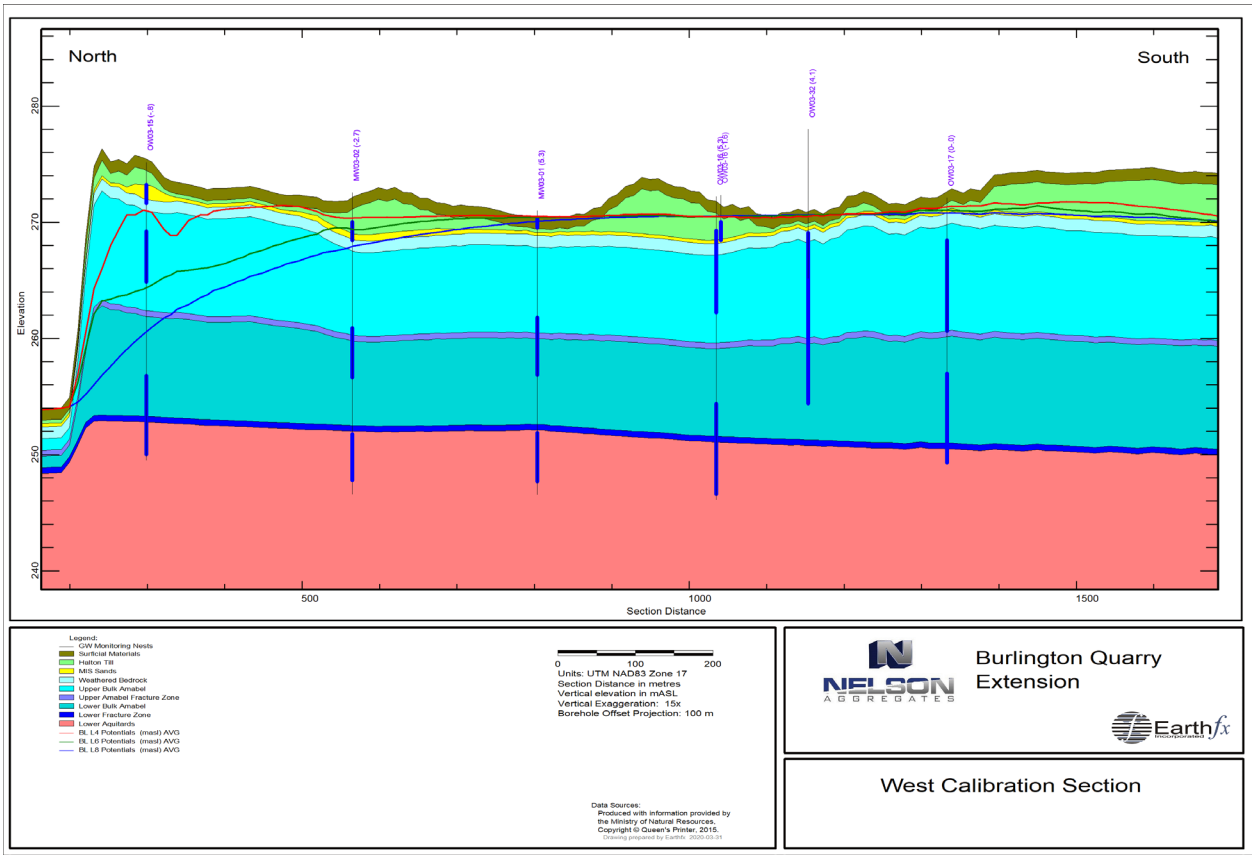


Figure 82: Cross section under Wetland 18

10 References

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11 Appendix A: Water Budget Figures

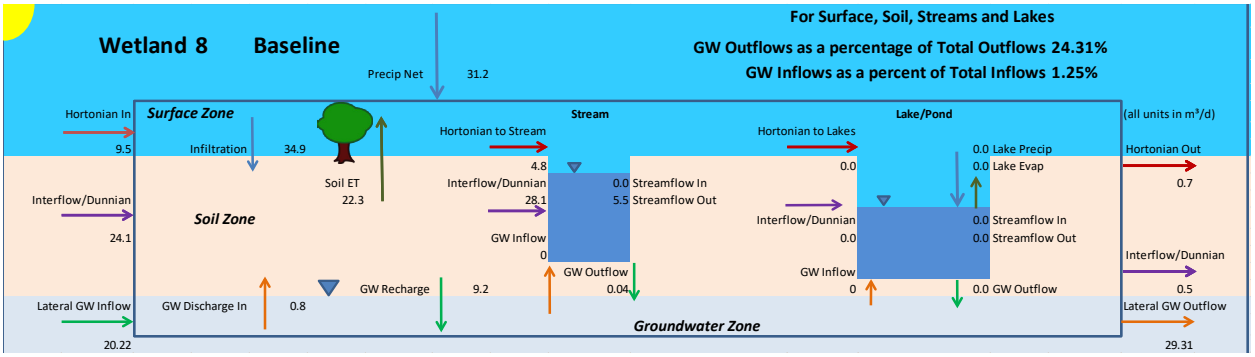


Figure 83: Baseline Water budget for Earthfx Wetland 8 (MNRF 13014)

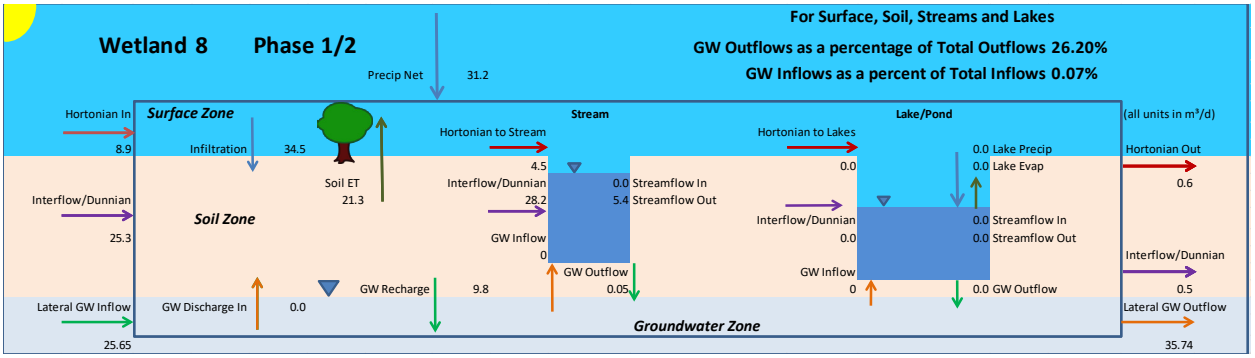


Figure 84: P12 Water budget for Earthfx Wetland 8 (MNRF 13014)

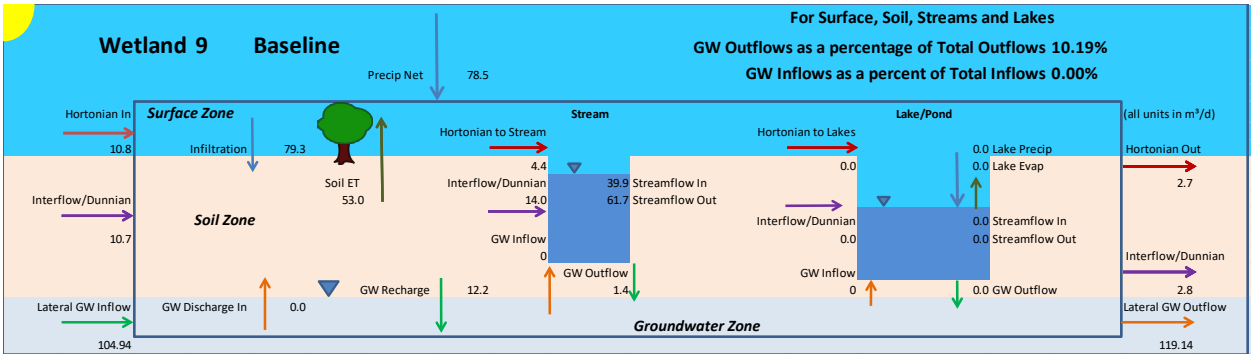


Figure 85: Baseline Water budget for Earthfx Wetland 9 (MNRF 13014)

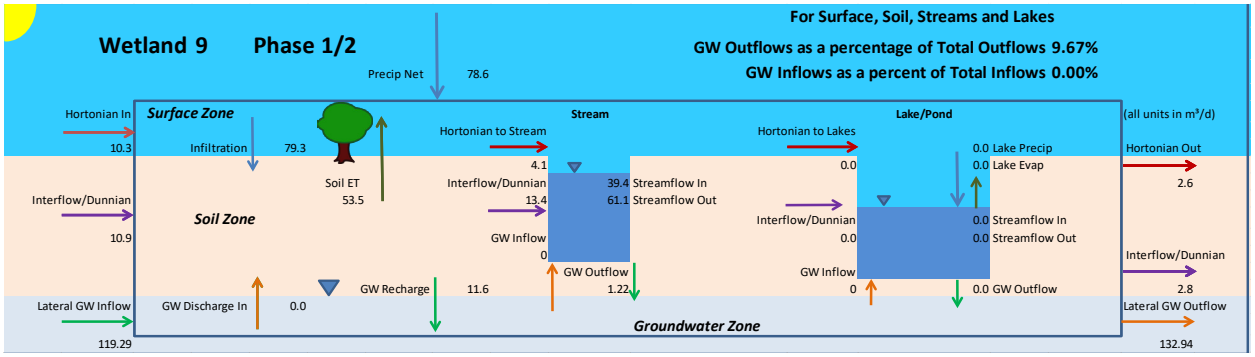


Figure 86: P12 Water budget for Earthfx Wetland 9 (MNRF 13014)

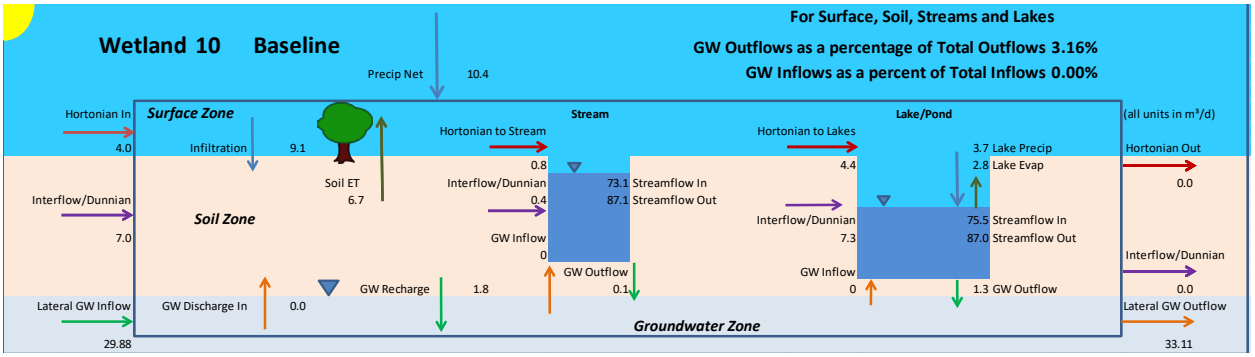


Figure 87: Baseline Water budget for Earthfx Wetland 10 (MNRF 13015)

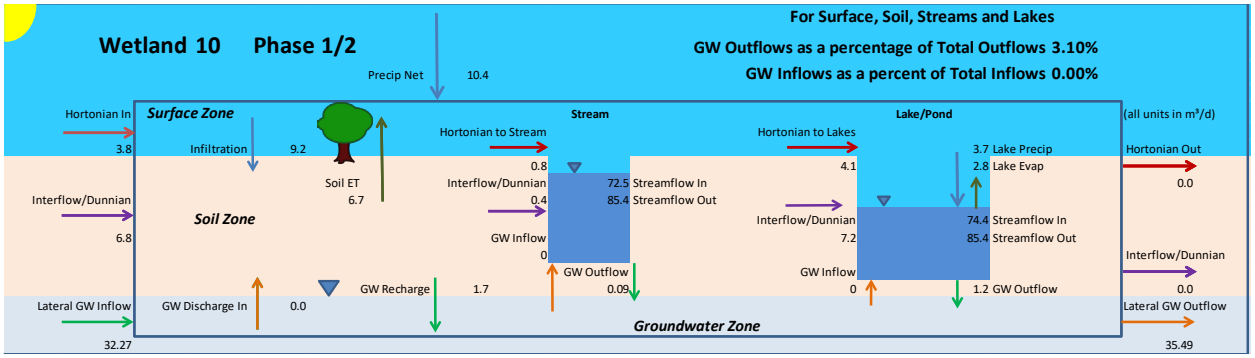


Figure 88: P12 Water budget for Earthfx Wetland 10 (MNRF 13015)

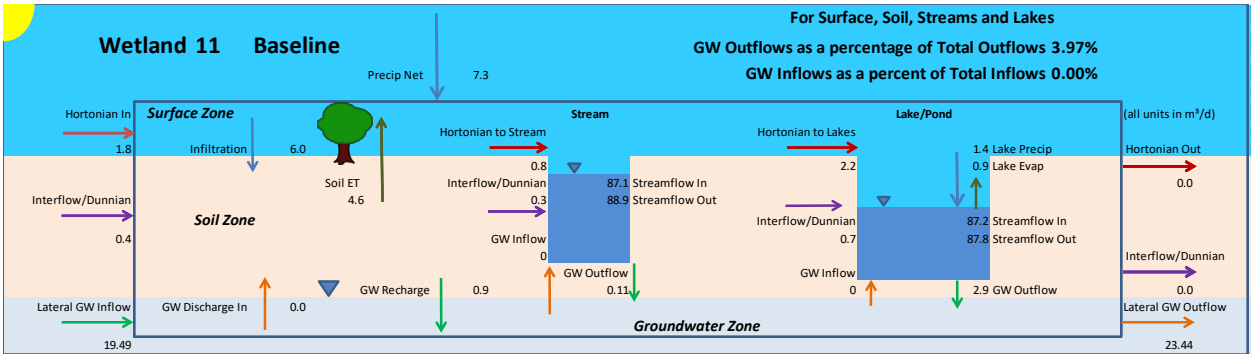


Figure 89: Baseline Water budget for Earthfx Wetland 11 (MNRF 13016)

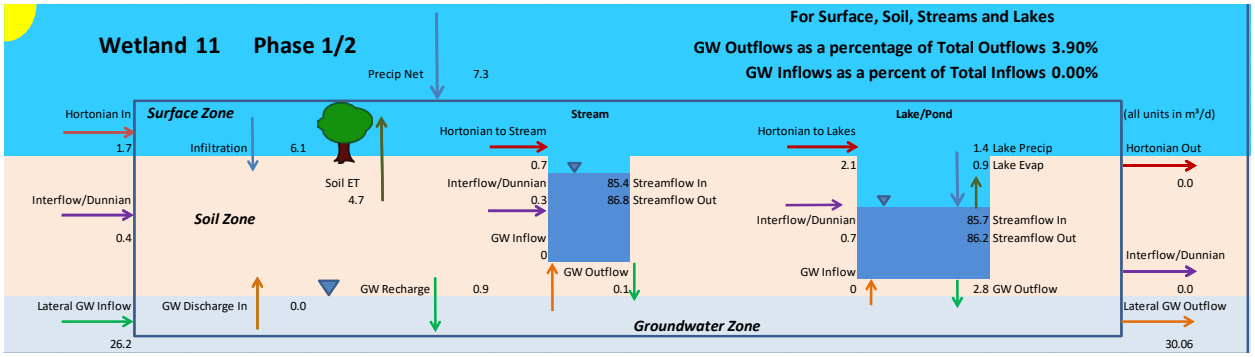


Figure 90: P12 Water budget for Earthfx Wetland 11 (MNRF 13016)

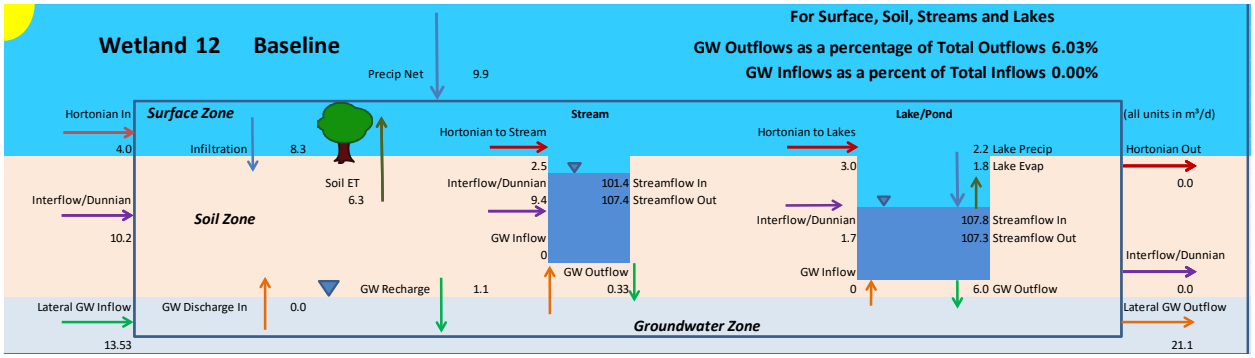


Figure 91: Baseline Water for budget Earthfx Wetland 12 (MNRF 13017 and 13018)

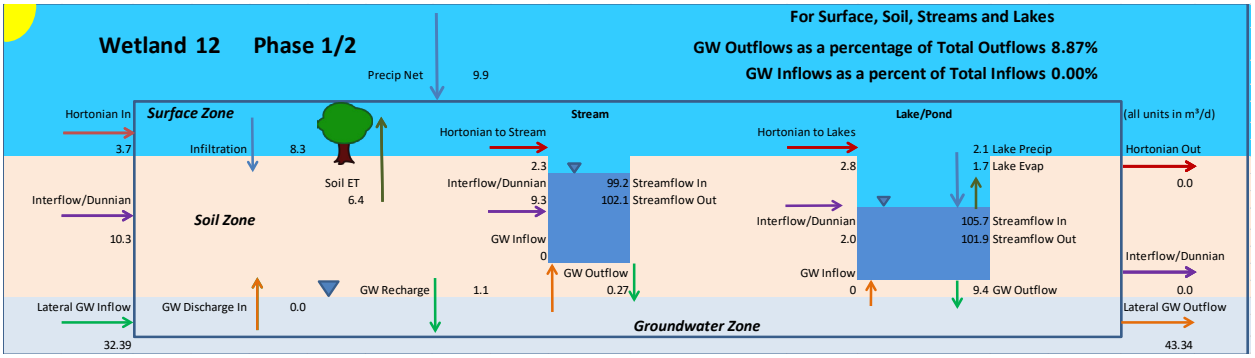


Figure 92: P12 Water budget for Earthfx Wetland 12 (MNRF 13017 and 13018)

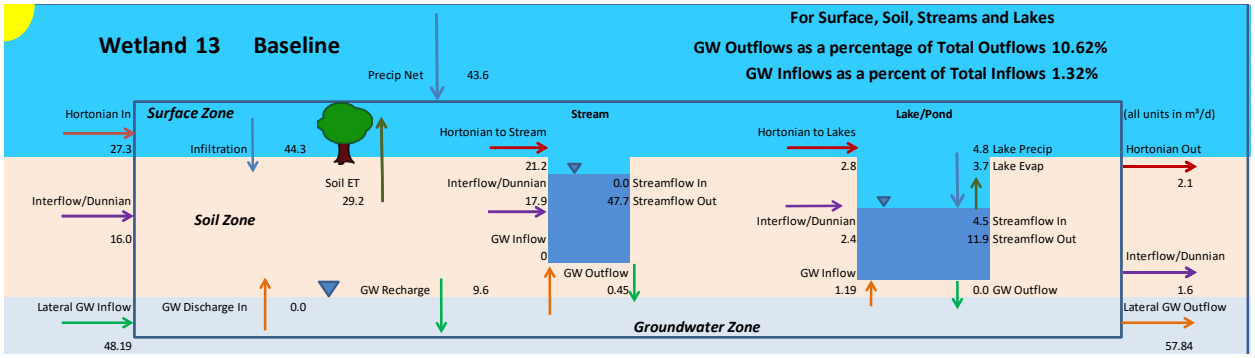


Figure 93: Baseline Water budget for Earthfx Wetland 13 (MNRF 13030)

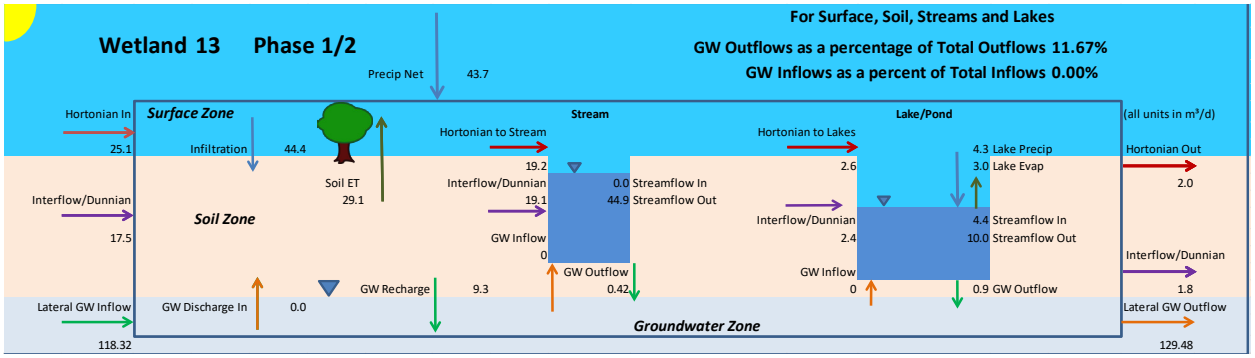


Figure 94: P12 Water budget for Earthfx Wetland 13 (MNRF 13030)

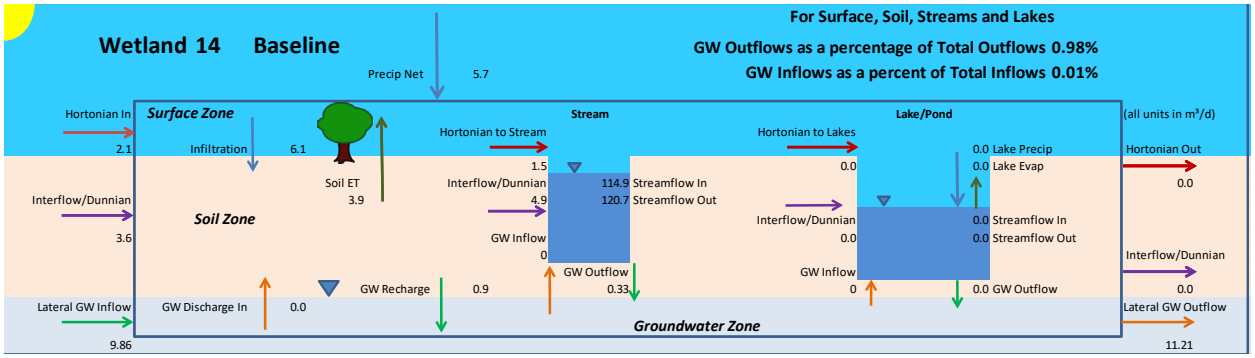


Figure 95: Baseline Water budget for Earthfx Wetland 14 (MNRF 13019)

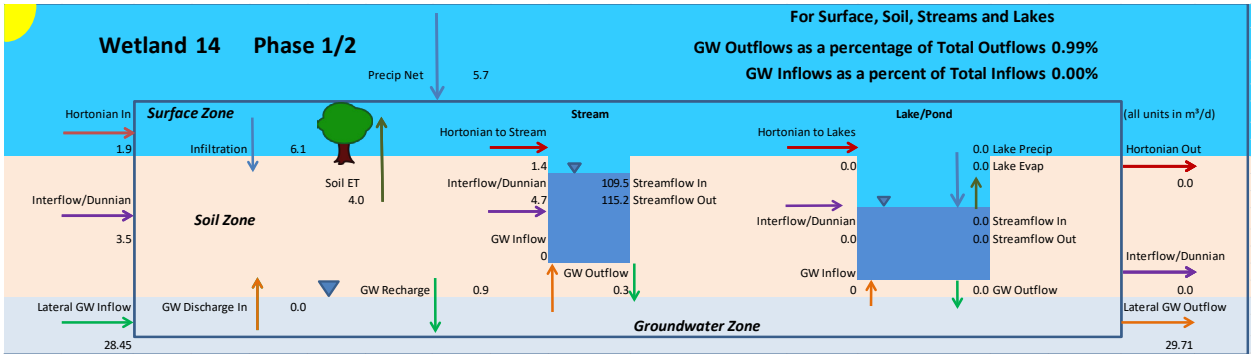


Figure 96: P12 Water budget for Earthfx Wetland 14 (MNRF 13019)

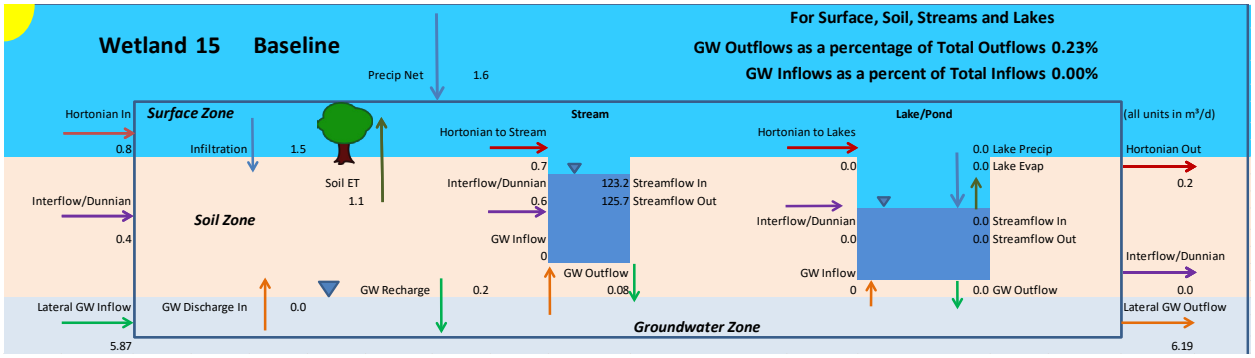


Figure 97: Baseline Water budget for Earthfx Wetland 15 (MNRF 13021)

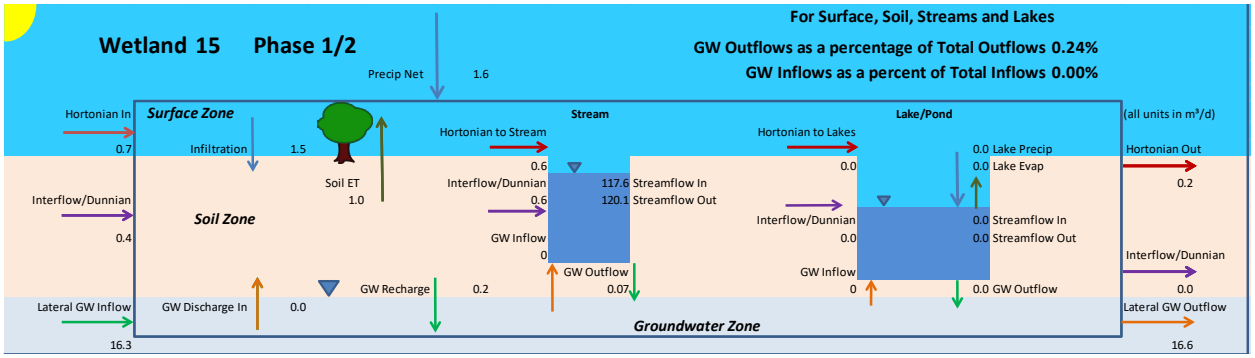


Figure 98: P12 Water budget for Earthfx Wetland 15 (MNRF 13021)

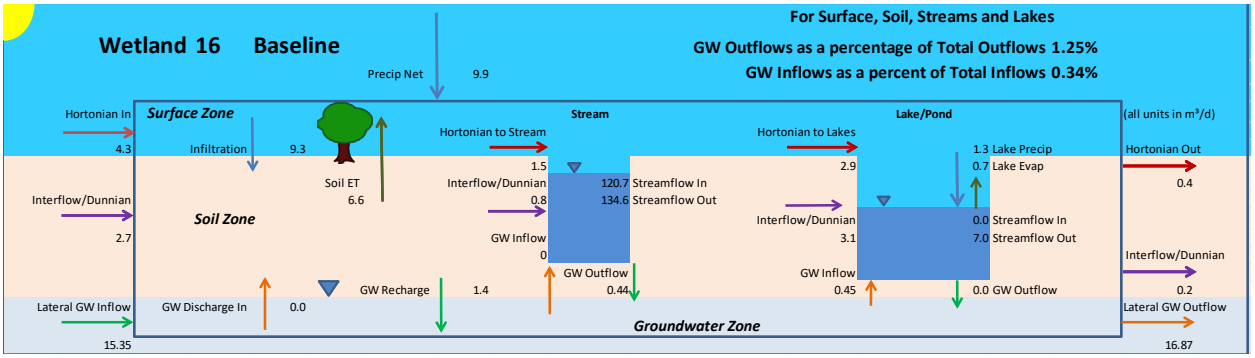


Figure 99: Baseline Water budget for Earthfx Wetland 16 (MNRF 13022)

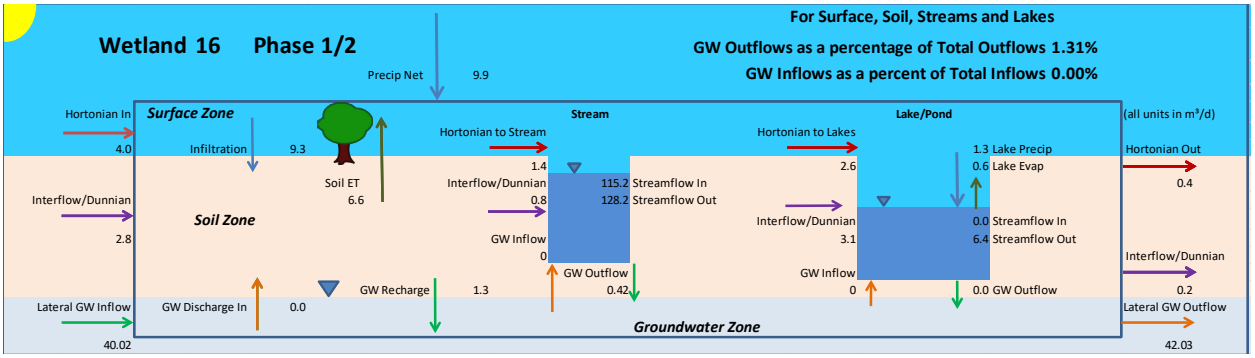


Figure 100: P12 Water budget for Earthfx Wetland 16 (MNRF 13022)

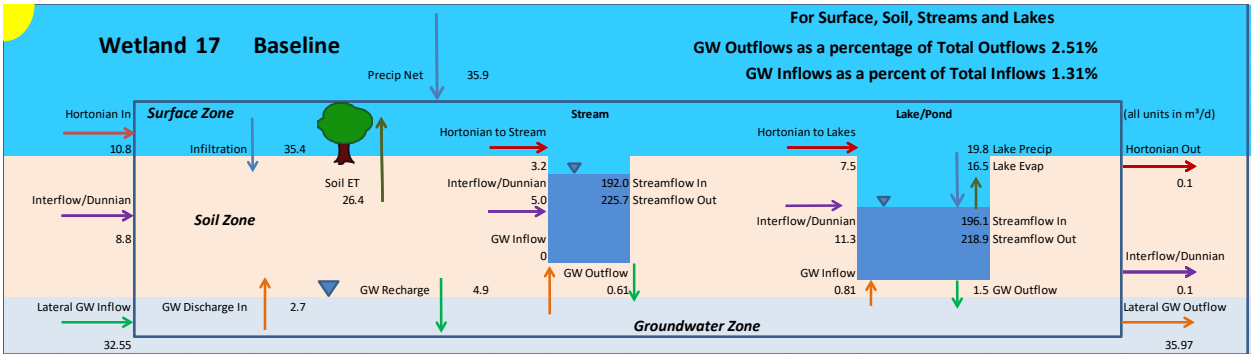


Figure 101: Baseline Water budget for Earthfx Wetland 17 (MNRF 13033)

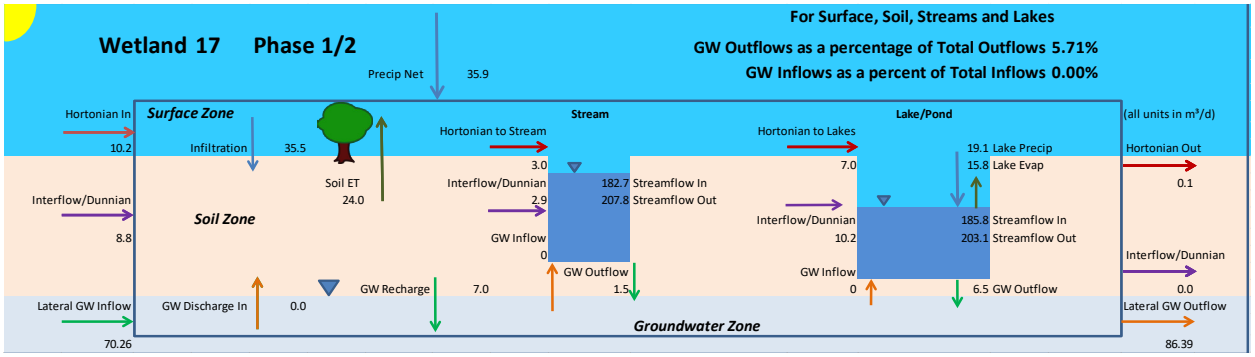


Figure 102: P12 Water budget for Earthfx Wetland 17 (MNRF 13033)

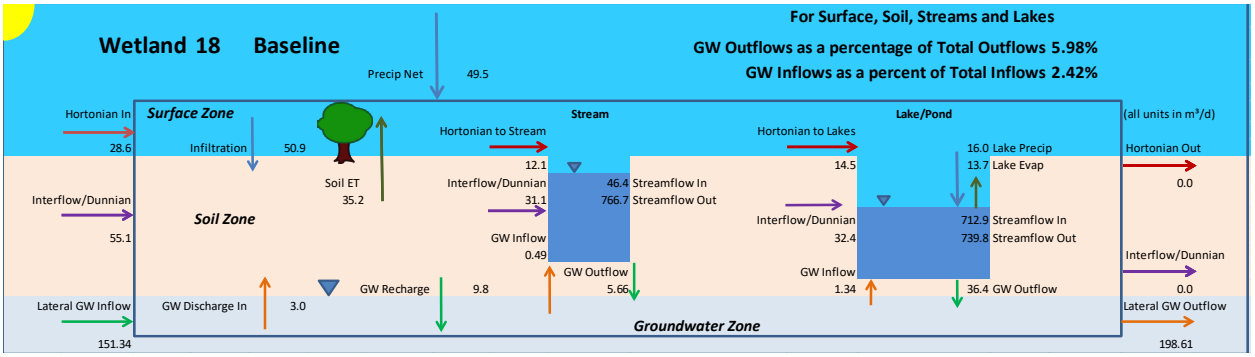


Figure 103: Baseline Water budget for Earthfx Wetland 18 (MNRF 13203)

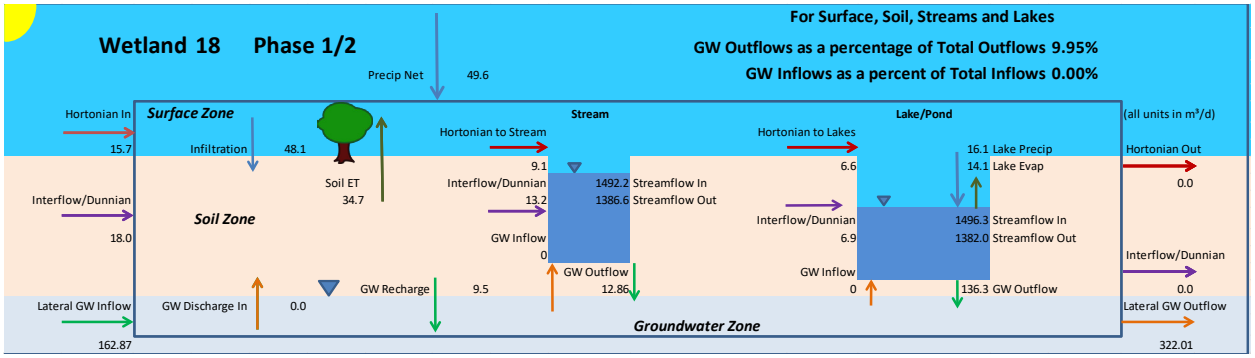


Figure 104: P12 Water budget for Earthfx Wetland 18 (MNRF 13203)

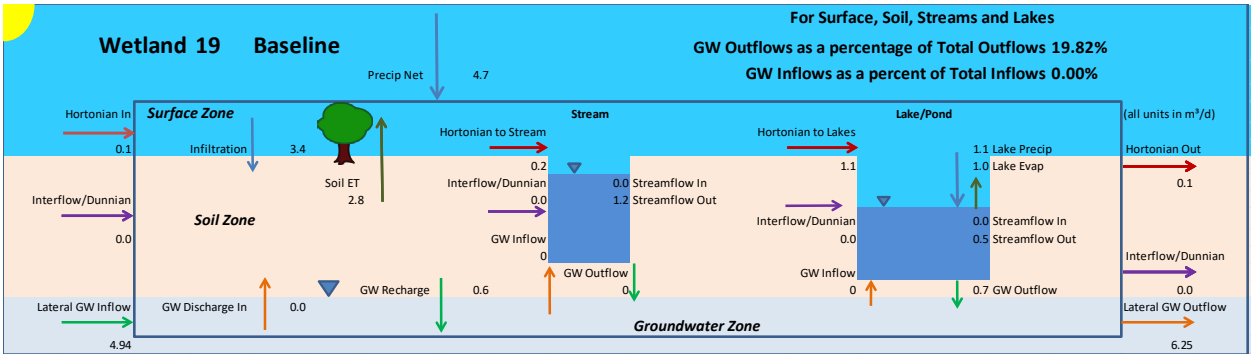


Figure 105: Baseline Water budget for Earthfx Wetland 19 (MNRF 13032)

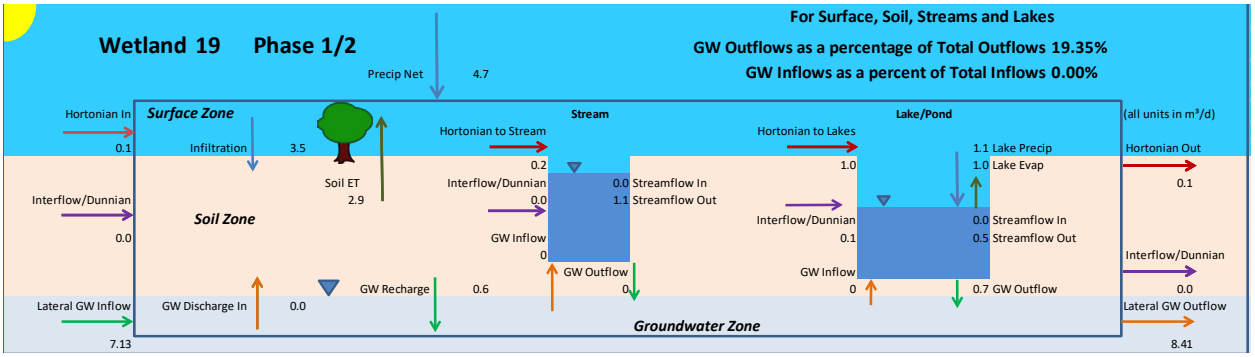


Figure 106: P12 Water budget for Earthfx Wetland 19 (MNRF 13032)

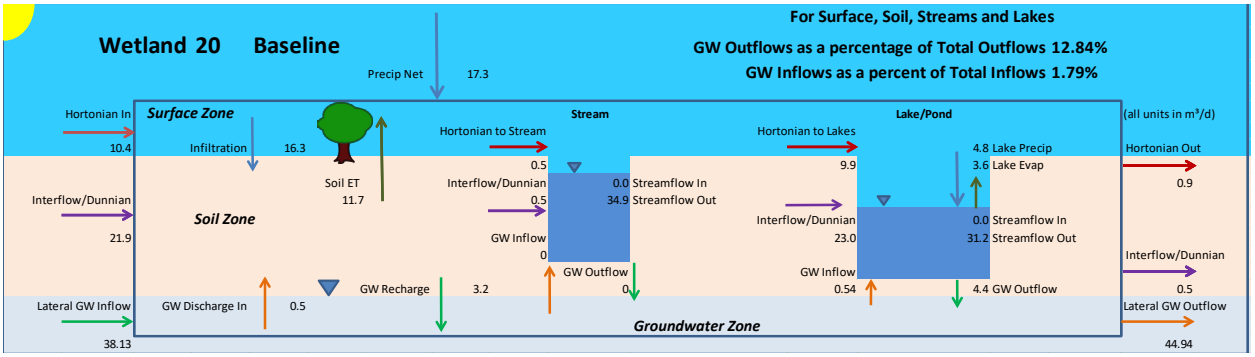


Figure 107: Baseline Water budget for Wetland 20 (MNRF 13036, 13037, 13038, 13039)

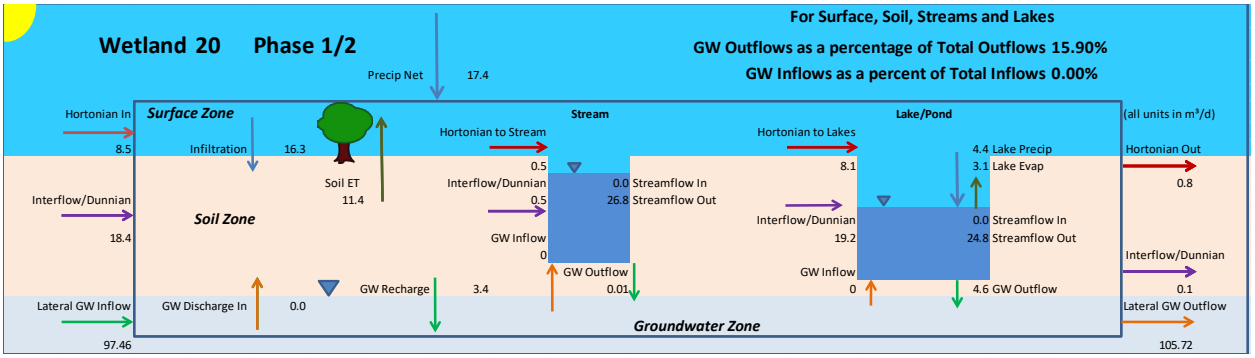


Figure 108: P12 Water budget for Wetland 20 (MNRF 13036, 13037, 13038, 13039)

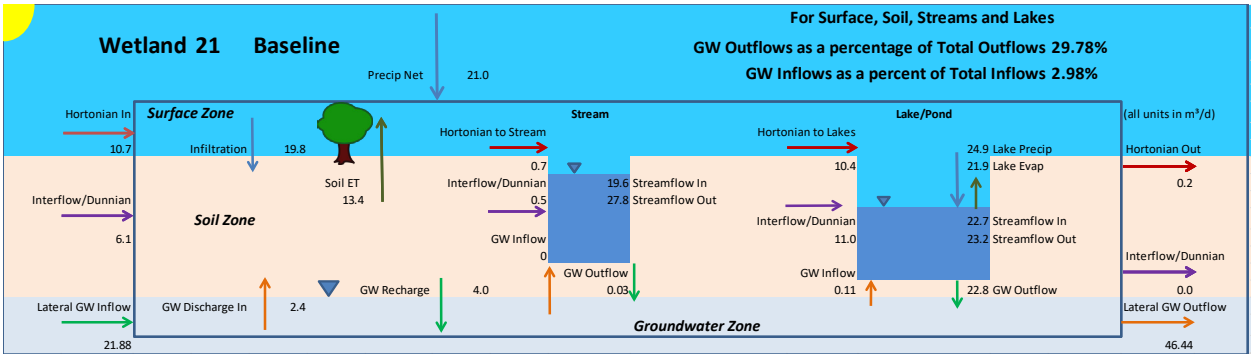


Figure 109: Baseline Water budget for Earthfx Wetland 21 (MNRF 13201)

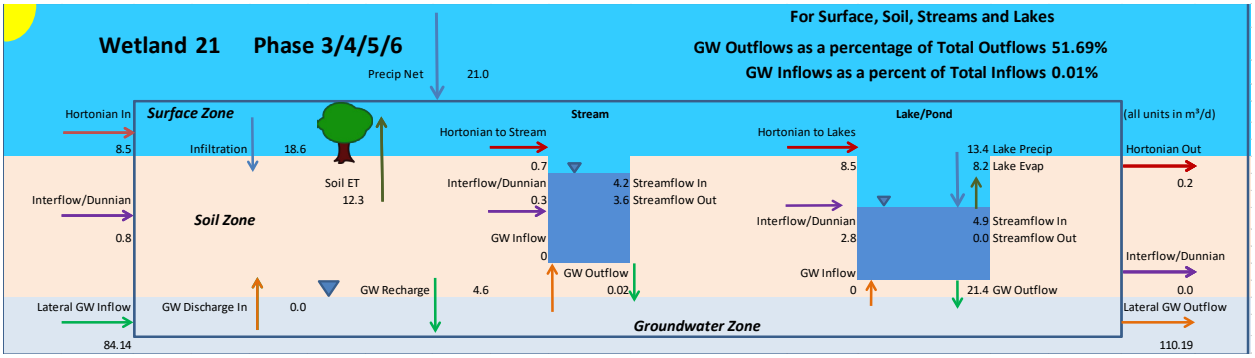


Figure 110: P3456 Water budget for Earthfx Wetland 21 (MNRF 13201)

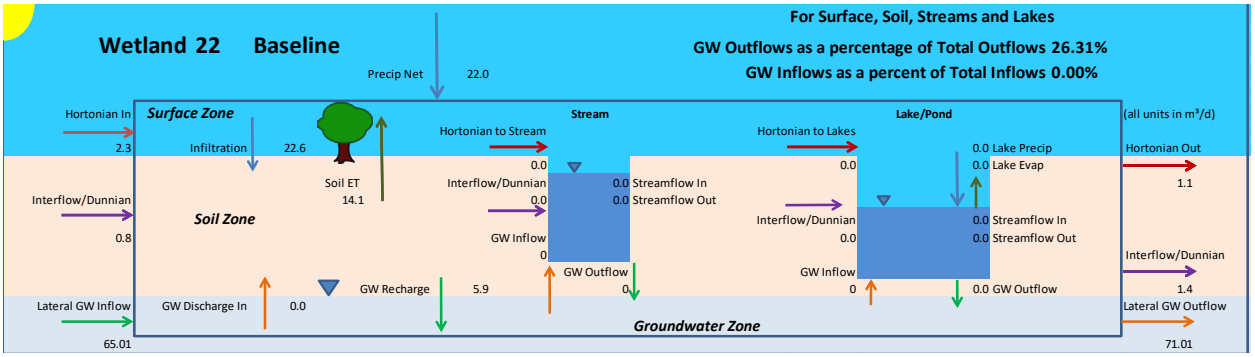


Figure 111: Baseline Water budget for Earthfx Wetland 22 (MNRF 13200)

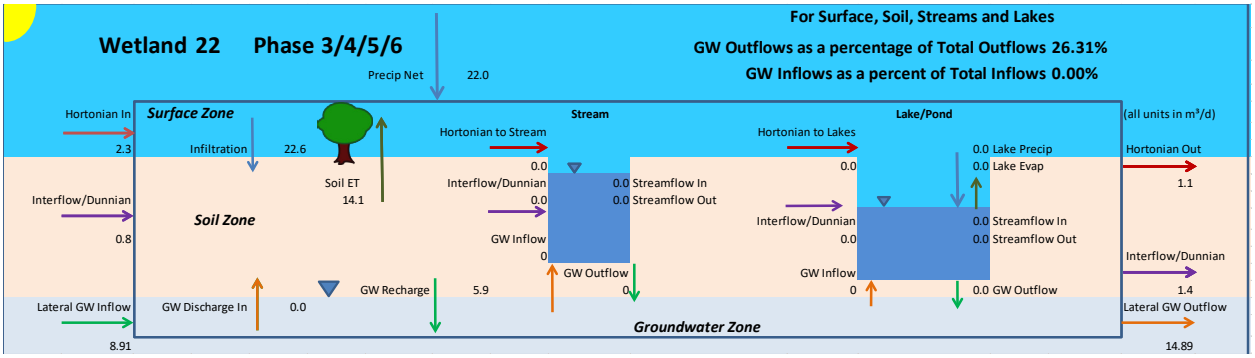


Figure 112: P12 Water budget for Earthfx Wetland 22 (MNRF 13200)

12 Appendix B: Borehole Logs

12.1 Minipiezometer Logs

PIEZOMETER LOG

JOB NUMBER:	021-1238	**JOB NAME:**	Nelson Aggreg-Extension-Burlington	**DATE:**	Jan. 4, 2006
PIEZOMETER NUMBER:	MP-1	**LOCATION:**	Proposed Extension Area	**ELEVATION:**	275.045
MACHINE TYPE:	Hand Auger	**PIEZOMETER SIZE:**	Approx. 0.05m in Diameter	**DATUM:**	275.895
TEMP/WEATHER:	Overcast, wet	**CONTRACTOR:**	Manual Labour		

Depth From (m)	Depth To (m)	Soil Description	Samples* No.	Samples* Depth (m)	Remarks
0.0	0.15	Organics			
0.15	1.5	Clayey silt			
1.5		End of PIEZOMETER	MP-1	1.5	LL= 30.0, PL= 16.7, PI= 13.3, GSD

Comments: *Water Conditions in PIEZOMETER:*

JOB No. 021-1238
PIEZOMETER No.: MP-1
Technician: Eric Goll

Golder Associates

JOB NUMBER:	021-1238	**JOB NAME:**	Nelson Aggreg-Extension-Burlington	**DATE:**	Jan. 4, 2006
PIEZOMETER NUMBER:	MP-2	**LOCATION:**	Proposed Extension Area	**ELEVATION:**	275.275
MACHINE TYPE:	Hand Auger	**PIEZOMETER SIZE:**	Approx. 0.05m in Diameter	**DATUM:**	275.815
TEMP/WEATHER:	Overcast, wet	**CONTRACTOR:**	Manual Labour		

Depth		Soil Description	Samples*		Remarks
From (m)	To (m)		No.	Depth (m)	
0.0	0.15	Organics			
0.15	1.5	Clayey silt			
1.5		End of PIEZOMETER	MP-2	1.5	LL= 30.4, PL= 17.3, PI= 13.1, GSD

Comments: *Water Conditions in PIEZOMETER:*

JOB No. 021-1238
PIEZOMETER No.: MP-2
Technician: Eric Goll

Golder Associates

PIEZOMETER LOG

JOB NUMBER:	021-1238	**JOB NAME:**	Nelson Aggreg-Extension-Burlington	**DATE:**	Jan. 4, 2006
PIEZOMETER NUMBER:	MP-3	**LOCATION:**	Proposed Extension Area	**ELEVATION:**	275.15
MACHINE TYPE:	Hand Auger	**PIEZOMETER SIZE:**	Approx. 0.05m in Diameter	**DATUM:**	276.44
TEMP/WEATHER:	Overcast, wet	**CONTRACTOR:**	Manual Labour		

Depth		Soil Description	Samples*		Remarks
From (m)	To (m)		No.	Depth (m)	
0.0	0.15	Organics			
0.15	1.5	Clayey silt			
1.5		End of PIEZOMETER			

Comments: *Water Conditions in PIEZOMETER:*

JOB No. 021-1238
PIEZOMETER No.: MP-3
Technician: Eric Goll

Golder Associates

PIEZOMETER LOG

JOB NUMBER:	021-1238	**JOB NAME:**	Nelson Aggreg-Extension-Burlington	**DATE:**	Jan. 4, 2006
PIEZOMETER NUMBER:	MP-4	**LOCATION:**	Proposed Extension Area	**ELEVATION:**	275.05
MACHINE TYPE:	Hand Auger	**PIEZOMETER SIZE:**	Approx. 0.05m in Diameter	**DATUM:**	276.15
TEMP/WEATHER:	Overcast, wet	**CONTRACTOR:**	Manual Labour		

Depth			Samples*		Remarks
From (m)	**To (m)**	**Soil Description**	**No.**	**Depth (m)**	
0.0	0.15	Organics			
0.15	1.5	Clayey silt			
1.5		End of PIEZOMETER	MP-4	1.5	LL= 40.3, PL= 23.2, PI= 17.1, GSD

Comments: *Water Conditions in PIEZOMETER:*

JOB No. 021-1238
PIEZOMETER No.: MP-4
Technician: Eric Goll

Golder Associates

PIEZOMETER LOG

JOB NUMBER:	021-1238	**JOB NAME:**	Nelson Aggreg-Extension-Burlington	**DATE:**	Jan. 4, 2006
PIEZOMETER NUMBER:	MP-5	**LOCATION:**	Proposed Extension Area	**ELEVATION:**	275.04
MACHINE TYPE:	Hand Auger	**PIEZOMETER SIZE:**	Approx. 0.05m in Diameter	**DATUM:**	276.32
TEMP/WEATHER:	Overcast, wet	**CONTRACTOR:**	Manual Labour		

Depth From (m)	Depth To (m)	Soil Description	Samples* No.	Samples* Depth (m)	Remarks
0.0	0.15	Organics			
0.15	1.5	Clayey silt			
1.5		End of PIEZOMETER			

Comments: *Water Conditions in PIEZOMETER:*

JOB No. 021-1238
PIEZOMETER No.: MP-5
Technician: Eric Goll

Golder Associates

PIEZOMETER LOG

JOB NUMBER:	021-1238	**JOB NAME:**	Nelson Aggreg-Extension-Burlington	**DATE:**	Jan. 4, 2006
PIEZOMETER NUMBER:	MP-6	**LOCATION:**	Proposed Extension Area	**ELEVATION:**	276.48
MACHINE TYPE:	Hand Auger	**PIEZOMETER SIZE:**	Approx. 0.05m in Diameter	**DATUM:**	275.66
TEMP/WEATHER:	Overcast, wet	**CONTRACTOR:**	Manual Labour		

Depth From (m)	Depth To (m)	Soil Description	Samples* No.	Samples* Depth (m)	Remarks
0.0	0.15	Organics			
0.15	1.5	Clayey silt			
1.5		End of PIEZOMETER	MP-6	1.5	LL= 28.4, PL= 17.1, PI= 11.3, GSD

Comments: *Water Conditions in PIEZOMETER:*

JOB No. 021-1238
PIEZOMETER No.: MP-6
Technician: Eric Goll

Golder Associates

PIEZOMETER LOG

JOB NUMBER:	021-1238	**JOB NAME:**	Nelson Aggreg-Extension-Burlington	**DATE:**	Jan. 4, 2006
PIEZOMETER NUMBER:	MP-7	**LOCATION:**	Proposed Extension Area	**ELEVATION:**	276.315
MACHINE TYPE:	Hand Auger	**PIEZOMETER SIZE:**	Approx. 0.05m in Diameter	**DATUM:**	276.61
TEMP/WEATHER:	Overcast, wet	**CONTRACTOR:**	Manual Labour		

Depth		Soil Description	Samples*		Remarks
From (m)	To (m)		No.	Depth (m)	
0.0	0.15	Organics			
0.15	1.5	Clayey silt			
1.5		End of PIEZOMETER	MP-7	1.5	LL= 32.6, PL= 17.8, PI= 14.8, GSD

Comments: *Water Conditions in PIEZOMETER:*

JOB No. 021-1238
PIEZOMETER No.: MP-7
Technician: Eric Goll

Golder Associates

PIEZOMETER LOG

JOB NUMBER:	021-1238	**JOB NAME:**	Nelson Aggreg-Extension-Burlington	**DATE:**	Jan. 4, 2006
PIEZOMETER NUMBER:	MP-8	**LOCATION:**	Proposed Extension Area	**ELEVATION:**	275.485
MACHINE TYPE:	Hand Auger	**PIEZOMETER SIZE:**	Approx. 0.05m in Diameter	**DATUM:**	275.905
TEMP/WEATHER:	Overcast, wet	**CONTRACTOR:**	Manual Labour		

Depth			Samples*		Remarks
From (m)	**To (m)**	**Soil Description**	**No.**	**Depth (m)**	
0.0	0.15	Organics			
0.15	1.5	Clayey silt			
1.5		End of PIEZOMETER	MP-8	1.5	GSD

Comments: *Water Conditions in PIEZOMETER:*

JOB No. 021-1238
PIEZOMETER No.: MP-8
Technician: Eric Goll

Golder Associates

PIEZOMETER LOG

JOB NUMBER:	021-1238	**JOB NAME:**	Nelson Aggreg-Extension-Burlington	**DATE:**	Apr. 21, 2006
PIEZOMETER NUMBER:	MP-9	**LOCATION:**	Proposed Quarry Extension Area	**ELEVATION:**	275.51
MACHINE TYPE:	Hand Auger	**PIEZOMETER SIZE:**	Approx. 0.05m in Diameter	**DATUM:**	276.79
TEMP/WEATHER:	8°C, Sunny	**CONTRACTOR:**	Manual Labour		

Depth		Soil Description	Samples		Remarks
From (m)	**To (m)**		**No.**	**Depth (m)**	
0.0	0.91	Mottled Grey/Brown Clayey SILT			
0.91		End of PIEZOMETER			

Comments: *Water Conditions in PIEZOMETER:* *WL at 275.23 masl on May. 24, 2006*

JOB No.	021-1238
PIEZOMETER No.:	MP-9
Technician:	Adam Kennedy

Golder Associates

PIEZOMETER LOG

JOB NUMBER:	021-1238	**JOB NAME:**	Nelson Aggreg-Extension-Burlington	**DATE:**	Apr. 21, 2006
PIEZOMETER NUMBER:	MP 10	**LOCATION:**	Proposed Quarry Extension Area	**ELEVATION:**	275.57
MACHINE TYPE:	Hand Auger	**PIEZOMETER SIZE:**	Approx. 0.05m in Diameter	**DATUM:**	276.67
TEMP/WEATHER:	8°C, Sunny	**CONTRACTOR:**	Manual Labour		

Depth From (m)	Depth To (m)	Soil Description	Samples No.	Samples Depth (m)	Remarks
0.0	1.05	Mottled Grey/Brown Clayey SILT w. some gravel near bottom of hole			
1.12		End of PIEZOMETER			

Comments: *Water Conditions in PIEZOMETER:* *WL at 275.39 masl on May. 24, 2006*

JOB No. 021-1238
PIEZOMETER No.: MP 10
Technician: Adam Kennedy

Golder Associates

PIEZOMETER LOG

JOB NUMBER:	021-1238	**JOB NAME:**	Nelson Aggreg-Extension-Burlington	**DATE:**	Apr. 21, 2006
PIEZOMETER NUMBER:	MP 11	**LOCATION:**	Proposed Quarry Extension Area	**ELEVATION:**	276.89
MACHINE TYPE:	Hand Auger	**PIEZOMETER SIZE:**	Approx. 0.05m in Diameter	**DATUM:**	278.30
TEMP/WEATHER:	8°C, Sunny	**CONTRACTOR:**	Manual Labour		

Depth		Soil Description	Samples		Remarks
From (m)	**To (m)**		**No.**	**Depth (m)**	
0.0	0.95	Grey/Brown Clayey SILT			
0.95		End of PIEZOMETER			

Comments: *Water Conditions in PIEZOMETER:* *WL at 276.79 masl on May. 24, 2006*

JOB No.	021-1238
PIEZOMETER No.:	MP 11
Technician:	Adam Kennedy

Golder Associates

PIEZOMETER LOG

JOB NUMBER:	021-1238	**JOB NAME:**	Nelson Aggreg-Extension-Burlington	**DATE:**	Apr. 21, 2006
PIEZOMETER NUMBER:	MP 12	**LOCATION:**	Proposed Quarry Extension Area	**ELEVATION:**	275.79
MACHINE TYPE:	Hand Auger	**PIEZOMETER SIZE:**	Approx. 0.05m in Diameter	**DATUM:**	276.84
TEMP/WEATHER:	8°C, Sunny	**CONTRACTOR:**	Manual Labour		

Depth		Soil Description	Samples		Remarks
From (m)	**To (m)**		**No.**	**Depth (m)**	
0.0	1.04	Grey/Brown Clayey SILT			
1.04		End of PIEZOMETER			

Comments: *Water Conditions in PIEZOMETER:* *WL at 275.71 masl on May. 24, 2006*

JOB No.	021-1238
PIEZOMETER No.:	MP 12
Technician:	Adam Kennedy

Golder Associates

PIEZOMETER LOG

JOB NUMBER:	021-1238	**JOB NAME:**	Nelson Aggreg-Extension-Burlington	**DATE:**	Apr. 21, 2006
PIEZOMETER NUMBER:	MP 13	**LOCATION:**	Proposed Quarry Extension Area	**ELEVATION:**	277.43
MACHINE TYPE:	Hand Auger	**PIEZOMETER SIZE:**	Approx. 0.05m in Diameter	**DATUM:**	278.42
TEMP/WEATHER:	8°C, Sunny	**CONTRACTOR:**	Manual Labour		

Depth		**Soil Description**	**Samples**		**Remarks**
From (m)	**To (m)**		**No.**	**Depth (m)**	
0.0	1.12	Mottled Grey/Brown Clayey SILT w. some gravel near bottom of hole			
1.12		End of PIEZOMETER			

Comments: *Water Conditions in PIEZOMETER:* *WL at 277.42 masl on May. 24, 2006*

JOB No.	021-1238
PIEZOMETER No.:	MP 13
Technician:	Adam Kennedy

Golder Associates

PIEZOMETER LOG

JOB NUMBER:	021-1238	**JOB NAME:**	Nelson Aggreg-Extension-Burlington	**DATE:**	Jan. 23, 2007
PIEZOMETER NUMBER:	MP 14	**LOCATION:**	Proposed Quarry Extension Area	**ELEVATION:**	271.34
MACHINE TYPE:	Hand Auger	**PIEZOMETER SIZE:**	Approx. 0.05m in Diameter	**DATUM:**	272.91
TEMP/WEATHER:	3°C, overcast	**CONTRACTOR:**	Manual Labour		

Depth		Soil Description	Samples		Remarks
From (m)	**To (m)**		**No.**	**Depth (m)**	
0.0	1.39	Brown Clayey SILT			
1.39		End of PIEZOMETER			

Comments: *Water Conditions in PIEZOMETER: DRY on Jan. 23, 2007*

JOB No.	021-1238
PIEZOMETER No.:	MP 14
Technician:	Adam Kennedy

Golder Associates

PIEZOMETER LOG

JOB NUMBER:	021-1238	**JOB NAME:**	Nelson Aggreg-Extension-Burlington	**DATE:**	Jan. 23, 2007
PIEZOMETER NUMBER:	MP 16	**LOCATION:**	Proposed Quarry Extension Area	**ELEVATION:**	N/A
MACHINE TYPE:	Hand Auger	**PIEZOMETER SIZE:**	Approx. 0.05m in Diameter	**DATUM:**	N/A
TEMP/WEATHER:	3°C, overcast	**CONTRACTOR:**	Manual Labour		

Depth		Soil Description	Samples		Remarks
From (m)	**To (m)**		**No.**	**Depth (m)**	
0.0	0.54	Brown Clayey SILT			
0.54		End of PIEZOMETER			

Comments: *Water Conditions in PIEZOMETER: DRY on Jan. 23, 2007*

JOB No.	021-1238
PIEZOMETER No.:	MP 16
Technician:	Adam Kennedy

Golder Associates

PIEZOMETER LOG

JOB NUMBER:	021-1238	**JOB NAME:**	Nelson Aggreg-Extension-Burlington	**DATE:**	Apr. 5, 2007
PIEZOMETER NUMBER:	MP 17	**LOCATION:**	Proposed Quarry Extension Area	**ELEVATION:**	277.71
MACHINE TYPE:	Hand Auger	**PIEZOMETER SIZE:**	Approx. 0.05m in Diameter	**DATUM:**	278.095
TEMP/WEATHER:	-3, light breeze	**CONTRACTOR:**	Manual Labour		

Depth From (m)	Depth To (m)	Soil Description	Samples No.	Samples Depth (m)	Remarks
0.0	0.2	Organics			
0.2	1.12	Mottled Grey/Brown Clayey SILT w. some gravel near bottom of hole	S-1	0.2 - 1.12	
1.12		End of PIEZOMETER			

Comments: *Water Conditions in PIEZOMETER:* *WL at 276.94 masl on Apr. 20, 2007*

JOB No.	021-1238
PIEZOMETER No.:	MP 17
Technician:	Matt Bowman

Golder Associates

PIEZOMETER LOG

JOB NUMBER:	021-1238	**JOB NAME:**	Nelson Aggreg-Extension-Burlington	**DATE:**	Apr. 5, 2007
PIEZOMETER NUMBER:	MP 18	**LOCATION:**	Proposed Quarry Extension Area	**ELEVATION:**	277.58
MACHINE TYPE:	Hand Auger	**PIEZOMETER SIZE:**	Approx. 0.05m in Diameter	**DATUM:**	278.235
TEMP/WEATHER:	-3, light breeze	**CONTRACTOR:**	Manual Labour		

Depth		Soil Description	Samples		Remarks
From (m)	**To (m)**		**No.**	**Depth (m)**	
0.0	0.3	Organics			
0.3	0.86	Mottled grey/brown clayey SILT w. some gravel	S-1	0.3- 0.86	
0.86		End of PIEZOMETER			

Comments: *Water Conditions in PIEZOMETER:* *WL at 276.87 masl on Apr. 20, 2007*

JOB No.	021-1238
PIEZOMETER No.:	MP 18
Technician:	M.att Bowman

Golder Associates

PIEZOMETER LOG

JOB NUMBER:	021-1238	**JOB NAME:**	Nelson Aggreg-Extension-Burlington	**DATE:**	Apr. 5, 2007
PIEZOMETER NUMBER:	MP 19	**LOCATION:**	Proposed Quarry Extension Area	**ELEVATION:**	277.615
MACHINE TYPE:	Hand Auger	**PIEZOMETER SIZE:**	Approx. 0.05m in Diameter	**DATUM:**	278.045
TEMP/WEATHER:	-3, light breeze	**CONTRACTOR:**	Manual Labour		

Depth From (m)	Depth To (m)	Soil Description	Samples No.	Samples Depth (m)	Remarks
0.0	0.3	Organics			
0.3	1.33	Mottled grey/brown/red clayey SILT w. some gravel, some sand near bottom of hole	S-1	0.3 – 1.33	
1.33		End of PIEZOMETER			

Comments: *Water Conditions in PIEZOMETER:* *WL at 277.29 masl on Apr. 20, 2007*

JOB No.	021-1238
PIEZOMETER No.:	MP 19
Technician:	Matt Bowman

Golder Associates

PIEZOMETER LOG

JOB NUMBER:	021-1238	**JOB NAME:**	Nelson Aggreg-Extension-Burlington	**DATE:**	Apr. 4, 2007
PIEZOMETER NUMBER:	MP 20	**LOCATION:**	Proposed Quarry Extension Area	**ELEVATION:**	277.45
MACHINE TYPE:	Hand Auger	**PIEZOMETER SIZE:**	Approx. 0.05m in Diameter	**DATUM:**	277.915
TEMP/WEATHER:	~0, light snow	**CONTRACTOR:**	Manual Labour		

Depth		Soil Description	Samples		Remarks
From (m)	**To (m)**		**No.**	**Depth (m)**	
0.0	0.3	Organics			
0.3	1.18	Clayey SILT	S-1	0.3 – 1.18	
1.18		End of PIEZOMETER			

Comments: *Water Conditions in PIEZOMETER:* *WL at 276.84 masl on Apr. 20, 2007*

JOB No.	021-1238
PIEZOMETER No.:	MP 20
Technician:	Matt Bowman

Golder Associates

PIEZOMETER LOG

JOB NUMBER:	021-1238	**JOB NAME:**	Nelson Aggreg-Extension-Burlington	**DATE:**	Apr. 5, 2007
PIEZOMETER NUMBER:	MP 21	**LOCATION:**	Proposed Quarry Extension Area	**ELEVATION:**	277.505
MACHINE TYPE:	Hand Auger	**PIEZOMETER SIZE:**	Approx. 0.05m in Diameter	**DATUM:**	278.015
TEMP/WEATHER:	-3, light breeze	**CONTRACTOR:**	Manual Labour		

Depth		Soil Description	Samples		Remarks
From (m)	**To (m)**		**No.**	**Depth (m)**	
0.0	0.3	Organics			
0.3	1.17	Brown with red/grey clayey SILT Some gravel	S-1	0.3 – 1.17	
1.17		End of PIEZOMETER			

Comments: *Water Conditions in PIEZOMETER:* *WL at 276.62 masl on Apr. 20, 2007*

JOB No.	021-1238
PIEZOMETER No.:	MP 21
Technician:	Matt Bowman

Golder Associates

PIEZOMETER LOG

JOB NUMBER:	021-1238	**JOB NAME:**	Nelson Aggreg-Extension-Burlington	**DATE:**	Apr. 9, 2007
PIEZOMETER NUMBER:	MP 22	**LOCATION:**	Proposed Quarry Extension Area	**ELEVATION:**	276.84
MACHINE TYPE:	Hand Auger	**PIEZOMETER SIZE:**	Approx. 0.05m in Diameter	**DATUM:**	277.37
TEMP/WEATHER:	0, overcast	**CONTRACTOR:**	Manual Labour		

Depth From (m)	Depth To (m)	Soil Description	Samples No.	Samples Depth (m)	Remarks
0.0	0.3	Organics			
0.3	1.19	Brown with grey/orange mottling clayey SILT w. some gravel	S-1	0.3 – 1.19	
1.19		End of PIEZOMETER			

Comments: *Water Conditions in PIEZOMETER:* *WL at 275.86 masl on Apr. 20, 2007*

JOB No.	021-1238
PIEZOMETER No.:	MP 22
Technician:	Matt Bowman

Golder Associates

PIEZOMETER LOG

JOB NUMBER:	021-1238	**JOB NAME:**	Nelson Aggreg-Extension-Burlington	**DATE:**	Apr. 9, 2007
PIEZOMETER NUMBER:	MP 23	**LOCATION:**	Proposed Quarry Extension Area	**ELEVATION:**	277.68
MACHINE TYPE:	Hand Auger	**PIEZOMETER SIZE:**	Approx. 0.05m in Diameter	**DATUM:**	278.63
TEMP/WEATHER:	0, overcast	**CONTRACTOR:**	Manual Labour		

Depth From (m)	Depth To (m)	Soil Description	Samples No.	Samples Depth (m)	Remarks
0.0	0.4	Organics			
0.4	0.8	Brown w. some grey mottling clayey SILT w. some gravel	S-1	0.4-0.8	Hit rock(s) at 0.8m depth
0.8		End of PIEZOMETER			

Comments: *Water Conditions in PIEZOMETER:* *WL at 277.54 masl on Apr. 20, 2007*

JOB No. 021-1238
PIEZOMETER No.: MP 23
Technician: Matt Bowman

Golder Associates

PIEZOMETER LOG

JOB NUMBER:	021-1238	**JOB NAME:**	Nelson Aggreg-Extension-Burlington	**DATE:**	Apr. 9, 2007
PIEZOMETER NUMBER:	MP 24	**LOCATION:**	Proposed Quarry Extension Area	**ELEVATION:**	276.57
MACHINE TYPE:	Hand Auger	**PIEZOMETER SIZE:**	Approx. 0.05m in Diameter	**DATUM:**	276.97
TEMP/WEATHER:	0, overcast	**CONTRACTOR:**	Manual Labour		

Depth From (m)	Depth To (m)	Soil Description	Samples No.	Samples Depth (m)	Remarks
0.0	0.6	Organics			
0.6	1.3	Brown w. some grey/orange mottling clayey SILT Trace gravel/sand near bottom of hole	S-1	0.6 – 1.1	
1.3		End of PIEZOMETER	S-2	1.1 – 1.3	

Comments: *Water Conditions in PIEZOMETER:* *WL at 275.61 masl on Apr. 20, 2007*

JOB No.	021-1238
PIEZOMETER No.:	MP 24
Technician:	Matt Bowman

Golder Associates

PIEZOMETER LOG

JOB NUMBER:	021-1238	**JOB NAME:**	Nelson Aggreg-Extension-Burlington	**DATE:**	Apr. 9, 2007
PIEZOMETER NUMBER:	MP 25	**LOCATION:**	Proposed Quarry Extension Area	**ELEVATION:**	276.28
MACHINE TYPE:	Hand Auger	**PIEZOMETER SIZE:**	Approx. 0.05m in Diameter	**DATUM:**	276.68
TEMP/WEATHER:	0, overcast	**CONTRACTOR:**	Manual Labour		

Depth		Soil Description	Samples		Remarks
From (m)	**To (m)**		**No.**	**Depth (m)**	
0.0	0.5	Organics			
0.5	0.9	Grey-brown clayey SILT w. trace gravel	S-1	0.5-0.9	
0.9	1.1	Grey-brown SILT w. sand, gravel and clay	S-2	0.9-1.1	
1.1	1.4	Brown clayey SILT w. some grey mottling	S-3	1.1-1.4	
1.4		End of PIEZOMETER			

Comments: *Water Conditions in PIEZOMETER:* *WL at 275.50 masl on Apr. 20, 2007*

JOB No.	021-1238
PIEZOMETER No.:	MP 25
Technician:	Matt Bowman

Golder Associates

PIEZOMETER LOG

JOB NUMBER:	021-1238	**JOB NAME:**	Nelson Aggreg-Extension-Burlington	**DATE:**	Apr. 9, 2007
PIEZOMETER NUMBER:	MP 26	**LOCATION:**	Proposed Quarry Extension Area	**ELEVATION:**	276.07
MACHINE TYPE:	Hand Auger	**PIEZOMETER SIZE:**	Approx. 0.05m in Diameter	**DATUM:**	276.625
TEMP/WEATHER:	0, overcast	**CONTRACTOR:**	Manual Labour		

Depth From (m)	Depth To (m)	Soil Description	Samples No.	Samples Depth (m)	Remarks
0.0	0.4	Organics			
0.4	0.7	Brown clayey SILT w. some grey/black mottling w. trace gravel	S-1	0.4-0.7	
0.7	1.05	Brown clayey SILT w. some grey/black mottling w. some gravel and sand	S-2	0.7-1.05	
1.05		End of PIEZOMETER			Auger hit stones/rock at 1.05m depth

Comments: *Water Conditions in PIEZOMETER:* *WL at 275.24 masl on Apr. 20, 2007*

JOB No.	021-1238
PIEZOMETER No.:	MP 26
Technician:	Matt Bowman

Golder Associates

PIEZOMETER LOG

JOB NUMBER:	021-1238	**JOB NAME:**	Nelson Aggreg-Extension-Burlington	**DATE:**	Apr. 10, 2007
PIEZOMETER NUMBER:	MP 27	**LOCATION:**	Proposed Quarry Extension Area	**ELEVATION:**	275.765
MACHINE TYPE:	Hand Auger	**PIEZOMETER SIZE:**	Approx. 0.05m in Diameter	**DATUM:**	276.185
TEMP/WEATHER:	0, sunny	**CONTRACTOR:**	Manual Labour		

Depth		Soil Description	Samples		Remarks
From (m)	**To (m)**		**No.**	**Depth (m)**	
0.0	0.6	Organics			
0.6	1.4	Grey-green, transitioning to brown with depth, SILT w. brown/orange mottling w. some clay	S-1	0.6-1.4	
1.4		End of PIEZOMETER			

Comments: *Water Conditions in PIEZOMETER:* *WL at 275.17 masl on Apr. 20, 2007*

JOB No.	021-1238
PIEZOMETER No.:	MP 27
Technician:	Matt Bowman

Golder Associates

PIEZOMETER LOG

JOB NUMBER:	021-1238	**JOB NAME:**	Nelson Aggreg-Extension-Burlington	**DATE:**	Apr. 10, 2007
PIEZOMETER NUMBER:	MP 28	**LOCATION:**	Proposed Quarry Extension Area	**ELEVATION:**	277.03
MACHINE TYPE:	Hand Auger	**PIEZOMETER SIZE:**	Approx. 0.05m in Diameter	**DATUM:**	277.57
TEMP/WEATHER:	0, sunny	**CONTRACTOR:**	Manual Labour		

Depth		Soil Description	Samples		Remarks
From (m)	**To (m)**		**No.**	**Depth (m)**	
0.0	0.4	Organics			
0.4	0.9	Brown clayey SILT w. red/orange/black mottling w. trace sand and gravel	S-1	0.4-0.9	
0.9	1.05	Brown clayey SILT w. red/orange/black mottling w. some sand and gravel	S-2	0.9-1.05	
1.05		End of PIEZOMETER			Auger hit stones at 1.05m depth

Comments: *Water Conditions in PIEZOMETER:* *WL at 276.25 masl on Apr. 20, 2007*

JOB No.	021-1238
PIEZOMETER No.:	MP 28
Technician:	Matt Bowman

Golder Associates

PIEZOMETER LOG

JOB NUMBER:	021-1238	**JOB NAME:**	Nelson Aggreg-Extension-Burlington	**DATE:**	Apr. 10, 2007
PIEZOMETER NUMBER:	MP 29	**LOCATION:**	Proposed Quarry Extension Area	**ELEVATION:**	276.62
MACHINE TYPE:	Hand Auger	**PIEZOMETER SIZE:**	Approx. 0.05m in Diameter	**DATUM:**	277.03
TEMP/WEATHER:	0, sunny	**CONTRACTOR:**	Manual Labour		

Depth		Soil Description	Samples		Remarks
From (m)	**To (m)**		**No.**	**Depth (m)**	
0.0	0.4	Organics			
0.4	1.25	Grey/brown clayey SILT w. trace gravel increasing with depth	S-1	0.4-1.25	
1.25	1.35	Brown SILT w. sand and gravel	S-2	1.25-1.35	
1.35		End of PIEZOMETER			

Comments: *Water Conditions in PIEZOMETER:* *WL at 276.43 masl on Apr. 20, 2007*

JOB No.	021-1238
PIEZOMETER No.:	MP 29
Technician:	Matt Bowman

Golder Associates

PIEZOMETER LOG

JOB NUMBER:	021-1238	**JOB NAME:**	Nelson Aggreg-Extension-Burlington	**DATE:**	Apr. 10, 2007
PIEZOMETER NUMBER:	MP 30	**LOCATION:**	Proposed Quarry Extension Area	**ELEVATION:**	275.915
MACHINE TYPE:	Hand Auger	**PIEZOMETER SIZE:**	Approx. 0.05m in Diameter	**DATUM:**	276.47
TEMP/WEATHER:	0, sunny	**CONTRACTOR:**	Manual Labour		

Depth From (m)	Depth To (m)	Soil Description	Samples No.	Samples Depth (m)	Remarks
0.0	0.4	Organics			
0.4	0.7	Brown/grey clayey SILT	S-1	0.4-0.7	
0.7	1.0	Brown/grey clayey SILT w. some gravel	S-2	0.7-1.0	
1.0		End of PIEZOMETER			Auger hit stone(s) at 1.0m depth

Comments: *Water Conditions in PIEZOMETER:* *WL at 275.05 masl on Apr. 20, 2007*

JOB No. 021-1238
PIEZOMETER No.: MP 30
Technician: Matt Bowman

Golder Associates

PIEZOMETER LOG

JOB NUMBER:	021-1238	**JOB NAME:**	Nelson Aggreg-Extension-Burlington	**DATE:**	Apr. 9, 2007
PIEZOMETER NUMBER:	MP 31	**LOCATION:**	Proposed Quarry Extension Area	**ELEVATION:**	277.96
MACHINE TYPE:	Hand Auger	**PIEZOMETER SIZE:**	Approx. 0.05m in Diameter	**DATUM:**	278.56
TEMP/WEATHER:	0, overcast	**CONTRACTOR:**	Manual Labour		

Depth From (m)	Depth To (m)	Soil Description	Samples No.	Samples Depth (m)	Remarks
0.0	0.4	Organics			
0.4	0.75	Brown w. some grey/orange mottling clayey SILT w. trace gravel	S-1	0.4-0.75	
0.75	0.95	Brown clayey SILT with gravel	S-2	0.75-0.95	
0.95		End of PIEZOMETER			Hit stones/rock at 0.95m depth

Comments: *Water Conditions in PIEZOMETER:* *WL at 277.28 masl on Apr. 20, 2007*

JOB No.	021-1238
PIEZOMETER No.:	MP 31
Technician:	Matt Bowman

Golder Associates

PIEZOMETER LOG

JOB NUMBER:	021-1238	**JOB NAME:**	Nelson Aggreg-Extension-Burlington	**DATE:**	Apr. 10, 2007
PIEZOMETER NUMBER:	MP 32	**LOCATION:**	Proposed Quarry Extension Area	**ELEVATION:**	276.595
MACHINE TYPE:	Hand Auger	**PIEZOMETER SIZE:**	Approx. 0.05m in Diameter	**DATUM:**	277.065
TEMP/WEATHER:	0, sunny	**CONTRACTOR:**	Manual Labour		

Depth		Soil Description	Samples		Remarks
From (m)	To (m)		No.	Depth (m)	
0.0	0.5	Organics			
0.5	1.0	Brown/grey mottled clayey SILT w. trace gravel	S-1	0.5-1.0	
1.0	1.35	Brown/red SILT w. sand and gravel	S-2	1.0-1.35	
1.35		End of PIEZOMETER			

Comments: *Water Conditions in PIEZOMETER:* *WL at 275.77 masl on Apr. 20, 2007*

JOB No.	021-1238
PIEZOMETER No.:	MP 32
Technician:	Matt Bowman

Golder Associates

PIEZOMETER LOG

JOB NUMBER:	021-1238	**JOB NAME:**	Nelson Aggreg-Extension-Burlington	**DATE:**	Apr. 14, 2010
PIEZOMETER NUMBER:	MP 33	**LOCATION:**	East of Proposed Quarry Extension Area ("Wong's Pond")	**ELEVATION:**	NA
MACHINE TYPE:	Hand Auger	**PIEZOMETER SIZE:**	Approx. 0.025m Diameter	**DATUM:**	NA
TEMP/WEATHER:	Sunny, 10°C	**CONTRACTOR:**	Golder		

Depth From (m)	Depth To (m)	Soil Description	Samples No.	Samples Depth (m)	Remarks
0.0	0.64	Stiff, dark brown with rusty colour, Silty Clay, trace sub round coarse Sand to fine Gravel, moist, some organics and rootlets	MP33	0 - 0.64	
0.64	0.97	Very stiff, mottled brown and grey with rusty colour, Silty Clay, trace sub round fine Gravel.	MP33	0.64 – 0.97	
0.97		End of PIEZOMETER			Borehole diameter is approx 0.05 m Hand cut screen approx 0.20 m length Well details: #2 Sand from 0.97 to 0.71 mbgs Benseal from 0.71 mbgs to ground surface Well stick up 0.60 m UTM COORDINATES NAD83, 17t, 591589; 4805514

Comments: *Water Conditions in PIEZOMETER:* *Water visible in bottom of borehole*

JOB No.	021-1238
PIEZOMETER No.:	MP 33
Technician:	Kyle Schepanow

PIEZOMETER LOG

Golder Associates

JOB NUMBER:	021-1238	**JOB NAME:**	Nelson Aggreg-Extension-Burlington	**DATE:**	Apr. 14, 2010
PIEZOMETER NUMBER:	MP 34	**LOCATION:**	Seasonally flooded area adjacent to Burlington Springs Golf Course	**ELEVATION:**	NA
MACHINE TYPE:	Hand Auger	**PIEZOMETER SIZE:**	Approx. 0.025m Diameter	**DATUM:**	NA
TEMP/WEATHER:	Sunny, 10°C	**CONTRACTOR:**	Golder		

Depth From (m)	Depth To (m)	Soil Description	Samples No.	Samples Depth (m)	Remarks
0.0	0.25	Soft, dark brown-black, Silt, trace fine Sand, organics and rootlets			
0.25	0.51	Stiff, Mottled brown and grey with some rusty colour, Silty Sand, trace sub round coarse Sand to fine Gravel, moist.	MP34	0.25 – 0.51	
0.51		End of PIEZOMETER			Borehole diameter is approx 0.05 m Hand cut screen approx 0.15 m length Well details: #2 Sand from 0.51 to 0.31 mbgs Benseal from 0.31 mbgs to ground surface Well stick up 0.52 m UTM COORDINATES NAD83, 17t 589858; 4804974

Comments: *Water Conditions in PIEZOMETER:* *Water visible in borehole*

JOB No.	021-1238
PIEZOMETER No.:	MP 34
Technician:	Kyle Schepanow

Golder Associates

PIEZOMETER LOG

JOB NUMBER:	021-1238	**JOB NAME:**	Nelson Aggreg-Extension-Burlington	**DATE:**	Apr. 14, 2010
PIEZOMETER NUMBER:	MP 35	**LOCATION:**	Flooded area north of Existing Quarry, north of Collins Rd.	**ELEVATION:**	NA
MACHINE TYPE:	Hand Auger	**PIEZOMETER SIZE:**	Approx. 0.025m Diameter	**DATUM:**	NA
TEMP/WEATHER:	Sunny, 10°C	**CONTRACTOR:**	Golder		

Depth From (m)	Depth To (m)	Soil Description	Samples No.	Samples Depth (m)	Remarks
0.0	0.20	Soft, dark brown-black, Clay, trace Silt, organics and rootlets			
0.20	0.97	Stiff, Mottled brown and grey with some rusty colour, Clayey Silt, trace sub round coarse Sand to fine Gravel, moist	MP35	0.20 – 0.97	
0.97	1.22	Very Stiff, mottled brown and grey, Silt, moist	MP35	0.97 – 1.22	
1.22		End of PIEZOMETER			
					Borehole diameter is approx 0.05 m Hand cut screen approx 0.2 m length Well details: #2 Sand from 1.22 to 0.94 mbgs Benseal from 0.94 mbgs to ground surface Well stick up 0.85 m UTM COORDINATES NAD83, 17t 590002; 4807119

Comments: *Water Conditions in PIEZOMETER:* *Water visible in borehole*

JOB No.	021-1238
PIEZOMETER No.:	MP 35
Technician:	Kyle Schepanow

Golder Associates

12.2 Pond and Trib Soil Sample Logs

SOIL SAMPLE LOG

JOB NUMBER:	021-1238	**JOB NAME:**	Nelson Aggreg-Extension-Burlington	**DATE:**	Apr. 15, 2010
SAMPLE NUMBER:	Pond1-B	**LOCATION:**	Across Wong's Pond from MP33	**ELEVATION:**	NA
MACHINE TYPE:	Hand Auger	**BOREHOLE SIZE:**	Approx. 0.05m Diameter	**DATUM:**	NA
TEMP/WEATHER:	~15°C, Sunny	**CONTRACTOR:**	Golder		

Depth From (m)	Depth To (m)	Soil Description	Samples No.	Samples Depth (m)	Remarks
0.0	0.31	Soft, dark brown, Clayey Silt, wet, organics and rootlets			
0.31	0.71	Very stiff, mottled brown and grey, Clay, trace Silt, trace sub round fine Gravel, wet	Pond1-B	0.31 – 0.71	
0.71	1.04	Very stiff, mottled brown and grey, Sandy Silt, grades to Clayey Silt, and trace sub round coarse Sand to fine Gravel, wet. Auger refusal at 1.04 m	Pond1-B	0.71 – 1.04	
1.04		End of Borehole			
					UTM COORDINATES NAD83, 17t 591544; 4805513

Comments:

Auger refusal did not feel like bedrock. Not possible to advance hand auger through very stiff soil.

Water Conditions in PIEZOMETER: Water visible in borehole7

JOB No. 021-1238
BOREHOLE No.: Pond1-B
Technician: Kyle Schepanow

Golder Associates

SOIL SAMPLE LOG

JOB NUMBER:	021-1238	**JOB NAME:**	Nelson Aggreg-Extension-Burlington	**DATE:**	Apr. 15, 2010
SAMPLE NUMBER:	Pond2	**LOCATION:**	Adjacent to Pond south of Wong's Pond on property east of Proposed Quarry Extension	**ELEVATION:**	NA
MACHINE TYPE:	Hand Auger	**BOREHOLE SIZE:**	Approx. 0.05m Diameter	**DATUM:**	NA
TEMP/WEATHER:	~15°C, Sunny	**CONTRACTOR:**	Golder		

Depth From (m)	Depth To (m)	Soil Description	Samples No.	Samples Depth (m)	Remarks
0.0	0.86	Stiff, dark brown and grey, Clay, trace Silt, moist, rootlets, gets stiffer with depth. Auger refusal at 0.86 m	Pond2	0 – 0.86	
0.86		End of Borehole			
					UTM COORDINATES NAD83, 17t 591752; 4805420

Comments:

This location requested by Nelson for soil grain size analysis.

Pond depth is approx 1.22 m deep near centre. Bottom is very soft. Probe pushed an additional 0.15 m into bottom and then auger refusal (hit what felt like rock).

Golder Associates

JOB No. 021-1238
PIEZOMETER No.: Pond2
Technician: Kyle Schepanow

SOIL SAMPLE LOG

JOB NUMBER:	021-1238	**JOB NAME:**	Nelson Aggreg-Extension-Burlington	**DATE:**	Apr. 15, 2010
SAMPLE NUMBER:	TR1B-01	**LOCATION:**	Adjacent to Tributary on western side of Proposed Quarry Extension near OW03-15	**ELEVATION:**	NA
MACHINE TYPE:	Hand Auger	**BOREHOLE SIZE:**	Approx. 0.05m Diameter	**DATUM:**	NA
TEMP/WEATHER:	~15°C, Sunny	**CONTRACTOR:**	Golder		

Depth From (m)	Depth To (m)	Soil Description	Samples No.	Samples Depth (m)	Remarks
0.0	0.25	Soft, dark brown-black, Clayey Silt, wet, organics and rootlets			
0.25	0.61	Very stiff, mottled brown and grey, Clayey Silt, trace sub round coarse Sand, wet. Auger refusal at 0.61 m	TR1B-01	0.25 – 0.61	
0.61		End of Borehole			
					UTM COORDINATES NAD83, 17t 590486; 4805285

Comments:

Sample collected from location directly adjacent of flowing tributary near well OW03-15.

JOB No.	021-1238
PIEZOMETER No.:	TR1B-01
Technician:	Kyle Schepanow

Golder Associates

SOIL SAMPLE LOG

JOB NUMBER:	021-1238	**JOB NAME:**	Nelson Aggreg-Extension-Burlington	**DATE:**	Apr. 15, 2010
SAMPLE NUMBER:	TR1B-02	**LOCATION:**	Adjacent to Tributary on western side of Proposed Quarry Extension near MW03-02	**ELEVATION:**	NA
MACHINE TYPE:	Hand Auger	**BOREHOLE SIZE:**	Approx. 0.05m Diameter	**DATUM:**	NA
TEMP/WEATHER:	~15°C, Sunny	**CONTRACTOR:**	Golder		

Depth		Soil Description	Samples		Remarks
From (m)	To (m)		No.	Depth (m)	
0.0	0.1	Soft, dark brown-black, Clayey Silt, wet, organics and rootlets			
0.1	0.41	Very stiff, mottled brown and grey, Clayey Silt, trace sub round coarse Sand, wet. Auger refusal at 0.41 m	TR1B-02	0.2 – 0.56	
0.41		End of Borehole			
					UTM COORDINATES NAD83, 17t 590486; 4805285

Comments:

Sample collected from location directly adjacent of flowing tributary.
Approx 26 m east of MW03-02 on western side of tributary.

JOB No.	021-1238
PIEZOMETER No.:	TR1B-02
Technician:	Kyle Schepanow

Golder Associates

SOIL SAMPLE LOG

JOB NUMBER:	021-1238	**JOB NAME:**	Nelson Aggreg-Extension-Burlington	**DATE:**	Apr. 15, 2010
SAMPLE NUMBER:	TR1B-03	**LOCATION:**	Along Tributary halfway between wells MW03-02 and OW03-15	**ELEVATION:**	NA
MACHINE TYPE:	Hand Auger	**BOREHOLE SIZE:**	Approx. 0.05m Diameter	**DATUM:**	NA
TEMP/WEATHER:	~15°C, Sunny	**CONTRACTOR:**	Golder		

Depth From (m)	Depth To (m)	Soil Description	Samples No.	Samples Depth (m)	Remarks
0.0	0.2	Soft, dark brown-black, Clayey Silt, wet, organics and rootlets			
0.2	0.56	Very stiff, mottled brown and grey, Clayey Silt, trace sub round coarse Sand, wet. Auger refusal at 0.56 m	TR1B-03	0.2 – 0.56	
0.56		End of Borehole			
					UTM COORDINATES NAD83, 17t 590427; 4805334

Comments:

Sample collected from location directly adjacent of flowing tributary. Sample located on eastern side of tributary, approx halfway between wells OW03-15 and MW03-02.

JOB No.	021-1238
PIEZOMETER No.:	TRIB-03
Technician:	Kyle Schepanow

Golder Associates

12.3 Soil Sample Logs

SOIL SAMPLE LOG

JOB NUMBER:	021-1238	**JOB NAME:**	Nelson Aggreg-Extension-Burlington	**DATE:**	July 12, 2010
SAMPLE NUMBER:	SA1-A	**LOCATION:**	Wetland area 13015 15m north west of SA1 Adjacent to GP-3 location	**ELEVATION:**	NA
MACHINE TYPE:	Hand Auger	**BOREHOLE SIZE:**	Approx. 0.05m Diameter	**DATUM:**	NA
TEMP/WEATHER:	29ºC, Sunny, some clouds	**CONTRACTOR:**	Golder		

Depth From (m)	Depth To (m)	Soil Description	Samples No.	Samples Depth (m)	Remarks
0.0	0.41	Soft, moist to wet, dark brown Silty Clay, trace fine Sand, roots and organics (Topsoil)	-	-	
0.41	0.78	Compact, moist, brown and grey mottled, fine Sandy Silt, trace rootlets, grades to moist-wet at 0.67 to 0.78, sharp lower contact	1	0.41 - 0.67	
0.78	0.82	Stiff, moist, brown and grey mottled, Clayey Silt, trace fine Sand	2	0.78 – 0.96	
0.82	0.96	Stiff, moist to wet, brown and grey mottled, Clayey Silt, trace fine Sand, wet at 0.85 m	-	-	
0.96	1.20	Very Stiff, moist, brown and grey mottled Clayey Silt, trace fine Sand	3	0.96 – 1.20	
1.20		Auger refusal, end of borehole			UTM COORDINATES NAD83, 17t 590913; 4805813

Comments:

JOB No. 021-1238
BOREHOLE No.: SA1-A
Technician: Kyle Schepanow

Golder Associates

SOIL SAMPLE LOG

JOB NUMBER:	021-1238	**JOB NAME:**	Nelson Aggreg-Extension-Burlington	**DATE:**	July 12, 2010
SAMPLE NUMBER:	SA2	**LOCATION:**	Wetland area 13016	**ELEVATION:**	NA
MACHINE TYPE:	Hand Auger	**BOREHOLE SIZE:**	Approx. 0.05m Diameter	**DATUM:**	NA
TEMP/WEATHER:	29°C, Sunny, some clouds	**CONTRACTOR:**	Golder		

Depth			Samples		Remarks
From (m)	**To (m)**	**Soil Description**	**No.**	**Depth (m)**	
0.0	0.30	Soft, moist to wet, black to dark brown Silty Clay, roots and organics (Topsoil)	-	-	
0.30	0.50	Stiff, moist, brown and grey mottled, Clayey Silt, trace fine Sand and trace rootlets, noticeably more stiff at 45 to 50 cm	1	0.30 – 0.50	
0.50	0.73	Stiff to very stiff, moist, brown and grey mottled, Clayey Silt, trace fine Sand	2	0.50 – 0.73	
0.73	0.86	Very Stiff, moist, brown and grey mottled, Clayey Silt, trace fine Sand	3	0.73 – 0.86	
0.86		Auger refusal, end of borehole			
					UTM COORDINATES NAD83, 17t 590941; 4805700

Comments:

JOB No. 021-1238
BOREHOLE No.: SA2
Technician: Kyle Schepanow

Golder Associates

SOIL SAMPLE LOG

JOB NUMBER:	021-1238	**JOB NAME:**	Nelson Aggreg-Extension-Burlington	**DATE:**	June 10, 2010
BOREHOLE NUMBER:	SA3	**LOCATION:**	Wetland Area 13018 Adjacent to SA3 pit location	**ELEVATION:**	NA
MACHINE TYPE:	Hand Auger	**BOREHOLE SIZE:**	Approx. 0.05m Diameter	**DATUM:**	NA
TEMP/WEATHER:	Sunny, partly cloudy, 19ºC	**CONTRACTOR:**	Golder		

Depth From (m)	Depth To (m)	Soil Description	Samples No.	Samples Depth (m)	Remarks
0.0	0.28	Soft, moist, dark brown-black, Silt, trace fine Sand, organics and rootlets (Topsoil)	1	0 – 0.28	
0.28	0.51	Firm, moist, brown and grey, Silty Clay, some sand	2	0.28 - 0.51	
0.51	0.64	Very stiff, moist, brown and grey, Silty Clay	3	0.51 - 0.64	
0.64	1.12	Firm, wet, brown and grey, Sandy Silt, some Clay, trace coarse Sand and fine Gravel,	4 5	0.64 – 0.81 0.81 – 1.12	
1.12	1.14	Very stiff to hard, moist, mottled brown and grey, Silty Clay	-	-	Poor recovery, no sample collected
1.14		Auger refusal, End of Borehole			
					UTM COORDINATES NAD83, 17t, 591103; 4805680

Comments:

JOB No.	021-1238
BOREHOLE No.:	SA3
Technician:	Kyle Schepanow

Golder Associates

SOIL SAMPLE LOG

JOB NUMBER:	021-1238	**JOB NAME:**	Nelson Aggreg-Extension-Burlington	**DATE:**	June 10, 2010
BOREHOLE NUMBER:	SA4	**LOCATION:**	Wetland Area 13020 Adjacent to SA4 pit location	**ELEVATION:**	NA
MACHINE TYPE:	Hand Auger	**BOREHOLE SIZE:**	Approx. 0.05m Diameter	**DATUM:**	NA
TEMP/WEATHER:	Sunny, partly cloudy, 19ºC	**CONTRACTOR:**	Golder		

Depth		Soil Description	Samples		Remarks
From (m)	**To (m)**		**No.**	**Depth (m)**	
0.0	0.38	Soft, dark brown-black, Silt, trace fine Sand, organics and rootlets (Topsoil)	-	-	
0.38	0.91	Stiff, moist to wet, mottled brown and grey with some rusty colour, Silty Clay, some fine Sand, trace coarse Sand	1	0.38 – 0.91	
0.91	1.27	Very stiff, wet, mottled brown and grey with some rusty colour, Clayey Silt, trace fine Sand	2	0.91 – 1.27	
1.27		Auger refusal, end of borehole			
					UTM COORDINATES NAD83, 17t 591019; 4805569

Comments:

Soil profile information collected by hand auger from 0 to 0.91 mbgs (June 10, 2010), and then extended to 1.27 mbgs using a combination of test pit excavation and soil coring using a Shelby tube (June 30, 2010).

JOB No.	021-1238
BOREHOLE No.:	SA4
Technician:	Kyle Schepanow

Golder Associates

SOIL SAMPLE LOG

JOB NUMBER:	021-1238	**JOB NAME:**	Nelson Aggreg-Extension-Burlington	**DATE:**	June 29, 2010
BOREHOLE NUMBER:	SA5	**LOCATION:**	Wetland area 13019 Adjacent to SA5 pit location	**ELEVATION:**	NA
MACHINE TYPE:	Soil Probe	**BOREHOLE SIZE:**	Approx. 0.02m Diameter	**DATUM:**	NA
TEMP/WEATHER:	19ºC, Sunny	**CONTRACTOR:**	Golder		

Depth From (m)	Depth To (m)	Soil Description	Samples No.	Samples Depth (m)	Remarks
0.0	0.12	Very soft, wet, dark brown-black, Clayey Silt, organics and rootlets (Topsoil).	-	-	
0.12	0.32	Soft, moist, mottled brown and grey, Clayey Silt, trace organics and rootlets.	1	0 – 0.32	
0.32	0.65	Firm, moist, mottled brown and grey, Clayey Silt, trace fine Sand and fine sub-round Gravel	2	0.32 – 0.65	
0.65	0.94	Very stiff, moist, mottled brown and grey, Sandy Silt, some Clay, trace fine sub-round Gravel	3	0.65 – 0.94	Very hard to push probe from 0.85 to 0.94 m
0.94	1.05	Very stiff, moist, mottled brown and grey, Clayey Silt, some fine Sand and fine sub-round Gravel	-	-	Poor recovery, no sample
1.05	1.29	Very stiff, moist, brown, Silty Sand, some Clay, trace sub-round fine Gravel	-	-	
1.29		Probe refusal			UTM COORDINATES NAD83, 17t 591125; 4805488

Comments:

JOB No.	021-1238
BOREHOLE No.:	SA5
Technician:	Kyle Schepanow

Golder Associates

SOIL SAMPLE LOG

JOB NUMBER:	021-1238	**JOB NAME:**	Nelson Aggreg-Extension-Burlington	**DATE:**	June 29, 2010
BOREHOLE NUMBER:	SA6	**LOCATION:**	Wetland area 13023 Adjacent to SA6 pit location	**ELEVATION:**	NA
MACHINE TYPE:	Soil Probe	**BOREHOLE SIZE:**	Approx. 0.02m Diameter	**DATUM:**	NA
TEMP/WEATHER:	19ºC, Sunny	**CONTRACTOR:**	Golder		

Depth			Samples		Remarks
From (m)	**To (m)**	**Soil Description**	**No.**	**Depth (m)**	
0.0	0.11	Very soft, wet, dark brown-black, Clayey Silt, organics and rootlets (Topsoil).			
0.11	0.32	Soft, moist, mottled brown and grey, Clayey Silt, trace rootlets.	1	0 – 0.32	
0.32	0.68	Firm, moist, mottled brown and grey, Clayey Silt, trace rootlets	-	-	Poor sample recovery
0.68	0.88	Firm to stiff, moist, mottled brown and grey, Clayey Silt, trace fine Sand	2	0.68 – 0.88	
0.88	1.10	Very stiff, dry to moist, mottled brown and grey, Clayey Silt, trace fine Sand and trace sub round fine gravel	3	0.88 – 1.10	
1.10	1.15	Very stiff, moist, mottled brown and grey, Clayey Silt, trace sub-round fine Gravel	-	-	
1.15	1.32	Very stiff, moist, mottled brown and grey, Sandy Silt, some Clay, trace sub-round fine Gravel	4	1.15 – 1.30	
1.32		Probe refusal			
					UTM COORDINATES NAD83, 17t 591199; 4805610

Comments:

JOB No. 021-1238
BOREHOLE No.: SA6
Technician: Kyle Schepanow

Golder Associates

SOIL SAMPLE LOG

JOB NUMBER:	021-1238	**JOB NAME:**	Nelson Aggreg-Extension-Burlington	**DATE:**	June 10, 2010
BOREHOLE NUMBER:	SA7	**LOCATION:**	Wetland Area 13029 Adjacent to SA7 pit location	**ELEVATION:**	NA
MACHINE TYPE:	Hand Auger	**BOREHOLE SIZE:**	Approx. 0.05m Diameter	**DATUM:**	NA
TEMP/WEATHER:	Sunny, partly cloudy, 19ºC	**CONTRACTOR:**	Golder		

Depth From (m)	Depth To (m)	Soil Description	Samples No.	Samples Depth (m)	Remarks
0.0	0.20	Soft, dark brown-black, Silt, trace fine Sand, organics and rootlets (Topsoil)	-	-	
0.20	0.53	Very stiff, moist, mottled brown and grey with some rusty colour, Clayey Silt, some fine Sand	1	0.20 – 0.53	
0.53		Auger refusal, end of borehole			
					UTM COORDINATES NAD83, 17t 591267; 4805476

Comments:

JOB No.	021-1238
BOREHOLE No.:	SA7
Technician:	Kyle Schepanow

Golder Associates

SOIL SAMPLE LOG

JOB NUMBER:	021-1238	**JOB NAME:**	Nelson Aggreg-Extension-Burlington	**DATE:**	June 29, 2010
BOREHOLE NUMBER:	SA8	**LOCATION:**	Wetland area 13030 Adjacent to SA8 pit location	**ELEVATION:**	NA
MACHINE TYPE:	Soil Probe	**BOREHOLE SIZE:**	Approx. 0.02m Diameter	**DATUM:**	NA
TEMP/WEATHER:	19ºC, Sunny	**CONTRACTOR:**	Golder		

Depth			Samples		Remarks
From (m)	**To (m)**	**Soil Description**	**No.**	**Depth (m)**	
0.0	0.14	Very soft, wet, dark brown-black, Silt, some Clay, organics and rootlets (Topsoil).	-	-	
0.14	0.27	Soft, moist, mottled brown and grey, Silt, some Clay, trace rootlets.	1	0 – 0.27	Composite sample
0.27	0.57	Firm, moist to wet, mottled brown and grey, Silty Clay, trace rootlets	-	-	
0.57	0.84	Soft to firm, moist, mottled brown and grey, Silt Clay, some fine Sand at 0.8 to 0.84m	2	0.57 – 0.84	
0.84	1.10	Firm to stiff, moist, mottled brown and grey, Clayey Silt, trace fine Sand	3	0.84 – 1.10	
1.10	1.20	Very stiff, dry, mottled brown and grey, Clayey Silt, trace fine Sand	4	1.10 – 1.20	
1.20		Probe refusal			
					UTM COORDINATES NAD83, 17t 591350; 4805479

Comments:

Could not find physical location of pit, borehole placed as close as possible to SA#8 UTM coordinates.

JOB No. 021-1238
BOREHOLE No.: SA8
Technician: Kyle Schepanow

Golder Associates

JOB NUMBER:	021-1238	**JOB NAME:**	Nelson Aggreg-Extension-Burlington	**DATE:**	July 12, 2010
SAMPLE NUMBER:	SA9	**LOCATION:**	Wetland area 13022	**ELEVATION:**	NA
MACHINE TYPE:	Hand Auger	**BOREHOLE SIZE:**	Approx. 0.05m Diameter	**DATUM:**	NA
TEMP/WEATHER:	29ºC, Sunny, some clouds	**CONTRACTOR:**	Golder		

Depth		Soil Description	Samples		Remarks
From (m)	To (m)		No.	Depth (m)	
0.0	0.30	Firm, moist, black to dark brown, Silty Clay, trace rootlets and organics (Topsoil)	-	-	
0.30	0.42	Very stiff, moist, moist, brown and grey mottled, Silty Clay, trace fine Sand, trace rootlets, difficult to auger	1	0.30 – 0.42	
0.42	0.63	Very stiff to hard, moist, moist, brown and grey mottled, Silty Clay, trace fine Sand, trace rootlets, difficult to auger	2	0.42 – 0.63	
0.63	0.76	Very Stiff, moist, brown and grey mottled, Silt, some Clay, trace fine Sand	3	0.63 – 0.76	
0.76		Auger refusal, end of borehole			UTM COORDINATES NAD83, 17t 591119; 4805392

Comments:

JOB No.	021-1238
BOREHOLE No.:	SA9
Technician:	Kyle Schepanow

Golder Associates

SOIL SAMPLE LOG

JOB NUMBER:	021-1238	**JOB NAME:**	Nelson Aggreg-Extension-Burlington	**DATE:**	July 15, 2010
SAMPLE NUMBER:	SA10	**LOCATION:**	Tree plantation field	**ELEVATION:**	NA
MACHINE TYPE:	Hand Auger	**BOREHOLE SIZE:**	Approx. 0.05m Diameter	**DATUM:**	NA
TEMP/WEATHER:	29ºC, Sunny, some clouds	**CONTRACTOR:**	Golder		

Depth From (m)	Depth To (m)	Soil Description	Samples No.	Samples Depth (m)	Remarks
0.0	0.17	Compact, dry, dark brown Silt, some fine Sand, trace Clay, trace rootlets (Topsoil)	-	-	
0.17	0.30	Stiff, moist, moist, brown and grey mottled, Clayey Silt, trace fine Sand	1	0.17 – 0.30	
0.30	0.52	Stiff to very stiff, moist, brown and grey mottled, Clayey Silt, trace fine Sand and trace rootlets	2	0.30 – 0.52	
0.52	0.72	Very Stiff, moist, brown and grey mottled, Clayey Silt, some fine Sand, trace fine Gravel	3	0.52 – 0.71	
0.72		Auger refusal, end of borehole			UTM COORDINATES NAD83, 17t 591135; 4805318

Comments:

JOB No.	021-1238
BOREHOLE No.:	SA10
Technician:	Kyle Schepanow

SOIL SAMPLE LOG

Golder Associates

SOIL SAMPLE LOG

JOB NUMBER:	021-1238	**JOB NAME:**	Nelson Aggreg-Extension-Burlington	**DATE:**	June 29, 2010
BOREHOLE NUMBER:	SA11	**LOCATION:**	Tree plantation Adjacent to SA11 sample pit location	**ELEVATION:**	NA
MACHINE TYPE:	Soil Probe	**BOREHOLE SIZE:**	Approx. 0.02m Diameter	**DATUM:**	NA
TEMP/WEATHER:	19°C, Sunny	**CONTRACTOR:**	Golder		

Depth		Soil Description	Samples		Remarks
From (m)	To (m)		No.	Depth (m)	
0.0	0.14	Soft, moist, dark brown-black, Silt, some Clay, organics and rootlets (Topsoil).	-	-	
0.14	0.32	Firm, moist, brown, Silt, some Clay, trace rootlets.	1	0 – 0.32	Composite sample
0.32	0.70	Firm, moist, brown, Clayey Silt, trace rootlets and trace sub-round fine Gravel	2	0.32 – 0.70	
0.70	0.90	Very stiff, dry, light brown, Silt, trace clay and trace sub-round fine Gravel	3	0.70 – 0.90	
0.90	1.04	Very stiff, dry, mottled brown and grey, Silty Clay, trace fine Sand	4	0.90 – 1.04	
1.04	1.17	Very stiff, moist, mottled brown and grey, Sandy Silt with Clay, trace fine Gravel	5	1.04 – 1.17	
1.17		Probe refusal			
					UTM COORDINATES NAD83, 17t 591363; 4805327

Comments:

JOB No.	021-1238
BOREHOLE No.:	SA11
Technician:	Kyle Schepanow

Golder Associates

SOIL SAMPLE LOG

JOB NUMBER:	021-1238	**JOB NAME:**	Nelson Aggreg-Extension-Burlington	**DATE:**	June 10, 2010
BOREHOLE NUMBER:	SA12	**LOCATION:**	Wetland Area 13037 Adjacent to SA12 pit location	**ELEVATION:**	NA
MACHINE TYPE:	Hand Auger	**BOREHOLE SIZE:**	Approx. 0.05m Diameter	**DATUM:**	NA
TEMP/WEATHER:	Sunny, partly cloudy, 19°C	**CONTRACTOR:**	Golder		

Depth		Soil Description	Samples		Remarks
From (m)	**To (m)**		**No.**	**Depth (m)**	
0.0	0.36	Soft, dark brown-black, Silt, trace fine Sand, organics and rootlets (Topsoil).	-	-	
0.36	0.58	Stiff, moist, mottled brown and grey, Silty Clay, trace fine Sand	1	0.36 – 0.58	
0.58	0.64	Compact, wet, brown, Sandy Silt, trace coarse Sand	2	0.58 – 0.64	
0.64	0.81	Very stiff, moist, mottled brown and grey, Sandy Clayey Silt, trace Gravel	3	0.64 – 0.81	
0.81		Auger refusal, end of borehole			
					UTM COORDINATES NAD83, 17t 591139; 4805247

Comments:

JOB No.	021-1238
BOREHOLE No.:	SA12
Technician:	Kyle Schepanow

Golder Associates

SOIL SAMPLE LOG

JOB NUMBER:	021-1238	**JOB NAME:**	Nelson Aggreg-Extension-Burlington	**DATE:**	June 10, 2010
BOREHOLE NUMBER:	SA13	**LOCATION:**	Open field east of Wetland Area 13033	**ELEVATION:**	NA
MACHINE TYPE:	Hand Auger	**BOREHOLE SIZE:**	Approx. 0.05m Diameter	**DATUM:**	NA
TEMP/WEATHER:	Sunny, partly cloudy, 19ºC	**CONTRACTOR:**	Golder		

Depth		Soil Description	Samples		Remarks
From (m)	To (m)		No.	Depth (m)	
0.0	0.41	Soft, dark brown-black, Silt, trace fine Sand, organics and rootlets (Topsoil).	-	-	
0.41	0.74	Stiff, moist, mottled brown and grey, Silty Clay, trace fine Sand, grades to Clayey Silt at 0.74m	1	0.41 – 0.74	
0.74	0.84	Very stiff, moist, mottled brown and grey, Clayey Silt, some fine Sand	2	0.74 – 0.84	
0.84		Auger refusal, end of borehole			
					UTM COORDINATES NAD83, 17t 591159; 4805170

Comments:

JOB No.	021-1238
BOREHOLE No.:	SA13
Technician:	Kyle Schepanow

Golder Associates

SOIL SAMPLE LOG

JOB NUMBER:	021-1238	**JOB NAME:**	Nelson Aggreg-Extension-Burlington	**DATE:**	July 12, 2010
SAMPLE NUMBER:	SA14	**LOCATION:**	Tree plantation field	**ELEVATION:**	NA
MACHINE TYPE:	Hand Auger	**BOREHOLE SIZE:**	Approx. 0.05m Diameter	**DATUM:**	NA
TEMP/WEATHER:	29ºC, Sunny, some clouds	**CONTRACTOR:**	Golder		

Depth From (m)	Depth To (m)	Soil Description	Samples No.	Samples Depth (m)	Remarks
0.0	0.10	Soft, moist, dark brown Clayey Silt, trace fine Sand, trace rootlets (Topsoil)	-	-	
0.10	0.25	Stiff, moist, brown and grey mottled, Clayey Silt, trace fine Sand and trace rootlets	1	0.10 – 0.25	
0.25	0.32	Stiff to very stiff, moist, brown and grey mottled, Clayey Silt, some fine Sand, trace sub round fine Gravel	2	0.25 – 0.42	
0.32	0.44	Very Stiff, dry to moist, brown and grey mottled, Clayey Silt, some fine Sand, trace sub round fine Gravel			
0.44		Auger refusal, end of borehole			UTM COORDINATES NAD83, 17t 591191; 4805455

Comments:

JOB No. 021-1238
BOREHOLE No.: SA14
Technician: Kyle Schepanow

Golder Associates

SOIL SAMPLE LOG

JOB NUMBER:	021-1238	**JOB NAME:**	Nelson Aggreg-Extension-Burlington	**DATE:**	June 29, 2010
BOREHOLE NUMBER:	SA15	**LOCATION:**	Wetland area 13039 Adjacent to MP16, South West Woodlot	**ELEVATION:**	NA
MACHINE TYPE:	Soil Probe	**BOREHOLE SIZE:**	Approx. 0.02m Diameter	**DATUM:**	NA
TEMP/WEATHER:	19°C, Sunny	**CONTRACTOR:**	Golder		

Depth From (m)	Depth To (m)	Soil Description	Samples No.	Samples Depth (m)	Remarks
0.0	0.17	Very soft, wet, dark brown-black, Silt, some Clay, organics and rootlets (Topsoil).	-	-	
0.17	0.32	Soft to firm, moist, mottled brown and grey, Silty Clay, trace sub-round fine Gravel, trace rootlets	1	0 – 0.32	Composite sample
0.32	0.67	Soft to firm, moist to wet, mottled brown and grey, Silty Clay, trace fine Sand	2	0.32 – 0.67	
0.67	1.04	Soft, wet, mottled brown and grey, Silty Clay, some fine Sand, trace sub-round fine Gravel	3	0.67 – 1.04	
1.04	1.40	Firm, wet, mottled brown and grey, Clayey Silt, some fine Sand and fine sub-round Gravel	-	-	Poor recovery, no sample collected
1.40	1.65	Stiff, wet, mottled brown and grey, Silt with fine Sand, trace Clay, trace sub-round fine Gravel, grades to stiff to very stiff material at 1.65 mbgs	4	1.40 – 1.65	
1.65		Probe refusal			
					UTM COORDINATES NAD83, 17t 590995; 4804969

Comments:

JOB No.	021-1238
BOREHOLE No.:	SA15
Technician:	Kyle Schepanow

Golder Associates

SOIL SAMPLE LOG

JOB NUMBER:	021-1238	**JOB NAME:**	Nelson Aggreg-Extension-Burlington	**DATE:**	June 29, 2010
BOREHOLE NUMBER:	SA16	**LOCATION:**	Wetland area 13037 Adjacent to MP14, South West Woodlot	**ELEVATION:**	NA
MACHINE TYPE:	Soil Probe	**BOREHOLE SIZE:**	Approx. 0.02m Diameter	**DATUM:**	NA
TEMP/WEATHER:	19°C, Sunny	**CONTRACTOR:**	Golder		

Depth From (m)	Depth To (m)	Soil Description	Samples No.	Samples Depth (m)	Remarks
0.0	0.22	Very soft, wet, dark brown-black, Silt, some Clay, organics and rootlets (Topsoil)	-	-	
0.22	0.32	Soft, moist, mottled brown and grey, Silty Clay, trace rootlets	-	-	Poor sample recovery
0.32	0.72	Firm to stiff, moist, mottled brown and grey, Silty Clay, trace fine Sand and trace sub-round fine Gravel	1	0.32 – 0.70	
0.72	1.10	Soft, wet, mottled brown and grey, Silty Clay, trace fine Sand, trace sub-round fine Gravel	-	-	Poor sample recovery
1.10	1.30	Soft, wet, mottled brown and grey, Silty Clay, trace fine Sand, trace sub-round fine Gravel	-	-	Poor sample recovery
1.30	1.45	Compact, wet, Sandy Silt, some medium Sand, trace Clay	-	-	Poor sample recovery
1.45	1.80	Firm, wet, Clayey Silt, some fine Sand	-	-	Poor sample recovery
1.80	2.25	Stiff, wet, brown, Silt, some Clay, some fine Sand, trace sub-round fine Gravel	2	1.90 – 2.25	
2.25		End of borehole; probe refusal			UTM COORDINATES NAD83, 17t 590916; 4804899

Comments:

JOB No.	021-1238
BOREHOLE No.:	SA16
Technician:	Kyle Schepanow

Golder Associates

SOIL SAMPLE LOG

JOB NUMBER:	021-1238	**JOB NAME:**	Nelson Aggreg-Extension-Burlington	**DATE:**	June 30, 2010
TEST PIT NUMBER:	SA17	**LOCATION:**	Farmers Field, just north of South West Woodlot	**ELEVATION:**	NA
MACHINE TYPE:	Hand Dug Test Pit and Soil Probe	**BOREHOLE SIZE:**	NA	**DATUM:**	NA
TEMP/WEATHER:	19°C, Sunny	**CONTRACTOR:**	Golder		

Depth From (m)	Depth To (m)	Soil Description	Samples No.	Samples Depth (m)	Remarks
0.0	0.10	Compact, moist, brown, Sandy Silt (Topsoil)			
0.10	0.40	Compact to dense, moist, brown, Silt, some fine Sand, trace sub-round fine and coarse Gravel, trace rootlets			
0.40	0.80	Hard, dry, brown, Silt, trace Clay, trace fine Sand, trace rootlets and trace sub-round fine and coarse Gravel (5-10cm diameter)	1	0.40 – 0.60	
0.80	0.90	Dense, moist, Silt, some Clay, trace fine sand, trace sub-round coarse Gravel	2	0.80 – 0.90	Slightly softer material than above
0.90	1.27	Dense, wet, Sandy Silt, some Clay, trace sub-round Gravel	3	0.90 – 1.27	
1.27		End of soil profile, probe refusal			
					UTM COORDINATES NAD83, 17t 590907; 4805004

Comments:

Soil profile observed during excavation of small test pit, from 0 to 0.95 mbgs. Soil core collected from 0.95 mbgs to 1.27 mbgs using a Shelby tube.

JOB No.	021-1238
Test Pit No.:	SA17
Technician:	Kyle Schepanow

Golder Associates

12.4 GMP Logs

SOIL SAMPLE LOG

JOB NUMBER:	021-1238	**JOB NAME:**	Nelson Aggreg-Extension-Burlington	**DATE:**	July 13, 2010
BOREHOLE NUMBER:	GPM-1	**LOCATION:**	Wetland Area 13015	**ELEVATION:**	NA
MACHINE TYPE:	Hand Auger GP Kit Equipment	**BOREHOLE SIZE:**	Approx. 0.06m Diameter	**DATUM:**	NA
TEMP/WEATHER:	Sunny, partly cloudy, 25°C	**CONTRACTOR:**	Golder		

Depth			Samples		
From (m)	**To (m)**	**Soil Description**	**No.**	**Depth (m)**	**Remarks**
0.0	0.30	Soft, moist, dark brown-black, Silt, trace fine Sand, organics and rootlets (Topsoil)	-	-	Guelph Permeameter base set at 0.23 mbgs
0.30	0.50	Firm, moist, brown and grey, Clayey Silt, some Sand, trace Gravel	1	0.30 - 0.50	Guelph Permeameter base set at 0.5 mbgs
0.50		End of borehole			
					UTM COORDINATES NAD83, 17t, 591293; 4805215

Comments:
Testing of topsoil layer at GPM-1 occurred on May 27, 2010. At that time soil was too saturated to test lower soil layer. Lower soil layer test completed on July 13, 2010.

JOB No.	021-1238
TEST LOCATION No.:	GPM-1
Technician:	Kyle Schepanow

Golder Associates

SOIL SAMPLE LOG

JOB NUMBER:	021-1238	**JOB NAME:**	Nelson Aggreg-Extension-Burlington	**DATE:**	May 28, 2010
BOREHOLE NUMBER:	GPM-2	**LOCATION:**	Wetland Area 13017 "Willow Pond"	**ELEVATION:**	NA
MACHINE TYPE:	Hand Auger GP Kit Equipment	**BOREHOLE SIZE:**	Approx. 0.06m Diameter	**DATUM:**	NA
TEMP/WEATHER:	Sunny, partly cloudy, 25°C	**CONTRACTOR:**	Golder		

Depth		Soil Description	Samples		Remarks
From (m)	**To (m)**		**No.**	**Depth (m)**	
0.0	0.43	Soft, dark brown-black, Silt, trace fine Sand, organics and rootlets (Topsoil)	1	0 – 0.43	Guelph Permeameter base set at 0.31 mbgs
0.43	0.72	Very stiff, moist, mottled brown and grey with some rusty colour, Silt, some Clay, some fine Sand, trace Gravel	2	0.43 – 0.72	Guelph Permeameter base set at 0.72 mbgs
0.72		End of borehole			
					UTM COORDINATES NAD83, 17t 590997; 4805606

Comments:

Both the topsoil and "hard pan" soil layers were tested on May 28, 2010.

JOB No.	021-1238
TEST LOCATION No.:	GPM-2
Technician:	Kyle Schepanow

Golder Associates

SOIL SAMPLE LOG

JOB NUMBER:	021-1238	**JOB NAME:**	Nelson Aggreg-Extension-Burlington	**DATE:**	July 13, 2010
BOREHOLE NUMBER:	GPM-3	**LOCATION:**	Wetland Area 13015	**ELEVATION:**	NA
MACHINE TYPE:	Hand Auger GP Kit Equipment	**BOREHOLE SIZE:**	Approx. 0.06m Diameter	**DATUM:**	NA
TEMP/WEATHER:	Sunny, partly cloudy, 25°C	**CONTRACTOR:**	Golder		

Depth		Soil Description	Samples		Remarks
From (m)	**To (m)**		**No.**	**Depth (m)**	
0.0	0.44	Very soft, moist, dark brown, Clayey Silt, some fine Sand, organics and rootlets (Topsoil)	-	-	Guelph Permeameter base set at 0.24 mbgs
0.44	1.02	Firm, moist, mottled brown and grey with some rusty colour, Silt with Sand, some Clay, wet at 0.8 mbgs	1	0.42 – 0.62	Guelph Permeameter base set at 0.62 mbgs
1.02	1.17	Very Stiff, wet, mottled brown and grey, Clayey Silt	-	-	
					UTM COORDINATES NAD83, 17t 590913; 4805813

Comments:
Testing of topsoil layer at GPM-3 occurred on June 1, 2010. At that time soil was too saturated to test lower soil layer. Lower soil layer test completed on July 13, 2010.

JOB No.	021-1238
TEST LOCATION No.:	GPM-3
Technician:	Kyle Schepanow

Golder Associates

SOIL SAMPLE LOG

JOB NUMBER:	021-1238	**JOB NAME:**	Nelson Aggreg-Extension-Burlington	**DATE:**	June 4, 2010
BOREHOLE NUMBER:	GPM-4	**LOCATION:**	Wetland Area 13014	**ELEVATION:**	NA
MACHINE TYPE:	Hand Auger GP Kit Equipment	**BOREHOLE SIZE:**	Approx. 0.06m Diameter	**DATUM:**	NA
TEMP/WEATHER:	Sunny, 25°C	**CONTRACTOR:**	Golder		

Depth		Soil Description	Samples		Remarks
From (m)	**To (m)**		**No.**	**Depth (m)**	
0.0	0.25	Very soft, moist, dark brown, Clayey Silt, organics and rootlets (Topsoil).	-	-	
0.25	0.53	Very stiff, moist, mottled brown and grey, Silt with Clay, trace Sand	1	0.3 – 0.5	Guelph Permeameter base set at 0.53 mbgs
0.53		End of borehole			
					UTM COORDINATES NAD83, 17t 591057; 4805779

Comments:
No permeameter testing completed on the topsoil layer at this location.

JOB No.	021-1238
TEST LOCATION No.:	GPM-4
Technician:	Kyle Schepanow

Golder Associates

SOIL SAMPLE LOG

JOB NUMBER:	021-1238	**JOB NAME:**	Nelson Aggreg-Extension-Burlington	**DATE:**	July 22, 2010
BOREHOLE NUMBER:	GPM-5	**LOCATION:**	Wetland Area 13019	**ELEVATION:**	NA
MACHINE TYPE:	Hand Auger GP Kit Equipment	**BOREHOLE SIZE:**	Approx. 0.06m Diameter	**DATUM:**	NA
TEMP/WEATHER:	Sunny, 29°C	**CONTRACTOR:**	Golder		

Depth		Soil Description	Samples		Remarks
From (m)	To (m)		No.	Depth (m)	
0.0	0.25	Very soft, moist, dark brown, Clayey Silt, organics and rootlets (Topsoil).	-	-	
0.25	0.47	Firm, moist, mottled brown and grey, Clayey Silt, some fine Sand, trace rootlets	1	0.25 – 0.45	Guelph Permeameter base set at 0.47 mbgs
0.47	1.2	Firm, dry-moist, mottled brown and grey, Clayey Silt, trace fine Sand, trace rootlets, fining of grain size with increased depth	2	0.47 – 1.2	Guelph Permeameter base set at 1.2 mbgs
1.2	1.52	Stiff, moist, mottled brown and grey, Silt, some Clay, trace fine Sand	3	1.2 – 1.52	Guelph Permeameter base set at 1.52 mbgs
					UTM COORDINATES NAD83, 17t 591065; 4805494

Comments:
A more detailed vertical profile of the mottled till soil was conducted at this location because of the field observations that indicated a relatively greater amount of Sand in the sample compared to other testing locations.

JOB No.	021-1238
TEST LOCATION No.:	GPM-5
Technician:	Kyle Schepanow

Golder Associates

SOIL SAMPLE LOG

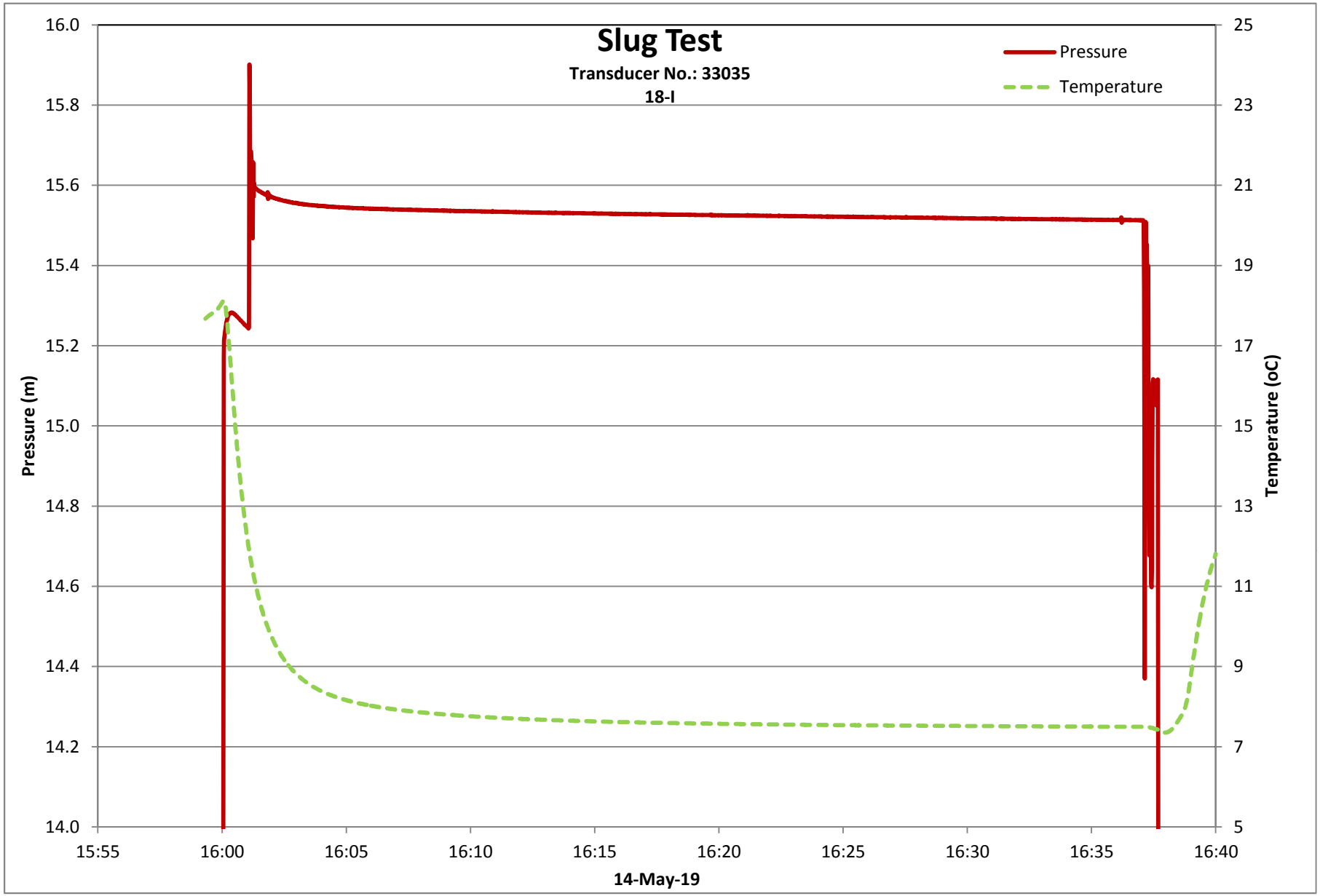
JOB NUMBER:	021-1238	**JOB NAME:**	Nelson Aggreg-Extension-Burlington	**DATE:**	July 14, 2010
BOREHOLE NUMBER:	GPM-6	**LOCATION:**	Wetland Area 13037 Southwest Woodlot	**ELEVATION:**	NA
MACHINE TYPE:	Hand Auger GP Kit Equipment	**BOREHOLE SIZE:**	Approx. 0.06m Diameter	**DATUM:**	NA
TEMP/WEATHER:	Sunny, 29°C	**CONTRACTOR:**	Golder		

Depth From (m)	Depth To (m)	Soil Description	Samples No.	Samples Depth (m)	Remarks
0.0	0.25	Soft, moist, dark brown-black, Clayey Silt, organics and rootlets (Topsoil).	-	-	
0.25	0.52	Firm, moist, mottled brown and grey, Sandy Silt, some Clay, trace Gravel	1	0.25 – 0.52	Guelph Permeameter base set at 0.52 mbgs
0.52		End of borehole			
					UTM COORDINATES NAD83, 17t 590916; 4804899

Comments:
No permeameter testing completed on the topsoil layer at this location.

JOB No. 021-1238
TEST LOCATION No.: GPM-6
Technician: Kyle Schepanow

Golder Associates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Transducer No.: 33035
18-I
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Temperature (oC)
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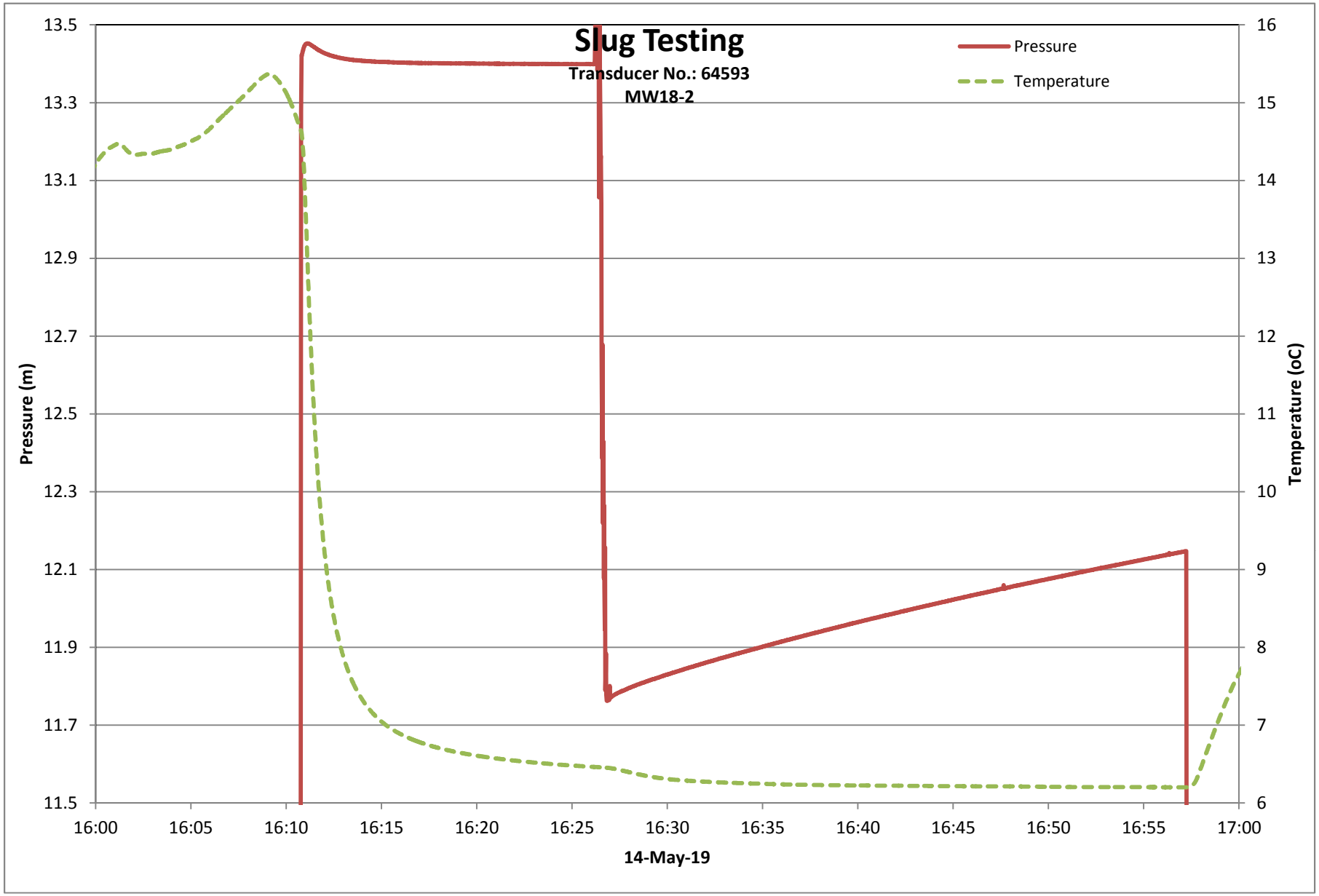
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Transducer No.: 64593
MW18-2
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Temperature
Pressure (m)
Temperature (oC)
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13.3
13.1
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12.7
12.5
12.3
12.1
11.9
11.7
11.5
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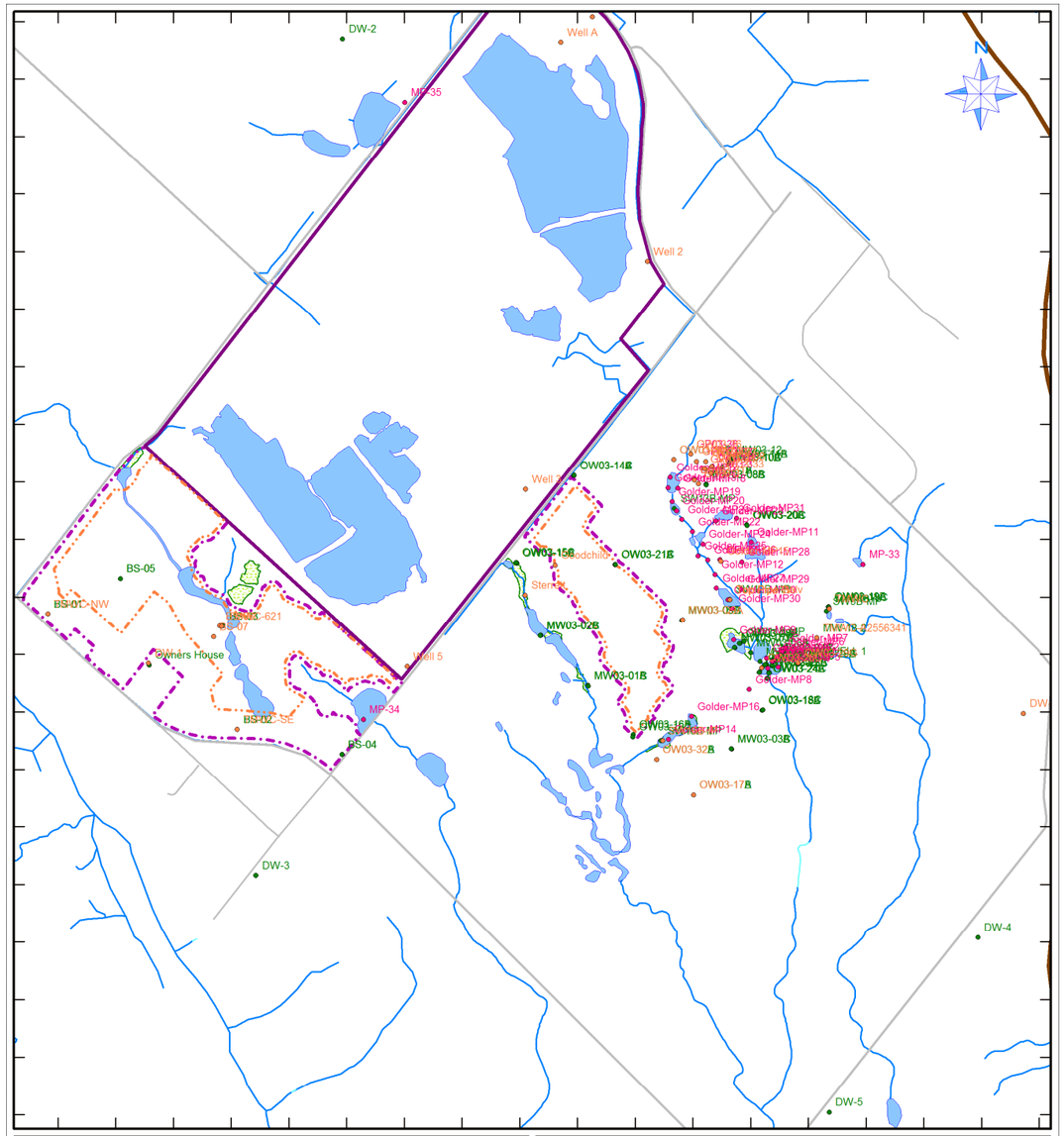
14-May-19



Legend:

- Roads
- Express/Highway
- Existing Quarry
- Expansion Lands
- Extraction Area
- River/Stream
- Lake
- Wetland
- Niagara Escarpment
- Model Boundary
- Cross Section
- Active Monitor Wells
- Inactive Monitor Wells
- Other Monitor Wells

0 200 400 600
Units: UTM NAD83 Zone 17

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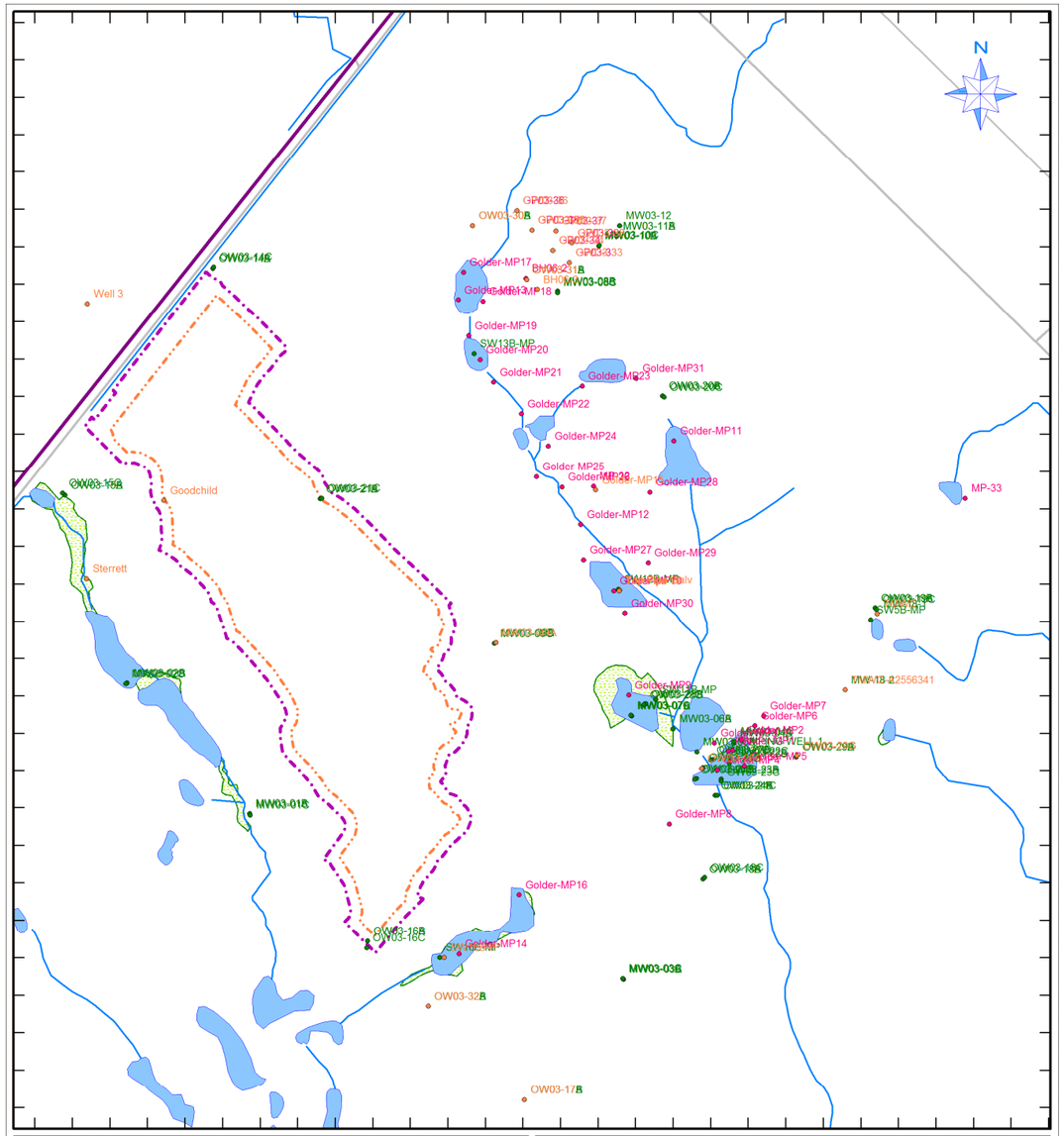
Drawing prepared by Earthfx 7/05/21

NELSON AGGREGATES

Burlington Quarry Extension

Earthfx Incorporated

Location of all Monitoring Wells



Legend:

- Roads
- Express/Highway
- Existing Quarry
- Expansion Lands
- Extraction Area
- River/Stream
- Lake
- Wetland
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- Model Boundary
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- Active Monitor Wells
- Inactive Monitor Wells
- Other Monitor Wells

0 100 200
Units: UTM NAD83 Zone 17

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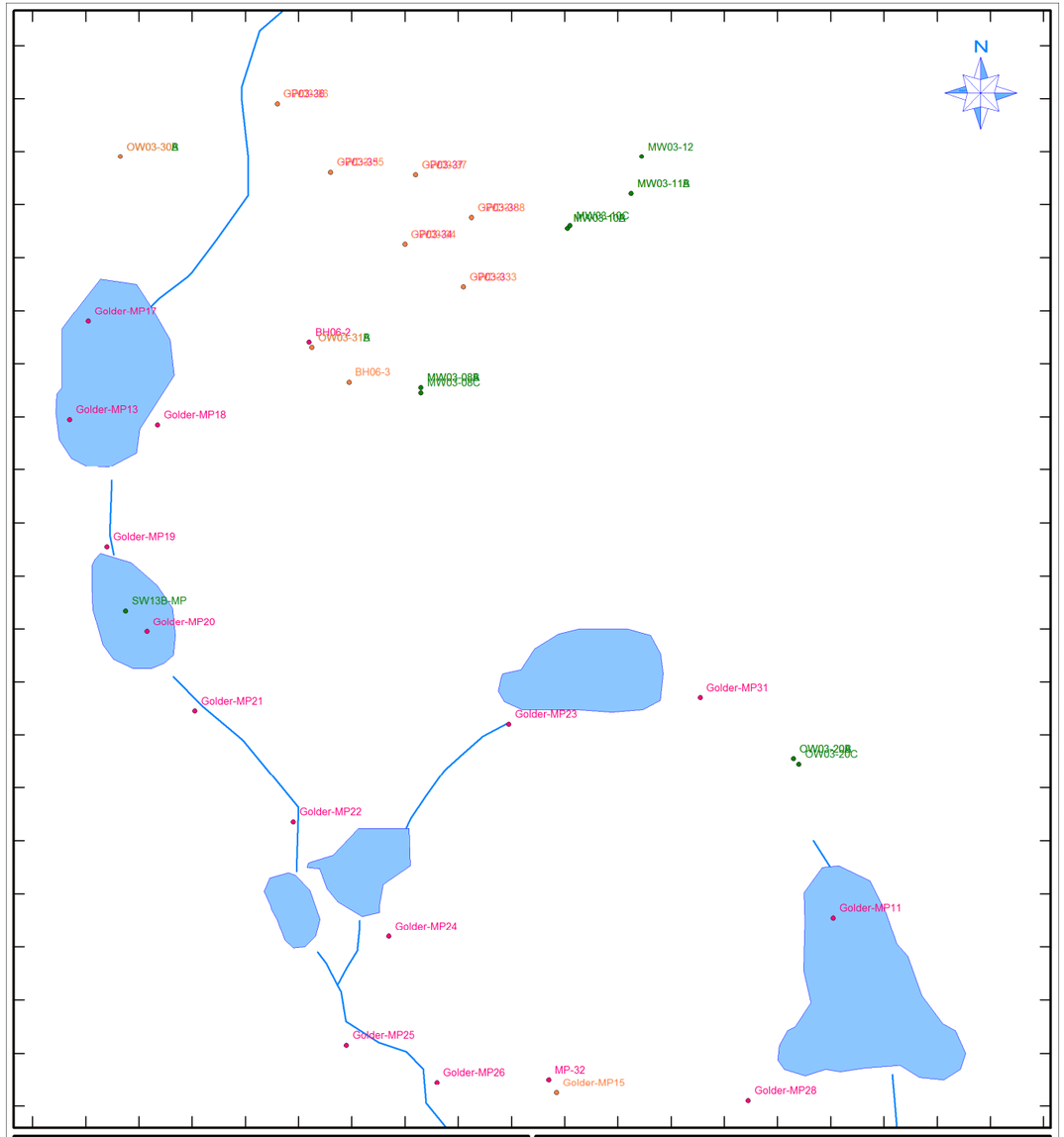
NELSON AGGREGATES

Burlington Quarry Extension

Earthfx Incorporated

Monitoring Wells in South Extension Area



Legend:

- Roads
- Express/Highway
- Existing Quarry
- Expansion Lands
- Extraction Area
- River/Stream
- Lake
- Wetland
- Niagara Escarpment
- Model Boundary
- Cross Section
- Active Monitor Wells
- Inactive Monitor Wells
- Other Monitor Wells

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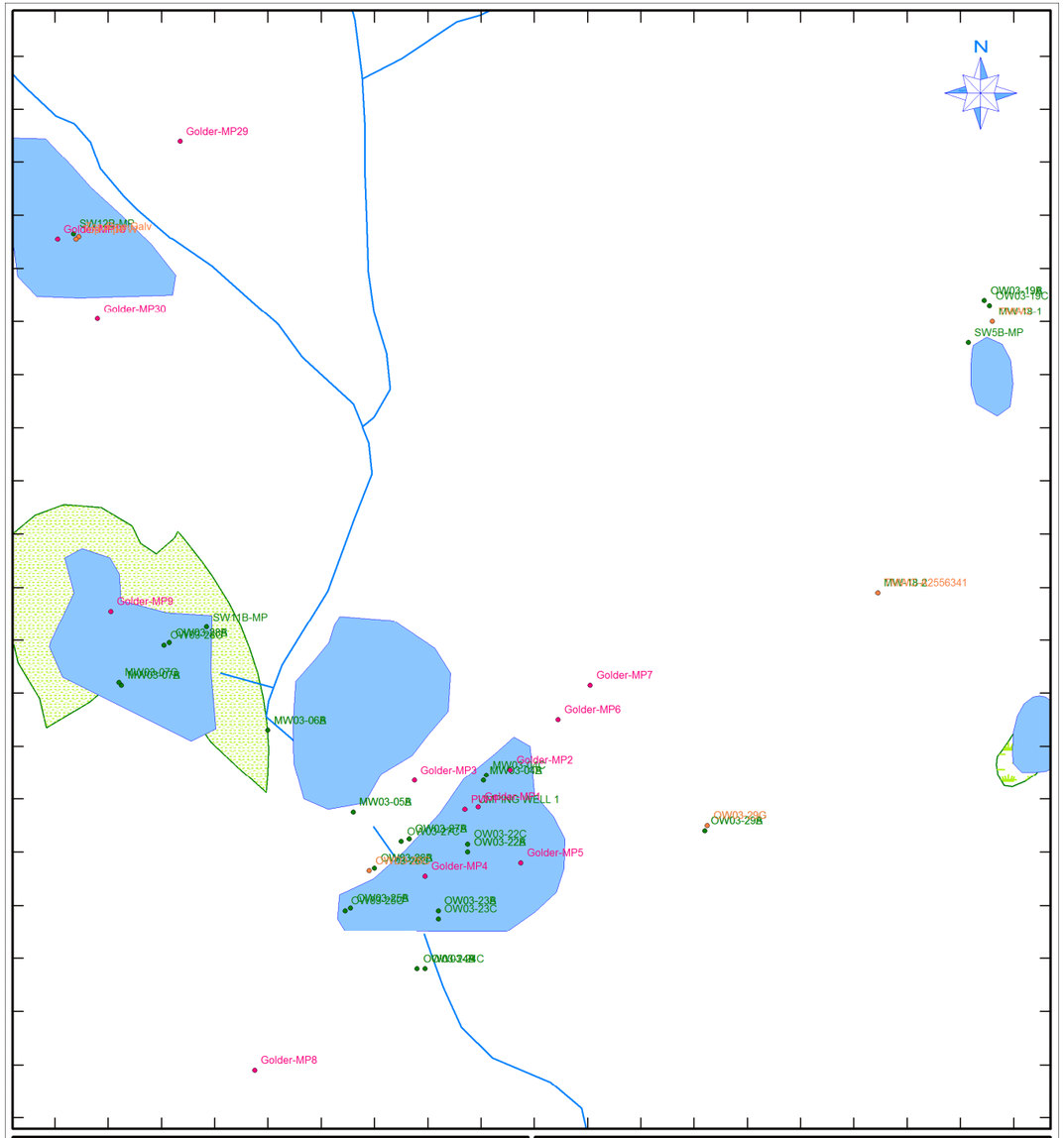
0 20 40 60
Units: UTM NAD83 Zone 17

NELSON AGGREGATES

Burlington Quarry Extension

Earthfx Incorporated

Monitoring Wells Inset Map 1



Legend:

- Roads
- Express/Highway
- Existing Quarry
- Expansion Lands
- Extraction Area
- River/Stream
- Lake
- Wetland
- Niagara Escarpment
- Model Boundary
- Cross Section
- Active Monitor Wells
- Inactive Monitor Wells
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0 20 40 60
Units: UTM NAD83 Zone 17

NELSON AGGREGATES

Burlington Quarry Extension

Earthfx Incorporated

Monitoring Wells Inset Map 2

Monitoring Well Locations and Related Data

Int_Name	Easting	Northing	Gnd_Elev	Bottom_Elev	Bottom_Depth	Active	QA_Code	IsNested	Mon_Top	Mon_Bot	Stratigraphy	Avg_WL	STdate_WL	EndDate_WL	Logger_WL	Manual_WL
BH06-1	590991	4805822	278.940	255.45	23.49		3	0			Amabel					
BH06-2	591004	4805808	277.835	263.10	14.74	0	3	0			Amabel	273.24	2004-04-27	2013-04-18		2004 to 2013
BH06-3	591019	4805793	279.135	254.10	25.03		3	0			Amabel					
BS-01C	588765	4805342	268.300	243.93	24.37	1		1	265.50	257.20		259.39	2019-01-23	2019-05-14	2019 to 2019	2019 to 2019
BS-01B	588765	4805342	268.300	243.93	24.37	1		1	253.50	252.00		259.24	2019-01-23	2019-08-14	2019 to 2019	2019 to 2019
BS-01A	588765	4805342	268.300	243.93	24.37	1		1	249.80	246.80		258.99	2019-01-23	2019-10-11	2019 to 2019	2019 to 2019
BS-02B	589421	4804939	272.000	244.70	27.30	1		1	256.10	253.10		267.79	2019-01-23	2019-08-14	2019 to 2019	2019 to 2019
BS-02C	589421	4804939	272.000	244.70	27.30	1		1	270.50	261.90		267.72	2019-01-23	2019-08-14	2019 to 2019	2019 to 2019
BS-02A	589421	4804939	272.000	244.70	27.30	1		1	250.40	248.90		267.41	2019-01-23	2019-10-11	2019 to 2019	2019 to 2019
BS-03	589372	4805300	271.732	247.33	24.40	1	3	1	271.73	247.33		266.05	2019-01-23	2019-08-14	2019 to 2019	2019 to 2019
BS-03A	589372	4805300	271.732	247.33	24.40	1	3	1	255.73	252.73		264.53	2019-08-14	2019-10-11	2019 to 2019	
BS-03B	589372	4805300	271.732	247.33	24.40	1	3	1	261.73	258.73		264.57	2019-08-14	2019-10-11	2019 to 2019	
BS-04A	589784	4804852	270.452	245.88	24.57	1	3	1	248.95	245.95		264.34	2019-08-14	2019-10-11	2019 to 2019	
BS-04C	589784	4804852	270.452	245.88	24.57	1	3	1	258.45	256.45		264.70	2019-08-14	2019-10-11	2019 to 2019	
BS-04B	589784	4804852	270.452	245.88	24.57	1	3	1	253.45	250.45		264.69	2019-08-14	2019-10-11	2019 to 2019	
BS-05	589016	4805465	270.000	245.40	24.60	1	3	1				265.60	2019-06-20	2019-08-14	2019 to 2019	
BS-05B	589016	4805465	270.000	245.40	24.60	1	3	1	254.00	251.50		265.11	2019-08-14	2019-10-11	2019 to 2019	
BS-05C	589016	4805465	270.000	245.40	24.60	1	3	1	260.00	255.00		265.10	2019-08-14	2019-10-11	2019 to 2019	
BS-05A	589016	4805465	270.000	245.40	24.60	1	3	1	248.30	245.00		265.03	2019-08-14	2019-10-11	2019 to 2019	
BS-06A	589360	4805300	271.392	246.39	25.00		3	1								
BS-07B	589339	4805262	271.212	246.21	25.00		3	1								
BS-07A	589339	4805262	271.212	246.21	25.00		3	1								
DW-1	589114	4805170	271.008	253.33	17.68		3	0	266.13	253.33						
DW-2	589786	4807340	277.494	249.15	28.35	1	3	0	262.86	249.15		271.62	2019-08-15	2019-11-15	2019 to 2019	
DW-3	589486	4804431	269.652	248.32	21.33	1	3	0	257.46	248.32		258.59	2019-09-04	2019-11-15	2019 to 2019	
DW-4	591987	4804216	278.545	257.70	20.85	1	3	0	264.52	257.70		263.61	2019-08-21	2019-11-15	2019 to 2019	
DW-5	591472	4803608	267.996	253.67	14.33	1	3	0	261.90	253.67		263.54	2019-08-15	2019-11-15	2019 to 2019	
DW-6	591220	4803372	264.077	251.28	12.80		3	0	258.44	251.28						
DW-7	592145	4804995	270.325	251.43	18.90		3	0	265.75	251.43						
Golder-MP1	591279	4805177	275.045	273.55	1.50	0	4	0			Top Layer	274.65	2007-06-05	2013-11-25		2007 to 2013
Golder-MP10	591121	4805391	278.171	276.97	1.20	0	4	0			Top Layer	275.13	2006-05-20	2013-11-25	2006 to 2013	2006 to 2013
Golder-MP11	591201	4805591	279.500	278.30	1.20	0	4	0			Top Layer	276.53	2007-09-11	2013-11-25	2007 to 2013	2007 to 2013
Golder-MP12	591077	4805479	278.072	276.87	1.20	0	4	0			Top Layer	275.29	2006-05-20	2013-11-25	2006 to 2013	2006 to 2013
Golder-MP13	590914	4805779	279.096	277.90	1.20	0	4	0			Till	277.12	2006-05-20	2013-11-25	2006 to 2013	2003 to 2013
Golder-MP14	590915	4804905	274.572	273.37	1.20	0	4	0			Top Layer	270.93	2007-06-05	2013-11-25		2007 to 2013
Golder-MP15	591097	4805525	279.964	278.76	1.20		4	0			Top Layer					
Golder-MP16	590995	4804984	276.371	275.17	1.20	0	4	0				273.45	2007-05-24	2013-11-25	2007 to 2013	2007 to 2013
Golder-MP17	590921	4805816	279.139	277.94	1.20	0	8	0			Till	276.99	2007-06-05	2013-04-18		2007 to 2013
Golder-MP18	590947	4805777	278.528	277.33	1.20	0	4	0			Till	277.12	2007-06-05	2013-04-18		2007 to 2013
Golder-MP19	590928	4805731	278.561	277.36	1.20	0	4	0			Till	276.90	2007-06-05	2013-11-25		2007 to 2013
Golder-MP2	591291	4805191	275.275	273.77	1.50	0	4	0			Top Layer	274.95	2007-06-05	2013-04-18		2007 to 2013
Golder-MP20	590943	4805699	278.364	277.16	1.20	0	4	0			Till	276.86	2007-06-05	2013-11-25		2007 to 2013
Golder-MP21	590961	4805669	278.388	277.19	1.20	0	4	0			Till	276.98	2007-06-05	2013-11-25		2007 to 2013
Golder-MP22	590998	4805627	278.410	277.21	1.20	0	4	0			Till	276.08	2012-05-16	2013-11-25		2012 to 2013
Golder-MP23	591079	4805664	280.174	278.97	1.20	0	4	0			Top Layer	277.26	2007-06-05	2013-11-25		2007 to 2013

Int_Name	Easting	Northing	Gnd_Elev	Bottom_Elev	Bottom_Depth	Active	QA_Code	IsNested	Mon_Top	Mon_Bot	Stratigraphy	Avg_WL	STdate_WL	EndDate_WL	Logger_WL	Manual_WL
Golder-MP24	591034	4805584	279.687	278.49	1.20	0	4	0			Top Layer	275.78	2007-06-05	2013-11-25		2007 to 2013
Golder-MP25	591018	4805543	278.353	277.15	1.20	0	4	0			Till	275.60	2007-06-05	2013-04-18		2007 to 2013
Golder-MP26	591052	4805529	278.221	277.02	1.20	0	4	0			Till	275.57	2007-06-05	2013-04-18		2007 to 2013
Golder-MP27	591081	4805432	278.606	277.41	1.20	0	4	0			Top Layer	275.23	2007-06-05	2013-04-18		2007 to 2013
Golder-MP28	591169	4805522	279.323	278.12	1.20	0	4	0			Top Layer	276.57	2007-06-05	2013-04-18		2007 to 2013
Golder-MP29	591167	4805428	277.658	276.46	1.20	0	4	0			Top Layer	276.23	2007-06-05	2013-11-25		2007 to 2013
Golder-MP3	591255	4805187	275.150	273.65	1.50	0	4	0			Top Layer	274.85	2007-06-05	2013-04-18		2007 to 2013
Golder-MP30	591136	4805361	279.123	277.92	1.20	0	4	0			Top Layer	275.31	2007-06-05	2013-04-18		2007 to 2013
Golder-MP31	591151	4805674	280.628	279.43	1.20	0	4	0			Top Layer	277.26	2007-06-05	2013-04-18		2007 to 2013
Golder-MP4	591259	4805151	275.150	273.65	1.50	0	4	0			Top Layer	274.80	2007-06-05	2013-04-18		2007 to 2013
Golder-MP5	591295	4805156	275.040	273.54	1.50	0	4	0			Top Layer	274.75	2007-06-05	2013-04-18		2007 to 2013
Golder-MP6	591309	4805210	276.480	274.98	1.50	0	4	0			Top Layer	275.18	2007-06-05	2013-04-18		2007 to 2013
Golder-MP7	591321	4805223	276.315	274.82	1.50	0	4	0			Top Layer	274.74	2007-06-05	2013-04-18		2007 to 2013
Golder-MP8	591195	4805078	275.485	273.98	1.50	0	4	0			Top Layer	274.70	2007-06-05	2013-04-18		2007 to 2013
Golder-MP9	591141	4805251	278.706	277.51	1.20	0	4	0			Top Layer	275.12	2006-05-20	2013-11-25	2006 to 2013	2006 to 2013
Goodchild	590522	4805511	280.733	255.04	25.69		3	0			Amabel					
GP03-33	591062	4805829	277.960	275.14	2.82	0	3	0			Till	276.24	2003-12-23	2013-04-18		2003 to 2013
GP03-34	591040	4805845	277.961	274.30	3.66	0	3	0			Till	275.61	2003-12-23	2013-04-18		2003 to 2013
GP03-35	591012	4805872	277.946	274.90	3.05	0	3	0			Till	275.70	2003-12-23	2013-04-18		2003 to 2013
GP03-36	590992	4805898	277.939	273.86	4.08	0	3	0			Till	275.60	2003-12-23	2013-04-18		2003 to 2013
GP03-37	591044	4805871	277.947	274.75	3.20	0	3	0			Till	275.97	2003-12-23	2013-04-18		2003 to 2013
GP03-38	591065	4805855	278.026	275.21	2.82	0	3	0			Till	276.45	2003-05-09	2013-04-18		2003 to 2013
MP-32	591094	4805530	276.595	275.52	1.07	0	3	0			Till	275.99	2007-06-05	2013-04-18		2007 to 2013
MP-33	591589	4805514	279.180	278.21	0.97	0	3	0			Top Layer	278.80	2010-04-15	2013-04-19	2010 to 2013	2010 to 2013
MP-34	589858	4804974	273.660	273.15	0.51	0	3	0				273.26	2010-04-15	2013-11-25	2010 to 2013	2010 to 2013
MP-35	590002	4807119	272.570	271.35	1.22	0	3	0				272.23	2010-04-15	2013-11-25	2010 to 2013	2010 to 2013
MW03-01A	590636	4805092	270.940	246.54	24.40	1	3	1	251.89	247.70	Amabel	269.33	2004-05-01	2019-10-11	2004 to 2019	2003 to 2019
MW03-01B	590636	4805092	270.940	256.84	14.10	1	3	1	261.80	256.84	Amabel	269.37	2004-05-01	2019-08-14	2004 to 2019	2003 to 2019
MW03-01C	590637	4805090	270.970	269.45	1.52	1	3	1	270.36	269.51	Amabel	270.13	2004-05-01	2013-11-25	2004 to 2013	2003 to 2019
MW03-02A	590473	4805267	272.480	246.58	25.90	1	3	1	251.75	247.79	Amabel	259.76	2004-05-01	2013-11-25	2004 to 2013	2003 to 2019
MW03-02B	590473	4805267	272.480	256.68	15.80	1	3	1	260.90	256.63	Amabel	262.02	2004-05-01	2013-11-25	2004 to 2013	2003 to 2019
MW03-02C	590471	4805266	272.540	268.44	4.10	1	3	1	270.03	268.44	Amabel	269.89	2004-05-01	2013-11-25	2004 to 2013	2003 to 2019
MW03-03A	591134	4804871	274.780	245.68	29.10	1	3	1	255.58	251.61	Amabel	273.33	2003-05-09	2019-05-15		2003 to 2019
MW03-03B	591134	4804871	274.780	260.78	14.00	1	3	1	264.72	260.76	Amabel	273.69	2003-05-09	2019-05-15		2003 to 2019
MW03-03C	591133	4804872	274.730	272.13	2.60	1	3	1	274.11	272.08	Top Layer	272.93	2003-05-09	2019-05-15		2003 to 2019
MW03-04A	591281	4805187	274.920	247.32	27.60	1	3	1	257.24	253.28	Amabel	274.79	2004-05-01	2013-11-25	2004 to 2013	2003 to 2019
MW03-04B	591281	4805187	274.920	262.42	12.50	1	3	1	266.69	262.42	Amabel	274.71	2004-05-01	2013-11-25	2004 to 2013	2003 to 2019
MW03-04C	591282	4805189	274.860	271.66	3.20	1	3	1	273.46	271.66	Amabel	274.66	2004-05-01	2013-11-25	2004 to 2013	2003 to 2019
MW03-05A	591232	4805175	275.010	271.61	3.40	1	3	1	272.42	271.66	Amabel	274.70	2003-05-09	2019-05-15		2003 to 2019
MW03-05B	591232	4805175	275.010	272.91	2.10	1	3	1	273.94	272.88	Top Layer	274.54	2003-05-09	2019-05-15		2003 to 2019
MW03-06A	591200	4805206	275.010	272.61	2.40	1	3	1	273.03	272.60	Amabel	274.83	2003-05-09	2019-05-15		2003 to 2019
MW03-06B	591200	4805206	275.010	273.31	1.70	1	3	1	273.79	273.33	Till	274.82	2003-05-09	2019-05-15		2003 to 2019
MW03-07A	591145	4805223	275.370	247.77	27.60	1	3	1	260.89	256.60	Amabel	274.83	2003-05-09	2019-05-15		2003 to 2019
MW03-07B	591145	4805223	275.380	267.48	7.90	1	3	1	269.74	267.46	Amabel	275.03	2003-05-09	2019-05-15		2003 to 2019
MW03-07C	591144	4805224	275.370	271.57	3.80	1	3	1	273.54	271.56	Amabel	275.11	2003-05-09	2019-05-15		2003 to 2019
MW03-08A	591046	4805791	278.040	253.34	24.70	1	3	1	261.94	257.97	Amabel	275.19	2004-05-01	2013-11-25	2004 to 2013	2003 to 2019
MW03-08B	591046	4805791	278.050	266.95	11.10	1	3	1	271.12	266.90	Amabel	275.58	2003-05-09	2019-05-15		2003 to 2019
MW03-08C	591046	4805789	278.160	275.26	2.90	1	3	1	277.25	275.26	Till	276.11	2004-05-01	2013-11-25	2004 to 2013	2003 to 2019

Int_Name	Easting	Northing	Gnd_Elev	Bottom_Elev	Bottom_Depth	Active	QA_Code	IsNested	Mon_Top	Mon_Bot	Stratigraphy	Avg_WL	STdate_WL	EndDate_WL	Logger_WL	Manual_WL
MW03-09A	590964	4805321	280.090	249.42	30.67	1	3	1	260.91	258.32	Amabel	276.29	2018-11-27	2019-10-11	2018 to 2019	2003 to 2019
MW03-09B	590964	4805321	280.100	270.70	9.40	1	3	1	274.61	270.73	Amabel	276.68	2018-11-27	2019-10-11	2018 to 2019	2003 to 2019
MW03-09C	590962	4805320	280.200	277.30	2.90	1	3	1	279.19	277.30	Top Layer	277.60	2003-05-09	2019-05-15		2003 to 2019
MW03-10A	591101	4805851	278.120	251.72	26.40	1	3	1	260.16	257.85	Amabel	275.79	2003-05-28	2019-05-15		2003 to 2019
MW03-10B	591101	4805851	278.140	268.54	9.60	1	3	1	272.96	268.54	Amabel	275.80	2003-05-28	2019-05-15		2003 to 2019
MW03-10C	591102	4805852	278.080	275.18	2.90	1	3	1	276.96	275.16	Amabel	276.32	2003-05-28	2019-05-15		2003 to 2019
MW03-11A	591125	4805864	278.000	275.10	2.90	1	3	1	275.74	275.13	Amabel	276.57	2003-05-28	2019-05-15		2003 to 2019
MW03-11B	591125	4805864	278.000	276.00	2.00	1	3	1	276.63	275.97	Till	277.03	2003-05-28	2019-05-15		2003 to 2019
MW03-12	591129	4805878	278.150	276.55	1.60	1	3	0	277.18	276.55	Till	277.00	2003-05-28	2019-05-15		2003 to 2019
MW03-Q9A	590964	4805321	280.090	249.39	30.70		3	0			Amabel					
MW-18-1	591472	4805360	284.600	278.56	6.04	1	1	0	281.60	278.60		281.58	2018-11-27	2019-10-11	2018 to 2019	
MW-18-2	591429	4805258	281.100	277.65	3.45	1	1	0	279.00	277.50		264.98	2018-11-27	2019-10-11	2018 to 2019	
OW03-14A	590587	4805821	280.060	247.96	32.10	1	3	1	261.06	250.87	Amabel	261.32	2018-11-27	2019-10-11	2018 to 2019	2003 to 2019
OW03-14B	590587	4805821	280.070	272.67	7.40	1	3	1	278.07	272.72	Amabel	273.21	2003-07-11	2019-05-15		2003 to 2019
OW03-14C	590588	4805823	279.890	278.29	1.60	1	3	1	279.79	278.29	Till	278.38	2003-05-09	2019-05-15		2003 to 2019
OW03-15A	590390	4805518	275.120	249.49	25.63	1	3	1	256.80	250.02	Amabel	259.11	2004-05-01	2019-10-11	2004 to 2019	2003 to 2019
OW03-15B	590390	4805518	275.120	264.92	10.20	1	3	1	269.20	264.88	Amabel	268.97	2004-05-01	2019-10-11	2004 to 2019	2003 to 2019
OW03-15C	590387	4805521	275.130	271.63	3.50	1	3	1	273.23	271.63	Amabel	272.93	2004-05-01	2019-05-14	2004 to 2019	2003 to 2019
OW03-16A	590793	4804922	272.200	246.10	26.10	1	3	1	254.38	246.60	Amabel	268.28	2003-05-09	2019-05-15		2003 to 2019
OW03-16B	590793	4804922	272.200	262.20	10.00	1	3	1	269.28	262.23	Amabel	270.22	2003-07-11	2019-05-15		2003 to 2019
OW03-16C	590792	4804913	272.330	268.43	3.90	1	3	1	270.03	268.43	Amabel	270.55	2003-05-09	2019-05-15		2003 to 2019
OW03-17	591002	4804710	272.089	249.32	22.77		3	0			Amabel					
OW03-17A	591002	4804710	272.090	249.79	22.30	1	3	1	256.99	249.32	Amabel	270.22	2003-08-29	2019-05-15		2003 to 2019
OW03-17B	591002	4804710	272.090	260.69	11.40	1	3	1	268.43	260.65	Amabel	270.44	2007-06-05	2019-05-15		2003 to 2019
OW03-18A	591240	4805005	275.640	246.74	28.90	1	3	1	258.94	248.64	Amabel	273.93	2003-05-09	2019-05-15		2003 to 2019
OW03-18B	591240	4805005	275.650	263.75	11.90	1	3	1	270.17	263.75	Amabel	274.17	2003-07-11	2019-05-15		2003 to 2019
OW03-18C	591242	4805007	275.250	270.65	4.60	1	3	1	272.26	270.68	Amabel	274.41	2003-05-09	2019-05-15		2003 to 2019
OW03-19A	591469	4805368	284.870	253.77	31.10	1	3	1	262.09	255.37	Amabel	276.91	2018-11-27	2019-10-11	2018 to 2019	2003 to 2019
OW03-19B	591469	4805368	284.870	267.27	17.60	1	3	1	273.88	267.32	Amabel	277.23	2018-11-27	2019-08-14	2018 to 2019	2003 to 2019
OW03-19C	591471	4805366	284.980	275.08	9.90	1	3	1	276.68	275.08	Top Layer	277.27	2018-11-27	2019-08-14	2018 to 2019	2003 to 2019
OW03-20A	591186	4805651	277.680	251.58	26.10	1	3	1	259.03	252.18	Amabel	277.03	2004-05-01	2013-11-25	2004 to 2013	2003 to 2019
OW03-20B	591186	4805651	277.690	268.19	9.50	1	3	1	275.19	268.15	Amabel	276.90	2004-05-01	2013-11-25	2004 to 2013	2003 to 2019
OW03-20C	591188	4805649	277.660	273.86	3.80	1	3	1	275.46	273.86	Amabel	276.74	2004-05-01	2013-11-25	2004 to 2013	2003 to 2019
OW03-21A	590730	4805513	279.740	248.64	31.10	1	3	1	256.79	251.34	Amabel	273.75	2018-11-27	2019-10-11	2018 to 2019	2003 to 2019
OW03-21B	590730	4805513	279.740	270.84	8.90	1	3	1	276.22	270.84	Amabel	274.12	2003-07-11	2019-05-15		2003 to 2019
OW03-21C	590732	4805514	279.810	277.51	2.30	1	3	1	279.11	277.51	Top Layer	278.00	2003-05-09	2019-05-15		2003 to 2019
OW03-22A	591275	4805160	275.010	246.71	28.30	1	3	1	255.41	247.31	Amabel	274.15	2003-05-09	2019-05-15		2003 to 2019
OW03-22B	591275	4805160	275.020	263.82	11.20	1	3	1	271.19	263.82	Amabel	274.44	2003-07-25	2019-05-15		2003 to 2019
OW03-22C	591275	4805163	274.920	271.62	3.30	1	3	1	273.22	271.62	Amabel	274.58	2003-05-09	2019-05-15		2003 to 2019
OW03-23A	591264	4805138	274.960	248.26	26.70	1	3	1	256.31	249.66	Amabel	274.18	2003-05-09	2019-05-15		2003 to 2019
OW03-23B	591264	4805138	274.910	264.21	10.70	1	3	1	270.88	264.21	Amabel	274.44	2003-07-25	2019-05-15		2003 to 2019
OW03-23C	591264	4805135	274.780	271.68	3.10	1	3	1	273.28	271.68	Amabel	274.46	2003-05-09	2019-05-15		2003 to 2019
OW03-24A	591256	4805116	274.880	247.88	27.00	1	3	1	256.75	250.13	Amabel	274.16	2003-05-09	2019-05-15		2003 to 2019
OW03-24B	591256	4805116	274.880	264.28	10.60	1	3	1	270.88	264.24	Amabel	274.26	2003-07-25	2019-05-15		2003 to 2019
OW03-24C	591259	4805116	274.740	271.34	3.40	1	3	1	272.97	271.39	Amabel	274.35	2003-05-09	2019-05-15		2003 to 2019
OW03-25A	591231	4805139	275.000	246.40	28.60	1	3	1	255.90	247.48	Amabel	274.14	2003-05-09	2019-05-15		2003 to 2019
OW03-25B	591231	4805139	274.990	264.19	10.80	1	3	1	270.69	264.22	Amabel	274.43	2003-07-25	2019-05-15		2003 to 2019
OW03-25C	591229	4805138	274.990	271.59	3.40	1	3	1	273.19	271.59	Amabel	274.50	2003-05-09	2019-05-15		2003 to 2019

Int_Name	Easting	Northing	Gnd_Elev	Bottom_Elev	Bottom_Depth	Active	QA_Code	IsNested	Mon_Top	Mon_Bot	Stratigraphy	Avg_WL	STdate_WL	EndDate_WL	Logger_WL	Manual_WL
OW03-26A	591240	4805154	275.020	246.12	28.90	1	3	1	255.82	248.42	Amabel	274.16	2003-05-09	2019-05-15		2003 to 2019
OW03-26B	591240	4805154	275.030	263.73	11.30	1	3	1	272.04	263.70	Amabel	274.46	2003-07-25	2019-05-15		2003 to 2019
OW03-26C	591238	4805153	275.005	271.11	3.90	1	3	1	272.71	271.11	Amabel	274.22	2003-05-09	2019-05-15		2003 to 2019
OW03-27A	591253	4805165	275.050	246.15	28.90	1	3	1	256.05	247.28	Amabel	274.19	2003-05-09	2019-05-15		2003 to 2019
OW03-27B	591253	4805165	275.060	263.86	11.20	1	3	1	270.91	263.88	Amabel	274.50	2003-07-25	2019-05-15		2003 to 2019
OW03-27C	591250	4805164	275.040	271.14	3.90	1	3	1	272.74	271.14	Amabel	274.48	2003-05-09	2019-05-15		2003 to 2019
OW03-28A	591163	4805239	275.460	248.16	27.30	1	3	1	256.76	248.96	Amabel	275.33	2004-05-01	2013-11-25	2004 to 2013	2003 to 2019
OW03-28B	591163	4805239	275.460	265.66	9.80	1	3	1	272.36	265.66	Amabel	275.07	2003-07-25	2019-05-15		2003 to 2019
OW03-28C	591161	4805238	275.400	272.30	3.10	1	3	1	273.90	272.30	Amabel	275.11	2004-05-01	2013-11-25	2004 to 2013	2003 to 2019
OW03-29A	591364	4805168	277.060	247.56	29.50	1	3	1	256.46	248.92	Amabel	274.84	2004-05-01	2019-10-11	2004 to 2019	2003 to 2019
OW03-29B	591364	4805168	277.050	266.85	10.20	1	3	1	273.93	266.83	Amabel	275.47	2018-11-27	2019-10-11	2004 to 2019	2003 to 2019
OW03-29C	591365	4805170	277.020	275.12	1.90	1	3	1	276.72	275.12	Top Layer	275.79	2004-05-01	2019-08-04	2004 to 2019	2003 to 2019
OW03-29G	591365	4805170	277.020	275.12	1.90		3	1			Top Layer					
OW03-30	590933	4805878	278.740	254.41	24.33		3	0			Amabel					
OW03-30A	590933	4805878	278.060	258.66	19.40	1	3	1	263.64	259.35	Amabel	274.00	2004-05-01	2019-10-11	2004 to 2019	2004 to 2019
OW03-30B	590933	4805878	278.340	269.84	8.50	1	3	1	274.52	269.88	Amabel	274.52	2004-05-01	2019-10-11	2004 to 2019	2007 to 2019
OW03-31	591005	4805806	278.465	254.24	24.23		3	0			Amabel					
OW03-31A	591005	4805806	278.470	263.27	15.20	1	3	1	268.62	263.16	Amabel	275.30	2004-05-01	2013-11-25	2004 to 2013	2004 to 2019
OW03-31B	591005	4805806	277.840	270.54	7.30	1	3	1	273.96	270.38	Amabel	274.93	2004-05-01	2013-11-25	2004 to 2013	2007 to 2019
OW03-32	590874	4804835	271.460	248.06	23.40		3	0			Amabel					
OW03-32A	590874	4804835	277.990	254.59	23.40	1	3	1	264.98	254.39	Amabel	268.62	2004-05-01	2013-11-25	2004 to 2013	2004 to 2019
OW03-32B	590874	4804835	271.020	261.32	9.70	1	3	1	269.10	261.28	Amabel	268.63	2004-05-01	2013-11-25	2004 to 2013	2003 to 2019
OW03-34	591040	4805845	277.960	274.26	3.70		3	0	277.51	275.98	Till					
OW03-36	590992	4805898	277.940	273.84	4.10		3	0	277.94	275.79	Till					
OW03-37	591044	4805871	277.950	274.75	3.20		3	0	277.95	276.44	Till					
OWD3-26C	591238	4805153	275.010	271.11	3.90		3	0			Amabel					
OWD3-33	591062	4805829	270.960	268.16	2.80		3	0			Amabel					
OWD3-35	591012	4805872	277.950	274.85	3.10		3	0			Till					
OWD3-38	591065	4805855	278.030	275.23	2.80		3	0			Till					
5191 Cedar Spr Rd	589116	4805163	271.950			1		0				262.32	2019-01-23	2019-10-11	2019 to 2019	
Pumping Well 1	591274	4805176				1	3	0				274.78	2003-05-09	2019-05-15		2003 to 2019
PW-1	591274	4805176	274.980	249.08	25.90	0	3	0	250.08	249.08	Amabel	274.77	2003-05-09	2013-04-18		2003 to 2013
Sterrett	590419	4805407	276.551	253.18	23.37		3	0			Amabel					
SW11B	591177	4805245				1		0				275.36	2018-10-23	2019-09-15	2018 to 2019	
SW12B	591127	4805393				1		0				275.77	2018-10-23	2019-09-15	2018 to 2019	
SW13B	590935	4805707				1		0				277.39	2018-10-23	2019-09-15	2018 to 2019	
SW16B-IP	590895	4804900						0								
SW16B	590889	4804900				1		0				271.83	2018-11-02	2019-09-15	2018 to 2019	
SW5B	591463	4805352				1		0				284.71	2018-11-02	2019-09-15	2018 to 2019	
TMWC	591472	4805360	284.650					0								
TMWC-621	589368	4805299	270.380					0								
TMWC-A2556341	591429	4805258	281.130					0								
TMWC-NW	588765	4805342	267.290					0								
TMWC-SE	589421	4804939	271.300					0								
1096-Top Pipe Gal	591129	4805392	275.950					1								
1095-Top Pipe W	591128	4805391	276.020					1								
Well 1-1	590651	4807417	280.242	252.05	28.19		4	1			Amabel					
Well 1-2	590651	4807417	280.242	262.68	17.56		4	1			Amabel					

Int_Name	Easting	Northing	Gnd_Elev	Bottom_Elev	Bottom_Depth	Active	QA_Code	IsNested	Mon_Top	Mon_Bot	Stratigraphy	Avg_WL	STdate_WL	EndDate_WL	Logger_WL	Manual_WL
Well 2	590842	4806566	283.317	260.49	22.83		4	0			Amabel					
Well 3	590420	4805774					4	0								
Well 5	590010	4805158	275.000	250.37	24.63		4	0			Amabel					
Well A	590542	4807328	276.073	262.47	13.60		4	0			Amabel					
Well-1	590638	4807453	277.730				3	0								

PROJECT: 021-1238

RECORD OF DRILLHOLE: OW 03-21

SHEET 1 OF 2

LOCATION: N 4805294.3 ;E 590700.2 UTM NAD 27

DRILLING DATE: FEB.-MAR, 2003

DATUM: GEODETIC

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: Tamrock HL1000 3.5" Top Hammer Rotary Percussion

DRILLING CONTRACTOR: Nelson Aggregates

JN - Joint; FLT - Fault; SHR- Shear; VN - Vein; CJ - Conjugate
BD- Bedding; FO- Foliation; CO- Contact; OR- Orthogonal; CL - Cleavage
PL - Planar; CU- Curved; UN- Undulating; ST - Stepped; IR - Irregular
PO- Polished; K - Slickensided; SM- Smooth; Ro - Rough; MB- Mechanical Break
BR - Broken Rock
NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	FLUSH	COLOUR % RETURN	RECOVERY: TOTAL CORE %	RECOVERY: SOLID CORE %	R.Q.D. %	FRACT. INDEX PER 0.3 m	DISCONTINUITY DATA: B Angle	DISCONTINUITY DATA: DIP w.r.t. CORE AXIS	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	HYDRAULIC CONDUCTIVITY K, cm/sec	Diametral Point Load Index (MPa)	RMC -Q' AVG.	NOTES WATER LEVELS INSTRUMENTATION
								80 60 40 20	80 60 40 20	80 60 40 20	5 10 15 20	0 90 180 270	0 30 60 90					10^{-6} 10^{-5} 10^{-4} 10^{-3}	2 4 6		OW 03-21
		GROUND SURFACE		279.64																	(C) (B,A)
0		Overburden		0.00																	
2				277.34																	(C) (B) (A)
		Bedrock Surface Amabel Formation		2.30																	
4																					Fine Sand Sand
6																					Screen (B)
8																					Sand
10																					
12																					
14																					Bentonite
16																					
18																					
20		*CONTINUED NEXT PAGE*																			

MIS-RCK 004 0211238AARCK.GPJ GAL-MISS.GDT 9/9/10 MK

DEPTH SCALE

1 : 100

Golder Associates

LOGGED: W.M.

CHECKED:

PROJECT: 021-1238

RECORD OF DRILLHOLE: OW 03-21

SHEET 2 OF 2

LOCATION: N 4805294.3 ;E 590700.2 UTM NAD 27

DRILLING DATE: FEB.-MAR, 2003

DATUM: GEODETIC

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: Tamrock HL1000 3.5" Top Hammer Rotary Percussion

DRILLING CONTRACTOR: Nelson Aggregates

JN - Joint; FLT - Fault; SHR- Shear; VN - Vein; CJ - Conjugate
BD- Bedding; FO- Foliation; CO- Contact; OR- Orthogonal; CL - Cleavage
PL - Planar; CU- Curved; UN- Undulating; ST - Stepped; IR - Irregular
PO- Polished; K - Slickensided; SM- Smooth; Ro - Rough; MB- Mechanical Break
BR - Broken Rock
NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	COLOUR % RETURN / FLUSH	RECOVERY: TOTAL CORE %	RECOVERY: SOLID CORE %	R.Q.D. %	FRACT. INDEX PER 0.3 m	DISCONTINUITY DATA: B Angle	DISCONTINUITY DATA: DIP w.r.t. CORE AXIS	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	HYDRAULIC CONDUCTIVITY K, cm/sec	Diametral Point Load Index (MPa)	RMC -Q' AVG.	NOTES WATER LEVELS INSTRUMENTATION
		--- CONTINUED FROM PREVIOUS PAGE ---																		OW 03-21
																				(C) (B,A)
20		Bedrock Surface Amabel Formation																		
22																				Bentonite
24																				Fine Sand Sand
26																				Screen (A)
28				250.68																
		Inferred Thorold Formation Contact		28.96																
30																				Caved Material
				248.54																
		END OF BOREHOLE		31.10																A and B wells constructed with 1" dia. Schedule 40 PVC flush threaded pipe and No. 10 slot screen, C well constructed with 2" dia. Schedule 40 PVC flush threaded pipe and No. 10 slot screen
32		Notes: 1. Rotary Percussion Borehole drilled and logged by Nelson 2. Monitoring well installation constructed by Golder																		Note: Water levels taken on July 25, 2003.
34																				
36																				
38																				
40																				

DEPTH SCALE

1 : 100

Golder Associates

LOGGED: W.M.

CHECKED:

MIS-RCK 004 0211238AARCK.GPJ GAL-MISS.GDT 9/9/10 MK

PROJECT: 021-1238

RECORD OF DRILLHOLE: OW 03-31

SHEET 1 OF 2

LOCATION: N 4805588.2 ;E 590975.1 UTM NAD 27

DRILLING DATE: AUGUST 19, 2003

DATUM: GEODETIC

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: Tamrock HL1000 3.5" Top Hammer Rotary Percussion

DRILLING CONTRACTOR: Nelson Aggregates

JN - Joint; FLT - Fault; SHR- Shear; VN - Vein; CJ - Conjugate

BD- Bedding; FO- Foliation; CO- Contact; OR- Orthogonal; CL - Cleavage

PL - Planar; CU- Curved; UN- Undulating; ST - Stepped; IR - Irregular

PO- Polished; K - Slickensided; SM- Smooth; Ro - Rough; MB- Mechanical Break

BR - Broken Rock

NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	FLUSH	COLOUR % RETURN	RECOVERY TOTAL CORE % (80 60 40 20)	RECOVERY SOLID CORE % (80 60 40 20)	R.Q.D. % (80 60 40 20)	FRACT. INDEX PER 0.3 m (5 10 15 20)	DISCONTINUITY DATA: B Angle (0 30 60 90)	DISCONTINUITY DATA: DIP w.r.t. CORE AXIS (0 30 60 90)	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	HYDRAULIC CONDUCTIVITY K, cm/sec (10^{-6} 10^{-5} 10^{-4} 10^{-3})	Diametral Point Load Index (MPa) (2 4 6)	RMC -Q' AVG.	NOTES WATER LEVELS INSTRUMENTATION
		GROUND SURFACE		278.47																	(B,A)
0		Overburden		0.00																	
				276.80																	
2		Bedrock Surface Amabel Formation		1.67																	Bentonite
4																					Sand
6																					Screen (B)
8																					Sand
10																					Bentonite
12																					Sand
14																					Screen (A)
16																					Sand
18																					Bentonite
20		*CONTINUED NEXT PAGE*																			

OW 03-31

A

MIS-RCK 004 0211238AARCK.GPJ GAL-MISS.GDT 9/9/10 MK

DEPTH SCALE

1 : 100

Golder Associates

LOGGED:

CHECKED:

PROJECT: 021-1238

RECORD OF DRILLHOLE: OW 03-31

SHEET 2 OF 2

LOCATION: N 4805588.2 ;E 590975.1 UTM NAD 27

DRILLING DATE: AUGUST 19, 2003

DATUM: GEODETIC

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: Tamrock HL1000 3.5" Top Hammer Rotary Percussion

DRILLING CONTRACTOR: Nelson Aggregates

JN - Joint; FLT - Fault; SHR- Shear; VN - Vein; CJ - Conjugate
BD- Bedding; FO- Foliation; CO- Contact; OR- Orthogonal; CL - Cleavage
PL - Planar; CU- Curved; UN- Undulating; ST - Stepped; IR - Irregular
PO- Polished; K - Slickensided; SM- Smooth; Ro - Rough; MB- Mechanical Break
BR - Broken Rock
NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	FLUSH	COLOUR % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACT. INDEX PER 0.3 m	DISCONTINUITY DATA: B Angle	DISCONTINUITY DATA: DIP w.r.t. CORE AXIS	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	HYDRAULIC CONDUCTIVITY K, cm/sec	Diametral Point Load Index (MPa)	RMC -Q' AVG.	NOTES WATER LEVELS INSTRUMENTATION
		--- CONTINUED FROM PREVIOUS PAGE ---																			(B,A)
20		Bedrock Surface Amabel Formation																			
22																					Bentonite
24				254.24																	
		END OF BOREHOLE Note 1) Rotary Percussion Borehole drilled and logged by Nelson Note 2) Monitoring well installation constructed by Golder		24.23																	Wells constructed with 1" dia. Schedule 40 PVC flush threaded pipe and No. 10 slot screen Note: Water levels taken on April 27, 2004.
26																					
28																					
30																					
32																					
34																					
36																					
38																					
40																					

OW 03-31

DEPTH SCALE
1 : 100

Golder Associates

LOGGED:

CHECKED:

MIS-RCK 004 0211238AARCK.GPJ GAL-MISS.GDT 9/9/10 MK

Ontario

Ministry of the Environment and Climate Change

Measurements recorded in: ☐ Metric ☒ Imperial

Well Tag No. *(Place Sticker and Stub Below)* Tag#: A 235628 #4

Well Record

Regulation 903 Ontario Water Resources Act

Page 3 of 3

Well Owner's Information

First Name	Last Name / Organization	E-mail Address	☐ Well Constructed by Well Owner
	BURLINGTON SPRINGS GOLF CLUB		

Mailing Address (Street Number/Name)	Municipality	Province	Postal Code	Telephone No. *(inc. area code)*
5232 CEDAR SPRINGS ROAD	BURLINGTON	ONT	L7P 0C1	

Well Location

Address of Well Location (Street Number/Name)	Township	Lot	Concession
	CITY OF BURLINGTON	2	2

County/District/Municipality	City/Town/Village	Province	Postal Code
HALTON		Ontario	

UTM Coordinates	Zone	Easting	Northing	Municipal Plan and Sublot Number	Other
NAD 83	17	589019	4805464		

Overburden and Bedrock Materials/Abandonment Sealing Record *(see instructions on the back of this form)*

General Colour	Most Common Material	Other Materials	General Description	Depth (m/ft) From	Depth (m/ft) To
BROWN	CLAY SILTY STONES			0	11ft
BROWN	LIMESTONE			11ft	43ft
GRAY	LIMESTONE			43ft	77ft
GRAY	LIMESTONE SHALE			77ft	82ft

Annular Space

Depth Set at (m/ft) From	Depth Set at (m/ft) To	Type of Sealant Used (Material and Type)	Volume Placed (m^3/ft^3)
0	14ft	BENTONITE SLUYRY	60gal

Method of Construction

☐ Cable Tool ☐ Diamond
☒ Rotary (Conventional) ☐ Jetting
☐ Rotary (Reverse) ☐ Driving
☐ Boring ☐ Digging
☐ Air percussion
☐ Other, *specify* _____

Well Use

☐ Public ☐ Commercial ☐ Not used
☐ Domestic ☐ Municipal ☐ Dewatering
☐ Livestock ☒ Test Hole ☒ Monitoring
☐ Irrigation ☐ Cooling & Air Conditioning
☐ Industrial
☐ Other, *specify* _____

Construction Record - Casing

Inside Diameter (cm/in)	Open Hole OR Material (Galvanized, Fibreglass, Concrete, Plastic, Steel)	Wall Thickness (cm/in)	Depth (m/ft) From	Depth (m/ft) To
6¼	steel	.188	0	14ft
6in	open hole		14ft	82ft

Construction Record - Screen

Outside Diameter (cm/in)	Material (Plastic, Galvanized, Steel)	Slot No.	Depth (m/ft) From	Depth (m/ft) To

Status of Well

☐ Water Supply
☐ Replacement Well
☐ Test Hole
☐ Recharge Well
☐ Dewatering Well
☒ Observation and/or Monitoring Hole
☐ Alteration (Construction)
☐ Abandoned, Insufficient Supply
☐ Abandoned, Poor Water Quality
☐ Abandoned, other, *specify*
☐ Other, *specify*

Water Details

Water found at Depth	Kind of Water	Hole Diameter Depth (m/ft) From	Hole Diameter Depth (m/ft) To	Hole Diameter (cm/in)
27ft (m/ft) ☐ Gas	☒ Fresh ☐ Untested ☐ Other, *specify*	0	14ft	9in
40ft-60ft (m/ft) ☐ Gas	☒ Fresh ☐ Untested ☐ Other, *specify*	14ft	82ft	6in
(m/ft) ☐ Gas	☐ Fresh ☐ Untested ☐ Other, *specify*			

Results of Well Yield Testing

After test of well yield, water was:
☐ Clear and sand free
☐ Other, *specify* _____

If pumping discontinued, give reason: pump later time

Pump intake set at *(m/ft)*

Pumping rate *(l/min / GPM)*

Duration of pumping ____ hrs + ____ min

Final water level end of pumping *(m/ft)*

If flowing give rate *(l/min / GPM)*

Recommended pump depth *(m/ft)*

Recommended pump rate *(l/min / GPM)*

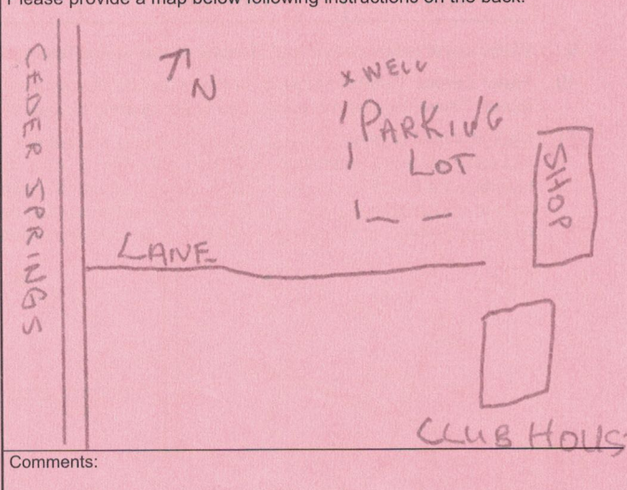
Well production *(l/min / GPM)* 15gpm

Disinfected? ☒ Yes ☐ No 150ppm

	Draw Down Time (min)	Draw Down Water Level (m/ft)	Recovery Time (min)	Recovery Water Level (m/ft)
Static Level		13ft		
1			1	
2			2	
3			3	
4			4	
5			5	
10			10	
15			15	
20			20	
25			25	
30			30	
40			40	
50			50	
60			60	

Map of Well Location

Please provide a map below following instructions on the back.



Comments:

Well Contractor and Well Technician Information

Business Name of Well Contractor	Well Contractor's Licence No.
KEITH LANG WELL DRILLING INC	7154

Business Address (Street Number/Name)	Municipality
251 ELDON ST GODERICH	

Province	Postal Code	Business E-mail Address
ONT	N7A3R9	

Bus. Telephone No. *(inc. area code)*	Name of Well Technician (Last Name, First Name)
519-524-8159	KEITH LANG

Well Technician's Licence No.	Signature of Technician and/or Contractor	Date Submitted
T446	K. Lang	2019/06/05

Well owner's information package delivered	Date Package Delivered	Date Work Completed
☐ Yes ☐ No		2019/5/28

Ministry Use Only

Audit No. Z305923

Received

0506E (2014/11)

Well Owner's Copy

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Ontario

Ministry of the Environment and Climate Change

Measurements recorded in: ☐ Metric ☒ Imperial

Well Tag No. *(Place Sticker and/or Print Below)* Tag#: A 235621

Well Record

Regulation 903 Ontario Water Resources Act

Well Owner's Information

First Name	Last Name / Organization	E-mail Address	☐ Well Constructed by Well Owner
	BURLINGTON SPRINGS GOLF CLUB		

Mailing Address (Street Number/Name)	Municipality	Province	Postal Code	Telephone No. *(inc. area code)*
5232 CEDAR SPRINGS ROAD	BURLINGTON	ONT	L7P0C1	

Well Location

Address of Well Location (Street Number/Name)	Township	Lot	Concession
	CITY OF BURLINGTON	1	2

County/District/Municipality	City/Town/Village	Province	Postal Code
HALTON		Ontario	

UTM Coordinates	Zone	Easting	Northing	Municipal Plan and Sublot Number	Other
NAD 83	17	589366	4805280		

Overburden and Bedrock Materials/Abandonment Sealing Record *(see instructions on the back of this form)*

General Colour	Most Common Material	Other Materials	General Description	Depth (m/ft) From	Depth (m/ft) To
BROWN	CLAY SILTY STONES			0	8ft
BROWN	COARSE GRAVEL SAND			8ft	20ft
BROWN	LIMESTONE SOFT			20ft	24ft
BROWN	LIMESTONE			24ft	45ft
GRAY	LIMESTONE			45ft	76ft
GRAY	LIMESTONE SHALE			76ft	82ft

Annular Space

Depth Set at (m/ft) From	To	Type of Sealant Used (Material and Type)	Volume Placed (m^3/ft^3)
0	24ft	BENTONITE SLURRY	60gal

Method of Construction

☐ Cable Tool ☐ Diamond
☒ Rotary (Conventional) ☐ Jetting
☐ Rotary (Reverse) ☐ Driving
☐ Boring ☐ Digging
☐ Air percussion
☐ Other, *specify*

Well Use

☐ Public ☐ Commercial ☐ Not used
☐ Domestic ☐ Municipal ☐ Dewatering
☐ Livestock ☒ Test Hole ☐ Monitoring
☐ Irrigation ☐ Cooling & Air Conditioning
☐ Industrial
☐ Other, *specify*

Construction Record - Casing

Inside Diameter (cm/in)	Open Hole OR Material (Galvanized, Fibreglass, Concrete, Plastic, Steel)	Wall Thickness (cm/in)	Depth (m/ft) From	Depth (m/ft) To
6¼	steel	.188	0	24ft
6in	open hole		24ft	82ft

Construction Record - Screen

Outside Diameter (cm/in)	Material (Plastic, Galvanized, Steel)	Slot No.	Depth (m/ft) From	Depth (m/ft) To

Status of Well

☐ Water Supply
☐ Replacement Well
☐ Test Hole
☐ Recharge Well
☐ Dewatering Well
☒ Observation and/or Monitoring Hole
☐ Alteration (Construction)
☐ Abandoned, Insufficient Supply
☐ Abandoned, Poor Water Quality
☐ Abandoned, other, *specify*
☐ Other, *specify*

Water Details

Water found at Depth	Kind of Water	Hole Diameter Depth (m/ft) From	To	Diameter (cm/in)
26ft (m/ft) ☐ Gas	☒ Fresh ☐ Untested ☐ Other, *specify*	0	24ft	9in
34ft (m/ft) ☐ Gas	☒ Fresh ☐ Untested ☐ Other, *specify*	24ft	82ft	6in
40-60ft (m/ft) ☐ Gas	☒ Fresh ☐ Untested ☐ Other, *specify*			

Well Contractor and Well Technician Information

Business Name of Well Contractor	Well Contractor's Licence No.
KEITH LANG WELL DRILLING INC	7154

Business Address (Street Number/Name)	Municipality
251 ELDON ST GODERICH	

Province	Postal Code	Business E-mail Address
ONT	N7A3R9	

Bus. Telephone No. *(inc. area code)*	Name of Well Technician (Last Name, First Name)
519-524-8159	KEITH LANG

Well Technician's Licence No.	Signature of Technician and/or Contractor	Date Submitted
T446	K. Lang	2019/08/15

Results of Well Yield Testing

After test of well yield, water was:
☒ Clear and sand free
☐ Other, *specify*

If pumping discontinued, give reason: pump later date

Pump intake set at *(m/ft)*

Pumping rate *(l/min / GPM)*

Duration of pumping ____ hrs + ____ min

Final water level end of pumping *(m/ft)*

If flowing give rate *(l/min / GPM)*

Recommended pump depth *(m/ft)*

Recommended pump rate *(l/min / GPM)*

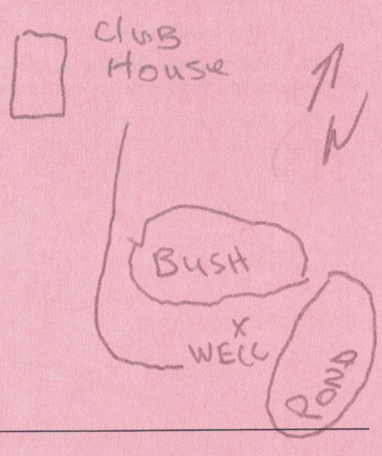
Well production *(l/min / GPM)* 30gpm

Disinfected? ☒ Yes ☐ No 150ppm

	Draw Down Time (min)	Draw Down Water Level (m/ft)	Recovery Time (min)	Recovery Water Level (m/ft)
Static Level		12ft		
1			1	
2			2	
3			3	
4			4	
5			5	
10			10	
15			15	
20			20	
25			25	
30			30	
40			40	
50			50	
60			60	

Map of Well Location

Please provide a map below following instructions on the back.



Comments:

Well owner's information package delivered ☐ Yes ☒ No

Date Package Delivered: Y Y Y Y M M D D

Date Work Completed: 2019 527

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Ministry of the Environment and Climate Change

Measurements recorded in: ☐ Metric ☐ Imperial

Well Tag No. (Place Sticker and/or Print Below) Tag#: A 235624

235624

Well Record

Regulation 903 Ontario Water Resources Act

Page 3 of 3

Well Owner's Information

First Name	Last Name / Organization	E-mail Address	☐ Well Constructed by Well Owner
	BURLINGTON SRRINGS GOLF CLUB		

Mailing Address (Street Number/Name)	Municipality	Province	Postal Code	Telephone No. (inc. area code)
5235 CEDER SPRINGS ROAD	BURLINGTON	ONT	L7P0C1	

Well Location

Address of Well Location (Street Number/Name)	Township	Lot	Concession
	CITY OF BURLINGTON	1	2

County/District/Municipality	City/Town/Village	Province	Postal Code
HALTON		Ontario	

UTM Coordinates	Zone	Easting	Northing	Municipal Plan and Sublot Number	Other
NAD 83	17	589775	4804851		

Overburden and Bedrock Materials/Abandonment Sealing Record *(see instructions on the back of this form)*

General Colour	Most Common Material	Other Materials	General Description	Depth (m/ft) From	Depth (m/ft) To
BROWN	SANDY CLAY & STONES			0	12ft
BROWN	LIMESTONE			12ft	46ft
GRAY	LIMESTONE			46ft	78ft
SHALE	GRAY			78ft	82ft

Annular Space

Depth Set at (m/ft) From	To	Type of Sealant Used (Material and Type)	Volume Placed (m^3/ft^3)
0	14ft	BENTONITE SLURRY	/)30gal

Method of Construction

☐ Cable Tool ☐ Diamond
☒ Rotary (Conventional) ☐ Jetting
☐ Rotary (Reverse) ☐ Driving
☐ Boring ☐ Digging
☐ Air percussion
☐ Other, specify

Well Use

☐ Public ☐ Commercial ☐ Not used
☐ Domestic ☐ Municipal ☐ Dewatering
☐ Livestock ☒ Test Hole ☒ Monitoring
☐ Irrigation ☐ Cooling & Air Conditioning
☐ Industrial
☐ Other, specify

Construction Record - Casing

Inside Diameter (cm/in)	Open Hole OR Material (Galvanized, Fibreglass, Concrete, Plastic, Steel)	Wall Thickness (cm/in)	Depth (m/ft) From	Depth (m/ft) To
6¼	steel	.188	0	14ft
6in	open hole		14ft	82ft

Construction Record - Screen

Outside Diameter (cm/in)	Material (Plastic, Galvanized, Steel)	Slot No.	Depth (m/ft) From	Depth (m/ft) To

Status of Well

☐ Water Supply
☐ Replacement Well
☐ Test Hole
☐ Recharge Well
☐ Dewatering Well
☒ Observation and/or Monitoring Hole
☐ Alteration (Construction)
☐ Abandoned, Insufficient Supply
☐ Abandoned, Poor Water Quality
☐ Abandoned, other, specify
☐ Other, specify

Water Details

Water found at Depth	Kind of Water	
35ft (m/ft) ☐ Gas	☒ Fresh ☐ Untested ☐ Other, specify	
50ft (m/ft) ☐ Gas	☒ Fresh ☐ Untested ☐ Other, specify	
(m/ft) ☐ Gas	☐ Fresh ☐ Untested ☐ Other, specify	

Hole Diameter

Depth (m/ft) From	To	Diameter (cm/in)
0	14ft	9in
14ft	82ft	6in

Results of Well Yield Testing

After test of well yield, water was:
☐ Clear and sand free
☐ Other, specify

If pumping discontinued, give reason: PUMP AT LATER TIME

Pump intake set at (m/ft)

Pumping rate (l/min / GPM)

Duration of pumping ____ hrs + ____ min

Final water level end of pumping (m/ft)

If flowing give rate (l/min / GPM)

Recommended pump depth (m/ft)

Recommended pump rate (l/min / GPM)

Well production (l/min / GPM) 15gpm

Disinfected? ☒ Yes ☐ No 150ppm

	Draw Down Time (min)	Draw Down Water Level (m/ft)	Recovery Time (min)	Recovery Water Level (m/ft)
Static Level		##11ft		
1			1	
2			2	
3			3	
4			4	
5			5	
10			10	
15			15	
20			20	
25			25	
30			30	
40			40	
50			50	
60			60	

Map of Well Location

Please provide a map below following instructions on the back.



Comments:

Well Contractor and Well Technician Information

Business Name of Well Contractor	Well Contractor's Licence No.
KEITH LANG WELL DRILLING INC	7154

Business Address (Street Number/Name)	Municipality
251 ELDON ST GODERICH	

Province	Postal Code	Business E-mail Address
ONT	N7A3R9	

Bus. Telephone No. (inc. area code)	Name of Well Technician (Last Name, First Name)
519-524-8159	KEITH LANG

Well Technician's Licence No.	Signature of Technician and/or Contractor	Date Submitted
T446	K. Lang	2019 10 15

Well owner's information package delivered	Date Package Delivered	Date Work Completed
☐ Yes ☒ No		2019 5 27

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Ministry of the Environment and Climate Change

Measurements recorded in: ☐ Metric ☒ Imperial

Well Tag No. *(Place Sticker and/or Print Below)* 2356 Tag#: A 235622

Well Record

Regulation 903 Ontario Water Resources Act

Well Owner's Information

First Name	Last Name / Organization	E-mail Address	☐ Well Constructed by Well Owner
	BURLINGTON SPRINGS GOLF CLUB		

Mailing Address (Street Number/Name)	Municipality	Province	Postal Code	Telephone No. *(inc. area code)*
5232 CEDAR SPRINGS ROAD	BURLINGTON	ONT	L7P 0C1	

Well Location

Address of Well Location (Street Number/Name)	Township	Lot	Concession
	CITY OF BULINGTON	1	2

County/District/Municipality	City/Town/Village	Province	Postal Code
HALTON		Ontario	

UTM Coordinates	Zone	Easting	Northing	Municipal Plan and Sublot Number	Other
NAD 8 3	17	589331	4805364		

Overburden and Bedrock Materials/Abandonment Sealing Record *(see instructions on the back of this form)*

General Colour	Most Common Material	Other Materials	General Description	Depth (m/ft) From	Depth (m/ft) To
BROWN	CLAY SILTY STONES			0	8ft
BROWN	SAND CLAY			8ft	17ft
BROWN	LIMESTONE			17ft	48ft
GRAY	LIMESTONE			48ft	79ft
GRAY	LIMESTONE SHALE			79ft	82ft

Annular Space

Depth Set at (m/ft) From	Depth Set at (m/ft) To	Type of Sealant Used (Material and Type)	Volume Placed (m^3/ft^3)
0	19ft	BENTONITE SLURRY	60gal

Method of Construction

☐ Cable Tool ☐ Diamond
☒ Rotary (Conventional) ☐ Jetting
☐ Rotary (Reverse) ☐ Driving
☐ Boring ☐ Digging
☐ Air percussion
☐ Other, *specify* _____

Well Use

☐ Public ☐ Commercial ☐ Not used
☐ Domestic ☐ Municipal ☐ Dewatering
☐ Livestock ☒ Test Hole ☐ Monitoring
☐ Irrigation ☐ Cooling & Air Conditioning
☐ Industrial
☐ Other, *specify* _____

Construction Record - Casing

Inside Diameter (cm/in)	Open Hole OR Material (Galvanized, Fibreglass, Concrete, Plastic, Steel)	Wall Thickness (cm/in)	Depth (m/ft) From	Depth (m/ft) To
6¼	steel	.188	0	19ft
6in	open hole		19ft	82ft

Construction Record - Screen

Outside Diameter (cm/in)	Material (Plastic, Galvanized, Steel)	Slot No.	Depth (m/ft) From	Depth (m/ft) To

Status of Well

☐ Water Supply
☐ Replacement Well
☐ Test Hole
☐ Recharge Well
☐ Dewatering Well
☐ Observation and/or Monitoring Hole
☐ Alteration (Construction)
☐ Abandoned, Insufficient Supply
☐ Abandoned, Poor Water Quality
☐ Abandoned, other, *specify*
☐ Other, *specify*

Water Details

Water found at Depth	Kind of Water	Hole Diameter Depth (m/ft) From	Hole Diameter Depth (m/ft) To	Hole Diameter (cm/in)
24ft (m/ft) ☐ Gas	☒ Fresh ☐ Untested ☐ Other, *specify*	0	19ft	9in
40-60ft (m/ft) ☐ Gas	☒ Fresh ☐ Untested ☐ Other, *specify*	19ft	82ft	6in
(m/ft) ☐ Gas	☐ Fresh ☐ Untested ☐ Other, *specify*			

Results of Well Yield Testing

After test of well yield, water was:
☐ Clear and sand free
☐ Other, *specify* _____

If pumping discontinued, give reason: pump later time

Pump intake set at *(m/ft)*

Pumping rate *(l/min / GPM)*

Duration of pumping ____ hrs + ____ min

Final water level end of pumping *(m/ft)*

If flowing give rate *(l/min / GPM)*

Recommended pump depth *(m/ft)*

Recommended pump rate *(l/min / GPM)*

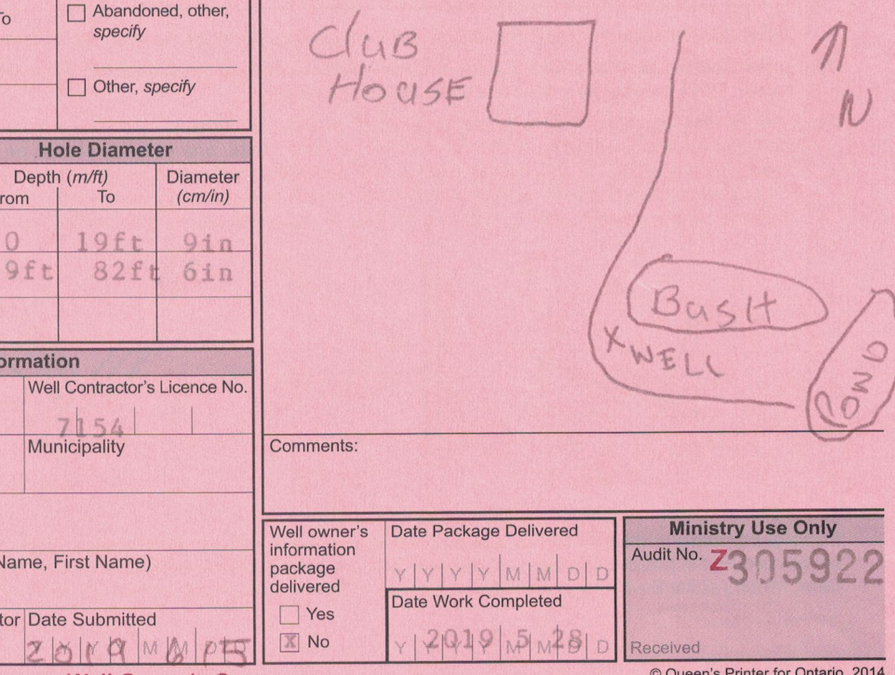
Well production *(l/min / GPM)* 25gpm

Disinfected? ☒ Yes ☐ No 150ppm

	Draw Down Time (min)	Draw Down Water Level (m/ft)	Recovery Time (min)	Recovery Water Level (m/ft)
Static Level	11ft			
1			1	
2			2	
3			3	
4			4	
5			5	
10			10	
15			15	
20			20	
25			25	
30			30	
40			40	
50			50	
60			60	

Map of Well Location

Please provide a map below following instructions on the back.



Comments:

Well Contractor and Well Technician Information

Business Name of Well Contractor	Well Contractor's Licence No.
KEITH LANG WELL DRILLING INC	7154

Business Address (Street Number/Name)	Municipality
251 ELDON ST GODERICH	

Province	Postal Code	Business E-mail Address
ONT	N7A3R9	

Bus. Telephone No. *(inc. area code)*	Name of Well Technician (Last Name, First Name)
519-524-8159	KEITH LANG

Well Technician's Licence No.	Signature of Technician and/or Contractor	Date Submitted
T446	K. Lang	2019/06/25

Well owner's information package delivered: ☐ Yes ☒ No

Date Package Delivered: ____

Date Work Completed: 2019/5/28

Ministry Use Only

Audit No. Z305922

Received

Well Owner's Copy

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ACOUSTIC and OPTICAL TELEVIEWER PLOT

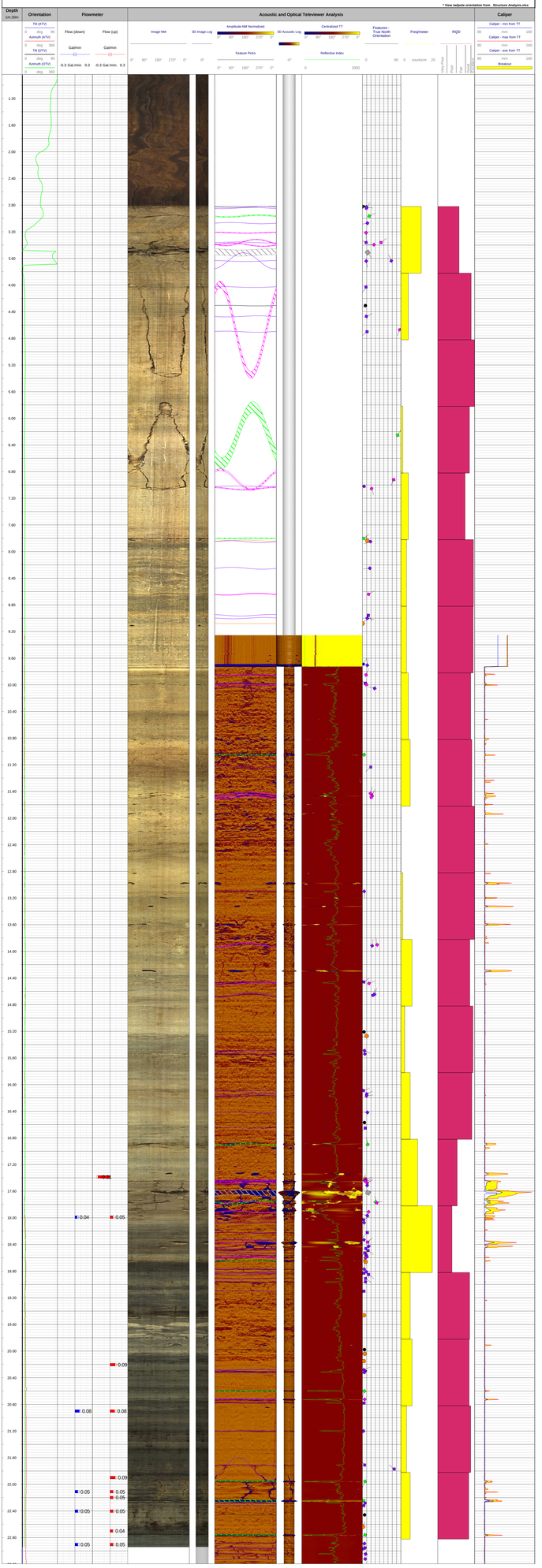
DGI GEOSCIENCE INC.

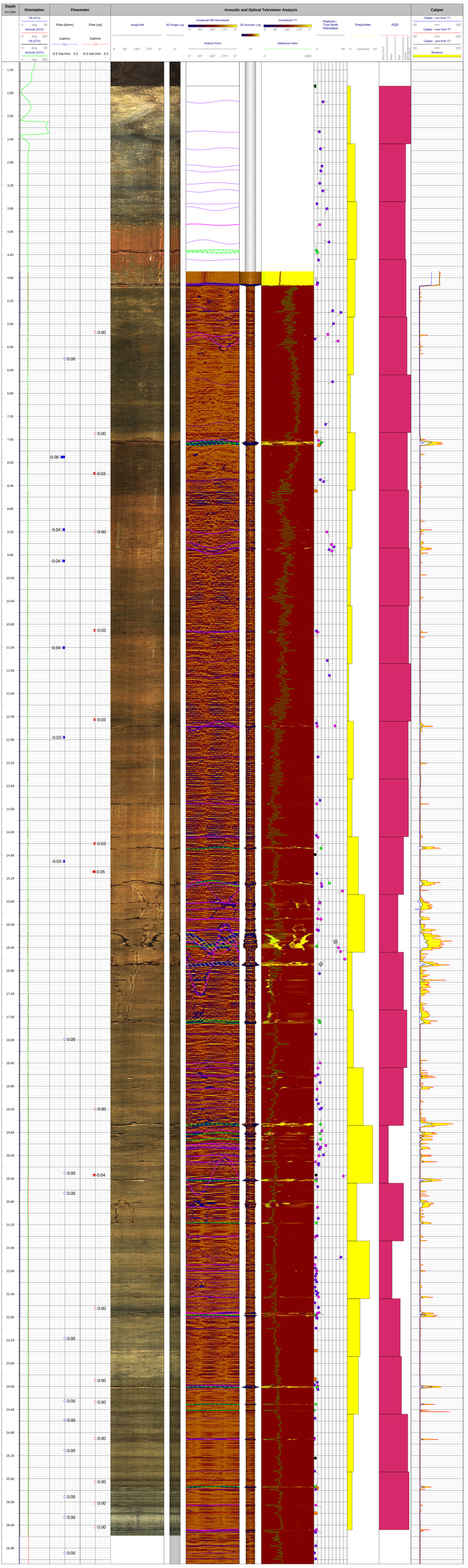
Company:	Azimuth	**Total Depth:**	24 m	**UTM X (Easting):**	---	**Notes:**	
Hole ID:	BS-01	**Surveyed Depth:**	23 m	**UTM Y (Northing):**	---		
Acquisition date(s):	Oct. 10, 2018	**Hole Diameter:**	96 mm	**UTM Z (Elevation):**	---		
Field Personnel:	K. Smylie, O. Fomenko	**Hole Type:**	Diamond				
Legal Location:	Burlington	**Casing Depth:**	2.8 m				
Survey Day(s):	1	**Fluid Type:**	Water				

LEGEND - STRUCTURE TYPE

JointFracture - Fuzzlimits Open (20mm) · JointFracture - Moderately Open (10-20mm) · JointFracture - Open (5-10mm) · JointFracture - Tight (0-5mm) · Bedding Bedding Foliation · Contact · Bin of Casing · Water Level

* View tadpole orientation from Structure Analysis.xlsx

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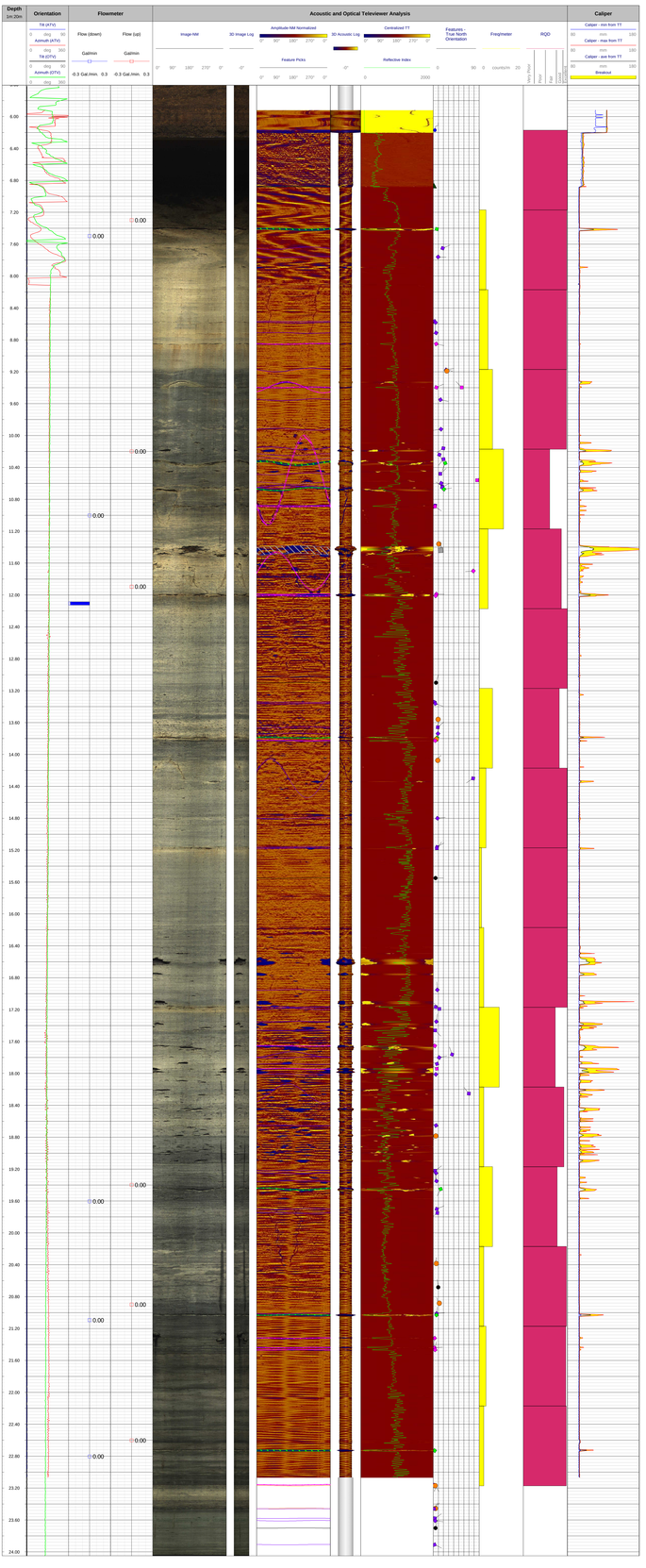
1in:20m
Orientation
Tilt (ATV)
Azimuth (ATV)
Tilt (DTV)
Azimuth (DTV)
Flowmeter
Flow (down)
Flow (up)
Gal/min
Acoustic and Optical Televiewer Analysis
Image-NM
3D Image Log
Amplitude-NM Normalized
3D Acoustic Log
Centralized TT
Feature Picks
Reflective Index
Features - True North Orientation
Freq/meter
RQD
Caliper
Caliper - min from TT
Caliper - max from TT
Caliper - ave from TT
Breakout


Depth
1m:20m
Orientation
Tilt (ATV)
0 deg 90
Azimuth (ATV)
0 deg 360
Tilt (DTV)
0 deg 90
Azimuth (DTV)
0 deg 360
Flowmeter
Flow (down)
Flow (up)
Gal/min
Gal/min
-0.3 Gal./min. 0.3
-0.3 Gal./min. 0.3
Acoustic and Optical Televiewer Analysis
Image-NM
3D Image Log
Amplitude-NM Normalized
3D Acoustic Log
Centralized TT
Features - True North Orientation
Freq/meter
RQD
Feature Picks
Reflective Index
counts/m
Very Poor
Poor
Fair
Good
Excellent
Caliper
Caliper - min from TT
Caliper - max from TT
Caliper - ave from TT
Breakout
0.00
6.00
6.40
6.80
7.20
7.60
8.00
8.40
8.80
9.20
9.60
10.00
10.40
10.80
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11.60
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12.40
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17.60
18.00
18.40
18.80
19.20
19.60
20.00
20.40
20.80
21.20
21.60
22.00
22.40
22.80
23.20
23.60
24.00

ACOUSTIC AND OPTICAL TELEVIEWER PLOT

DGI GEOSCIENCE INC.

Company:	Azimuth	**Total Depth:**	25 m	**UTM X (Easting):**	---
Hole ID:	BS-04	**Surveyed Depth:**	24.2 m	**UTM Y (Northing):**	---
Acquisition date(s):	June 05, 2019	**Hole Diameter:**	6"	**UTM Z (Elevation):**	---
Field Personnel:	R. Morrison	**Hole Type:**	Percussion	**Legal Location:**	Burlington, ON
Data Analysis:	P. Patraskovic, A. Leighton	**Casing Depth:**	3.7 m		
Survey Day(s):	1	**Fluid Level:**	---		

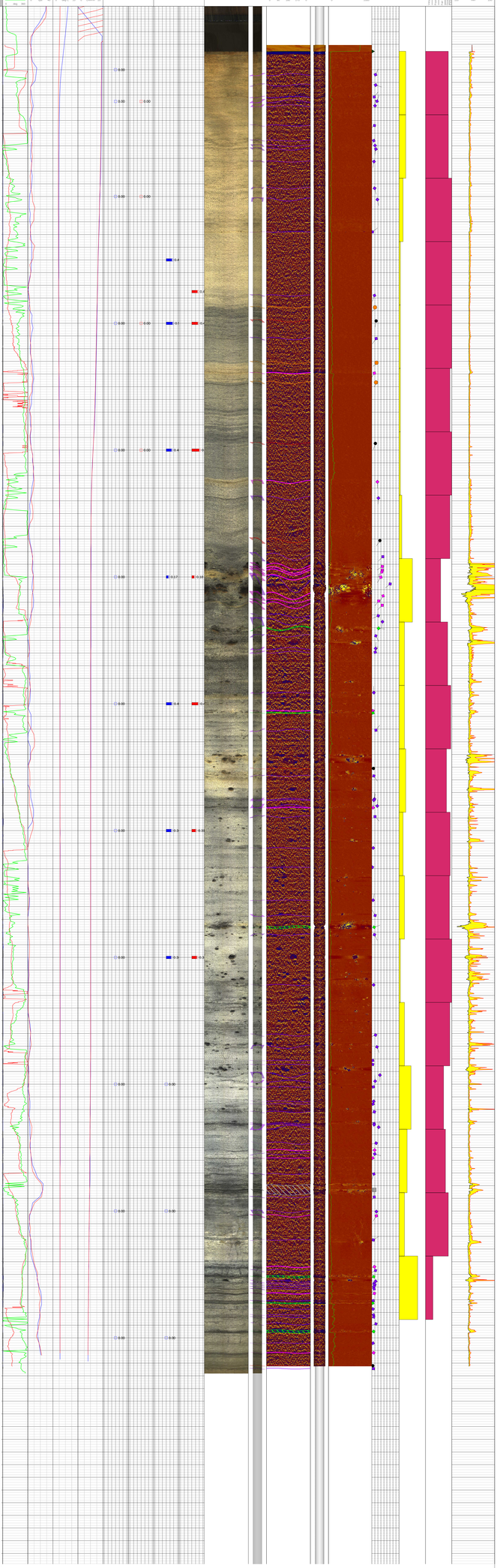
Notes:

Acoustic and optical televiewer final results. Flowmeter collected in both Static and Dynamic mode. Down direction is the survey run, with control points being acquired in the up direction for quality control. Natural gamma data relative.

LEGEND - STRUCTURE TYPE

JointFracture - Wide Open (30mm) | JointFracture - Moderately Open (10-30mm) | JointFracture - Open (3-10mm) | JointFracture - Tight (0-3mm) | Bedding/ Bedding Foliation | Contact | Bit of Casing

* View tadpole orientation from [HoleID] FeatureAnalysis.xlsx



ACOUSTIC AND OPTICAL TELEVIEWER PLOT

DGI GEOSCIENCE INC.

Company:	Azimuth	**Total Depth:**	25 m	**UTM X (Easting):**	---
Hole ID:	BS-05	**Surveyed Depth:**	24.4 m	**UTM Y (Northing):**	---
Acquisition date(s):	June 4 -5, 2019	**Hole Diameter:**	6"	**UTM Z (Elevation):**	---
Field Personnel:	R. Morrison	**Hole Type:**	Percussion	**Legal Location:**	Burlington
Data Analysis:	S. Reese, P. Patraskovic	**Casing Depth:**	3.7 m		
Survey Day(s):	2	**Fluid Level:**	3.6 m		

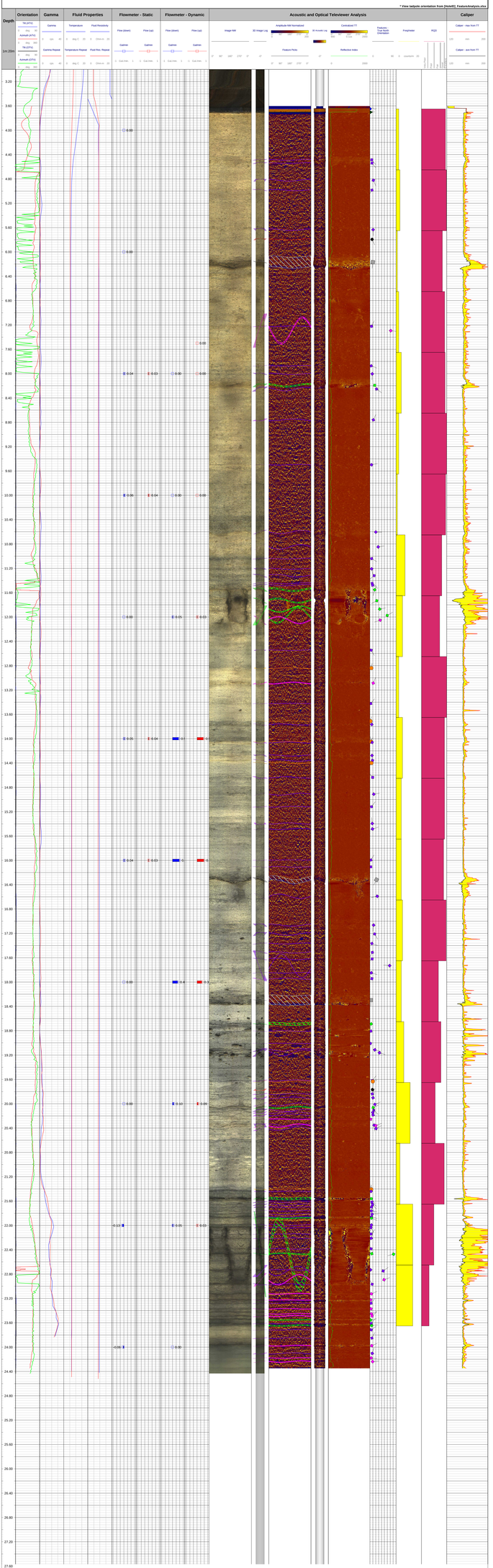
Notes:

Acoustic and optical televiewer final results. Flowmeter collected in both Static and Dynamic mode. Down direction is the survey run, with control points being acquired in the up direction for quality control. Natural gamma data relative.

LEGEND - STRUCTURE TYPE

Joint/Fracture - Wide Open (50mm+) | Joint/Fracture - Moderately Open (10-50mm) | Joint/Fracture - Open (1-10mm) | Joint/Fracture - Tight (<1mm) | Bedding/ Banding/ Foliation | Contact | Bed of Casing | Water Level

*** View ladjusite orientation from [Hole/ID]_FeaturesAnalysis.xlsx**



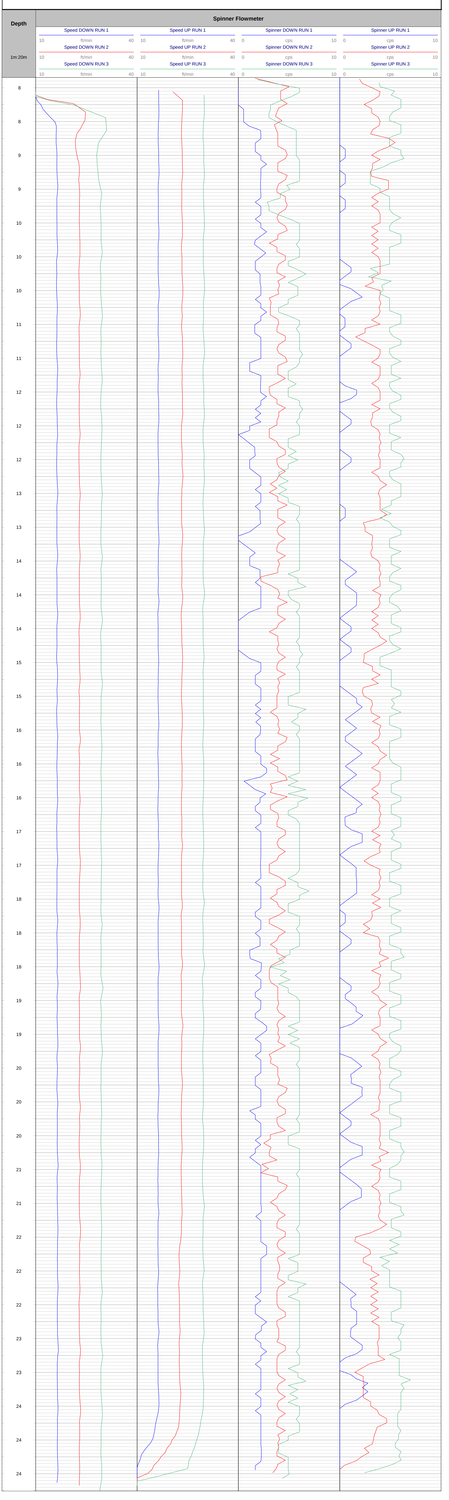
PHYSICAL PROPERTIES PLOT

DGI GEOSCIENCE INC.

Company:	Azimuth	**Total Depth:**	25 m	**UTM X (Easting):**	---
Hole ID:	BS-06	**Surveyed Depth:**	25 m	**UTM Y (Northing):**	---
Acquisition date(s):	Jun. 06, 2019	**Hole Diameter:**	155 mm	**UTM Z (Elevation):**	---
Field Personnel:	R. Morrison	**Hole Type:**	Percussion	**Legal Location:**	Burlington, ON
Data Analysis:	P. Patrakovic	**Casing Depth:**	---		
Survey Day(s):	1	**Fluid Level:**	---		

Notes:

Flowmeter surveyed at 5, 7 and 9 m/min, in both the down and up direction. Pump at 7m, pumping at 5L/min.



PHYSICAL PROPERTIES PLOT

DGI GEOSCIENCE INC.

Company:	Azimuth	**Total Depth:**	25 m	**UTM X (Easting):**	---
Hole ID:	BS-07	**Surveyed Depth:**	25 m	**UTM Y (Northing):**	---
Acquisition date(s):	Jun. 06, 2019	**Hole Diameter:**	155 mm	**UTM Z (Elevation):**	---
Field Personnel:	R. Morrison	**Hole Type:**	Percussion	**Legal Location:**	Burlington, ON
Data Analysis:	P. Patrakovic	**Casing Depth:**	---		
Survey Day(s):	1	**Fluid Level:**	---		

Notes:

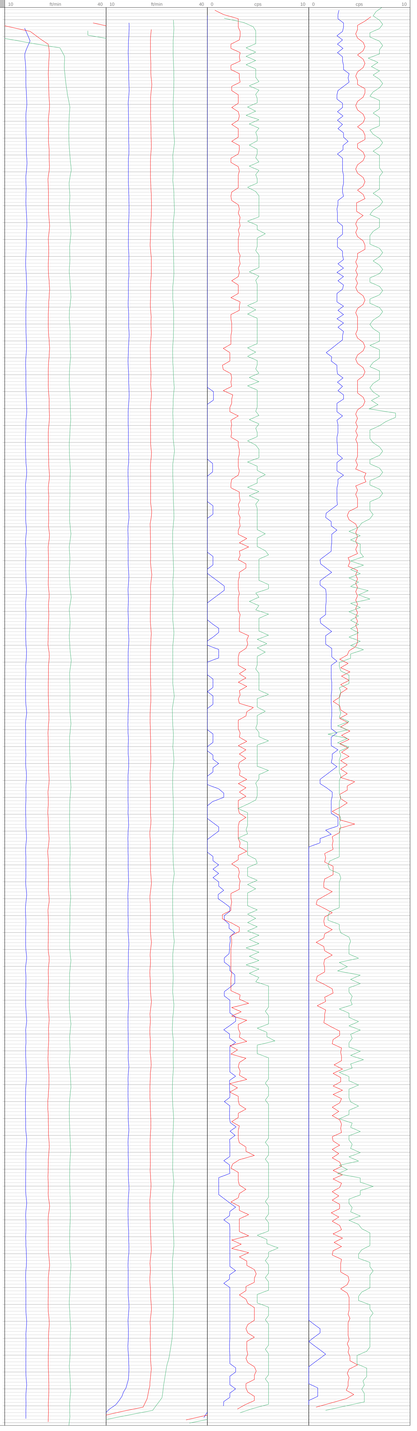
Flowmeter surveyed at 5, 7 and 9 m/min, in both the down and up direction. Pump at 7m, pumping at 5L/min.

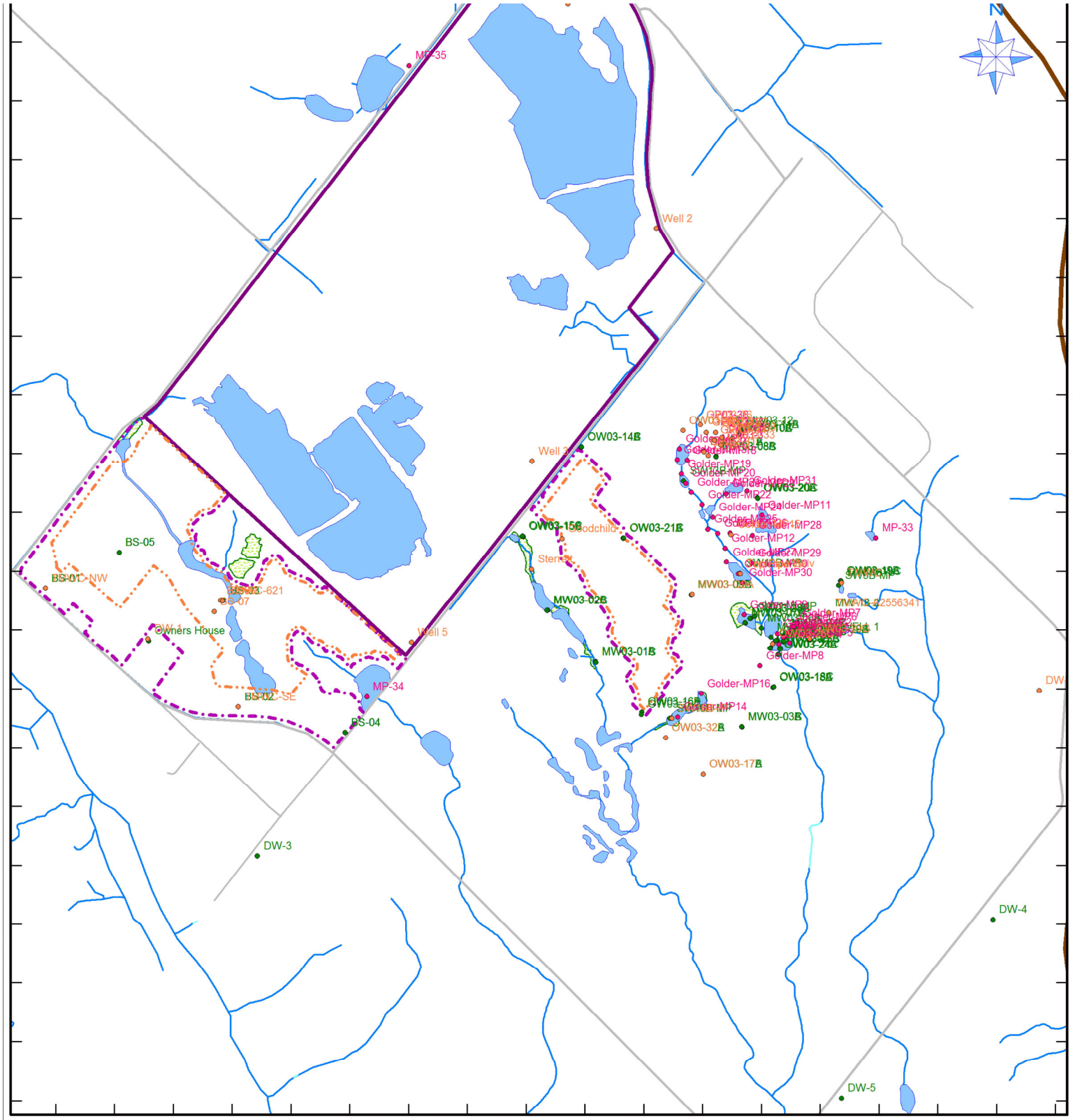
Depth

1m:20m

Spinner Flowmeter

Speed DOWN RUN 1	Speed UP RUN 1	Spinner DOWN RUN 1	Spinner UP RUN 1
10 m/min 40	10 m/min 40	0 cps 10	0 cps 10
Speed DOWN RUN 2	**Speed UP RUN 2**	**Spinner DOWN RUN 2**	**Spinner UP RUN 2**
10 m/min 40	10 m/min 40	0 cps 10	0 cps 10
Speed DOWN RUN 3	**Speed UP RUN 3**	**Spinner DOWN RUN 3**	**Spinner UP RUN 3**
10 m/min 40	10 m/min 40	0 cps 10	0 cps 10





Legend:

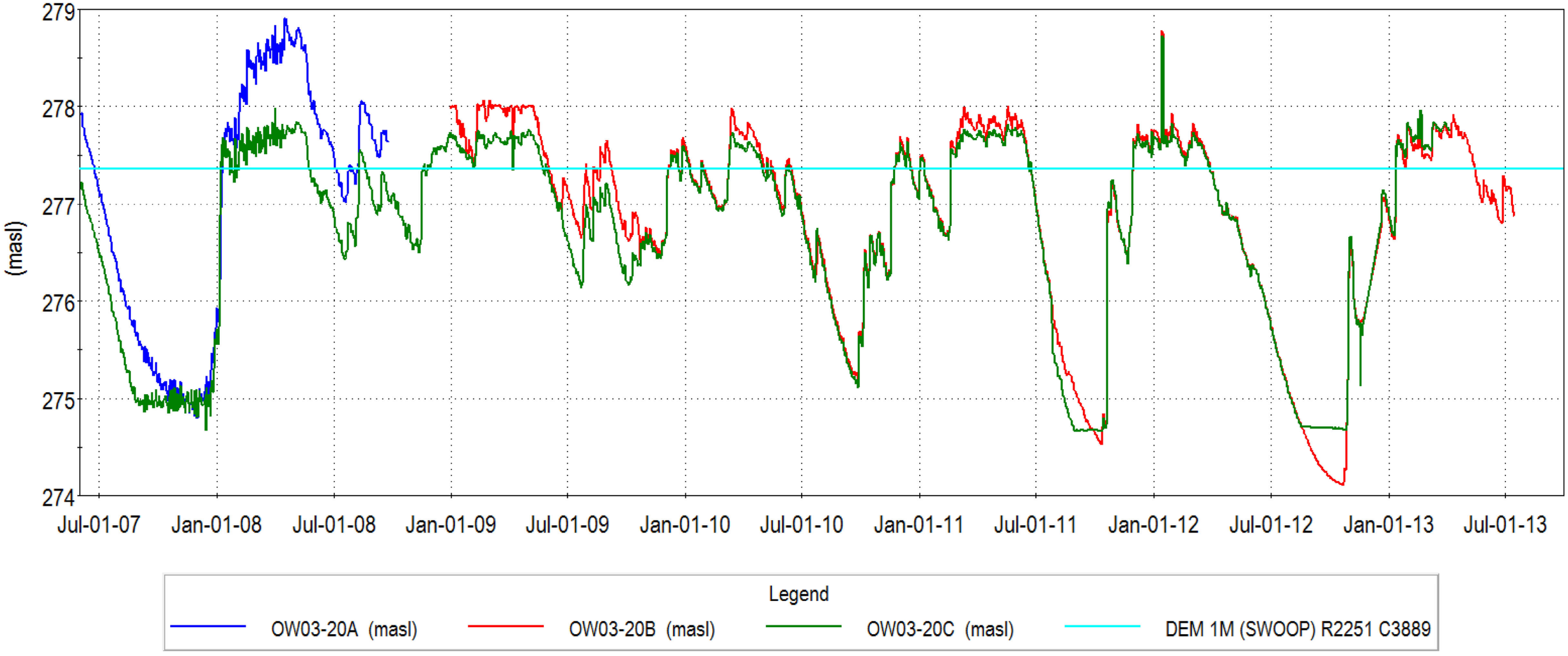
- Roads
- Express/Highway
- Existing Quarry
- Expansion Lands
- Extraction Area
- River/Stream
- Lake
- Wetland
- Niagara Escarpment
- Model Boundary
- Cross Section
- Active Monitor Wells
- Inactive Monitor Wells
- Other Monitor Wells

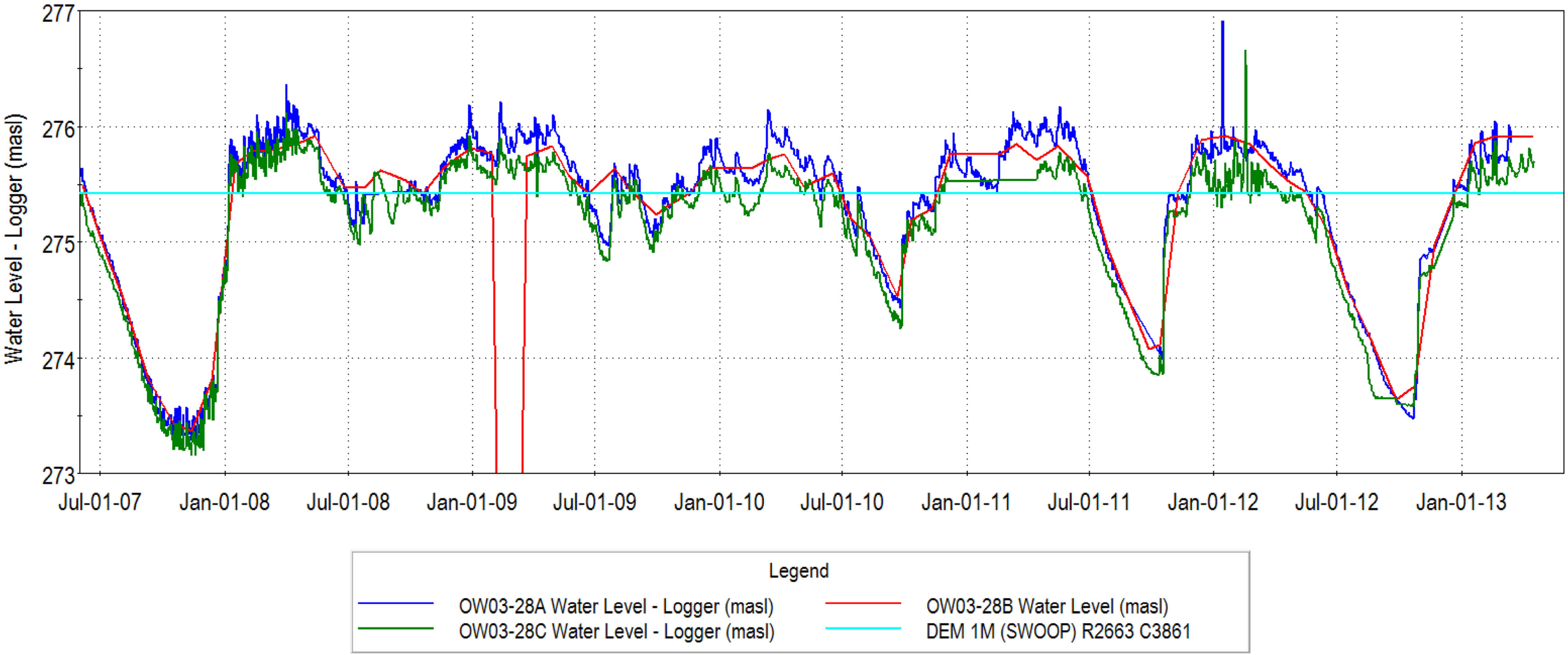
NELSON AGGREGATES

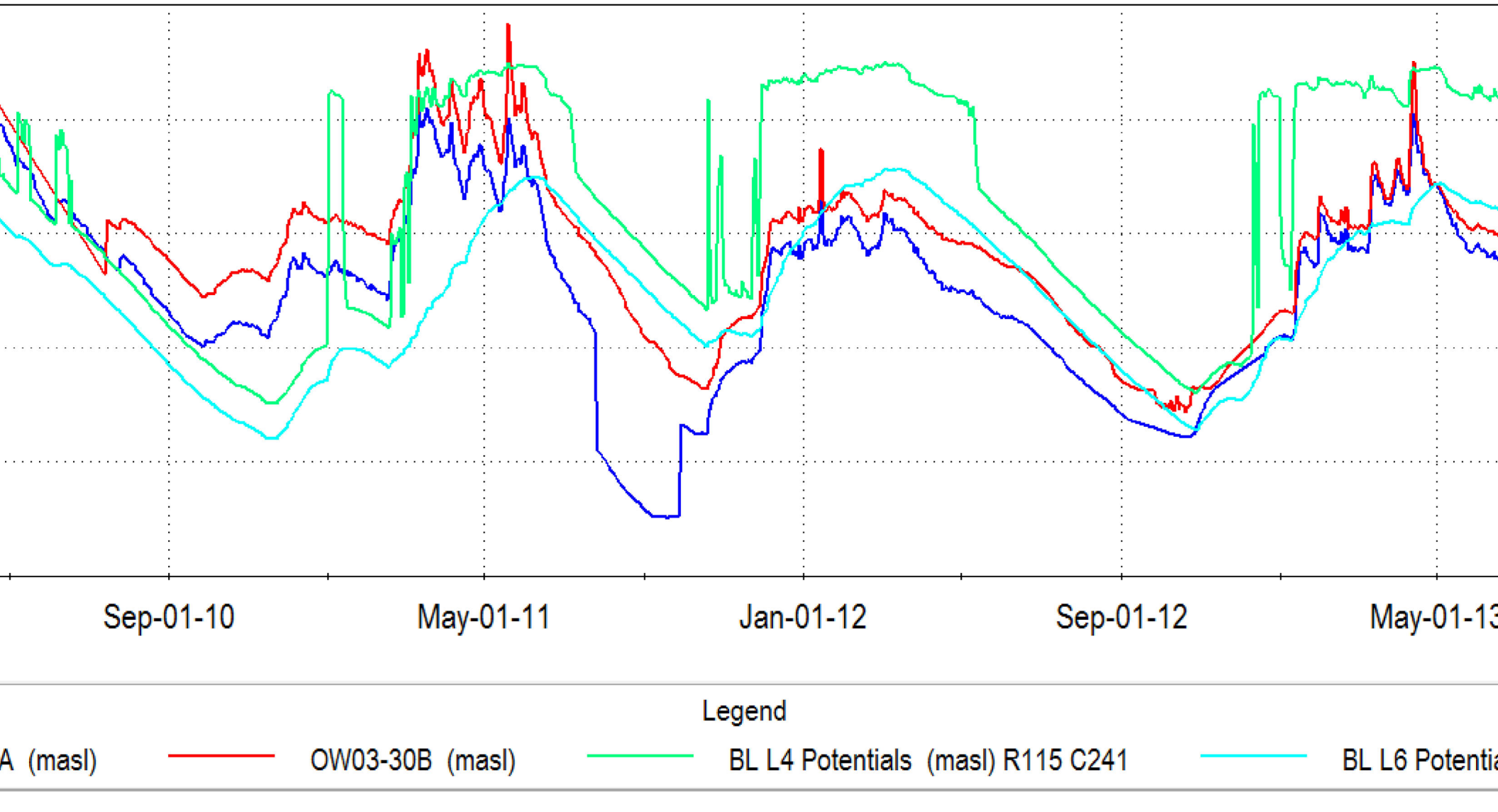
Burlington Quarry Extension

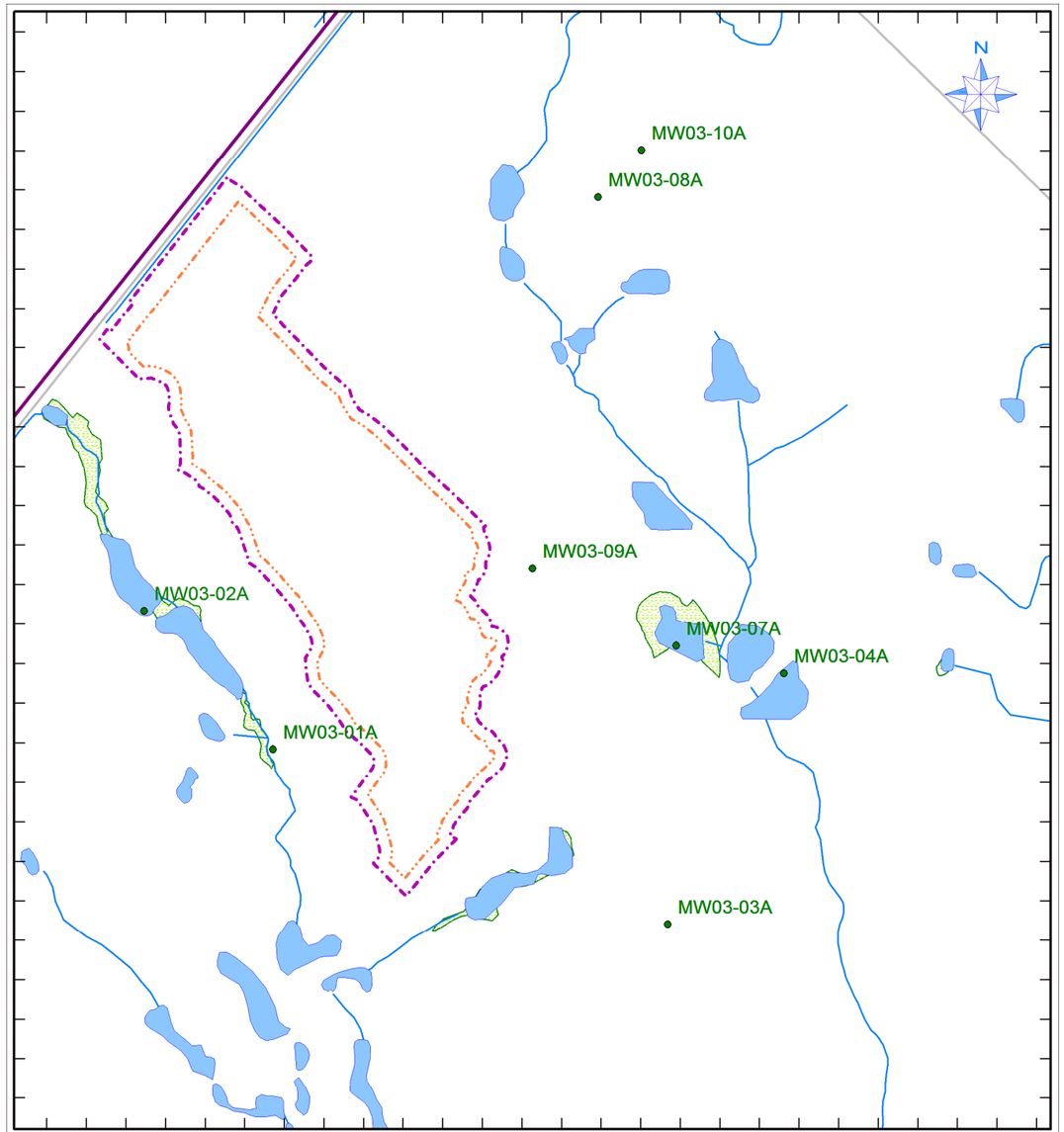
Earthfx Incorporated

Location of all Monitoring Wells


279
278
277
276
275
274
(masl)
Jul-01-07
Jan-01-08
Jul-01-08
Jan-01-09
Jul-01-09
Jan-01-10
Jul-01-10
Jan-01-11
Jul-01-11
Jan-01-12
Jul-01-12
Jan-01-13
Jul-01-13
Legend
OW03-20A (masl)
OW03-20B (masl)
OW03-20C (masl)
DEM 1M (SWOOP) R2251 C3889


277
276
275
274
273
Water Level - Logger (masl)
Jul-01-07
Jan-01-08
Jul-01-08
Jan-01-09
Jul-01-09
Jan-01-10
Jul-01-10
Jan-01-11
Jul-01-11
Jan-01-12
Jul-01-12
Jan-01-13
Legend
OW03-28A Water Level - Logger (masl)
OW03-28B Water Level (masl)
OW03-28C Water Level - Logger (masl)
DEM 1M (SWOOP) R2663 C3861


Sep-01-10
May-01-11
Jan-01-12
Sep-01-12
May-01-13
Legend
A (masl)
OW03-30B (masl)
BL L4 Potentials (masl) R115 C241
BL L6 Potentia



Legend:

- Roads
- Express/Highway
- Existing Quarry
- Expansion Lands
- Extraction Area
- Packer Tests
- River/Stream
- Lake
- Wetland
- Niagara Escarpment
- Model Boundary
- Cross Section

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0 100 200

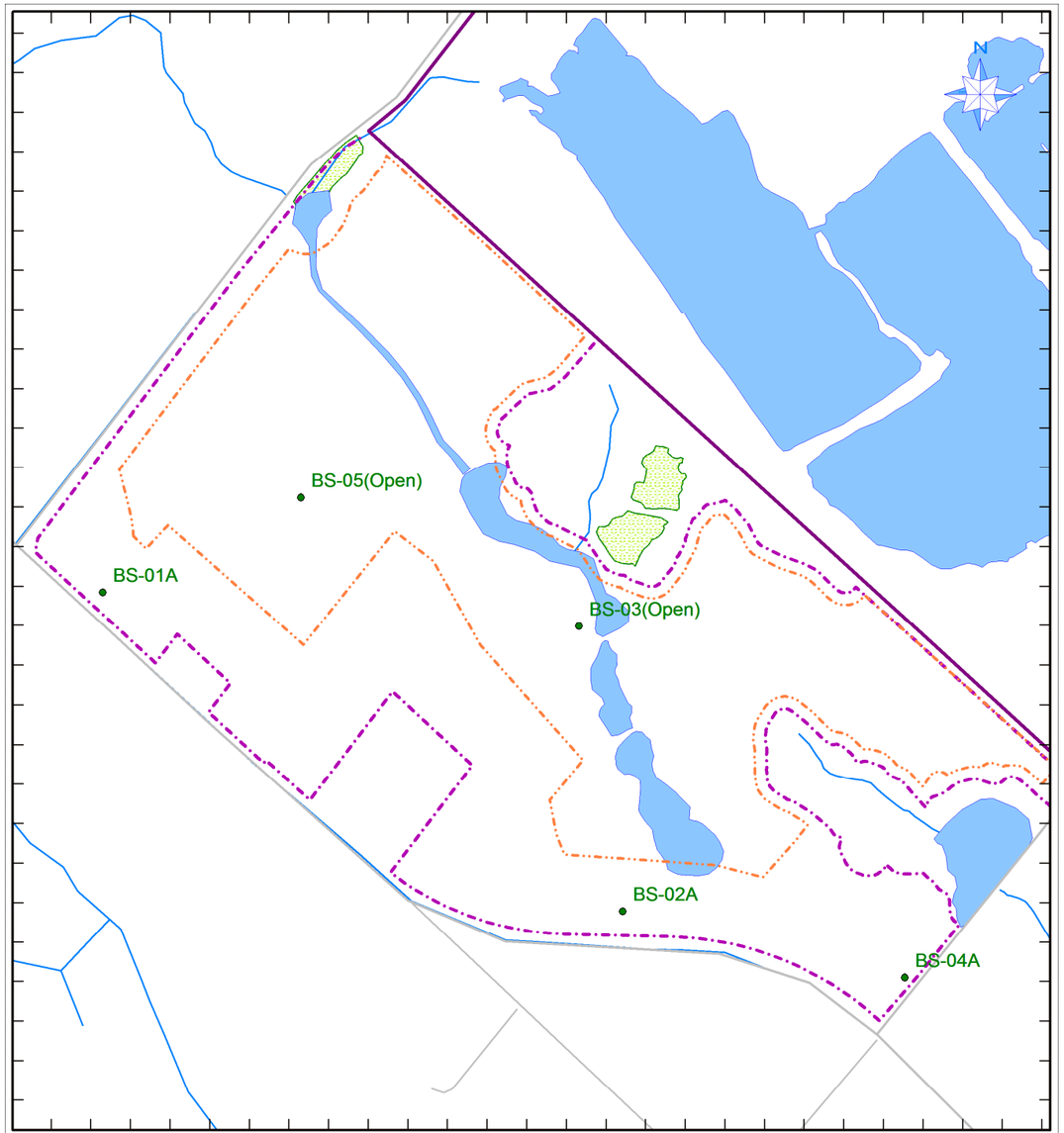
Units: UTM NAD83 Zone 17

NELSON AGGREGATES

Burlington Quarry Extension

Earthfx Incorporated

Packer Tests - South Extension



Legend:

- Roads
- Express/Highway
- Existing Quarry
- Expansion Lands
- Extraction Area
- Packer Tests
- River/Stream
- Lake
- Wetland
- Niagara Escarpment
- Model Boundary
- Cross Section

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Drawing prepared by Earthfx 7/06/21

0 100 200

Units: UTM NAD83 Zone 17

NELSON AGGREGATES

Burlington Quarry Extension

Earthfx Incorporated

Packer Tests - West Extension

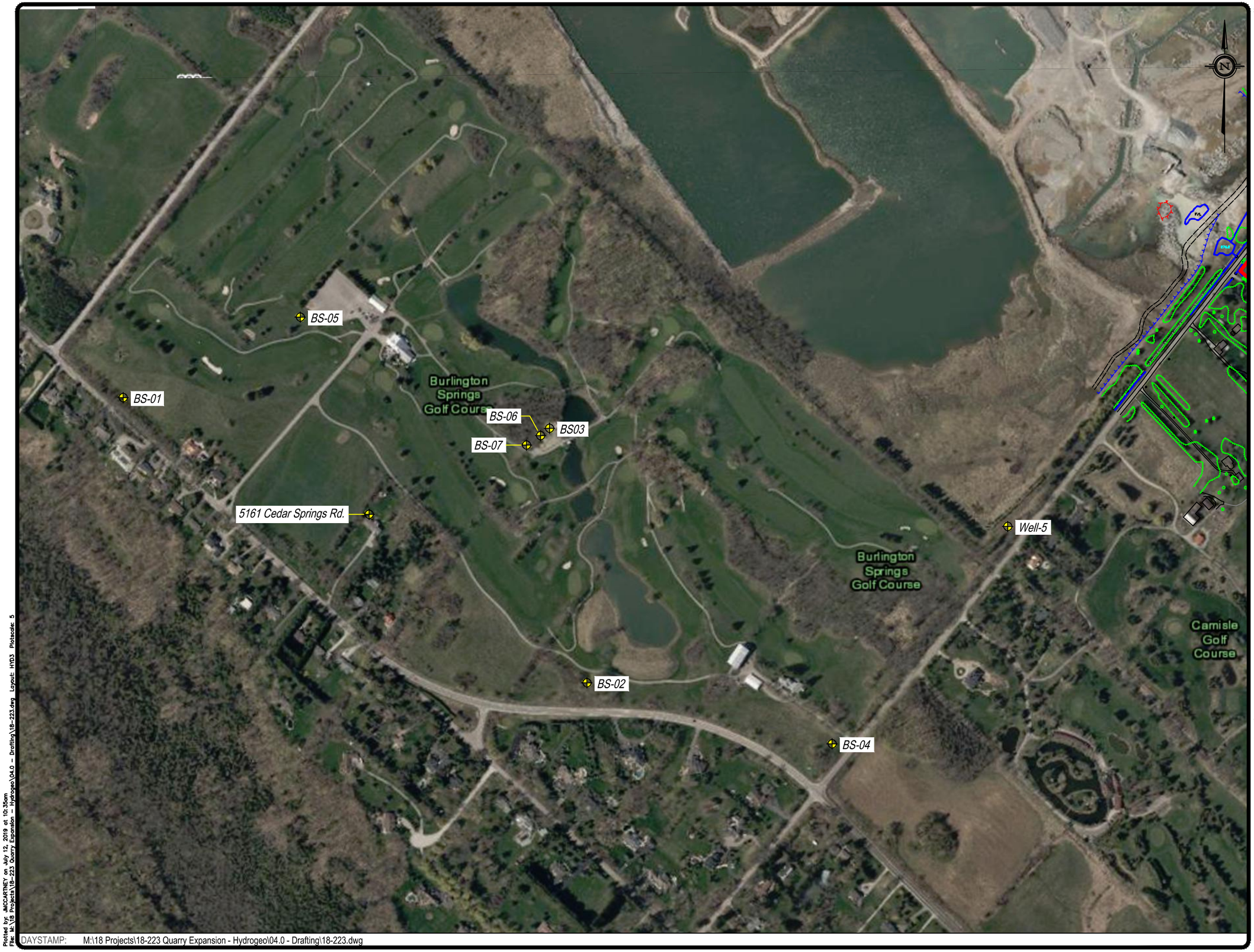
Packer Test Locations and Related Data

INT_NAME	Easting	Northing	Ground Elv	Bottom Elv	Description	Interval Top	Interval Bot	Hyd. Cond. (m/s)	Test Year	Stratigraphy
MW03-01A	590635.61	4805092.18	270.94	246.49	Packer Test 4	256.61	253.71	6.60E-06	2003	Amabel
MW03-01A	590635.61	4805092.18	270.94	246.49	Packer Test 5	258.9	256	2.80E-06	2003	Amabel
MW03-01A	590635.61	4805092.18	270.94	246.49	Packer Test 6	261.18	258.29	9.90E-06	2003	Amabel
MW03-01A	590635.61	4805092.18	270.94	246.49	Packer Test 7	263.47	260.57	1.10E-05	2003	Amabel
MW03-02A	590473.10	4805266.68	272.48	246.6	Packer Test 3	255.86	252.97	1.30E-05	2003	Amabel
MW03-02A	590473.10	4805266.68	272.48	246.6	Packer Test 3b	255.86	252.97	1.20E-05	2003	Amabel
MW03-02A	590473.10	4805266.68	272.48	246.6	Packer Test 4	258.15	255.25	1.00E-05	2003	Amabel
MW03-02A	590473.10	4805266.68	272.48	246.6	Packer Test 4b	258.15	255.25	1.60E-05	2003	Amabel
MW03-02A	590473.10	4805266.68	272.48	246.6	Packer Test 5	260.44	257.54	1.60E-06	2003	Amabel
MW03-03A	591134.42	4804870.51	274.78	245.7	Packer Test 4	255.57	252.83	3.30E-06	2003	Amabel
MW03-03A	591134.42	4804870.51	274.78	245.7	Packer Test 5	257.71	254.96	1.40E-06	2003	Amabel
MW03-03A	591134.42	4804870.51	274.78	245.7	Packer Test 6	259.84	257.1	2.10E-06	2003	Amabel
MW03-03A	591134.42	4804870.51	274.78	245.7	Packer Test 7	261.98	259.23	1.90E-06	2003	Amabel
MW03-03A	591134.42	4804870.51	274.78	245.7	Packer Test 8	264.11	261.37	1.90E-06	2003	Amabel
MW03-03A	591134.42	4804870.51	274.78	245.7	Packer Test 9	266.24	263.5	1.70E-07	2003	Amabel
MW03-03A	591134.42	4804870.51	274.78	245.7	Packer Test 10	268.38	265.63	3.40E-07	2003	Amabel
MW03-04A	591280.82	4805187.43	274.92	247.28	Packer Test 5	259.07	256.32	4.00E-07	2003	Amabel
MW03-04A	591280.82	4805187.43	274.92	247.28	Packer Test 6	261.2	258.46	1.50E-06	2003	Amabel
MW03-04A	591280.82	4805187.43	274.92	247.28	Packer Test 7	263.33	260.59	3.10E-06	2003	Amabel
MW03-04A	591280.82	4805187.43	274.92	247.28	Packer Test 8	265.16	262.42	5.10E-06	2003	Amabel
MW03-04A	591280.82	4805187.43	274.92	247.28	Packer Test 9	266.99	264.25	4.60E-06	2003	Amabel
MW03-04A	591280.82	4805187.43	274.92	247.28	Packer Test 10	268.82	266.08	1.00E-05	2003	Amabel
MW03-07A	591144.92	4805222.60	275.37	247.79	Packer Test 4	257.38	254.64	1.30E-06	2003	Amabel
MW03-07A	591144.92	4805222.60	275.37	247.79	Packer Test 5	259.52	256.77	1.50E-04	2003	Amabel
MW03-07A	591144.92	4805222.60	275.37	247.79	Packer Test 6	261.65	258.91	2.70E-05	2003	Amabel
MW03-07A	591144.92	4805222.60	275.37	247.79	Packer Test 7	263.78	261.04	9.90E-06	2003	Amabel
MW03-07A	591144.92	4805222.60	275.37	247.79	Packer Test 8	265.92	263.17	7.30E-06	2003	Amabel
MW03-07A	591144.92	4805222.60	275.37	247.79	Packer Test 9	267.75	265	7.90E-06	2003	Amabel
MW03-07A	591144.92	4805222.60	275.37	247.79	Packer Test 10	269.12	266.38	2.40E-06	2003	Amabel
MW03-08A	591046.31	4805790.86	278.04	253.35	Packer Test 3	260.66	257.92	1.90E-05	2003	Amabel
MW03-08A	591046.31	4805790.86	278.04	253.35	Packer Test 4	262.8	260.05	5.40E-05	2003	Amabel
MW03-08A	591046.31	4805790.86	278.04	253.35	Packer Test 5	264.93	262.19	3.80E-05	2003	Amabel
MW03-08A	591046.31	4805790.86	278.04	253.35	Packer Test 6	267.06	264.32	1.00E-05	2003	Amabel
MW03-08A	591046.31	4805790.86	278.04	253.35	Packer Test 7	269.2	266.45	1.30E-05	2003	Amabel
MW03-08A	591046.31	4805790.86	278.04	253.35	Packer Test 8	271.33	268.59	1.50E-05	2003	Amabel
MW03-09A	590963.53	4805320.56	280.09	249.42	Packer Test 3	256.92	254.18	3.50E-05	2003	Amabel
MW03-09A	590963.53	4805320.56	280.09	249.42	Packer Test 4	259.05	256.31	7.80E-08	2003	Amabel
MW03-09A	590963.53	4805320.56	280.09	249.42	Packer Test 5	261.19	258.44	9.40E-08	2003	Amabel
MW03-09A	590963.53	4805320.56	280.09	249.42	Packer Test 6	263.32	260.58	4.50E-07	2003	Amabel
MW03-09A	590963.53	4805320.56	280.09	249.42	Packer Test 7	265.46	262.71	1.40E-06	2003	Amabel
MW03-09A	590963.53	4805320.56	280.09	249.42	Packer Test 8	267.59	264.85	2.00E-07	2003	Amabel
MW03-09A	590963.53	4805320.56	280.09	249.42	Packer Test 9	269.72	266.98	2.00E-07	2003	Amabel
MW03-09A	590963.53	4805320.56	280.09	249.42	Packer Test 10	271.86	269.11	5.20E-06	2003	Amabel
MW03-09A	590963.53	4805320.56	280.09	249.42	Packer Test 11	273.69	270.64	5.30E-06	2003	Amabel
MW03-10A	591100.90	4805850.94	278.12	251.76	Packer Test 4	261.35	258.61	9.30E-08	2003	Amabel

INT_NAME	Easting	Northing	Ground Elv	Bottom Elv	Description	Interval Top	Interval Bot	Hyd. Cond. (m/s)	Test Year	Stratigraphy
MW03-10A	591100.90	4805850.94	278.12	251.76	Packer Test 5	263.49	260.74	1.40E-07	2003	Amabel
MW03-10A	591100.90	4805850.94	278.12	251.76	Packer Test 6	265.62	262.88	1.10E-06	2003	Amabel
MW03-10A	591100.90	4805850.94	278.12	251.76	Packer Test 7	267.75	265.01	7.80E-06	2003	Amabel
MW03-10A	591100.90	4805850.94	278.12	251.76	Packer Test 8	269.89	267.14	2.90E-05	2003	Amabel
MW03-10A	591100.90	4805850.94	278.12	251.76	Packer Test 9	272.02	269.28	7.60E-06	2003	Amabel
MW03-01A	590635.61	4805092.18	270.94	246.49	Packer Test 3	254.02	251.43	2.70E-05	2003	Amabel/Reynales
MW03-03A	591134.42	4804870.51	274.78	245.7	Packer Test 3	253.44	250.54	2.30E-06	2003	Amabel/Reynales
MW03-04A	591280.82	4805187.43	274.92	247.28	Packer Test 3	254.8	252.05	1.50E-07	2003	Amabel/Reynales
MW03-04A	591280.82	4805187.43	274.92	247.28	Packer Test 4	256.93	254.19	2.20E-07	2003	Amabel/Reynales
MW03-07A	591144.92	4805222.60	275.37	247.79	Packer Test 3	255.25	252.5	6.80E-07	2003	Amabel/Reynales
MW03-08A	591046.31	4805790.86	278.04	253.35	Packer Test 2	258.53	255.78	1.10E-05	2003	Amabel/Reynales
MW03-09A	590963.53	4805320.56	280.09	249.42	Packer Test 2	254.79	252.04	1.80E-07	2003	Amabel/Reynales
MW03-10A	591100.90	4805850.94	278.12	251.76	Packer Test 3	259.22	256.47	1.20E-07	2003	Amabel/Reynales
MW03-01A	590635.61	4805092.18	270.94	246.49	Packer Test 1	249.6	246.56	2.90E-07	2003	Reynales/Thorold/Grimsby
MW03-01A	590635.61	4805092.18	270.94	246.49	Packer Test 2	252.04	249.29	1.60E-07	2003	Reynales/Thorold
MW03-02A	590473.10	4805266.68	272.48	246.6	Packer Test 1	249.61	246.6	6.10E-08	2003	Thorold/Grimsby
MW03-02A	590473.10	4805266.68	272.48	246.6	Packer Test 2	251.44	248.7	1.65E-07	2003	Reynales/Thorold
MW03-03A	591134.42	4804870.51	274.78	245.7	Packer Test 1	248.87	245.7	1.30E-07	2003	Thorold/Grimsby
MW03-03A	591134.42	4804870.51	274.78	245.7	Packer Test 2	251	248.26	1.00E-07	2003	Reynales/Thorold
MW03-04A	591280.82	4805187.43	274.92	247.28	Packer Test 1	250.53	247.28	1.80E-07	2003	Thorold/Grimsby
MW03-07A	591144.92	4805222.60	275.37	247.79	Packer Test 1	250.83	247.79	2.70E-07	2003	Reynales/Thorold/Grimsby
MW03-07A	591144.92	4805222.60	275.37	247.79	Packer Test 2	253.11	250.37	5.90E-07	2003	Reynales/Thorold
MW03-08A	591046.31	4805790.86	278.04	253.35	Packer Test 1	256.39	253.35	3.80E-05	2003	Reynales/Thorold
MW03-09A	590963.53	4805320.56	280.09	249.42	Packer Test 1	252.65	249.42	1.80E-08	2003	Amabel/Reynales/Thorold
MW03-10A	591100.90	4805850.94	278.12	251.76	Packer Test 2	257.08	254.34	3.00E-08	2003	Reynales/Thorold
BS-01A	588765	4805342	268.3	243.93	Packer Test BS-01 - 1	244.92	244.02	4.50E-05	2019	Reynales/Cabot Head
BS-01A	588765	4805342	268.3	243.93	Packer Test BS-01 - 2	245.82	244.92	1.50E-04	2019	Reynales/Cabot Head
BS-01A	588765	4805342	268.3	243.93	Packer Test BS-01 - 3	246.72	245.82	6.00E-08	2019	Reynales/Cabot Head
BS-01A	588765	4805342	268.3	243.93	Packer Test BS-01 - 4	247.62	246.72	1.20E-07	2019	Amabel/Reynales
BS-01A	588765	4805342	268.3	243.93	Packer Test BS-01 - 5	248.52	247.62	1.80E-06	2019	Amabel/Reynales
BS-01A	588765	4805342	268.3	243.93	Packer Test BS-01 - 6	249.42	248.52	1.50E-03	2019	Amabel
BS-01A	588765	4805342	268.3	243.93	Packer Test BS-01 - 7	250.32	249.42	2.50E-03	2019	Amabel
BS-01A	588765	4805342	268.3	243.93	Packer Test BS-01 - 8	251.22	250.32	4.50E-05	2019	Amabel
BS-01A	588765	4805342	268.3	243.93	Packer Test BS-01 - 9	252.12	251.22	1.50E-05	2019	Amabel
BS-01A	588765	4805342	268.3	243.93	Packer Test BS-01 - 10	253.02	252.12	1.10E-03	2019	Amabel
BS-01A	588765	4805342	268.3	243.93	Packer Test BS-01 - 11	253.92	253.02	1.50E-04	2019	Amabel
BS-01A	588765	4805342	268.3	243.93	Packer Test BS-01 - 12	254.82	253.92	1.10E-05	2019	Amabel
BS-01A	588765	4805342	268.3	243.93	Packer Test BS-01 - 13	255.72	254.82	2.80E-04	2019	Amabel
BS-01A	588765	4805342	268.3	243.93	Packer Test BS-01 - 14	256.62	255.72	9.20E-06	2019	Amabel
BS-01A	588765	4805342	268.3	243.93	Packer Test BS-01 - 15	256.62	256.57	1.10E-04	2019	Amabel
BS-01A	588765	4805342	268.3	243.93	Packer Test BS-01 - 14A	257.91	256.57	1.08E-05	2019	Amabel
BS-01A	588765	4805342	268.3	243.93	Packer Test BS-01 - 1 P3	244.02	243.12	1.00E-08	2019	Reynales/Cabot Head
BS-02A	589421.1	4804939	272	244.7	Packer Test BS-02 - 1 - P3	244.11	244	9.20E-06	2019	Reynales/Cabot Head
BS-02A	589421.1	4804939	272	244.7	Packer Test BS-02 - 2 - P3	244.79	244.11	1.00E-05	2019	Reynales/Cabot Head
BS-02A	589421.1	4804939	272	244.7	Packer Test BS-02 - 1	245.69	244.79	6.20E-06	2019	Amabel/Reynales
BS-02A	589421.1	4804939	272	244.7	Packer Test BS-02 - 2	246.59	245.69	1.30E-05	2019	Amabel/Reynales
BS-02A	589421.1	4804939	272	244.7	Packer Test BS-02 - 3	247.49	246.59	1.40E-04	2019	Amabel
BS-02A	589421.1	4804939	272	244.7	Packer Test BS-02 - 4	248.39	247.49	1.60E-06	2019	Amabel

INT_NAME	Easting	Northing	Ground Elv	Bottom Elv	Description	Interval Top	Interval Bot	Hyd. Cond. (m/s)	Test Year	Stratigraphy
BS-02A	589421.1	4804939	272	244.7	Packer Test BS-02 - 5	249.29	248.39	3.30E-06	2019	Amabel
BS-02A	589421.1	4804939	272	244.7	Packer Test BS-02 - 6	250.19	249.29	6.70E-04	2019	Amabel
BS-02A	589421.1	4804939	272	244.7	Packer Test BS-02 - 7	251.09	250.19	9.90E-04	2019	Amabel
BS-02A	589421.1	4804939	272	244.7	Packer Test BS-02 - 8	251.99	251.09	1.70E-04	2019	Amabel
BS-02A	589421.1	4804939	272	244.7	Packer Test BS-02 - 9	252.89	251.99	5.80E-05	2019	Amabel
BS-02A	589421.1	4804939	272	244.7	Packer Test BS-02 - 10	253.79	252.89	9.20E-04	2019	Amabel
BS-02A	589421.1	4804939	272	244.7	Packer Test BS-02 - 11	254.69	253.79	2.40E-03	2019	Amabel
BS-02A	589421.1	4804939	272	244.7	Packer Test BS-02 - 12	255.59	254.69	2.00E-03	2019	Amabel
BS-02A	589421.1	4804939	272	244.7	Packer Test BS-02 - 13	256.49	255.59	9.90E-04	2019	Amabel
BS-02A	589421.1	4804939	272	244.7	Packer Test BS-02 - 14	257.39	256.49	2.60E-04	2019	Amabel
BS-02A	589421.1	4804939	272	244.7	Packer Test BS-02 - 15	258.29	257.39	5.80E-05	2019	Amabel
BS-02A	589421.1	4804939	272	244.7	Packer Test BS-02 - 16	259.19	258.29	2.90E-04	2019	Amabel
BS-02A	589421.1	4804939	272	244.7	Packer Test BS-02 - 17	260.09	259.19	3.80E-05	2019	Amabel
BS-02A	589421.1	4804939	272	244.7	Packer Test BS-02 - 18	260.99	260.09	5.00E-05	2019	Amabel
BS-02A	589421.1	4804939	272	244.7	Packer Test BS-02 - 19	261.89	260.99	2.80E-05	2019	Amabel
BS-02A	589421.1	4804939	272	244.7	Packer Test BS-02 - 20	262.79	261.89	1.80E-05	2019	Amabel
BS-02A	589421.1	4804939	272	244.7	Packer Test BS-02 - 22	264.59	263.69	3.00E-07	2019	Amabel
BS-02A	589421.1	4804939	272	244.7	Packer Test BS-02 - 21	263.69	262.79	1.20E-04	2019	Amabel
BS-02A	589421.1	4804939	272	244.7	Packer Test BS-02 - 23	264.77	264.59	5.60E-06	2019	Amabel
BS-02A	589421.1	4804939	272	244.7	Packer Test BS-02 - 22A	265.67	264.77	4.00E-05	2019	Amabel
BS-02A	589421.1	4804939	272	244.7	Packer Test BS-02 - 23A	266.9	265.67	7.00E-05	2019	Amabel
BS-03(Open)	589366	4805299	271.7317	247.3317	Packer Test BS-03 - 1	247.9	247	2.00E-08	2019	Reynales/Cabot Head
BS-03(Open)	589366	4805299	271.7317	247.3317	Packer Test BS-03 - 2	248.8	247.9	2.00E-08	2019	Reynales/Cabot Head
BS-03(Open)	589366	4805299	271.7317	247.3317	Packer Test BS-03 - 3	249.7	248.8	3.70E-07	2019	Amabel/Reynales
BS-03(Open)	589366	4805299	271.7317	247.3317	Packer Test BS-03 - 4	250.6	249.7	7.40E-07	2019	Amabel
BS-03(Open)	589366	4805299	271.7317	247.3317	Packer Test BS-03 - 5	251.5	250.6	6.40E-06	2019	Amabel
BS-03(Open)	589366	4805299	271.7317	247.3317	Packer Test BS-03 - 6	252.4	251.5	2.50E-05	2019	Amabel
BS-03(Open)	589366	4805299	271.7317	247.3317	Packer Test BS-03 - 7	253.3	252.4	2.30E-04	2019	Amabel
BS-03(Open)	589366	4805299	271.7317	247.3317	Packer Test BS-03 - 8	254.2	253.3	1.40E-07	2019	Amabel
BS-03(Open)	589366	4805299	271.7317	247.3317	Packer Test BS-03 - 9	255.1	254.2	4.90E-05	2019	Amabel
BS-03(Open)	589366	4805299	271.7317	247.3317	Packer Test BS-03 - 10	256	255.1	1.10E-06	2019	Amabel
BS-03(Open)	589366	4805299	271.7317	247.3317	Packer Test BS-03 - 11	256.9	256	6.20E-06	2019	Amabel
BS-03(Open)	589366	4805299	271.7317	247.3317	Packer Test BS-03 - 12	257.8	256.9	7.90E-07	2019	Amabel
BS-03(Open)	589366	4805299	271.7317	247.3317	Packer Test BS-03 - 13	258.7	257.8	7.10E-05	2019	Amabel
BS-03(Open)	589366	4805299	271.7317	247.3317	Packer Test BS-03 - 14	259.6	258.7	1.00E-05	2019	Amabel
BS-03(Open)	589366	4805299	271.7317	247.3317	Packer Test BS-03 - 15	260.5	259.6	3.60E-06	2019	Amabel
BS-03(Open)	589366	4805299	271.7317	247.3317	Packer Test BS-03 - 16	261.4	260.5	3.40E-06	2019	Amabel
BS-03(Open)	589366	4805299	271.7317	247.3317	Packer Test BS-03 - 17	262.3	261.4	4.70E-06	2019	Amabel
BS-03(Open)	589366	4805299	271.7317	247.3317	Packer Test BS-03 - 16A	263.2	262.3	1.40E-05	2019	Amabel
BS-03(Open)	589366	4805299	271.7317	247.3317	Packer Test BS-03 - 17A	269.43	263.2	3.00E-09	2019	Amabel
BS-04A	589777	4804855	270.4519	245.88	Packer Test BS-04 - 1 - P3	246.89	246.43	3.70E-03	2019	Reynales/Cabot Head
BS-04A	589777	4804855	270.4519	245.88	Packer Test BS-04 - 1	247.79	246.89	1.10E-05	2019	Amabel/Reynales
BS-04A	589777	4804855	270.4519	245.88	Packer Test BS-04 - 2	248.69	247.79	9.90E-07	2019	Amabel
BS-04A	589777	4804855	270.4519	245.88	Packer Test BS-04 - 3	249.59	248.69	1.00E-06	2019	Amabel
BS-04A	589777	4804855	270.4519	245.88	Packer Test BS-04 - 4	250.49	249.59	1.10E-06	2019	Amabel
BS-04A	589777	4804855	270.4519	245.88	Packer Test BS-04 - 5	251.39	250.49	1.80E-06	2019	Amabel
BS-04A	589777	4804855	270.4519	245.88	Packer Test BS-04 - 6	252.29	251.39	1.50E-05	2019	Amabel
BS-04A	589777	4804855	270.4519	245.88	Packer Test BS-04 - 7	253.19	252.29	1.20E-05	2019	Amabel
BS-04A	589777	4804855	270.4519	245.88	Packer Test BS-04 - 8	254.09	253.19	1.80E-06	2019	Amabel

INT_NAME	Easting	Northing	Ground Elv	Bottom Elv	Description	Interval Top	Interval Bot	Hyd. Cond. (m/s)	Test Year	Stratigraphy
BS-04A	589777	4804855	270.4519	245.88	Packer Test BS-04 - 9	254.99	254.09	1.80E-06	2019	Amabel
BS-04A	589777	4804855	270.4519	245.88	Packer Test BS-04 - 10	255.89	254.99	4.60E-06	2019	Amabel
BS-04A	589777	4804855	270.4519	245.88	Packer Test BS-04 - 11	256.79	255.89	5.20E-06	2019	Amabel
BS-04A	589777	4804855	270.4519	245.88	Packer Test BS-04 - 12	257.69	256.79	5.80E-06	2019	Amabel
BS-04A	589777	4804855	270.4519	245.88	Packer Test BS-04 - 13	258.59	257.69	5.60E-06	2019	Amabel
BS-04A	589777	4804855	270.4519	245.88	Packer Test BS-04 - 14	259.49	258.59	3.20E-06	2019	Amabel
BS-04A	589777	4804855	270.4519	245.88	Packer Test BS-04 - 15	260.39	259.49	7.70E-07	2019	Amabel
BS-04A	589777	4804855	270.4519	245.88	Packer Test BS-04 - 16	261.29	260.39	8.90E-08	2019	Amabel
BS-04A	589777	4804855	270.4519	245.88	Packer Test BS-04 - 17	262.19	261.29	2.00E-07	2019	Amabel
BS-04A	589777	4804855	270.4519	245.88	Packer Test BS-04 - 18	263.3	262.19	1.00E-07	2019	Amabel
BS-04A	589777	4804855	270.4519	245.88	Packer Test BS-04 - 17-A	264.2	263.3	9.21E-07	2019	Amabel
BS-04A	589777	4804855	270.4519	245.88	Packer Test BS-04 - 18-A	267.99	264.2	8.87E-07	2019	Amabel
BS-05(Open)	589015	4805462	270	245.4	Packer Test BS-05 - 3	246.8	246.4	1.10E-06	2019	Reynales/Cabot Head
BS-05(Open)	589015	4805462	270	245.4	Packer Test BS-05 - 1	247.92	246.8	2.30E-03	2019	Reynales/Cabot Head
BS-05(Open)	589015	4805462	270	245.4	Packer Test BS-05 - 4	248.82	247.92	4.50E-05	2019	Reynales/Cabot Head
BS-05(Open)	589015	4805462	270	245.4	Packer Test BS-05 - 5	249.72	248.82	6.70E-05	2019	Reynales/Cabot Head
BS-05(Open)	589015	4805462	270	245.4	Packer Test BS-05 - 6	250.62	249.72	7.20E-07	2019	Amabel/Reynales
BS-05(Open)	589015	4805462	270	245.4	Packer Test BS-05 - 7	251.52	250.62	5.60E-07	2019	Amabel
BS-05(Open)	589015	4805462	270	245.4	Packer Test BS-05 - 8	252.42	251.52	1.30E-04	2019	Amabel
BS-05(Open)	589015	4805462	270	245.4	Packer Test BS-05 - 9	253.32	252.42	1.50E-04	2019	Amabel
BS-05(Open)	589015	4805462	270	245.4	Packer Test BS-05 - 10	254.22	253.32	2.40E-05	2019	Amabel
BS-05(Open)	589015	4805462	270	245.4	Packer Test BS-05 - 11	254.42	254.22	1.30E-04	2019	Amabel
BS-05(Open)	589015	4805462	270	245.4	Packer Test BS-05 - 12	255.32	254.42	1.20E-04	2019	Amabel
BS-05(Open)	589015	4805462	270	245.4	Packer Test BS-05 - 13	256.22	255.32	5.20E-07	2019	Amabel
BS-05(Open)	589015	4805462	270	245.4	Packer Test BS-05 - 14	257.12	256.22	1.10E-06	2019	Amabel
BS-05(Open)	589015	4805462	270	245.4	Packer Test BS-05 - 15	258.02	257.12	5.10E-06	2019	Amabel
BS-05(Open)	589015	4805462	270	245.4	Packer Test BS-05 - 16	258.92	258.02	1.40E-04	2019	Amabel
BS-05(Open)	589015	4805462	270	245.4	Packer Test BS-05 - 17	259.82	258.92	1.40E-04	2019	Amabel
BS-05(Open)	589015	4805462	270	245.4	Packer Test BS-05 - 18	260.72	259.82	7.20E-06	2019	Amabel
BS-05(Open)	589015	4805462	270	245.4	Packer Test BS-05 - 19	261.62	260.72	1.60E-06	2019	Amabel
BS-05(Open)	589015	4805462	270	245.4	Packer Test BS-05 - 20	262.52	261.62	1.10E-05	2019	Amabel
BS-05(Open)	589015	4805462	270	245.4	Packer Test BS-05 - 21	263.42	262.52	1.10E-05	2019	Amabel
BS-05(Open)	589015	4805462	270	245.4	Packer Test BS-05 - 22	264.32	263.42	1.40E-05	2019	Amabel
BS-05(Open)	589015	4805462	270	245.4	Packer Test BS-05 - 23	265.32	264.32	2.50E-05	2019	Amabel
BS-05(Open)	589015	4805462	270	245.4	Packer Test BS-05 - 22A	267.85	265.32	8.80E-07	2019	Amabel
BS-05(Open)	589015	4805462	270	245.4	Packer Test BS-05 - 23A	267.91	267.85	1.60E-06	2019	Amabel



LEGEND:

- Approx. Property Boundary
- Watercourse
- Wetland
- Well Locations
- Golder Well Locations

75m 0 150m

HORIZONTAL SCALE 1:5,000

AZIMUTH ENVIRONMENTAL CONSULTING, INC.

Golf Course Monitoring Network

Sideways Quarry Expansion
Burlington, ON

DATE ISSUED:	October 2018	Figure No.
CREATED BY:	JLM	3
PROJECT NO.:	18-223	
REFERENCE:	Burlington Mapping	

DAYSTAMP: M:\18 Projects\18-223 Quarry Expansion - Hydrogeo\04.0 - Drafting\18-223.dwg

Plotted by: JMCCARTNEY on July 12, 2019 at 10:35am
File: M:\18 Projects\18-223 Quarry Expansion - Hydrogeo\04.0 - Drafting\18-223.dwg Layout: HYD3 Plotscale: 5