APPENDIX Q

Numerical Modelling

APPENDIX Q

Integrated Groundwater - Surface Water Modelling

Proposed Caledon Pit / Quarry

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1.0 INTRODUCTION

CBM Aggregates (CBM), a division of St. Marys Cement Inc. (Canada), is applying to the Ministry of Natural Resources and Forestry (MNRF) for a Class A License (Pit and Quarry Below Water) and to the Town of Caledon for an Official Plan Amendment and Zoning By-law Amendment to permit a mineral aggregate operation for the proposed CBM Caledon Pit / Quarry.

CBM controls approximately 323 hectares of land located at the northwest, northeast and southwest intersection of Regional Road 24 (Charleston Sideroad) and Regional Road 136 (Main Street). Of these lands, approximately 261 hectares are proposed to be licensed under the Aggregate Resources Act and designated / zoned under the Planning Act to permit the proposed CBM Caledon Pit / Quarry. The lands proposed to be licensed under the Aggregate Resources Act are referred to herein as the “Subject Site” (or “Site”) and are legally described as Part of Lots 15-18, Concession 4 WSCR and Part of Lot 16, Concession 3 WSCR (former Geographic Township of Caledon). The area located to the northwest of the intersection of Regional Road 24 and 136 is referred to as the “Main Area”. The area to the northeast of the intersection of Regional Road 24 and 136 is referred to as the “North Area”, and the area located to the southwest of the intersection of Regional Road 24 and 136 is referred to as the “South Area” (Figure 1).

The objective of this report is to document the development of (and results from) an integrated groundwater-surface water model used to assess the potential changes in hydrogeological conditions associated with the proposed Project. This includes estimates of the extent of drawdown during the various stages of development and rehabilitation stage, including the implementation of a proposed mitigation system, and groundwater inflow estimates to the proposed pit / quarry during operations.

2.0 MODEL CONSTRUCTION AND CALIBRATION

2.1 Approach

The objective of the hydrogeological modelling assessment is to provide estimates of the potential impact of the proposed Caledon Pit / Quarry on local and regional groundwater and surface water conditions. This includes potential changes in groundwater elevations and flow rates in nearby surface features relative to background conditions. Given the emphasis on both groundwater and surface water impacts, a coupled surface water/groundwater (SW/GW) modelling approach was applied. This entailed the construction of a 3D numerical model of the pit / quarry and surrounding regional groundwater flow system, with the addition of a 2D grid that represented the surface flow domain (which is coincident with the top of the 3D model domain).

The 3D model was constructed based on the Conceptual Site Model (CSM) presented in Section 5.10 of the Water Report (Golder 2022) and was calibrated to observed groundwater elevations and surface water flows under steady state conditions. The model was also calibrated transiently to a four-day pumping test that took place as part of the Northwest Investigation (summarized in Section 5.8 of Golder 2022). This calibrated numerical flow model was then used as the basis for forecast simulations of the proposed pit / quarry development.

2.2 Code Selection

HydroGeoSphere (HGS), a finite element modelling package developed jointly by the University of Waterloo, Laval University, and Aquanty (Aquanty 2015), was used as the numerical simulation tool for the assessment. In addition to its basis as a fully-integrated, groundwater / surface water code, HGS was selected for this project given its capabilities to efficiently discretize local features around the Site and Study Area, within a larger footprint around the Site in order to calibrate to water elevations and water balances within the surrounding region.

HGS uses a globally-implicit approach to simultaneously solve the 2D diffusion-wave equation (surface flow domain) and the 3D form of Richards' equation (i.e., variably-saturated flow) in the subsurface domain. The HGS platform uses a Newton iteration to handle nonlinearities in the governing flow equations, a robust and efficient iterative sparse matrix solver, which has been parallelized to utilize high performance computing facilities for addressing large-scale problems.

HGS revision 2270 (build date June 3, 2021) was used to complete the simulations presented in this report. Assumptions and limitations of the numerical integrated groundwater- surface water model are as follows:

- In the HGS model, the groundwater flow system is represented by an 'equivalent porous medium' (EPM). Under this assumption, the rate of groundwater flow occurs as a function of hydraulic gradient, hydraulic conductivity, and the porosity of the aquifer (governed by Darcy's Law and the 3D form of the Richards' equations for variably saturated flow). While groundwater flow in sedimentary rock can be influenced by fracture networks within the rock mass, an EPM approach is commonly used to represent these flow systems. This EPM representation is considered reasonable for this study, as the scale of the groundwater head and flow observations (and forecasts) are much greater than the size of individual fractures.
- Surface flow is assumed to be governed by the 2D diffusion-wave equations (Aquanty 2015).

2.3 Model Domain and Boundary Conditions

The model domain is shown on Figure 1, and encompasses three sub-watersheds (No.15, No.17, No.18) within the larger Credit Valley watershed (CVC 2021). The 3D model is discretized into a triangular prismatic mesh with horizontal nodal spacing of approximately 2 m along the west and south property boundary transitioning to 50 m in the area of the Site, and within a 1 km buffer area around the Site, to provide greater resolution in the simulation of hydraulic heads near the proposed quarry. This spacing transitions to a maximum nodal spacing of ~500 m beyond the proposed pit / quarry footprint, with some additional refinement around the Credit River valley (maximum nodal spacing of 200 m). A total of 66,629 elements are specified per model layer, for a total of 1,732,354 elements across the full 26 layers of the model domain. A summary of the model mesh is shown on Figure 2. The vertical discretization of the model is further described below.

The boundary conditions for the steady state calibration model are comprised of an average annual net surplus of 364 mm/yr applied to the surface flow domain (i.e., the upper surface of the model), and critical depth nodes around the perimeter of the surface flow domain (Figure 2). A critical depth boundary condition allows water to flow freely from the surface flow domain if surface water ponding occurs. In the subsurface domain, all side boundaries are interpreted as locations of groundwater flow divides and therefore defined as a "no-flow" boundary condition. The base of the model (250 masl within the Queenston Formation) is also assigned as a no-flow boundary.

For the transient model calibration, an additional boundary condition was added to reflect pumping from Well PW22-01. The boundary condition applies a constant rate of 80.4 L/min through the four-day test period, with extraction of groundwater by pumping applied across the full thickness of the Gasport Formation.

2.4 Hydrostratigraphy and Parameterization

The generalized hydrostratigraphy for the Study Area is described in the CSM presented in Section 5.10 of the Water Report (Golder 2022). To represent hydrostratigraphy within the HGS model, a total of 26 numerical layers are used. Whereas this is greater than the number of hydrostratigraphic units present in the model domain, the additional number of layers were adopted to allow for increased resolution of vertical hydraulic heads within the model domain, as well as to capture vertical variability in overburden and bedrock stratigraphy.

The distribution of hydrostratigraphic units within these layers and the hydraulic conductivity values applied to each unit are shown on Figure 3. The initial horizontal hydraulic conductivity assigned to these units was based on the range of values estimated from Site hydraulic conductivity testing (Golder 2022) as well as estimates used in Tier 2 (AquaResource, 2009) and Tier 3 (AquaResource, 2011) groundwater modelling studies previously conducted in the area. The values were later adjusted during the calibration process to match observed groundwater elevations and stream flows within the Site and Study Area. The hydrostratigraphic units, from the ground surface down, are summarized as follows:

- **Overburden**: Model Layers 1 to 11 represent the overburden geology within the model, which is defined collectively by the total thickness from ground surface to the top of bedrock. Within this sequence, there are three hydrostratigraphic units incorporated: Upper Sand, Till, and Lower Sand (Golder 2022). The upper sand unit exists where sand is observed at ground surface, and where the entirety of the overburden sequence is described as sand. The till unit exists either where there is till at surface, or where there is till underlying the upper sand unit. The lower sand exists where there is sand beneath till, and above the bedrock. These units were delineated using Site borehole data, the Ministry of Environment and Climate Change (MECP) Water Well Record (WWR) database borehole information (MECP 2020), borehole data obtained from several studies conducted for Armbro-Pinchin and James Dick quarry sites located to the southwest of the Site (CRA 1990, CRA 1994, Harden 2016) and regional surficial geology mapping (OGS 2010). Model layer 1 has a fixed thickness of 1 m, and the thickness of model layers 2 to 11 represent the total overburden thickness remaining divided evenly into 10 layers with a minimum total thickness of 3 m (minimum layer thickness of 0.3 m).

- **Valley Skin**: The valley skin unit is defined in the model as a local unit within Layers 1 to 12 along the Credit River valley to the east and south of the Site. This area was conceptualized and defined during the model calibration process to improve the match to observed groundwater elevations in this specific area.
- **Weathered Bedrock**: A uniform 3 m thick weathered bedrock layer is assigned along the top of the bedrock surface in the model and is located primarily in Layer 12. In the Site area, the weathered bedrock is divided into seven sub-zones (shown on Figure 3). The zones are delineated based on groundwater levels and flow patterns observed in the Site monitoring wells and are coincident with the sub-zones defined in the underlying Gasport Formation. Hydraulic conductivity values were informed by field observations and refined through the model calibration process. They generally reflect the same pattern observed in the underlying Gasport Formation (described below), yielding lower hydraulic conductivity values in the sub-zones north of the Site, and higher hydraulic conductivity values south of the Site.
- **Guelph Formation:** Model Layer 13 represents the Guelph Formation, which is present on the westernmost edge of the model domain and is not present in the area of the Site. This unit is defined within the model domain by the surface / thickness in the OGS Leapfrog Files for the 3D Bedrock Geology Model of Southern Ontario (Carter et al. 2019). The thickness of Layer 13 varies from a minimum thickness of 1 m to 21 m thick as the westernmost edge of the model domain.
- **Eramosa Formation:** Model Layer 14 represents the Eramosa Formation, which is present on the western side of the model domain, pinching out approximately 2.5 km west of the Site (MW20-26 location). The thickness of Layer 14 varies from a minimum thickness of 1 m to 21 m thick to the west of the model domain.
- **Goat Island Formation:** Model Layer 15 represents the Goat Island Formation, which is present on the west side of the model domain, pinching out approximately 500 m west of the Site. The thickness of Layer 15 varies from a minimum thickness of 1 m to 41 m thick.
- **Gasport Formation:** Model Layers 16 to 21 represent the Gasport Formation, which is defined collectively by the total thickness of the Gasport Formation and has been subdivided into 6 vertical layers. The thickness of this layer package ranges from a total minimum thickness of 1 m (0.17 m per numerical layer) to 51 m (8.6 m per numerical layer). In the Site area, the Gasport Formation is divided into seven sub-zones that are coincident with the sub-zones defined in the weathered bedrock layer (shown on Figure 3). The zones are delineated based on groundwater levels and flow patterns observed in the Site monitoring wells. Monitoring data shows a greater horizontal hydraulic gradient across the north area of the Site, while the water levels south of the Site have a lower horizontal hydraulic gradient. The hydraulic conductivity of each sub-zone was determined through the model calibration process, where the Gasport sub-zones north of the Site have lower hydraulic conductivity values than the sub-zones south of the Site. This is consistent with measured hydraulic conductivity.

- **Shaley Dolostone Unit:** Model Layer 22 represents the shaley dolostone unit that underlies the Gasport Formation. The thickness of this layer is defined by Site borehole data in the area of the Site and is assigned a fixed thickness of 2 m (average thickness measured in Site borehole data) outside of 1 km of the Site. Layer 22 ranges in thickness from a minimum thickness of 1 m to 4 m thick.
- **Cabot Head Formation:** Model Layer 23 represents the Cabot Head Shale Formation. The thickness of Layer 23 varies from a minimum thickness of 1 m to 20 m thick.
- **Whirlpool Formation:** Model Layer 24 represents the Whirlpool Formation. The thickness of Layer 24 varies from a minimum thickness of 1 m to 8 m thick.
- **Manitoulin Formation:** Model Layer 25 represents the Manitoulin Formation. The thickness of Layer 25 varies from a minimum thickness of 1 m to 5 m thick.
- **Queenston Formation:** Model Layer 26 represents the Queenston Formation. The thickness of this layer varies from 20 m to 120 m, with the base of the unit representing the base of the model domain at 250 masl.

All bedrock unit model layers (from the bedrock surface down) have a minimum thickness of 1 m. Where this minimum thickness exists (i.e., the unit is discontinuous and been ‘pinched out’) the hydraulic properties of the underlying unit are assigned to the ‘pinched out” layer in that area.

2.5 Model Calibration

2.5.1 Calibration Approach

The approach adopted to calibrate an integrated surface water - groundwater model is somewhat different than that for conventional groundwater models because of the addition of the 2D surface flow domain at the ground surface. Here, water surplus (the difference between precipitation and evapotranspiration / sublimation) is the only input of water to the system, and one of the main calibration considerations (in addition to groundwater elevations) becomes the distribution of surface and groundwater flows observed throughout the system. The model calibration process for this assessment involved the refinement of horizontal and vertical hydraulic conductivity, and storage parameters of the various geologic units until the simulated hydraulic head distribution and surface water flows compared reasonably well with the measured (observed) conditions. The first step in the calibration process was to calibrate the model to average, long-term hydraulic heads observed at Site monitors, water level information obtained from consultant reports (CRA 1990, 1994, 2012), water wells in the MECP WWR database, and long-term average flow rates at surface water monitoring stations for the current condition. This steady state calibrated model formed the initial condition for the transient pumping test calibration, where hydraulic conductivity and storage parameters were further refined to capture the transient response observed at peripheral monitoring wells the during the pumping test.

The following calibration measures were used in the assessment:

- Average groundwater levels at 88 groundwater monitoring well locations across the Site area, over the period of record for each location. The monitoring locations include 24 sets of nested monitoring wells. Average head differences between each nested pair of monitoring wells are also considered as part of the calibration process.
- Average streamflow measurements in 16 surface water monitoring stations in the Site area, over the period of record for each location.

- Average groundwater levels at 40 monitoring well locations at the Armbro-Pinchin site over the period of record for each location as outlined in CRA (1990 and 1994). These monitoring well locations are within 1 km of the Site and were therefore considered in the Site calibration data set.
- Average groundwater levels at 39 monitoring well locations at the James Dick Pit over the period of record for each location as outlined in Harden (2016). These monitoring well locations are located ~2 km or more from the Site and were therefore considered in the regional calibration data set.
- Groundwater level measurements from 1857 water well records in the MECP WWR database, located within the model domain (MECP 2020).
- Transient water level drawdown responses at 8 monitoring well locations (5 of which are nested monitoring wells, amounting to 16 monitoring points in total) during a four-day pumping test conducted as part of the Northwest Investigation (described in Section 5.8.6 of Golder 2022).

2.5.2 Calibration Assessment

The simulated calibrated model results are shown on Figures 4 through 6, and in Table 1 (next page). A review of the results is as follows:

- Plan view maps of the simulated hydraulic head distribution and groundwater flow direction in the overburden, Gasport Formation, and Manitoulin/ Whirlpool Formation (Figure 4) are, in general, consistent with the conceptual understanding of the groundwater flow system in the Credit River Watershed. West of the Niagara escarpment, shallow groundwater flow follows topographic relief, and generally flows from northwest to southeast, towards the escarpment. Closer to the Niagara escarpment, the water table declines significantly, following the ground surface topography. The simulated hydraulic head distribution and groundwater flow direction in the Gasport Formation is consistent with observed data at the Site (Figures 5-2 to 5-6 of Golder 2022).
- A scatter plot of the regional simulated hydraulic head versus the average head for the target observation points (both MECP WWR measurements, additional water level information from consultant reports (CRA 1990, 1994, 2012 and Harden 2016) and Site monitoring wells, 2024 total water levels) shows the simulated points generally close to the 45-degree line and in reasonable agreement with the observed values (Figure 4). Regionally, the mean residual is calculated to be 3.2 m, while the normalized root mean square (RMS) error is 3.8%. Looking at the Site data only (128 total average water level measurements), the mean residual is calculated to be 0.03 m, while the normalized root mean square (RMS) error is 3.8%.
- A plot of the observed and simulated head differences at nested monitoring locations (Figure 4) generally shows good agreement between the two datasets, with more upward gradients to the west of the Site transitioning to neutral / slight downward gradients to the east, and downward gradient to the north. The observed head difference values used for comparison represent the averages over the period of record, though it is recognized that there could be variability in the magnitude (and direction) of the gradient throughout the year.
- A plot of the unit yield for each surface water station (i.e., the simulated and observed flows divided by the surface water monitoring station catchment area) is shown on Figure 5. These unit yield values, when compared to the normalized applied surplus can be used to infer whether the catchment is exhibiting ‘gaining’ or ‘losing’ behaviour. When the observed unit yield value for a given catchment is less than the surplus, that indicates that the catchment is ‘losing’ water (i.e., some of the net surplus water entering the

catchment is being lost to deeper groundwater flowing toward the escarpment valley/Credit River rather than discharging locally and flowing through the surface water feature at the monitoring location), while the inverse is considered to be ‘gaining’. The plot shows that the model results are consistent with the conceptual behaviour in the Site area (Figure 5). Comparing the observed unit yield values to the applied surplus shows that the catchment areas for almost all the surface water stations exhibit a ‘losing’ behaviour. When comparing the simulated unit yield values to the applied surplus, although they are higher in general than the observed unit yield values, they show a similar ‘losing’ behaviour, where the model applied surplus is being lost to deeper groundwater flow and being measured at model locations closer to the Credit River valley (for example, the relatively high simulated unit yield at SW9 and SW13).

- The results of the transient pumping test calibration are presented on Figure 6. In general, the simulated drawdown at the pumping well (PW22-01) and nearby monitoring wells (MW20-15 at 11 m away and MW22-02 at 281 m away) is slightly underpredicted, while the drawdown at monitoring wells farther away from the pumping well (PW21-1 at 321 m away and MW21-1-3 at 408 m away) is well represented by the simulation. The focus of the transient calibration for the purpose of this assessment was primarily on the more distant monitoring wells, recognizing the objective of the forecast simulations is to estimate drawdown away from the proposed pit / quarry development. The lesser match to observed water levels at the wells in close proximity to the pumping well likely reflects local scale variability in the hydraulic properties of the bedrock aquifer at this particular location.

Table 1: Comparison of Steady State Simulated and Average Measured Groundwater Elevation at Site Well Locations

Well ID	Average Measured Water Level (masl)[1]	Simulated Water Level (masl)	Residual (m)[2]
JHL_BH1	405.9	406.3	0.4
JHL_BH16	400.7	399.2	-1.6
JHL_BH17	400.8	398.9	-1.9
JHL_BH18	396.7	394.7	-2.0
JHL_BH19	402.1	401.3	-0.8
JHL_BH2	411.3	409.2	-2.0
JHL_BH3	405.1	404.5	-0.7
JHL_BH7	402.7	401.9	-0.8
MW20-01A	391.0	394.3	3.3
MW20-01B	390.9	394.3	3.5
MW20-02	390.2	390.3	0.1
MW20-03	384.9	385.5	0.6
MW20-04	389.4	387.3	-2.1
MW20-05A	393.2	395.4	2.1
MW20-06A	396.8	397.8	1.0
MW20-06B	397.0	397.8	0.8
MW20-07A	402.3	399.6	-2.7
MW20-07B	402.4	399.6	-2.8
MW20-08A	404.4	401.7	-2.7
MW20-08B	404.4	401.8	-2.6
MW20-09	396.3	392.5	-3.8
MW20-10A	400.6	397.3	-3.3
MW20-10B	400.6	397.4	-3.2
MW20-11A	405.7	404.4	-1.2
MW20-11B	405.7	404.9	-0.7
MW20-12A	406.5	405.7	-0.8
MW20-12B	406.5	405.8	-0.7
MW20-13A	411.1	408.3	-2.9
MW20-13B	411.2	408.3	-2.9
MW20-13C	412.8	410.3	-2.5
MW20-14A	402.1	402.1	0.1

Well ID	Average Measured Water Level (masl)[1]	Simulated Water Level (masl)	Residual (m)[2]
MW20-14B	402.1	402.1	0.1
MW20-15A	415.8	416.1	0.3
MW20-15B	415.7	416.6	0.9
MW20-15C	415.5	417.0	1.5
MW20-16A	419.6	414.7	-4.9
MW20-16B	419.6	414.7	-4.8
MW20-17A	402.7	405.5	2.8
MW20-17B	402.5	405.2	2.8
MW20-18	391.6	397.9	6.3
MW20-19A	390.7	395.0	4.3
MW20-19B	390.7	395.0	4.3
MW20-20A	405.4	402.7	-2.7
MW20-20B	405.5	402.9	-2.6
MW20-20C	401.4	402.9	1.6
MW20-21A	413.9	415.4	1.5
MW20-21B	414.2	415.5	1.4
MW20-22A	396.4	400.0	3.6
MW20-22B	395.3	399.6	4.3
MW20-23A	391.8	395.4	3.6
MW20-23B	391.6	395.4	3.8
MW20-23C	391.5	395.3	3.9
MW20-24A	433.7	433.6	-0.1
MW20-24B	434.1	434.5	0.3
MW20-25A	419.9	420.0	0.2
MW20-25B	419.2	419.5	0.3
MW20-26A	433.7	433.5	-0.2
MW20-26B	433.9	433.5	-0.4
MW20-26C	436.1	434.1	-2.1
MW20-27A	423.7	421.2	-2.6
MW20-27B	423.7	421.2	-2.4
MW20-28A	418.4	415.1	-3.3
MW20-28B	418.5	415.1	-3.4
MW22-01	418.8	418.5	-0.3

Well ID	Average Measured Water Level (masl)[1]	Simulated Water Level (masl)	Residual (m)[2]
MW22-02A	418.4	418.7	0.3
MW22-02B	418.6	419.0	0.4
MW22-02C	418.3	419.0	0.7
MW22-03A	420.6	420.5	-0.1
MW22-03B	419.8	420.6	0.8
OVG-MW10-20	388.5	393.4	4.8
OVG-MW11-20	392.1	392.8	0.8
OVG-MW12-20	393.9	393.2	-0.7
OVG-MW13-20	394.7	392.7	-2.0
OVG-MW16-20	392.4	392.0	-0.5
OVG-MW18-20	389.6	390.2	0.7
OVG-MW19-20	391.1	391.3	0.2
OVG-MW24-20	400.3	396.5	-3.7
OVG-MW25-20	397.4	396.5	-0.9
OVG-MW5-20	387.1	388.3	1.2
OVG-MW6-20	392.7	387.9	-4.8
OVG-MW7-20	387.0	388.0	1.1
OVG-MW8-20	386.5	387.2	0.7
OVG-MW9-20	388.8	393.7	4.8
PW21-1	416.8	412.2	-4.5
PW21-2	407.8	407.2	-0.6
PW21-3	395.9	399.3	3.4
PW21-4	402.7	402.2	-0.5
PW22-01	416.2	416.6	0.4
OW10B-90	388.3	387.7	-0.6
OW11B-90	388.7	389.3	0.6
OW12-90	392.1	393.9	1.8
OW13-90	390.3	391.9	1.6
OW14-90	389.1	389.1	0.0
OW15-90	388.4	386.9	-1.5
OW16-90	387.7	388.3	0.6
OW17-90	392.6	394.6	2.0
OW18-90	388.2	389.5	1.3

Well ID	Average Measured Water Level (masl)[1]	Simulated Water Level (masl)	Residual (m)[2]
OW19-94	389.2	390.9	1.6
OW20-94	387.8	387.9	0.0
OW21-94	388.4	389.4	1.1
OW22-94	387.1	386.4	-0.7
OW23-94	385.1	385.5	0.5
OW3B-90	391.5	393.0	1.5
P-1	379.9	379.1	-0.9
P-10	382.6	381.6	-1.0
P-12	378.8	380.3	1.4
P-2	386.5	386.7	0.3
P-3	384.5	384.8	0.4
P-4	385.3	385.7	0.4
P-6	385.7	385.4	-0.3
P-7	385.7	383.2	-2.5
P-8	383.1	383.9	0.9
P-9	386.7	385.8	-0.9
POND1	388.5	389.3	0.8
POND2	388.6	389.1	0.5
POND3	389.0	389.3	0.4
POND4	388.3	388.0	-0.3
TH10-89	388.2	386.1	-2.2
TH11-89	388.6	388.6	-0.1
TH1-89	388.8	388.4	-0.4
TH2-89	391.1	392.5	1.4
TH3-89	391.5	393.0	1.5
TH4-89	391.5	390.7	-0.8
TH5-89	387.7	387.8	0.1
TH6-89	389.0	390.4	1.4
TH7-89	388.2	391.9	3.7
TH8-89	388.1	389.8	1.7
TH9-89	389.6	390.9	1.3

1. Average measured water level represents the average water level over the period of record for each location.

2. Residual is calculated by subtracting the measured water level from the simulated water level.

3.0 FORECAST SIMULATIONS

3.1 Approach

The approach to the forecast simulations was to utilize the calibrated model to assess the potential impacts of proposed pit / quarry development on groundwater levels and surface water flows. A total of eight model forecast simulations were completed, each representing a different phase of quarry development (including the final Rehabilitation phase) as shown in Figure 7.

Initial simulations indicated that pit / quarry dewatering during later the stages of operations (Phases 4 to 7) may result in a decline in groundwater levels in the water table aquifer that would extend southward and to the southwest of the licence area. If so, these forecast changes in groundwater levels could potentially impact natural features, groundwater users, and influence groundwater levels beneath active aggregate operations that were licensed to extract sand and gravel above the water table. To mitigate the potential impact of these forecast changes in groundwater levels during the operational phases of the proposed CBM Caledon Pit / Quarry, groundwater mitigation measures were developed by Golder and implemented in the modelling simulations for Operational Phase 3 to 7. The groundwater mitigation measures developed are described in Appendix R, and further discussed in Section 9 of Golder 2022. The mitigation measures consist of six infiltration trench zones along a 1,900 m alignment along the west side of the Main Area and the west and south side of the South Area, in the setback area between the licence limit and the limit of extraction. Additionally, a slurry wall would be installed in the overburden between the infiltration trenches and the extraction limit, in order to minimize the flow of water back into the pit / quarry. The weathered upper bedrock zone along the proposed slurry wall alignment was also assumed to be grouted in the simulation. Each phase of quarry development and its associated mitigation system is shown on Figure 7.

The forecast simulations representing the seven phases of quarry development, and the final rehabilitation scenario are completed under steady state conditions. Steady state simulations were completed to provide a conservative estimate of the extent of drawdown for each operational phase of quarry development. Groundwater elevations, water level drawdown relative to current conditions, reduction in surface water flows at surface water monitoring stations, and quarry inflows were tracked through each model simulation. In addition, a sensitivity analysis was done by increasing and decreasing the hydraulic conductivity of the slurry wall / grouting alignment to simulate the potential range of quarry inflow that may occur at each development phase.

3.2 Model Parameterization for Forecast Simulations

To complete the forecast simulations, several assumptions are made to approximate the proposed development phases of the CBM Caledon pit / quarry. These are outlined below:

- The soil/rock material (i.e., overburden and underlying aggregate) removed during each phase of extraction is simulated as a relatively high hydraulic conductivity zone (a value of 1 m/s).
- Progressive rehabilitation, or the placement of till material against the pit / quarry walls during each phase of development is simulated as a separate hydraulic conductivity zone with a value of $1x10^{-6}$ m/s for Phases 1 to 7.
- For each phase of pit / quarry development (i.e., Phases 1 to 7), a head-constrained specified flux was assigned at a single node to act as a sump at the base of the quarry (i.e., water is removed the model at a rate that facilitates maintaining the quarry water level at a specified elevation). Sump locations for the Main, North, and South areas during each phase are shown on Figure 7. Water removed from the sump was re-

introduced to the surface flow domain at the Credit River directly to the east of the North Area to simulate off-Site discharge.

- The numerical simulations for Operational Phases 3 to 7 presented in the subsections below include the implementation of the following groundwater mitigation system elements:
  - Phase 3 – Implementation of the slurry wall / grouting of the weathered bedrock zone on the west side of the Main Area prior to the start of Phase 3 extraction.
  - Phases 4 and 5 – Implementation of the infiltration trench system (Trench Zones 1 and 2) on the west side of the Main Area prior to the start of Phase 4 and 5 extraction.
  - Phase 6 and 7 – Implementation of the second slurry wall / grouting of the weathered bedrock zone and the second phase of the infiltration trench system (Trench Zones 4 to 6) prior to the start of Phase 6 and 7 extraction.
- The numerical simulation for the post-Rehabilitation scenario includes the removal of the slurry wall in the overburden in the southwest corner of the South Area (adjacent to Trench Zones 4 and 5), to reinstate hydraulic connection between the South Area and the lands to the south and southwest of the Site.
- The proposed slurry walls through the overburden (model layers 1-11) and grouting of the upper bedrock (model layer 12) at the base of the slurry wall alignments was simulated as a low hydraulic conductivity zone (a value of $1x10^{-7}$ m/s). The six infiltration trench zones were simulated as constant head boundaries. The head values assigned to each of these infiltration trench zones (see Table 2 below) were assigned based on the average calibrated model head along the trench alignment.
- For the rehabilitation phase, the Main Pond and North Pond elevations are controlled at 400 masl and 399 masl respectively by using a head-constrained specified flux at a single node within the pond areas. Water removed from the ponds is re-introduced to the surface flow domain at the Credit River to the east of the North Area to simulate off-Site discharge.

A summary of the modelled mitigation system configurations implemented for each of the eight forecast simulations is presented in Table 2.

Table 2: Simulated Mitigation System at Each Phase of Quarry Development

Phase	Operational Year	Slurry Wall / Grout Zone	Infiltration Trench Zone / Constant Head (masl)
End of Phase 1	End of Year 8	N/A	N/A
End of Phase 2	End of Year 13	N/A	N/A
End of Phase 3	End of Year 17	West side of Main Area	N/A
End of Phase 4	End of Year 22	West side of Main Area	Trench Zone 1: 399.0 Trench Zone 2: 397.5
End of Phase 5	End of Year 26	West side of Main Area	Trench Zone 1: 399.0 Trench Zone 2: 397.5
End of Phase 6	End of Year 32	West side of Main Area	Trench Zone 1: 399.0 Trench Zone 2: 397.5

Phase	Operational Year	Slurry Wall / Grout Zone	Infiltration Trench Zone / Constant Head (masl)
		West and south side of South Area	Trench Zone 3: 395.5 Trench Zone 4: 393.0 Trench Zone 5: 392.0 Trench Zone 6: 394.0
End of Phase 7	End of Year 38	West side of Main Area West and south side of South Area	Trench Zone 1: 399.0 Trench Zone 2: 397.5 Trench Zone 3: 395.5 Trench Zone 4: 393.0 Trench Zone 5: 392.0 Trench Zone 6: 394.0
Post-Rehabilitation	Year 39+	Slurry wall removed along Trench Zones 4 and 5	N/A

3.3 Results

3.3.1 Simulated Head and Drawdown

The simulated hydraulic head, drawdown of the water table, and head change within the Gasport Formation, and the Whirlpool / Manitoulin Formations for Phases 1 to 7 and the Rehabilitation phase are shown on Figure 8A-H, and Figure 9A-H respectively.

The general simulated groundwater flow direction across the Site in each unit remained consistent with the current condition; groundwater flow is southeast across the Site toward the Credit River and bedrock valley.

The simulated water table drawdown is consistent with the head change in the Gasport Formation south and southwest of the Site. During operation, the extent of drawdown in this area is the largest during Phase 3, prior to the implementation of the infiltration trench mitigation system in the Main Area, and Phase 5, prior to the implementation of the mitigation system in the South Area.

To the northwest, and north of the Site, where fine grained material is present, the water table drawdown is less than the head change in the Gasport Formation. The finer grained, lower hydraulic conductivity materials provide a significant degree of hydraulic isolation between the shallow overburden and the underlying Gasport Formation layers, where dewatering mainly occurs during operations. The progressive rehabilitation of the pit / quarry walls during operation provides further hydraulic isolation between the pit / quarry operation and the surrounding environment, helping to minimize drawdown and dewatering requirements.

There is also drawdown observed in the Whirlpool / Manitoulin Formations, but is relatively small in magnitude relative to the available drawdown in this aquifer, given its depth and typical static water level. The drawdown beyond the Site is predicted to reach a maximum of approximately 3 m, which represents a fraction of the available water column in wells screened in that aquifer, as discussed in Section 9.3.1 of Golder (2022). Upon rehabilitation, the residual change in groundwater heads within all aquifer units is small typically less than +/- 1 m. Further discussion of the potential impact to aquifers during pit / quarry operations and upon rehabilitation is found in Section 9.2 of Golder (2022).

3.3.2 Surface Flow

A summary of the simulated changes in surface water flow at the 16 surface water monitoring stations for Operational Phases 1 to 7 and post-Rehabilitation is shown on Figure 10. Surface water stations SW1 to SW4, SW6 to SW10, SW13, and SW16 generally experience simulated reduction in flows of less than 10% of the current conditions. Station SW11 experiences a reduction of 15% during Phase 2, but recovers during the subsequent phases showing a reduction of 6-7% in Phases 3 to 7. Similarly, SW15 experienced a 14% reduction in Phase 4, but shows a reduction of 8-9% in subsequent phases.

Station SW14 experiences a reduction in simulated flow of up a 16% (during Phases 3 and 4), and 12-14% during Phases 5 to 7. The largest percentage of simulated reduction in flows occurs at SW5; ranging from 14% to 23% throughout the quarry development; this reduction represents a maximum simulated change of 0.6 L/s. Further discussion of these predicted changes in flow based on HGS model simulations and the potential impact to surface water is provided in Section 9.1 of Golder (2022).

3.3.3 Quarry Inflows

The steady state simulated groundwater inflow during Operational Phases 1 to 7 for each area (Main, North, South) is summarized in Table 3.

Table 3: Simulated Quarry Inflow at Each Phase of Development

Phase	Main Area Simulated Inflow (L/s)	North Area Simulated Inflow (L/s)	South Area Simulated Inflow (L/s)	Total Inflow (L/s)
1	14.3	0.0	0.0	14.3
2	18.0	2.8	0.0	20.8
3	17.4	2.9	0.0	20.3
4	25.3	2.9	0.0	28.2
5	70.8	2.9	0.0	73.7
6	81.3	2.9	7.7	91.9
7	53.6	2.5	77.5	133.6

1.The inflows include the surplus applied to the pit area.

Overall, the total simulated inflow to all areas of the pit / quarry during operations ranges from 14.3 L/s to 133.7 L/s. The majority of the simulated inflow is in the Main Area of the pit / quarry, with inflows up to 81.3 L/s during Phase 6 of the operation. During Phase 7 of operation, the majority of the simulated inflow is in the South Area, with an inflow of 77.5 L/s.

Upon rehabilitation, the maximum water level in the Main Pond will be controlled by an outflow to the North Pond at an approximate elevation of 400 masl, and the maximum water level in the North Pond will be controlled by an outflow and pipe to the Osprey Valley Golf Course irrigation system at an approximate elevation of 399 masl. The simulated elevation of the South Pond is estimated to be 393.5 masl and will be internally contained, with no surface outflow. The simulated steady state outflow from the Main and North Ponds to the golf course irrigation system is estimated to be approximately 12 L/s.

A sensitivity analysis was done by increasing and decreasing the hydraulic conductivity of the slurry wall / grouting alignment to simulate the potential increase and decrease in quarry inflows at each development phase. The results are summarized in Table 4:

Table 4: Simulated Change in Quarry Inflow at Each Phase of Development

Phase	K wall: 1E-06 m/s, % change				K wall: 1E-08 m/s, % change			
	Main Area	South Area	North Area	Total Inflow	Main Area	South Area	North Area	Total Inflow
3	0%		0%	0%	0%		0%	0%
4	0%		0%	0%	0%		0%	0%
5	8%		0%	8%	-2%		0%	-1%
6	9%	0%	0%	8%	-1%	0%	0%	-1%
7	8%	6%	0%	7%	-1%	-1%	0%	-2%

1.The inflows include the surplus applied to the pit area.

The simulated pit / quarry inflow is more sensitive to an increase in the hydraulic conductivity of the slurry wall / weathered zone grouting to $1x10^{-6}$ m/s, with the increase in total quarry inflow ranging from 8 to 9% when the hydraulic conductivity is increased by an order of magnitude. The largest predicted increase (9%) occurs in the inflow to the Main Area during Operational Phase 6. The reduction of predicted water inflow when the hydraulic conductivity of the slurry wall / weathered zone grouting is reduced to $1x10^{-8}$ m/s is relatively small, ranging from 1 to 2% when the hydraulic conductivity is decreased by an order of magnitude. The water table drawdown is not affected by the increase and decreasing the hydraulic conductivity of the slurry wall / grouting alignment.

4.0 REFERENCES

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Signature Page

We trust that this report meets your current requirements. Please contact the undersigned should you have any questions.

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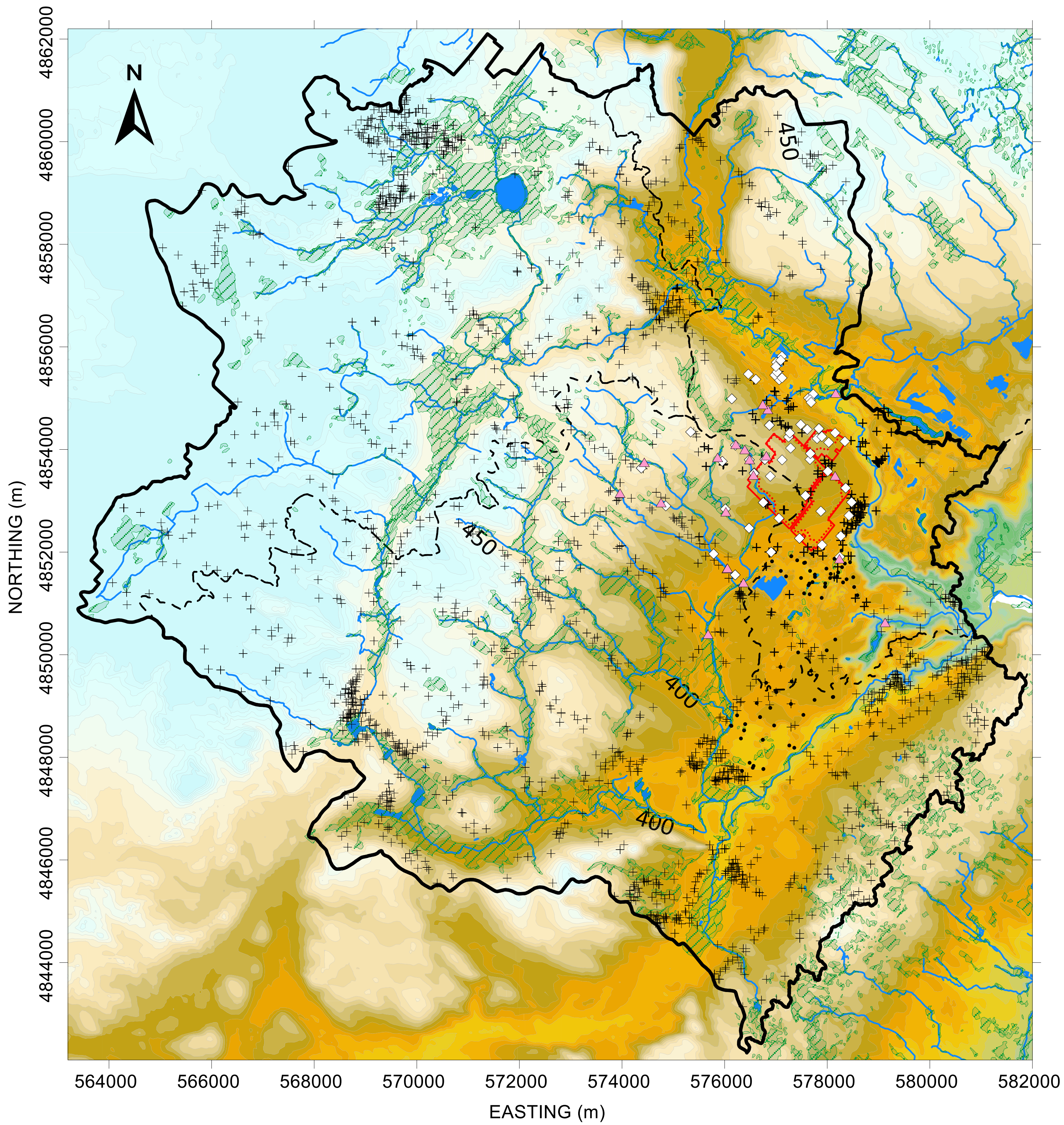
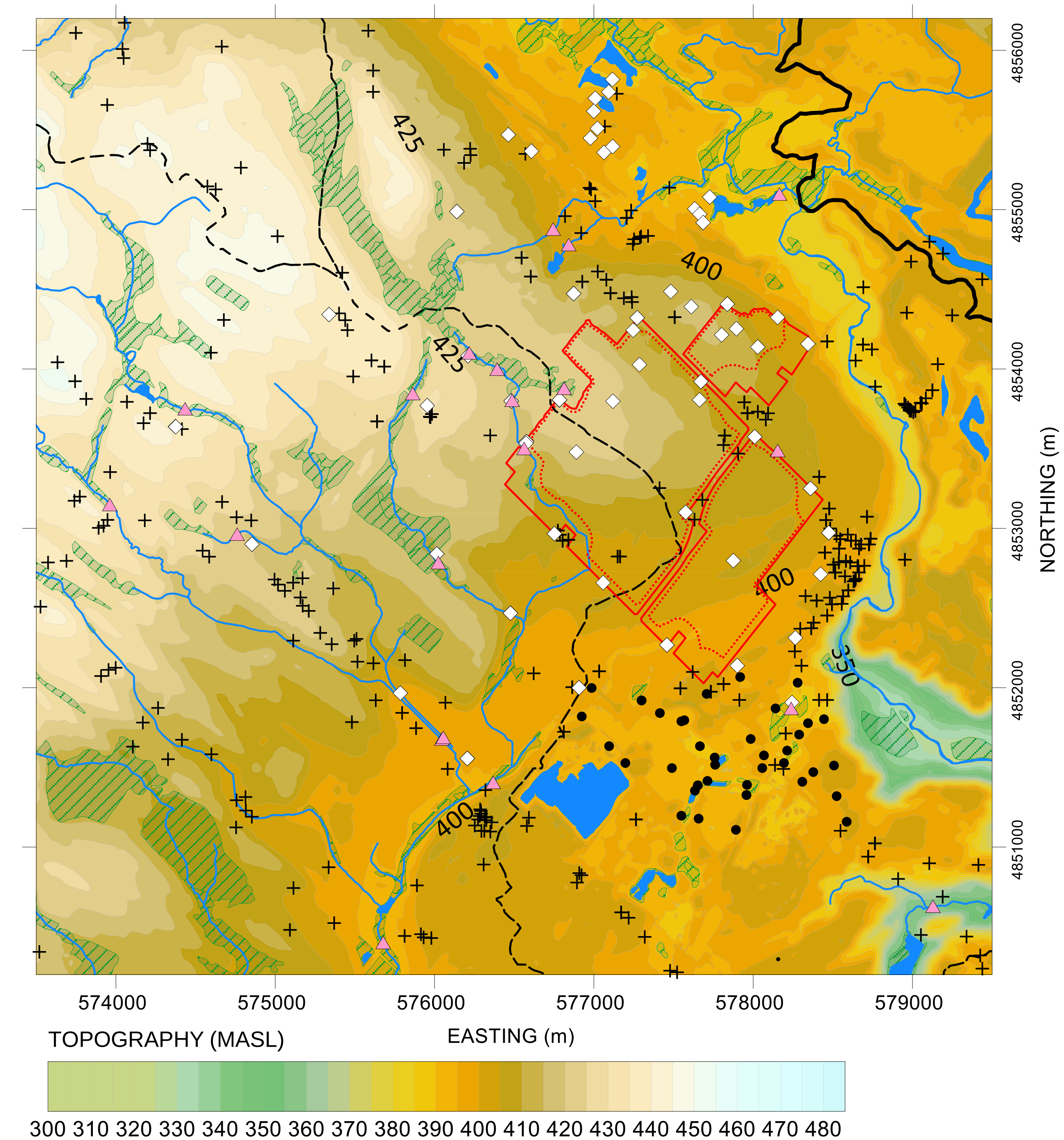
FIGURES





LEGEND

- LAKES
- RIVERS/ STREAMS
- WETLAND
- MODEL DOMAIN
- CVC SUBWATERSHED
- LICENSE LIMIT
- MODELLED EXTRACTION EXTENT
- MECP WWR WELL LOCATION
- SITE GROUNDWATER MONITORING LOCATION
- SITE SURFACE WATER MONITORING LOCATION
- ADDITIONAL GROUNDWATER MONITORING LOCATION[6]

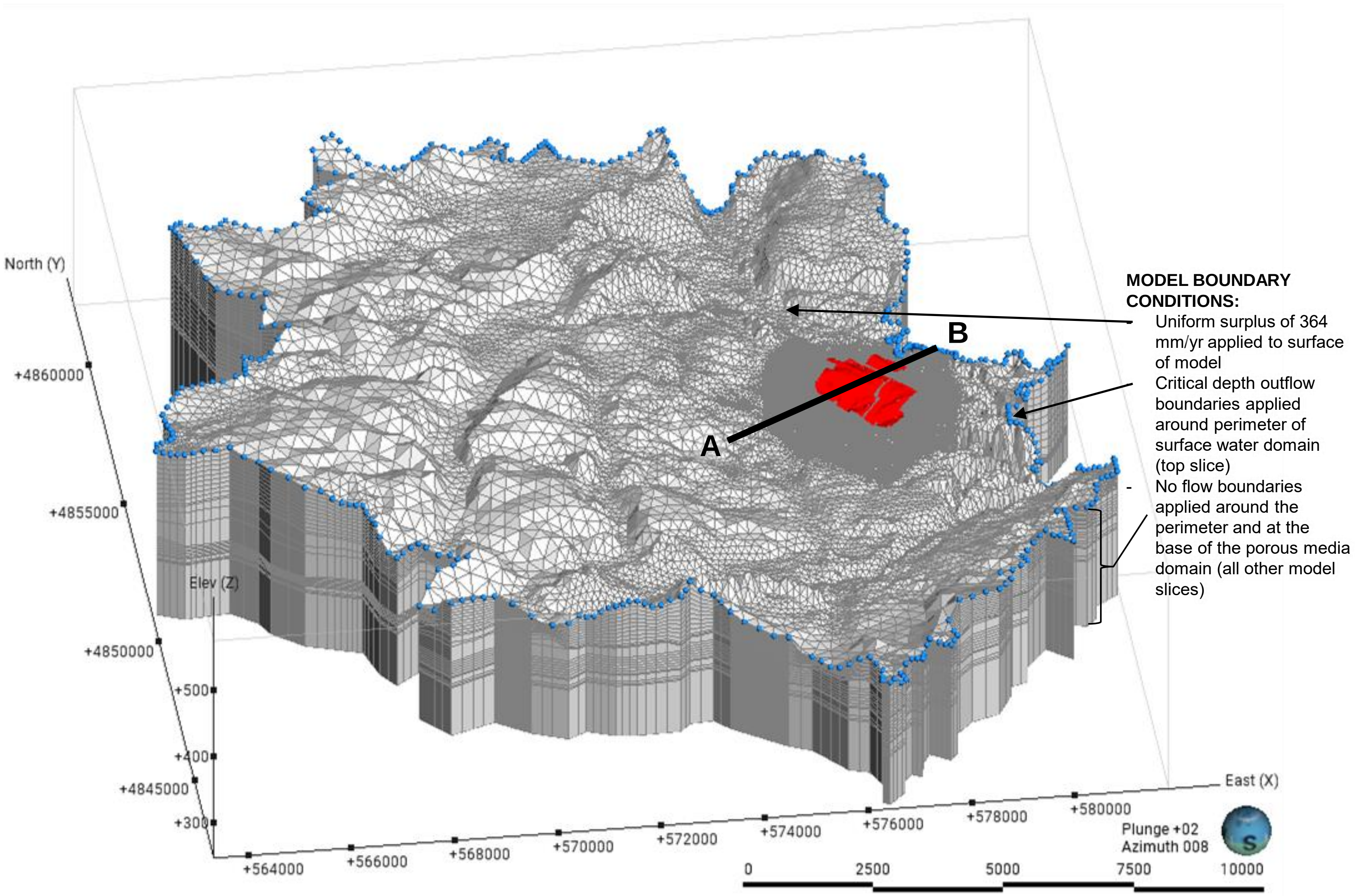
NOTES

1. Source of spatial mapping of watercourses, waterbodies, and wetlands: Land Information Ontario (MNRF, 2018)
2. Source of Regional Topography dataset Ontario Ministry of Natural Resources and Forestry (MNRF) Southwestern Ontario Orthophotography (SWOOP) 2019
3. Source of Site Topography dataset provided by Firstbase Solutions (Spring 2021)
4. Ministry of Environment Conservation and Parks (MECP) Water Well Information System Database (MECP, 2020).
5. Quarry license and modelled limit of extraction provided by MHBC (May, 2023)
6. Additional groundwater monitoring points from CRA (2012) and Harden (2016) reports

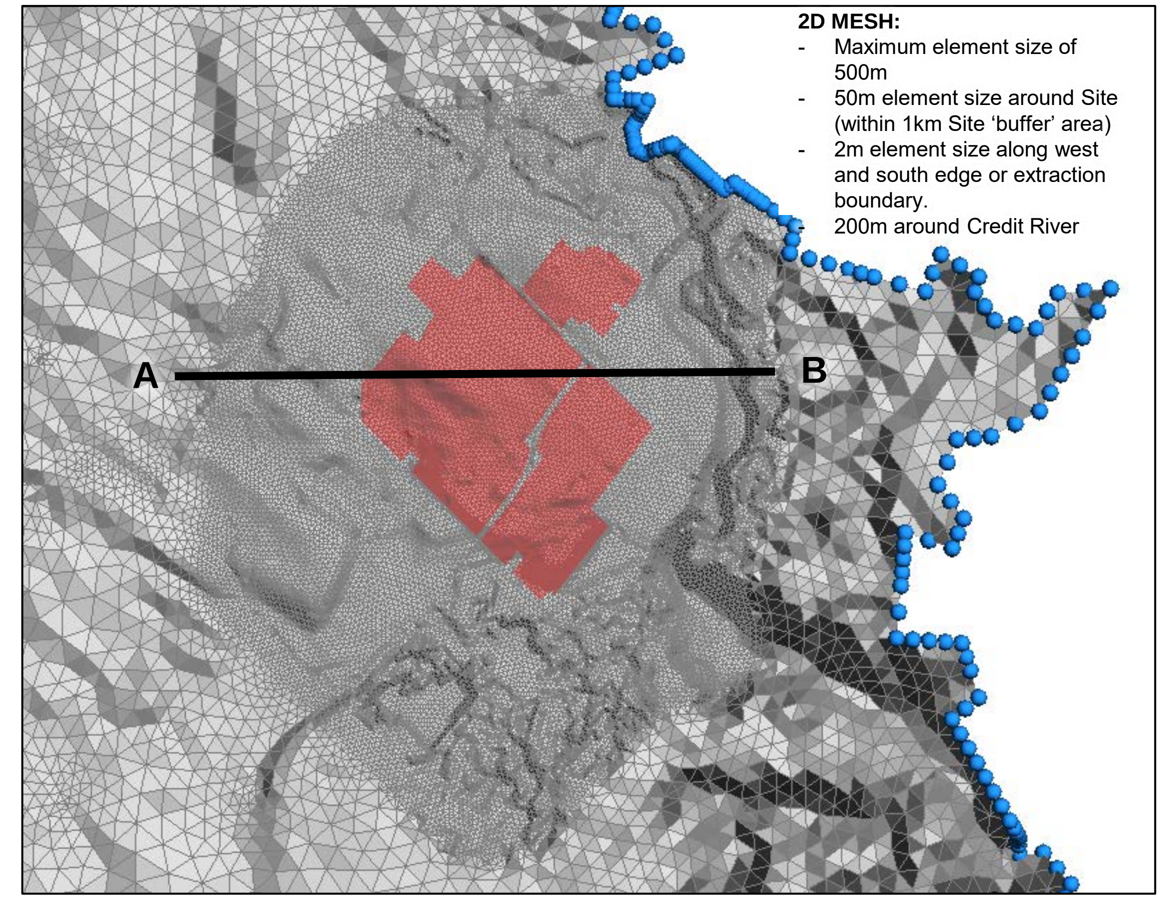
CLIENT	CBM AGGREGATES (CBM), A DIVISION OF ST. MARYS CEMENT INC. (CANADA)
PROJECT	CALEDON PIT AND QUARRY NUMERICAL MODELLING
CONSULTANT	GOLDER MEMBER OF WSP
YYYY-MM-DD	2023-04-26
PREPARED	HW
DESIGN	HW
REVIEW	SD
APPROVED	GS
TITLE	STUDY AREA AND MODEL DOMAIN
PROJECT No.	19129150
Rev.	0
FIGURE	1

1. 3D PERSPECTIVE VIEW OF MODEL MESH (LOOKING NORTH)

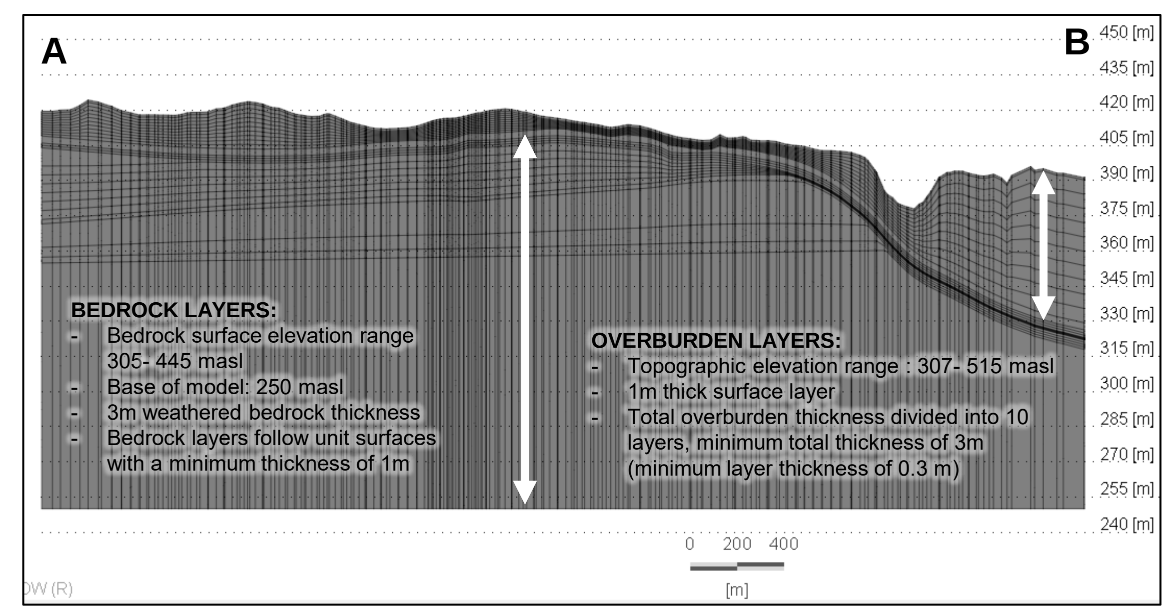
OVERALL MODEL MESH:
- 26 vertical layers (27 slices)
- 906,471 mesh nodes (33,573 nodes per slice)
- 1,732,354 mesh elements (66,629 elements per layer)



2. PLAN VIEW OF MODEL MESH IN SITE AREA



3. CROSS SECTION VIEW OF MODEL MESH IN SITE AREA



LEGEND

- LICENSE LIMIT
- CRITICAL DEPTH MODEL BOUNDARY

Hydrostratigraphic Unit		Primary Model Layer
Overburden	Surficial Sediment	1
	Till	2-11
	Upper Sand	2-11
	Lower Sand	2-11
	Valley Skin	1-12 (in river valley)

Hydrostratigraphic Unit		Primary Model Layer
Bedrock	Weathered Bedrock	1-12 (primarily 12)
	Guelph Formation	13
	Eramosa Formation	14
	Goat Island Formation	15
	Gasport Formation	16- 21
	Shaley Dolostone Unit	22
	Cabot Head Formation	23
	Manitoulin Formation	24
	Whirlpool Formation	25
	Queenston Formation	26

CLIENT
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PROJECT
CALEDON PIT AND QUARRY NUMERICAL MODELLING

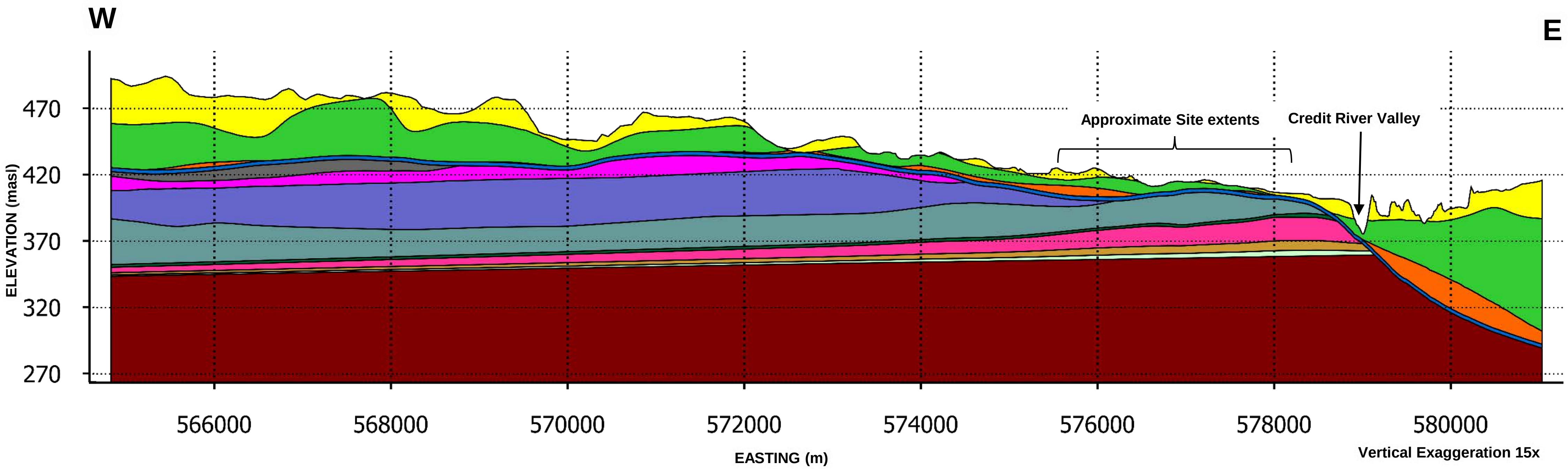
CONSULTANT
GOLDER MEMBER OF WSP

YYYY-MM-DD	2023-07-20
PREPARED	HW
DESIGN	HW
REVIEW	SD
APPROVED	GS

TITLE
MODEL MESH AND BOUNDARY CONDITIONS

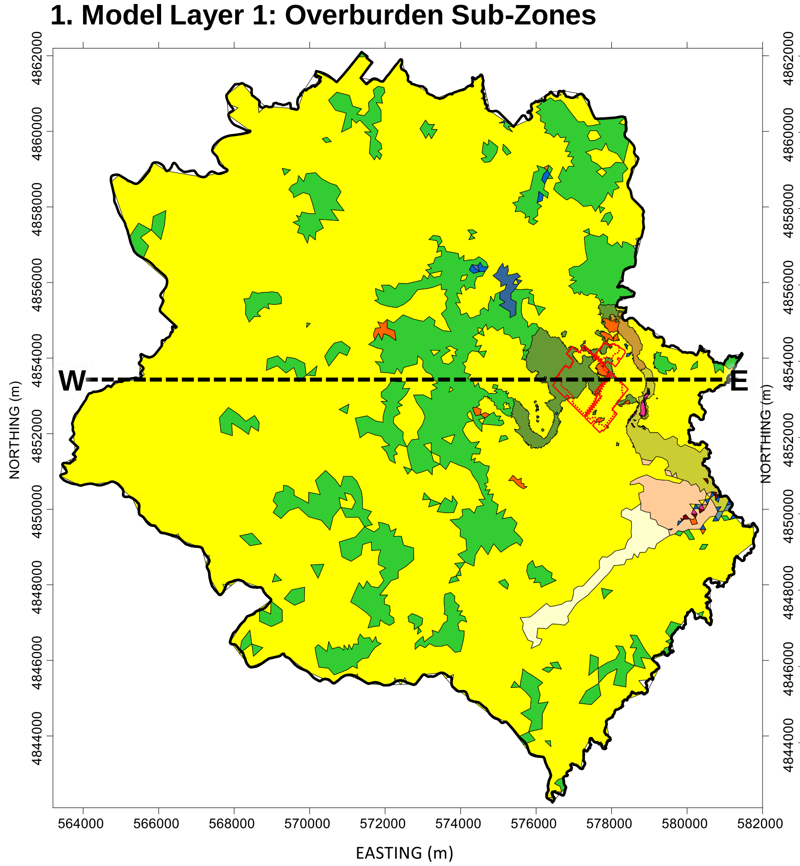
PROJECT No.	Rev.	FIGURE
19129150	0	2

CROSS SECTION: GENERAL MODEL HYDROSTRATIGRAPHY

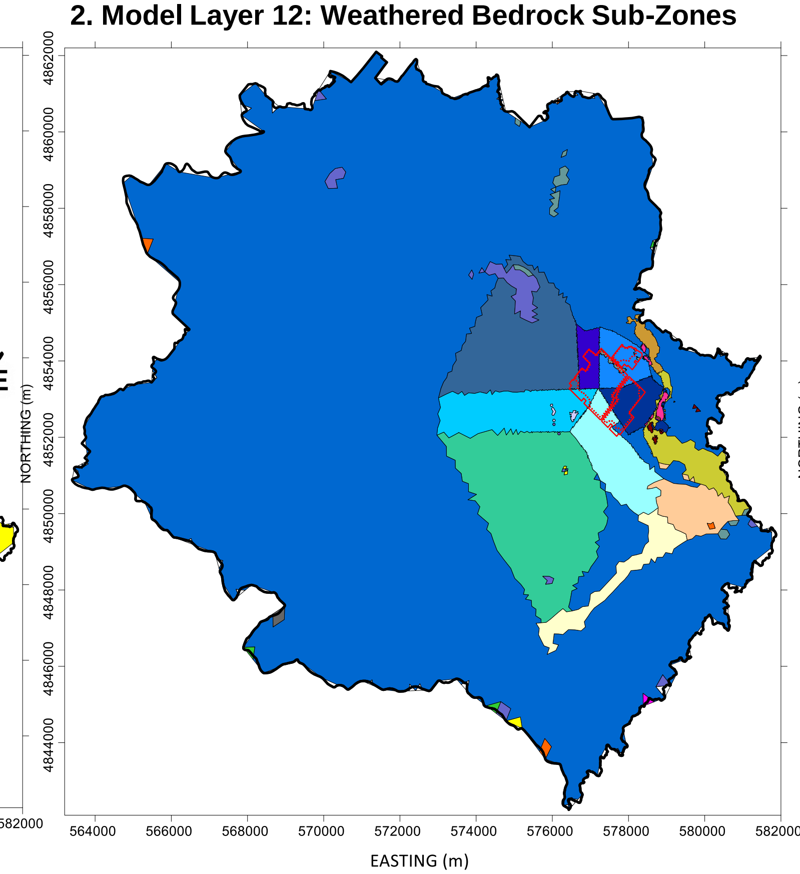


PLAN VIEW: MODEL UNIT SUB-ZONES WITHIN PARENT UNITS

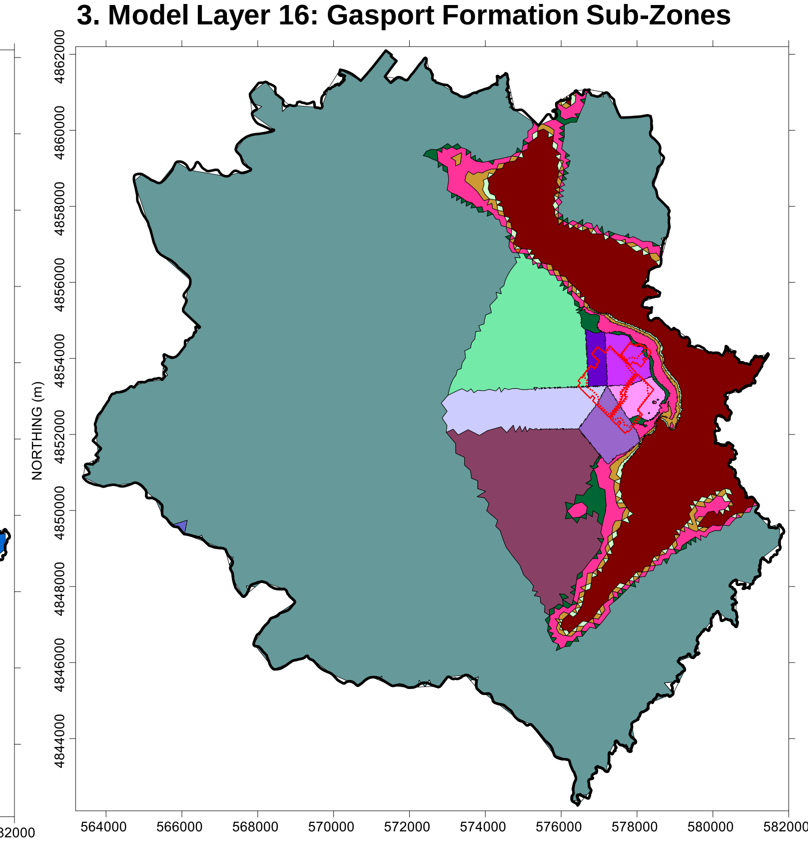
1. Model Layer 1: Overburden Sub-Zones



2. Model Layer 12: Weathered Bedrock Sub-Zones



3. Model Layer 16: Gasport Formation Sub-Zones



Unit	Kh (m/s)	Kv (m/s)	Porosity	Specific Storage (1/m)
Regional Till	1.E-06	1.E-06	0.3	1.E-04
Local Till	1.E-08	5.E-09	0.3	1.E-04
Upper Sand	1.E-04	1.E-04	0.3	1.E-04
Lower Sand	1.E-04	1.E-04	0.3	1.E-04
Till (Valley Skin) Zone 1	4.E-06	4.E-06	0.3	1.E-04
Till (Valley Skin) Zone 2	1.E-06	1.E-06	0.3	1.E-04
Till (Valley Skin) Zone 3	5.E-06	5.E-06	0.3	1.E-04
Till (Valley Skin) Zone 4	2.E-04	2.E-04	0.3	1.E-04
Weathered Bedrock (Regional)	2.E-04	5.E-06	0.01	5.E-06
Weathered Bedrock Zone 1	5.E-06	5.E-07	0.01	5.E-06
Weathered Bedrock Zone 2	4.E-06	4.E-06	0.01	5.E-06
Weathered Bedrock Zone 3	4.E-06	4.E-06	0.01	5.E-06
Weathered Bedrock Zone 4	1.E-03	1.E-03	0.01	5.E-06
Weathered Bedrock Zone 5	5.E-05	5.E-06	0.01	5.E-06
Weathered Bedrock Zone 6	5.E-04	5.E-04	0.01	5.E-06
Weathered Bedrock Zone 7	5.E-06	5.E-07	0.01	5.E-06
Guelph Formation	5.E-05	5.E-06	0.01	5.E-06
Eramosa Formation	9.E-08	9.E-09	0.01	5.E-06
Goat Island Formation	1.E-06	1.E-07	0.01	5.E-06
Gasport Formation Regional	1.E-06	1.E-07	0.01	5.E-06
Gasport Formation Zone 1	5.E-06	5.E-07	0.01	5.E-06
Gasport Formation Zone 2	5.E-07	5.E-08	0.01	5.E-06
Gasport Formation Zone 3	1.E-06	1.E-07	0.01	5.E-06
Gasport Formation Zone 4	1.E-05	1.E-06	0.01	5.E-06
Gasport Formation Zone 5	1.E-05	1.E-06	0.01	5.E-06
Gasport Formation Zone 6	1.E-07	1.E-08	0.01	5.E-06
Gasport Formation Zone 7	5.E-06	5.E-07	0.01	5.E-06
Shaley Dolostone Unit	1.E-07	2.E-09	0.01	5.E-06
Cabot Head Formation	1.E-08	1.E-09	0.01	5.E-06
Manitoulin Formation	1.E-05	1.E-06	0.01	5.E-06
Whirlpool Formation	1.E-06	1.E-07	0.01	5.E-06
Queenston Formation	1.E-08	1.E-09	0.01	5.E-06

LEGEND

- LICENSE LIMIT
- MODELLED EXTRACTION EXTENT
- MODEL DOMAIN

NOTES

1. Quarry license and modelled limit of extraction provided by MHBC (May, 2023)
2. Only parent units are shown in cross section view (not sub-zones)
3. Figure 1 shows the sub-zones within the modelled overburden layers, which are assigned form model layer 1-11. Layer 1 is shown as an example of the hydraulic conductivity distribution.
4. Figure 2 shows the weathered bedrock unit sub-zones, which are assigned primarily to model layer 12
5. Figure 3 shows the Gasport Formation sub-zones, which are assigned to model layers 16-21.

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CBM AGGREGATES (CBM), A DIVISION OF ST. MARYS CEMENT INC. (CANADA)

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MEMBER OF WSP

YYYY-MM-DD	2023-07-20
PREPARED	HW
DESIGN	HW
REVIEW	SD
APPROVED	GS

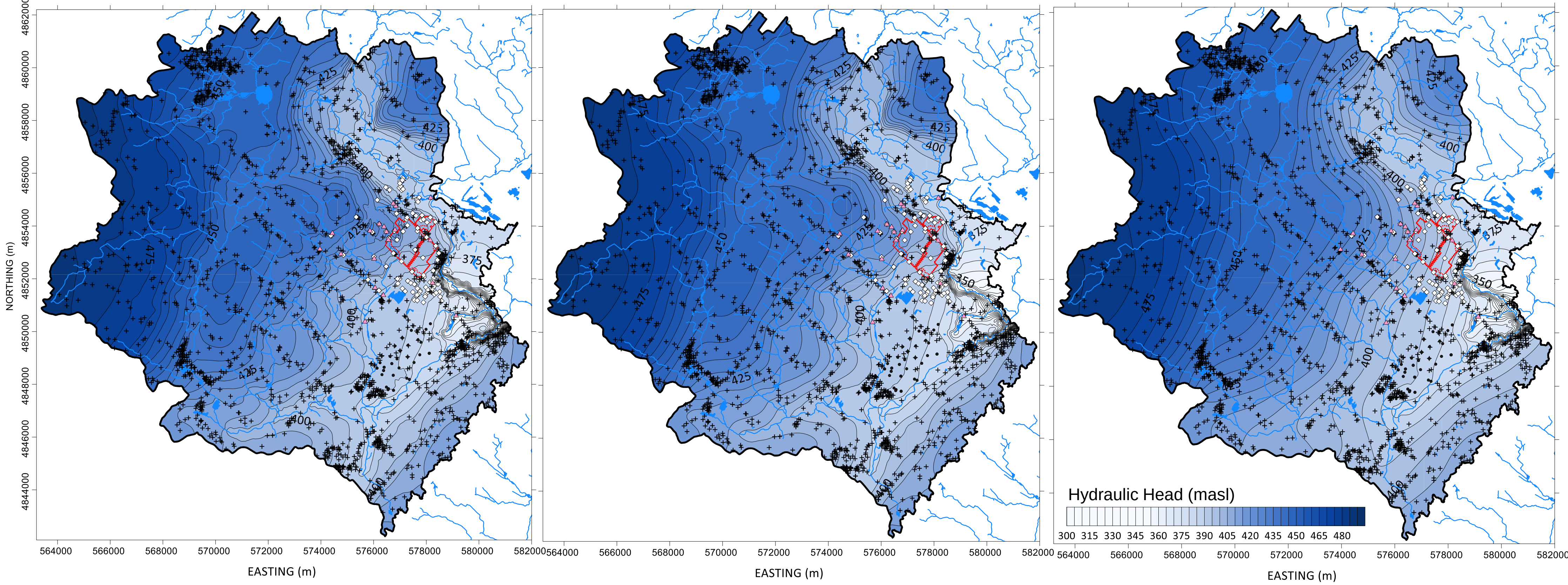
PROJECT
CALEDON PIT AND QUARRY NUMERICAL MODELLING

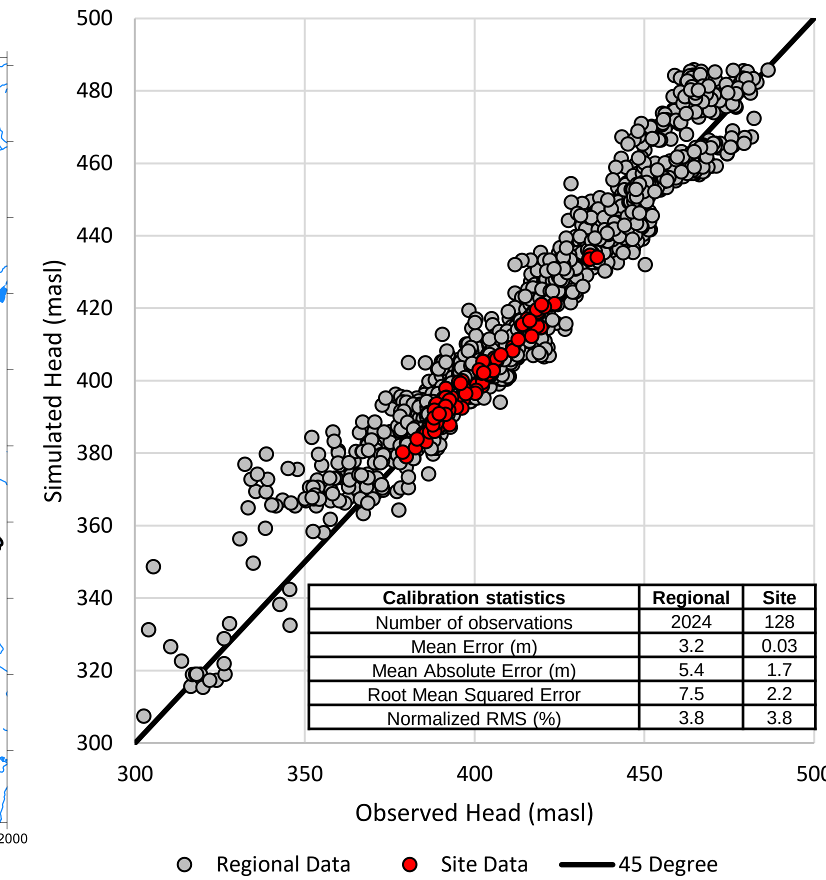
TITLE
MODEL PARAMETERIZATION

PROJECT No.	Rev.	FIGURE
19129150	0	3

SIMULATED HYDAULIC HEAD: REGIONAL (masl)

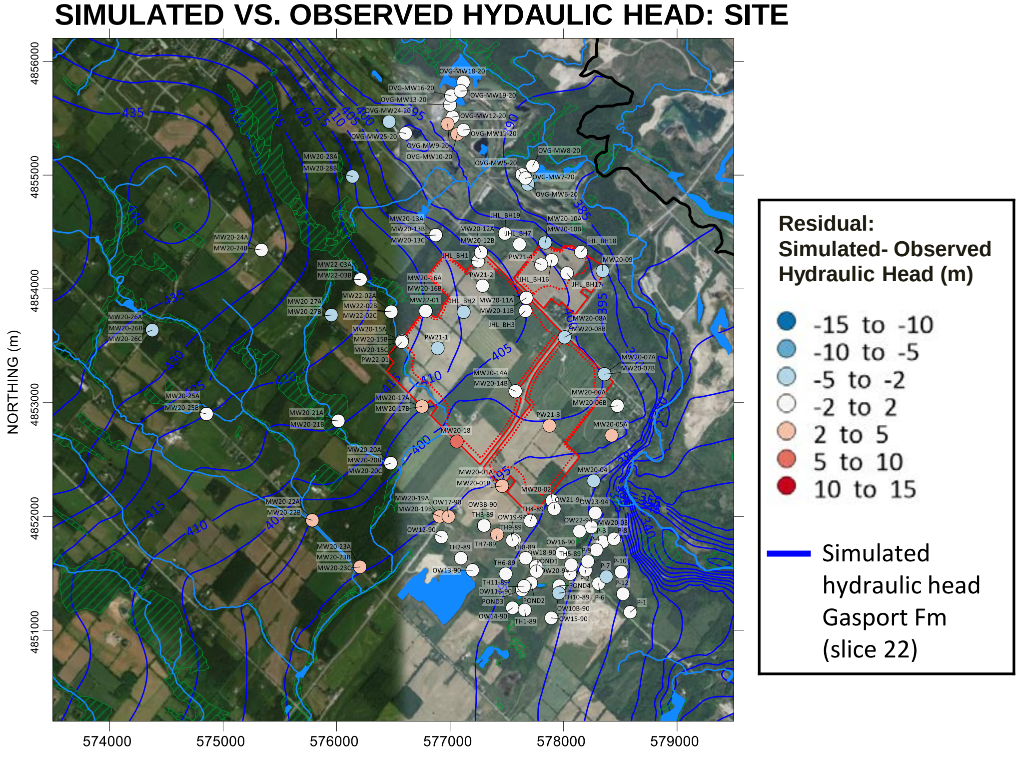
1. Simulated Water Table Elevation
2. Gasport Formation (Model Slice 22)
3. Manitoulin/ Whirlpool Formation (Model Slice 25)



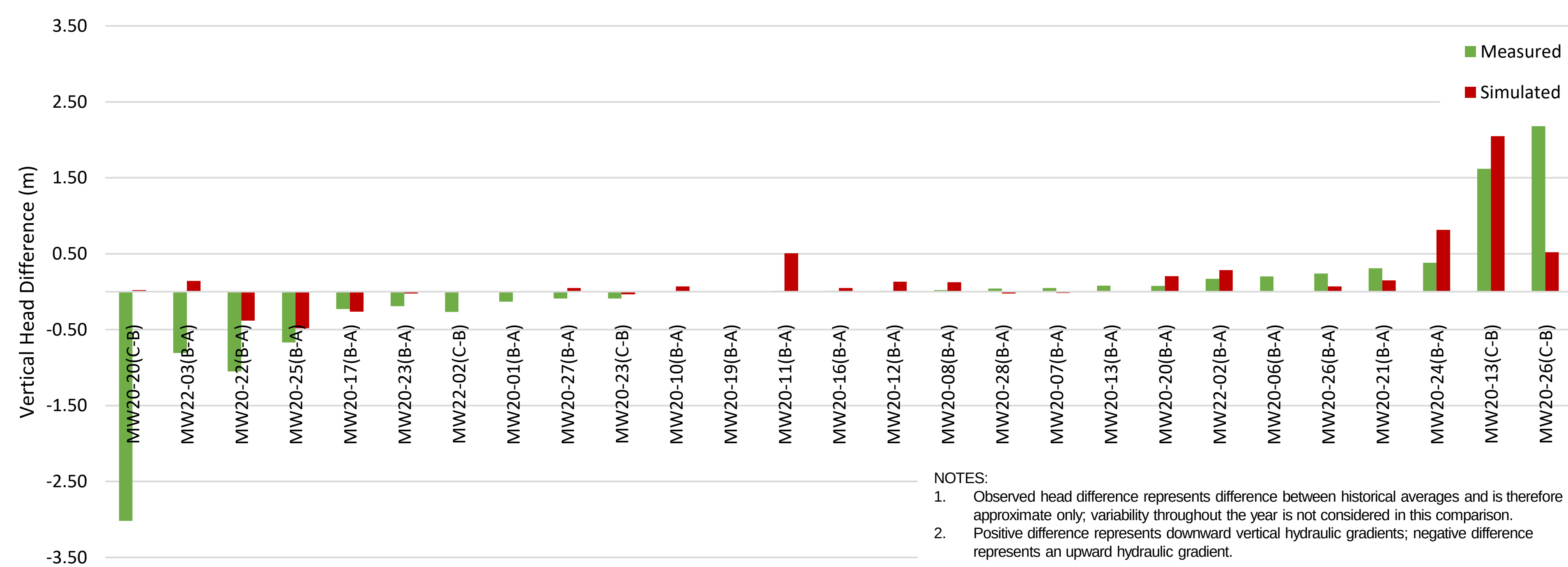


Calibration statistics	Regional	Site
Number of observations	2024	128
Mean Error (m)	3.2	0.03
Mean Absolute Error (m)	5.4	1.7
Root Mean Squared Error	7.5	2.2
Normalized RMS (%)	3.8	3.8

SIMULATED VS. OBSERVED HYDAULIC HEAD: SITE



SIMULATED VS. OBSERVED HYDRAULIC HEAD DIFFERENCE IN NESTED MONITORING WELLS



NOTES:
1. Observed head difference represents difference between historical averages and is therefore approximate only; variability throughout the year is not considered in this comparison.
2. Positive difference represents downward vertical hydraulic gradients; negative difference represents an upward hydraulic gradient.

LEGEND

- LAKES
- RIVERS/ STREAMS
- WETLAND
- MODEL DOMAIN
- CVC SUBWATERSHED
- LICENSE LIMIT
- MODELLED EXTRACTION EXTENTS
- MECP WWR WELL LOCATION
- SITE GROUNDWATER MONITORING LOCATION
- SITE SURFACE WATER MONITORING LOCATION
- ADDITIONAL GROUNDWATER MONITORING LOCATION[6]

NOTES

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PROJECT
CALEDON PIT AND QUARRY NUMERICAL MODELLING

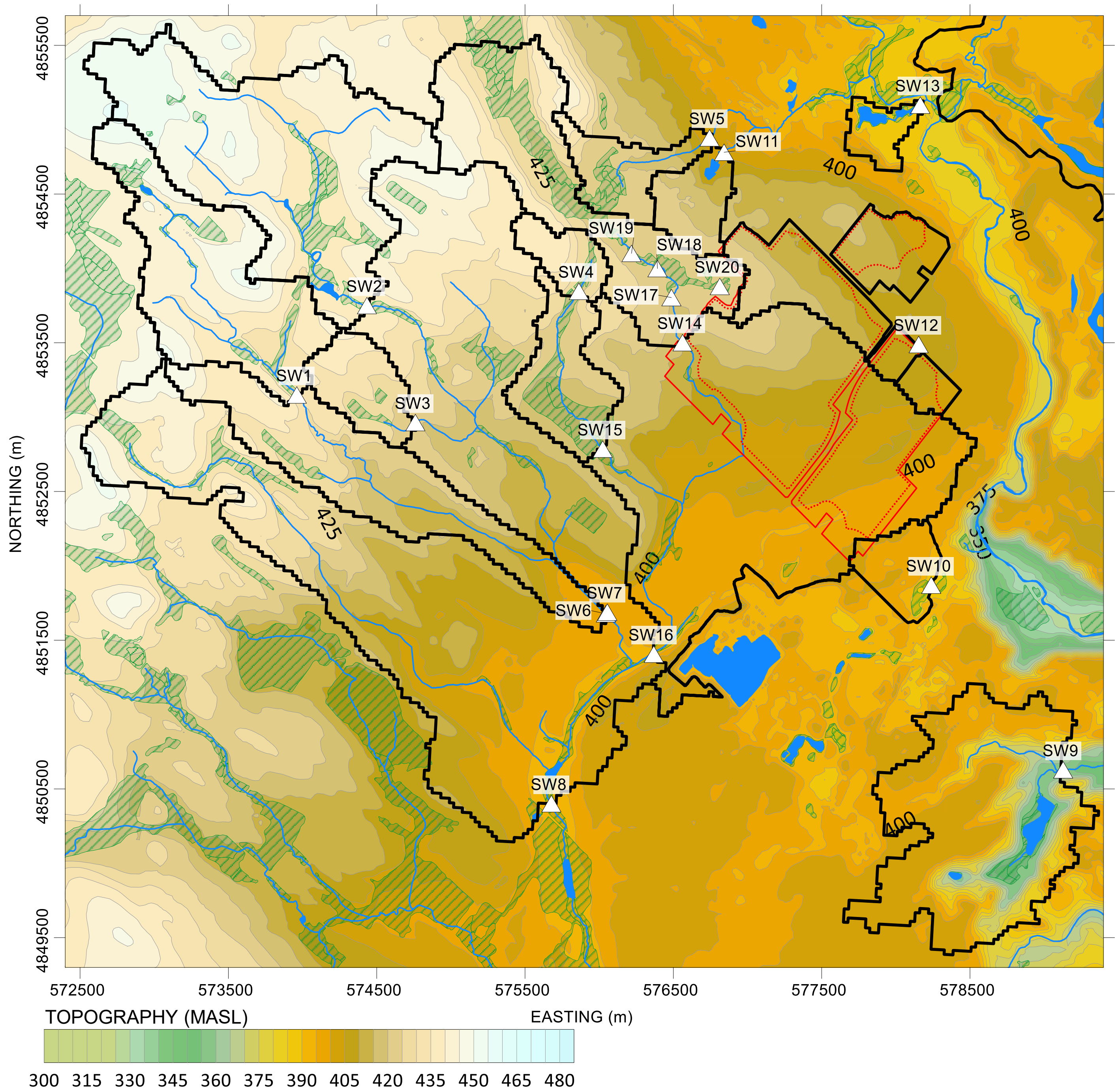
CONSULTANT
GOLDER MEMBER OF WSP

YYYY-MM-DD	2023-07-20
PREPARED	HW
DESIGN	HW
REVIEW	SD
APPROVED	GS

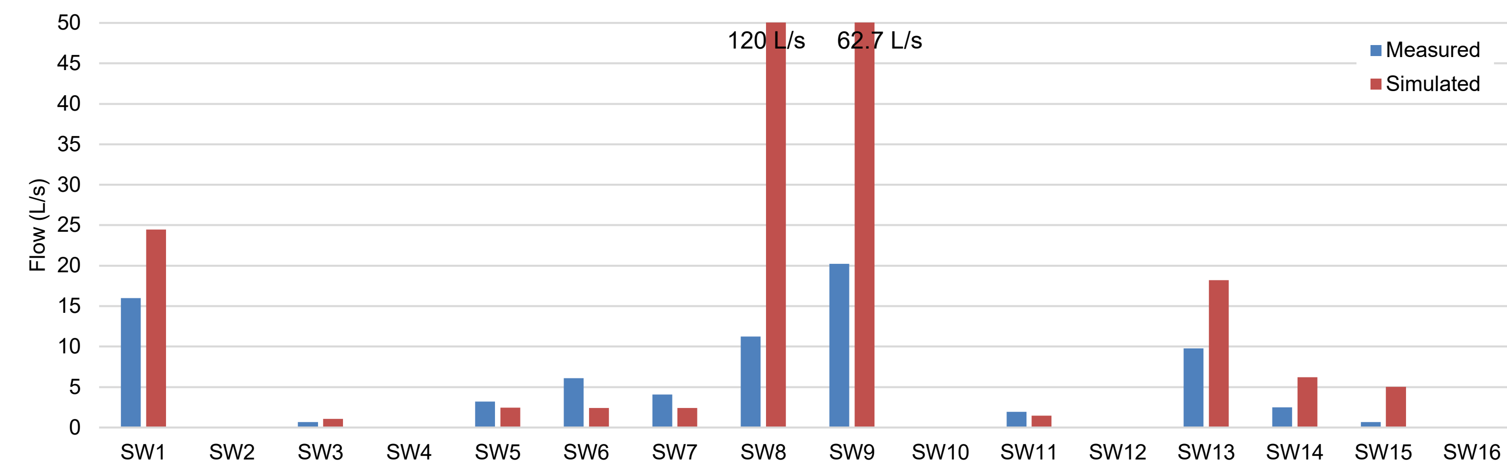
TITLE
CURRENT CONDITIONS SIMULATED HYDRAULIC HEAD

PROJECT No.	Rev.	FIGURE
19129150	0	4

SURFACE WATER MONITORING STATIONS AND CATCHMENT AREAS



AVERAGE MEASURED AND SIMULATED FLOW (L/s)



AVERAGE MEASURED AND SIMULATED UNIT YIELD (L/s/km²)

Stations	Catchment Area (km^2)	Flow (L/s)		Unit Yield ($L/s/km^2$)		
		Average Measured	Model Simulated	Average Measured	Model Simulated	Surplus
SW1	1.32	16.00	24.45	12.12	18.52	11.54
SW2	2.21	0.03	0.00	0.01	0.00	11.54
SW3	0.35	0.68	1.06	1.98	3.07	11.54
SW4	0.22	0.00	0.02	0.00	0.09	11.54
SW5	0.35	3.20	2.46	9.20	7.07	11.54
SW6/7	7.73	10.17	2.41	1.32	0.31	11.54
SW8	17.40	11.25	119.98	0.65	6.90	11.54
SW9	1.81	20.23	62.71	11.19	34.68	11.54
SW10	0.26	0.00	0.00	0.00	0.00	11.54
SW11	0.28	1.94	1.45	6.83	5.11	11.54
SW12	0.06	0.00	0.00	0.02	0.00	11.54
SW13	0.16	9.79	18.23	60.44	112.51	11.54
SW14	1.41	2.50	6.20	1.77	4.39	11.54
SW15	0.73	0.65	5.03	0.89	6.86	11.54
SW16	5.94	0.00	0.00	0.00	0.00	11.54

NOTES:
1. Average measured surface water flows represent the average over the period of record for each station (approximately May 2020 to December 2021). There may be considerable variability in flows as a results of short-term climate events, which is shown in the hydrograph figures in the main report.
2. Several surface water stations have an average flow of 0.00 L/s (SW4, SW10, SW12, and SW16).
3. The 'unit yield' for both average measured and simulated surface water flow represents the average measured flow and model simulated flow for each surface water monitoring station divided by the catchment area.
4. The 'unit yield' surplus value represents the surplus value of 364 mm/yr applied to the top surface of the model (surface water domain), normalized by area.

LEGEND
- LAKES
- RIVERS/ STREAMS
- WETLAND
- CATCHMENT AREA
- LICENSE LIMIT
- MODELLED EXTRACTION EXTENTS
- SURFACE WATER MONITORING STATION

ADDITIONAL MAP NOTES
5. Source of spatial mapping of watercourses, waterbodies, and wetlands: Land Information Ontario (MNRF, 2018)
6. Source of Regional Topography dataset Ontario Ministry of Natural Resources and Forestry (MNRF) Southwestern Ontario Orthophotography (SWOOP) 2019
7. Source of Site Topography dataset provided by Firstbase Solutions (Spring 2021)
8. Quarry license and modelled limit of extraction provided by MHBC (May, 2023)

CLIENT
CBM AGGREGATES (CBM), A DIVISION OF ST. MARYS CEMENT INC. (CANADA)

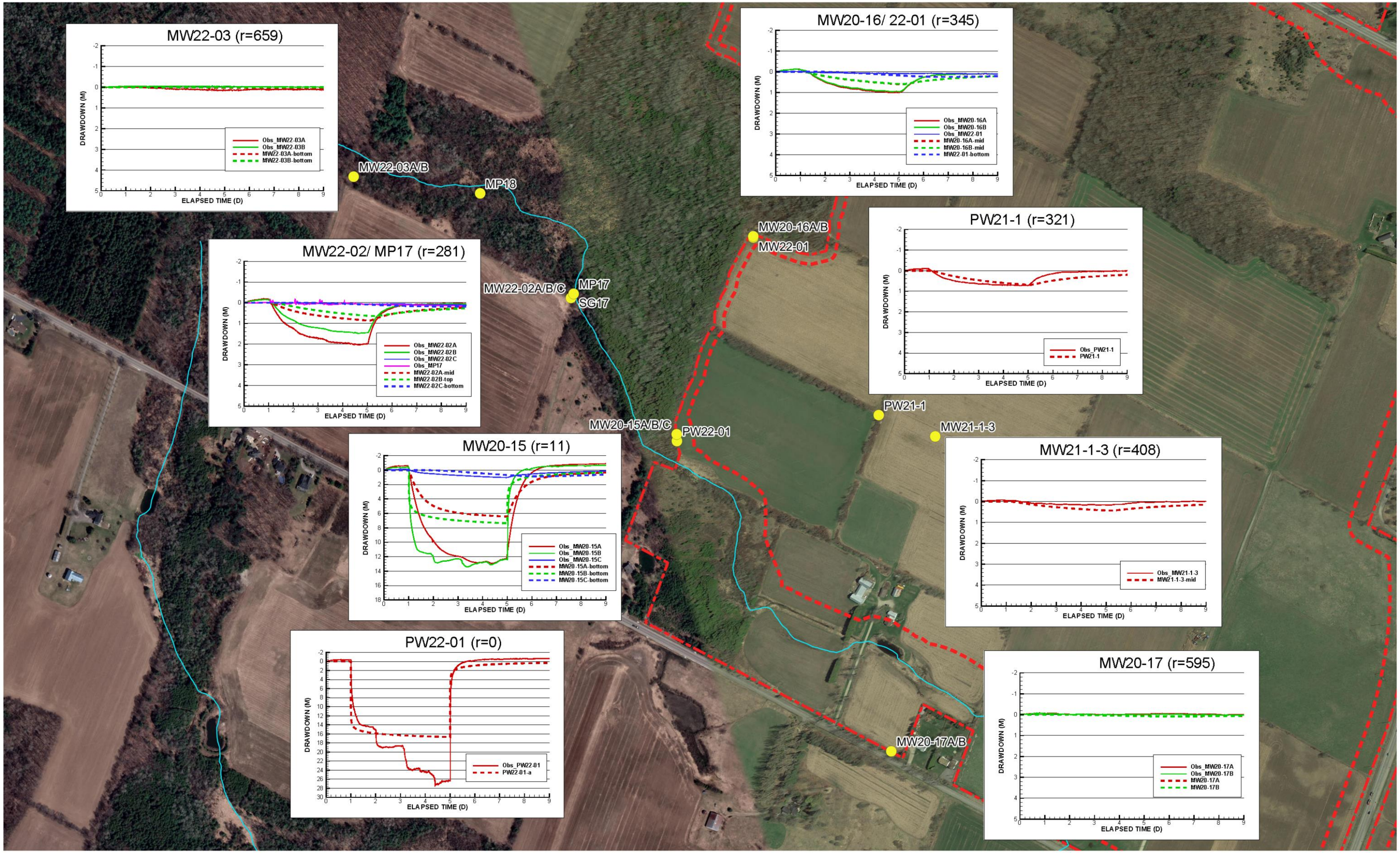
PROJECT
CALEDON PIT AND QUARRY NUMERICAL MODELLING

CONSULTANT
GOLDER
MEMBER OF WSP

YYYY-MM-DD	2023-07-20
PREPARED	HW
DESIGN	HW
REVIEW	SD
APPROVED	GS

TITLE
CURRENT CONDITIONS SIMULATED SURFACE WATER FLOW

PROJECT No. 19129150 | Rev. 0 | FIGURE 5



LEGEND

- LAKES
- RIVERS/ STREAMS
- LICENSE LIMIT
- MODELLED EXTRACTION EXTENTS
- MONITORING WELL LOCATION
- r DISTANCE FROM PUMPING WELL

ADDITIONAL MAP NOTES

1. Source of spatial mapping of watercourses, waterbodies, and wetlands: Land Information Ontario (MNRF, 2018)
2. Quarry license and modelled limit of extraction provided by MHBC (May, 2023)
3. The pumping test was conducted over a 4-day period from August 26, 2022, to August 30, 2022 at an average rate of 80.4 L/min, with monitoring continuing from August 23, 2022, to September 7, 2022.
4. Additional details on the pumping test methodology and interpretation are described in section 5.8.6 of the main report.
5. Gasport aquifer transmissivity is estimated to be 4.5 m2/day, and with an aquifer thickness of 23.8m the hydraulic conductivity is 2E-06 m/s.

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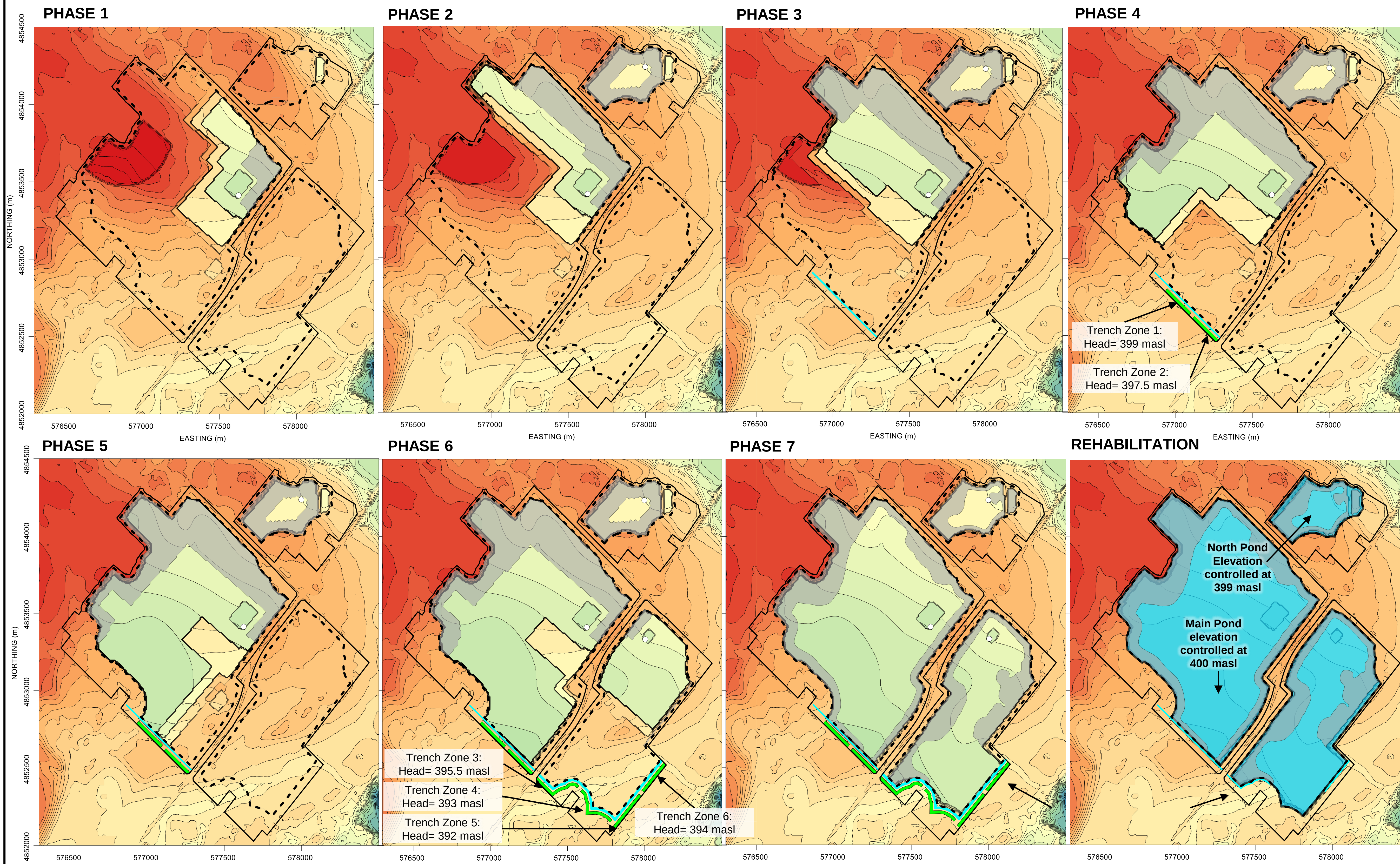
DESIGN	HW
REVIEW	SD
APPROVED	GS

PROJECT
CALEDON PIT AND QUARRY NUMERICAL MODELLING

TITLE
TRANSIENT CALIBRATION: NORTHWEST PUMPING TEST

PROJECT No.	Rev.	FIGURE
19129150	0	6



TIMELINE OF QUARRY DEVELOPMENT

Phase of Operation	Years
1	1 to 8
2	9 to 13
3	14 to 17
4	18 to 22
5	23 to 26
6	27 to 32
7	33 to 38

QUARRY SUMP ELEVATIONS

Phase of Operation	Main Area	North Area	South Area
1	384.63	-	-
2	384.63	393.79	-
3	384.63	393.79	-
4	384.63	393.79	-
5	384.63	393.79	-
6	384.63	393.79	387.67
7	384.63	393.79	387.67

NOTES ON MODEL SETUP:

1. Quarry area is simulated as a high hydraulic conductivity zone (K= 1m/s)
2. Till backfill has an assumed value of 1E-6 m/s. There is no till backfill placed along trench zones 4 and 5 in the South Quarry, and along an 80m length adjacent to trench zone 2 in Phase 7 and the rehabilitation phase (as shown right).
3. Infiltration trench zones are simulated as constant head boundaries.
4. Slurry wall and grout alignment is modelled as a hydraulic conductivity zone with K= 1E-7m/s. Slurry wall is removed along trench zones 4 and 5 during the rehabilitation phase.
5. Sump locations are set in the South Quarry, Main Quarry, and North Quarry as they are developed. These sump nodes discharge to the Credit River directly to the east of the North Quarry, as shown in Figure 7-4 (potential discharge location) of the main report.

LEGEND

- LAKES
- RIVERS/ STREAMS
- LICENSE LIMIT
- MODELLED EXTRACTION EXTENTS
- QUARRY SUMP LOCATION
- TILL BACKFILL MATERIAL
- SLURRY WALL/ GROUT ALIGNMENT
- INFILTRATION TRENCH

ELEVATION (masl)

360 364 368 372 376 380 384 388 392 396 400 404 408 412 416 420 424

ADDITIONAL MAP NOTES

4. Source of spatial mapping of watercourses, waterbodies, and wetlands: Land Information Ontario (MNRF, 2018)
5. Source of Regional Topography dataset Ontario Ministry of Natural Resources and Forestry (MNRF) Southwestern Ontario Orthophotography (SWOOP) 2019
6. Source of Site Topography dataset provided by Firstbase Solutions (Spring 2021)
7. Quarry license and ultimate modelled limit of extraction provided by MHBC (May, 2023)

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PROJECT
CALEDON PIT AND QUARRY NUMERICAL MODELLING

CONSULTANT
GOLDER
MEMBER OF WSP

YYYY-MM-DD	2023-07-20
PREPARED	HW
DESIGN	HW
REVIEW	SD
APPROVED	GS

TITLE
MODELLED QUARRY DEVELOPMENT PHASES AND MITIGATION

PROJECT No.	Rev.	FIGURE
19129150	0	7