



GEMTEC Consulting Engineers and Scientists Limited
 6695 Millcreek Drive, Unit 7,
 Mississauga, ON, Canada
 L5N 5M4
 gta@gemtec.ca
 www.gemtec.ca

October 4, 2024

File: 1000876.086 – Rev2

Tatham Engineering Limited
 41 King Street, Unit 4
 Barrie, Ontario
 L4N 685

Attention: Alicia Kimberley, P.Geo., Group Leader - Hydrogeology

**Re: Geotechnical Berm and Slope Stability Feasibility Study
 Proposed Strata Shelburne Quarry/Pit, 437159 4 Line, Melancthon, Ontario**

Enclosed is our Geotechnical Feasibility Study to support the proposed quarry/pit berms, trench, and ponds of the proposed Shelburne Quarry/Pit in Melancthon, Ontario. The report presented herein is based on the scope of work summarized in our proposal dated April 16, 2024, the subsequent change order dated June 10, 2024, and peer review comments received on August 27, 2024. Authorization to proceed was given by Grant C. Horan of Strada Aggregates on May 16, 2024 for the original scope of work, and on June 11, 2024 for the extended scope of work. This report was prepared by Connor McCormick, P.Eng., and reviewed by Graeme Skinner, PhD., P.Eng.

A handwritten signature in blue ink, appearing to read "Connor McCormick".

Connor McCormick, P.Eng.
 Geotechnical Engineering

A handwritten signature in blue ink, appearing to read "Graeme Skinner".

Graeme Skinner, PhD., P.Eng.
 Principal Geotechnical Engineer

JCM/GDS/sv/af

N:\Projects\100800\100876.086\03_Submittals\Reports\Geotech\100876.086_LTR_Geotechnical Report_Shelburne Quarry_2024-10-04_Rev2.docx

4.1.1 Quarry/Pit Berm Global and Sliding Stability Analysis

It is understood that the current conceptual design of the quarry/pit excavation includes the use of low permeability/impermeable berms to limit infiltration of groundwater through the identified permeable soil and bedrock strata. The proposed berms would be placed on the benches where the permeable units have been identified. The Client provided three (3) cross sections showing the proposed quarry/pit and berm construction (Sections A-A', B-B' and C-C'; see Appendix B). The stratigraphy elevations and composition included in the preliminary stability assessment discussed herein were taken directly from these cross sections. While the Client cross sections appear to show the berms as near vertical features (due to horizontal versus vertical scale exaggeration), it was confirmed that they would have a typical inclination of 2 Horizontal to 1 Vertical (2H:1V). Section C-C' was identified as the critical section, due to the presence of relatively thick overburden, and high groundwater (head) pressure from the hydrogeological models. The proposed upper berm will abut the soil overburden at the site, while the middle and lower berms will abut permeable bedrock; and all berms are expected to be founded on competent bedrock. The Factor of Safety (FOS) for global stability of the berm slopes was analysed based on limit equilibrium analysis using the commercially available program Slide 2018, produced by Rocscience Inc., employing the Morgenstern Price method of analysis for static loading conditions. The lowest, or minimum, FOS against slope instability is presented herein. The FOS against potential sliding of the berms along the berm / bedrock interface was analyzed and is presented herein. The results of the global slope stability and sliding analyses for quarry/pit Section C-C' are provided below:

Section	Berm Inclination	Berm Height (m)	Stability Mode	Estimated Minimum Factor of Safety	Target Factor of Safety
Section C-C' (Upper Quarry/Pit Section)	2H:1V	19.6	Global ¹	0.90	1.3 to 1.5
			Sliding ²	1.0	2.0
Section C-C' (Middle Quarry/Pit Section)	2H:1V	10.8	Global ¹	0.74	1.3 to 1.5
			Sliding ²	1.0	2.0
Section C-C' (Lower Quarry/Pit Section)	2H:1V	12.2	Global ¹	0.73	1.3 to 1.5
			Sliding ²	1.0	2.0

Note: 1. The global stability analysis evaluates the stability of the berm but does not fully account for the potential high hydraulic pressures found in the lower berms.

2. The sliding analysis assumes the berms will behave "monolithically", and potential instability of the berm due to groundwater pressures was not assessed.

Based on the results of our analyses, the current berm configurations (i.e., 2H:1V slopes) are not meeting the target minimum FOS for global stability or sliding.

The FOS for the berms can be increased by:

- Decreasing the slope inclination from 2H:1V to 3H:1V;
- Adding positive drainage to the berms (i.e., lower the groundwater level in the berms); and / or,
- A combination of both.

A preliminary global and sliding stability assessment was undertaken incorporating the additional stability measures outlined above, and it showed that these measures still fall short of the target minimum FOS where the berm is composed entirely of impermeable (i.e., clayey) material.

Therefore, it is recommended that, at the feasibility level, a composite berm construction using a 'core' of impermeable clay (or sufficiently impermeable material) with a well compacted cohesionless granular shell or outer material comprising of the majority of the berm backfill be utilized for the berm construction. Based on an initial limited global stability and sliding assessment, a composite berm structure could provide satisfactory FOS for both global and sliding stability at a 2H:1V slope. It should be noted that potential high hydraulic heads are anticipated at the lowest berms, and consideration may need to be given to raising the berm height in order to extend the "clay core" across the bedrock units, while also increasing the berm thickness (and stability) at contact. This would be expected to limit groundwater "punching" through the berm where it is thinnest. As noted above, the feasibility level sliding analysis did not consider partial failure i.e., "punching" or "piping" of the berms, and the overall stability of the berms, including these potential failure mechanisms, should be confirmed during the detailed design stage based on a site-specific geotechnical field investigation and prior to construction.

4.1.2 Quarry/Pit Trench and Pond Global Stability Analysis

Global slope stability analyses were carried out for two water control features. A drainage trench located toward the northwest end of the site (within Section A-A'; see Appendix B) and an infiltration pond located south of the main quarry pit (within Section C-C'; see Appendix B). Cross sections for the trench and pond were provided by the Client (Appendix B). Further, based on information provided by the Client, it is understood that the trench would have a bottom elevation of about 503.0 m (about 7.0 m below grade) and that the West wall of the trench would be coincidental with the back side of a quarry/pit berm. It is understood that the north and west pond walls would be provided with an impermeable (i.e., clayey) liner, while the south and east walls would be left as native soils. The global stability of the trench and pond slopes was analyzed based on limit equilibrium analysis, again using the commercially available program Slope/W®, produced by Geo-Slope International Ltd., employing the Morgenstern Price method of analysis for static loading conditions. The slope stability assessment considered both the steady-state and elevated design groundwater level in the trench, while the pond only considered the design

steady-state groundwater level, and it is understood the temporary elevated groundwater level is not applicable to the feasibility design at this time. The results of the global stability analysis are provided below:

Section	Berm Inclination	Slope Height (m)	Minimum Factor of Safety		Target Factor of Safety
			Steady-State Groundwater Level (Dry)	Temporary Elevated Groundwater	
Section A-A' (West Trench Wall)	2 H : 1 V	7.0	1.68	1.54	1.3 to 1.5
Section A-A' (East Trench Wall)	2 H : 1 V	7.0	1.37	1.28	1.3 to 1.5
Section C-C' (North Pond Wall)	3 H : 1 V*	17.0	1.84	N/A	1.3 to 1.5
Section C-C' (South Pond Wall)	2 H : 1 V	17.0	1.40	N/A	1.3 to 1.5

* The impermeable liner on the north pond wall is expected to be unstable / marginally stable at inclinations steeper than 3 H:1V.
N/A – Not applicable.

Based on the results of our feasibility analysis, we expect that these two water control features will generally be stable with respect global stability at the given FOS ranges. With that said, we note that both the trench and pond walls may be marginally stable to unstable in the event of rapid drawdown and with an impermeable liner. The effects of rapid drawdown and slope liner stability should be further analyzed during the detailed design stage using site specific information.

4.2 Re-Use of On-Site Soils for Impermeable Layers

It is understood that the quarry/pit developer is proposing to re-use any on-site fine grained (i.e., clayey) soils from the site to construct the impermeable pond liner and cores which form part of the composite berms. An initial review of the soils from the available borehole information (see Appendix A) indicate that the fine grained till present on site may be suitable for re-use as an impermeable liner for the pond and berms. However, site specific borings (i.e., field investigation drilling and sampling), particle size analyses and Atterberg Limits testing would be required to verify that the soils encountered on site are suitable for this use, which should be conducted prior to construction and re-use of soils on site as detailed below.

All materials to be used in the construction of a compacted clay / impermeable liner shall be analyzed for particle size distribution following ASTM D2487 and ASTM 422-63, and Atterberg

Limits following ASTM D4318, or any other method pre-approved by the ultimate approval / regulatory agency (as applicable).

Typical particle size ranges (by weight) for a compacted clay liner are provided below, where the fines are defined as the soil fraction which passes through a No. 200 (75 μm) US standard sieve, and clay and sand are defined in the ASTM Standard D2487-00:

- Percents fines $\geq 50\%$;
- Clay Content $\geq 20\%$; and,
- Sand content $\leq 45\%$.

Acceptable Atterberg Limits:

- Plasticity Index (PI): PI $\geq 20\%$; and
- Liquid Limit (LL): LL $\geq 30\%$.

A detailed geotechnical study including site specific boreholes and relevant geotechnical testing should be carried out during the detailed design phase and prior to construction and re-use of on-site materials for the berm construction. Should the fine grained material on-site not meet these requirements then additional testing may be conducted to demonstrate a design (i.e., laboratory testing) and / or an “as-constructed” field hydraulic conductivity of 1×10^{-9} m/s or less. Otherwise, importing of suitable low-permeable materials may be required.

4.3 Constructability Considerations

During the Phase 2 stage of excavation of the quarry, it has been noted that there will be a point where about 2 m of the Ancaster/Niagara Formation would be left overlying the permeable Gasport unit. The effects of groundwater uplift on the underside of the 2 m layer of the Ancaster/Niagara Falls unit should be considered during the detailed design phase. At the current feasibility level assessment, it is anticipated that potential excess pressures from the Gasport unit can be managed with through pressure relief wells and drainage galleries within the excavation.

At the final (Phase 4) stage of the excavation, it is not expected that significant uplift pressures would develop within the relatively thick layer of Cabot Head Shale (generally understood to be impermeable). However, if evidence of fractures and / or bulging due to uplift are noticed, then again, these pressures are anticipated to be manageable through the use of pressure and drainage galleries in the excavation.

Again, both aspects of the quarry development should be reviewed during the detailed design phase.