THURBER ENGINEERING LTD.

December 23, 2021 File: 33256

Clean Harbors Canada Inc.
4090 Tefler Road, R.R. #1
Corunna, Ontario N0N 1G0

Attention: Mr. Michael Parker
Vice President, Canadian Environmental Compliance

GEOTECHNICAL PEER REVIEW
GHD GEOTECHNICAL EVALUATION AND REMEDIAL PLAN
CELL 20-1 SLOPE STABILITY ISSUES
CLEAN HARBORS LAMBTON LANDFILL FACILITY
CORUNNA, ONTARIO

Dear Mr. Parker:

Thurber Engineering Ltd. (Thurber) has been retained by Clean Harbors Canada Inc. (Clean Harbors) to undertake a peer review of the following reports prepared by GHD:

- Geotechnical Evaluation and Remedial Plan (GHD Report)
  Cell 20-1, Slope Issues – Clean Harbors
  Lambton Facility Landfill Corunna, Ontario
  Prepared by GHD for Clean Harbors, dated November 12, 2021

- Addendum to the Geotechnical Evaluation and Remedial Plan (GHD Addendum)
  Cell 20-1, Slope Issues – Clean Harbors
  Lambton Facility Landfill Corunna, Ontario
  Prepared by GHD for Clean Harbors, dated December 17, 2021

This GHD Report presents an outline of the events around the failure of the excavated west slope and base of landfill Cell 20-1, remedial efforts completed by Clean Harbors to stabilize the slope, geotechnical stability modelling relative to the remedial efforts and plans for confirmation of the ground conditions related to the slope movement. GHD has prepared its report to address requirements set out by the Ontario Ministry of Environment, Conservation and Parks (MECP) for continued use of the landfill cell.

The GHD Addendum presents the results of additional studies completed by GHD and further assessment of slope stability and recommendations for use of Cell 20-1.

The purpose of Thurber's peer review is to assess the GHD geotechnical stability modelling to determine if it is a viable model for planning the remediation of the slope and design for filling of Cell 20-1 in a safe manner going forward. A key component of our review will be to determine if data gaps remain with respect to subsurface soil or groundwater conditions which may impact the ability to make engineering decisions with respect to the use of the existing Cell 20-1.

Our peer review included review of the following additional reports/documentation:

- Geotechnical Investigation (GHD Geotechnical Design Report)
  Cell 20, Subcell 1
  Clean Harbors Lambton Facility Landfill
  Corunna, Ontario
  Prepared by GHD for Clean Harbors, dated January 19, 2021

- Geotechnical Evaluation and Remedial Plan
  Slope Failure – Trench 1401
  Cell 18, Subcell 14
  Lambton Facility, Corunna, Ontario
  Prepared for Clean Harbors by Inspec-Sol Inc. (now GHD), dated August 31, 2009

- GHD Presentation Slides
  Clean Harbors Lambton Facility Landfill
  Staff Presentation, undated

- Design Report for Subcell 3 Mitigation
  Prepared for Safety-Kleen Ltd. by Amec Earth and Environmental Limited, dated February 2001

- The Analysis of a Deep Excavation in a Gassy Soil, A Thesis Submitted to the Queens University Department of Civil Engineering by Ahmed Badr Mabrouk, dated August 2012

A site visit was completed by the author on November 9, 2021, to obtain a general understanding of the site layout, grades, and Cell 20-1 slope conditions. Thurber has not completed an independent evaluation of ground conditions or soil strength parameters. Thurber's review does not include any environmental assessment. This peer review should not be considered design advise.

1. PROJECT UNDERSTANDING

The excavation for Cell 20-1 was advance in the spring/summer of 2021, and was within three weeks of completion when the west slope experienced a slide on August 18, 2021. We understand that the west part of the excavation was complete to the design depth of 182 m AMSL, and the contractor was progressing toward the east to the north-east to establish final grades for a designed ramp.

The slope movement resulted in damage to the existing leachate collection system for the adjacent pre-1986 cells and associated flow of leachate into the newly excavated cell.

Remedial efforts were undertaken to stabilize the failed slope and leachate release, including:

- Confirmation of ground surface stability through multiple drone topographic surveys.

- Multiple engineering inspections.
- Installation of a leachate management berm and a clay buttress to stabilize the slope between August 20 and September 20, 2021.
- Installation of a temporary leachate control and collection system.
- Additional slope stability modelling by GHD to help determine the best course of remedial action to prevent further slope movement and to allow waste placement to take place in Cell 20-1.

Cell 20-1 is a proposed below grade landfill cell located in the south-east portion of the Site, adjacent to historical subgrade cells to the west and north. We understand that the waste placement to the west is complete pre-1986, and that an accurate as built condition is not available. Based on review of available reports and discussions with Clean Harbors and GHD personnel, the waste in the pre-1986 cells extend to a depth of approximately elevation 176 m AMSL, which is 6 m below the design depth of Cell 20-1. The slope of the side of the pre-1986 waste is assumed to be at a 1 to 1 inclination.

At the time of the excavation of Cell 20-1, Cell 19-3 was being filled as an above grade cell on top of the historical Pre-1986 cell to the west of Cell 20-1.

Thurber has reviewed the conditions related to two historical slope failures that occurred at the site at Subcell 18-3 and Subcell 18-14.

The first historical slope failure occurred at Subcell 18-3 in September 1999, and was attributed to base heave from hydrostatic pressure from a high than normal bedrock elevation. The presence of natural gas pressure at the bedrock interface was also considered to be a contributing factor.

The historical slope failure at Subcell 18-14 occurred in July 2001, and was attributed to contractor error in over-excavating a slope by removing a required bench.

We understand that GHD proposed to install 9 cone penetration test (CPT) soundings to further investigate the cause of the slope failure. By email dated November 17, 2021, GHD informed Thurber of the following modifications to the subsurface investigations resented in the GHD Report:

1. *Two and potentially three of the CPT locations will be extended to bedrock or refusal. The CPT location that is uncertain north of Cell 20-1. If waste is encountered, the CPT location will not be extended to bedrock due to environmental concerns.*

2. *Two boreholes will also be drilled at the Site. The boreholes will be installed on the south and east side of the cells. The boreholes will be extended to bedrock. Pressure transducers will be installed at key elevations (shallow, mid, and deep) to assess pore water pressure. Collection of soil via Shelby tubes of deeper soils is being considered and will depend on the field information and CPT results.*

2. THURBER PEER REVIEW COMMENTS

2.1 GHD Report

Section 2.1:

- We note on Figure 4 that the surface grade at Sta. 0+050 was at a top elevation of approximately 213 m, which is much higher than was modelled presented in the GHD Geotechnical Design Report. This higher elevation would be a general destabilizing factor for the slope and does not match other plan drawings provided. Can GHD confirm the elevation of the surface grade at the time of the slope movement.

Section 2.4:

- In Figure 5, GHD shows the assumptions used for "back-calculation" of slope failure and for future assessment of stability measures. Thurber has the following comments on the stratigraphy in this figure:
    - The positioning of the failed waste could not be in line with the non-failed waste.
    - The Black Shale sub unit 2A appears to be thicker in the failed area than the original.
    - The failure surface does not account for the heaved materials at the east end of the failure.
    - The bedrock surface is not shown.

Section 2.5:

- The piezometric conditions should include the bedrock piezometric head, which would remain constant during cell excavation and would be a destabilizing force.

Section 2.7:

- The failure surface selected by GHD is not considered to be an obvious or unique solution, and does not match the east heaved surface.
- In order to assess the viability of the failure surface against known conditions and assess any data gaps in the design, Thurber completed preliminary stability modelling of the pre-failed site conditions using Slope/W. Figure 1 through 3 show the modelled conditions and some of the pertinent results.
  Figure 1 presents the general arrangement of grades and soil units. We have assumed similar grades as presented in the GHD Design Report. We have also used the same lower bound parameters used in the GHD Report, however, have included the bedrock layer which was missing in the GHD assessment. The location and depth of waste fill in the pre-1986 cell is approximated based on available data.
  Figure 2 presents the results of the failure model without considering hydrostatic uplift from the bedrock aquifer. The minimum factor of safety (FOS) is 1.04, which is below the design target of 1.3.

Figure 3 presents the further effect of uplift for the hydrostatic aquifer. The minimum FOS is 1.06. More important, the modelling shows that the assessment of the ground conditions using the hydrostatic uplift presents a possible failure scenario which is similar in extent as the actual event. Overall, this modelling shows that the failure surface selected by GHD may not be correct. We recommend that GHD complete further stability assessment assuming at least two additional deeper failure surfaces.

- Thurber agrees that the installation of the stabilizing berm has provided additional stability to the failed slope. However, further assessment is required, as noted above, to confirm that the current slope is safe for filling above the slope crest.
- GHD should provide an assessment of the potential destabilizing effects of natural gas pockets noted in the Queens University thesis, or why this issue as not been addressed.

Section 2.8:

- Thurber agrees with the general scope of investigation proposed by GHD, as augment and noted above. However, it is unlikely that the CPT work will provide sufficient evidence of the failure surface. Additional modelling should be completed as noted.

Section 3:

- Thurber recommends additional modelling be completed prior to the resumption of filling, particularly at the slope crest.
- The stability and safety of the north, east and south slopes should be assessed using all available information.
- Thurber recommends that a robust slope stability monitoring program be included with any future plans for filling at the site in order to confirm that that design assumptions are correct. The monitoring plan should provide the types of monitoring points, frequency of monitoring relative to landfill operations and displacement triggers for modifying or ceasing operations if safety concerns is identified.

2.1 GHD Addendum

Section 2:

- Please provide northing, easting and ground elevations for all VWP and CPT locations.
- Confirm that Figure 1 has been corrected to show as installed locations for CPT and VWP soundings. Show previous boreholes on Figure 1 for ease of comparison.
- Please confirm if natural gas pockets have been identified within any of the previous or new soundings.

Section 3:

- Provide missing geotechnical laboratory test results and assess any impacts to the modelling.

Section 4:

- The presence of water bearing sand lenses within the clay would be a destabilizing condition for the slopes. Please confirm that the data is sufficient to rule out this condition for the west slope, and provide slope stability assessments for the north, east and south slopes.

Section 5:

- Slope stability assessments must be completed to assess the impact of the excavation base stability from the bedrock artesian piezometric pressure and groundwater pressure from any intermediate sand units.

Section 6 and 7:

- Additional slope stability modelling should be conducted which addresses our comments presented above for the GHD Report.

Section 8:

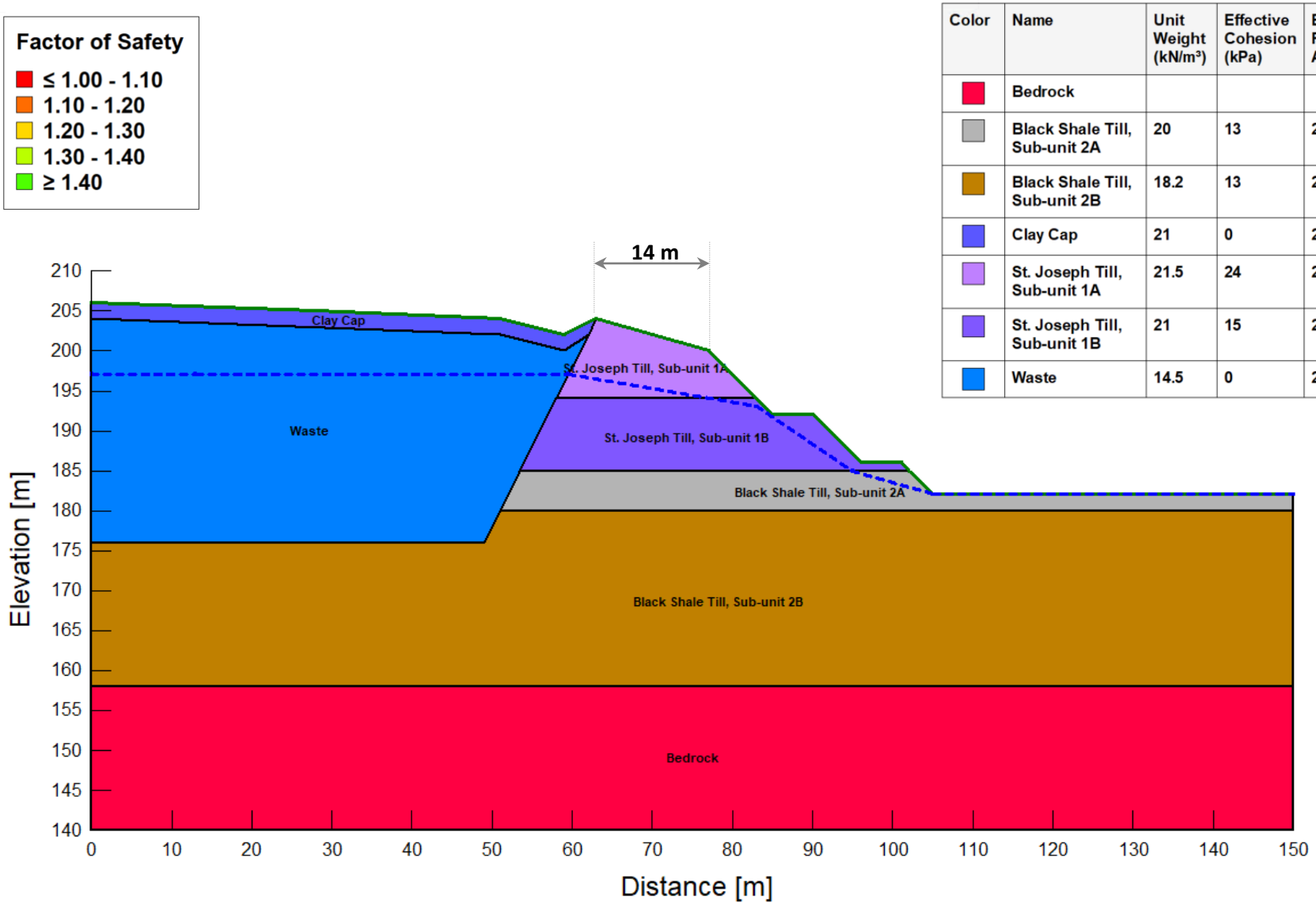
- Thurber agrees that filling the lower elevations of Cell 20-1 would generally be a stabilizing condition for the excavation slopes. The assessment of the risk of the movement of slopes during or after filling should be further assessed using all known subsurface conditions. A robust monitoring plan should be implemented as a confirmation of the modelling results, as described above.

3. CLOSURE

We would like to thank you for the opportunity to submit this peer review. Please feel free to contact us with any questions or comments.

Yours truly,
Thurber Engineering Ltd.

Renato Pasqualoni, P.Eng.
Principal
Attachments: Figures 1 through 3



Color	Name	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	Bedrock			
	Black Shale Till, Sub-unit 2A	20	13	26
	Black Shale Till, Sub-unit 2B	18.2	13	26
	Clay Cap	21	0	25
	St. Joseph Till, Sub-unit 1A	21.5	24	25
	St. Joseph Till, Sub-unit 1B	21	15	28
	Waste	14.5	0	25

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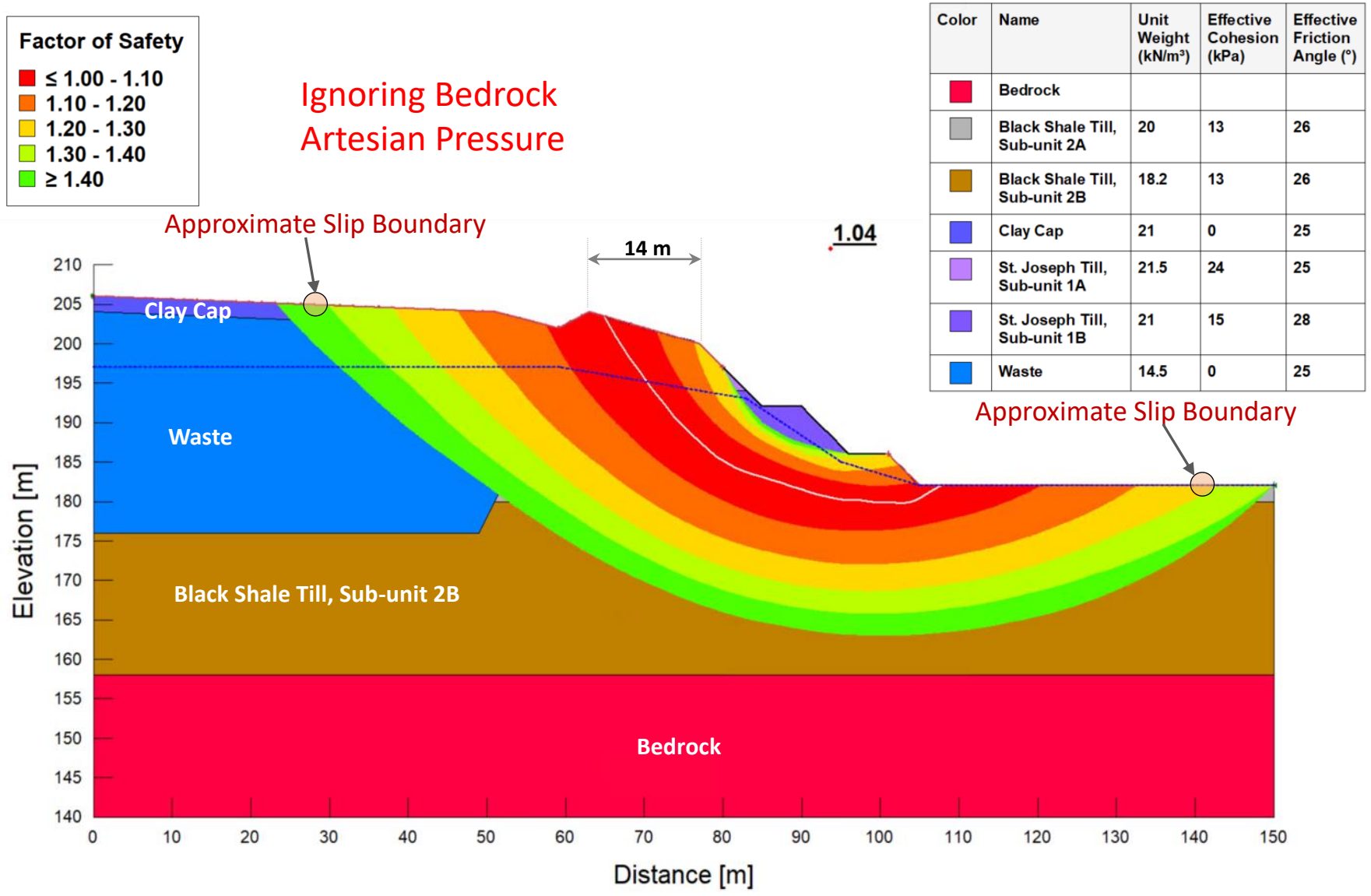
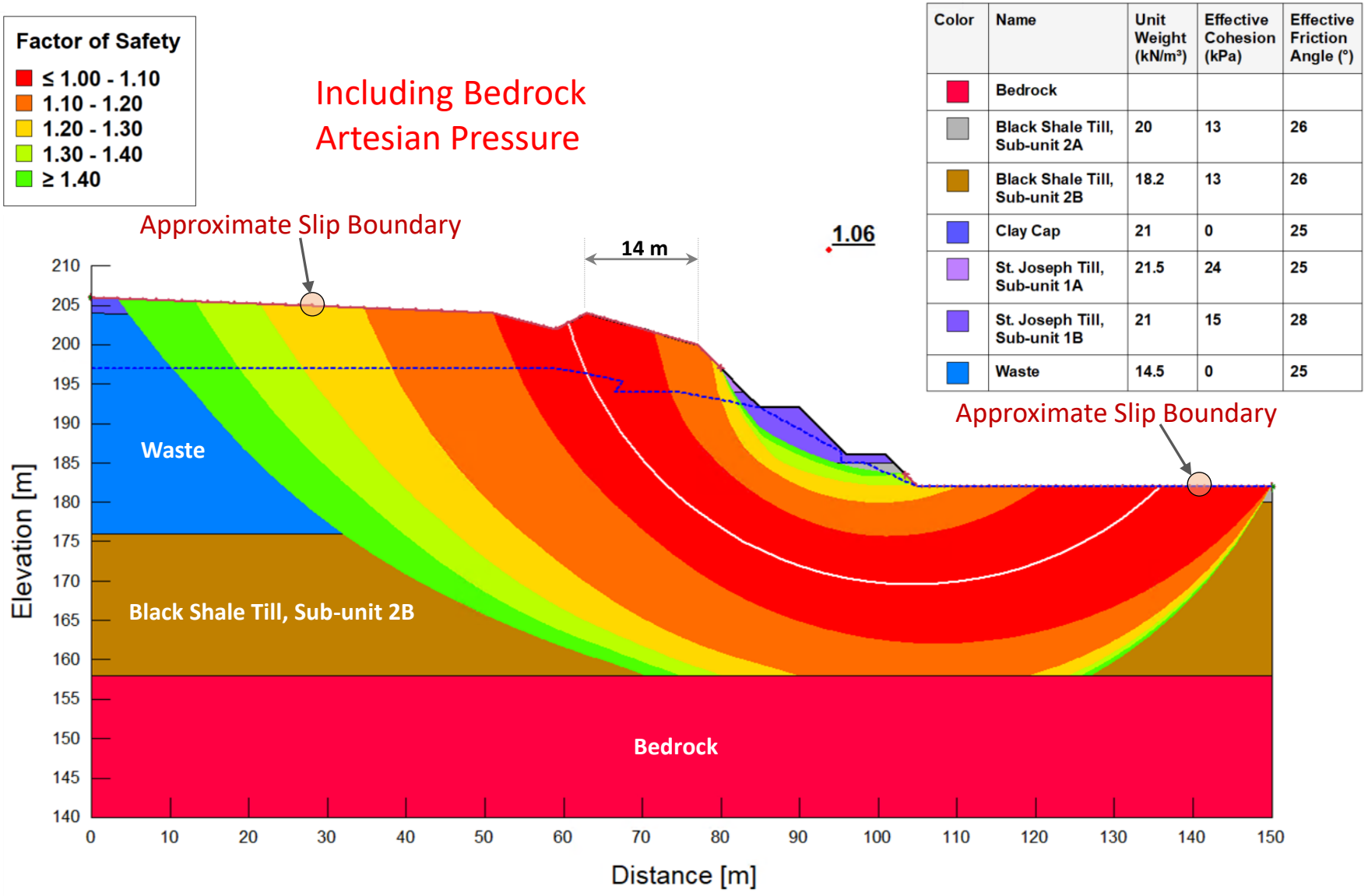
Clean Harbors Lambton Landfill	**Figure 1**	**Designed by: MAH**
Slope Stability Analysis of Cell 20-1 [West Wall]		**Checked by: MH/RP**
		Date: November 26, 2021



Color	Name	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	Bedrock			
	Black Shale Till, Sub-unit 2A	20	13	26
	Black Shale Till, Sub-unit 2B	18.2	13	26
	Clay Cap	21	0	25
	St. Joseph Till, Sub-unit 1A	21.5	24	25
	St. Joseph Till, Sub-unit 1B	21	15	28
	Waste	14.5	0	25

THURBER ENGINEERING LTD.	**Clean Harbors Lambton Landfill**	**Figure 2**	**Designed by: MAH**
	Slope Stability Analysis of Cell 20-1 [West Wall]		**Checked by: MH/RP**
			Date: November 26, 2021



Color	Name	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	Bedrock			
	Black Shale Till, Sub-unit 2A	20	13	26
	Black Shale Till, Sub-unit 2B	18.2	13	26
	Clay Cap	21	0	25
	St. Joseph Till, Sub-unit 1A	21.5	24	25
	St. Joseph Till, Sub-unit 1B	21	15	28
	Waste	14.5	0	25

THURBER ENGINEERING LTD.	**Clean Harbors Lambton Landfill**	**Figure 3**	**Designed by: MAH**
	Slope Stability Analysis of Cell 20-1 [West Wall]		**Checked by: MH/RP**
			Date: November 26, 2021